# THE EFFECT OF WATER STRESS ON ETHYLENE PRODUCTION AND ETHYLENE SENSITIVITY OF FREESIA INFLORESCENCES

G. Spikman
Department of Horticulture
Agricultural University
P.O. Box 30
6700 AA Wageningen
The Netherlands
Publication 522

## Abstract

The Freesia is an important cut flower in the Netherlands. However, its keeping quality is moderate. From detached inflorescences held in water up to 40% of the buds does not grow out to give flowers. Malformation of buds and flowers also occurs.

It is not yet understood which role ethylene plays in the inflorescence development of Freesia. A maximum production of about 8 nl.inflorescence$^{-1}$.h$^{-1}$ is measured. There is no evidence that senescence of individual florets is preceded or accompanied by a higher ethylene production. Ethylene production of waterstressed inflorescences is higher than that of non-stressed inflorescences. An ethylene peak is reached at day 3 after the stress period for waterstressed inflorescences, at day 4 for the non-stressed inflorescences. After the ethylene peak the production rapidly declines to a low level. Until then no difference in the rate of senescence of individual flowers of an inflorescence is observed when stressed and non-stressed flowers are compared. However, more malformation and dying of buds occurs in the waterstressed inflorescences. Freesia inflorescences are very sensitive to ethylene. Exposure to ethylene concentrations (ranging from 0.05 to 1.0 $\mu$l.l$^{-1}$) causes considerable damage to buds (die or get malformed).

## 1. Introduction

The genus Freesia (Iridaceae) has its habitat in the Cape Province of South Africa. Freesia flowers face upward in apparently one-sided spikes held more or less horizontally. An inflorescence on the main branch consists of 8-14 buds. Anthesis proceeds from the base to the apex of the inflorescence. In general, on the plant all buds reach anthesis. Freesias are grown under cool conditions. If possible the temperature in the greenhouse has to be kept at 12 to 18$^{o}$C (Smith, 1979).

More than 70% (= 460 ha) of all Freesias in Europe are grown in the Netherlands. In 1984 Freesia had an auction turnover of Dfl. 156.10$^{6}$ and held fifth place in the cut flower 'top ten' (Anonymous, 1985). Freesia is an important export crop, but after long distance transport it often reaches the consumer in a poor condition (Barendse, 1979). Up to 40% of the buds on an inflorescence may die, or buds and flowers may get malformed (in-rolling of tepals, bending of buds). Some research has been done on the vase life of Freesia as affected by: post-harvest handling and preserving solutions (Barendse, 1979), sensitivity to ethylene (Harkema and Woltering, 1981) and the effect of silverthiosulphate (STS) treatments (Sytsema and Elfering-Koster, 1984).

The aim of this study is to get information on post-harvest physiology of Freesia inflorescences in order to explain the existing keeping

quality problems. This paper deals with:
- the production of ethylene by inflorescences
- the effect of ethylene exposure on bud and flower quality.

## 2. Methods and materials

### 2.1. Plant material

The experiments were carried out with Freesia 'Ballerina'. 'Ballerina' has been chosen because of its availability, the regular build of the inflorescence and its moderate keeping quality. Flowers were purchased from Van Gellecum at Huissen or grown in the greenhouse at the Department of Horticulture at Wageningen. Corms were purchased from Wülfinghoff at Rijswijk and Van den Bosch at Honselersdijk. Inflorescences were cut with the first bud at full colour and ready to open. Stem length was reduced to 25 cm beneath the base of the inflorescence.

During the experiments bud stages were recorded every day. For this an arbitrary scale was designed. Marks correspond with stages of development.

| mark | description of bud stage |
|---|---|
| 5 | small, green bud (about 1 cm) |
| 4 | light green bud, tepal colour becomes visible |
| 3 | chlorophyll has disappeared from tepals, bud size about 6 cm |
| 2 | bud starts to open |
| 1 | bud almost open |
| 0 | fully open flower |
| -1 | wilting flower |
| -2 | wilted flower |

### 2.2. Storage and growth conditions

Water stress was given to inflorescences by keeping them dry in a dark chamber. Non-waterstressed flowers were kept in the same chamber in deionized water. After treatments the inflorescences were put in 200 ml water in 300 ml Erlenmeyer flasks (6 to 10 inflorescences per flask) in a growth chamber (12 h light/day; 10 $W.m^{-2}$: Philips TL 57/40W fluorescent tubes; RH 70 ± 5%; temperature 20 ± 1°C).

### 2.3. Ethylene measurements

For ethylene measurements 3 inflorescences in a small vase with 5 ml water (stem 1-2 cm) were enclosed in a glass chamber (650 ml). Before closing, the chambers were ventilated with fresh air. Air samples were taken after 1½ hours incubation time. Via a sample loop air samples of 1 ml were introduced into a Packard 437 gaschromatograph equipped with a Porapak Q (80/100) column and a flame ionization detector (column temperature 80°C, injector temperature 100°C, detector temperature 150°C; carrier gas N2, flow rate 40 $ml.mn^{-1}$). After each sampling the glass chambers were flushed with fresh air and left open until the next incubation period.

### 2.4. Ethylene exposure

Freesia inflorescences in the bud stage were exposed to ethylene concentrations in 70 l containers (equipment provided by the Sprenger Institute, Wageningen). During the exposure the flowers were kept dry or with the base of their stems in deionized water. Temperature 21 ± 0.2°C. Ethylene was introduced into the containers up to the desired concen-

tration. $C_2H_4$-concentrations were checked ½ h after the start and ½ h before the end of the exposure time. In the control containers emanating ethylene was oxidized by activated Al-oxide (Ethysorb: Stay Fresh Ltd., London). $CO_2$ and $O_2$ were kept at normal level (about 0.03% and about 20.8%, respectively). For each treatment 24 inflorescences were used. After the $C_2H_4$-treatment the inflorescences were weighed, the stems were re-cut and put in Erlenmeyer flasks in the growth chamber (20 ± 1°C, RH 70 ± 5 %. 12 h irradiance 10 $W.m^{-2}$). Four days after treatment for every inflorescence numbers of normal flowers, malformed buds and flowers and dying buds were recorded.

## 3. Results

### 3.1. Ethylene production of Freesia inflorescences

Ethylene measurements were done with individual florets and buds and with complete inflorescences. So far, results obtained from experiments with individual buds and flowers were unreliable. Ethylene release is very low and irregular. Complete inflorescences gave an ethylene production pattern that could be reproduced in different experiments (Fig. 1). Ethylene measurements were started after a 24 h storage period (wet or dry, at 17°C). Ethylene was measured twice a day during the 12 h light (10 $W.m^{-2}$) period. Fresh weight of the inflorescences was 3-4 g. Waterstressed inflorescences produce more ethylene than non-waterstressed. A peak is reached on the third day after storage. Non-stressed flowers reach this peak one day later. There is no significant difference between the height of these peaks. Five days after storage (i.e. 6 days after cutting) ethylene production of both treatments has declined to a low level. From stressed and non-stressed inflorescences the bud in position 1 has wilted, 2 is wilting, 3 is open and 4 is coloured and ready to open. In case of waterstressed inflorescences buds in position 7 and further towards the apex become white and will die.

### 3.2. Effect of ethylene exposure on the development of Freesia inflorescences

The aim of these experiments is to examine the sensitivity of Freesia inflorescences to ethylene. During the exposure time inflorescences which were kept dry lost 3% of their original fresh weight, inflorescences held in water increased about 7% in fresh weight. Ethylene affects both the number of developing buds and the rate of senescence of florets (Table 1). In case of waterstressed inflorescences more damage is done by other factors than by the applied exogenous ethylene. There is a clear effect of the ethylene treatment on inflorescences that were held in water during the exposure time: the number of buds that develop decreases from 7 (control) to 4 (1.0 $\mu l.l^{-1}$ ethylene). Figure 2 shows that ethylene increases the percentage of malformed plus dying buds. For buds in position 1 no effect is observed. Starting with bud position 4 an effect on waterstressed buds not caused by the exogenous ethylene becomes visible. The bud in position 5 (waterstressed) shows 54% malformation while no ethylene was applied. Pretreatment with silverthiosulphate (0.2 mM $Ag^+$) brings this % down to 8 (data not presented here), so this malformation could be due to endogenous ethylene (under present investigation).

## 4. Discussion

Water stress is known to promote ethylene production. Apelbaum and

Yang (1981) observed a 30-fold increase of the ethylene production of wheat leaves within four hours after the water stress. Borochov et al. (1982) subjected carnation flowers to water stress conditions of short duration (12 h), which led to earlier appearance of wilting symptoms and reduced longevity. Stressed flowers showed an earlier rise in ethylene production but a peak was reached at the same day as the control. We observed a gradual increase in ethylene production of both control and stressed inflorescences. The ethylene production of stressed inflorescences is higher than that of the control flowers. A peak is reached by the stressed inflorescences one day before the control. From then on the ethylene production rapidly declines. During our experiments with complete inflorescences no visible difference was observed in stages of development between control and stressed flowers. At the time ethylene production has declined to a low level, buds are still developing, flowers are open or are wilting. The only difference observed between control and stressed inflorescences is that of the stressed inflorescences buds in position 8 and onward will not develop (white margins appear at the tepals). To what extent the dying of buds is a direct or indirect result of the stimulated ethylene production of waterstressed inflorescences has to be examined.

A concentration of 0.05 $\mu l.l^{-1}$ during 24 h at 21°C causes a significant damage to Freesia inflorescences. Exposure of mature carnation flowers to about 1 $\mu l.l^{-1}$ for 24 h results in inrolling of petals (Nichols and Frost, 1985). With Freesia most damage is done to young buds. This does not fit with the finding that young buds (e.g. carnation) are less sensitive to ethylene (Camprubi and Nichols, 1978).

References


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Table 1 - Effect of ethylene exposure (24 h, 21°C) on the stages of buds and flowers. Inflorescences were kept wet (not waterstressed) or dry (waterstressed) during $C_2H_4$-treatment, then put on water at 20°C. Presented are the stages of the first 8 buds/flowers of the inflorescences, recorded 4 days after treatment (-2 = wilted, -1 = wilting, 0 = fully open flower, 1-5 = bud stages, w = dying bud).

| | inflorescences not waterstressed | | | | | | | | inflorescences waterstressed | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bud position: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| $C_2H_4$, $\mu l.l^{-1}$ | | | | | | | | | | | | | | | | |
| 0.00 | -2 | 0 | 0 | 3 | 4 | 5 | 5 | w | -2 | 0 | 0 | 3 | 4 | w | w | w |
| 0.05 | -2 | -1 | 0 | 3 | 4 | 5 | w | w | -2 | -1 | 0 | 2 | w | w | w | w |
| 0.10 | -2 | -1 | 0 | 2 | 4 | w | w | w | -2 | -1 | 0 | 2 | w | w | w | w |
| 0.20 | -2 | -1 | 0 | 2 | 4 | w | w | w | -2 | -1 | 0 | 2 | w | w | w | w |
| 0.50 | -2 | -1 | 0 | 2 | 4 | w | w | w | -2 | -1 | 0 | 2 | w | w | w | w |
| 1.00 | -2 | -1 | 0 | 2 | w | w | w | w | -2 | -2 | 0 | 2 | w | w | w | w |

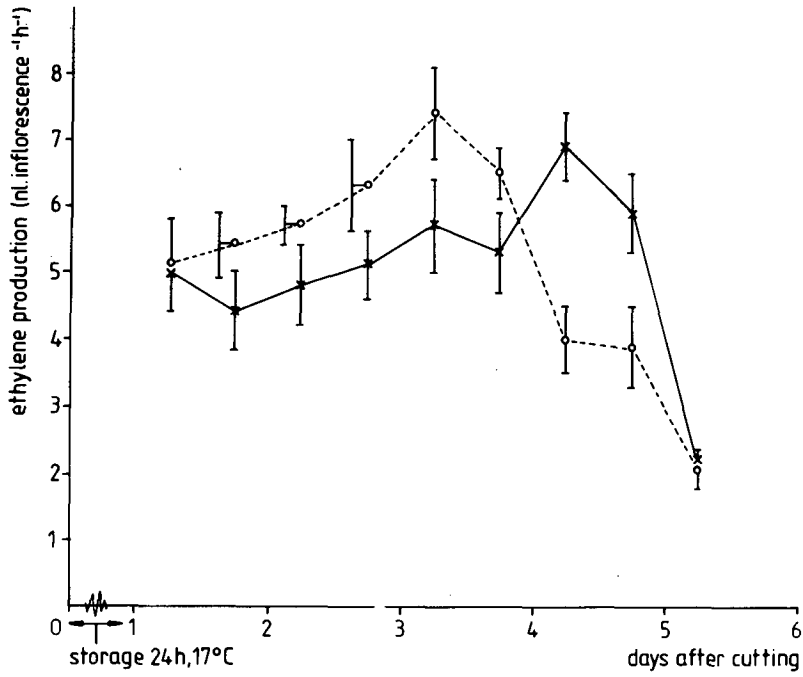


Figure 1 - Ethylene production of Freesia inflorescences during a 5 day period at 20 ± 1°C after 24 h storage (17°C, RH 80 ± 5%).
x——x inflorescences on water during storage
o---o inflorescences kept dry during storage
Vertical bars represent 95% confidence intervals.

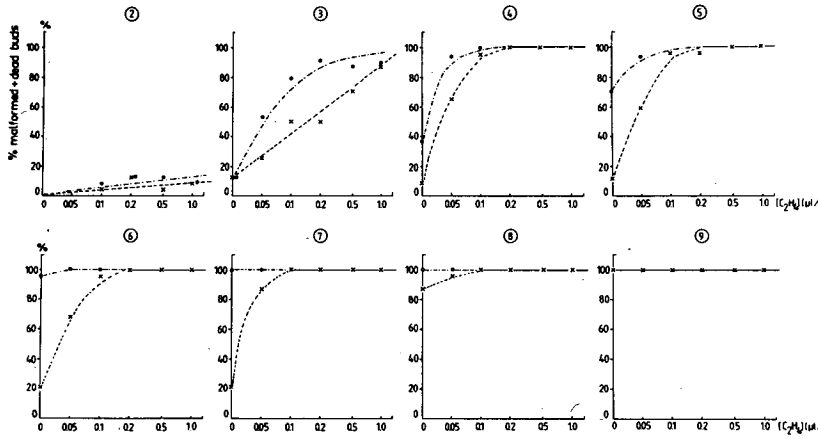


Figure 2 - Effect of ethylene concentrations on malformation and dying of Freesia buds. Observations were made 4 days after ethylene treatments.
Numbers indicate the position of the bud in the inflorescence.
Ethylene exposure during 24h at 21 ± 0.2°C;
($CO_2$ conc. 0.025 - 0.035%).
-x-----x- flowers held in water during $C_2H_4$ treatment.
·o-·-·-o- flowers kept dry during $C_2H_4$ treatment.