Europ.J.Hort.Sci., **75** (2). S. 71–76, 2010, ISSN 1611-4426. © Verlag Eugen Ulmer KG, Stuttgart

South African Geophytes: Comparison of Temperature and Light Intensity Requirements for Container Production under Central European Conditions

L. Ehrich[1)], H. Grüneberg[1)] and C. Ulrichs[2)]
([1)]Institute for Horticultural Sciences, Section Ornamentals, Humboldt University, Berlin, Germany and [2)]Institute for Horticultural Sciences, Section Urban Horticulture, Humboldt University, Berlin, Germany)

Summary

South African *Iridaceae* contain many genera with a high potential for new floricultural crops. This potential was accessed in four geophytic species of the genera *Freesia*, *Sparaxis* and *Tritonia,* native to the Cape Floral Region which are winter growing and spring flowering in the Southern Hemisphere. If forced as pot plants for the European autumn and winter months, their low temperature requirements during cultivation could represent substantial energy savings. The aim of this study was to evaluate and compare temperature and light intensity requirements of the chosen species when subjected to selected forcing regimes for pot plant production under Central European conditions. The trials focused on the following aspects: export during corm dormancy, storage conditions after export, forcing experiments at different periods of the year in Berlin and general cultivation requirements of the different species/hybrid. These were compared to *Freesia* x *hybrida*, a well known geophytic ornamental crop originating from South Africa, although mostly grown as a cut flower. Results were obtained by regular monitoring of inflorescence initiation in the shoot apex meristem as well as of the plant development.

The export of dormant corms from South Africa proved to be uncomplicated as their dormancy could be further maintained by subsequent storage at temperatures above 20 °C. Temperature during forcing was found to be the main factor affecting flowering after planting. The species varied in their sensitivity to growth temperatures above 20 °C, but generally cultivation at 13 °C at night was essential, with temperatures of 17 °C and above possible during the day. During the Central European summer months, inflorescences in the terminal bud failed to completely develop or flower primordia were aborted within the corm due to the high growth temperatures. Also, low natural light levels during European autumn months increased flower abortion of the investigated species. A reduction in plant height and enhanced flowering could be achieved for some species by specific storage regimes.

Key words. *Freesia* – inflorescence initiation – new floricultural crops – *Sparaxis* – *Tritonia*

Introduction

From the huge reservoir of potential new floricultural crops in the Cape Floral Region (CFR) (Van Wyk and Smith 2001) of South Africa, its outstanding variety of geophytes, namely 16 % of the total species (Van Wyk and Smith 2001), form a largely untouched plant group in horticulture. The *Iridaceae* of the CFR contain 27 genera with ca. 700 species (Manning et al. 2002) – amongst them the well-known ornamental genera *Freesia* and *Gladiolus*– and they are characterized by a large diversity of flower colours (Niederwieser et al. 2002).

The genotypes of *Freesia*, *Sparaxis* and *Tritonia* have a wide flower colour range of mainly shades of orange, red and pink. These species form corms that enable them to survive the hot and dry summers at dormancy stage, grow during winter and flower in spring. Flower stems are 15 to 40 cm tall. The temperature decrease and the onset of winter rains evoke their sprouting and vegetative growth, following which an inflorescence is formed by the shoot apex meristem (Manning et al. 2002). Hence, unlike species forming true bulbs (e.g. *Lachenalia* and *Ornithogalum dubium*), the inflorescence formation is only initiated within the apical meristem once the vegetative growth has commenced, but not during summer dormancy. A similar physiological pattern is known for *Freesia* x *hybrida* (Imanishi 1993).

Exporting the dormant corms from South Africa and leaving them in their South African growth rhythm in order to force them during the European winter offers two interesting prospects. Firstly, the European pot plant assortment during that season is very limited and needs diversification. Secondly, originating from a Mediterranean climate, the chosen species and hybrids have low temperature requirements for forcing in greenhouses and their production is therefore energy cost saving compared to crops originating in the tropics, e.g. *Euphorbia pulcherrima*.

To be able to force the chosen species and hybrids as pot plants, detailed investigations on their growth rhythms

and growth requirements are needed in order to provide information on their physiology and on how their cultivation can be regulated and optimised to eventually determine their potential as new pot plants (Rees 1992; Dole 2003). Due to the limited information regarding the physiology and cultivation of the investigated species/hybrids, the different trial treatments were based on and the results compared to findings for *Freesia* x *hybrida*. The investigations focused on different storage and pre-planting temperature regimes to enhance sprouting, to shorten the time until flowering and to increase flowering percentage and quality. The presented results highlight the mechanisms of flower induction in the investigated species, as well as the influence of temperature and light intensity during forcing stage to that process.

Materials and Methods

Freesia laxa Goldblatt & Manning, *Sparaxis* x *tricolor*, *Tritonia deusta* Ker Gawler and *Tritonia securigera* Ker Gawler (Fig. 1) obtained from New Plant Nursery in George, South Africa, were chosen for their potential ornamental value and their availability in sufficient quantities to conduct adequate trials. At New Plant Nursery, corms were propagated vegetatively via cormlets. For the trials, the biggest corms available per species/hybrid were manually chosen to avoid juvenility of corms in respect to flowering. The corms were at least two years old and had the following circumferences: *Freesia laxa*: 40–60 mm, *Sparaxis* x *tricolor*: 40–60 mm, *Tritonia deusta*: 45–75 mm and *Tritonia securigera*: 50–70 mm. The corms of dried-off plants were harvested in January 2005 and 2006 and stored at 20 to 25 °C at the nursery before air-freighting them to Europe in April 2005 and 2006.

In 2005 (planting April to June), a set of preliminary experiments was carried out to determine general growth requirements of the chosen species/hybrids. In 2006, detailed investigations were carried out to determine the specific storage and forcing requirements of the chosen species and hybrids, of which the results are presented in this paper.

After arrival in Germany, the corms were stored in climatic chambers at specific temperature regimes (22 °C and 65 % relative humidity or 2 °C and 75 % relative humidity depending on the treatment). The corms were planted individually in 12 cm pots in a medium composed of peat and perlite (2:1) and monitored at the research facilities in Berlin (latitude 52° 31' North). Liquid fertilization was carried out with Kristalon Weiss (N:P:K ratio: 15:5:30 plus trace elements) in weekly intervals. Regular pest and disease control was applied during the cultivation.

In 2006, two experimental sets were performed. The spring batch (SB) was planted in May, following corm storage of 4.5 months. The second batch was planted in September (autumn batch, AB), following corm storage of 8.5 months in total. The treatments realized in both batches are listed in Table 1. The forcing temperatures in the greenhouse were programmed for 17 °C (day) and 13 °C (night), but during hot weather in the spring and summer months, these temperatures were exceeded (Fig. 2). During these hot weeks, shading in the greenhouses opened automatically above an ambient light intensity of 1.3×10^3 µmol m^{-2} s^{-1}. Similarly, in the winter months, automated energy screen opening was programmed when the ambient light intensity was lower than 3.7×10^2 µmol m^{-2} s^{-1}. Per treatment, 50 corms were planted, except for Treatment 4 (35 corms) and Treatment 5 (15 corms). Corms and plant development were regularly monitored and measurements taken of all plants including plant height (in cm) as well as the percentage of flowering plants (first open flower of the inflorescence) per treatment and batch. The flowering plants were analysed regarding their number of inflorescences per plant and the number of flower primordia (flower buds and open flowers) per inflorescence. Flower initiation was de-



Fig. 1. *Freesia laxa* (A), *Sparaxis* x *tricolor* (B), *Tritonia deusta* (C) and *T. securigera* (D).

Table 1. Treatments realized in the spring (SB) and autumn batch (AB) 2006/2007.

Treatment	Planting time	Warm storage	Pre-planting storage	Forcing temperature (day/night)	Forcing light conditions
1 (control)	(SB and AB)	22 °C	3 weeks at 13 °C	17/13 °C	ambient
2	(SB and AB)	22 °C	4 weeks at 5 °C	17/13 °C	ambient
3	(SB and AB)	22 °C	6 weeks at 13 °C	17/13 °C	ambient
4	(SB and AB)	22 °C	3 weeks at 13 °C	> 20 °C	ambient
5	(SB and AB)	22 °C	3 weeks at 13 °C	13 °C	250 W h^{-1} 12 h d^{-1}
6	(AB)	2 °C	3 weeks at 13 °C	17/13 °C	ambient
7	(AB)	22 °C	3 weeks at 13 °C	17/13 °C	400 W h^{-1} 12 h d^{-1}

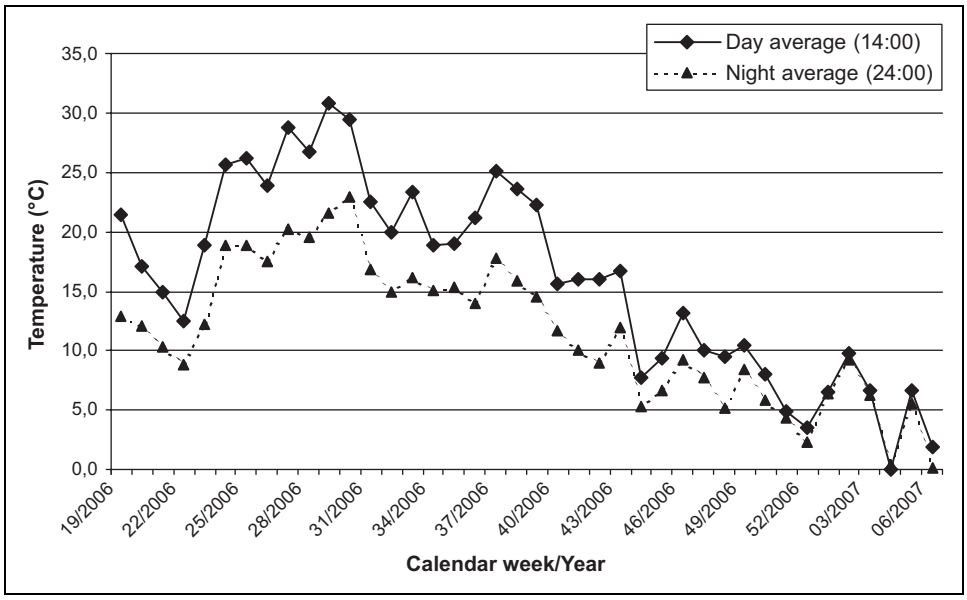


Fig. 2. Average ambient temperatures during spring and autumn batch 2006/2007.

Table 2. Number of weeks from planting until first microscopic determination of floral meristem initiation of the treatments of *Freesia laxa*, *Sparaxis* x *tricolor*, *Tritonia deusta* and *Tritonia securigera* realized in the spring and autumn batch 2006/2007.

Treatment	*Freesia laxa*	*Sparaxis* × *tricolor*	*Tritonia deusta*	*Tritonia securigera*
	Spring batch (SB)			
1	13	7	10	–
2	13	7	10	–
3	13	7	4	–
4	–	7	10	–
5	13	7	10	7
	Autumn batch (AB)			
1	12	6	12	14
2	12	6	14	–
3	9	6	6	14
4	17	12	14	–
5	9	9	9	9
6	6	6	6	9
7	14	6	6	12

1 (Control); 2 (Pre-planting storage at 5 °C for 4 wk.); 3 (Pre-planting storage at 13 °C for 6 wk.); 4 (Forcing at continuous >20 °C); 5 (Forcing at continuous 13 °C); 6 (Storage at 2 °C for 15 wk.); 7 (Supplemental lighting at 400 W h^{-1})

termined by regular microscopic examination of the shoot apex meristem of two or three randomly chosen specimens of each of the different treatments every two to four weeks. For this purposes, fresh cuts were evaluated using a light microscope (Hund, Wetzlar type H600) in a magnification of ×40, ×100 and ×200. The experiments with the single factor treatment were arranged in a completely randomised design with 15 (Treatment 5), 35 (Treatment 4) to 50 plants per treatment for each species/hybrid. Statistical analysis of data via an analysis of variance was performed (where applicable) with the programme Statgraphics Plus version 4.1 for Windows. If the assumptions for the analysis of variance (normal distribution of the residuals as well as homogeneity of variances) were fulfilled and the subsequent F-test possible, the Tukey-test would follow the latter to detect significant differences. But if the described assumptions were not fulfilled, the use of alternative non-parametric tests (e.g. Kruskal-Wallis-test, Mann-Whitney-test) was necessary to evaluate the results.

Results and Discussion

Effect of different temperature regimes during forcing

The inflorescence differentiation in the terminal bud, which was microscopically determined, was temperature independent for *Freesia laxa*, *Tritonia deusta* and *Sparaxis* x *tricolor*, and was even accomplished in the mentioned hot summer months of the spring batch (Table 2). This can be compared to the physiological reaction of *Freesia* hybrids, for which 12 °C is optimal for flower initiation and differentiation, but for which higher average temperatures (up to 20 °C according to Gilbertson-Ferriss 1989) will delay, but not inhibit these processes (Imanishi 1993). Only for *Tritonia securigera* a cool temperature regime (17 °C day and 13 °C night or continuous 13 °C) was found to be compulsory for the formation of a floral meristem (Table 2). This can be compared to findings of Ascough et al. (2006) for several species of Watsonia, also members of the *Iridaceae* originating in South Africa, for which the authors showed facultative or obligate vernalization requirements for successful flowering. Unfortunately, no statistical analysis could be applied to the data in Table 2, as the random sample size of two or three specimens per microscopic investigation was insufficient. The different stages of inflorescence initiation were digitally photographed for each species/hybrid and two of them are illustrated for *Freesia laxa* as examples in Fig. 3 and 4.

For all chosen species and hybrids, however, continuous high temperatures after inflorescence initiation in the apical meristem resulted in its abortion within the corm or shortly before emergence, *Freesia laxa* being the least sensitive in that regard with the highest percentage of flowering plants compared to the other investigated species/hybrids during the spring batch 2006 (values of up to 49 % compared to values of only 0 to 33 %). This reaction is also known for *Freesia* hybrids when subjected to high temperatures during the period of flower development (Imanishi 1993). The lower growing temperatures realised in the autumn batch led to a higher percentage of flowering plants of all investigated species and hybrids, as summarized in Table 3, and were essential to achieve adequate plant qualities (attractive foliage and a satisfactory number of flowering plants per treatment).

Plants grown at continuous 20 °C or above (Treatment 4) demonstrated that cultivation at these temperatures led to a delay or inhibition of flowering for all investigated species/hybrids (Table 2 and 3), confirming the results of the spring batch for the control treatment due to the naturally high temperatures. Plants of Treatment 5 grown in the climatic chamber at continuous 13 °C in comparison displayed 70 to 100 % flowering in both batches of all species/hybrids (Table 3), although their number of inflorescences per plant as well as their number of flower primordia per inflorescence was usually lower than those of Treatment 7 plants grown under supplemental lighting (Table 4).

Effect of different light intensity regimes during forcing

Plants grown in the spring batch under naturally high light intensity and high temperatures during the hot European summer months (over 22 °C during the day almost daily for longer than two months) were more compact that those grown under a naturally cooler temperature regime and a lower light intensity in the autumn batch. Moreover, during the lower temperatures of the autumn batch, high light intensities (Treatment 7) led to a statistically significant increase in plant height for *Tritonia securigera* and *Sparaxis* x *tricolor* (both ca. 7 cm) as well as in number of flower primordia per inflorescence for both *Tritonia* species (ca. 2 to 7) and *Sparaxis* x *tricolor* (ca. 1), but these effects were not observed on *Freesia laxa* (Table 4).

Besides these effects, the naturally low light intensities of the non-irradiated treatments during the winter months of the autumn batch also led to flower abortion or a delay in flowering of *Sparaxis* x *tricolor*, *Tritonia deusta* and *Tritonia securigera*, similar to the reaction of *Freesia* hybrids (Imanishi 1993) as well as *Gladiolus* (Halevy 1975) in this regard. Surprisingly, the described low light intensities had no negative effect on *Freesia laxa*, as can be confirmed by a similar or higher percentage of flowering plants of the non-irradiated plants of Treatment 1 of this species compared to Treatment 7 in Table 3.

Effect of different storage regimes

The pre-planting storage of the corms for 4 weeks at 5 °C (Treatment 2) had no advantageous effects on reducing the plant height and advancing the anthesis date of all investigated species and hybrids compared to the control and to the findings of Wulster et al. (1991) for potted freesias (Table 3 and 4). The statistically significant reduction of plant height of pot freesias achieved by Berghoef and Zevenbergen (1990) by an extended storage at 13 °C before planting (Treatment 3) could be confirmed for *Freesia laxa* (over 5 cm), but only for the spring batch (data not shown). This treatment also increased the percentage of flowering plants in *Freesia laxa* compared to the control in the spring as well as the autumn batch (Table 3). For *Tritonia deusta* this treatment lead to a 4 to 6 week earlier inflorescence formation in the apex meristem (Table 2) and to a 3 week advanced anthesis, although only less than 20 % of these plants flowered in the spring as well as autumn batch (Table 3). This was

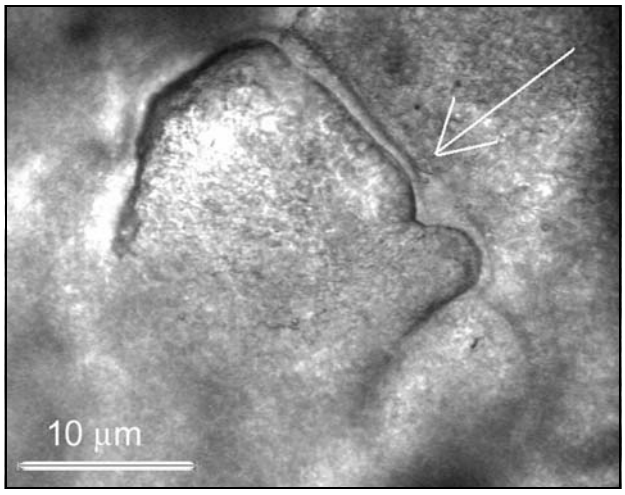


Fig. 3. Stage Pr–Br* of inflorescence initiation in *Freesia laxa*: The bract primordium is formed opposite the last leaf and another primodium initiated in its axil (see arrow) (* Standard abbreviations for the stages of inflorescence initiation in flower bulbs according to De Hertogh and Le Nard (1993): Pr: First flower primordia visible; Br: Flowers bearing bracts, specialized leaves).

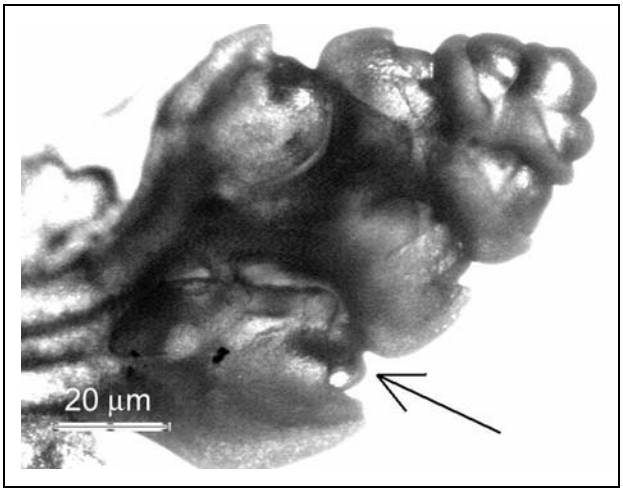


Fig. 4. Stage P_1–P_2* of inflorescence initiation in *Freesia laxa*: The perianth primodia develop (see arrow) (* Standard abbreviations for the stages of inflorescence initiation in flower bulbs according to De Hertogh and Le Nard (1993): P_1: 1st whorl of perianth; P_2: 2nd whorl of perianth).

Table 3. Percentage of flowering plants (%) from calendar week 48 (2006) to calendar week 07 (2007) of the treatments of *Freesia laxa*, *Sparaxis* × *tricolor*, *Tritonia deusta* and *Tritonia securigera* realised in the autumn batch (AB).

Week/ Treatment[y]	48	51	03	07[z]	n (in 07)	48	51	03	07[z]	n (in 07)
	Freesia laxa					*Sparaxis* x *tricolor*				
1	0	0	0	43 b	28	0	5	13	13 a	40
2	0	0	4	46 bc	28	0	0	0	3 a	39
3	0	0	6	74 d	31	0	0	0	0 a	37
4	0	0	0	5 a	19	0	0	0	0 a	22
5	0	0	0	82 cde	11	0	8	75	75 b	12
6	3	50	76	94 e	33	0	8	8	8 a	12
7	0	0	3	50 bc	36	2	32	72	93 b	43
	Tritonia deusta					*Tritonia securigera*				
1	0	0	5	34 b	44	0	0	0	3 a	34
2	0	0	9	30 b	44	0	0	0	0 a	38
3	0	0	9	11 a	45	0	0	0	0 a	42
4	0	0	0	20 ab	25	0	0	0	0 a	29
5	0	0	54	92 c	13	0	0	33	100 b	0
6	0	33	45	45 b	20	0	0	0	0 a	43
7	0	0	17	74 c	47	0	0	0	83 b	7

[y]1 (Control); 2 (Pre-planting storage at 5 °C for 4 wk.); 3 (Pre-planting storage at 13 °C for 6 wk.); 4 (Forcing at continuous > 20 °C); 5 (Forcing at continuous 13 °C); 6 (Storage at 2 °C for 15 wk.); 7 (Supplemental lighting at 400 W h^{-1})
[z]Data of calendar week 07 was subjected to the Chi-Square test for homogeneity for contingency tables. Any two percentages of each species not followed by the same letter are significantly different in pair wise comparisons with $\alpha = 5$ %.

probably caused by the growing conditions favouring flower abortion after inflorescence formation, namely the mentioned prevailing high temperatures during the spring batch as well as the low light intensities during the autumn batch. Plant quality of *Sparaxis* x *tricolor* and *Tritonia securigera* was greatly reduced by subjecting the corms to a longer storage at 13 °C before planting, as this treatment lead to irregular and poor growth.

The long-term storage at 2 °C for Treatment 6 of the autumn batch was carried out after the corms of all species and hybrids had already undergone a 3 to 4 month warm storage in South Africa, and so this temperature treatment can not be fully compared with the cold storage carried out commercially for freesia corms directly after harvest and before the high temperature treatment as described by Imanishi (1993). After planting, the effect of the storage at 2 °C differed among the chosen species and hybrids. A portion of the corms subjected to the 2 °C-storage of *Tritonia deusta* and *Sparaxis* x *tricolor* pupated after planting, an unexpected result. This physiological phenomenon is known in freesias (Imanishi 1993) and denotes a process in which the original corm is replaced by a daughter corm without any aerial vegetative growth, the new corm remaining dormant. The rest of the corms sprouted and grew very poorly. The plants of the same treatment of *Tritonia securigera* displayed a non-satisfying, i.e. less vigorous growth compared to the control plants, although no pupation was observed. In comparison, the reaction to the cold storage of *Freesia laxa* was most surprising. The plants whose corms were subjected to a 2 °C-storage before planting had reduced plant height (ca. 10 cm, Table 4), inflorescences formed 8 weeks earlier (Table 2), and anthesis was 7 weeks earlier (Table 3) and there was a statistically significant increase in the number of inflorescences per plant compared to control plants (Table 4). Furthermore, almost 100 % flowering was achieved among the plants subjected to a 2 °C-storage (Treatment 6) and just over 40 % in the control (Table 3).

Conclusion

This study showed that the export of dormant corms of all the investigated species/hybrids was possible and that their dormancy could be further maintained by storing the corms at either 2 °C or 22 °C. A common feature of all studied species/hybrids was that the best quality plants in respect to attractive foliage, the number of inflorescences per plant and the number of flowers per inflorescence were obtained at a temperature regime of 17 °C (day) and 13 °C (night) compared to continuous 13 °C (Treatment 5) or 20 °C and above (Treatment 4). Besides sharing similar temperature requirements, the species/hybrids differed in their light intensity requirements during cultivation. During naturally low light conditions in the European winter months, supplemental lighting was essential to produce plants of adequate quality for both *Tritonia* species and *Sparaxis* x *tricolor*, but it was not required for *Freesia laxa*.

In conclusion, the investigations showed a great potential for an energy saving production system of the investigated species and hybrids to enrich the pot plant assortment during autumn and winter months in Europe.

Table 4. Height, number of inflorescences and of flower primordia per inflorescence of the investigated species/hybrids in calendar week 07 (2007) of the autumn batch (AB).

Treatment	Height (cm)	Number of inflorescences*	Number of flower primordia per inflorescence*	Height (cm)	Number of inflorescences*	Number of flower primordia per inflorescence*
	Freesia laxa			*Sparaxis* x *tricolor*		
Statistical test (α = 5 %)	Tukey	Mann-Whitney	Nemenyi	Nemenyi	Approx. t	Kruskal-Wallis
1	48.14 bc	1.67 a	6.39 ab	43.75 bc	–	–
2	52.50 cd	1.62 a	7.63 b	44.15 bc	–	–
3	47.68 bc	1.87 ab	5.73 ab	39.81 abc	–	–
4	60.16 d	–	–	46.09 cd	–	–
5	29.64 a	1.33 a	–	34.42 ab	2.56 a	1.86 a
6	37.21 a	2.71 b	4.55 a	27.58 a	–	–
7	49.44 bc	1.61 a	8.35 b	51.09 d	6.15 b	2.82 b
	Tritonia deusta			*Tritonia securigera*		
Statistical test (α = 5 %)	Nemenyi	Mann-Whitney	Nemenyi	Tukey	Kruskal-Wallis	Kruskal-Wallis
1	33.41 bc	1.47 a	7.00 a	39.11 cd	–	–
2	32.57 bc	1.31 a	6.31 a	41.55 d	–	–
3	25.80 a	–	–	29.62 a	–	–
4	37.28 c	–	–	46.45 e	–	–
5	27.92 abc	1.50 a	7.50 a	38.08 bcd	2.25 b	7.05 a
6	24.50 ab	1.33 a	4.50 a	34.70 b	–	–
7	37.57 c	2.23 b	14.43 b	46.29 e	1.77 a	9.50 b

[y]1 (Control); 2 (Pre-planting storage at 5 °C for 4 wk.); 3 (Pre-planting storage at 13 °C for 6 wk.); 4 (Forcing at continuous >20 °C); 5 (Forcing at continuous 13 °C); 6 (Storage at 2 °C for 15 wk.); 7 (Supplemental lighting at 400 W h^{-1})
*Average of flowering plants only. No statistical analysis was applied if no or only one inflorescences present in treatment or before first flower primordium of inflorescence reached anthesis.

The different physiological reactions of the investigated species/hybrids clarified that some of them share these with *Freesia* x *hybrida* also originating in the CFR, e.g. flower blasting in *Sparaxis* x *tricolor* when forced temperatures over 20 °C, but others have to be individually determined for each new species, e.g. the requirement for low temperatures for the floral initiation in *Tritonia securigera*. It is expected that the presented results will increase the interest in South African geophytes, especially with regard to their potential as new floricultural crops.

References

Ascough, G.D., N.P. Mtshali, D.I. Thompson, N.O. Anderson, J.E. Erwin and J. van Staden 2006: *Watsonia*. In: Texeira Da Silva, J.A. (ed.): Floriculture, ornamental and plant biotechnology. Vol. **IV**. Global Science Books, Isleworth, UK, 599–605.

Berghoef, J. and A.P. Zevenbergen 1990: The effect of pre-cooling environmental factors and growth-regulating substances on plant height of *Freesia* as a pot plant. Acta Hort. **266**, 251–257.

De Hertogh, A.A. and M. Le Nard 1993: The physiology of flower bulbs. Elsevier, Amsterdam.

Dole, J.M. 2003: Research approaches for determining cold requirements for forcing and flowering of geophytes. HortScience **38**, 341–346.

Gilbertson-Ferris, T.L. 1989: *Freesia* x *hybrida*. In: Halevy, A.H. (ed.): Handbook of flowering, Vol. **3**, CRC Press, Boca Raton, Florida, 34–37.

Halevy, A.H. 1975: Light energy flux and distribution of assimilates as factors controlling the flowering of flower crops. Proc. 19th International Horticultural Congress (1974) **4**, 125–134.

Imanishi, H. 1993: *Freesia*. In: De Hertogh, A.A. and M. Le Nard (eds.): The physiology of flower bulbs. Elsevier, Amsterdam, 285–296.

Manning, J.C., P. Goldblatt and D. Snijman 2002: The Color Encyclopedia of Cape Bulbs. Timber Press, Oregon, Cambridge.

Niederwieser, J.G., R. Kleynhans and F.L. Hancke 2002: Development of a new flower bulb crop in South Africa. Acta Hort. **570**, 67–73.

Rees, A.R. 1992: Ornamental bulbs, corms and tubers. CAB-Publishing International, Wallingford, UK.

Van Wyk, A.E. and G.F. Smith 2001: Regions of Floristic Endemism in Southern Africa. Umdaus Press, Hatfield, South Africa.

Wulster, G.J., S. Cartwright and T.J. Gianfagna 1989: The effects of greenhouse temperature and ancymidol concentration on height and flowering time of *Freesia hybrida* grown as container plant. Acta Hort. **252**, 97–103.

Received December 17, 2008 / Accepted January 21, 2010

Addresses of authors: Luise Ehrich, and Heiner Grüneberg (corresponding author), Humboldt University of Berlin, Institute for Horticultural Sciences, Section Ornamentals, Lentzeallee 55–75, 14195 Berlin, Germany, and Christian Ulrichs, Humboldt University of Berlin, Institute for Horticultural Sciences, Section Urban Horticulture, Lentzeallee 55–75, 14195 Berlin, Germany, e-mail: hgrueneberg@agrar.hu-berlin.de.