EFFECTS OF TEMPERATURE AND LIGHT ON GROWTH, FLOWERING AND CORM FORMATION IN FREESIA

Invloed van temperatuur en licht op groei, bloei en knolvorming bij Freesia

M. M. MANSOUR

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Dit proefschrift met stellingen van

BAYOUMI MOHAMAD MOHAMAD MANSOUR,

B.Sc. (Agric) en M.Sc. (Floriculture), Cairo Univ., geboren te Cairo, Egypte (V.A.R.), 2 augustus 1935, is goedgekeurd door de promotor, Dr. Ir. J. Doorenbos, hoogleraar in de tuinbouwplantenteelt.

De Rector Magnificus van de Landbouwhogeschool

F. HELLINGA

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PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD
VAN DOCTOR IN DE LANDBOUWWETENSCHAPPEN
OP GEZAG VAN DE RECTOR MAGNIFICUS, DR. IR. F. HELLINGA,
HOOGLERAAR IN DE CULTUURTECHNIEK,
TE VERDEDIGEN TEGEN DE BEDENKINGEN
VAN EEN COMMISSIE UIT DE SENAAT
VAN DE LANDBOUWHOGESCHOOL TE WAGENINGEN
OP VRIJDAG, 7 JUNI 1968, TE 16.00 UUR

DOOR

B. M. M. MANSOUR

H. VEENMAN & ZONEN N.V. – WAGENINGEN

EFFECTS OF TEMPERATURE AND LIGHT ON GROWTH, FLOWERING AND CORM FORMATION IN FREESIA

THESIS

IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF AGRICULTURAL SCIENCES
AT THE AGRICULTURAL UNIVERSITY,
WAGENINGEN, THE NETHERLANDS
ON FRIDAY, 7 JUNE 1968, AT 16 O'CLOCK

BY

B. M. M. MANSOUR

B. SC. (AGR.) AND M. SC. (FLORICULTURE),
CAIRO UNIVERSITY, EGYPT, U.A.R.

THEOREMS

I

In Freesia, flowers and corms may compete for the available assimilates.

This thesis.

II

Flowering of Freesia from corms is improved by a high temperature (18–20 °C) during the first 6 weeks after planting.

This thesis.

III

'Pupation' of Freesia corms (i.e. the formation of new corms under certain storage conditions) can be used to promote vegetative propagation.

IV

A simple classification of plants according to their response to daylength is impossible.

MATHON, C. C. et al. Proc. of symp. Praha-Nitra 1964: 313–322.

V

A type of the Egyptian cotton, *Gossypium barbadense* L., resistant to the leafworm *Prodenia latura* would be more important than any other improvement in crop production.

PAINTER, R. H: Insect resistance in crop plants, 1951: 275–325.
HUTCHINSON, J.: Application of genetics to cotton improvement, 1959.
DAHMS, R. G.: Insect resistance in sorghum and cotton, Amer. Soc. Agron. Journ. 35, 1943: 704–715.

VI

Mutations, whether spontaneous or induced, do not generally arise at random.

GUSTAFSSON, A. et al. conf. on Chromosomes, Wageningen, 1956: 131–139.

VII

In a birth control program the number of children should be regulated in accordance with the income and education of the individual family and not with the national income.

VIII

Visits of foreign experts could be of greater benefit to the developing countries than the sending out of students to be educated abroad.

IX

The prevailing idea that protein from the mammal intestinal tract is absorbed only in the form of amino acids, is not justified.

MUNRO, H. N. Mammalian protein metabolism **1**, 1964: 566.

B. M. M. MANSOUR
Wageningen, 7th June 1968.

What we perceive at the
frontiers of knowledge is
still enveloped in haze
but what shines through
is exciting.

Prof. J. van Overbeek

To my parents
and
their moral support

FOREWORD

It is with great pleasure that I avail myself of this opportunity to express my thanks to all those who have contributed to my scientific education.

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1. GENERAL

1.1 THE GENUS AND ITS HISTORY IN CULTIVATION

The genus *Freesia* is rather small. N. E. BROWN (1935) recognises 19 species, but many of these are not considered to be worthy of specific rank by other taxonomists. Nevertheless, there has been considerable confusion, and the literature abounds with synonyms and misidentifications.

In 1768 BURMAN published the description of *Ixia caryophyllacea* and *Gladiolus corymbosus*. The former had been introduced from Cape of Good Hope to Europe where it flowered in 1759. Both are now considered to belong to *Freesia*. The horticulturally important *Freesia refracta* was described by JACQUIN in 1786 as *Gladiolus refractus*. Its discoverer and locality are not mentioned.

The history of the generic name *Freesia* is rather curious. The genus was set up by KLATT in 1866, who got the name from the very imperfectly described *Freesea miniato-lateritia*, named by ECKLON in 1827 after his friend F. H. TH. FREESE. The latter apparently was not involved in any way with the plant, which according to N. E. BROWN was not a *Freesia* anyhow, but a *Tritonia*. As ECKLON did not describe his genus *Freesea*, it is not validly published and the name *Freesia* KLATT stands.

There is no need to go into the history of the discovery, introduction and taxonomic treatment of all species of *Freesia*. The discussion will be limited to those which contributed to the modern cultivated varieties.

Freesia refracta (JACQ.) KLATT has been in cultivation for a long time, at least since 1786. According to BROWN the name has often been used for other species. The true *F. refracta* has 30–38 mm long flowers, which are dingy greenish yellow suffused with dull violaceous or purplish on the back of the upper lobes, marked with fulvous or brownish yellow.

The plant called *F. refracta* var. *alba* KLATT in horticultural literature, which according to N. E. BROWN should be called *F. lactea* FENZL, has flowers 50–63 mm long, entirely white except the lower part of the tube, which is yellow. This was described in 1878 from material that had been sent to Europe shortly before, probably in 1877 or so. At about the same time *F. leichtlinii* KLATT (*F. xanthospila* (RED.) KLATT var. *leichtlinii* (KLATT) N.E. BR.) was introduced. This is said to have been found by MAX LEICHTLIN among some neglected plants in the Botanic garden at Padua in 1873. The flowers are 32–48 mm long; the lobes and tube are yellow, with the three lower lobes marked with orange blotches.

The fourth important introduction was *F. armstrongii* WATSON, collected by W. ARMSTRONG in 1898. (It had flowered in Kew in 1826, but got lost again). The flowers are 29–36 mm long, bright rosy pink.

Although N. E. BROWN in 1935 expressed the expectation that species unknown in cultivation (or even to science) could become of importance in

horticulture, only the four species mentioned have so far played a role in the breeding of the cultivated varieties.

Hybridising appears to have been started as early as 1873 by RAGIONIERI in Florence. Much progress could not be made because the variation between the species known at the time was very limited. The big step forward came after the introduction of the pink *Freesia armstrongii*. This was crossed with F. *lactea* by TH. M. HOOG of Messrs C. G. VAN TUBERGEN at Haarlem. The offspring, introduced in 1905 under the collective name *Freesia tubergenii* showed a wide range of colours, e.g. pink, mauve, carmine, red, orange and deep yellow.

Initially, these new colours could only be propagated asexually. This was a handicap as Freesias are extremely susceptible to virus and a clone becomes infected very easily. (Seedlings are free of virus).

Messrs. KONIJNENBURG and MARK at Noordwijk, continuing breeding work of E. LUZ from Felbach near Stuttgart in Germany from whom they purchased a collection of hybrids in 1936, managed to develop Freesia strains in a number of colours which came true from seed (K & M 'Super Freesias').

As this strain became famous, some other growers selected similar strains which they also introduced under the name 'Super Freesias'.

LAWRENCE (1945) found three chromosome numbers in Freesia hybrids, viz. diploid, triploid and tetraploid ($2n = 22$, 33 and 44).

MOHR (1958) examined several varieties and found that all the Freesias propagated from seeds (K & M and O. E. Super Freesias) are diploid having $2n = 22$, while the cultivars propagated from corms are either diploid, triploid, or tetraploid. SAITO (1961) obtained similar results and classified the diploid Freesias into two different types: the forcing Freesias such as *F. refracta alba* which flower early but with small flowers, and the 'Super Freesias' which are distinguished by their longer stems, abundant variation in flower colour, thinner petals, weaker scent and higher fertility.

Where and when the first tetraploid form arose is not known. SAITO suggested that the polyploid forms would be better adapted to the conditions under which they are cultivated, which are warmer and moister than the natural environment. The triploid and tetraploid varieties would be more heat tolerant and have a more extensive adaptability for the various climates in the temperate regions than the diploids.

1.2. MORPHOLOGICAL CHARACTERISTICS

Freesia plants develop from corms covered by a tunic consisting of the dry, membranous, net-veined basal parts of leaves of the last year. These leaf sheaths bear buds in their axils. The uppermost of these normally develops into a new plant; the others develop into cormlets which may serve for vegetative propagation.

The ensiform leaves are implanted in two alternating rows on the stem base, which very soon starts to swell to form the new corm. The first leaves are shorter than those formed subsequently. The upper 3–4 leaves are implanted

on the flower stem. The leaves hang over at the tip; this characteristic varies among the different cultivars, as does the intensity of the green colour.

The flower stem appears on the top of the new corm after the inflorescence has been initiated. It is slender (3–4 mm in diameter) and bent at the tip at about a right angle. Normally the flowers are only implanted on this horizontal part. In the axils of the leaves on the main stem, lateral stems may develop. They also bear inflorescences. The lower side stems are the largest. Number and stiffness of these branches are very important as they may form the secondary crops of cut Freesia flowers.

The inflorescence is a spike on which the flowers are implanted in two alternating rows. Normally, it is in a horizontal position, all flowers pointing upwards.

The perianth is tubular at the base and curves out in funnel shape towards the top which is divided into 6 slightly unequal sepals. The 3 stamens are inserted in the tube. The filiform style has 3 branches each of which is again divided into two. It is mostly longer than the stamens. The ovary is ovoid or oblong, 3-celled, with crowded ovules. The fruit is 3-valved capsule.

1.3. Cultivation methods

In their native habitat in South Africa, Freesia corms sprout in autumn (February-March) and flower in winter (July-August) at the relatively low temperature of 8–10 °C. Subsequently, the plants die off and the corms are 'ripened' by the high temperatures of summer which prepare them for sprouting when the temperature drops and moisture becomes available.

When Freesia was taken into cultivation on the Northern hemisphere, the growers initially kept the plants on this same seasonal rhythm, with the difference of course that the corms were planted in a different month (August or September). Seeds were sown in April. In both cases, flowering occurred in January and February.

In 1898 the Scientific Committee of the Royal Horticultural Society examined some corms sent from Holland which had failed to sprout but had formed fresh corms upon the old ones. They called this super tuberation and ascribed it to the fact that Freesia corms expended their energy in a wrong direction when planted unripened. Nowadays the phenomenon is known as the 'pupation' of Freesia corms. When Hartsema and Luyten (1939, 1944) noticed that this pupation does not happen with corms from Southern France, they started investigations into the effect of the storage temperature. They advised that Freesia corms should be stored at high temperature to insure sprouting. Later, van de Nes (1955) and Kragtwijk (1961) found that to ensure 100% sprouting and early flowering corms of Freesia have to be stored at high temperature (31 °C) for about 10 weeks followed by 13 °C for another 4 weeks.

The pupation phenomenon was used commercially when it was found that the new corms formed on the old ones during cool storage flowered earlier. Such corms and the plants that grew from them were called 'Paradise Freesias'

(JEFFERS, 1956). Pupation leads to a loss in corm weight. The practice became obsolete when it was found that corms could be kept at a temperature of 1–5°C without forming new corms (VAN DE NES, 1964).

This opened the possibility of storing corms for indefinite periods which made year around planting of Freesias possible.

1.4. ECONOMIC IMPORTANCE

Freesia did not attract the interest of horticulturists until after the introduction of the large flowered white *Freesia lactea* (about 1877) and the large flowered yellow *F. leichtlinii* (1873). Even then it did not become important, probably because the flowers, although elegant and fragrant, had only a very limited range of colours. This changed after the introduction of *F. armstrongii* (1898) and the subsequent hybrids of this species, introduced from 1905 onwards. Of crucial importance was the discovery that Freesia could give a very lucrative crop of cut flowers when grown under glass in the autumn, after the tomatoes had been cleared out. In the Westland area in the Netherlands the Freesia increased rapidly, especially after 1945. In 1948, 13.4 million Freesias where grown. This number steadily increased to 186.5 million in 1965. In May 1966, 121 hectares of greenhouses had been planted with Freesias.

Comparable statistical data of other countries are hard to find. Denmark produced in 1954 an estimated 32 million cut Freesias; in the same year, the Netherlands produced 50 million. The Freesia is also very popular in the other Scandinavian countries. It is grown to a lesser extent in England, Germany, and France, and almost unknown in Belgium. In Western Germany the area with Freesia under glass was 57 ha in 1966.

Freesias are also grown in Italy, where there is an important production of seeds, in the United States and in Japan. Judging by the space alloted to the Freesia in the American textbooks (e.g. K. POST's Florist Crop production and marketing, 1952) it is not important in the U.S.A.

To return to the Netherlands, here the Freesia takes the fourth place among the cut flowers after roses, carnations and chrysanthemums, with total sales at the auctions in 1965 of 18.6 million guilders, or 10% of all cut flowers. When the number of cut branches is taken as a measure, the Freesia even takes second place, after carnation.

The strong points of the Freesia are: the flowers are elegant, fragrant and present a wide variety of colours; they live long in a vase and do not soil the water; the branches are easily transported, because they are light and not bulky; year around production is possible.

In the Netherlands, the peak of the production (22%) falls in March. The 'Freesia season' lasts from October to April, but even in the period from May to September some Freesias are offered (about 13% of the total production).

1.5. Scope of the present work

When Freesias are planted throughout the year several problems arise. In some months, flowers are produced too rapidly and abundantly, with a corresponding loss in quality; in other months, flower production is limited and too slow. Simultaneously, there is a great variation in stem length, in number and shape of the flowers and in corm production.

This study was undertaken to establish the effect of the two major inveronmental factors, temperature and light, on the characteristics mentioned, from the moment of planting to the harvest of the corms.

2. MATERIAL AND METHODS

2.1 PLANT MATERIAL

Throughout this study, the variety 'Rijnveld's Golden Yellow' was used. Corms of the standard commercial size of 5 cm circumference, which had been stored at 31 °C for 10 weeks, were obtained from Messrs. WÜLFINGHOFF's Bloembollenbedrijf Ltd. at Rijswijk, as they could supply these corms the year around.

The corms used in experiments 12 and 19 were received at the start of this work from Messrs. KONIJNENBURG and MARK at Noordwijk as a free sample.

In some experiments, other varieties were used to see if these would give different results. These varieties include 'Sonata', obtained from the raisers, Messrs. VAN STAAVEREN at Aalsmeer, 'Orange Favourite', 'Blaauwe Wimpel', and 'Pimpernel', supplied as free samples by the Institute of Horticultural Plant Breeding at Wageningen, and 'Princess Marijke', obtained from Messrs. WÜLFINGHOFF'S.

'Rijnveld's Golden Yellow' was used in all 21 experiments, 'Sonata' in experiments 8, 13, 15, and 16 and 'Princess Marijke' in experiments 11, 13, 14 and 17. The other varieties were used in one experiment only: 'Orange Favourite' in experiment 2, 'Blaauwe Wimpel' and 'Pimpernel' in experiment 20.

2.2. PHYTOTRON

This installation comprises 6 greenhouses, 6 light rooms and 6 dark rooms, all with air conditioning. Three series of temperatures 9°, 12°, 15°, 18°, 21° and 24°C are provided in daylight, artificial light, and darkness. The artificial light is provided by 400 fluorescent tubes Philips TL 40W/55 in each room which give a total light intensity of 35,000 erg cm^{-2} sec^{-1} measured at table height in the center of the room (for more details see DOORENBOS 1964).

2.3 AUTOMATIC LIGHT CABINETS

Experiments on the effect of daylength were carried out in a system of 7 connected light cabinets with a surface of 1.35×0.70 m. and a height of 1 m. These were each illuminated by 4 fluorescent tubes (Philips TL 55, 1.20 m long, 40 W) and 4 incandescent lamps of 25 W. These gave a total irradiation of about 35,000 erg cm^{-2} sec^{-1}. The photoperiod was automatically controled by an electric switch clock. These cabinets were placed in a greenhouse where the temperature was kept, as far as possible, at 18 °C, which means that it never dropped below this value but rose above it on sunny days in spring and summer.

2.4 TROLLEYS

Four trolleys were placed in the open to receive 8 hours of natural daylight

from 8 a.m. to 4 p.m., after which they were rolled into sheds where no daylight penetrated. There the 8 hrs of natural light were supplemented by weak light from incandescent lamps for periods of 0, 4, 8 and 12 hours. Another trolley was left outside to receive the complete natural day.

2.5 Soil

The soil used for pots was a mixture of 1/3 sand and 2/3 horticultural compost (consisting of peat, clay and manure). The soil in the greenhouse was a light loamy clay mixed with the same garden compost.

2.6. Abbreviations

AL Artificial light
Hr Hour
Hrs Hours
LD Long day
NL Natural light
SD Short day
TL Fluorescent light

3. OBSERVATIONS ON FLOWER BUD FORMATION

For studies on the relation between flowering and environment it is necessary to be acquainted with all stages of the process of initiation and development of the flower of the plant involved. The progression of flower formation of Freesia has already been studied by HARTSEMA (1962). In the course of the present work, Freesia plants were sampled periodically, dissected (removing all the leaves until the apical primordia became visible) and examined under a binocular microscope. HARTSEMA's results were confirmed. The following stages of inflorescence initiation could be distinguished (terminology according to BEYER, 1942):

Stage I: Vegetative. The flat meristem differentiates leaf primordia in two alternatings rows. Each leaf base completely encircles the meristem.

Stage II: Generative. The meristem is no longer flat but more or less globular or slightly conical.

Stages Pr-Br: Opposite the last leaf a new primordium arises, which can be distinguished as a bract primordium because it is smaller and it is rapidly followed by the initiation of a primordium in its axil.

Stage Bo: The inner bract (bracteole, prophyll) is being initiated opposite the outer one. The primordium of the latter is now well developed and it is clear it does not surround the whole apical meristem, as a leaf primordium does. The meristem in its axil has risen and assumed a globular shape. The terminal meristem has risen further and is now conical in shape.

Stage A: Three stamen primordia have appeared.

Stage P_1: The primordia of the outer whorl of the perianth have been formed; these primordia are opposite those of the stamens.

Stage P_2: The three primordia of the inner perianth develop, alternating with the primordia of the three stamens and those of the outer perianth whorl.

Stage G: Flower initiation is completed with the formation of the gynoecium. This consists of three carpels which at first are separate and opposite the stamen primordia. Soon afterwards the carpels unite.

The number of flower primordia in the main inflorescence may be as high as 24, but the uppermost usually whither away. In the axils of the 1 or 2 lower bracts, inflorescences are formed, and also in the axils of the 2 or 3 uppermost leaves. According to HARTSEMA (1962), the axils of the lowest bracts of these lateral inflorescences may bear inflorescences of the second order, and even inflorescences of the third order may occur. The lower leaves on the stem may also bear flower primordia in their axils but these do not develop further. This has not been investigated further in the course of the present study.

For pictures of the various stages of inflorescence development the reader is referred to HARTSEMA (1962).

4. THE TEMPERATURE EFFECT

4.1. INTRODUCTION

In its natural habitat in South Africa, Freesia has one season of flowering during the winter time. After flowering is over the leaves wither away. The corms have a rest period of about 3 months during the summer time until they are ready to sprout again in the autumn.

After Freesia had been brought to Europe and become a popular flower there, it was tried to concentrate its flowering time around Christmas. TOMKIN described in the Gardeners Chronicle of 1888 how corms planted in August bloomed at Christmas. HURT in 1896 advised another method of cultivation, starting in July and resulting in flowers in January at a temperature of 50°F. Many others found that Freesias from seed sown in March or April flower in the autumn.

Later experimental work showed that temperature had a strong influence on all the developmental stages of the Freesia plant. This will now be discussed in some more detail.

4.2. THE EFFECT OF TEMPERATURE ON FREESIA SEEDS

Freesia seeds need to be pre-germinated. KRAGTWIJK and BIK (1958) showed that pre-germinated seed produced a better stand and more flowers than seed that was not pre-germinated. VAN DE NES (1964) stated that seeds should be pre-treated by soaking them in water 20°C for about 24 hours before planting. SENNELS (1951) found that Freesia seeds must have heat to germinate and that the best temperature is around 20°–22°C. If germination occurred under cool conditions germination is poor, the roots become long and thick and the plant is difficult to prick out. Too high a temperature has about the same inhibiting effect on germination as too low a temperature. SENNELS obtained a germination percentage of only 20% in 12°C and 30°C, but at 20°C 95% of the seeds germinated in about 18–20 days. At Aalsmeer KRAGTWIJK investigated the possibility of vernalizing Freesia seed in 1954 but found that low temperature resulted only in a reduction of germination.

4.3. THE TEMPERATURE REQUIREMENTS FOR SEEDLING FREESIAS

Freesia seedlings should be kept in a constant temperature of about 20–22°C until the plants are 5–6 cm high. Thereafter the temperature can be lowered to 12–14°C (VAN RAALTE, 1952). HEIDE (1965) also advised to grow the plants at a relatively high temperature until they have 7 visible leaves and then to subject them to temperature below 18° (preferably 12–15°C) for about 2 months.

Freesia seedlings require about 7 months to flower. Seeds can be sown from March to August (SENNELS, 1951; OTTO, 1958). Temperature is the major environmental factor affecting their flowering. After a cold summer Freesias

grown in the open flower earlier, while flowering is retarded after a warm summer (OTTO, 1958). DEBUISSON (1962) subjected seedlings of *Freesia refracta alba* to a succession of periods of different temperatures (13° and 20°C) and concluded that their reaction was complex, but early flowering seemed to depend on a period of low temperature at a determined daylength. KLOUGART and JØRGENSEN (1962) found that the plants did not flower when grown during summer in a greenhouse where the air temperature did not drop below 20°C.

The factors controlling development of Freesia seedlings were investigated by HEIDE (1965), who found a pronounced effect on flower differentiation and flowering of age of the plants, temperature, and duration of the treatment. He planted seeds in April in a greenhouse of 21°C with natural daylight which varied in length between 15 and 20 hours. The temperature treatments were given to plants 3, 6 and 9 weeks old in airconditioned rooms where the temperature was controlled at 12°, 15°, 18° or 21°C, and the light was supplied by fluorescent tubes. He found the optimum temperature for flower initiation to be 12–15°C. With old plants and a longer duration of the treatments more flowering plants were obtained. The flowering response decreased with increasing temperature. Abnormal flowering occurred when the plants were treated at an early stage and for a short time.

4.4. THE REACTION OF FREESIA CORMS TO TEMPERATURE

When Freesia corms are harvested early in the summer they lie dormant for about 3 months until they are ready again to grow. In the Gardeners Chronicle of 1888 (page 52) R.H.L. complained that corms stored in a cupboard after harvesting did not grow when he potted them again in September. In 1898 the members of the Royal Horticultural Scientific Committee examined corms which had been planted early in July and had never thrown up any leaves but formed fresh corms upon the old ones, which had withered. They judged that due to the fact that the corms had been planted at the wrong time of the year, their energy was being expended in a wrong direction. The phenomenon is now known as the 'pupation' of Freesia corms (SENNELS, 1951; HARTSEMA, 1961; VAN DE NES, 1964; KRABBENDAM and BAARDSE, 1967).

In 1939 HARTSEMA and LUYTEN observed that corms brought from Southern France did not behave as 'sleepers'. They started to investigate the effect of the temperature during the storage period. They could ascertain that when corms of Freesia 'Buttercup' and 'Daffodil' were stored at different levels of temperature, viz. 28°, 25½°, 23°, 20° and 9°C for 10 weeks, corms sprouted in all temperatures but not a single leaf appeared at 9°C. In 1944, they found that to ensure 100% sprouting and early flowering, corms should be kept for 10 weeks at 31°C followed by 4 weeks at 13°C. HARTSEMA (1962a) stored corms at 33°C but found that this is not advisable, since the plant developed better after 31°C. She also investigated the effect of storage conditions on corms of 'Golden Yellow' and 'Apotheose' and obtained early flowering of 'Golden Yellow' after 9–10 weeks storage at 31°C followed by 3 or 2 weeks 13°C, and of

'Apotheose' after 8 weeks at 31 °C followed by 4 weeks at 13 °C.

At the Experimental Station at Naaldwijk trials have been made to find the optimal length of storage at 31 °C. It was found that there were slight varietal differences with regard to the optimal length of warm storage. The earliest flowering was induced by a combination of 31 °C and a subsequent cooling period at 13 °C from 2 to 4 weeks. ABE et al. (1964) confirmed that the length of the dormant period differed among varieties. All varieties, however, sprouted and showed early flowering after 13 weeks storage at 31 °C followed by 4 weeks at 13 °C. (Anon., 1954, 1954a; VAN DE NES, 1955).

At Aalsmeer similar results were obtained by KRAGTWIJK (1961), who found that flowering was advanced by more than 2 months when the corms had been 'prepared' at 28–30 °C followed by a further 4 weeks of storage at 13 °C. In 1962 KRAGTWIJK investigated the different levels of cold storage by using 17°, 13°, or 9° for 2 or 3 weeks and found that sprouts were longer and resulted in longer stems after planting out, when the corms had been stored at the higher temperatures for a longer period of time.

There are of course conditions under which the grower is not interested in obtaining rapid sprouting but, on the contrary, wants to retard sprouting. This can be done in two ways.

In the first place, corms can be stored at about 13°–15 °C from the harvest in June until January or February. At this temperature the corms do not sprout but use their food material to form new corms upon the old ones. These new corms are removed and given warm storage at 31 °C for about 3 months, after which they are ready to be planted out and sprout. When corms are stored at a lower temperature than 13 °C the 'pupation' process is slower and the new corms are smaller (VAN DE NES, 1964). The disadvantage of this method is that the corms formed during storage are not as heavy and strong as the corms from which they are formed. VAN DE NES (1953) found a loss of about 40% in the weight of corms produced by this method after 9 months in 13 °C. This may affect the quality of the flowers. In addition, many of the small corms produced by this method dry out completely during the high temperature treatment.

In 1957, VAN DE NES (1964) found that corms can be successfully kept dormant for a long time (about 9–11 months) at 1–2 °C. After this period the corms, which do not lose much of their weight, can be treated normally at 31 °C.

He found that after storage in this way the plants emerge about 9 days earlier and the flowers are harvested 15–18 days earlier than after storage at higher temperature. In comparison to the previous method corm production in the open was also higher following storage at a temperature below 5 °C than after storage at higher temperature (VAN DE NES, 1957).

In conclusion, the basic treatment for early corm sprouting is to store corms at 31 °C for about 10 weeks, followed by 4 weeks of 13 °C to accelerate flowering further. To retard sprouting, corms can either be kept at 13 °C for 6 to 9 months, during which they form new corms, or at 1–2 °C where they can be kept up to about 9 months and do not form new corms. In both cases, the corms must be given a treatment at 31 °C subsequently to ensure sprouting.

In 1966 REHNSTRÖM demonstrated that the breaking of the dormancy of Freesia corms is due to growth substances synthesised during the storage period. No growth substances were found in corms of 'Rijnveld's Golden Yellow' kept at 5 °C for more than a month. In corms kept at 10 °C for approximately 3 weeks small quantities were found which he assumed to be of importance for the 'pupation' process. After the cessation of dormancy it was possible to demonstrate the presence of an auxin which was localized in the apical and basal parts of the corm and which had the chromatographical properties of indol acetic acid.

4.5. THE EFFECT OF TEMPERATURE ON PLANTS RAISED FROM CORMS

The main purpose of the research with Freesia has been to find methods to shorten the time required from sprouting until flowering. In the preceding section the promotive effect on flowering of a treatment of the dry corms with a relatively low temperature was discussed. Several investigators applied the low temperature to corms in moist storage, i.e. under conditions which approximate those after planting.

In 1954 KOSUGI and OTANI studied the effect of this storing method on Freesias planted on every third day of the month from August to December. they found a maximal reduction of the time to flower bud initiation and flowering of about one month after moist storage at 10 °C for 40–50 days. However, this treatment reduced the percentage of flowering plants, the number of flowers per plant, the height of the plants, and the number of leaves, while the period over which flowers were harvested was prolonged.

KRAGTWIJK (1960) treated Freesia corms which had previously been stored at 30 °C with either 13 ° or 17 °during three weeks. The corms were then planted out in boxes and given 9 °C for 1, 2 or 3 weeks. Subsequently they were planted out in the greenhouse in November at 20 °C. Dry storage at 13 °C for 3 weeks followed by moist storage (in the soil) at 9 ° for 2 weeks resulted in the shortest growth period. Flowering occurred after 88–122 days according to the variety. It was also observed that high air temperature during the first 6 weeks of plant growth led to longer plants with denser foliage.

'Buttercup' corms in which early flowering had been induced by dry storage at 31 °C for 10 weeks followed by 13 °C for 4 weeks, had not yet initiated flowers at the moment of planting in September (HARTSEMA, 1962). Two weeks after planting, however, flower formation had started at all temperatures, viz. 5°, 7°, 9° 13°, 15°, 17° and 20 °C. In all cases the number of foliage leaves was about 5, except in some plants at 17 °C and 20 °C which had a greater number of leaves. She also observed that the optimal flower development occurred at 15° and 17 °C. At 20 °C some deviations occurred which resulted in retarded initiation. Flowering started first after planting at 15 ° and 17 °C.

Moist cold storage of corms has also been studied by ABE et al. since 1959. According to their results, published in 1964, 10 °C for about 30–35 days was most suitable. The effect of cold storage was closely related to the planting time.

It was most effective when the corms were planted after the end of September, when the air temperature was usually below 20 °C. Delay of flowering, increase of leaf number, and abnormal inflorescences occurred when the corms were subjected to high temperature immediately after planting. This indicates that high temperature retards the initiation of a flower bud so that leaf formation is prolonged. ABE et al. considered this to be a kind of devernalization. Another result of their experiments was that the flower stems from cold-stored corms are much shorter than those of the controls, reaching only 70% of the length of the latter. Cold storage also decreased the number of lateral flower stalks, but not as a rule the number of flowers on the main inflorescence.

In 1942 POST advised that Freesia plants should be grown at a night temperature of 8–13 °C but also stated that this is not specific for flower bud formation.

Our own experiments extend the work on the effect of the temperature on the development of the Freesia plant from sprouting onwards. We did not study the effect of temperature on the corms during storage (those used had all been kept at 31 °C) but concentrated our efforts on elucidating the effects on growth and development of the Freesia plant of the following conditions: different levels of constant temperature; different day and night temperatures, and changes of temperature at various plant ages.

4.6. EXPERIMENTS WITH CONSTANT TEMPERATURE

4.6.1. *Experiment 1.* – In this experiment the effect was investigated of five constant temperatures, viz., 12°, 15°, 18°, 21° and 24 °C. It was done in the glasshouses of the phytotron. The experiment fell in a period when the cooling system of the Phytotron had broken down. Nevertheless, the temperatures were fairly constant, except on sunny days which led to irregularities in the control of the 12, 15 and 18 °C houses on, respectively, 84, 66 and 44 days of the 130 days between 21 December 1965 and 1 May 1966. During these days, the temperatures rose above the desired values during approximately 3–5 hours a day. The maximum differences were about 2–9 °C in the period from December to January, and about 3–14 °C in February and March. In April the temperatures occasionally reached more than 30 °C in all rooms for about 9 hours a day.

Corms of 'Rijnveld's Golden Yellow' were planted separately in 5 inch plastic pots on 19 November 1965. Two plants were sampled every week and dissected under a binocular microscope to observe the flower bud initiation. The other data were taken from 5 plants per treatment.

Results (Table 1): The data show that corms sprouted earlier as the temperature was higher. The first leaf appeared above the ground after 9 days in 24 °C, but only after 20 days at 12 °C. High temperature also had a promotive effect on some other vegetative characteristics, viz. plant height (52 cm in 12 °C and 90 cm in 24 °C), number of leaves (9 in 12° and 15 in 24 °C) and dry weight of corms (4 g in 12° and 6.5 g in 24 °C). As the number of leaves already indicates, flower initiation showed the opposite trend. The first flowers were initiated in

12 °C, about 3 weeks earlier than in 21° or 24 °C. The plants in the lowest temperature did not give the earliest flowering, however. This occurred at 18 °C; plants at both lower and higher temperatures were retarded.

TABLE 1. Experiment 1: Effect of constant temperatures on Freesia 'Rijnveld's Golden Yellow.' Averages of 5 plants.

	12°	15°	18°	21°	24 °C
Days to sprouting	20.3	15.4	14.2	10.2	9.4
Plant height (cm)	52	66	73	91	90
Number of leaves	9	10	11	12	15
Leaf dry weight (g)	1.47	1.70	1.82	3.40	3.76
Days to flower initiation	27	29	28	45	51
Days to flowering	113.8	102.8	96.4	122.0	147.6
Number of flowers on main inflorescence	8.8	9.8	10.6	13.5	14.0
Number of lateral stems	1.8	2.2	2.0	2.0	0.0
Total number of flowers	22.6	29.2	29.6	33.3	14.0
Stem length (cm)	46.5	67.0	70.4	77.0	60.5
Corm dry weight (g)	3.95	3.80	4.61	6.04	6.48
Number of cormlets	5	3	3	1	0
Cormlet dry weight (g)	0.83	0.91	1.41	0.43	0.00
Corm + Cormlets/leaf ratio	3.25	2.77	3.38	1.90	1.72

From 12 to 21 °C, flower stem length increased with the temperature but it decreased again at 24 °C. There were about two lateral stems at all temperatures, except at 24 °C where none were formed. The number of flowers in the main inflorescence increased with the temperature from 6 at 12° to 12 at 24 °C. The total number of flowers on a plant increased between 12 and 18 °C, was slightly by lower again at 21 °C and as low at 24° as at 12 °C, no doubt because of the absence of lateral stems at the higher temperature. Another effect of temperature was that the number of cormlets decreased by every increase in temperature. Five cormlets were formed at 12°, none at 24 °C. However, the total production of corms and cormlets measured as dry weight, increased with temperature.

As the dry weight of leaves increased simultaneously with that of corms and cormlets, the question arises which relation exist between the organs which produce the assimilates (the leaves) and the organs that store them (corms and cormlets). The data about the ratios of the corm + cormlets dry weight and leaf dry weight show that the efficiency of the leaves in relation to corm + cormlet production was highest at 18 °C and dropped sharply at higher temperatures.

4.6.2. *Experiment 2.* – This experiment is similar to the preceding, but it was done with both 'Rijnvelds' Golden Yellow' and 'Orange Favourite', and the plants were started in the greenhouse before being placed in the phytotron. Actually this experiment preceded experiment 1, but as the results can be interpreted better with knowledge of the more comprehensive results of the

latter, it is treated here as experiment 2. Corms were planted on 21 October 1964 in plastic pots and kept in a warm greenhouse (about 15°C) until 17 November 1964, when they were moved to the greenhouses of the phytotron. In this case all six levels of temperature, i.e. 9°, 12°, 15°, 18°, 21° and 24°C were used. The data represent the average of 6 uniform plants per treatment.

Results: The conditions in the ordinary greenhouse were favourable for flowering, so that at the moment the plants were moved to the phytotron and the experiment started, they were on the verge of initiating flowers, and some of them had already done so. This explains why the differences in leaf number, leaf dry weight and number of days to flowering were much smaller than in experiment 1. The difference in leaf number between the plants at 12° and at 24° was 1.1 in 'Rijnveld's Golden Yellow' and 2.1 in 'Orange Favourite.'

There was one striking difference to experiment 1: the minimum number of days to flowering was not found at 18° but at 21°C, and the plants at 12° were slower than those at 24°. Those at 9° were the last to flower.

For the rest there was a very close agreement not only between the two experiments but also between the two cultivars used in experiment 2. All conclusion drawn in experiment 1 with regard to the relation between temperature and plant height, stem length, number of lateral stems, number of flowers, corm dry weight and cormlet formation were confirmed with only very minor differences.

4.7. Effect of temperature shifts

4.7.1. *Experiment 3.* – In this experiment plants were removed from 12°, 15°, 18°, 21° or 24°C to other temperature levels 2, 3, 4, 5 or 6 weeks after corm sprouting. The total number of temperature treatments was 125. All were given in the greenhouses of the phytotron. Each treatment comprised 5 corms of 'Rijnveld's Golden Yellow' planted in one 10 inch plastic pot. The experiment started on 19 November 1965.

Results: As in all 125 treatments 10 characteristics of the plants were noted, the results comprise 1250 figures. Space does not permit the publication of all of these; many of them would not be of interest to the general reader anyhow. We will therefore only mention the most important.

The results with regard to leaf number (a physiological measure of flower initiation) are in accordance with those of experiment 1. At 12°, plants formed 7.8 leaves, at 24°, they formed 13.9. However, while in experiment 1 the fastest rise in leaf number lay between 21° (12) and 24° (15), here it lay between 18° (9.1) and 21° (12.4).

It appeared that as early as two weeks after planting, temperature had already had its effect on floral induction, at least in 12°C. Removal of plants after these 2 weeks from 12 to 21° or 24°C did not lead to an increase in leaf number. It may be that at this moment flower initiation had already begun; from the microscopical observations in previous experiments this may be considered to be probable. At 15°, removal after 2 weeks to 21° and 24° led to a small increase in leaf number. Removal after 3 weeks had no effect anymore so that

by this time the induction must have been completed. In 18 °C, there still was an effect from removal to 21° and 24 °C after three weeks, but probably not after 4 weeks. At 21° and 24° induction had apparently not been achieved and in any case initiation had not yet begun even after 6 weeks, because removal to low temperature always significantly reduced the number of leaves.

The data of plants that remained at one temperature throughout show that in accordance with experiment 1 those at 18 °C were the first to flower, although the difference with the plants at 15° was not significant. The plants at 24° were very much retarded (103 days at 18 °C, 174 days at 24 °C). This may have been partly due to the fact that under these conditions of continuously increasing natural daylength the flower bud had to compete with the fast growing corms. A number of plants did not flower at all.

The data of the plants switched from one temperature to another show that high temperature promoted the development of the inflorescence after floral induction (and perhaps initiation) had taken place, but that this effect was dependent on the previous temperature. Thus, plants moved from 12° to 24 °C flowered earlier than those which remained in 12° (after an average of 90 and 122 days, respectively), but in plants removed from 15° to 24° the effect was smaller (93 vs. 106 days) and in plants removed from 18° it was insignificant (105 vs. 103 days). However, the plants removed from 18° to 21° after 4 or more weeks showed accelerated flowering (94 vs. 103 days). Plants removed from 21° to 24° showed retarded flowering (131 vs. 148 days).

A switch from 15° or 18° to a lower temperature always retarded the development of the inflorescence. The removal from 21° and 24° to a lower temperature accelerated flowering. No doubt this is partly due to the fact that such a switch promoted floral initiation. However, plants kept at 21° throughout initiated flowers after the same number of leaves as those switched from 24° to 21 °C, yet the latter flowered later (viz. after 138 days) than the former (131 days). This means that 24° had also a specific effect on inflorescence development.

It should be noted that plants moved from 12°, 15° or 18° to 24° or 21 °C showed abnormal inflorescences (enlarged bracts and irregularly spaced flowers).

The height of the plant – primarily a consequence of the length of the leaves – did not yield data of particular interest. In accordance with the results of the previous experiments the highest plants were those at 21° and 24 °C, the former being slightly higher than the latter. Changing plants from a high to a low temperature reduced plant height, switching from low to high temperature increased it. In both cases the effect was stronger when the switch occurred earlier.

Stem length on the other hand did not react as simply to the temperature. Again in accordance with previous results, it increase with the temperature between 12° and 21° but fell off again at 24 °C. Switching from low to high temperature had an effect that was dependent on the first temperature. When plants were removed from 12° to a higher temperature, there was no effect at all, not even on plants switched after 2 weeks 12° to 24°. Plants switched from

15° to a higher temperature reacted with a reduction of stem length when removed to 24°C; when switched to 18° or 21° the differences with the plants remaining at 15° were not significant. Plants switched from 18°C to 21° showed no response but those removed to 24°C had much shorter stems. Plants switched from 21° to 24°C also showed a much reduced stem length. It is worthy of note that in the plants switched from 15°, 18° or 21°C to 24°C, stem length was not only reduced in comparison to that of the plants remaining in those temperatures, but also considerably shorter than the stem length of the plants that stayed in 24° throughout. For the plants removed from 15° and 18°C to 24°C this held true for all switches. For plants removed from 21° to 24°C only for those removed after 2, 3 or 4 weeks; removal after 5 or 6 weeks led to a smaller, and perhaps not significant difference.

Removal from a higher to a lower temperature had less spectacular effects. The difference between plants at 15°/15° and at 15°/12° was not significant; nor was there any difference between 18°/18° and 18°/12°.

Plants switched from 18° to 15° were slightly reduced in stem length, an effect which is hard to explain. Removal from 21° to lower temperature led to no reduction in stem length, not even when the plants were switched from 21° to 12°, provided this was done after 3 or more weeks. Removal from 24° to 12° did not lead to shorter stems, and at 15°, 18° and 21° stem length was enhanced in comparison to the plants that remained in 24° throughout, provided the shift had been made after 3 or more weeks. It even looks as if the plants of the 24°/21° and 24°/18° groups had similar or longer stems than those at 21° throughout, which had the longest stems of the plants at constant temperatures.

The number of lateral shoots, showed a different trend from that in experiment 1. There it was about the same at all temperatures except at 24°C, where it was nil, but in the present experiment it regularly decreased with increasing temperature, from 1.9 at 12° to 0 at 24°C. Switching plants from lower to higher temperature reduced the number of side shoots, switching them from high to low temperature increased it. The interesting fact is that in both cases the effect of the second temperature was amplified. Thus plants switched after 2–4 weeks from 12° to 21° did not form any laterals at all, although those at 21° throughout had an average of 0.9 side shoots. Similar reactions were shown by plants switched from 12° to 18° and from 15° to 18°. In the other cases, the number of side shoots was intermediate. When the plants were switched from a higher to a lower temperature, the number of lateral shoots was always higher than that of the plants which remained at either temperature throughout. This was very marked in e.g. the plants removed from 21° to 15°, which formed 2.3 side shoots, while those at 21° had 0.9 and those at 15° had 1.4. This effect was already present in plants removed after only 2 weeks at the higher temperature, but in most cases it could still be noted in plants moved after 6 weeks.

The number of flowers in the main inflorescence followed the same trend as in experiment 1 and 2, with one exception: it was reduced at 24°C. Removal from a low temperature to a higher one increased the number of flowers provided it occurred after 2 weeks; later switches rarely had a significant effect.

By contrast, removal to lower temperatures reduced the number of flowers also when the switch did not take place until after 6 weeks. Removal from 24° to 21° slightly enhanced the number of flowers.

The number of cormlets showed the same trend as in the previous experiments except that it was not only nil at 24°C but at 21°C also. Removal from low to high temperature showed that even 2 weeks at 12° or 15° was sufficient for the formation of some (1.6 to 2) cormlets. A longer stay in low temperature, however, did not increase this number, while the plants moved from 18° to 24° formed hardly any cormlets at all. A switch from 24° or 21° to a lower temperature appreciably increased the number of cormlets. However, those moved from 24° to lower temperature never reached the level of the plants that were at those lower temperatures throughout, and the plants moved from 21° only reached this level when the switch was made very early.

4.8. The effect of daily temperature changes

4.8.1. *Experiment 4.* – This experiment was carried out in the phytotron. The plants received 8 hours artificial (fluorescent) light. Corms of Freesia 'Rijnveld's Golden Yellow' were planted on 3 August 1964. Three corms in one 10 inch plastic pot were considered as one treatment. The experiment was designed to compare the effect of treatments with equal 'heat sums', but different day and night temperatures. The chosen combinations of day and night temperatures and their heat sum (temperature × hours) per day and the data collected from this experiment appear in table 2.

Results (Table 2): As could be expected, the number of days required by the corm to sprout was reversedly proportional to the temperature; 20 days were required at a daily heat sum of 216° and 7.7 days at a heat sum of 576°. However, low temperature (9° or 12°C), especially when given during the day delayed sprouting for a few additional days. At a heat sum of 432° for instance, the plants at 18°/18° and 24°/15° sprouted after about 11 days but those at 12°/21° required 14.3 days.

The number of leaves per plant increased with the heat sum from 6.5 to 12.5 but in this case there are no significant differences between treatments with one heat sum and consequently no specific effects of either night or day temperature. Of the groups at constant temperatures, the one at 15° flowered first, viz. after 87 days. The plants at 9° flowered after 107 days, those at 24° after 112 days. None of the groups at changing temperatures flowered before the one at 15°C. A higher night than day temperature always delayed flowering, except in plants at 9°/18°C. A lower night than day temperature accelerated flowering when the day temperature was 21° or 24° but delayed it when the day temperature was lower. (It is possible, of course, that a combination like e.g. 18°/15°, which was not given, would have given a different result). When the data about flowering are plotted against the 'heat sum', an optimum curve emerges, with quickest flowering at a daily sum temperature of 360°C. Within one 'heat sum', flowering was faster at the combination with the lower night temperature than

TABLE 2. Experiment 4. Effect of daily temperature changes on Freesia 'Rijnveld's Golden Yellow' in an 8 hour photoperiod. Averages of 3 plants.

Day temperature (8 hrs)	9°			12°		15°			18°			21°		24°C		
Night temperature (16 hrs)	9°	12°	18°	12°	21°	9°	15°	24°	9°	18°	24°	12°	21°	15°	21°	24°
Daily 'heat sum'	216°	264°	360°	288°	432°	264°	360°	504°	288°	432°	528°	360°	504°	432°	528°	576°
Days to sprouting	19.7	20.7	16.0	18.7	14.3	18.0	14.0	11.0	17.0	11.3	10.7	15.7	9.0	11.0	10.0	7.7
Plant height (cm)	30	29	36	35	48	47	50	63	40	55	67	59	79	70	72	74
Number of leaves	6.5	7.0	7.5	6.8	10.6	7.0	7.6	11.0	6.7	8.2	10.8	8.0	11.6	9.6	11.6	12.8
Days to flowering	147	141	119	129	120	124	108	132	120	113	132	113	119	117	122	127
Number of flowers on main inflorescence	6.4	6.2	7.5	6.2	11.2	6.2	9.4	12.0	6.2	9.6	13.8	8.2	13.8	10.8	14.6	15.0
Number of lateral stems	2.2	2.0	2.0	2.2	2.2	1.8	1.7	1.3	2.0	1.5	2.0	1.8	1.8	1.8	1.4	2.0
Total number of flowers	13.2	15.7	21.0	17.3	28.2	17.8	24.6	30.3	14.0	27.0	30.3	20.2	37.0	24.2	32.8	29.3
Stem length (cm)	29.7	26.9	28.2	30.6	39.5	44.4	41.4	48.7	37.7	43.5	52.9	48.9	71.3	59.4	65.1	68.9
Corm dry weight (g)	0.66	0.77	0.86	0.61	3.31	0.94	1.94	5.45	1.17	2.42	4.01	2.47	6.22	3.09	5.14	7.26
Number of cormlets	4.8	5.2	5.2	7.2	3.0	5.8	4.6	2.7	6.7	5.0	1.8	5.0	1.5	3.4	2.0	1.0
Cormlet dry weight (g)	0.79	0.74	1.15	1.25	1.46	1.19	1.78	0.65	1.48	2.04	0.94	1.67	0.37	1.79	1.03	0.15

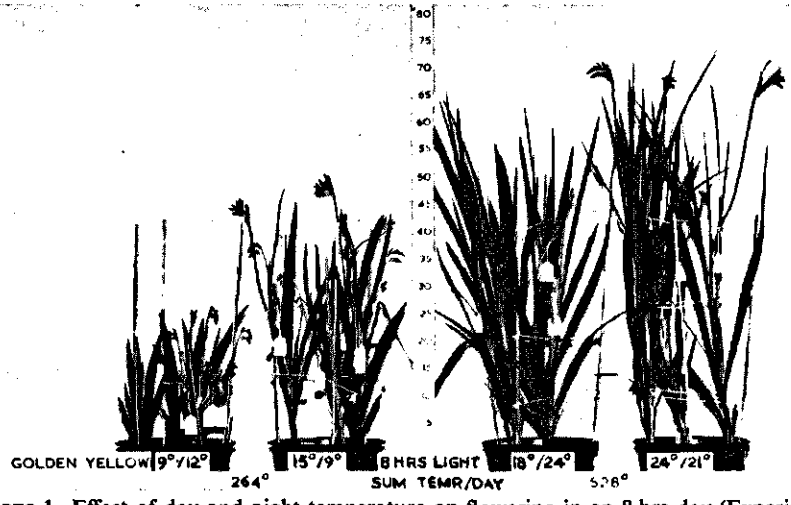


PHOTO 1. Effect of day and night temperature on flowering in an 8 hrs day (Experiment 4). Plants flowered earlier when the night temperature was lower than the day temperature.

at that with the lower day temperature:

	264 °C		360 °C			528 °C	
	9°/12°	15°/9°	9°/18°	15°/15°	21°/12°	18°/24°	24°/21°
Days to flowering	141	124	119	108	113	132	122

In accordance with previous experiments, the number of flowers on the main inflorescence increased with the temperature. It was 6.2 at the lowest temperature and 15.0 at 24 °C. Day and night temperature had a similar effect, so that there were no great differences between treatments with the same heat sum. The total number of flowers on the plant showed the same trend as there were no significant differences in the number of lateral stems.

Stem length varied between about 27 and 71 cm. It was proportional to the temperature, but the effect of day temperature was much stronger than that of night temperature, so that there were significant differences between treatments with one 'heat sum.' For instance, a heat sum of 360 °C gave stem lengths of 28.2, 41.4 and 48.9 cm for treatments with 9°/18 °C, 15°/15 °C and 21°/12 °C, respectively. Especially at low day temperatures (9°, 12° or 15 °C), the effect of night temperature was only slight.

Corm dry weight increased regularly with the temperature from 0.7 g at 9°/9° to 7.3 g at 24°/24°. Both day and night temperature increased corm size but the effect of day temperature was much stronger than that of the night temperature, as the following figures show.

	264 °C		360 °C			528 °C	
	9°/12°	15°/9°	9°/18°	15°/15°	21°/12°	18°/24°	24°/21°
Corm dry weight (g)	0.77	0.94	0.86	1.94	2.47	4.01	5.14

Cormlet production was greatest at the lower temperatures, with a maximum of 7.2 at 12°/12° and a minimum of 1.0 at 24°/24°. The effect of night and day temperature was similar, but as the following figures illustrate, the effect of night temperature was stronger than that of the day temperature.

	264 °C		360 °C			528 °C	
	9°/12°	15°/9°	9°/18°	15°/15°	21°/12°	18°/24°	24°/21°
Corml. number	5.20	5.80	5.20	4.60	5.00	1.80	2.00
Corml. dry wt (g)	0.74	1.19	1.15	1.78	1.67	0.94	1.03

4.8.2. *Experiment 5.* – As experiment 4 had not all the factorial combinations of day and night temperature, it was repeated in the present experiment. This was done in the greenhouses of the phytotron with the different combinations of 5 different day and night temperatures (12°, 15°, 18°, 21° and 24°C). The day temperatures lasted 8 hrs and the night temperatures 16 hrs. The daylength was the natural one which increased with the season from 8 to 14 hrs. The experiment started on 19 November, 1965. Corms of 'Rijnveld's Golden Yellow' were planted in 10 inch plastic pots. One pot with 5 plants was considered as one treatment.

Results (Table 3): The number of leaves increased with both day and night temperature. At day temperatures of 12°–18°C it was strictly proportional to the 'heat sum', but at day temperatures of 21° and 24°C it was higher than would be expected on the basis of the heat sum, which points to a specific inhibiting effect on flower initiation of these high day temperatures.

Flowering occurred first at 18°/18°; at lower constant temperature it was slightly delayed, at 21° and 24°C strongly so. Night temperature proved to be much more important than day temperature, and not only because it lasted twice as long as the latter. A night temperature of 18°C was particularly favourable. This effect is so strong that there is no relation between flowering and the daily heat sum.

The number of flowers in the main inflorescence increased with the temperature as had been found before. There was not much difference between the effect of day and night temperature, but night temperatures of 21° and 24° appeared to have a special enhancing effect. The lowest number was 7.8 flowers in the 12°/12°C treatment and the highest was 17 flowers on the main stalk in the 24°/24°C treatment.

In contrast to the previous experiment there was a clear effect of temperature on the number of lateral stems, which varied between 0 and 2.4. Two or more lateral stems could be formed at all temperatures, provided the night temperature was not too high (12°–18°C). At 21° and 24°C night temperature the number of side shoots was considerably reduced, the more so as the day temperature was higher. At a combination of low night and day temperature (12°/12° and 15°/12°) it was also somewhat reduced.

The total number of flowers on the plant was highest (33.0) at 24°/18° and

TABLE 3. Experiment 5. Effect of different day and night temperature on Freesia 'Rijnveld's Golden Yellow.

Day temperature (8 hrs)	12 °C					15 °C				
Night temperature (16 hrs)	12°	15°	18°	21°	24°	12°	15°	18°	21°	24°
Daily 'heat sum'	288	336	384	432	480	312	360	408	456	504
Plant height (cm)	55	49	53	65	68	58	62	67	68	69
Number of leaves	8.0	8.3	8.5	10.6	11.6	8.3	8.6	8.8	10.6	11.8
Days to flowering	120	117	106	115	140	113	111	101	120	141
Flowers on main inflorescence	7.8	8.2	8.8	11.3	13.2	8.5	9.0	9.4	11.5	12.6
Number of lateral stems	1.6	2.2	1.3	1.8	0.6	1.6	2.4	1.8	1.5	0.8
Total number of flowers	19.8	22.2	21.8	24.2	19.4	21.8	27.0	22.0	23.3	19.8
Total number of open flowers	16.6	20.2	20.5	20.6	15.5	20.7	24.8	20.0	22.8	15.8
Stem length (cm)	56	44	45	55	51	53	60	54	64	55

lowest (13.0) at 24°/24°C. On the whole, the differences were not very great as most temperature combinations which increased the number of flowers on the main inflorescence decreased the number of lateral stems and vice versa.

Stem length was greatest at 21°/21° (78 cm) and 24°/18° (76 cm). In general, it increased with the day temperature: for instance, stems were 51 cm at 12°/24° but 64 cm at 24°/12°. The effect of night temperature, although it lasted 16 hrs of every 24 hrs cycle, was only slight.

4.9. THE EFFECT OF LOW TEMPERATURE

4.9.1. *Experiment 6.* – In this experiment the after-effect of low temperature (5 °C) was studied under both short day (8 hrs) and long day (16 hrs) conditions. Corms of Freesia 'Rijnveld's Golden Yellow' planted on 8 October, 1965, one corm in a 5 inch pot. Directly after sprouting 1, 2, 3 or 4 weeks of 5 °C were given under both SD and LD conditions (8 or 16 hrs fluorescent light). Subsequently, each group was divided again over SD and LD in the automatic light cabinets. Here SD was 8 hrs fluorescent light and long day 8 hrs fluorescent + 10 hrs incandescent light.

Results: There were no significant differences in the number of leaves per plant which means that flower initiation was not affected.

Flowering was delayed up to 3–8 days by the low temperature treatment under all daylength conditions. Long day during the cold treatment accelerated flowering by up to 6 days as compared to SD. Long day after the treatment gave a further acceleration of 5–10 days. As a consequence, plants that had received SD throughout flowered one or two weeks later than those that had been permanently in LD.

The number of flowers in the main inflorescence showed a slight but significant increase with an increasing period of low temperature treatment. Especially after only 1 or 2 weeks of cold, it was also increased by long day after the low temperature.

The number of lateral stems was strongly affected by the light conditions after the cold treatment. In short day 1.1 to 1.8 lateral stems were formed, but

Averages of 5 plants.

18 °C					21 °C					24 °C				
12°	15°	18°	21°	24°	12°	15°	18°	21°	24°	12°	15°	18°	21°	24°
336	384	432	480	528	360	408	456	504	552	384	432	480	528	576
63	63	74	73	73	71	71	74	91	77	74	74	80	83	86
8.4	8.4	9.4	11.2	11.6	10.0	10.0	10.0	12.2	12.0	10.2	10.4	11.8	11.6	11.6
111	104	102	127	147	113	108	113	128	151	123	116	111	139	159
8.6	10.6	10.0	10.8	15.7	9.0	9.0	9.8	12.8	16.0	7.6	9.0	11.0	12.2	17.0
2.2	2.2	2.0	1.5	0.5	2.3	2.0	2.2	1.6	0.0	1.8	2.0	2.4	0.8	0.0
22.2	28.8	25.0	20.5	22.0	22.0	27.0	25.4	27.0	16.0	18.0	23.0	33.0	18.8	17.0
20.4	27.6	23.3	18.8	17.7	20.6	24.0	24.8	18.8	13.3	17.0	22.6	28.8	15.4	13.0
57	57	68	66	57	66	63	62	78	61	64	68	76	63	65

long day prevented their formation almost completely. As a consequence of this, the number of flowers per plant was greater in short day than in long day.

The percentage of open flowers was not affected by the cold treatment, but in long day about half of the buds never opened against 10–20% in short day.

A long day after-treatment gave slightly longer stems than short day. There was no consistent effect of low temperature.

4.9.2. *Experiment 7. – Vernalization of plants.*

During summer, high temperature and long days delay flower bud initiation. This experiment was devised to investigate the possibility of overcoming this inhibiting effect by plant vernalization at 5 °C. There were 13 treatments, viz. 1, 2, 3 or 4 weeks 5 °C given to plants 1, 2 or 3 weeks old, one treatment being left in the greenhouse as a control. The one week old plants had 4 leaves 6 cm high; those of 2 weeks had 5–6 leaves with a maximum length 14 cm and those of 3 weeks had 7 leaves with a plant height of 20 cm. The daylength during the cold treatment was 16 hours. Corms of 'Rijnveld's Golden Yellow' were planted separately in 10 cm clay pots in a greenhouse on 10 June 1966. After the treatments had been given, plants were transplanted in the soil of the greenhouse. At the end of every cold treatment 2 plants were sampled to investigate the initiation of flower buds. The first bract stage could be seen clearly under the microscope when the plants had been subjected to 3–4 weeks of 5 °C, irrespective the age of the plants. No generative development was noticed after 1 or 2 weeks of 5 °C.

Results: Data collected from this experiment after flowering are included in table 4.

These results show a strong effect of the cold treatment. Perhaps the most interesting is the effect on the number of leaves, as this is a measure of flower initiation. It will be seen that leaf number is strongly reduced after 4 weeks of 5 °C, not at all after 1 or 2 weeks of 5 °C and only very slightly after 3 weeks of 5°. The latter is surprising, as after 3 weeks 5 °C the first signs that the plant had become generative could already be detected. It therefore looks as if in this case, a certain 'devernalization' by subsequent high temperature has taken place.

TABLE 4. Experiment 7. The effect of 5 °C at different plant ages on Freesia 'Rijnveld's Golden Yellow'. Averages of 10 plants.

Duration of cold treatment	1 week			2 weeks			3 weeks			4 weeks			
Plant age before treatment	1 w	2 w	3 w	1 w	2 w	3 w	1 w	2 w	3 w	1 w	2 w	3 w	Control
Plant height (cm)	99.0	95.9	97.9	96.9	96.2	96.0	82.6	77.2	73.3	47.2	45.9	61.9	82.6
Number of leaves	15.0	15.8	16.6	15.5	15.7	16.1	14.5	14.9	14.3	9.1	10.3	11.6	15.7
Leaf dry weight (g)	4.49	4.67	4.42	4.17	5.07	4.53	3.68	4.15	3.76	1.52	2.13	2.40	3.32
Days to flowering	197	199	201	197	197	201	180	184	171	116	116	139	210
Flowers on main inflorescence	12.0	11.7	12.1	11.9	12.2	12.3	13.1	12.5	13.0	13.1	11.6	15.2	9.6
Number of lateral stems	2.5	2.5	2.4	2.2	2.4	2.2	1.7	1.6	1.4	0.9	1.0	0.0	3.2
Total number of flowers	38.7	38.4	37.7	34.3	48.3	39.2	31.8	27.7	29.1	21.4	20.6	15.2	33.1
Stem length (cm)	97	92	94	92	98	97	71	73	90	20	19	19	75
Corm dry weight (g)	9.11	9.37	8.23	8.63	8.00	8.17	5.95	5.43	7.53	4.49	4.85	5.00	8.87
Number of Cormlets	8.5	7.8	9.3	7.5	9.8	12.1	7.3	8.7	6.4	5.8	5.8	6.1	7.8
Cormlet dry weight (g)	4.68	4.39	5.57	3.98	6.79	7.92	5.12	5.18	7.08	3.80	3.62	5.59	3.81
Corm + Cormlet dry weight (g)	13.79	13.76	13.80	12.61	12.79	16.09	11.09	10.61	14.61	8.29	8.47	10.59	12.68
Corm + Cormlets/leaf ratio	3.07	2.95	3.12	3.02	2.52	3.55	3.01	2.56	3.89	5.45	3.98	4.41	3.82

Although the difference in leaf number was very small, plants after 3 weeks 5° flowered well ahead of the other groups, although not as early as those treated for 4 weeks. The plants treated with 1 or 2 weeks 5° did not differ among each other but flowered 8 to 10 days ahead of the controls.

Stem length was increased by about 20 cm after 1 or 2 weeks 5°C. After 3 weeks of 5°, it was about the same as in the controls, while plants kept at 5° for 4 weeks had stunted stems, only 19 cm long, whereas the untreated plants had stems of 74.5 cm. The number of lateral stems gradually decreased with the length of the cold treatments, from 3.2 in the controls to 1.0–0 in plants treated with 4 weeks 5°.

The number of flowers in the main inflorescence was higher after 1 or 2 weeks 5° (11.7 to 12.3) than in the controls (9.6). In some cases there was a further increase after 3–4 weeks of 5°C. The total number of flowers on the plant was increased by a cold treatment of 1 or 2 weeks but reduced by 3 or 4 weeks 5°C, no doubt because of the strong reduction of the number of lateral stems in the latter treatments.

Leaf length was increased by 1 or 2 weeks 5°, and so was total leaf dry weight (from 3.3 to about 4.5 g). Three weeks 5°C still gave a slightly higher leaf dry weight but after 4 weeks 5° this was strongly reduced.

Corm dry weight from plants treated with 1 or 2 weeks 5° was similar to the controls, but it was reduced by 3 or 4 weeks 5°. Cormlet number per plant was increased by 1 or 2 weeks 5°C, similar to the controls after 3 weeks 5° and reduced by 4 weeks 5°. Cormlet dry weight was increased in all the cold treatments except with plants 1 or 2 weeks old which had received 4 weeks 5°C.

Corm + cormlets dry weight showed a gradual decrease as the cold period was longer. Plants 3 weeks old at the moment of the cold treatment gave a higher production than younger plants.

The relation of the leaves to corm + cormlets production shows that the longer cold period (4 weeks 5°C) gave the highest efficiency.

4.10. Discussion

These experiments demonstrated that flower initiation in Freesia is promoted by relatively low temperature. This confirms results of Kosugi (1953) and Kosugi and Otani (1954), obtained also with Freesias from corms, and of Klougart and Jørgensen (1962) and Heide (1965) obtained with seed Freesias.

The effect of temperature on leaf number has already been reached 2 weeks after planting at 12°, 2–3 weeks after planting at 15° and 3–4 weeks after planting at 18°. This probably explains why in experiment 6 no effect was found of a period of 5°: induction may already have taken place before the plants were moved to the low temperature. Experiment 7 showed that at 5° flower initiation occurs after 3 weeks and has become irreversible after 4 weeks. At 21 and 24°, the induction has not been completed (i.e. has not yet become irreversible) 6 weeks after planting (experiment 3).

At temperatures too high for optimal flower induction, leaf initiation

continues for a longer period so that more leaves are formed. This increase in leaf number at high temperature had also been found by ABE et al. (1964) and HEIDE (1965). Plant height increased proportionaly to the temperature, in accordance with results of HARTSEMA (1962) who also noticed a greater final leaf length at 17° and 20° C than at lower temperatures.

The results of experiments 4 and 5 show that there were no differential effects of day and night temperature on flower initiation. The number of leaves depended on the 'heat sum' and plants at different day and night temperatures but the same heat sum had the same number of leaves.

A pretreatment at 5°, even for as short a period as one week, promoted flowering, although initiation was not affected. At constant temperatures, optimal flowering occurred at 18° (at 21° in experiment 2 and at 15° in experiment 4). Experiment 3 showed that flower bud development is accelerated by high temperature. This promotive effect is stronger, when the preceding temperature has been lower: removal of the plants to 24° resulted in earlier flowering only when the preceding temperature was 12 or 15° (or 5° in experiment 7). The results of experiments 4 and 5 showed that flower bud development is specifically promoted by a low night temperature. This confirms results of KLOUGART and JØRGENSEN (1962).

The number of flowers in the main inflorescence was increased by a pretreatment at 5° (experiment 6 and 7). By contrast, in plants kept at constant temperatures in the range of 12 to 24° it was increased by the higher temperatures (experiment 1–5). There does not seem to be a specific effect of either day or night temperature (experiment 4), although in experiment 5 there was an indication that the night temperature played a somewhat larger role than the day temperature.

Stem length was promoted by 1 or 2 weeks 5° (experiment 7). When the cold treatment lasted longer, the promotive effect disappeared and after 4 weeks 5° the stems were stunted, possibly because flowering had been promoted too strongly. In plants not pretreated at low temperature stemlength increased with the temperature up to 21°, but was reduced again at 24°. Experiment 3 showed that plants switched from 12° to 24° showed no reduction in stemlength in comparison to those which remained at 12° (in other words, 12° had a promotive after effect just as 5°, but not as strong). Plants switched from 15–21° to 24° had stems that were not only shorter than those at the lower temperature but also shorter than those of the plants that stayed in 24° throughout, a fact which suggest that 24° might be promotive during early stages and become inhibitive only later on. Experiment 5 showed that the effect of night temperature on stem length is only slight, especially in the lower temperature range (9–15°), and that it is determined primarily by the day temperature.

A pretreatment at low temperature reduced the number of lateral stems in proportion to the length of the period at 5°. The effect of higher temperatures during later stages is not completely clear. In experiment 3, the number of lateral stems decreased regularly from 12° to 24°. In experiments 1, 2, 4 and 5 the optimal temperature for side stem formation was either higher (18°), or not

clear. All results point to an unfavourable effect of 24°. According to the results of experiment 5, this effect could be overcome by low night temperature.

In experiment 3 it became clear that the moment at which the plant is subjected to these temperatures is important. Plants switched from a higher to a lower temperature after 2–6 weeks always had more lateral stems than those which remained at either tempearture throughout; in other words, the promotive effect of the lower temperature became more pronounced. In plants switched from a lower to a higher temperature sometimes showed a similar phenomenon, i.e. a stronger inhibition by the higher temperature, but this effect was not as consistent. Apparently the sensitivity of the plants changes during development, and shoot initiation is promoted by relatively high temperature in an early phase and by relatively low temperature later on.

The number of cormlets was increased by a short (1–2 weeks) pretreatment at 5°. In the other experiments, the number of cormlets decreased with every increase in temperature in the 12–24° range. A stay at 12° during the first 2 weeks was already sufficient for the formation of some cormlets. On the whole, switching the plants from high to low temperature or vice versa resulted in an intermediate number of cormlets. This means that there was no specific period of development during which the effect of temperature was crucial (experiment 3). The effect of day and night temperature was similar, but that of the night temperature was stronger (experiment 4).

Corm dry weight increased with the temperature. In this case, the day temperature was more important than the night temperature. As a rule, the heaviest corms were formed under conditions where there were the greatest number of leaves. Perhaps the fact that at high temperature very few cormlets were formed is also significant; it could be that the assimilates required for cormlet development now accumulated in the corm. Following this line of reasoning one might wonder if the fact that flowering was retarded at high temperature might be ascribed to a competition for assimilates between the corm and the bud, with in this case the corm as the more effective sink.

5. THE EFFECT OF LIGHT

5.1. INTRODUCTION AND REVIEW OF LITERATURE

Light is another factor that has a great influence on growth and flowering of Freesia plants. The effect of daylength was first studied by GARNER and ALLARD in 1920. They found that Freesias flower very little when given a longer daylength than that prevailing in December and January, but flower profusely in short days. This was confirmed by LAURIE and POESCH (1932), who found that the additional illumination which they used for *Freesia* 'Purity' was unfavourable because it reduced yield without a compensating earliness of bloom. POST (1942) obtained similar results.

KOSUGI and SUMITOMO (1955) studied the responses of Freesia to the photoperiod before and after flower bud differentiation. They found that the time of flower bud differentiation was shortened by a short photoperiod but that its development was promoted by long day. A short photoperiod also increased the total number of flowers on a plant. This was confirmed with seedlings of *F. refracta alba* by DEBUISSON (1962).

KLOUGART and JØRGENSEN (1962) observed that short day accelerated flowering in 60 and 76-day old plants grown from seed but delayed flowering of 90-day old plants.

HEIDE (1965) found that short days (9 hrs) slightly stimulated flower initiation in yellow K & M 'Super Freesias', but delayed it in blue K & M 'Super Freesias.' A short day treatment in the open during the summer had no significant effect, whereas shading markedly hastened flowering.

The latter observation points to an effect of light intensity on flowering of Freesia. KRAGTWIJK (1954) demonstrated that shading of young Freesia plants had little effect on growth but resulted in earlier flowering. Soil temperature was reduced by the shade mats. In 1958, he found that shading during the early stages of growth (June-August) increased flower production by 100% and seed production by 15% as compared with later shading. WHETMAN (1963) supported these results when he shaded plants raised from seeds at the 4–6 inch stage for 9 weeks from the end of June and found that in February the shaded plants had produced 50% more spikes than the unshaded ones.

5.2. THE EFFECT OF DAYLENGTH

5.2.1. *Experiment* 8. – This experiment was carried out from 3 March, 1965 onwards in the automatic light cabinets. As a basic illumination a short day of 8 hrs was given. Two kinds of light were used: natural day light from 9 a.m. to 5 p.m., and artificial light provided by the 4 fluorescent tubes in the cabinets. To obtain longer photoperiods than 8 hrs the basic illumination was supplemented by weak incandescent light. The following 15 treatments were given: 8 hrs natural daylight supplemented by 0, 2, 4, 6, 8, 10 or 12 hrs of incandescent light; complete natural day; 8 hrs artificial light supplemented by 0, 2, 4, 6, 8, 10 or 12 hrs of incandescent light. Two varieties, 'Rijnveld's Golden Yellow' and 'Sona-

ta' were used in each treatment. Corms of the standard size (5 cm circumference) were planted separately in a 12 cm plastic pot. The experiment was terminated when the aerial part of the plants started to die off. This moment varied between 2 August 1965 and 10 November 1965.

Results: Some of the data from this experiment are summarized in tables 5 and 6.

The number of leaves per plant was measured in monthly intervals. During the first three months of growth there were no big differences between the treatments. At flowering time, however, plants at 8 + 4 hrs had a greater number of leaves than those at shorter photoperiods. There was a slight difference between the plants at 8 + 2 and at 8 hrs, but this was not significant. Plants at photoperiods of 8 + 6 to 8 + 12 hrs did not flower (with one exception: 'Rijnveld's Golden Yellow' at 8 + 6 hrs artificial light). Their leaf number was reduced in comparison to that at 8 + 4 hrs, the more so as the photoperiod was longer (again there was one exception in artificial light: 'Sonata' formed the maximum number of leaves at 8 + 8 hrs).

Apparently, leaf development came to an end either by flower formation, which puts a stop to leaf initiation, or by the dying off of the plant which terminates leaf growth. Short day promoted flower initiation and thereby reduced leaf number, very long days had also a reducing effect because they reduced the active life of the plant.

When 'Rijnveld's Golden Yellow' and 'Sonata' are compared, the maximum number of leaves are found at a shorter daylength (about 8 + 4 hours of light) in the former varety than in the latter (about 8 + 8 hours of light. In both varieties the maximum leaf number is about the same in the two light conditions (NL or AL during the main light period) but both at the shortest and at the longest daylengths the number of leaves was greater in AL than in NL. This means that AL, either because of its weaker intensity or because of its different spectral composition, delayed flower initiation as well as the death of the upper parts of the plant. As said before, 'Rijnveld's Golden Yellow' flowered at 8 + 6 hrs artificial light but not at 8 + 6 hrs when the first 8 hrs were daylight.

It should be emphasized that all plants, also the ones that died without having flowered, initiated flowers. The initiation of the first bract was noted after 31 days in 'Rijnveld's Golden Yellow' and after 37 days in 'Sonata' in 8 hours of daylight. When the daylength was greater, flower initiation was retarded, but after 111 days all plants were generative. There are indications that in luminescent light flower initiation was somewhat later than in daylight.

Where flowering occurred, it required the smallest number of days either in 8 or in 8 + 2 hrs, being delayed in greater daylengths. In almost all cases flowering occurred earlier when the basic light period was daylight than when it was fluorescent light.

The number of flowers in the main inflorescence did not show differences between 8 and 8 + 2 hrs but was smaller in 8 + 4 hrs in 'Sonata' and in 8 + 6 hrs in 'Rijnveld's Golden Yellow'. In the former variety, less flowers were

TABLE 5. Experiment 8. Effect of daylength on Freesia 'Rijnveld's Golden Yellow'. Basic illumination: 8 hrs natural light. Averages of 4 plants.

	8+0	8+2	8+4	8+6	8+8	8+10	8+12	NL
Plant height (cm)	67.0	64.0	79.0	85.3	82.0	73.3	67.0	77.5
Number of leaves	10.8	11.8	14.0	13.3	13.0	11.7	10.0	12.0
Days to flower initiation	31	37	68	79	79	99	111	111
Days to flowering	100.8	104.5	170.0	–	–	–	–	–
Flowers on main inflorescence	13	13	11	–	–	–	–	–
Number of lateral stems	2.3	2.0	1.0	–	–	–	–	–
Total number of flowers	37	37	18	–	–	–	–	–
Total number of open flowers	36	35	13	–	–	–	–	–
Stem length (cm)	71.5	65.5	71.5	–	–	–	–	–
Stem length to 1st node (cm)	26.0	23.0	15.5	–	–	–	–	–
Corm dry weight (g)	3.01	3.99	4.39	4.83	5.73	5.17	5.95	6.21
Number of cormlets	1	0	0	0	0	0	0	0
Cormlet dry weight (g)	0.44	0	0	0	0	0	0	0
Days from planting to harvesting	215	215	210	203	177	146	146	168

TABLE 6. Experiment 8. Effect of daylength on Freesia 'Rijnveld's Golden Yellow'. Basic illumination: 8 hrs artificial light. Averages of 4 plants.

	8+0	8+2	8+4	8+6	8+8	8+10	8+12
Plant height (cm)	109.3	104.8	113.5	115.8	101.8	109.5	97.8
Number of leaves	11.5	12.3	13.3	13.3	12.0	12.3	10.8
Days to flower initiation	44	44	66	66	79	111	111
Days to flowering	126.0	120.3	153.3	168.5	–	–	– –
Flowers on main inflorescence	11.0	13.0	12.5	7.0	–	–	–
Number of lateral stems	0.3	0.5	0.0	0.0	–	–	–
Total number of flowers	13.0	17.8	12.5	7.0	–	–	–
Total number of open flowers	12.5	17.0	7.8	3.5	–	–	–
Stem length (cm)	88.0	88.3	93.8	91.5	–	–	–
Stem length to 1st node (cm)	22.5	23.3	19.5	12.0	–	–	–
Corm dry weight (g)	1.83	2.76	3.20	4.29	3.83	4.15	3.37
Number of cormlets	0.0	0.0	0.0	0.0	0.0	0.5	0.0
Cormlet dry weight (g)	0.0	0.0	0.0	0.0	0.0	0.16	0.0
Days from planting to harvesting	246	246	246	213	181	146	146

formed when the basic illumination was fluorescent light, in the latter variety the differences were irregular. The number of side stems decreased with the daylength in both varieties, and was invariably smaller in luminescent light than in daylight. Total number of flowers showed the same trend.

Stem length of flowering plants did not appear to be much affected by daylength. There was, however, a strong influence of light quality, stems of both varieties being much longer in luminescent light than in daylight.

In the groups receiving daylight, corm dry weight was determined after 44, 64 and 99 days in 'Sonata' and after 44, 79 and 111 days in 'Rijnveld's Golden Yellow'. In all cases, it proved to be strictly proportional to daylength. When corm dry weight was determined for the fourth time at harvesting time, the

PHOTO 2. Effect of daylength (8 hours fluorescent light supplemented by incandescent light) on flowering and corm formation (Experiment 8). Plants flowered in short days but in long days corm formation was accelerated and the plants died off early.

same trend was still apparent, but the regularity of the figures had become somewhat disturbed by early dying off of plants at very long photoperiods. Probably for the same reason, corm weight in luminescent light, determined only at harvesting time, was proportional to daylength only from 8 + 0 to 8 + 10 hours; at 8 + 12 hrs it fell off again. In daylight the corms were much (very roughly: one and a half times) heavier than in luminescent light.

Cormlets were formed by 'Rijnveld's Golden Yellow' and by 'Sonata' only in 8 + 0 and 8 + 2 hrs. No cormlets were formed in artificial light.

5.2.2. *Experiment 9.* – As in experiment 8 the high temperature of summer no doubt had an adverse effect on the development of the plants, a similar experi-

TABLE 7. Experiment 9. Effect of daylength on Freesia 'Rijnveld's Golden Yellow'. Averages of 6 plants.

	Natural light						Artifical light				
	8+0	8+2	8+4	8+8	8+12	NL	8+0	8+2	8+4	8+8	8+12
Plant height (cm)	90	92	89	97	94	97	103	100	100	106	99
Number of leaves	11.2	10.7	10.7	11.3	11.0	11.0	11.3	10.8	10.2	11.2	11.5
Days to flowering	113	111	116	106	102	134	109	108	107	102	100
Flowers on main inflorescence	9.8	10.2	10.8	11.8	9.2	13.7	10.7	9.5	9.8	9.2	10.0
Number of lateral stems	2.0	2.0	1.3	0.7	0.0	0.3	2.0	2.3	1.0	1.0	0.6
Total number of flowers	23.8	24.7	20.8	17.2	9.2	16.3	24.8	25.0	16.8	17.7	13.6
Total number of open flowers	22.0	22.0	17.7	10.7	3.8	11.8	22.0	22.0	15.5	10.8	9.6
Stem length (cm)	74	75	76	74	70	85	97	95	91	88	82
Corm dry weight (g)	3.22	4.45	4.20	4.83	3.86	5.37	2.09	2.65	3.35	4.54	3.69
Number of cormlets	2.4	2.9	1.7	1.9	0.9	0.0	2.6	3.3	2.6	3.0	2.1
Cormlet dry weight (g)	0.70	0.71	0.50	0.22	0.05	0.00	0.42	1.16	0.75	0.55	0.22

ment was started in the wintertime from 22 November 1965 onwards. The treatments were 8 hrs light (natural or artificial) supplemented by 0, 2, 4, 8, or 12 hrs incandescent light. In addition one group of plants remained in natural light. Corms of 'Rijnveld's Golden Yellow' were planted as specified in experiment 8. The temperature could be kept at 18 °C during the first four months of the experiment. Every week plants were sampled to establish the time of flower bud initiation.

Results: The time of flower bud initiation did not show such wide variations as in experiment 8. Plants in 8, 8 + 2 and 8 + 4 hrs reached the first bract stage during the third week after sprouting, both in natural daylight and in artificial light. The other treatments, 8 + 8 and 8 + 12 hours and the complete natural day, gave the first bract initiation during the fourth week from sprouting.

Other data collected from this experiment are shown in table 7. A striking difference with the previous experiments is that there were no significant differences between the daylength treatments with regard to the number of leaves per plant. As far as can be judged from the somewhat irregular figures, there are no differences either in the time of flowering in the different daylengths, except that plants receiving natural day where slightly later than those receiving fluorescent light. Flowering of plants in continuous natural day was considerably delayed. It also appears that in the long photoperiods the first flower opened one to two weeks earlier than in the short photoperiods.

The number of flowers in the main inflorescence showed no significant differences except that in the plants which received NL only it was somewhat greater.

The total number of flowers per plant, however, was much greater in short than in long photoperiods. This is largely due to the fact that in 8 and 8 + 2 hrs the plants had about 2 lateral stems, which number fell off to 0–0.6 in 8 + 12 hrs. It should be noted also that in short day almost all flower buds opened but in long day a considerable number remained 'blind'.

The length of the stem was greater as the days where shorter, at least in luminescent light. In daylight the differences were slight, except that stems in continuous NL were much longer than those in 8 hrs NL + incandescent light.

Corm dry weight increased with the photoperiod up to 8 + 8 hrs, but fell off again in 8 + 12 hrs, both in NL and AL. The biggest corms were found in continuous NL.

In the NL treatments cormlet production (number of cormlets per plant as well as dry weight) gradually decreased with increasing photoperiods from 2.9 at 8 + 2 hrs to 0.9 at 8 + 12 hrs. At 8 hrs 2.4 cormlets were formed, and none in continuous NL. In AL the optimal photoperiod for cormlet formation was also 8 + 2 hrs, but the numbers were higher than in NL and the decrease in longer days was not nearly as strong.

5.2.3. *The effect of daylength after flower bud initiation*

5.2.3.1. Experiment 10. – This experiment was set up to study the effect of

TABLE 8. Experiment 10. Effect of daylength on Freesia 'Rijnveld's Golden Yellow' after flower bud initiation in different light intensities. Averages of 5 plants.

	Initiation in 100% light					Initiation in 25% light				
	8+0	8+4	8+8	8+12	NL	8+0	8+4	8+8	8+12	NL
Plant height (cm)	73	75	75	76	73	77	78	75	83	73
Number of leaves	11.4	11.8	10.0	10.8	11.0	11.6	13.2	11.2	12.6	11.2
Days to flowering	141	157	141	136	169	160	186	179	165	177
Flowers on main inflorescence	12.5	13.6	11.5	11.3	9.8	13.9	11.4	11.0	11.0	10.0
Number of lateral stems	3.4	1.1	0.0	0.2	1.8	3.6	0.0	0.3	0.3	2.0
Total number of flowers	54.9	25.0	11.5	13.0	23.8	62.6	11.4	14.0	14.3	26.1
Total number of open flowers	45.9	18.3	5.5	6.0	23.2	49.7	10.9	8.3	5.3	22.9
Stem length (cm)	51	42	50	55	41	53	51	51	64	41
Corm dry weight (g)	5.23	6.57	6.70	8.96	5.02	4.41	6.60	6.62	7.70	5.02
Number of cormlets	2	4	4	4	0	2	1	3	3	2
Cormlet dry weight (g)	0.19	0.34	0.41	1.90	0	0.14	0.05	0.39	0.27	0.10

daylength on plants which had already initiated flowers. Corms of 'Rijnveld's Golden Yellow' were planted 2 June, 1965 in 12 cm plastic pots and left to initiate their flower buds in photoperiod of 8 hrs at 4 different light intensities, viz. 25%, 50%, 75% and 100% of the artificial light in the phytotron. Plants were removed on 20 July 1965 to 4 different lorries which received 8 hrs natural daylight in the open and were moved at night to sheds where they received incandescent light to during 0, 4, 8 or 12 hrs, respectively. One lorry was left outside to receive natural daylight continuously.

Part of the results of this experiment are shown in table 8. From the number of leaves it appears that the light intensity has had little effect on flower initiation, although there is a slight tendency for a delay at lower light intensities. There is a strong aftereffect of the light intensity at which flowers were initiated on the number of days to anthesis. Plants which initiated flower buds in the highest light intensity flowered first and were followed by the groups which initiated flowers at 75%, 50% and 25% light intensity, in this order. The photoperiod to which plants were subjected after initiation had a pronounced effect on the time of flowering. The last to flower were the plants subjected to 8 + 4 hrs, the first usually either those at 8 + 0 or at 8 + 12 hrs which did not differ much in this respect, while those at 8 + 8 hrs were intermediate.

The number of flowers on the main inflorescence and per plant does not show an after effect of the light intensity before initiation, but a strong influence of the subsequent daylength. In 8 + 0 and 8 + 2 hrs there are a few more flowers on the main inflorescence than in the longer daylengths. With regards to the number of flowers per plant the difference is very large; in 8 hrs this varied between 46 and 63, at 8 + 4 hrs this was reduced to 11–25 and at 8 + 12 hrs to 11–14. This was largely due to the number of lateral stems, which was 2.9 to 3.6 in 8 + 0 hrs and 0–0.3 in 8 + 12 hrs. There is a small effect of the light intensity here: in 8 + 4 hrs, some side stems developed in plants from high light intensities but none on plants from low intensities. In spite of the small number of flowers formed in the long photoperiods, many of these flowers did not open.

The stem length in the different treatments did not show great variations. Plants grown in continuous NL had the shortest stems, while for some unexplained reason the plants in 8 + 4 hrs had short stems too.

Corm dry weight as well as cormlet dry weight increased with the photoperiods. The corms from plants which were initially in 25% light intensity were slightly smaller than those of the other groups. The plants in continuous NL had some very cold and windy nights outside which may explain the lower corm production. The number of cormlets shows a tendency to be larger in shorter photoperiods. Plants from the lower light intensity had less cormlets.

5.2.3.2. Experiment 11. – This experiment is similar to experiment 9, but it was carried out in the wintertime. The daylength was controlled in the automatic cabinets. Corms of 'Rijnveld's Golden Yellow' and 'Princess Marijke' were planted on 7 October 1965, one corm in a 12 cm plastic pot. They were left to initiate flowerbuds in 8 hrs natural daylight. On 1 December, 1965 the

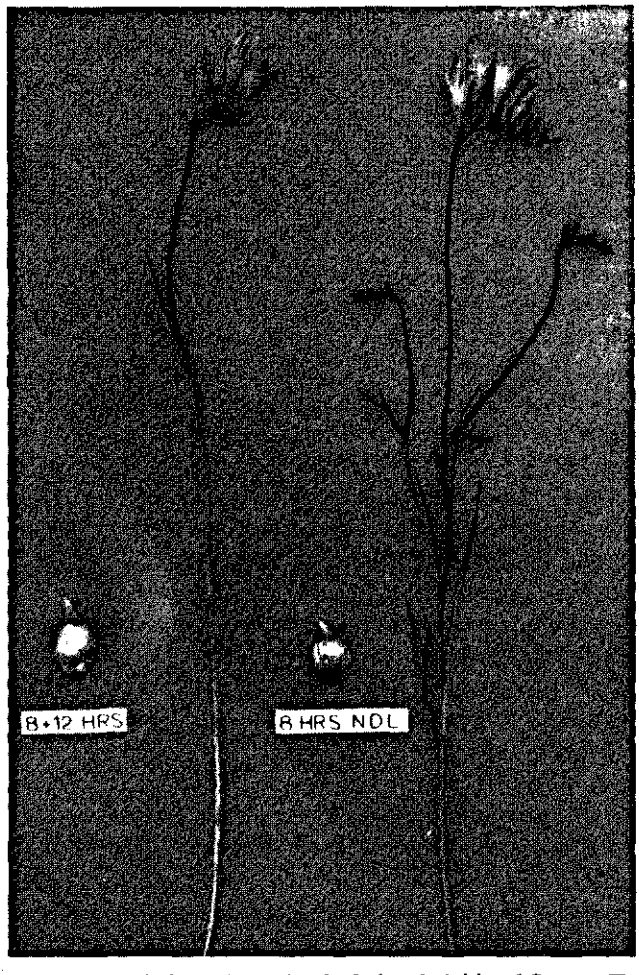


PHOTO 3. Effect of photoperiod on plants that had already initiated flowers (Experiment 10). The quality of flowers formed in short day is better than in long days. In short day there are more side stems and less blind flowers. In long days the corms are bigger.

daylength treatments started. The basic illumination consisted of 8 hrs of either natural daylight or artificial (fluorescent) light. For 'Princess Marijke' only fluorescent light was used. This was supplemented by incandescent light to give photoperiods of $8+0$, $8+2$, $8+4$, $8+8$ and $8+12$ hrs.

The results of this experiment are partly summarised in table 9. They agree closely with the results of the previous experiment. The plants initiated flowers after about the same number of leaves. Plants in $8+8$ or $8+12$ hrs flowered much earlier than those in $8+0$, $8+2$ or $8+4$ hrs or than those in NL, which varied between about 8 and 13 hrs in the course of the experiment.

The number of flowers on the main inflorescence showed no significant differences, but the number of flowers per plant was greater in short day than in

TABLE 9. Experiment 11. 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.

	8+0	8+2	8+4	8+8	8+12	N.L
Plant height (cm)	93	91	95	95	96	102
Number of leaves	10.6	11.0	10.8	10.6	10.4	10.4
Days to flowering	130	135	129	118	114	135
Flowers on main inflorescence	9.7	8.7	9.6	10.0	8.9	9.0
Number of lateral stems	1.4	1.6	1.1	1.0	0.6	0.3
Total number of flowers	17.9	17.0	16.3	16.8	12.6	10.8
Total number of open flowers	16.4	15.4	14.0	9.1	6.0	8.1
Stem length (cm)	76	75	76	75	74	83
Corm dry weight (g)	3.31	3.35	4.02	4.16	3.95	5.20
Number of cormlets	3.6	4.3	2.3	2.0	1.3	2.4
Cormlet dry weight (g)	1.11	1.44	1.06	0.43	0.25	0.65

long day. Long day also increased the number of flowers that did not open. In AL more flowers were formed than in NL, but the percentage of flowers that did not open was about the same. As in the previous experiment, the reduction in the total number of flowers by long photoperiods could be explained by the number of side stems which decreased when the photoperiods were longer. The differences were not as great as in experiment 10, however.

Daylength did not affect stemlength. The stems were longer in AL than in NL, probably because the intensity of the AL was higher. In the same way it could be explained why continuous NL gave longer stems than when only 8 hrs of NL was given. 'Princess Marijke' had shorter stems in 8 + 12 hrs than in the shorter day lengths.

Corm dry weight increased again with the photoperiods but the corms in 8 + 12 hrs were consistently smaller than those formed in 8 + 8 hrs. The corms in NL were slightly heavier than in AL. Continuous NL gave the largest corms.

The number of cormlets increased with decreasing photoperiod from 8 + 12 to 8 + 2 hrs. In the 8 hrs photoperiod the number of cormlets was lower again. The variety 'Princess Marijke' gave very few cormlets in 8 hrs. The greatest number of cormlets (2.5) where formed in 8 + 4 hrs.

5.2.4. *Experiment 12.* – This experiment was devised to distinguish between the effects of the photoperiod on flower formation and the effects on flower development. Corms of 'Rijnveld's Golden Yellow' were planted on 3 August, 1964, 3 in one 22 cm black plastic pot. Plants were left to grow under 8, 12 or 16 hrs of the artificial light in the phytotron, and removed to 8, 12 or 16 hrs of the same light as soon as the inflorescence became visible, i.e. 85 to 110 days after planting.

Results (Table 10): As could be expected, plants initiated flowers after a smaller number of leaves in short day than in long day. The differences are small, however. The effect of the photoperiod is much more pronounced when the number of days to flowering is taken into consideration. Two effects

TABLE 10. Experiment 12. Effect of photoperiod before and after flower initiation on Freesia 'Rijnveld's Golden Yellow'. Averages of 3 plants.

Daylength before initiation	8 hrs			12 hrs			16 hrs		
Daylength after initiation	8 hrs	12 hrs	16 hrs	8 hrs	12 hrs	16 hrs	8 hrs	12 hrs	16 hrs
Plant height (cm)	6	53	60	62	66	63	63	65	65
Number of leaves	9.7	8.8	8.7	10.0	10.0	9.5	10.4	10.5	10.7
Days to flowering	110	105	103	109	117	119	133	129	127
Flowers on main inflorescence	10.3	10.8	10.8	12.8	12.3	11.7	13.2	12.3	12.8
Number of lateral stems	2.7	1.8	1.5	1.8	1.7	1.0	1.6	0.8	1.0
Total number of flowers	37.3	26.5	21.7	33.5	33.0	21.7	29.6	20.8	17.7
Total number of open flowers	33.3	23.8	16.8	29.0	28.0	14.0	26.0	16.0	10.3
Stem length (cm)	50	47	55	53	57	51	53	56	59
Corm dry weight (g)	2.82	4.59	5.69	3.52	5.15	5.94	4.27	5.81	6.04
Number of cormlets	4.7	2.0	2.2	3.3	2.7	2.2	4.4	2.0	2.8
Cormlet dry weight	1.74	0.88	0.71	1.66	1.39	0.55	1.66	0.93	1.09

can be distinguished: a promotive effect on flowering of short day during the initial stages, and a promotive effect of long day during the later stages. The latter effect is not very pronounced (about one week, while short day in the initial stages promoted subsequent flowering by about three and half weeks).

More flowers were formed in the main inflorescence of plants in the long photoperiods than in the short ones. This effect was caused only by the daylength in the early stages. The number of flowers per plant showed the opposite trend. There are more flowers in short day than in long day. These figures run parallel to the number of lateral shoots, which is also higher in short day, an effect of the daylength both before and after visible flower initiation. As in previous experiments, long day (in later stages) increased the number of 'blind' flowers.

The length of the stem is increased by longer photoperiods, both in the initial and in later stages, but in neither case the effect is very strong. The length in 8 hrs throughout is 49.5 cm, the length in 16 hrs throughout 58.6 cm.

Corm dry weight increased with the photoperiod, especially during the later stages, but the initial photoperiod had also promotive effect. The number of cormlets per plant and their dry weight were only affected by the photoperiod in the later stages. The highest number of cormlets were formed in 8 hrs; the difference between the number in 12 hrs and in 16 hrs was negligible.

5.3. Experiments with light intensity

5.3.1. *Experiment 13.* – Corms of three Freesia varieties, 'Rijnveld's Golden Yellow', 'Sonata' and 'Princess Marijke', were used in this experiment which was undertaken to investigate the effect of 4 levels of light intensities, viz. 25%, 50%, 75% and 100% of the artificial light in phytotron, with photoperiods of 8, 12 and 16 hrs. The temperature used in this experiment was 22–24°C. Four corms were planted in one 22 cm plastic pot. Some corms of the variety 'Rijnveld's Golden Yellow' were planted separately in a 12 cm plastic pot to be sampled periodically to establish the time of the initiation of the first bract.

Results (Table 11): The number of leaves per plant was higher in a 12 or 16 hrs photoperiod than in 8 hrs. There were no significant differences between plants in 12 and 16 hrs. This holds true for all three varieties. The light intensity did not significantly influence the number of leaves per plant, except that plants that received 100% during 16 hrs had a lower number of leaves than those at 75% during 16 hrs. This was true for 'Sonata' and 'Princess Marijke' (where there was also a reduction at 100% during 12 hrs), but not for 'Rijnveld's Golden Yellow'.

The time of initiation of the first bract was recorded only for 'Rijnveld's Golden Yellow.' At 8 hrs 100% or 75%, this stage was reached after 35 days. These plants were followed by those at 12 hrs 100% and 75% which showed the first bract after 53 days. Plants at 8 hrs 50% initiated flowers after 57 days, 8 hrs 25% after 73 days, 12 hrs 50% after 76 days, while plants at 16 hrs 75%, 100% and 50% had the first bract after 90, 97 and 97 days, respectively. Plants

TABLE 11. Experiment 13. Effect of photoperiod and light intensity on Freesia 'Rijnveld's Golden Yellow'. Averages of 4 plants.

	8 hrs				12 hrs				16 hrs			
	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%
Plant height (cm)	95	87	79	74	85	93	83	83	105	89	92	83
Number of leaves	11.3	11.8	10.8	10.8	14.3	15.0	12.5	14.5	12.3	12.8	13.3	13.7
Days to initiation	73	57	35	35		76	53	53		97	90	97
Days to flowering	143	133	112	112	–	154	135	148	–	–	–	–
Flowers on main inflorescence	6.5	11.5	12.0	13.3	–	14.0	17.0	14.0	–	–	–	–
Number of lateral stems	0.0	1.0	1.7	3.0	–	2.0	1.5	0.0	–	–	–	–
Total numbers of flowers	6.5	15.5	25.5	40.5	–	24.0	25.0	11.0	–	–	–	–
Total number of open flowers	4.8	4.0	24.0	40.5	–	24.0	25.0	11.0	–	–	–	–
Stem length (cm)	57	62	69	67	–	91	81	76	–	–	–	–
Corm dry weight (g)	0.39	2.71	4.47	4.13	0.62	3.04	6.89	3.97	3.10	3.70	5.75	4.44
Number of cormlets	2	1	1	2	0	0	1	0	0	0	0	0
Cormlet dry weight (g)	0.18	0.18	0.36	0.92	–	–	1.01	–	–	–	–	–

which were grown in 25% light intensity at photoperiods of 12 and 16 hrs were still vegetative when the last sample was taken 97 days after planting.

The number of days to flowering follows the same trend. Earliest flowering occurred in 100% 8 hrs for all three varieties. It was retarded by low light intensity; the difference in flowering time between 100% 8 hrs and 25% 8 hrs was 31 days in 'Rijnveld's Golden Yellow' and 61 days in 'Princess Marijke', while 'Sonata' did not flower at all in 25% light intensity. The retarding effect of daylength was even greater. No flowers opened in 25% 12 hrs; 'Sonata' did not flower in 50% 12 hrs either. None of the varieties reached the flowering stage in a daylength of 16 hrs.

The number of flowers formed on the main inflorescence showed differences between the varieties. In 'Rijnveld's Golden Yellow', it was greater in 12 hrs than in 8 hrs. In 'Princess Marijke' the difference was even greater, but in 'Sonata' it was the same in both daylengths. In all varieties, the number of flowers increased with the light intensity when the photoperiod was 8 hrs. At 12 hrs, the effect of light intensity (except when it was so low that it prevented flowering) was not clear.

There were no lateral stems in 16 hrs. 'Sonata' did not form any in 12 hrs either. 'Princess Marijke' formed quite a few in 12 hrs at 75% and 100% intensity but none in 50% and 25%. 'Rijnveld's Golden Yellow' formed some in 12 hrs 50 and 75% but none at 25% nor, strangely enough, at 12 hrs 100%. In the 8 hrs photoperiod, all varieties formed more lateral stems at high than low light intensities; at 25%, none were formed.

The total number of flowers per plant follows the same trend. It was highest at 75% 8 hrs in 'Princess Marijke' and at 100% 8 hrs in the other two varieties. In 8 hrs of light, the percentage of open flowers was very high at 100% and decreased with the light intensity. In 12 hrs, it was rather low (sometimes as low as 30–50%, and never higher than 80%) in all varieties.

Stem length was proportional to the light intensity in an 8 hr photoperiod. In 12 hrs, the picture is not clear: in 'Rijnveld's Golden Yellow' stems were longer than in 8 hrs and decreased in length with the light intensity. In 'Princess Marijke', stems in 12 hrs were about as long as those in 100% 8 hrs while light intensity did not appear to have much effect.

The data of corm production show that plants of 'Rijnveld's Golden Yellow' and 'Princess Marijke' produced the biggest corm at 75% 12 hrs. Higher light quantities (100% 16 hrs, 100% 12 hrs and 75% 16 hrs) gave a smaller corm weight. Below 75% 12 hrs and in 8 hrs, corm dry weight decreased fairly regularly with the light quantity. In 'Sonata', corm weight reached its maximum in a 16 hr photoperiod at 75% and 100% light intensity. At 25% light intensity no new corms were produced even in a photoperiod of 16 hrs (although 50% 8 hrs still gave a corm dry weight of 1.95 g).

Cormlet formation was poor in this experiment, perhaps because of the relatively high temperature under which plants were grown. Cormlets were formed only in the 8 hr photoperiod. The variety 'Princess Marijke' did not form any cormlets at al. The two cormlets of 'Rijnveld's Golden Yellow' in

25% 8 hrs were formed from buds on the aerial part of the stems and not from the lower buds on the new corm as is normally the case.

5.3.2. *Experiment 14.* – This experiment was a repetition of the previous one to give the results a firmer factual basis.

Corms of the two varieties 'Rijnveld's Golden Yellow' and 'Princess Marijke' were planted on 22 September, 1965, one corm of 5 cm circumference in a 12 cm plastic pot. The light intensities, 100%, 75% and 50% of the artificial light in the phytotron, and the photoperiods, 8 hrs, 12 hrs and 16 hrs, were the same as in experiment 12. The temperature lay between 21–25°C. Samples were collected every week after sprouting to determine the time of flower bud initiation.

Results: There were no differences in leaf number between the plants of the different treatments, or between the two varieties. The weekly examinations showed that flower bud initiation occurred first in the 8 hr photoperiod followed by 12 hrs. In each photoperiod it was retarded by low light intensity. 'Rijnveld's Golden Yellow' initiated flower buds sooner than 'Princess Marijke.'

The plants flowered in the same order as they had initiated flowers. No flowering occurred in 16 hrs and in the lowest intensity at 12 hrs.

The number of flowers per plant was smaller than in the previous experiment. The number of flowers on the main inflorescence was increased by a short photoperiod and by high light intensity. The percentage of open flowers per plant was high in 'Princess Marijke' but very low in 'Rijnveld's Golden Yellow', especially in the longer photoperiod.

Lateral stems developed only in 8 hrs, and even there their number was very small. The number of flowers per plant therefore very closely follows the number of flowers on the main inflorescence, except in 'Rijnveld's Golden Yellow' at 75% 8 hrs.

Stem length results follows the same trend as in experiment 13. On the whole, stems were slightly longer in low than in high light intensity.

Corm dry weight was proportional to light quantity, although there may have been a promotive effect of long day, as in both varieties corms were heavier in 50% 16 hrs than in 100% 8 hrs. No cormlets were formed.

5.4. Experiments with changing light regimes

5.4.1. *Experiment 15.* – This experiment was set up to distinguish between the effect of light energy and that of daylength. The two light regimes were 100% 8 hrs and 50% 16 hrs (same light quantity, but different photoperiod). The treatments were given in the artificial light rooms of the phytotron. Plants were removed from one light regime to the other after 2, 3, 4 or 5 weeks. Each treatment comprised 4 corms planted in one 22 cm black plastic pot. The two varieties used were 'Rijnveld's Golden Yellow' and 'Sonata.' The experiment started on 3 March 1965.

Results (Table 12): With regards to flower initiation 'Sonata' proved to be

TABLE 12. Experiment 15. Effect of a change in the photoperiod on Freesia 'Rijnveld's Golden Yellow'. Averages of 4 plants.

	Plants changed from 8 hrs 100%→16 hrs 50% after				Plants changed from 16 hrs 50%→8 hrs 100% after			
	2	3	4	5	2	3	4	5
	(weeks)				(weeks)			
'Rijnveld's Golden Yellow'								
Plant height (cm)	96	97	93	90	80	82	84	85
Number of leaves	13.3	13.5	12.0	11.5	10.3	10.8	11.0	11.3
Days to flowering	–	–	137	98	112	116	119	128
Flowers on main inflorescence	–	–	8.5	12.5	14.7	13.5	13.3	14.3
Number of lateral stems	–	–	0.0	0.5	2.3	1.8	1.8	1.8
Total number of flowers	–	–	8.5	16.3	40.7	34.8	29.5	36.5
Total number of open flowers	–	–	6.0	12.3	34.0	31.8	27.3	36.0
Stem length (cm)	–	–	83	84	69	77	76	76
'Sonata'								
Plant height (cm)	95	95	97	95	85	82	81	87
Number of leaves	14.0	14.0	13.0	15.0	11.0	11.3	11.0	11.7
Days to flowering	–	–	–	–	111	113	117	121
Flowers on main inflorescence	–	–	–	–	15.3	15.3	15.0	16.0
Number of lateral stems	–	–	–	–	1.8	1.8	1.7	2.0
Total number of flowers	–	–	–	–	34.3	36.5	36.7	37.7
Total number of open flowers	–	–	–	–	30.0	30.3	31.7	32.0
Stem length (cm)	–	–	–	–	67.8	63.5	62.3	69.7

sensitive of the photoperiod. Plants removed to 16 hrs formed 2 or 3 more leaves than those removed to 8 hrs. As there was no effect of the time of removal, flowers apparently had not been initiated even after 5 weeks. Nor can there have been a great effect of the daylength on the rate of leaf initiation. In 'Rijnveld's Golden Yellow' 16 hrs also retarded flower initiation but here the effect is not so pronounced and apparently after 5 weeks flower initiation had already taken place in 8 hrs, as removal to 16 hrs had no longer an effect.

Plants of 'Rijnveld's Golden Yellow' removed to 16 hrs after only 2 or 3 weeks at 8 hrs did not flower. 'Sonata' did not flower at all in 16 hrs. Plants removed to 8 hrs flowered earlier as their stay in 16 hrs had been shorter. Plants of Rijnveld's Golden Yellow' removed to 16 hrs after 5 weeks at 8 hrs were the earliest to flower of all groups, while those removed to 16 hrs after 4 weeks at 8 hrs were the latest. Apparently the time between 4 and 5 weeks at 8 hrs there had been a change in the response to daylength presumably because some decisive stage in flower development had been reached.

The number of flowers on the main inflorescence was very much lower in plants that developed in 16 hrs than in those in 8 hrs. The daylength in the early stages apparently did not affect this characteristic to any extent, as there are no consistent differences between plants removed from 16 to 8 hrs after 2, 3, 4 or 5 weeks.

Lateral stems were formed only on plants removed to 8 hrs. The time of removal did not play a role. Plants removed to 16 hrs, even after 5 weeks of 8 hrs, did not form laterals.

The total number of flowers per plant followed the same trend as the number of flowers on the main inflorescence.

Stem length was much greater in plants changed to 16 hrs than in those changed to 8 hrs. Among the latter, the time of removal from 16 hrs to 8 hrs did not show any consistent effects.

5.4.2. *Experiment 16.* – To get some further insight into the effect of light intensity at various moments of the growth period, the next experiment was carried out in a photoperiod of 16 hrs and four light intensities, viz. 25, 50, 75 and 100% of the fluorescent light in the phytotron. The following switches were made:

100%→ 25%	75%→25%	100%→ 50%
25%→100%	25%→75%	50%→100%

each 2, 3, 4 or 5 weeks after planting. Two varieties were used, 'Rijnveld's Golden Yellow' and 'Sonata'. The temperature was 22–24°C. One treatment comprised 4 corms in one 22 cm plastic pot. The experiment started on 3 March, 1965.

Results: None of the plants flowered, no doubt because of the long day and the high temperature.

The number of leaves was not affected by the light regimes. There were differences (from 11.3 to 14.7 in Rijnveld's Golden Yellow' and from 12.7 to

15.8 in 'Sonata') but these were not in any way consistent. Plant height, on the other hand, did show consistent differences: in all cases, plants moved from a high to a low light intensity were higher (i.e., had longer leaves) than those moved in the other direction. At the time of the final measurement, there were no longer significant differences in plant height between plants kept at same light intensity but moved at various dates.

The figures of corm dry weight showed that all plants kept at a low light intensity during the later stages of growth yielded much smaller corms than those at high light intensity. There are no consistent differences which could be due to the time of removal to the lower light intensity, so apparently corm formation was not affected by the light intensity during the first 5 weeks. No doubt as a consequence of high temperature and long day no cormlets were formed.

5.4.3. *Experiment 17.* – In an effort to improve upon the previous experiment, it was repeated under similar conditions, but with a photoperiod of 8 hrs instead of 16 hrs. Another difference was that the 25% light intensity was not used, so that the treatments were as follows:

100%→ 75%	100%→ 50%	75%→50%
75%→100%	50%→100%	50%→75%

The variety 'Princess Marijke' was used instead of 'Sonata.' The experiment started on 22 September, 1965.

Results (Table 13): In contrast to experiment 16, all plants flowered. The same number of leaves were formed in all treatments. There were no differences in leaf length (plant height), not even between the groups changed from 100% to 50% and from 50% to 100%, which showed significant differences in the previous experiment.

The time from planting to flowering varied between 133 and 160 days in 'Rijnveld's Golden Yellow' and between 129 and 187 days in 'Princess Marijke.' High light intensity promoted flower development, low light intensity reduced it. As there was no effect of light intensity on flower initiation (as the number of leaves shows) earliest flowering occurred in plants switched to 100% light intensity at the earliest date, i.e. after 2 weeks, while flowering showed the maximal retardation when plants were switched after 2 weeks to the lowest light intensity.

Most of the other figures can be explained by this trend, although there are exceptions which are hard to explain, e.g. why switching from 100 to 75% and vice versa had a greater effect than switching from 100 to 50%.

There was a strong effect of the light intensity on the number of flowers in the main inflorescence. This ranged between 10 and 18 in 'Rijnveld's Golden Yellow' and between 7 and 24 in 'Princess Marijke'. Small numbers were found in plants at a low light intensity during the later stages of growth. Plants moved to 50% after two weeks had the smallest number of flowers. Again, the series of figures shows some irregularities that are hard to explain and may be due to the small number of plants per treatment.

TABLE 13. Experiment 17. Effect of changes in light intensity in an 8 hrs photoperiod on two Freesia cultivars. Averages of 4 plants.

	changed	'Rijnveld's Golden Yellow'						'Princess Marijke'					
	after (weeks)	100% →75%	75% →100%	100% →50%	50% →100%	75% →50%	50% →75%	100% →75%	75% →100%	100% →50%	50% →100%	75% →50%	50% →75%
Number of leaves	2 w	12.7	12.5	12.8	12.8	12.5	13.3	13.0	12.5	13.3	13.3	12.8	13.8
	3 w	12.5	13.3	12.5	13.0	12.8	13.3	13.3	13.0	12.8	13.3	13.5	13.5
	4 w	13.3	12.8	12.8	12.8	13.3	12.7	13.0	13.5	13.3	13.5	13.3	13.8
	5 w	13.0	12.5	12.7	12.5	12.3	12.8	13.5	12.5	13.5	12.5	12.0	13.5
Days to flowering	2 w	155	133	144	146	138	151	187	129	145	144	168	162
	3 w	151	144	150	145	147	143	170	140	abnormal	148	151	150
	4 w	160	148	146	147	144	141	183	157	158	159	164	158
	5 w	144	143	145	136	147	137	151	165	148	153	167	140
Flowers on main inflorescence	2 w	10.3	17.0	11.0	15.0	12.5	15.7	11.0	21.0	13.5	16.7	7.5	11.3
	3 w	16.3	17.3	11.0	16.7	10.5	17.3	18.0	17.5	abnormal	17.8	20.5	17.3
	4 w	14.3	15.8	12.0	16.3	13.3	14.7	13.7	13.5	10.0	24.3	14.5	16.5
	5 w	17.0	17.0	18.0	17.3	13.3	16.3	20.0	22.0	16.0	23.0	14.0	19.8
Stem length (cm)	2 w	60.3	65.0	72.8	72.5	73.8	63.7	99.3	78.0	94.0	87.0	87.5	94.3
	3 w	70.0	70.8	70.8	76.3	74.5	68.3	104.0	89.5	abnormal	94.0	92.0	100.3
	4 w	66.0	66.8	71.5	68.5	72.8	66.0	92.7	77.3	89.0	74.0	101.5	91.8
	5 w	64.0	58.0	73.0	66.3	70.5	75.0	81.3	92.3	77.0	90.0	93.7	88.3
Corm dry weight (g)	2 w	1.85	2.20	1.22	2.51	1.51	2.25	1.38	3.19	0.98	2.24	0.82	2.39
	3 w	1.79	2.65	1.18	2.68	1.22	1.87	1.09	2.66	0.83	2.45	0.79	1.89
	4 w	1.41	1.93	1.31	1.81	1.55	2.02	0.75	1.95	1.20	1.94	0.88	1.63
	5 w	1.22	2.00	1.24	2.38	1.77	2.21	1.26	2.00	0.92	1.76	0.84	2.26

As the number of lateral stems was very small, the number of flowers per plant follows the same trend as the number of flowers in the main inflorescence.

The differences between plants moved to high light intensity and those moved to low intensity became more pronounced when instead of the number of flower buds per plant the number of open flowers is taken into consideration. Obviously low light intensity inhibited the development from the bud into an open flower.

Stem length varied between 60 and 76 cm in 'Rijnveld's Golden Yellow' and between 78 and 101.5 cm in 'Princess Marijke.' In 13 out of 24 cases stems were longer when plants were moved to low light intensity than when they were moved to high intensity; in 8 treatments the opposite was the case. One may perhaps conclude from these figures that there was a small tendency for longer stems in lower light intensity.

Corm dry weight was much higher for the plants changed from low to high light intensities than for those moved in the opposite direction. In 'Princess Marijke' it looks as if plants moved to high light intensity at an early date had larger corms than those moved later. In 'Rijnveld's Golden Yellow' the figures are even more irregular and there is no effect of the moment of the switch.

Cormlet production was low, presumably because of the high temperature. 'Princess Marijke' did not form any cormlets at all, 'Rijnveld's Golden Yellow' only a few.

5.5. The effect of days shorter than 8 hours

5.5.1. *Experiment 18A.* – As flowering of Freesia is promoted by an 8 hr day, an experiment was set up to study the effect of photoperiods or less than 8 hrs. The following treatments were given: 1, 2, 3, 4, 5, 6, 7 or 8 hrs. 100% and 2, 4, 6 or 8 hrs 50% of the artificial light in the phytotron.

The variety was 'Rijnveld's Golden Yellow'. Corms were planted on 22 September, 1965, one in a 12 cm plastic pot. The temperature was 22–24°C during the photoperiod; in the dark it was a few degrees lower.

Results (Table 14): In 100% light, the leaf number was about the same (9–10) in all daylengths. In 50% light, it was higher (11 to 13.5). Leaf length was greater in 50% than in 100%, except in 1 hr 100% where it was also rather high. There was no clear effect of daylength. As is already clear from the number of leaves, flower initiation was not affected by daylength but strongly by light intensity. It appears that this is indeed an effect of light intensity, not of light quantity, as e.g. plants at 4 hrs 50% initiated flowers much later and after a greater number of leaves than those at 2 hrs 100%. The plants at 1 and 2 hrs 100% and at 2 and 4 hrs 50% died before flowering. The number of days to anthesis decreased with increasing photoperiod, from 125 at 4 hrs 100% to 110 at 8 hrs 100%. The plants at 50% were much later, as could be expected from the retardation of initiation.

The number of flowers in the main inflorescence was the same in all daylengths at 100% but was slightly higher in 8 hrs 50%. In 100% light, the number

TABLE 14. Experiment 18A. Effect of very short days on Freesia 'Rijnveld's Golden Yellow'. Averages of 4 plants.

	Photoperiods in hours											
	100% light								50% light			
	1	2	3	4	5	6	7	8	2	4	6	8
Plant height (cm)	88	78	82	74	80	75	80	77	89	92	91	96
Number of leaves	9.3	9.5	10.3	9.8	10.8	10.0	10.3	10.3	11.3	13.7	13.5	12.3
Age of plants at flower initiation (weeks)	4	4	5	5	5	5	5	4	9	9	9	6
Days to flowering	Died	Died	125	121	115	113	113	110	Died	Died	*	150
Flowers on main inflorescence	–	–	9.0	9.0	9.0	8.8	8.8	9.5	–	–	*	10.8
Number of lateral stems	–	–	0.5	1.0	1.8	1.8	1.3	2.0	–	–	*	0.0
Total number of flowers	–	–	11.5	12.8	18.5	19.5	15.0	20.8	–	–	*	10.8
Total number of open flowers	–	–	6.8	9.3	14.5	16.7	14.8	20.5	–	–	*	5.0
Stem length (cm)	–	–	51	51	63	62	65	70	–	–	*	69
Corm dry weight (g)	–	–	1.10	1.80	2.39	2.75	3.01	3.59	–	–	0.30	1.15

* No flowering after 220 days

of lateral stems increased regularly with the daylength from 0.5 in 3 hrs to 2.0 in 8 hrs. In 50% it was nil. The total number of flowers per plant showed a tendency to increase with the daylength. The number of open flowers showed the same tendency, but much stronger as the longer the day, the higher the percentage of flower buds that actually opened.

In 100% light intensity, stem length increased with the photoperiods from 51 cm in 4 hrs to 69.5 cm in 8 hrs. In 50% light the plants had long stems (68.5 cm).

Corm dry weight increased with the light quantity, from 1.1 g in 3 hrs 100% to 3.6 g in 8 hrs 100%.

In 50% light it was relatively low, i.e. lower than one would expect on the basis of corm production in 100% light.

Cormlet formation was negligible.

5.5.2. *Experiment 18B.* – As plants in very short photoperiods initiated flower buds but died without flowering, while plants in somewhat longer photoperiods which did flower had small flowers and a weak stem, three plants were moved after 9 weeks from the photoperiods 1, 2, 3, 4, 5, 6 and 7 hrs and 100% light intensity to 8 hrs 100% light.

Results: The conclusions, drawn from the results of experiment 18A, regarding the effect of photoperiod on various characteristics of the plant, were confirmed, except that the tendency for the number of side stems to increase with the photoperiod was very slight in this experiment. Another difference – no doubt due to the fact that all plants received a relatively high quantity of light during the later stages – was that the percentage of buds which developed into open flower was consistently high.

5.6 Discussion

5.6.1. *The effect of daylength.*

Flower initiation was generally promoted by short day (experiment 8, 12, 13, 14). The effect was not always very strong, however, and absent in experiments 9 and 11. Much more pronounced is the effect of short day during the initial stages of flower development (experiment 12). In the same experiment it was found that during the later stages there is a slight promotive effect of long day. This might explain why in some experiments (9, 10, 11) the promotive effect of short day was not clear or absent, and perhaps also why Heide (1965) found only a slight promotive effect of SD in yellow K & M Super Freesias and no promotion at all in blue ones. The results of experiment 18 show that days shorter than 8 hrs did not have any additional photoperiodic effect. The differences between the treatments can all be explained as effects of light quantity. The effect of the photoperiod of course depends on the temperature. In experiment 8, done in the summer at high temperatures, there were 74 days between flower initiation in the shortest and the longest photoperiod. In experiment 13, the difference was 55 days. In expiriment 9, however, which was car-

ried out in the winter, there was only one week between flower initiation in the shortest and the longest photoperiod and the number of leaves was not affected.

The effect of daylength on the number of flower buds on the terminal inflorence was not unequivocal. Sometimes there was no effect (experiment 9, 11), sometimes there were more in SD (experiment 8, 10), sometimes more in LD (experiments 12, 13). Long day led to a decrease of the percentage of buds that opened into flowers (experiments 11, 12). In short day not only was the number of 'blind' flowers smaller but the plants looked healthier and the leaves were darker green.

The number of lateral stems in all the experiments increased when the days were shorter. Consequently, the total number of flowers per plant was always greater in short days than that in long days.

The flower stems were longer in long days than in short days (experiment 13, 14 and 15). The long day appears to have its effect in an early stage; when it was applied in a later stage it did not promote stem length anymore (experiments 10 and 11).

Long days strongly promoted corm formation at all stages of plant growth. A similar photoperiodic effect was observed in onions bulbs and garlic (ALLARD and GARNER, 1940; PARIBOK, 1963). KOSUGI et al. (1957) found that weight and number of cormels of Gladiolus were greatest under short day (9–10 hrs). This last case is much more common and has been found also in potato, tuberous Begonia, Dahlia and other tuberous plants. More in line with the latter cases is the fact that cormlet formation in Freesia was found to be promoted by short day. Experiment 12 brought out the fact that SD acted on this process especially during the later stages of plant development.

The fact that long day promotes corm growth but inhibits the initial stages of flower development again raises the question if there exists a competition between the two processes.

5.6.2. *The effect of light intensity*

In this discussion of the effect of the light intensity it should be emphasised that the highest light intensity was that of the artificial light in the phytotron and that the lowest was 25% of this intensity. It should be kept in mind that higher intensities of light might have had a different effect.

The different light intensities did not significantly influence the number of leaves per plant, which means that there was little effect on flower initiation.

Flower development, however, was strongly enhanced by high light intensity. In the lowest light intensity, plants in 16 hrs or 12 hrs did not flower at all. WASSINK (1960) obtained similar results in Gladiolus, where flowering was also much reduced at low light intensities.

There was no particular sensitive phase for light intensity; plants switched from low light intensities to higher ones flowered better, and those switched in the other direction flowered more slowly, irrespective of when the switch was made. Evidently, the earlier the plants were moved, the stronger the effect of the second light intensity.

The number of flowers on the main inflorescense increased with the light intensity when the photoperiod was favourable (8 hrs). Longer days were inhibitive and this effect could not be overcome by a higher light intensity (experiment 13, 14, 17).

The percentage of open flowers also increased with the light intensity (experiment 17). As the number of lateral stems per plant followed the same trend, the greatest number of flowers per plant was found at short photoperiods and high light intensity (experiment 13).

Stem length was usually promoted by high light intensity, at least when the photoperiod was short. In a 12 hour day, stem elongation of 'Rijnveld's Golden Yellow' was promoted by low light intensity (experiment 13 and 14) but 'Princess Marijke' and 'Sonata' showed a different pattern.

As corms are storage organs one would expect their dry weight to be proportional to the light quantity as this determines the intensity of photosynthesis. Generally speaking this is indeed the case, although the figures of experiments 13–15 are not very regular. Experiment 16 showed that especially the light intensity during the later stages is very important, while during the first 5 weeks it did not seem to have any effects, but the figures of experiment 17, although pointing in the same direction, are again rather irregular.

6. THE INTERACTION BETWEEN TEMPERATURE AND LIGHT

6.1. INTRODUCTION

The environmental factors never operate separately upon plants. Temperature and light, for instance, almost always interact. Temperature not only determine the reactions of the plants to the daylength, but also to light intensity, and vice versa.

The relations between temperature and the photoperiodic response are complicated. As a consequence of a rise in temperature, the critical daylength may either increase or decrease. There are even reports of species which are short day plants at one temperature but long day plants at another (ROBERTS and STRUCKMEYER, 1938). The latter cases are enigmatic (and require further study), but most other cases can be explained by the knowledge that in morphogenetic responses, e.g. flower induction, promoting as well as inhibiting processes play a role. Temperature affects both processes, and the visible reaction of the plant depends on which effect predominates. In some short day plants, a rise in temperature may promote the inductive dark processes more than the inhibitive processes occurring in the light, in other species the effect may be just the other way round. In the first case, the critical daylength increases, in the second, it decreases.

In Freesia, short day or long night were reported to promote flower initiation (GARNER and ALLARD, 1920; LAURIE and POESCH, 1932; POST, 1942; DEBUISSON, 1962; KLOUGART and JØRGENSEN, 1962), but high temperature was shown to interfere with this effect (HEIDE, 1965). KLOUGART (1962) found that Freesia plants from seeds did not flower in the summer (long days) as long as the air temperature did not drop below 20 °C, and concluded that both short day and a low night temperature accelerated flowering.

TABLE 15. Experiment 19. Effect of temperature and photopertiod on Freesia 'Rijnveld's Golden Yellow'

	8 hrs TL light					
	9°	12°	15°	18°	21°	24°
Days to sprouting	19.7	18.7	14.0	11.3	9.0	7.7
Plant height (cm)	30	35.3	49.5	54.7	78.7	74.0
Number of leaves	6.5	6.8	7.6	8.2	11.6	12.8
Days to flowering	147	129	108	113	119	127
Flowers on main inflorescence	6.4	6.2	9.4	9.6	13.8	15.0
Number of lateral stems	2.2	2.2	2.0	2.0	1.8	2.0
Total number of flowers	13.2	17.3	24.6	27.0	37.0	39.3
Stem length (cm)	29.7	30.6	41.0	43.5	71.3	68.3
Corm dry weight (g)	0.66	0.61	1.94	2.42	6.22	7.26
Number of cormlets	4.8	7.2	4.6	5.0	1.5	1.0
Cormlet dry weight (g)	0.79	1.25	1.78	2.04	0.34	0.15

6.2. Experiments with temperature and light

6.2.1. *Experiment 19*: This experiment was set up to study the effect of 6 levels of temperature (9°, 12°, 15°, 18°, 21° and 24°C) at each of 4 light conditions, viz. 8 hrs, 12 hrs, and 16 hrs artificial light in the phytotron and the normal daylight. On 3 August 1964, corms of 5 cm circumference of the variety 'Rijnveld's Golden Yellow' were planted. Three corms in one 22 cm black plastic pot were used per treatment.

Results (partly summarized in table 15): The time required for sprouting was reversedly proportional to the temperature. At 24°C corms sprouted after about 7 days while at 9°C they required about 19 days. There were no significant differences between the light conditions.

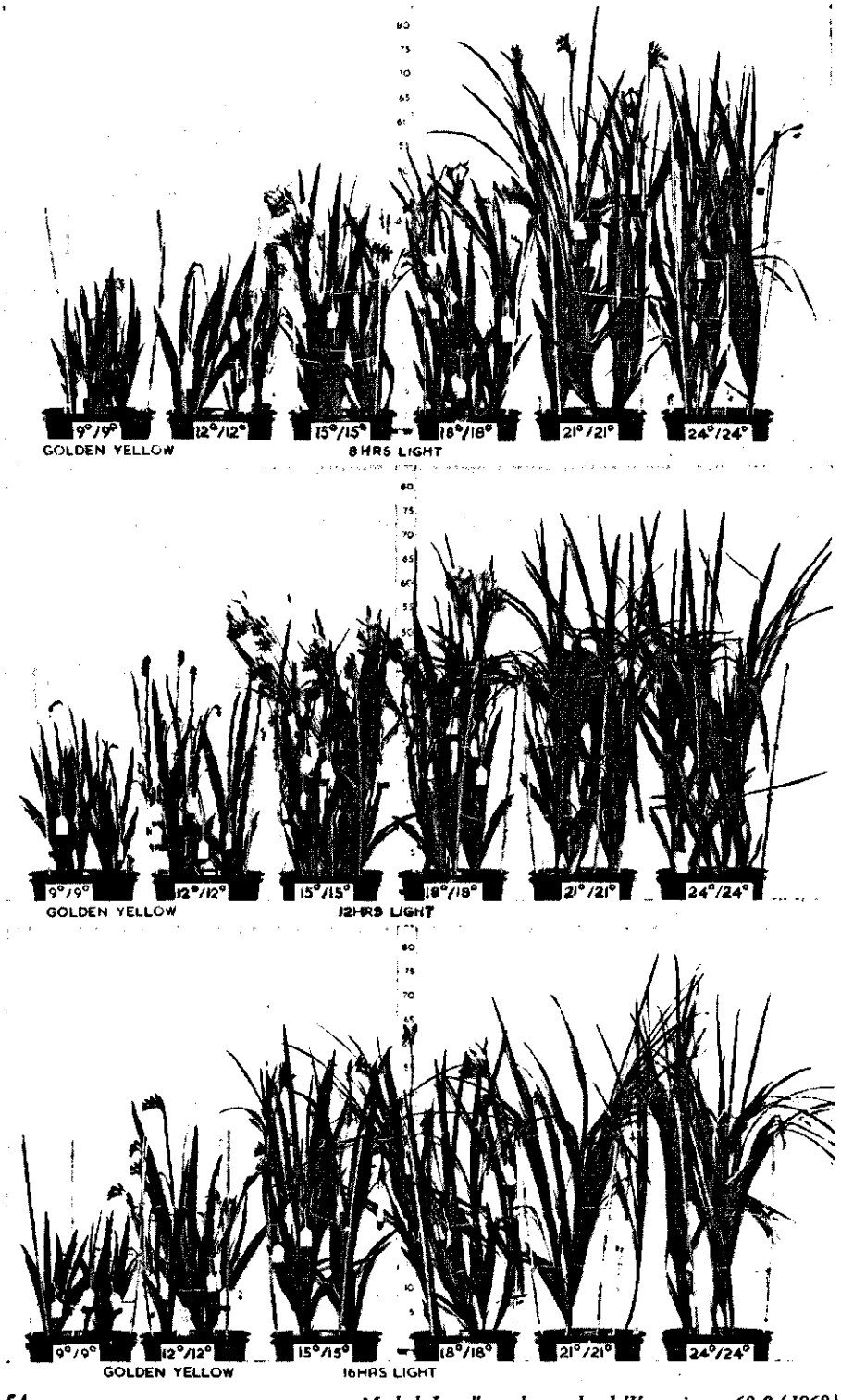
Plant height was measured four times with intervals of one month. In all stages of growth plant height increased with the temperature from 9° to 21°, while those at 24° were somewhat lower again. In all temperatures plants in 8 hrs of light were lower than those in the other light conditions. Those in 12 hrs of light were usually highest, although the difference with 16 hrs was only small. Plants grown in natural day light were the shortest at all levels of temperature.

The number of leaves per plant increased with the temperature but also with the quantity of light. As a consequence, the greatest number of leaves (13.8) was found in natural daylight at 24° and the lowest number (6.5) in 8 hrs of light at 9°. An exception to this trend are plants in 16 hrs at 21° and 24° which had a rather low number of leaves (10.8 and 11.3, respectively). The effect of temperature is much greater than that of light.

The number of days from planting to anthesis also increased with the light quantity. The relation with the temperature, however, is more complicated. In accordance with experiments 1 and 3, the optimal temperature for flowering was 15° (at 12 hrs of light, it was 18°C). At both lower and higher temperature flowering was retarded. At 8 hrs of light, the retarding effect of 12° and 9° was greater than that of 21° and 24°, but at the other light conditions it was the

Averages of 3 plants.

12 hrs TL light						16 hrs TL light					
9°	12°	15°	18°	21°	24°	9°	12°	15°	18°	21°	24°
19.0	16.7	13.3	12.3	10.0	6.7	18.7	16.3	12.0	11.7	10.3	6.7
34.5	43.9	60.3	66.0	81.4	75.8	27.3	40.8	63.2	65.3	78.6	74.0
7.0	7.0	8.2	10.0	14.0	12.7	7.6	7.8	9.8	10.7	10.8	11.3
155	130	116	109	160	179	155	127	111	117	180	–
6.0	7.6	8.8	13.5	15.4	12.4	6.8	8.0	12.4	11.5	7.5	–
2.5	2.6	2.3	1.8	2.4	0.6	2.4	1.8	1.6	1.2	0.0	–
20.0	28.6	25.7	37.5	46.8	17.0	22.0	22.8	30.6	20.2	7.5	–
36.3	41.0	45.3	52.4	81.5	71.6	26.1	35.9	49.6	55.0	64.8	–
1.98	2.64	4.80	7.33	8.68	6.71	1.91	3.56	7.69	7.04	9.95	7.42
4.5	4.9	2.2	3.5	1.0	0.6	5.8	5.4	3.8	3.3	1.0	0.0
13.6	1.49	1.01	2.58	0.29	0.11	1.34	2.14	2.10	1.53	0.69	0.0


9°/9°
12°/12°
15°/15°
18°/18°
21°/21°
24°/24°
GOLDEN YELLOW
8 HRS LIGHT
9°/9°
12°/12°
15°/15°
18°/18°
21°/21°
24°/24°
GOLDEN YELLOW
12HRS LIGHT
9°/9°
12°/12°
15°/15°
18°/18°
21°/21°
24°/24°
GOLDEN YELLOW
16HRS LIGHT

other way around. In 16 hrs of artificial light the plants at 24 °C never reached the flowering stage at all.

The number of flowers on the main inflorescence was not significantly affected by the light regime, but it showed a strong influence of the temperature. In 8 hrs AL and in NL it increased regularly with the temperature from about 6.5 at 9° to about 15 at 24°C. In 12 hrs AL it increased from 9° to 21°, but at 24° it decreased again. At 16 hrs AL, it increased up to 15° but fell off at temperatures of 18° and higher.

The number of lateral stems did not appear to be affected by temperature as such, but there were strong interactions between temperature and light regime. At 8 hrs AL, the plants formed about 2 side stems at all temperatures. At 12 hrs AL, this number was somewhat higher (about 2.5) except at 24° where it was only 0.6. In 16 hrs AL, the number of lateral stems decreased from 2.4 at 9° to 0 at 21°. In NL it increased from 1.0 at 12° to 2.2 at 21°, then fell off to 1.0 again at 24°.

The total number of flowers per plant reflects the tendencies of the number of flowers on the main inflorescence and the number of lateral inflorescences. The smallest number of flowers was formed in NL. More were formed in 8 hrs AL. In the latter case, the number of flowers increased from 9° to 24°; in NL it increased only to 21° and fell off a little at 24°. In 12 hrs AL, it was still higher than at 8 hrs, but it dropped strongly at 24°. In 16 hrs AL, it was higher at 9°–15 °C but rapidly fell off at 18° and 21 °C. The greatest number of flowers per plant was about 47 in 12 hrs AL at 21 °C. The smallest was 0, in conditions not so very much different: 16 hrs AL at 24 °C.

Stem length was primarily affected by temperature. It showed a continuous increase from 9° to 21 °C, but fell off slightly at 24 °C. There was also an effect of the light regime. Shortest stems were formed in NL, followed by 8 hrs AL which was again followed by 12 hrs AL. At 9°–15° the differences were greater than at 18°–24°C. At 16 hrs the curve is steeper (Fig. 1) because stems were shorter at low and high temperature but longer at the intermediate temperatures 15° and 18 °C.

Corm formation, expressed as dry weight, increased both with the temperature and the light quantity, except that at 24 °C in 12 and 16 hrs AL the values were somewhat lower than at 21 °C (in 16 hrs AL no doubt due to the shorter life of the plants). As a consequence, the heaviest corms were formed in 16 hrs AL at 21°, and the lightest in 8 hrs AL at 9° and 12 °C. The dry weight of the corms formed in NL lay in between that of the corms in 8 hrs and 16 hrs AL.

The number of cormlets per plant was affected primarily by the temperature. The optimal temperature appears to have been 12 °C. At higher temperatures cormlet number rapidly decreased (Fig. 2). The 8 hr photoperiod gave more

PHOTO 4–6. Effect of 6 levels of constant temperature and 3 daylengths in the phytotron. Earliest flowering occurred at 15–18 °C. Long day slightly promoted flowering at low temperature but reduced it at 21–24°. In 16 hrs of light, plants at 24 °C did not flower at all (Experiment 19).

TABLE 16. Experiment 20. Effect of temperature and photoperiodism on Freesia 'Blauwe Wimpel' after

	8 hrs TL light						12 hrs TL			
	9°	12°	15°	18°	21°	24°	9°	12°	15°	18°
Days to flowering	127	120	113	107	107	109	118	116	104	99
Flowers on main inflorescence	7.7	6.7	8.3	8.3	11.3	10.3	6.0	6.3	10.0	10.3
Length of first outer bract	1.46	1.50	1.70	1.73	19.33	23.27	1.77	1.63	1.73	2.00
Length of first inner bract	1.37	1.57	1.40	1.40	4.33	6.00	1.60	1.40	1.43	1.63
Length of inflorescence	6.33	4.83	6.00	7.50	19.50	15.83	5.33	5.33	7.17	7.50
Distance between 1st and 2nd flower	2.17	1.40	1.50	2.50	12.50	8.77	2.17	1.83	2.17	2.33
Stem length (cm)	33	28	34	38	48	52	31	30	40	43

cormlets per plant than in 12 or 16 hrs, especially at low temperature. The greatest number of cormlets were produced under the natural daylight conditions, however. In 16 hrs AL and in NL, no cormlets were produced at 24°C.

The dry weight of the cormlets yields a new item of information: it appears that although the maximum number of cormlets was formed at 12°, the maximum dry weight was produced at 18°, except in 16 hrs AL.

6.2.2. *Experiment 20.* – This experiment was similar to the preceding except that the corms, which were planted on 21 October 1964, were left in a greenhouse with a controlled temperature of about 15°C until the treatments started on 9 November 1964. Other differences were that the corms were planted separately in 12 cm plastic pots and that the varieties used were

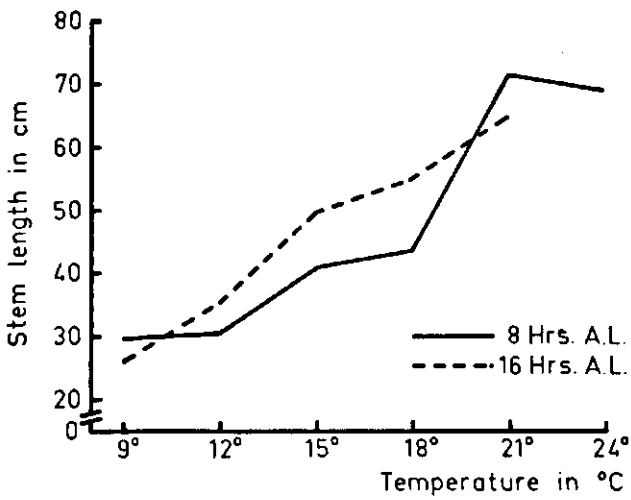


FIG. 1. Effect of photoperiod and temperature on the stem length (experiment 19).

initiation. Averages of 3 plants.

light		16 hrs TL light						Natural daylight					
21°	24°	9°	12°	15°	18°	21°	24°	9°	12°	15°	18°	21°	24°
103	136	114	111	102	101	93	101	134	131	118	108	103	158
11.0	9.7	5.7	7.0	11.3	10.0	14.0	abnormal	14.0	7.0	6.0	7.7	9.0	11.0
12.07	14.60	1.40	1.63	2.67	3.13	29.83	16.50	1.50	1.73	1.47	2.27	2.27	1.53
3.67	2.77	1.20	1.37	1.70	1.77	5.50	3.75	1.50	1.50	1.37	1.60	1.43	1.37
13.00	15.83	3.00	5.33	9.83	9.17	13.00	16.00	5.67	5.67	5.83	9.50	10.33	6.67
6.33	3.27	1.07	1.90	4.33	4.17	8.00	12.50	2.07	2.47	1.37	5.50	4.17	1.43
70	68	33	34	44	57	52	69	43	41	54	46	66	74

'Blauwe Wimpel' and 'Pimpernel.'

Results (Table 16): The number of days to flowering was much smaller than in the previous experiment, especially at the high temperatures up to 21 °C and in the long photoperiods. In accordance with experiment 19, more light led to guicker flowering. This time, plants in NL were the last to flower, which can be explained by the low light intensity at the time of the year. The reaction to temperature was different, however. Plants of 'Blauwe Wimpel' flowered optimally, i.e. after the minimum number of days, at 21 ° (except in 12 hrs AL, where 18 ° was slightly earlier) while for 'Pimpernel' the optimal temperature was 18 °C.

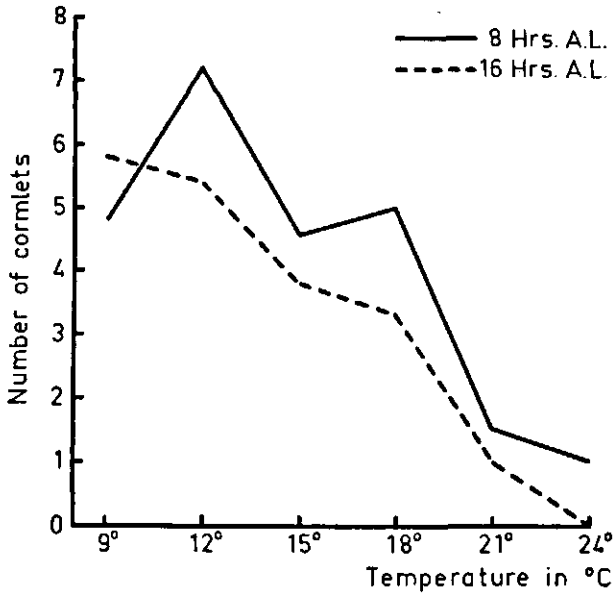


FIG. 2. Effect of photoperiod and temperature on the number of cormlets per plant (experiment 19).

In all cases the retarding effect of 24° was very strong, except for 'Blauwe Wimpel' in 8 hrs AL and in 16 hrs AL. In the last case, however, the inflorescences were abnormal: there was only one flower, followed by a vegetative rosette at the top of the stem.

The number of flowers per inflorescence showed the same trend as in the previous experiment: it increased with the temperature and did not show a consistent effect of the light regime.

The most striking result of this experiment was the formation of abnormal inflorescences.

The normal shape of the Freesia inflorescence is that the top portion of the stem on which the flowers are inserted is at a right angle with the rest of the stem. The length of this horizontal end varies from about 4 to 12 cm, according to the environmental conditions and to the number of flowers. The latter are usually evenly spaced at about 1 to 2 cm. The flowers are 5 to 7 cm long, and the green bracts about 1.2 to 2 cm.

In this experiment, however, the stem tips were not bent and the bracts and especially the first flower were very long. The distances between flowers were irregular. These abnormally shaped inflorescences mostly occurred at high temperature and in long photoperiods. The variety 'Blauwe Wimpel' was more susceptible than 'Pimpernel.' In NL there were fewer abnormal inflorescences than in the other light regimes.

6.3. Discussion

The results of experiments 19 and 20 allow a comparison of the effects of temperature and light. Within the given ranges of these two factors, the effect of temperature was usually greater than that of light. Corm sprouting and number of flowers on the main inflorescence were not affected by light at all. Among the characters studied only the number of lateral stems was determined primarily by the light conditions.

As a rule, a higher temperature had a similar effect as a longer photoperiod (which in the present experiments also meant more light). The leaf number increased with temperature and light, which means that both factors delayed flower initiation. The number of days to flowering decreased with light quantity but there was an optimal temperature of 15° in experiment 19 and 18°–21° in experiment 20, above which the number of days increased again.

Plant height increased with the temperature to 21° and with the photoperiod to 12 hrs; at 24° and 16 hrs it was slightly lower again, probably due to the fact that the plants at 24° and 16 hrs of light died before flowering. Stem length showed the same trend with respect to temperature; as to photoperiod, 16 hrs gave the longest stems.

Corm formation also increased with light and temperature, the heaviest corms being formed at 21° and 16 hrs of light. Cormlet formation showed the opposite trend with regard to both factors: the greatest number were formed at 12° and 8 hrs of light.

The number of flowers in the main inflorescence increased with the temperature, but, as said before, it was not affected by the photoperiod. This is in accordance with the experiments 8 to 12 where no consistent effects of daylength were found.

In previous experiments it was found that the number of lateral stems was increased with short day and with increasing light intensity. The latter observation probably explains why in experiment 19 there were slightly more lateral stems in 12 hrs than in 8 hrs. In 16 hrs, the inhibitive effect of the long photoperiod became predominant, but it proved to be proportional to the temperature. At 9 °, there were as many lateral stems in 16 hrs as in 12 or 8 hrs.

7. THE EFFECT OF PLANT DENSITY AND TIME OF PLANTING

Experiment 21. – To see if the results of the previous experiments can be used to interpret the behaviour of Freesia plants under the conditions of horticultural practice, an experiment was set up to study plants grown under the normal greenhouse conditions throughout a year and at different planting densities.

Corms of the standard size 5 cm circumference of the variety 'Rijnveld's Golden Yellow' were planted on the 1st of each month in 3 planting densities, viz. at distances of 7, 10 and 15 cm between the corms. The temperature of the greenhouse was not controlled during the summer, but it was heated in the winter months (November-March) to about 15–20 °C during the day. The night temperature was always lower than the day temperature.

Results: Plant height reached its maximum after planting during the summer months (June to August) and then decreased with the planting date until a minimum (half the maximum height) was reached after planting in February. Plants at wide distances were shorter than those at a narrow distance. This difference may be due to an etiolating effect, as it did not appear in plants started in June or July.

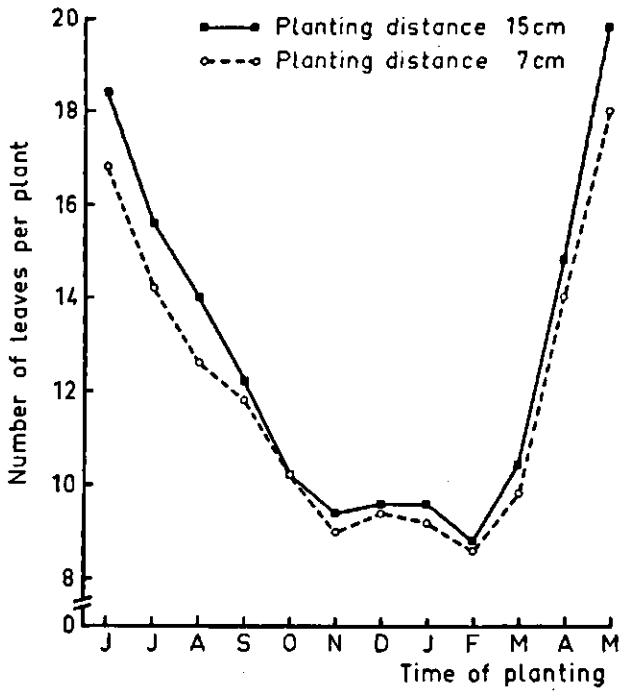


FIG. 3. Effect of planting distance and time of planting on the number of leaves per plant (experiment 21).

The number of leaves per plant shows a similar trend (Fig. 3). The greatest number of leaves (18 or more) were formed after planting in May or June; the smallest number (8.8) after planting in February. In plants started between October and February there was no difference in leaf number between plants at different distances, but those planted in the other months of the year formed more leaves when planted at 15 cm than at 7 cm. The difference was particularly great (1.6 to 1.8 leaves) in the May and June plantings.

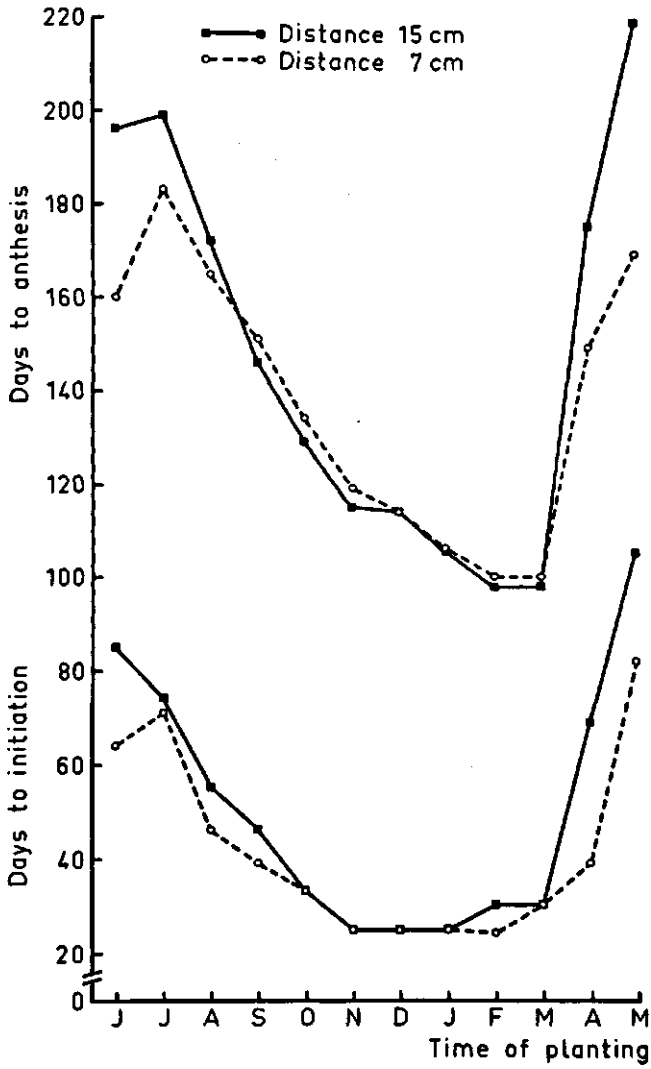
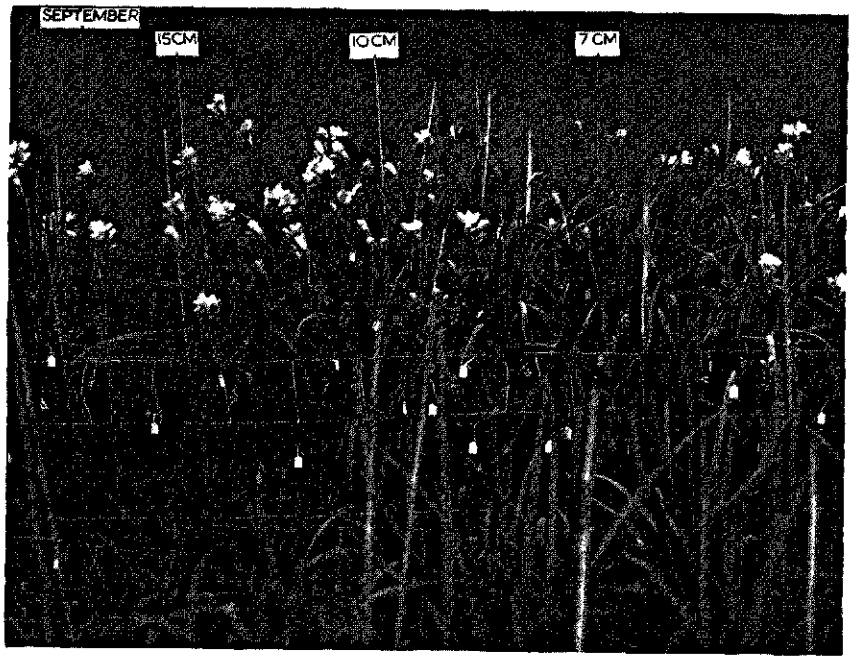


FIG. 4. Effect of planting distance and time of planting on the number of days to flower initiation and to anthesis (experiment 21).


15CM
10CM
7CM
JUNE


SEPTEMBER
15CM
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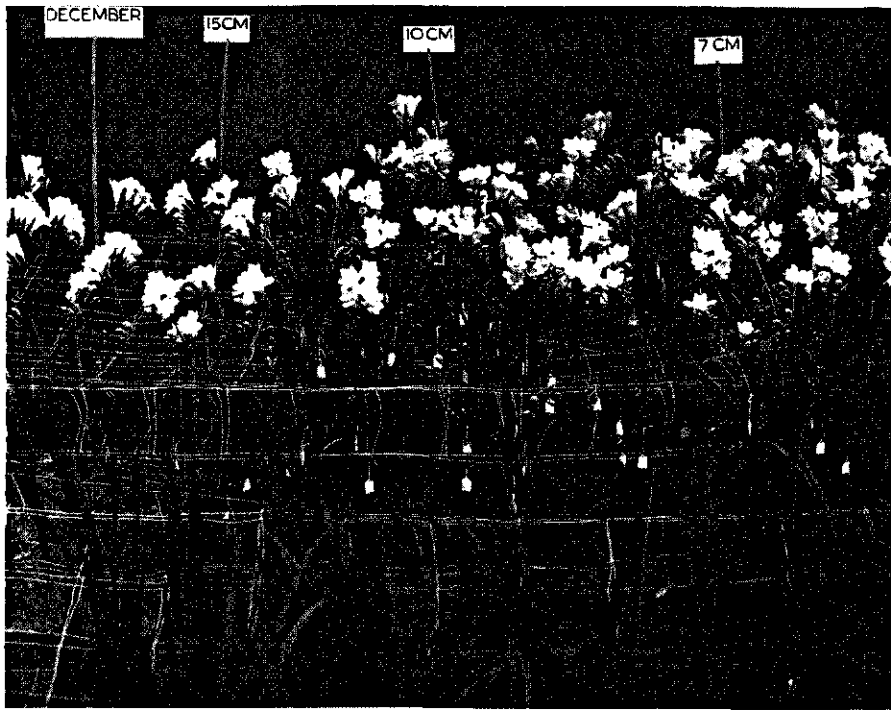

PHOTO 7–9. Effect of plant density and time of planting (Experiment 21). Plants started on June 1st 1965 flowered earlier at a 7 cm planting distance, those started on September 1st 1965 gave earlier flowering at 15 cm, while after planting on December 1st 1965 there were no differences in the time of flowering between the three planting distances.

The differences became more pronounced when instead of leaf number the number of days to the initiation of the first bract of the inflorescence was taken as a measure (Fig. 4). The minimum number of days was 25 after planting in November, December or January, irrespective of the planting distance. Initiation required the longest time after planting in May, viz. 82 days in plants at a distance of 7 cm, 92 days at 10 cm and 105 days at 15 cm. These differences were still present at anthesis, although they had become relatively smaller (Fig. 4). The first to flower were plants started in January and February, which required 85 to 87 days, while plants started in May required 155 to 196 days.

The number of flowers on the main inflorescence reached a maximum of about 14 in plants started in May and June and a minimum of about 8 flowers after planting from October to February. In May and June plantings the plants at 15 cm had slightly more flowers in the main inflorescence than those planted closer together; in July and August plantings, it was the other way around. The differences are small, however, and it is doubtful whether they are significant.

The number of lateral stems was highest (about 3.5) in plants started in June.

In plants started from July to October it was low (less than 1 in July and August plantings) in plants close together and high in plants 15 cm apart. In plants started between December and March it was about 2–2.5 irrespective of the planting distance. Planting in November and April resulted in few lateral stems (0.4 to 2). the plants at a greater distance having more side stems than those close together (Fig. 5).

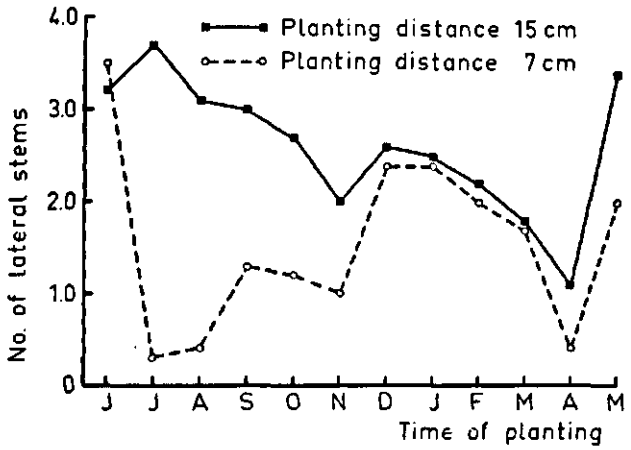

FIG. 5. Effect of planting distance and time of planting on the number of lateral stems (experiment 21).

The total number of open flowers per plant showed considerable variation, from 33 to 47 in plants started in June to 12 to 18 in plants started in April. In all plantings, plants spaced 15 cm had more flowers than those closer together. This tendency was strongest in plants started in July and August, and very weak or absent in plants started in December and January.

Total length of the main stem was greatest (about 100 cm) after planting in June, July or August, while the shortest stems (42–59 cm) were formed after planting in February and March.

In plants started between December and March, the longest stems were formed at the smallest planting distance. In the July planting the difference was the other way around (91 cm at 7 cm, 101 cm at 10 cm and 107 cm at 15 cm). In other plantings the differences were small.

When stem length was measured only to the first node below the main inflorescence, the trend is different: the longest stems (29–34 cm) were found in plants started from November to January, the shortest (13–25 cm) in plants started from April to June. In this case there do not seem to have been consistent effects of the planting distance.

The leaf area of the plant was measured twice: first at the moment of flower initiation and a second time at anthesis. In both cases it decreased from a maximum after planting in June (352–382 cm^2 at the time of flower initiation and 681–704 cm^2 at the time of flowering) to a minimum after planting in

March (24–33 cm^2 at the time of flower initiation and 151–167 cm^2 at the time of anthesis). In most plantings the wide distances gave a smaller leaf area. An exception were plants started in July and October: at the time of flowering, plants at 15 cm had the largest leaf area, those at 10 cm the smallest, while those at 7 cm were intermediate. In plants started in May a similar situation existed at the time of flower initiation.

In dry weight of the leaves was also determined at the time of flower bud initiation and at anthesis. The maximum dry weight was found in plants started in June (4.1 g at initiation and 7.4 g at flowering time), the minimum after planting in February (0.16 g at initiation and 1.5 g at flowering time).

At the time of flower initiation the dry weight of the leaves was affected by planting distance in the following way: in plants started in May and June, leaf dry weight was greater as the plants were further apart, but in all other groups planting distance had little or no effect (in plants started in April and July, those at 7 cm had the greatest leaf dry weight). At the time of anthesis the trend was slightly different; the greatest leaf dry weight was now found at 15 cm when the plants had been started between June and November, while the other groups showed no great effect of planting distance, except that plants started from March to May had the heaviest leaves when grown at the intermediate distance of 10 cm.

The differences in leaf dry weight are apparently not consistent with those in leaf area. In many cases, plants at the widest distance had a relatively small leaf area but a relatively great leaf weight. This must be due to the fact that the leaves are thicker when the plants are further apart.

Corm dry weight was determined at three stages: at the time of flower bud initiation, at anthesis and after harvesting. At the time of flower bud initiation the corms were very small in all plants started between July and March. In these plants the dry weight lay between 0.01 and 0.04 g. In plants started in May and June, however, corm dry weight at the time of flower initiation was 0.31 to 0.69 g, i.e. more than fifteen times as high. In plantings from April to July corm dry weight at the time of flower initiation was proportional to the planting distance. The differences were most pronounced in plants started in April, where corm dry weight was 0.09 g at 7 cm planting distance, 0.19 g at 10 cm and 0.51 g at 15 cm. In other plantings the differences were slight and not consistent.

Corm dry weight at flowering time was also highest (3.6 to 6.3 g) in plants started from April to June. In later plantings it decreased to a minimum of 0.16–0.28 g in plants started in October. Corm dry weight at flowering time increased with the planting distance, except in the November planting where the differences were not significant.

Corm dry weight at harvest time did not show such large differences. It was 3.4 to 5.8 g in plants started from November to January and 6.1 to 11.0 g in plants started in July or August. In all plantings, corm dry weight at harvest increased with the planting distance.

The number of cormlets per plant also tended to be greater when the plants

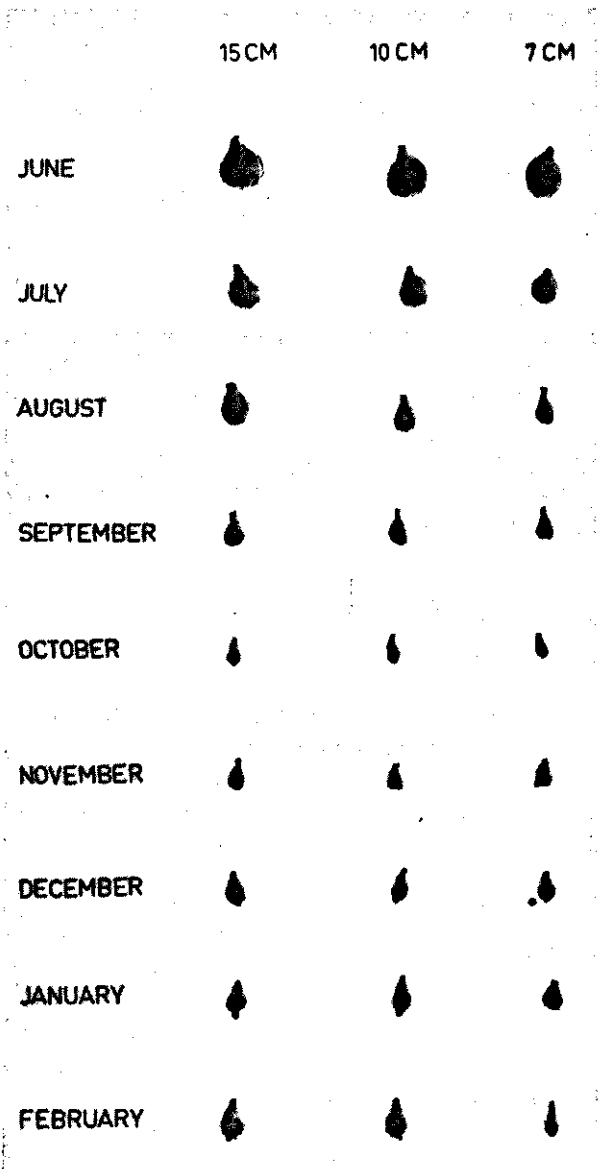

PHOTO 10. Corm size (at the time of flower anthesis) of plants started at various times of the year and planted at various distances (Experiment 21). The larger corms were formed after planting in June, the smallest after planting in October.

were wider apart. It was highest (5.8–10.8) in plants started in June and July and lowest (4.2–5.3) in plants started in March. Cormlet dry weight showed the same trend.

The time from planting to the harvest of the corms varied with the planting

date. It was shortest (192 days) for plants started in February and longest (365 days) for plants started in May.

Discussion

At the beginning of this chapter it was stated that experiment 21 was undertaken to see if the results of previous experiments could be used to explain the behaviour of Freesias under normal greenhouse conditions. This effort will now have to be made.

The number of leaves increases in high temperature (experiments 1–5) and in long photoperiods (exp. 8, 11, 12, 14). This is enough to explain the trend shown in fig. 3, but it does not give an explanation for the fact that more leaves were formed when the plants were 15 cm apart than when the distance was 7 cm. In the previous experiments (exp. 9, 10, 13, 17) there was little effect of light intensity on leaf number; but one would not expect this to be the explanation anyhow, because the differences were particularly great in the May and June plantings, when light intensity was high.

Flower initiation is promoted by short day (exp. 8, 9, 13, 14) and relatively low temperature (exp. 1, 3). This explains why the shortest period between planting and initiation was found in the winter plantings, and the longest period after planting in May. Again, why the latter group initiated flowers earlier at planting distances of 7 cm than at 15 cm remains obscure. In previous experiments (13 and 14) little effect of light intensity was found, while very low light intensity inhibited initiation in experiment 13.

Flowering is promoted by short day in the early stages (exp. 7, 11, 12, 13, 14) and perhaps by long day in later stages (exp. 12), while high light intensity is favourable (exp. 10, 13, 17). It is therefore not surprising to find that plants started in January and February are the first to flower, while those started in May are the last.

The number of flowers is increased by high temperature (exp. 1–5) and high light intensity (exp. 13, 17), so it is not surprising to find the largest inflorescences on plants started in May or June and the smallest on those started in October to February. Incidentally, this supports the results of experiments 12 and 13, where a promotive effect of LD was found, rather than those of exp. 7, 10, 14, 15 where more flowers were formed in SD.

The number of lateral stems is promoted by short day (exp. 7–15), high light intensity (exp. 10, 13, 18) and relatively low temperature (exp. 1–5). These factors may still react in a rather late stage of development (exp. 15, 18b). These observations go a long way to explain the results of the present experiments, although more information about the critical moments at which these environmental factors have their effect would be required to give exact information about such problems as why plants started in June have many lateral stems while those started a month later have only a few.

Stem length in previous experiments was promoted by relatively high temperature (21° or 24°C, exp. 1–5), but the effect of the light factor was not clear:

sometimes short day was promotive (exp. 9), sometimes long day (exp. 12–15); sometimes they were longer at high light intensity, sometimes at low light intensity. The present experiment throws no new light on these controversies, although there were considerable differences in stem length. When the light intensities during the initial stages were low (plantings between December and March), stems were longer at the smallest planting distance, which points to a promotive effect on stem length of low light intensity. But this does not explain why the longest stems were formed after planting in summer, nor why after planting in July the plants at 15 cm had much longer stems than those at 7 cm. Possibly the situation would have been clearer if stem length had been measured node by node.

Corm dry weight increased in all previous experiments with temperature, daylength and light quantity. This explains the data of the present experiment, except why plants started in April to June gave corms that were not as heavy as those from plants started in July or August.

Cormlet formation is promoted by short day (exp. 7–13) and relatively low temperature (1–4) during the later stages of plant development. This explains why plants started in June and July had the highest number and those started in March the lowest.

In conclusion, it can be said that many of the results of the present experiment can be explained by those of the previous ones. Yet one of the most striking observations, i.e. the promotive effect on flowering of narrow planting distances in summer, remains unexplained.

8. CONCLUSIONS

From this study on the effect of temperature and light on the development of the Freesia plant, the following conclusions could be drawn:

Effects of temperature in the range of 9–24 °C:

1. Sprouting of the corms was promoted by high temperature (experiments 1, 4, 19).
2. The number of leaves was reduced (i.e., flower initiation was promoted) by low temperature, and increased by high temperature, especially 21° and 24 °C (experiments 1, 3, 4, 5, 19). There was a further reduction by a pretreatment at 5 °C during 4 weeks (experiment 7). There was no specific effect of day or night temperature (experiment 4).
3. The number of days to flowering reached a minimum at 18° (experiments 1, 3, 5, 19, 20; in experiment 4 the optimal temperature was 15 °C and in experiment 2 it was 21 °C). The night temperature was especially important (experiments 4, 5). There was a further reduction in the number of days to flowering by a pretreatment at 5 °C for 3 or 4 weeks (experiment 7).
4. The number of flowers in the main inflorescence was increased by high temperature (experiments 1–5, 19, 20; in experiment 3 there was a reduction at 24 °C) but it was also increased by a pretreatment at 5 °C during 1 or 2 weeks (experiment 7).
5. The number of lateral stems was reduced by high temperature; the greatest number was formed at 12 °C (experiment 3) or 15 °C (experiments 1, 2). A low night temperature was especially important (experiment 5).
6. Stem length reached an optimum at 21 °C (experiments 1–5, 19, 20); 24 °C was unfavourable, especially in later stages (experiment 3). The effect of day temperature was much stronger than that of night temperature (experiments 4, 5). Stem length increased after a pretreatment at 5° during 1–2 weeks, but 4 weeks 5° led to stunted growth (experiment 7).
7. Corm dry weight increased with the temperature (experiments 1, 2, 4, 19). The effect of day temperature was stronger than that of the night temperature (experiment 4, 5). Corm weight was reduced after a pretreatment at 5° during 3 or 4 weeks (experiment 7).
8. The number of cormlets was decreased by high temperature (experiments 1–4, 19). A pretreatment of 1–2 weeks at 5 °C increased it, but 4 weeks 5 °C led to a decrease (experiment 7).

Effects of the photoperiod in the range of 8 to 16 hrs:

9. Leaf number was reduced (i.e. flower initiation was promoted) by short day (experiments 8, 12, 13, 19). The cultivar 'Sonata' was more responsive than 'Rijnveld's Golden Yellow' (experiment 15).

10. The development of the inflorescence was strongly promoted in the early stages by short day (experiments 12, 13, 19) but later stages were promoted by long day, although not as strongly (experiments 11, 12).

11. The number of flowers in the main inflorescence was reduced by long day (experiments 8, 10, 14), especially in the later stages (experiment 15). Long day also reduced the percentage of open flowers (experiments 9–12).

12. The number of lateral stems decreased with the daylength (experiments 8–14) which was especially effective in later stages (experiment 15).

13. There were no unequivocal effects of photoperiod on stem length experiments 9, 12, 15).

14. Corm dry weight was proportional to daylength (experiments 8, 10, 12, 14), although it was sometimes lower again in the longest photoperiod (experiments 9, 11).

15. The number of cormlets was greatest in short day (experiments 8–13).

Effect of light intensity:

16. Light intensity had little effect on the number of leaves (experiments 10, 13, 17), but low light intensity delayed flower initiation (experiments 13, 14), flower development (experiments 10, 13, 14, 17). It also reduced the number of flowers in the main inflorescence (experiments 13, 14, 17) and the precentage of open flowers (experiment 17). High light intensity increased the number of lateral stems (experiment 13). Stem length was usually slightly promoted by low light intensity (experiment 14, 17). Corm dry weight was proportional to light quantity (experiment 13, 14, 16, 17). The number of cormlets was reduced by low light intensity (experiment 10).

Comparison of effects on light and temperature:

17. Within the given ranges of these two factors the effect of temperature was usually greater than that of light. Only the number of lateral stems was determined primarily by the light conditions. As a rule, a higher temperature had a similar effect as a longer photoperiod (experiments 19, 20).

Effect of planting date (experiment 21):

18. The greatest number of leaves (and also the longest time to flower initiation) was found after planting in May and June, the smallest number of leaves after planting in February. The minimum number of days to flower initiation occurred after planting between November and January.

19. The minimum number of days between planting and flowering occurred after planting in January and February; plants started in May took the longest time to flower.

20. The number of flowers on the main inflorescence reached a maximum after planting in May and June and a minimum after planting between October and February.

21. The number of lateral stems was high in plants started in June and low after planting in November and April.

22. Stem length and plant height were greatest after planting between June and August and smallest after planting in February and March.

23. Corm and cormlet dry weight were highest after planting in summer and low after planting in winter; the number of days between planting and harvest showed the opposite trend.

Effect of planting density (experiment 21):

24. In comparison to plants at a small distance, those at a wider distance were shorter, had more lateral stems and more flowers, a greater corm dry weight and more cormlets.

25. The number of days to flowering was not affected by the planting density when the plants were started between November and March. Plants started between March and August flowered earlier when at a smaller distance; those started between September and November, however, flowered slightly earlier when at a greater distance.

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SAMENVATTING

Uit het onderzoek naar de invloed van de temperatuur en het licht op de ontwikkeling van de Freesia plant, konden de hier na volgende conclusies worden getrokken.

Over de invloed van temperaturen tussen 9 en 24 °C:

1. Het spruiten van de knollen werd bevorderd door hoge temperaturen (Proeven 1, 4, 19).
2. Het aantal bladeren werd verkleind (en de bloemaanleg bevorderd) door lage temperaturen en het nam toe door hoge temperaturen, vooral bij 21 en 24 °C (Proeven 1, 3, 4, 5, 19). Een verdere verkleining van het aantal bladeren volgde na een voorbehandeling bij 5 °C gedurende 4 weken (Proef 7). Er was geen verschillende invloed van de dag- en nachttemperatuur (Proef 4).
3. Het aantal dagen tot bloei was minimaal bij 18 °C (Proeven 1, 3, 5, 19, 20; in Proef 4 was de optimale temperatuur 15 °C en in Proef 2 was dit 21 °C). Vooral de nachttemperatuur was belangrijk (Proeven 4, 5). Het aantal dagen tot bloei werd nog verder verkleind door een voorbehandeling bij 5 °C gedurende 3 of 4 weken (Proef 7).
4. Het aantal bloemen in de hoofdbloeiwijze werd vergroot door hoge temperaturen (Proeven 1–5, 19, 20; in Proef 3 was er een verkleining bij 24 °C), maar het werd ook vergroot door een voorbehandeling bij 5 °C gedurende 1 of 2 weken (Proef 7).
5. Het aantal zijstengels werd door hoge temperaturen verkleind; het grootste aantal werd bij 12 °C gevormd (Proef 3) of bij 15 °C (Proeven 1, 2). Vooral een lage nachttemperatuur was belangrijk (Proef 5).
6. De stengellengte was het grootst bij 21 °C (Proef 1–5, 19, 20); 24 °C was ongunstig, vooral tijdens latere stadia (Proef 3). De dagtemperatuur had een veel grotere invloed dan de nachttemperatuur (Proeven 4, 5). De stengellengte nam toe door een voorbehandeling bij 5 °C gedurende 1–2 weken, doch 4 weken 5 °C werden gevolgd door een gedrongen groei (Proef 7).
7. Het drooggewicht van de knol nam toe met de temperatuur (Proef 1, 2, 4, 19). De invloed van de dagtemperatuur was groter dan van de nachttemperatuur (Proeven 4, 5). Het knolgewicht werd verminderd door een voorbehandeling bij 5 °C gedurende 3 of 4 weken (Proef 7).
8. Het aantal kralen werd door hoge temperaturen verminderd (Proeven 1–4, 19). Een voorbehandeling gedurende 1–2 weken bij 5 °C, gaf een toename, maar 4 weken 5 °C gaven weer een afname (Proef 7).

Over de invloed van photoperioden tussen 8 en 16 uur:

9. Het aantal bladeren werd verminderd (bloemaanleg bevorderd) door korte dagen (Proeven 8, 12, 13, 19). De cultivar 'Sonata' was gevoeliger dan 'Rijnveld's Golden Yellow' (Proef 15).
10. De ontwikkeling van de bloeiwijze werd krachtig bevorderd door korte dagen in de vroege stadia (Proeven 12, 13, 19) maar tijdens de latere stadia werd

deze ontwikkeling bevorderd door lange dagen, hoewel minder krachtig (Proeven 11, 12).

11. Het aantal bloemen in de hoofdbloeiwijze werd verkleind door lange dagen (Proeven 8, 10, 14) vooral tijdens de latere stadia (Proef 15). Lange dagen verminderden ook het aantal open bloemen (Proeven 9–12).

12. Het aantal zijstengels nam af met de daglengte (Proeven 8–14), welke vooral effectief was tijdens de latere stadia (Proef 15).

13. Er was een wisselende invloed van de fotoperiode op de stengellengte (Proeven 9, 12, 15).

14. Het drooggewicht van de knol nam evenredig toe met de daglengte (Proeven 8, 10, 12, 14), hoewel het soms weer lager werd in de langste fotoperiode (Proef 9, 11).

15. Het aantal kralen was het grootst in korte dagen (Proeven 8–13).

Over de invloed van de lichtintensiteit:

16. De lichtintensiteit had een geringe invloed op het aantal bladeren (Proeven 10, 13, 17), maar lage lichtintensiteiten vertraagden de bloemaanleg (Proeven 13, 14), en de bloemontwikkeling (Proeven 10, 13, 14, 17). Het verkleinde ook het aantal bloemen in de hoofdbloeiwijze (Proeven 13, 14, 17) en het percentage open bloemen (Proef 17). Hoge lichtintensiteiten gaven een toename van het aantal zijstengels (Proef 13). De stengellengte werd meestal iets vergroot door lage lichtintensiteiten (Proef 14, 17). Het drooggewicht van de knol nam evenredig toe met de lichthoeveelheid (Proef 13, 14, 16, 17). Het aantal kralen nam af door lage lichtintensiteiten (Proef 10).

Over de vergelijking van licht- en temperatuurinvloeden.

17. Binnen het gegeven traject van deze twee factoren was het effect van de temperatuur meestal groter dan dat van het licht. Alleen het aantal zijstengels werd in de eerste plaats bepaald door de lichtomstandigheden. Als regel had een hogere temperatuur hetzelfde effect als een langere fotoperiode of als een hogere lichtintensiteit (Proeven 19, 20).

Over de invloed van de plantdatum (Proef 21):

18. Het grootste aantal bladeren (en ook de langste tijd tot bloemaanleg) werd gevonden na opplanting in mei en juni. Het kleinste aantal bladeren na opplanting in februari. Het kleinste aantal dagen tot bloemaanleg werd gevonden na opplantingen tussen november en januari.

19. Het kleinste aantal dagen tussen opplanting en bloei werd gevonden na opplanting in januari en februari; opplanting in mei vergde de langste tijd tot bloei.

20. Het aantal bloemen aan de hoofdbloeiwijze bereikte een maximum na opplanting in mei en juni en een minimum na opplanting tussen oktober en februari.

21. Het aantal zijstengels was hoog voor opplantingen in juni en laag voor die in november en april.

22. De stengellengte en planthoogte waren het grootste na opplanting tussen juni en augustus en het kleinst na die in februari en maart.

23. De drooggewichten van de knol en van de kralen waren het grootst na opplanting in de zomer en laag na opplanting in de winter; het aantal dagen tot de oogst vertoonde het omgekeerde beeld.

Over de invloed van de plantdichtheid (Proef 21):

24. Vergeleken met planten in een dicht verband, waren die in een ruimer verband korter, hadden deze meer zijstengels en meer bloemen, een groter drooggewicht aan knollen en meer kralen.

25. Het aantal dagen tot bloei werd niet beïnvloed door de plantdichtheid na opplantingen tussen november en maart. Opplantingen tussen maart en augustus bloeiden vroeger in een dicht plantverband; die tussen september en november bloeiden echter iets vroeger in een ruimer verband staand.

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