FLOWERING IN FREESIA: TEMPERATURE AND CORMS

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INTRODUCTION

Year round cultivation of Freesia in glasshouses is rather complicated. Therefore a considerable amount of research was done in The Netherlands, where Freesia production is of economic importance. However, most of the data are only available as internal reports of the Glasshouse Crops Research Station at Naaldwijk, and they are in Dutch. Messrs.van de Nes and Dijkhuizen performed these experiments and produced the reports (see 1). This article has the aim to summarize very briefly all practically important data. Apart from the very early work by Hartsema and Luyten (2, 3, 4, 5) recently a study has been published by Mansour about his work in the phytotron of the Laboratory for Horticultural Crop Growing at Wageningen (7). Some of his tables are very nice summaries of work at Naaldwijk and they add new observations as well. Some of the data of this thesis are gratefully incorporated in this article.

EXPERIMENTAL DATA AND DISCUSSION

Storage

For year round production it is necessary to store corms between lifting and planting date. Storage of dry corms can be done at temperatures of $\frac{1}{2}$-17°C, for as long as 9 months. There are however a few complications. At the lowest temperatures very long storage results in so called "stones". Corms dry out and die, because of the water stress at these low temperatures. At higher temperatures the metabolism of the corms remains active to some degree. The young buds start to swell slowly and develop into new corms ontop of the original ones, with the bulk of storage material. In Holland they are called "pop",i.e. pupa. And the process is called "verpoppen", or pupation. In table 1 the temperature dependence of this process is shown.

At 13°C pupation is fastest and is completed after 8-9 months. Too young pupa, not yet fully developed, can not be used as planting material alone. So, when storage is done such that pupa start to develop, the treatment must be continued to completion of pupation before storage can be ended. This is one of the difficulties upon storage at 5-9°C.

A second problem is that all corms, whether newly lifted,cold stored, or after pupation are in a sort of rest-situation. In this situation they will continue with the pupation process, even a second generation may develop, at normal cultural temperatures. They develop into the so called "sleepers", neither forming roots, nor leaves. All material, to overcome this resttype character, must be treated with high temperatures (around 30°C) during a rather long period (10-15 weeks). The treatment can be applied to the dry corms (4,5).

Plant initiation

After proper high temperature pre-treatment, the corms must be started to develop plants, i.e. leaves and flowers must begin to differentiate. This treatment speeds up the initial development of the young plantlets and it also favours the relative development of flowers and causes the leaves to be less in numbers and also each individual leaf to be smaller. This complex but crucial function of the Freesia is demonstrated in the tables 2, 3 and 4. It is the main reaction for proper control of a Freesia crop.

Table 2 shows, for pupated material, that did receive a pre-treatment of saturating duration at 30°C, the effect on the date of flowering of a treatment at 13 or 9°C during 0, 4 or 6 weeks. Flowering is markedly enhanced, since after 6 weeks at 13°C it is some 80 days ahead of the control. 9°C is even slightly faster, and 6 weeks worked stronger than 4.

In table 3 some further refinement is presented, but with essentially the same result: low temperatures (9-17°C) must be applied during 4 to 6 weeks to obtain early flowering.

Also figure 1 is a demonstration of the flowering enhancing effect of a 13°C treatment following a saturating high temperature (31°C) pre-treatment.

In the three series of data presented (tables 2 and 3, and figure 1), one remarkable observation can be made. The effect of a 6 week treatment is stronger than of a 4 week treatment. But the difference between a 4 and a 2 week treatment is much larger, since the effect of 2 weeks is practically zero.

It is tempting to conclude that we are dealing with an induction effect, which becomes manifest upon treatments of some 4-6 weeks. This observation can also be found in Mansour's thesis (7). Table 4 gives the relevant part of one of his tables.

The effects of a 4 week cold treatment (5°C) is very strong as compared with only 3 weeks, relative to the non-cold treated control. It is especially marked for the number of leaves differentiated before flower initiation. However, number of days to flowering and stem length do react similarly.

The effect of plant age does not seem to be very important. It is practical to give the low-temperature treatment to the dry corms, but Mansour used planted out material of various ages. The promotion of flowering in dry material is different, however, in that the effects of treatments longer than 3 weeks will increasingly fall behind those of planted out corms (figure 2).

It is possible that for actual differentiation of flowers in Freesia a complete plant, with roots, might be a pre-requisite. In conclusion, for crop size and flower stalk length control the precise duration of the low-temperature treatment is critical. Best development being obtained usually after 3-4 weeks at 13°C. With respect to this 13°C-treatment it does not seem to make much difference, whether, after saturating 30°C-treatment the crop is started from corms, cormlets or pupated material.

Corm production

Lifting date can be important, especially in spring and summer. It is possible that the corms, when still in the soil, do receive high temperatures such that their rest-condition is already partly broken at the moment of lifting. However, with properly pre-treated material not much effect is found from variations in harvesting time.

Figure 3 gives an example of such an experiment. Plants were lifted on three dates: 6/4, 27/4 and 18/5. Material of these 3 groups was planted out:

a. at the same date (16/8) and
b. at 3 successive dates, after equally long storage (16/8,8/9 and 25/9).

The difference in flowering time is very small when the three groups are planted out at the same date (only 2 days). There is some retardation (6 days) in the group harvested late, probably because it was planted later in the season, in lower light and temperature conditions, so that overall growth was slower. But certainly, there are no specific effects. This result makes it possible to havest at the most profitable time with respect to corm production. The longer the plants, after flowering, can be kept alive the more material they produce (figure 4).

It can be seen that the loss of water from freshly harvested corms, upon wind drying for dry storage, is quite a bit less from older corms (28 versus 51%). The amount of saleable weight of corms is therefore strongly correlated with the duration of the producing crop.

Growth and flowering

The data of the tables 5, 6, 7 and 8 are taken from Mansour's thesis to discuss the effects of temperature, daylength and light intensity on growth of properly pretreated material.

When corms are planted out after receiving the 30°C pre-treatment and are then subjected immediately to a series of temperatures, data as in table 5 are obtained. It must be kept in mind that normally plants have also received a 13°C-treatment before planting out.

In the last column of table 5, early flowering shows an optimum at 18°C. Retardation into higher temperatures being stronger than into lower ones. This optimum must result from a combination effect of growth rate and earliness of floral induction. Initiation takes place after 9 leaves at 12°C and later at all higher temperatures. The moment of initiation, however, being equally fast over the whole range of temperatures from 12 to 18°C. Plant height also is strongly a function of temperature. Here we must assume interactions of numbers of leaves, internal shading and crop density, and direct temperature effects on elongation.

As can be seen from table 6, daylength as such, at otherwise optimal conditions, has a weak effect only after flower initiation. Flowering being slightly enhanced in longer daylengths, but plant height and stem length not being influenced.

There is, however, a very peculiar interaction of daylength with temperature (see table 7). As in table 5, flowering is very early between 15 and 18°C. At these medium temperatures, all three daylengths result in flowering after about 110 days. Down to lower temperatures there is a retardation, and this is daylength independent also. However, to higher temperatures retardation is much stronger in long days. The effect has nothing to do with the initiation of the flowers, nor with the growth of the crop, as can be also concluded from table 7. It is necessary to remark that the unfavourable combination of high temperature and long days is the normal summer condition, especially in greenhouses. We thus seem to have two means to overcome slow flowering in summer: lowering temperature down to 20 or 18°C, and shortening daylength down to below 12 hours. Both procedures might have practical possibilities. Especially also reduction of daylength seems promising since high light intensities do not seem to cause retardation of flowering, as can be seen from table 8.

We seem to be dealing with a real daylength effect on the later stages of floral growth.

A second effect of daylength is found on the development of secondary inflorescences. Their development is promoted by short days, in high light intensities, especially at lower temperatures. In general, however, after initiation, flowering is speeded up by high temperatures.

Flower quality

A last problem must be mentioned, be it that practically no data for interpretation are available. It is the malformation in an inflorescence called "thumbing". The first flower (and in serious cases more) sits too low on the stem and is separated by a rather long internode from the rest of the inflorescence (6,7). All flowers should be sitting on the nicely-hooked top section of the stem. There are some indications that this phenomenon results when during flower initiation the temperature treatment is suddenly shifted to a level which is relatively more favourable for vegetative growth. This would mean that any increase in temperature during initiation should be avoided. It may then even be necessary to begin induction at considerably higher temperatures than the optimal 9-13°C range.

SUMMARY

Data of work on Freesia obtained in The Netherlands over a long period of years, is very briefly surveyed. Year round culture of Freesia requires proper storage procedures for corms, a good method to start the crop, because planting material normally is in rest and since correct floral induction and plant size must be obtained and furthermore acceptable temperature and daylength conditions during growth.

Summarizing the suggestions presented in the above data, it seems justified to present the following tentative prescription:

1. Storage can be done at $\frac{1}{2}$°C up to 9 months, or at 13°C with a minimum duration of 8 months (pupation).

2. Plant material in rest must be kept at 27-31^{o}C for at least 10 weeks.
3. To initiate a proper plant, treatment at 13^{o}C during 3-6 weeks is necessary. This treatment can also be given, at least mainly, to dry corms. It is the crucial treatment for crop development.
4. Flower initiation is fastest at 13^{o}C (minimal time) but relative development of flowers is fastest at 5^{o}C (minimal number of leaves).
5. Development of side branches (secondary inflorescences) is promoted by low temperatures (slow development), short days and high light intensities.
6. Abnormal flowering ("thumbing") may be caused by shifts to infavourable temperatures during flower initiation.
7. Flowering (when initiation is completed) is delayed by high temperatures in combination with long day conditions.

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pupation and storage temperature					
°C	% pupation 0–5	5–75	75–100	dead corm %	mean flowering date
20	100	–	–	61	–
17	–	–	100	–	–
13	–	–	100	–	21
9	–	79	21	–	21
5	60	40	–	9	5
3	100	–	–	5	0
1	100	–	–	6	8
1/2	100	–	–	5	5

Table 1. Temperature dependence of pupation of Freesia, average values of 3 cv. 'Buttercup', 'Oranje Zon' and 'Snow Queen'. Temperature treatment 17/6/1955 - 17/3/1956, then 30°C till 9/6/1956 (internal report, Freesia 25).

pupation (4 months, 13°C)	
temperature treatment	mean flowering date
17w/30	84
13w/30 4w/13	37
13w/30 4w/9	28
11w/30 6w/13	5
11w/30 6w/9	0

Table 2. Mean flowering date, average values of 4 cv. of Freesia: 'Blauwe Wimpel', 'Buttercup', 'Oranje Zon' and 'Princess Marijke'. Day 0 = 18/10/1960. Pre-treatment 4 months at 13°C. Planting date 7/7/1960 in the open, 22/8 covered by glass (internal report, Freesia 32).

temperature and flowering		
after treatment	mean flowering date expt I	expt II
2w/17 + 2w9	22	
2w/17 + 4 w9	0	
4w/31	31	12
4w/20		10
4w/13	24	0
2w/13 + 2w/20		8
2w/20 + 2w/13		7

Table 3. Induction temperatures and flowering in Freesia. Expt. I: cv. 'Snow Queen' and 'Oranje Zon'. Planting date 16/9/1958. Average mean flowering day 0 = 23/2/1959. Expt. II: Averages of 6 cv, used in 4 series (planting dates: 8/9/1955, 3/9/1956, 3/9/1957 and 16/9/1958) (internal reports, Freesia 16, 10, 11, 12, 13 and 14).

5°C treatment and plant age							
cold treatment	3			4			control
age (weeks)	1	2	3	1	2	3	-
number of leaves	15	15	14	9	10	12	16
days to flowering	180	184	171	116	116	139	210
stem length (cm.)	71	73	90	20	19	19	75

Table 4. The effect of 5°C at different plant ages on Freesia 'Rijnveld's Golden Yellow'. Averages of 10 plants (Mansour, p. 24).

temperature and growth				
°C	plant height (cm)	number of leaves	days to initiation	days to flowering
12	52	9	27	114
15	66	10	29	103
18	73	11	28	96
21	91	12	45	122
24	90	15	51	148

Table 5. Effect of constant temperatures on Freesia 'Rijnveld's Golden Yellow'. Averages of 5 plants (Mansour, p. 14).

daylength and growth			
daylength 8 hrs NDL + x hrs inc. l.	plant height	days to flowering	stem length
8 + 0	93	130	76
8 + 2	91	135	75
8 + 4	95	129	76
8 + 8	95	118	75
8 + 12	96	114	74
N. L.	102	135	83

Table 6. Effect of daylength (8 hrs. natural light supplemented by incandescent light) after flower bud initiation on Freesia 'Rijnveld's Golden Yellow'. Averages of 6 plants (Mansour, p. 37).

temperature, daylength and growth									
	plant height			number of leaves			days to flowering		
°C	8	12	16	8	12	16	8	12	16
9	30	35	27	6.5	7.0	7.6	147	155	155
12	35	44	41	6.8	7.0	7.8	129	130	127
15	50	60	63	7.6	8.2	9.8	108	116	111
18	55	66	65	8.2	10.0	10.7	113	109	117
21	79	81	79	11.6	14.0	10.8	119	160	180
24	74	76	74	12.8	12.7	11.3	127	179	–

Table 7. Effect of the temperature and photoperiod on Freesia 'Rijnveld's Golden Yellow'. Averages of 3 plants (Mansour, p. 52 and 53).

daylength, lightint. and growth				
	irradiation intensity (%)	plant height	days to buds	days to flowers
8 hrs.	25	95	73	143
	53	87	57	133
	75	79	35	112
	100	74	35	112
12 hrs.	25	85	–	–
	50	93	76	154
	75	83	53	135
	100	83	53	148
16 hrs.	25	105	–	–
	50	89	97	–
	75	92	90	–
	100	83	97	–

Table 8. Effect of photoperiod and light intensity on Freesia 'Rijnveld's Golden Yellow'. Averages of 4 plants (Mansour, p. 40).

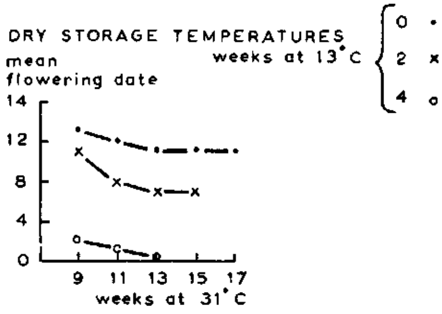

Figure 1. Mean flowering date, average values of 5 cv. of Freesia, 'Buttercup', 'Carlo Carlee', 'Oranje Zon', 'Snow Queen' and 'White Madonna'. Day 0 = 8/2/1954. Planting date 1/9/1953, under glass, 10 x 10 cm, 3 cm deep. Corm size 5-7 cm circumference (internal report, Freesia 0).

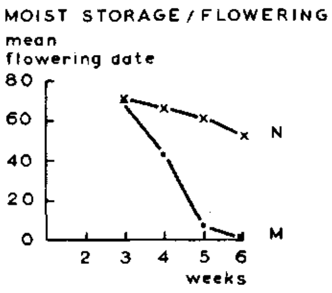

Figure 2. Mean flowering date and 13°C treatment on dry and planted corms of Freesia cv. 'Oranje Zon'. Day 0 = 7/12/1956. Pre-treatment 13 weeks at 30°C. Planting date 5/9/1956 (internal report, Freesia 40).

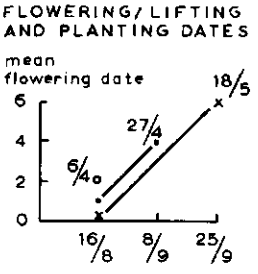

Figure 3. Lifting date and earliness of flowering of Freesia cv. 'Buttercup' and 'Oranje Zon'. Corms were lifted on three dates, three weeks apart, 6/4, 27/4 and 18/4/1954, and were 13-19 weeks dry stored at 31°C. Planting dates were 16/8, 8/9 and 25/9/1954. Flowering day 0 = 19/1/1955 (internal report, Freesia 4).

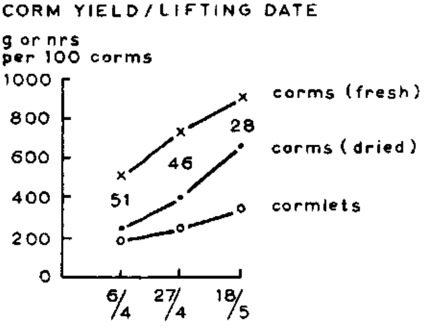

Figure 4. Corm production as a function of lifting date, of the material used and described in figure 3.