EFFECT OF TEMPERATURE ON FLOWERING OF *NERINE BOWDENII* W. WATTS

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Abstract

Nerine bowdenii flowers at the end of each growth period of approximately 7 months. Subsequently leaves die off. The bulbs are then lifted and stored at 2°C for 100 - 120 days. During a growth period the apex first initiates 6 - 10 leaves (which emerge after replanting) and then develops into an inflorescence primordium. A new apex is formed in the axil of the last initiated full leaf (sympodial axis). During the next growth period flower buds are formed by the inflorescence primordium, which will reach anthesis at the end of the next growth cycle. Thus, there are two growth cycles between initiation of an inflorescence primordium and anthesis.

If bulbs were grown at 9 to 25°C flowering was not affected by temperature. In the next year, however, flowering of bulbs previously grown at 21 or 25°C was reduced. Analysis of bulbs during growth showed that at 17°C the bud was 12 mm long, while at 25°C it was 8 mm. At 17°C most of the individual flowers had all floral organs, including distinct pistil primordia. At 25°C stamen primordia were rarely visible while no pistil primordia were found. Lack of pistil primordia of flowers initiated in a previous season, when bulbs were grown at 25°C instead of 17°C, may have been the cause of flower bud abortion observed in the next growing season. It is supposed that in *Nerine bowdenii* the absence of pistil primordia might result in reduced sink activity of a developing flower, thus causing flower bud abortion.

1. Introduction

In the Netherlands *Nerine bowdenii* W. Watts is grown for cut flower production in glasshouses as well as in the open. Although it is still a relatively minor crop, the supply to the Dutch auctions has steadily increased from 1.7 million flowers in 1970 to 13 million in 1978. Since then there has been hardly any further growth in production. The main reason for this is the sometimes low percentage of flowering bulbs.

Usually *Nerine* has a growth period of about 7 months followed by a period of dormancy of about 4 months during which the bulbs are dry-stored at 2°C. After several growth periods in the glasshouse the percentage of flowering bulbs may decrease from about 80 to below 30%. Replanting the bulbs in the open for one or two years to restore the quality of the bulbs is a common practice in the Netherlands. However, flowers harvested in the open are often of poor quality under Dutch climatic conditions. Moreover, out-door grown bulbs flower in September -November. This causes that more than 75% of the flowers are harvested in a short period. Shifting the culture period in the glasshouse is only possible to a limited extend as too short or too long storage periods also cause a decrease in flowering (Sytsema, 1970).

The decline in flowering potential may be caused by the higher prevailing temperatures in glasshouses. Van Brenk (1980) reported that temperatures above 21°C during a growth period decreased flowering in the following growth period. A more detailed analysis on the effect of temperature on flowering is presented in this study.

2. Material and methods

Bulbs of *N. bowdenii* 'Favourite' were obtained from Wülfinghoff Freesia B.V., Rijswijk, The Netherlands. Bulbs (12/14 cm circumference) were desinfected with 1.5% Difolatan and 0,3% Benlate for 1 h before planting in ordinary garden soil. Five bulbs were planted in a 5 l pot for the experiments in the phytotron, which offers complete control of temperature and duration of light. In the glasshouse, with natural daylength and a minimum temperature of 15°C, bulbs were planted directly in the soil. Each treatment comprised 50-100 bulbs, the experiments were repeated at least once in subsequent years.

The most important parameters of flowering and flowering quality were observed; in addition, a morphological analysis of 5-10 bulbs was made each time before, during and after a growth period.

Anatomical studies were made on inflorescence buds stored in FAA (formalin:acetic acid:ethanol = 5:5:90). The buds were dehydrated through a tertiary butanol concentration series and embedded in paraplast. Sections were cut 8 µm thick and stained with safranin fast green by the method of Jensen (1962).

3. Results

3.1. Structure of the bulbs

Fig. 1 describes the morphological characteristics of the bulbs at the end of a growth period. In the centre of the bulb one finds the apex which has just started to initiate new leaf primordia. Close to the apex is a small inflorescence bud, 1-2 mm in length. An inflorescence bud is always situated between two scales of which the outer one is semi-circular and the inner one quarter-circular. Then one finds 6-12 unemerged leaves of which the bases are circular. Outside the inner leaves an outer inflorescence bud of 10-12 mm in length and a number of leaves of which the bases are fleshy circular scales are situated. Then comes a flower stalk, which has just been flowering. Finally one finds a number of fleshy scales and, depending on bulb age, one or more old, desiccated flower stalks. The bulb is surrounded by a few old, papery bulb scales.

3.2. Growth of the bulbs

Generaly bulbs are planted after a dry storage at 2°C for a period of 100-120 days. Within a few weeks the leaves in the centre of the bulb emerge. After 3-4 months the outer inflorescence bud starts to elongate and it becomes visible after 5-6 months. Anthesis is reached 6-7 months after planting. About that time the leaves die off and the bulbs are lifted. Inside the bulb the small inner inflorescence bud grows to a length of about 12 mm. The apex differentiates new leaves, which will emerge in the next growth period. The number of leaves depends on temperature as will be shown later. Towards the end of a growth period the apex becomes generative and differentiates into a new inner inflorescence bud. The axillary bud of the last initiated

leaf becomes the new growing-tip, differentiating some new leaves. In this way a sympodial axis is built up.

Therefore, in a full grown bulb one finds two inflorescence buds at the end of a growth period . The outer one will flower the next year, the inner one in two years. Thus, there are two growth periods between initiation and anthesis of an inflorescence bud.

3.3. Effect of temperature on flowering

During growth in the phytotron temperatures ranging from 9-25°C did not affect the percentage of flowering bulbs (Table 1), except that at 9°C less plants reached anthesis due to the slow growth rate, so that many bulbs could not flower before they had to be lifted. A number of these inflorescence buds flowered soon after replanting in the glasshouse. Temperature only affected the number of days from planting till flowering, fastest at 17°C and 21°C, and the length of the flower stalk.

After lifting and storage at 2°C for 120 days, the bulbs were replanted in a glasshouse. It was shown that temperature during the preceding growth period had a pronounced effect on the percentage of flowering bulbs, the number of flowers per inflorescence, and days till flowering (Table 2). The percentage of flowering bulbs decreased with increasing temperatures during the preceding growth period, with a sharp decline at 25°C. Flowering was delayed by increasing temperatures.

After one growth period in the glasshouse and another dry storage period at 2°C, the bulbs were replanted in the glasshouse for the second year. The percentage of flowering bulbs grown at 13°C, 17°C or 21°C was about 80%. However, the bulbs grown at 9°C and 25°C two years before still showed a low percentage of flowering of 37% and 41% respectively. The other parameters were not affected anymore.

3.4. Morphological aspects

After each growth period a number of bulbs were analysed. At increasing temperatures the number of leaves initiated by the apex increased, while growth of the inner inflorescence bud decreased (Table 3). At all temperatures a new inflorescence bud was formed. However, at 9°C and 25°C these new inflorescence buds were very small.

Buds analysed after the first replant in the glasshouse showed no difference in number of leaves initiated, nor in size of the inner and outer inflorescence bud. However, the outer inflorescence bud, which was formed at the end of temperature treatment, was absent in 20% and 50% of the bulbs grown at 9°C and 25°C respectively. As all bulbs had initiated this inflorescence bud (Table 3) and no desciccated buds could be detected in the dry bulbs, atrophy of this bud must have occurred soon after replanting in the glasshouse.

During a second experiment in the phytotron 10 bulbs, grown at 17°C and 25°C were analysed every 3 weeks. The number of leaves initiated by the apex and growth of the inner inflorescence bud were recorded (Fig. 2). It was shown again that at 17°C less leaves were initiated than at 25°C. The difference became visible after about 100 days. At that time the apex became generative at 17°C, whereas at 25°C this occurred about 70 days later. Growth of the inner inflorescence bud is fastest around the time the apex has stopped initiation of leaves. Consequently, a larger inflorescence bud was formed at 17°C than at 25°C.

After lifting, five inflorescence buds of each temperature were

analysed anatomically. Grown at 17°C an inflorescence bud had about 8 flower primordia. On an average, two of these were undifferentiated, two had stamen primordia and four had already distinct pistil primordia (Fig. 3). At 25°C only 5-6 flower primordia could be found. No pistil primordia could be detected, while small stamen primordia were found in 1-2 flower buds per inflorescence. The other flower primordia had just started to initiate perianth primordia or were still undifferentiated (Fig. 3).

4. Discussion

The results of these experiments have confirmed the results reported by van Brenk (1980). Between initiation of an inflorescence and anthesis there are two growth periods. The percentage of flowering bulbs was lower when the plants had been growing at temperatures above 21°C in the preceding growth period. In this respect it is interesting to note that Fortanier et al. (1979), working with *Nerine flexuosa alba*, found that temperatures above 13°C given in a certain growth period decreased flowering in the next.

With *N. bowdenii* the main effects of temperature proved to be the rate of differentiation of the flower buds and the number of leaves initiated. These are affected in opposite ways which indicates that there is a competition between vegetative and generative development. This may be analogous with the results of Tse et al. (1974) with Bougainvillea and of Kinet (1976) with tomato, who found that removal of young leaves enhanced flower bud formation by a redirection of the flow of assimilates. At this stage of our work, however, we cannot say whether differentiation of the flower buds at high temperatures is less because of the initiation of more leaf primordia or vice versa.

There are indications that abortion takes place one year after growing at high temperatures, at the time the flower stalk should start elongation. We suppose that at this stage the inflorescence bud competes for assimilates with other sinks such as the apex, the inner inflorescence bud and the leaf bases which are to become bulb scales. Floral organs are important for flower growth due to their production of hormones thus creating a sink (e.g. Goldsmidt and Huberman, 1974; Murakami, 1975). We suppose that the absence of floral organs, in particular stamen and pistil primordia, in flower buds previously grown at 25°C, is the main cause of abortion.

To prove this hypothesis one should like to affect the developmental stage or sink-activity of the inflorescence bud, using growth-regulating substances. Unpublished results showed, however, that soaking the bulbs in various solutions of growth-regulating substances had no effect, whereas it has not yet been possible to apply the substances specifically to the inflorescence bud.

5. References

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Table 1 - Effect of temperature on percentage of flowering bulbs (Flow. %), number of days from planting till flowering (Days flow.), length of flower stalk (Flow. stalk) and mean number of flowers per inflorescence (No. flow.).

Temperature °C	Flow. %	Days flow.	Flow. stalk (cm)	No. flow.
9	34	224	30	6.6
13	82	182	41	6.6
17	81	156	50	7.1
21	81	159	52	7.0
25	82	183	50	7.0

Table 2 - First replant in the glasshouse. Effect of temperature during preceding growth period on percentage of flowering bulbs (Flow. %), number of days from planting till flowering (Days flow.), length of flower stalk (Flow. stalk) and number of flowers per inflorescence (No. flow.).

Temperature °C	Flow. %	Days flow.	Flow. stalk (cm)	No. flow.
9	99	162	49	5.3
13	94	176	56	6.9
17	93	184	59	7.6
21	83	194	54	7.1
25	39	209	48	6.3

Table 3 - Composition of the bulbs at the end of temperature treatments in the phytotron. The number of leaves initiated by the apex (No. leaves), length of the inner inflorescence (In. infl.) and the length of the outer inflorescence bud (Out. infl.).

Temperature °C	No. leaves	In. infl. (mm)	Out. infl. (mm)
9	6.4	0.7	11.0
13	7.3	2.2	11.9
17	7.3	2.1	11.3
21	8.6	1.8	10.1
25	10.5	0.3	8.3

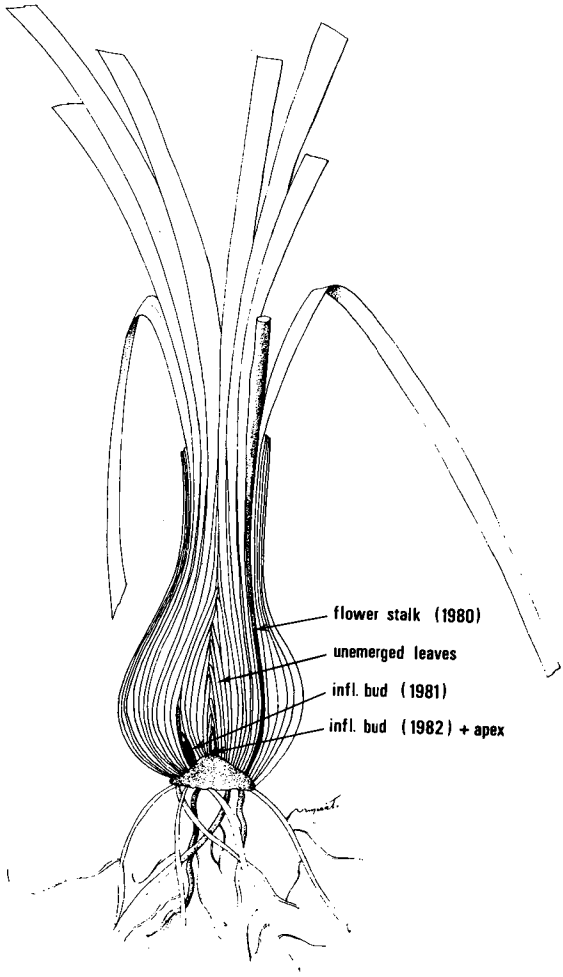

Figure 1 - Longitudinal section of Nerine bulb at lifting time (1980).

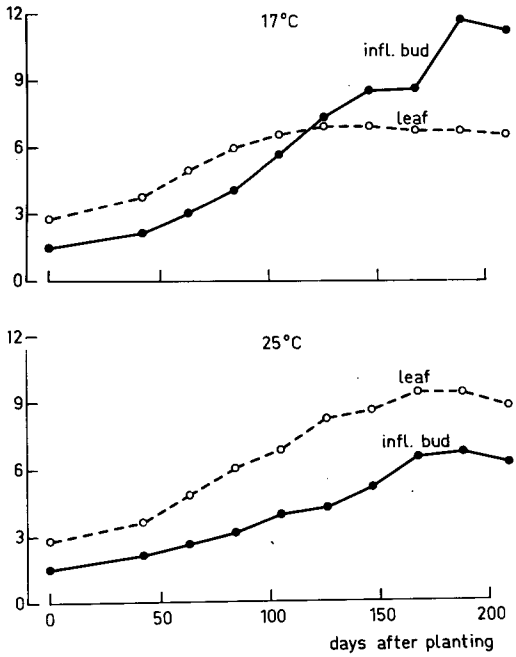

Figure 2 - Effects of 17°C and 25°C on the number of leaves initiated by the apex (leaves), and the growth of the inner inflorescence bud (infl. bud).

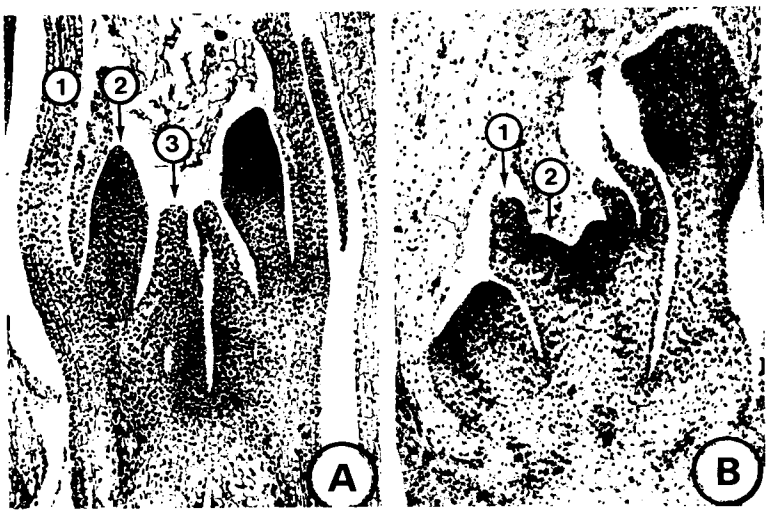

Figure 3 - A: Flower bud grown at 17°C with perianth (1), stamen (2) and pistil (3) primordia.
B: Flower bud grown ar 25°C with perianth (1) and stamen (2) primordia. On the left side an undifferentiated flower bud is visible.