MANIPULATION OF FLOWERING IN WHITE HEATHER

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Abstract

Clear evidence for the daylength control of flowering in *Calluna vulgaris* is presented. Flowering occurs after long day (LD) treatment and is inhibited by short days (SD). Results suggest that the critical photoperiod is between 12-16 h. A combination of fluorescent and tungsten illumination can be used to induce flowering. Temperature exerts an influence during the floral initiation period. Temperatures in excess of 14°C applied during initiation and development will encourage flowering and increase the numbers of flowers produced. This is a preliminary report of work still in progress.

1. Introduction

Calluna vulgaris is found widely distributed as heather communities throughout the moorlands of northern and central Europe and is tolerant of widely varying climatic conditions. This plant is found from the Arctic to hillsides in Italy and France. Although C. *vulgaris* is a monospecific genus a considerable range of varieties, forms and cultivars has been identified. Differences in habit, foliage and flower colour are exploited for horticultural purposes (Yates, 1985) mainly as plantings in open beds which provide interest throughout the year. A closely allied plant, *Erica gracilis* (Cape Heath) has been exploited as a potted flowering plant for more than a century. Flowering in this subject was shown to be under long day (LD) control (Zimmer and Bahnemann, 1985). A greater diversity of potted plants might be obtained using forms of C. *vulgaris* particularly white and double-flowered types classed in sections II and III by Fyfe Maxwell and Patrick (1966). Ecological studies of C. *vulgaris* indicated that flower initiation and subsequent development were a response to LD conditions (Kwolek & Woolhouse, 1981, 1982). Based on this information studies began with the aim of developing selected cultivars as flowering potted plants of "lucky white heather".

2. Materials and methods

Cultivars used were:

Fred J. Chapple, forms light mauve flowers on long spikes; foliage is yellow to green when grown indoors, but when exposed to low temperatures turns a darker green producing new growth which is bright yellow and red-tipped.

Loch Turret forms single white flowers on dark somewhat lanky foliage.

Kinlochruel has a highly floriferous double white form with dark green foliage and a neat compact habit.

All plants were grown in a mixture of peat:sand in the ratio 75:25 v/v with nutrients added as described by Anon (1981) for ericaceous plants. Etridiazole (Aaterra WP-35, ICI-Midox) was added at 0.07 g a.i./litre of peat. Long day conditions were achieved in a heated glasshouse by mounting fluorescent tubes (Thorn-EMI Pluslux 3500, 100 watt) 300 mm above bench height, the tubes were placed in pairs at 140 mm distance. This produced a light intensity of 9-10,000 lumen/m^2 at plant height. Control plants in SD conditions were covered automatically with black polyethylene (125 μ thickness) for the period 17.00-09.00 h. For all experiments reported here glasshouse temperature was usually maintained at a daily average of 17°C. An exception was one batch of plants used in experiment 4 for which temperature was reduced to 12°C. Unheated conditions were achieved using a hemispherical tunnel (19 m diameter) partially clad with clear polythene and fitted with netting sides permitting 60 per cent light penetration. Potted plants were placed on 100 mm of coarse gravel within the tunnel. In spring (May-June) an average daily temperature of 11°C was obtained later (June-July) this rose to 14°C. Experiments studying various regimes of fluorescent and tungsten lighting were made using a growth cabinet (Fisons model 600G3/TTL) calibrated to provide temperatures of 15°C day and 10°C night $\pm$ 1°C.

3. Results

3.1 The influence of long day conditions on flowering

Four successive batches of C. v u l g a r i s cv Fred J. Chapple were exposed to LD conditions in a glasshouse from early January to late June. These were compared with plants receiving naturally lengthening day light over the same period. The results are shown in Table 1. In early spring a total of 12 weeks exposure to LD was required to cause flowering, later 11 weeks appeared sufficient. Flower buds were visually obvious after 8-9 weeks in early spring and 6 weeks in late spring. The time required for flower opening appeared to be unaffected by LD and varied from 3-5 weeks. Control plants not given artificial illumination gradually flowered with increasing rapidity as spring advanced.

3.2 Effect of temperature on floral initiation and development

Plants of C. v u l g a r i s cv Loch Turret which had been initiated into a flowering state by exposure to LD conditions were used for this experiment. Plants maintained at 17°C in a glasshouse achieved full flowering within 6 weeks from initiation (Table 2). Plants initiated at 11°C and moved to 17°C when flower buds were obvious to the naked eye, required 9 weeks for full flower opening. Time to flower opening appeared to be slightly increased if the temperature was changed to 14°C when flower buds were obvious. Reductions in temperature were associated with the production of fewer flower buds per shoot.

3.3 Effect of light quality on flowering

Plants of C. *vulgaris* cv Kinlochruel placed in a growth cabinet and exposed to 16 h LD composed of 8 h fluorescent (20,000 lumen/m^2) and 8 h tungsten lighting (60-80 lumen/m^2) produced flower buds in 8 weeks (Table 3). When the total period of illumination was reduced to 12 h (8 h fluorescent and 4 h tungsten) flower development virtually ceased. Exposure to SD (8 h fluorescent) totally inhibited flowering.

3.4 Effect of alternating LD and SD conditions

Continuous LD treatment of C. *vulgaris* cv Loch Turret in a glasshouse caused flowering to commence in 14 weeks. Where plants were exposed to 7 weeks LD followed by 7 weeks SD flowering was virtually eliminated (Table 4). Flower buds which had begun to develop were malformed and eventually aborted when daylength was changed.

3.5 Studies of the floral apex in *Calluna*

In order to quantify the effects of day length treatments on the flowering of *Calluna*, stages in the change from vegetative to flowering meristem must be identified. The present study uses modifications of a scheme developed by Beijerinck (1940). Three stages of floral initiation are illustrated in Fig 1. These are:

Stage I: the last pair of bract primordia are differentiated, the apical dome is smooth and has a diameter of 60-70μ compared with the size of fully vegetative domes which are 40-60 μ.

Stage VII: the anther primordia are evident, gynoecium is differentiated into ovary and style, corolla tips almost meet over the stigma, the sepals enclose the corolla and the flower bud is up to 0.5 mm diameter.

Stage X: the flower bud is fully grown 3-5 mm long and is obvious to the naked eye, each bud contains 2 whorls of 2 sepals, a bell shaped corolla, 2 whorls of 4 stamens each with 'S' shaped filaments and with appendages attached to the anthers, the ovary is quadrilocular possessing an obvious style duct.

4. Discussion

The responses of woody perennial plants to photoperiodic effects are less well studied than those of herbaceous types. Results presented here show that flowering in selected cultivars of C. *vulgaris* is a function of LD conditions and these effects are enhanced by temperatures above 14°C. This evidence parallels that obtained under natural conditions by Kwolek & Woolhouse (1982). Current results have made it possible to develop a practical programme for the exploitation of cv Kinlochruel as a potted flowering plant. Further research is in progress to quantify the influence of processes used in micropropagation on flowering capacity and tissue juvenility. Reduced temperature storage is being utilised to preserve plants following floral initiation.

5. Acknowledgement

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Table 1 The influence of long day treatment on flowering in *Calluna vulgaris* cv Fred J. Chapple

		Week No+			
Batch	Treatment	Start of treatment	Flower buds obvious	Flowers open	Total weeks to flower
I	LD	5	13	17	12
	C	5	24	29	24
II	LD	8	17	20	12
	C	8	24	29	21
III	LD	12	18	23	11
	C	12	24	29	17
IV	LD	16	22	27	11
	C	16	26	29	13

LD = 16 h fluorescent lighting in a glasshouse
C = natural daylength during early spring
\+ = Calendar weeks from January 1st

Table 2 Effect of temperature on floral initiation and development cv Loch Turret

Temperature °C				
Floral initiation[1]	Floral development[2]	Flower number/shoot[3]	SE	Time to flower (weeks from initiation)
17	17	37	2.52	6
11	17	23	2.37	9
11	14	21	1.67	10

1. Floral initiation = period from floral initiation to the formation of obvious buds
2. Floral development = period of development from bud to open flower
3. Flower number = average number per shoot

All temperature treatments received natural daylength in spring

Table 3 Effect of lighting regime on the flowering of *Calluna vulgaris* cv Kinlochruel

Lighting period (h)			Response	
Fluorescent	Tungsten	Total (h)	Time to flower bud (wk)	No flowers per shoot
8	8	16	8	20
8	4	12	14	2
8	0	8	-	0

Table 4 Effect of LD followed by SD treatments on the flowering of *Calluna vulgaris* cv Loch Turret

LD	SD	Treatment	Time to flower (wk)	No flowers
14 wk	none	LD	14	18
7 wk	7 wk	LD/SD	14	3
none	14 wk	SD	no flowers	0

Figure 1 Stages in the development of the floral apex in Calluna (after Beijerinck, 1940)