THE EFFECT OF PRECOOLING, ENVIRONMENTAL FACTORS AND GROWTH-REGULATING SUBSTANCES ON PLANT HEIGHT OF FREESIA AS POTPLANT

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Abstract

Plant height of Freesia can be reduced by ancymidol or paclobutrazol, applied either as a soil-drench or as a dip before planting. Corm dipping resulted in leaf damage and a large variability at effective concentrations. Variability is not caused by differences in uptake. Soil drench reduced flower stem length more than leaf length, positioning the flowers between the leaves which makes the plants unmarketable. Reduction of plant height by growth-regulating substances varied by the season and from year to year, probably caused by differences in temperature and light-intensity. Precooling the corms at 13°C for 6-7 weeks reduced height, but less than needed for the European market. Precooling also reduced the number of flower buds per inflorescence and the number of flowering side-branches, resulting in a too short keepability. Due to the problems indicated, culture of Freesia as a potplant has no future in the Netherlands.

1. Introduction

An increasing number of species of bulbs and corms are forced and marketed as a potplant (DeHertogh and Kamp, 1986). In most cases height must be reduced. This can be done either by growth-regulating substances (e.g. Lewis and Lewis, 1979; Rees and Hanks, 1979; Hanks and Menhenett, 1983; Wulster and Gianfagna, 1987) or by temperature treatments before planting (Moe and Hagness, 1975; De Greef, 1986) or after planting. In research on flower initiation and flower development (Berghoef et al., 1986; Berghoef and Zevenbergen, 1989) it was noticed that Freesia height can be affected by environmental factors. Knowing this we investigated the possibilities to grow Freesia as a potplant, either by temperature treatments before and after planting or by the use of the growth-regulating substances. Since Gianfagna and Wulster (1986) reported on positive effects of ancymidol and paclobutrazol on height reduction of Freesia we also used these growth-regulating substances. It was shown, however, that flower stem length was more reduced than leaf length at the concentration used. Because potfreesia's are a new product it is essential to formulate the requirements with respect to various dimensions in order to judge the suitability of treatments. DeHertogh (1986) presented some forcing and market requirements for potfreesia in the USA. By discussions with both growers and traders we made an inventory of the demands for potfreesia for the Dutch and European market. Depending on pot size (11 or 16 cm diameter) leaf length should be between 25 - 35 cm. Flower stem length should be about 5 cm longer to have the flowers positionned just above the leaves. Leaves have to be healthy with a rather broad base. Cultivation has to be possible yearround with an uniform quality. Keepability should be at least double that of cutflowers, i.e. 2 - 3 weeks.

2. Material and methods

Experiments were done with Freesia 'Riande'. Corms, size 6/7 were obtained from Penning Freesia BV at Honselersdijk, The Netherlands. Dormancy was released by storage at 30°C for 13-15 weeks. Three corms per pot, diameter 11 cm, were planted in a mixture of peat, loam and sand. Experiments took place in the phytotron or in a glasshouse at temperatures indicated. In the phytotron light-intensity was 35 $W.m^{-2}$ (PAR) from SON/T and HPI/T lamps (Philips). Experiments started throughout the year for three successive years. All experiments were

repeated at least once, although often in another period of the year and adapted to previous results. Results of only some characteristic experiments are presented.
Growth-regulating substances used were ethephon, ancymidol and paclobutrazol, applied as a corm-dip, soil-drench or leaf-spraying at indicated concentrations. To solutions used for spraying, Tween 20 (1 ml/l) was added as a wetting agent.

Leaf length and flower stem length of each plant were measured at anthesis of the first flower bud. The number of flower buds, side-shoots and abnormalities like 'thumbing' were recorded. In some of the experiments keepability was determined at 20°C, 12 hrs light at 3-4 $W.m^{-2}$ (PAR) from fluorescent lamps.

Statistical analysis was done by ANOVA. The number of replicates and the number of pots in each replicate are given at each single experiment. Mean separation was done by Tukey's Honest Significance Difference (HSD)-test at $P=0.05$.

3. Results

3.1 Effect of corm-precooling at 13°

Corms were stored for 0,3,5,6 or 7 weeks at 13°C before planting. All corms were planted on July 10, 1986 in the glasshouse. Each treatment consisted of three replicates of 8 pots each. Mean day temperature ranged from 18-22°C for the first 14 weeks of growth, thereafter from 14-15°C. Corms precooled for 0 or 3 weeks did not show a flower stem after 180 days of growth, probably as a result of too high temperatures and a long daylength (Berghoef and Zevenbergen, 1989) Flowering plants after 5,6 or 7 weeks of precooling had significant shorter leaves than non-flowering plants (Table 1). Flower stem length was the same at these treatments and much too long for a potplant. Neither the number of buds per inflorescence (10-11) nor the number of side-shoots (2.3-2.6) was significantly affected by the duration of precooling. This experiment was not repeated in this way at another planting date. Plants precooled for 7 weeks at 13°C and planted on December 18, 1986 reached anthesis after 85 days, had a leaf length of 67 cm and a flower stem length of 70 cm, which is comparable with the results in Table 1. On the other hand corms planted on February 13, 1986 reached anthesis after 105 days and had a leaf and flower stem length of 42 and 45 cm respectively. In both experiments the number of flower buds per inflorescence was 6-7.5 and the number of side-shoots 0.5-0.9.

3.2 Effect of temperature after planting

Corms were planted in the phytotron at 9, 13, 17 and 21°C, at a daylength of 8 hrs, 10 pots per temperature. At 21°C the plants remained vegetative and were removed after 159 days. Both leaf and flower stem length increased at higher temperatures (Table 2). As temperatures were not replicated, statistical analysis of the results was not possible. Differences in length and the standard deviations (sd) make it, however, likely that plant height is affected by temperature. In the glasshouse precooled corms at 13°C for 7 weeks were used and planted in December at a day/night temperature of 15/12°C and 12/8°C. Leaf length was 67 (sd=6) and 56 (sd=6) and flower stem length 70 (sd=6) and 60 (sd=7) respectively.

3.3. Effect of growth-regulating substances

In the first 3 series of experiments in the glasshouse the use of ethephon was included, applied both as a soil drench and as a corm dip. Leaf length was affected by ethephon, flower stem length, however, was hardly affected. Only at high concentrations flower stem length was reduced. At these concentrations, however, the number of flower buds per inflorescence was reduced to 3-4. This made ethephon unsuitable for making a potplant of Freesia.

3.3.1. Soil drench

Corms were planted in the glasshouse on October 17, 1985 at a day/night temperature of 15/12°C. Each treatment consisted of 4 replicates with 4 pots each. Two weeks after planting a solution of ancymidol (0-80 mg/l) was poured on the soil, 50 ml per pot. Both leaf and flower stem length were reduced at increasing concentrations of ancymidol (Table 3). Flower stem length, however, was more reduced than leaf length, positioning the flowers between the leaves. The percentage of height reduction was the same throughout the growing period, indicating that ancymidol was active at least till anthesis. Neither the number of flowers per inflorescence nor the number of flowering side-shoots were significantly affected. Paclobutrazol was tested in a range from 5-160 mg/l. Length was reduced at concentrations of 20 mg/l or higher, at 80 mg/l leaf length was reduced by about 50%; 160 mg/l gave only slightly more reduction. As with ancymidol stem length was more reduced than leaf length. There were no significant differences whether application was done 2-5 weeks after planting.

3.3.2. Corm dipping

Corms were planted on October 17, 1985 in the glasshouse at day/night temperatures of 15/12°C. Each treatment consisted of 4 replicates with 4 pots each. Corms were dipped for 1-10 hrs in a solution of ancymidol of 50-200 mg/l. Height reduction of leaf and stem were affected by both concentration and duration (Table 4). Only at 150-200 mg/l height reduction was adequate. At these concentrations, however, 37 and 52% of the plants showed serious leaf damage of the 4 oldest leaves. They were curled or splitted, reducing markedly the value of the plant. The younger leaves looked normal, probably as ancymidol had lost its effect. This can also be concluded from the height measurements during growth. With 150 mg/l for 10 hrs leaf length after 61 days was 37% of the control and at anthesis (141 days) 57% of the control. Anthesis of the control was reached 136 days after planting, increasing concentrations had a small but significant effect, at the highest concentration anthesis was reached 6 days later. Using paclobutrazol height reduction was significant by dipping with 80 or 160 mg/l for 8 hrs. Lower concentrations and/or shorter duration did not significantly affect height. As in the case of ancymidol, however, leaf damage at the high concentrations was at an unacceptable level.

3.3.3 Plant spraying

Experiments on plant spraying were done at different planting periods in the glasshouse. Sprayings were done with ancymidol and paclobutrazol at concentrations from 20-160 mg/l. Leaves were sprayed till drip off. Sprayings 3, 6 or 9 weeks after planting as a single spray or on all 3 dates had no significant effect at all on plant height. When spraying was more abundant so that about half of the total sprayed solution (approximately 20 ml/pot) dripped off the leaves on the soil, 160 mg/l of paclobutrazol significantly affected plant height (Fig. 1). In this experiment with 4 replicates of 6 pots each, corms precooled for 7 weeks at 13°C were planted after a dip for 6 hrs in paclobutrazol at 0 or 40 mg/l. At a leaf length of 10 cm, after 15 days, plants were abundantly sprayed with 80 or 160 mg/l of paclobutrazol. Fig. 1 shows that at 160 mg/l reduction of leaf length became visible about 2 weeks after spraying 15 days after planting. Sprayings applied 59 days after planting, when the flower stem started to elongate gave rise to only a small, but significant reduction in leaf length (Table 5). Flower stem length was reduced by spraying after 59 days only at the corms dipped in 40 mg/l paclobutrazol before planting.

3.3.4. Seasonal effects.

During our experiments in the glasshouse we noticed that plant height of the untreated corms varied considerably, depending on planting date. With corms planted in January or February usually a leaf and flower stem length of 50 and 60 cm respectively were obtained. Corms planted in October/November were about 20-30 cm longer,whereas corms planted in May were still longer.

Three environmental factors might be responsible for this effect, i.e. temperature, daylength and light-intensity. The effect of temperature has been described in 3.3.2. Daylength has a small, but consistent effect on plant length (Mansour, 1968). At a daylength of 8 hrs leaf length is 5-10% shorter than at 16 hrs. The third environmental factor of importance is light-intensity Mansour (1968) reported that reducing light-intensity from 100% to 25% increased plant height. Although we have not done experiments on this particular factor, some conclusions can be drawn from comparison of experiments done in the phytotron and in the glasshouse. With corms of the same lot an experiment was simultaneously done in the phytotron and in the glasshouse at a day/night temperature of 15/12^{o}C, mean daily temperature was 13.1^{o}C. Apart from the first two weeks and the last three weeks of the growing period, mean radiation sum was 105 Wh.m^{-2}.day^{-1}, giving a light-intensity of approximately 10-20 W.m^{-2}. In the phytotron light-intensity was 35 W.m^{-2} at a daylength of 8 hrs, giving a radiation sum of 280 Wh.m^{-2}.day^{-1}. In the phytotron leaf and flower stem length at 13^{o}C reached a length of 60 and 65 cm respectively. Leaf and flower stem length in the glasshouse were 81 and 85 cm respectively. Experiments starting in February, with mean daily temperatures up to April of 14-15^{o}C and a radiation sum of 500 Wh.m^{-2}.day^{-1} or higher usually had a leaf and flower stem length of 50 and 60 cm respectively, indicating that high light-intensity reduces plant height.

4. Discussion

Plant height of Freesia can be reduced by the growth-regulating substances ancymidol and paclobutrazol. Both leaf length and flower stem length decreased by application either as a soil drench or as a corm dip. Corm dipping, however, had some serious drawbacks: 1. At concentrations high enough to reduce height, the first leaves were severely damaged making the plants hardly marketable. 2. Towards the end of the growing period inhibition of growth by the growth-regulating substances vanished. In particular when the bulbs were not precooled at 13^{o}C the growing period was relatively long (120 - 140 days) and this resulted in only a small height reduction at anthesis. 3. Plants showed a large variability, not only between pots, but also within pots. One of the reasons for this might be differences in uptake during dipping. By weighing we found that some corms took up 4 times more solution than other corms. Experiments in which the amount of solution was equal in each corm, either by injection or by dipping untill a fixed amount was taken up, showed, however, the same variability. By means of a soil drench leaf length could be reduced to an acceptable level without leaf damage. In all experiments, however, flower stem length was reduced more, resulting in flowers positioned between the leaves, as was also observed by Gianfagna and Wulster (1986). Moreover, we noticed that the required concentration for height reduction was not the same throughout the year. Corms planted in October needed 100 mg/l ancymidol to reduce leaf length by 50%, whereas 50 mg/l was required for corms planted in February. With 100 mg/l the plants were too short. The effect of growth-regulating substances not only depended on season, but that also year to year variation occurred. This is probably caused by differences in temperature and light-intensity, as they have shown to affect plant height. For compact plants low temperature and high light-intensity are required. In the Netherlands this situation is only found in early spring in the glasshouse. Yearly differences, however, in both temperature and light-intensity make it impossible to predict what concentration of growth-regulating substances is required to get the wanted quality. Interference during growth, necessary when the plants are growing too fast is hardly possible. Sprayings were ineffective at any time. Abundant sprayings, in fact a combination of spraying with soil drench was most effective two weeks after planting and hardly effective at a later stage, when too luxurous growth can be observed. This means that treatment has to be done before knowing that excessive height will be a problem as was also concluded by Larson et al. (1987).

Precooling the corms for 6-7 weeks at 13^{o}C reduced plant height. Height reduction, however, was not enough for the European market demands, so it should be combined with the use of growth-regulating substances. Moreover, precooling reduced the number of flower buds per inflorescence in most experiments to 6 - 7 flowers and it also reduced the number of flowering side-shoots. Keepability was reduced to only 7 - 10 days, which is too short for a

flowering potplant These effects make precooling less desirable, in spite of the shorter culture period. Keepability was a problem even with 10-12 flower buds and 1-2 flowering side-shoots. It never exceeded 20 days, usually it was 15-17 days.

In the reported experiments we used 'Riande'. In some experiments we also used 'Ballerina', 'Melanie' and 'Blue Heaven'. There were large differences between cultivars. 'Ballerina' was unusable as it was not possible to reduce height to an acceptable level. 'Melanie' reacted about the same as 'Riande', whereas with 'Blue Heaven' the smallest plants were obtained, especially after precooling.

In 1986 and 1987 a number of commercial growers in the Netherlands have grown Freesia as a potplant. Due to the reasons indicated here, in particular seasonal and yearly differences and the short keepability, they have all stopped by now.

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Table 1 - Effect of precooling at 13°C on days till flowering, leaf and stem length.

Number of weeks at 13°C	Days till flowering	leaf length (cm)	stem length (cm)
0	x	91.2 a	x
3	x	84.5 b	x
5	132	62.0 c	81.3 a
6	127	58.0 c	79.4 a
7	123	54.6 c	76.5 a

x: after 180 days no flower stem visible
Mean separation by Tukey's HSD-test ($P<0.05$)

Table 2 - Effect of temperature on days till flowering, leaf and stem length

Temperature	Days till flowering	leaf length (cm)	stem length (cm)	Number of plants
9°C	195	45 ± 4	58 ± 5	30
13°C	130	60 ± 5	66 ± 9	30
17°C	135	80 ± 5	78 ± 6	30

Table 3 - Effect of soil drench with ancymidol on days till flowering, leaf and stem length. Per pot 50 ml was added two weeks after planting.

Concentration (mg/l)	Days till flowering	leaf length (cm)	stem length (cm)	Number of flower buds
0	139a	81.3a	85.1a	10.1a
40	143b	59.3b	43.6b	8.9b
50	143b	53.3c	36.5c	8.8bc
60	144bc	50.3d	34.8c	9.0b
70	144bc	49.6d	32.8c	8.6bc
80	145c	45.2e	25.7d	8.4c

Mean separation by Tukey's HSD-test ($P<0.05$)

Table 4 - Effect of corm-dipping in ancymidol before planting on leaf and stem length.

Concentration (mg/l)	leaf length [1] duration (hrs)				stem length [2] duration (hrs)			
	1	2.5	5	10	1	2.5	5	10
0	80.6	83.3	78.8	81.5	83.8	88.1	84.3	84.6
50	81.0	79.4	77.8	80.6	82.3	82.0	82.2	80.7
100	75.6	75.3	71.5	62.1	75.4	74.2	69.3	59.4
150	67.1	60.4	52.7	46.4	63.4	58.2	55.0	45.7
200	54.3	51.0	42.2	41.1	53.5	46.8	41.8	38.8

[1] HSD=5.5 at P=0.05
[2] HSD=5.0 at P=0.05

Table 5 - Effect of sprayings with paclobutrazol 15 or 59 days after planting on days till flowering, leaf and stem length Plants were dipped before planting in paclobutrazol (0 or 40 mg/l for 6 hrs). Plants were precooled at 13°C for 7 weeks.

Concentration (ml/l)	Days till flowering	leaf length 0 mg/l	40 mg/l	stem length 0 mg/l	40 mg/l
15 days					
0	86	67a	56a	70a	60a
80	87	64b	53b	71a	57ab
160	86	51c	40c	46b	33c
59 days					
80	85	65ab	52b	70a	53b
160	85	63b	47d	69a	44d

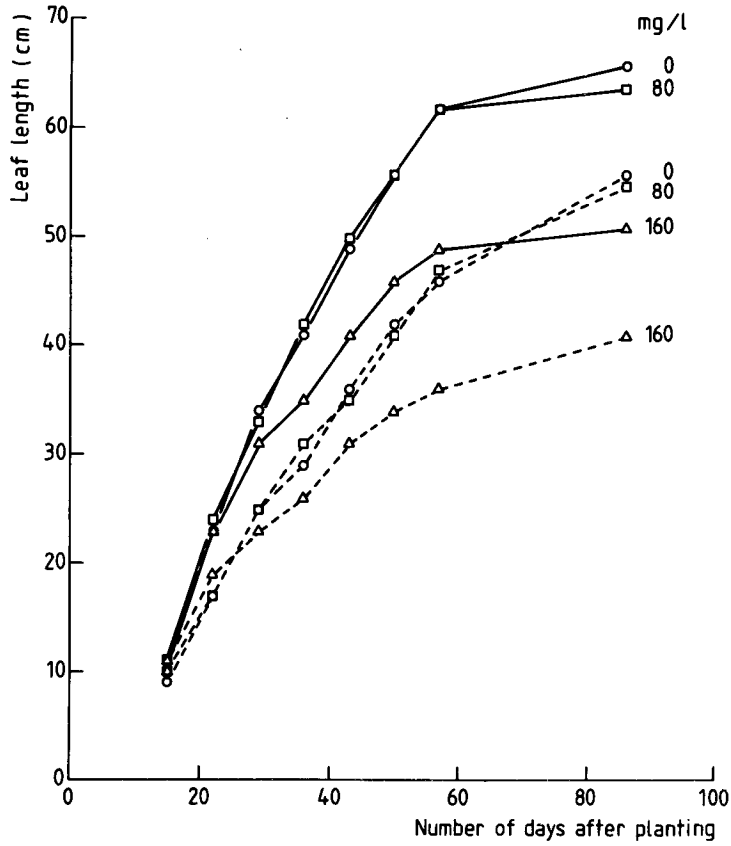

Figure 1 - Effect of sprayings with paclobutrazol on leaf length. Plants were dipped before planting in paclobutrazol at 0 mg/l (——) or 40 mg/l (-----) for 6 hours.