TIME AND INTENSITY OF FLOWERING AS INFLUENCED BY CERTAIN TEMPERATURE AND PHOTOPERIOD TREATMENTS

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Abstract

Treatments in a heated photoperiod house, started on either February 1st or March 1st, with initial daylengths of either 12 hours 53 minutes or 12 hours 45 minutes, combined with a glasshouse treatment using constant artificial dawns and heating, gave an extended range of flowering times. The best treatment for inducing flowering was one started on March 1st at an initial daylength of 12 hours 45 minutes. In the glasshouse treatment, temperature was found to play an important part in the production of tassels.

Introduction

Techniques developed at the Experiment Station enable the promotion of tasselling in all but a few clones; the development of these techniques has already been described (Brett[1], Brett and Harding[2]). The experiments reported here were directed at controlling the time of flowering and increasing its intensity during the 1974 season.

Materials and methods

The photoperiod and glasshouse facilities that were available for these experiments, and the methods used in carrying them out, have already been described (Brett and Harding[2]). The glasshouse treatment was started on February 8, 1973, on which day the sun rose at 5.30 a.m. The artificial lights were set to come on at this time, and this artificial dawn was then maintained for the duration of the experiment. Under these conditions the progressive decline in daylength was about one minute a day, at a time when natural daylengths were declining by about 1½ minutes a day.

In the photoperiod house the best treatment had been found to be one using natural sunsets with daylengths declining by half a minute a day. To achieve this, the artificial dawn had to be advanced by about half a minute each day to compensate for the sun setting about one minute earlier a day during the autumn period. However, during the first part of the treatment, i.e. during February, the sun did not set one minute earlier each day; the compensation therefore resulted in a decline of less than half a minute a day. During the later part of the treatment periodic adjustments were made to ensure that the daylength continued to decline by half a minute a day.

In order to ensure that plants received natural twilights as well as sunsets, as in previous work, they were not moved into the glasshouse or photoperiod house until about half an hour after sunset.

When the air was circulated, four fans were used to effect this, whereas in the past only one fan had been used.

The time of flowering was based upon the date on which the tassel became available for use in crossing. The field range of flowering of a clone was determined from the mean flowering dates of the first, and the last, batch of boents brought in from breeding plots.

Except as mentioned above, the procedures for growing and treating the plants, and the methods of expressing results, were those that have already been outlined by Brett and Harding[2]; only specific departures from the standard procedures are taken note of in reporting results.

Two separate experiments were carried out during 1974 and an outline of the treatments used in these experiments is given in Table 1. The glasshouse treatment was common to both Experiment I and Experiment II.

Results and discussion

Intensity of flowering

Eight clones that flower very rarely or not at all in the field were included in Experiment I and, accordingly, received the treatments outlined in Table 1. As similar treatments had been used in the past, and had always promoted greater flowering than that which occurred under field conditions, it was not thought necessary to include controls for this part of the experiment.

The results obtained are summarized in Table 2. Two clones, BH 10/12 and 51 NG 146 did not flower — although 51 NG 146 initiated — under all treatments; Co 213 flowered readily under all treatments. These three clones were omitted in arriving at totals.

TABLE 1
Outline of treatments used

Exp No	Treatment Code	Where carried out	Date started	Daylength		Min night temp in °c	Artificial air circulation
				At start in Hrs & Mins	Approx daily decline in mins		
1	G	Glasshouse	8 Feb	13,19	1	22	—
	F45	Photoperiod house	1 Feb	12,45	½	22	—
	F45f	Photoperiod house	1 Feb	12,45	½	22	+
	F53	Photoperiod house	1 Feb	12,53	½	22	—
	M45	Photoperiod house	1 Mar	12,45	½	22	—
	M53	Photoperiod house	1 Mar	12,53	½	22	—
2	G	Glasshouse	8 Feb	13,19	1	22	—
	01	Outside	8 Feb	13,19	1	α	—
	02	Outside	8 Feb	13,49	1	α	—
	C	Control	—	Natural conditions of daylength and temperature			

TABLE 2
Initiation and tasselling of sparser-flowering clones in Experiment I

Clone		Treatment																	
No	Name	G			F45			F45f			F53			M45			M53		
		Stalks	Initials	Tassels	Stalks	Initials	Tassels	Stalks	Initials	Tassels	Stalks	Initials	Tassels	Stalks	Initials	Tassels	Stalks	Initials	Tassels
1	Black Cheribon . . .	5	0	0	5	1	1	5	0	0	5	1	0	5	4	3	4	1	0
2	D 1135	5	0	0	5	0	0	5	0	0	5	2	2	5	4	4	5	4	3
3	D 109	5	0	0	5	1	0	5	0	0	5	0	0	5	4	4	5	3	2
4	Q 78	5	0	0	5	0	0	5	0	0	5	1	0	5	1	1	5	1	1
5	57 NG 191	5	5	0	5	5	2	5	5	3	5	5	1	5	5	2	5	5	3
6	Co 213	5	5	4	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5
7	BH 10/12	5	0	0	5	0	0	5	0	0	5	0	0	5	0	0	5	0	0
8	51 NG 146	5	5	0	4	4	0	5	5	0	5	5	0	5	5	0	3	3	0
	Totals for 1 to 5 . .	25	5	0	25	7	3	25	5	3	25	9	3	25	18	14	24	14	9

It will be seen from Table 2 that the glasshouse treatment, with daylengths declining progressively by a minute a day, resulted in less initiation and tasselling than the five photoperiod house treatments, all with daylengths declining progressively by only half a minute a day. This confirmed previous results.

Within the photoperiod house, treatments started in February did not give results as good as those started in March. There were three possible reasons for this: daylengths during February declined slowly; the plants during February may not have reached the stage of ripeness-to-flower; and temperatures during February may have been higher than the optimum. However, the treatment F53, started on February 1st with a daylength of 12 hours 53 minutes, received from March 1st identical conditions to another (M45), started on the latter date with a daylength of 12 hours 45 minutes. Nevertheless, F53 proved inferior to M45. It appears that induction in F53 did not take place in February, and that prolonged subjection to artificial lighting during the first hours of the day may have had an adverse effect upon subsequent induction when conditions became favourable in March. This suggestion is supported by the fact that, with treatments started on March 1st, an initial daylength of 12 hours 53 minutes proved inferior to one of 12 hours 45 minutes. This also suggests that daylengths above 12 hours 45 minutes are non-inductive, at any rate for clones of noble origin. However, when this daylength of 12 hours 53 minutes was started on March 1st, it was greater than the natural daylengths the plants had been receiving, and the possibility cannot be excluded that the change to longer days may itself have had some adverse effect.

The best treatment, namely that started on March 1st at a daylength of 12 hours 45 minutes, was one that in the past had been found to give very good results.

The use of fans had, if anything, an adverse effect upon initiation. In fact, so little initiation occurred that it was not possible to determine whether the use of fans had, as appeared to have been the case in the past, a favourable effect upon emergence.

Experiment II was carried out to determine the effect of different treatments upon the time of flowering. However, differences in the degree of initiation and tasselling also occurred; these results are shown in Table 3. It can be seen that treatments which gave good initiation also gave good emergence, and hence resulted in very good tasselling. The glasshouse treatment (G) was distinctly better than a treatment (01) with the same photoperiods but no heating, and this, in turn, was only slightly better than the control. The main effect

TABLE 3
Initiation and tasselling of relatively free-flowering clones used in Experiment II

Clone		Treatment											
No	Name	G			01			C			02		
		Stalks	Initials	Tassels	Stalks	Initials	Tassels	Stalks	Initials	Tassels	Stalks	Initials	Tassels
1	CB 36/14 . .	5	5	5	4	4	0	5	5	0			
2	Co 213 . .	4	4	4	5	4	0	5	1	0			
3	Co 285 . .	4	4	4	5	5	5	5	4	4			
4	N53/216 . .	5	5	5	5	3	0	5	3	0			
5	N55/805 . .	5	5	5	5	4	3	5	4	0			
6	NCo 310 . .	5	5	1	5	4	0	5	4	1			
7	NCo 376 . .	5	5	5	5	5	2	5	2	1			
8	POJ2878 . .	5	5	3	5	3	0	5	4	0			
9	NCo 293* .	12	12	12	12	12	12	12	12	12	12	12	12
10	Co 421* . .	12	12	12	12	11	8	12	12	1	12	5	0
	Totals 1-8 . .	38	38	32	39	32	10	40	27	6	—	—	—

* Marcotted stalks were used.

of heating was on the emergence of tassels, and it is to this improved emergence of tassels that the beneficial effect of the glasshouse treatment upon flowering can be mainly attributed. A comparison made from results obtained by using marcotted stalks of NCo 293 and Co 421 showed that the treatment 02, with an early artificial dawn, gave the poorest results of all — both as regards initiation and emergence.

Time of flowering

As already described, reluctant-flowering clones did not flower freely under all treatments used in Experiment I. They could not therefore be used in a comparison of treatments and times of flowering. (Generally, they flowered late, but there were considerable differences in the flowering times of different stalks of the same clone receiving the same treatment.) To determine the effect of different treatments upon time of flowering, use was made of a number of more freely-flowering clones — these had been included in the experiment specifically for this purpose. The results obtained with these clones are shown in Table 4. Clones that were not common to all treatments were omitted from the table. (These ranged from free-flowering to somewhat sparse-flowering types.) However, their inclusion in the table would not have resulted in appre-

TABLE 4

Mean dates of flowering for 3 comparatively free-flowering clones in Experiment I

Clone	Treatments						Field range
	G	F45	F45f	F53	M45	M53	
Co 213	6/6	24/6	24/6	9/7	11/7	7/8	*
NCo 310	5/6	20/6	1/7	5/7	7/7	24/7	24/6 — 24/7
NCo 376	4/6	20/6	24/6	27/6	30/6	19/7	10/7 — 22/8
Mean	5/6	21/6	26/6	4/7	6/7	27/7	

* Does not tassel.

ciable changes in the mean flowering dates for the different treatments; this gives added confirmation of the general trends.

It will be seen from Table 4 that tasselling occurred very much earlier in the glasshouse treatment, in which daylengths declined by one minute a day, as compared with photoperiod house treatments, in which the daylength declined by only half a minute a day. As was to be expected, the treatment M53, combining a late start with a long daylength, was the last to give tassels.

The use of fans had, if anything, a delaying effect, contradictory to what had been found in previous work.

The various treatments used, including the glasshouse treatment, resulted in a wide range of tasselling times — as much as two months for some varieties. Tasselling in the field shows a range of a month or more; it started later than in the glasshouse treatment, and, in some varieties, continued after tasselling in all treatments had been completed.

It can be seen from Table 4 that starting a particular treatment in March instead of in February did not delay flowering by a full month. However, as daylengths declined more slowly in February than in March, this is perhaps to be expected. Table 5 gives the daylength on March 1st, when all treatments became operative, and compares the relative times of flowering.

TABLE 5

Daylengths on March 1st and times of flowering

	G	F45	F45f	F53	M45	M53
Daylength on March 1st .	13-01	12-36	12-36	12-45	12-45	12-53
No of days after March 1st to a daylength of 12 hours 36 minutes	22	—	—	20	20	28
No of days to flowering after date when earliest photoperiod house treatment flowered . . .	−16	—	5	13	15	36
Daylength when flowering took place	11-33	11-41	11-40	11-39	11-38	11-35

The most advanced treatment was one receiving a daylength of 12 hours 36 minutes on March 1st. The number of days other treatments took to reach this daylength corresponds roughly to their relative delay in flowering. It will be seen that daylengths when flowering took place were about 11 hours and 35 or 40 minutes. This is perhaps not unexpected for photoperiod house treatments, in which daylengths eventually all declined by half a minute a day. It is not known whether it is significant or merely coincidental that flowering in the glasshouse treatment, where daylengths declined by a minute a day, also took place at approximately the same daylength.

TABLE 6

The number of days to flowering after specific daylengths were reached

Daylength	Treatment mean flowering date expressed as the number of days after specific daylengths					
	G	F45	F45f	F53	M45	M53
13 hrs	95					
12 hrs 53 mins	88			153		148
12 hrs 45 mins	82	140	145	125	127	133
12 hrs 40 mins	78	120	125	115	117	124
12 hrs 35 mins	73	109	114	104	106	118
12 hrs 30 mins	69	104	109	98	100	107
12 hrs 15 mins	58	71	76	70	72	72

Table 6 gives the number of days to flowering after specific daylengths were reached. It will be seen that the number of days to reach flowering, from the time a daylength of 12 hours 45 minutes became operative, varied between treatments, but that all photoperiod house treatments resulted in flowering about 120 days after 12 hours 40 minutes was reached, or 100 days after 12 hours 30 minutes was reached. It cannot, however, be definitely concluded from this that daylengths at or above 12 hours 45 minutes were non-inductive, as time of flowering depends not only upon time of induction but also upon the time taken to emerge, and this in turn is influenced by the rate the daylengths decline. The rates at which the daylengths declined are indicated in the Appendix, which gives the date each treatment reached specific daylengths; variations in the rate of daylength decline during February and March are illustrated.

TABLE 7

Mean dates of flowering for 4 free-flowering clones in Experiment II

Clones	Treatments				Field range
	G	01	C	02	
Co 285	6/6	28/6	4/7	—	25/6—20/7
NCo 376 . . .	5/6	27/7	6/8	—	10/7—22/8
Co 421* . . .	6/6	14/7	2/7	—	18/6—27/7
NCo 293* . . .	10/6	6/7	6/7	26/7	11/7—13/8
Mean	7/6	11/7	12/7	(26/7)	

* Marcotted stalks were used

The times of flowering of four free-flowering clones used in Experiment II are shown in Table 7. As was expected from previous work, the glasshouse treatment gave early flowering. The 01 treatment, in which daylengths declined more slowly than under natural conditions, was expected to give later flowering than the control. However, both sets flowered at about the same time. The only explanation that can be suggested is that the effects of the slow decline in daylength — and, presumably, a consequent delay in reaching optimum daylengths for induction — was offset by the greater number of inductive daylengths received.

The 02 treatment, with an early constant dawn, gave, as already mentioned, very little flowering, but when it occurred it was delayed relative to 01. (As tassels of Co 421 had still not emerged by the time the experiment was concluded, the delay in this variety was clearly extreme, but its actual extent could not be determined.) It would seem that the early dawn resulted, as had been intended, in a delay in reaching inductive daylengths, but that, by the time these daylengths were reached,

temperatures had become limiting. Presumably they also limited the rate of emergence of inflorescences that were initiated.

Conclusions

The treatments used in these experiments gave a reasonably good spread of flowering times. However, initial daylengths of 12 hours 53 minutes, as compared with 12 hours 45 minutes, not only delayed flowering, but also appeared to have some adverse effect upon initiation. It is thought that daylengths greater than 12 hours 45 minutes were non-inductive — at least for noble clones — and that prolonged exposure to periods of artificial daylength had an adverse effect upon subsequent induction.

In general, very good flowering was obtained. No treatments used in these experiments, however, were better than the best previous treatment — namely, one started on March 1st with an initial daylength of 12 hours 45 minutes.

It appears that although initiation can be delayed when stalks outside the photoperiod house are subjected to an early dawn, initiation is adversely affected because, by the time daylengths become inductive, temperatures have become limiting.

REFERENCES

1. Brett, P. G. C. (1974). Early experiments on the artificial induction of flowering at Mount Edgecombe. SASTA Proc. 48: 78-81.
2. Brett, P. G. C. and Harding, R. L. (1974). Artificial induction of flowering in Natal. ISSCT Proc. 15: 55-66.

Appendix

The date each treatment reached specific daylengths

Daylength	Date on which given daylengths were reached in each treatment					
	G	F45	F45f	F53	M45	M53
13 hrs	2/3					
12 hrs 53 mins	9/3			1/2		1/3
12 hrs 45 mins	15/3	1/2	1/2	1/3	1/3	16/3
12 hrs 40 mins	19/3	21/2	21/2	11/3	11/3	25/3
12 hrs 35 mins	24/3	4/3	4/3	22/3	22/3	31/3
12 hrs 30 mins	28/3	9/3	9/3	28/3	28/3	11/4
12 hrs 15 mins	8/4	11/4	11/4	25/4	25/4	16/5