Freesia hybrida Respond to Ancymidol, Cold Storage of Corms, and Greenhouse Temperatures

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Abstract. Growth and flowering of *Freesia hybrida* Bailey for the container-plant market can be controlled chemically using growth retardants and environmentally by cold storage of corms at 5C for 2 to 6 weeks before planting. Corms stored at 5C for 4 weeks flowered 20 days earlier than corms not stored at 5C. Preplant 5C storage of corms also reduced leaf and flower height. An ancymidol soil drench (3 mg) reduced leaf height and flower height by more than 50% and delayed flowering by 9 days. Combining growth regulator application with cold storage of corms produced the greatest reduction in leaf height and flower height. Moreover, plants flowered earlier than controls when corms were stored for at least 4 weeks, regardless of growth regulator treatment. Chemical name used: α -cyclopropyl- α -(4-methoxyphenyl)-5-pyrimidine methanol (ancymidol).

Freesia hybrida is grown extensively in Europe and Japan as a cut-flower crop. Its vividly colored and fragrant inflorescence would also make freesia a potential container-crop commodity if stem length could be reduced without adversely affecting flower quality. Gianfagna and Wulster (1986a) have reported that height can be reduced in freesia by use of the growth regulators ancymidol (A-Rest) and β -[4-(4-chlorophenyl)methyl]- α -(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol (paclobutrazol, Bonzi), although flowering was delayed by these treatments. Leaf height can also be affected by temperature. Mansaur (1968) reported that flower height decreased with decreasing day temperatures between 21 and 12C. He also found that final leaf height was reduced when flower-inducing conditions (10C) were provided soon after planting and that vernalization of corms at 5C induced early flowering and significantly shorter flowering spikes. For the production of cut flowers, these treatments reduce crop quality but clearly may be advantageous treatments for growing freesia as a container crop. The most effective procedure for height regulation in freesia may, therefore, involve a combination of chemical and environmental treatments. The objective of these experiments was to determine the effect of preplant cold storage of freesia corms in combination with a growth retardant treatment at two greenhouse temperature regimes on leaf height, flower height, and number of days to flowering.

Corms of each of three cultivars ('Stella',

'Royal Blue', and 'Uchida') were dug, cleaned, and then maintained in open-weave nylon bags at 30C for 15 weeks to break

corm dormancy (Hartsema, 1962). Five corms were planted, with the apical bud just below the soil surface, in 1.9-liter pots containing $\approx$ 1.5 liters of potting medium consisting of equal volumes of spagnum peat and vermiculite. The medium was supplemented with (kg·m⁻³): 4 dolomitic lime, 1 ON-8.7P-OK, 1.2 5N-4.4P-4.2K, 0.03 fritted trace elements (Peters, Fogelsville, Pa.), and 0.07 Aquagro granular surfactant (Aquatrols, Pennsauken, N.J.).

Corms were stored in trays in refrigerators at 5C for 0, 2, 4, or 6 weeks, then potted, and allowed to sprout for 1 week at 20C in the greenhouse, after which ancymidol (3 mg a.i./100 ml water) was applied as a soil drench. Corms were treated with a fungicide soak (Banrot, 250 ppm, 40% a.i. wettable powder; Mallinckrodt, St Louis) for 30 min before holding at 30C to break corm dormancy and after the cold storage period, i.e., before planting. Plants were maintained (December–April) either at 11 $\pm$ 1C for the duration of the experiment or transferred to a 20C day/15C night cycle after 7 weeks at 11 $\pm$ 1C. Upon emergence, plants were fertilized with 100 mg 15N-6.6P-12.5K/liter, along with the irrigation water, as required.

There were three independent variables in

Fig. 1. Effect of duration of corm cooling at 5C, growth regulator (ancymidol) application (+ GR, - GR), and greenhouse temperature (20C day/15C night or ILC constant) on flower height of 'Royal Blue', 'Uchida', and 'Stella' *Freesia hybrids*. Means separated by Duncan's multiple range test, $P = 0.05$ ($N = 8$). (▽) - GR, ILC. (○) - GR, 20/15C. (●) + GR, 20/15C.

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Fig. 2. Effect of duration of corm cooling at 5C, growth regulator (ancymidol) application (+GR, -GR), and greenhouse temperature (20C day/15C night or 11C constant) on leaf height of 'Royal Blue', 'Uchida', and 'Stella' *Freesia hybrida*. Means separated by Duncan's multiple range test, $P = 0.05$ ($N = 8$). (∇) -GR, 11C. ($\circ$) -GR, 20/15C. ($\blacktriangledown$) +GR, 11C. ($\bullet$) +GR, 20/15C.

Table 1. Sources of variation and two-way interactions for flowering time, flower height, and leaf height.

Source of variation	Flowering time	Flower ht	Leaf ht
Cultivar (Cul)	**	**	**
Greenhouse temp (GHT)	**	**	**
Cul $\times$ GHT	**	NS	**
Cooling period (Cooling)	**	**	**
Cul $\times$ Cooling	**	**	**
GHT $\times$ Cooling	NS	**	**
Growth regulator (GR)	**	**	**
Cul $\times$ GR	NS	**	**
GHT $\times$ GR	**	**	**
Cooling $\times$ GR	NS	**	**

NS,**Nonsignificant or significant at $P = 0.05$.

the experiment: a) duration of preplant 5C corm storage, b) ancymidol application, and c) greenhouse forcing temperature. Leaf height and flower height were measured and number of days to flower was recorded. Leaf height was measured from medium level to the tip of the longest leaf per plant; flower height was measured from the base of the spike to the first floret of the spike; and days to flowering were recorded from the time the corms were removed from cold storage to anthesis of the first flower (days to flower).

Data were analyzed by analysis of vari-

ante (SAS Inst., Cary, N. C.) and means separated by Duncan's multiple range test. Each pot of five plants constituted an experimental unit and there were eight replicate pots per treatment.

A preplant 5C treatment of corms (cooling) reduced the length of the flowering spike of all three cultivars. The effect of the cooling treatment on flower spike length was significant in the presence and absence of applied growth retardant (Fig. 1 A-C). Leaf height in the naturally shorter 'Royal Blue' was much less affected by the cooling period than that of the other cultivars. (Fig. 2A). Cooling treatments for as long as 6 weeks reduced leaf height by $> 50\%$ in both 'Uchida' (Fig. 2B) and 'Stella' (Fig. 2C). Holding corms at 5C for 2 weeks significantly reduced leaf height of 'Stella' (Fig. 2C). A significant interaction between cultivar and cooling period was evident (Table 1). The number of days to flower (flowering time) was also reduced by the preplant storage of corms at 5C (Fig. 3 A-C). Statistical differences in time to flowering in the presence of the growth regulator were evident among all three cultivars, regardless of duration of corm cooling (Fig. 3 A and C). Corms cooled for 4 weeks flowered ≈ 20 days before corms that were not cooled before planting but that were

treated with ancymidol (Fig. 3 A-C). The time to flower for all cultivars was also clearly related to greenhouse temperature and to the presence of ancymidol treatment. Flowering was most rapid for all cultivars in the warmest greenhouse in conjunction with 4 or 6 weeks of cooling and no ancymidol (Fig. 3 A-C).

The postplant greenhouse environment (20/15C vs. 11C) did reduce leaf height of 'Royal Blue' and 'Uchida' (Fig. 2 A and B), but had no impact on 'Stella' (Fig. 2C). Ancymidol largely eliminated the impact of greenhouse temperature on 'Royal Blue' (Fig. 2A), but not 'Uchida' (Fig. 2B).

Ancymidol significantly reduced both leaf and floral stem length at all combinations of corm cooling and greenhouse treatments (Fig. 1 A-C and 2 A-C). Moreover, significant interactions between growth regulator and greenhouse temperature were observed for all variables (Table 1).

Cooling of corms at 5C before planting significantly reduced plant height in freesia. The effect of this treatment is similar to that of the postplant application of growth regulators (Gianfagna and Wulster, 1986b), with one significant exception: time to flower was reduced by the low-temperature treatment, but increased by the growth regulator application. This suggests that the two treatments may reduce plant height by different mechanisms.

Cold storage of bulbs is a common cultural practice for Easter lily, hybrid lilies, tulips, and narcissus (DeHertogh, 1985). Easter lilies are somewhat similar to freesia in their response to low-temperature storage. In both crops, flower development is enhanced by storage at 5C, however, the plants will flower as long as the temperatures are below 21C. Cold storage of lily will also decrease plant height at flowering and will reduce the number of days to anthesis (DeHertogh and Wilkins, 1971a, 1971b).

There was a significant interaction between postplant greenhouse temperature and growth regulator treatment with regard to time to flower (Table 1). The delay in flowering induced by ancymidol was more apparent at the higher greenhouse day temperatures. At 11 ± 1 C constant temperature, days to flower was increased significantly even without growth retardant applications, and under these conditions, temperature rather than ancymidol treatment was the more important factor in determining flowering date. Days to flower of Easter lily also increased as greenhouse forcing temperature decreased (Rob and Wilkins, 1977). Ancymidol delayed flowering in lily, but only at very high rates (5 mg a.i.) (Gianfagna and Wulster, 1986b).

The response of plants to the 20C day/15C night cycles after an initial 7 weeks at 11 ± 1 C indicates that greenhouse temperatures can be used to reduce production time in conjunction with growth regulators without sacrificing control of the crop's final height. In fact, the 5C incubation period may satisfy the floral induction requirement and, therefore, could eliminate the necessity of maintaining plants at 10C for long periods.

Fig. 3. Effect of duration of corm cooling at 5C, growth regulator (ancymidol) application (+ GR, - GR), and greenhouse temperature (20C day/15C night or 11C constant) on time to flower of 'Royal Blue', 'Uchida', and 'Stella' *Freesia hybrida*. Means separated by Duncan's multiple range test, $P = 0.05$ ($N = 8$). (▽) -GR, 11C. (○) -GR, 20/15C. (▼) +GR, 11C. (●) +GR, 20/15C.

The results demonstrate that height in freesia can be controlled both chemically and environmentally to produce a compact container plant. The response of freesia to the various temperature regimes, both pre- and postplant, also suggests that it is possible to manipulate the time of maturity with greenhouse temperature despite prior corm cooling or growth regulator treatments.

The question remains: At what point in the temperature treatments does flower initiation occur? Taxonomic studies of the corm meristem during cold treatment may answer this question. Such studies would permit improved temperature management in relation to flower induction to reduce the significant interactions among environmental factors that were evident in this study.

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