FLOWERING OF SUGARCANE IN A PHOTOPERIOD HOUSE FROM 1971 TO 1981

By K. J. NUSS
South African Sugar Association Experiment Station, Mount Edgecombe 4300

Abstract

Artificial induction of flowering in the large photoperiod house at Mount Edgecombe is reviewed for the period 1971 to 1981. The rate of decline in daylength affects both time of flowering and number of flowers shedding pollen. The time of flowering is determined mainly by the time of flower initiation. Flowers have been obtained from 626 varieties, some of which are "shy-flowering" noble and commercial varieties. The photoperiod facility has been a valuable asset in the breeding programme to broaden the genetic base of the crosses, to ensure regular flowering and to enable crosses to be made between varieties that normally flower at different times in the crossing season.

Introduction

Sugarcane does not flower freely in Natal (30°S) nor set seed as readily as in tropical countries. Techniques were developed to improve seed set (Brett[2]) and later methods were developed to improve flowering (Brett[3]). In 1971 a new photoperiod house came into use, in which 800 or more cane stalks could be subjected to five different photoperiod treatments each year. The early results (Brett & Harding[4]; Brett, Harding & Paxton[5]) had shown that good flowering was obtained, even in shy-flowering varieties, by starting the photoperiod at between 12,5 and 12,75 h in February or March and shortening it by 30 s per day. These treatments have since become the standard treatments for producing flowers in many varieties for the breeding programme. This paper deals with some of the results obtained in the photoperiod house since 1971.

General Procedures

Single-budded setts are planted in bins filled with river sand in September. The cane is watered daily, and fertilized well, but N application is reduced six weeks before the photoperiod treatments start. The cane is moved into the heated photoperiod house at night and the lights are switched on at specified times in the mornings to give the desired day-lengths. When the inflorescences emerge, the stalks are cut and marcotted. The bases are kept in a crossing solution for two weeks to prevent wilting. When the florets open, they are inspected to note the presence or absence of pollen. Flowers with pollen are used as male parents in crosses and flowers without pollen are used as seed-bearing parents.

Rate of Decline in Daylength

The best treatment for producing flowers proved to be a continuous decline in daylength of 30 s per day (Brett *et al*[4]). Constant daylengths of 12 h to 12,5 h induced flowering, but flower emergence was delayed and pollen shed was reduced. When cane was subjected to a declining daylength, interrupted with a period of constant daylengths (eg for 20-28 days), flowering was delayed by a similar period of time (Nuss & Brett[13]). Time of flowering has also been delayed by either exposing the cane to a longer period of inductive daylengths (Paliatseas[14]) or by exposing the cane to long days just before the flowers emerge from the tassels (James[7]).

When the rate of decline in daylength was changed from 30 s (slow) to 60 s (fast), flowering was hastened by two to five days. However, the number of flowers shedding pollen was reduced (Nuss & Brett[13]). When the rate of decline was changed from fast to slow, the number of flowers shedding pollen was large (Anonymous[1]). James[7] also found that delayed flowering resulted in the production of more flowers with pollen.

Changes in daylength during the later stages of flower development had an effect on pollen shed. Pollen is formed during this period (Julien[8], MacColl[9]). When the time of flowering was delayed by long days (James[7]) or by a slow decline in daylength (Anon[1]) flowering was later and pollen development continued for a longer period so that more flowers produced fertile pollen. When time of flowering was hastened by delayed intiation in the tropics (Midmore[9]) or by a fast decline during the later stages of flower development (Nuss & Brett[13]), the period for pollen development was probably curtailed, so that fewer flowers produced pollen. Pollen shed can, therefore, be manipulated by changes in daylength during the period of flower differentiation when pollen development takes place. Ovule fertility did not appear to be affected by changes in daylength (unpublished Mount Edgecombe data).

Time of Flowering

Two treatments, P1 and P2, have been used as standard treatments since 1975 and 1974, respectively. In both treatments, the rate of decline in daylength is 30 s per day. P1 is started in February with a daylength of 12,5 h and P2 in March with a daylength of 12,75 h. Five varieties were planted in both treatments in most seasons. A method to compare two treatments is to calculate the number of days to flower from the day on which daylength is 12,5 h; the assumption is made that initiation starts when daylength reaches 12,5 h.

The mean number of days to flower is 102 days for both P1 and P2 (Table 1), although flowering takes place earlier in P1 than P2 because initiation occurs earlier. However, in any one season, the number of days to flower varies

TABLE 1
Mean number of days to flower of five varieties in two photoperiod treatments: 1974-1981

Season	P1*		P2*	
	Days to flower	SD	Days to flower	SD
1974			102,5	10,4
1975	109,5	9,0	92,6	15,2
1976	105,6	6,9	95,3	10,2
1977	103,5	5,0	114,7	11,7
1978	128,8	12,3	103,2	1,9
1979	95,7	15,1	93,8	6,1
1980	86,0	10,2	110,8	18,5
1981	116,6	10,2	105,4	12,4
Mean	102,8†	9,4	102,3	10,8

*P1, start mid-February with daylength of 12,5 h
*P2, start early March with daylength 12,75 h
† excludes the value for 1978

somewhat between the two treatments. During 1978, the clock for P1 ran erratically and flowering occurred 26 days later than usual. Treatments P1 and P2 are now commonly used to synchronize the flowering of varieties that normally flower at different times.

Varieties

The photoperiod house has largely been used for the commercial breeding programme. Several noble varieties that do not flower regularly have been included for nobilization purposes and RP8 (which flowers sparsely even in the tropics) has been included each year to test the efficacy of the photoperiod treatments. All the noble varieties subjected to the photoperiod treatments have flowered but the number of flowers obtained from the shy-flowering varieties BH10/12 and RP8 has been small (Table 2). Several noble varieties have also produced flowers in glasshouse photoperiod treatments, in which flower induction is usually less effective. Flowering of noble cane has also been induced artificially in sub-tropical Louisiana (29°35'N), by using long periods of inductive daylengths (Dunckleman[6]).

Some commercial varieties appear to be shy-flowering (Table 2). However, Q78, Q89 and Q91 were affected by poor growth and rust which may have resulted in some stalks not flowering. No flowers have yet been obtained from B6109 or M253/48; the latter variety possesses several attributes which would be useful in a breeding programme. Flowering is not always good in the tropics, and breeders have to move the breeding plots to areas of greater flowering intensity (Pollock[16]).

A total of 641 varieties has been subjected to photoperiodic treatments for the induction of flowering since 1971. Of these 626 have produced flowers for the crossing programme (Table 3), and 6352 flowers have been obtained. This number of flowers amounts to 66% of the number of stalks exposed to the treatments. In 1971, only 35% of stalks produced flowers when various treatments were tested with the object of finding the optimum treatment for flower production. Since then, the proportion of stalks producing flowers has ranged from 54,7% in 1981 to 84,3% in 1975. The proportion of flowers shedding pollen has varied with seasons and because the range of photoperiod treatments has not been precisely the same every year. Nevertheless, the number of flowers with pollen was always sufficient to enable large numbers of crosses to be made every year.

Synchronization of Flowering

Sugarcane varieties may flower up to eight weeks apart in the season. Thus it may normally not be possible to make desired crosses between early and late flowering varieties. The photoperiod house has five compartments and enables the breeder to obtain flowers at almost any time in the season. Varieties that normally flower late can be induced to flower earlier in the crossing season (in May-June) and varieties which flower early may be induced to flower later (June-July). Moreover, flowering can be delayed in

TABLE 2
Stalk and flower numbers from noble and shy-flowering commercial varieties

Variety	Number of				Comments
	stalks	flower initials	flowers	seasons tested	
Nobles					
BH10/12	94	2	1	4	
Badila	6	2	1	2	Flowered in GP*
Black Cheribon	69	11	6	6	Flowered in GP*
Black Innes	10	10	8	1	
Black Tanna	7	2	1	1	
Booth's Selection	36	8	7	2	Flowered in GP*
D74	5	5	3	1	
D109	35	9	6	2	
D1135	36	12	9	3	
D666/13	5	5	3	1	
Light Preanger	20	7	5	3	Flowered in GP*
MPR275	10	5	5	2	Seedling of BH10/12
51NG64	58	12	2	2	Flowered in GP*
57NG191	35	30	10	2	
Otaheite	5	4	4	1	
RP8	262	9	6	10	
16 Nobles	743	170 (23%)	80 (11%)	—	
Commercial					
B6109	18	0	0	3	
H61/1820	29	6	2	4	
M253/48	46	2	0	4	
Q78	67	3	3	6	Poor growth in sand
Q82	36	23	22	5	
Q89	30	7	1	3	Rust and poor growth
Q91	30	18	6	3	Rust and poor growth
Waya	23	10	8	4	
Total	279	69 (24%)	42 (15%)		
NCo 310 (Control)	405	378	300	10	
NCo 376 (Control)	292	283	271	8	

* GP, glasshouse photoperiod

TABLE 3
Numbers of varieties and stalks flowering and proportions of male flowers from 1971 to 1981

Season	No of varieties			No of stalks treated	% stalks		Flowers with
	treated	initiated	flowered		initiated	flowered	pollen (%)
1971	60	52	38	1,058	51,9	35,0	48,9
1972	72	71	68	763	89,2	72,9	54,5
1973	128	123	114	631	90,8	74,5	21,3
1974	102	96	85	833	80,3	58,5	25,4
1975	90	89	87	798	89,0	84,3	37,0
1976	94	91	88	938	85,6	75,7	53,2
1977	97	91	68	963	86,8	80,2	56,4
1978	97	81	77	832	77,2	63,9	33,3
1979	89	81	79	932	84,4	66,2	54,0
1980	98	88	88	940	87,0	69,8	70,2
1981	99	93	83	930	74,7	54,7	64,8
Total/Mean ..	641*	635*	626*	9 618	80,7	66,0	48,4

* not arithmetic total

any variety by interrupting the continuous decline in daylength with a period of constant daylength for 15-30 days. This delays flowering for a similar period of time. These methods ensure that varieties flower at predetermined times without affecting the number of flowers shedding pollen.

Elsewhere, methods have been developed to change the normal time of flowering. Flowering has been delayed by delaying initiation in the tropics and by the use of night-light-breaks after initiation (MacColl[9]), as well as by giving long days during the later stages of flower development (James[7], Paliatseas[15]). Flowering has hastened by exposure to short days soon after flower initiation had been completed Paliatseas[15]). The maipulation of the time of flowering has affected pollen shed in some instances (James[7], Midmore[10], Nuss[12]). This factor, therefore, has to be taken into consideration when planning photoperiod treatments, so that suitable flowers are obtained for the crossing programme.

Conclusion

The photoperiod house has proved to be a valuable asset for the breeding programme at Mount Edgecombe. Between 1971 and 1981 six hundred and twenty-six varieties, including shy-flowering noble and tropical varieties, have produced 6 352 flowers for the crossing programme. With these facilities, it has been possible to gain a better understanding of the artificial induction of flowering. Methods have been standardized to produce flowers from almost any variety, flowers of the same variety at various times in the crossing season, and a regular supply of flowers during each crossing season.

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REFERENCES

1. Anon (1981). Annual Report of the SA Sugar Ass Experiment Station: p 64.
2. Brett, P. G. C. (1946). Seed setting of sugarcane in South Africa. *Nature* **157**: 657.
3. Brett, P. G. C. (1974). Early experiments on the artificial induction of flowering at Mount Edgecombe. *SASTA Proc* **48**: 78–81.
4. Brett, P. G. C. and Harding, R. L. (1974). Artificial induction of flowering in Natal. *ISSCT Proc* **15**: 55–66.
5. Brett, P. G. C., Harding, R. L. and Paxton, J. G. (1975). Time and intensity of flowering as influenced by certain temperature and photoperiod treatments. *SASTA Proc* **49**: 202–205.
6. Dunckleman, P. H. (1977). Manipulation of photoperiod for flower control and crossing *Saccharum officinarum* L. *Amer SSCT Proc* (*NS*) **6**: 14–17.
7. James, N. I. (1969). Delayed flowering and pollen production in male sterile sugarcane subjected to extended daylength. *Crop Sci* **9**: 279–282.
8. Julien, M. H. R. (1973). Physiology of flowering in *Saccharum* I. Daylength control of floral initiation and development in *S spontaneum* L. *Jnl Exptal Bot* **24**: 549–557.
9. MacColl, D. (1977). Some aspects of the flowering of sugarcane in Barbados and its control in a breeding programme. *Ann Bot* **41**: 191–207.
10. Midmore, D. J. (1980). Effects of photoperiod on flowering and fertility of sugarcane (*Saccharum* sp). *Field Crops Res* **3**: 65–81.
11. Nuss, K. J. (1977). Synchronization of flowering to implement a proven cross breeding system in sugarcane. *ISSCT Proc* **16**: 111–119.
12. Nuss, K. J. (1980). Effects of photoperiod and temperature on initiation and development of flowers in sugarcane. *ISSCT Proc* **17**: 486–493.
13. Nuss, K. J. and Brett, P. C. G. (1977). Artificial induction of flowering in a sugarcane breeding programme. *Proc S Afr Genetic Soc Congress* **6**: 54–64.
14. Paliatseas, E. D. (1974). Flowering of sugarcane in Louisiana as related to interspecific hybridization. *ISSCT Proc* **15**: 46–54.
15. Paliatseas, E. D. (1975). Further studies on synchronization of flowering of sugarcane. Amer *SSCT Proc* **5** (*NS*): 148–153.
16. Pollock, J. S. (1981). Flowering in sugarcane at different localities in North Queensland. 1981 *Austr SSCT Proc*: 283–286.