Effects of Greenhouse Conditions on the Quality and Vase Life of *Freesia* 'Yvonne'. A Nursery Comparison

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Keywords: greenhouse conditions, climate, temperature, carbon dioxide, light, relative humidity, bud opening, keeping quality

Abstract

Postharvest trials showed marked differences in the length of vase life and in bud opening of *Freesia* stems of the same cultivar, obtained at a similar time from various nurseries. The factors that cause these differences in vase life and bud opening are yet unknown. We therefore made a detailed comparative investigation on the effect of greenhouse conditions. Corms of *Freesia* 'Yvonne' from the same stock were delivered to 29 nurseries. Various factors in the greenhouse that may influence vase life and bud opening were monitored. The vase life and bud opening of both the main and the lateral stems were examined with and without transport simulation. Using multivariate statistical techniques, the measured greenhouse conditions were related with the variance in vase life and bud opening. The main factors affecting vase life and bud opening were temperature, light level, CO_2 level, and relative humidity. The values of these factors during the last two weeks of production explained about half of the variance in bud opening and vase life. The results provide useful advise for growers on how to optimise greenhouse conditions in order to get the best possible postharvest quality of their product.

INTRODUCTION

Cut *Freesia* stems, even those of the same cultivar, show large differences in vase life and bud opening (van der Pluijm, 1993).This makes it hard for *Freesia* growers to guarantee the quality of their product. Sytsema-Kalkman (PPO Glasshouse Horticulture, unpublished) showed that the origin of the corms resulted in only small differences in vase life, and she concluded that the major differences were due to greenhouse conditions. In cut roses a similar situation exists, and here a comparison between nurseries proved to be a good tool to determine the correlation between quality and greenhouse conditions (Marissen and Benninga, 2001).

MATERIALS AND METHODS

Twenty-nine growers of *Freesia* 'Yvonne' were selected, located all over The Netherlands. *Freesia*-corms from one stock were distributed within four weeks in the summer of 2002 (2000 corms/nursery). The growers planted the corms in a plot between their own corms of 'Yvonne', and grew them as they were used to. Climate conditions were logged every 5 minutes with a data logger (CaTec, Delft), equipped with calibrated sensors for air temperature, soil temperature, relative humidity, CO_2 concentration, and light intensity. Soil samples were taken 6 weeks after planting and at the moment of harvest of the main stems and analysed at EC, pH, and main and spore elements. Soil humidity at corm depth was measured with a FD-sensor (Delta-T devices, England), at the moment of planting, after 6 weeks and at harvest. Planting density, covering material, soil type, days until harvest and crop protection measures were registered. Production (number, weight and length of the harvested stems) was registered by the growers.

A sample of 40 stems each of the main and lateral stems per nursery were harvested when the plants were at the commercial harvest stage. The stems were directly placed in tap water and transported to the laboratory in tap water. All stems were stored for 24 hours at 5°C in tap water. After storage, 20 stems per sample were placed in vases with tap water (1 stem per vase) in a climate room for examination of vase life and bud opening. 20 stems were sleeved and kept dry in a box at 8°C for 4 days, as a transport simulation, after which they were placed in vases as mentioned above. Conditions in the climate room were: 20°C, 60% RH, 12h light/day of fluorescent tubes (TL 84) with a photon flux density of 14 $\mu mol.m^2.s^{-1}$. Total number of buds and the number of well-opened buds were counted daily and the time to the end of vase life was also recorded daily. Vase life ended when the last opened flower wilted. Stem firmness was measured as flexural stiffness ($MNmm^2$) with a three-point bending test equipment (Instron), according to Verkerke and Doorduin (2000).

Data were analysed with multivariate statistical techniques to find out which greenhouse conditions affected quality and vase life. Partial Least Squares Regression Analysis (PLS2) was used to distinguish the main factors in the dataset with greenhouse factors that gave a maximum explanation for the variations in quality and vase life (Helland, 1988; Hoskuldsson, 1988; de Jong and ter Braak, 1994; Naes and Martens, 1989). With PLS regression coefficients equations could be made to estimate the consequences for quality and vase life of changing a specific greenhouse factor. Multivariate regression analysis was used to calculate what percentage variance was accounted for.

Finally, tables were made with cluster analysis from selected greenhouse factors. For every greenhouse factor that was important, the total number of nurseries investigated was divided into three groups. The mean values of the greenhouse factor and of the accompanying quality and vase life were calculated.

RESULTS

The results showed large differences in vase life, bud opening and stem firmness, between the stems from the 29 nurseries (Table 1). The correlation between bud opening and vase life was high; the more buds opened, the longer the vase life. Most of the variance in vase life and bud opening was related to the climate in the glasshouse. For the vase life of the main stems, the soil temperature during the first 16 weeks of the glasshouse period was of importance, with a favourable temperature between 14 and 15°C.

A good correlation between climate and the vase life was found in the last period in the glasshouse. Relative humidity, light intensity and CO_2 concentration, in the period from 16 weeks after planting until harvest accounted for 52% of the variance in vase life, of the main stems without transport simulation. Low CO_2 concentrations (around the ambient level) and long periods of darkness (no supplemental lighting) were related to a shorter vase life. When the period of only the last two weeks before harvest was examined, the same factors accounted for as much as 45% of the variance (Table 2 to 5). A RH between 80 and 90% for a longer total period led to a longer vase life (Table 2).

Table 3 shows a longer vase life when the light intensity was between 4 and 50 $\mu mol.m^2.s^{-1}$, for a longer total period, and Table 4 shows a shorter vase life when light intensity was below 4 $\mu mol.m^2.s^{-1}$ for a long total period. These data show the benefit of the use of supplemental lighting. Table 5 shows a longer vase life at higher CO_2 concentrations.

Harvesting longer stems lead to a longer vase life with a maximum of 2 extra days. All other factors such as soil type, fertilisation, plant density, days until harvest, crop protection and production had very little or no effect on vase life and bud opening. After transport simulation of the stems, the correlation between vase life and bud opening and greenhouse conditions was much lower than without the simulation, but the data pointed in the same direction. The first and second lateral stems reacted in the same way as the main stems.

Greenhouse conditions only accounted for a very low percentage of the large variance in stem firmness of stems from the different nurseries, with low soil- and air temperatures as favourable conditions.

DISCUSSION

In accordance to earlier research (van der Pluijm, 1993), we found a large variance in vase life and bud opening of *Freesia* stems from different nurseries. Most of the variance in vase life was related to the climate in the glasshouse. In particular, the conditions during the last period (of two weeks) in the glasshouse were important, with short dark periods and an elevated CO_2 concentration as the main factors that resulted in a longer vase life.

Previously, others described the beneficial effect of CO_2 enrichment (Doorduin, 1990) and of supplemental lighting (Sytsema-Kalkman, PPO Glasshouse Horticulture, unpublished) on the vase life of *Freesia*.

Spikman (1989) concluded that the length of the vase life of *Freesia* is mainly determined by its carbohydrate status. He also observed that bud opening is determined mainly by carbohydrate status. In line with these results, we found a high correlation between bud opening and vase life. However, van Meeteren et al. (1995) observed no good correlation between sugar content and bud opening in *Freesia,* indicating that other factors also play a role. It is known that inclusion of sugars in the vase water results in a longer vase life in *Freesia* (Sytsema, 1964; Woodson, 1987). The beneficial effect of short dark periods and high CO_2 concentrations on the vase life of *Freesia* stems may be due to high carbohydrate levels in the plant. Also a longer vase life of *Freesia* with longer stems, as found in this research, was found previously and explained to be due to the larger carbohydrate pool (Sytsema-Kalkman, PPO Glasshouse Horticulture, unpublished). In contrast to these results, van Meeteren et al. (1995) showed a large effect of stem length on the dry weight and carbohydrate content of *Freesia* buds, but this did not result in better flower opening, it only resulted in a larger flower size.

The low correlation of vase life after transport simulation and all measured factors could not easily be explained. We may have missed some factors that account for this variation. Actually, this effect is not so important for practice, as the real conditions during transport of most *Freesia* stems are much less severe than the stress imposed in the present research.

Also important is that a numerous factors did not account for any variance in vase life. Fertilisation, plant density and growth rate were not related to vase life, in contrast to what is often thought.

It is concluded that this investigation indicates that growers have a relatively easy tool to improve their product. The conditions during the last few weeks before harvest were found to be quite important. This means that the growers can easily apply, with a short time-scale, the optimum conditions for a good postharvest life of their product.

ACKNOWLEDGMENTS

The author wishes to thank Marco ten Hoope, Thomas Kern and Ton van der Wurff for practical assistance, Annette Bulle and Jaco Klap for statistical assistance and Nollie Marissen for assistance with the experimental set-up. The Product Board for Horticulture financed this research.

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Tables

Table 1. Highest and lowest mean values with standard deviation of vase life (days), the number of open flowers per stem (n open), percentage flower opening (% open), with and without transport simulation (tr. sim.), number of buds per stem at harvest (n buds) and stem firmness (NMmm^2) of the main and lateral stems of *Freesia* 'Yvonne', obtained from 29 nurseries.

		main stem		first lateral		second lateral	
	tr. sim.	lowest	highest	lowest	highest	lowest	highest
vase life	-	9.1 ± 1.3	12.8 ± 1.5	8.3 ± 1.7	11.4 ± 1.1	7.7± 0.8	11.8 ± 0.8
vase life	+	5.9 ± 0.8	9.3 ± 1.9	4.8 ± 0.9	11.7 ± 2.0	4.4 ± 0.9	10.3 ± 1.0
n open	-	2.7 ± 0.7	7.4 ± 0.9	2.0 ± 0.8	6.1 ± 0.8	2.9 ± 1.6	7.0 ± 0.6
% open	-	42 ± 8.0	78 ± 15	31 ± 16	93 ± 9.0	42 ± 27	98 ± 6.0
n open	+	2.2 ± 0.4	5.4 ± 1.0	0.7 ± 0.7	6.3 ± 1.3	1.5 ± 0.9	6.0 ± 0.6
% open	+	24 ± 4.0	61 ± 15	11 ± 11	66 ± 13	20 ± 13	89 ± 15
n buds		6.4 ± 0.6	12.0 ± 1.0	4.9 ± 0.8	10.6 ± 0.8	5.5 ± 0.6	10.3 ± 1.5
firmness		7.3 ± 2.1	30.9 ± 7.9	5.4 ± 1.8	14.3 ± 4.1	5.4 ± 2.0	16.8 ± 4.4

Table 2 to 5. Effects of the climate conditions during the last 2 weeks before harvest on the vase life of main stems of *Freesia* 'Yvonne', obtained from 28 nurseries. Data of vase life without transport simulation.

Table 2. Effect of the percentage of time in which the RH was between 80 and 90%.

Classification	Low	Medium	High
Number of nurseries per class	8	13	7
Time (%) RH was between 80 and 90%	34	58	78
Vase life (days)	10.1	10.5	11.4

Table 3. Effect of the percentage of time in which the light intensity was between 4 and 50µmol.m^2.s^{-1}.

Classification	Low	Medium	High
Number of nurseries per class	17	6	5
Time (%) light between 4 and 50µmol.m^2.s^{-1}	11	27	51
Vase life (days)	10.2	11.0	11.5

Table 4. Effect of the percentage of time in which the light intensity was below 4µmol.m^2.s^{-1}.

Classification	Low	Medium	High
Number of nurseries per class	6	4	18
Time (%) light below 4µmol.m^2.s^{-1}	29	43	63
Vase life (days)	11.4	11.1	10.2

Table 5. Effect of the average CO_2 concentration.

Classification	Low	Medium	High
Number of nurseries per class	22	4	2
Average CO_2 concentration (ppm)	509	850	1420
Vase life (days)	10.3	11.3	11.9