DORMANCY AND SPROUTING IN GLADIOLUS

S. S. APTE

DORMANCY AND SPROUTING IN GLADIOLUS

Met een samenvatting:

KIEMRUST EN KIEMING IN GLADIOLUS

THESIS

SUBMITTED TO

THE STATE AGRICULTURAL UNIVERSITY,

WAGENINGEN, THE NETHERLANDS, IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF AGRICULTURAL SCIENCES

27 JUNE 1962

STELLINGEN

I

It is doubtful whether *any democratic government*, especially of a developing country, will be successful in enforcing complete alcoholic prohibition by law.

II

For the survival of gladiolus in the flower industry, the present standards used for selection of cultivars should be changed and an extensive breeding work with a large number of wild species may be carried out.

III

Advisory agencies in the Netherlands, concerned with household machines to guide the homemaker, should have more and better data.

IV

For control of diseases in the planting stocks of gladiolus, the hot-water treatment may not be advised to the growers at this stage of research.

SCHENK, P. K.: Warmwaterbehandeling van gladiolekralen. Laboratorium voor Bloembollenonderzoek, Publikatie 145, 1961: 173–185.

SCHENK, P. K.: Biologie en bestrijding van Urocytis gladiolicola Ainsw. op gladiolen. Laboratorium voor Bloembollenonderzoek, Publikatie 149, 1961: 104 pp.

V

EVENARI's definition of germination as „those processes, starting with the imbibition of the seed and ending with the protrusion of the root, which take place inside the seed and prepare the embryo for normal growth" is not satisfactory from the viewpoint of ecological physiology.

EVENARI, M.: Symposia Soc. Exp. Biol. 11, 1957: 21–43.

DISSERTATIE S. S. APTE
Wageningen, juni 1962

TO

THE DUTCH PEOPLE

AMONG WHOM I COULD WORK AND LIVE

LIKE A DUTCHMAN

AND FROM WHOM I HAVE TAKEN MORE

THAN I COULD GIVE BACK,

MY THESIS IS

GRATEFULLY DEDICATED

PRELUDE

The first tune, that came out of a small booklet "The Netherlands, garden of Western Europe", moved me to write a letter to the Ministry of Agriculture in The Hague and thus started one of the sweetest melodies in my life. In the initial stages Dr. D. DE WAAL and Mr. E. L. HECHTERMANS, both from the diplomatic service, took considerable pains in presenting my case to the International Agricultural Centre.

I have no words to express my feelings exactly for what the International Agricultural Centre has done for me. It was this organization which supported me financially throughout my stay in Wageningen. Without this support my dream to study abroad would never had come true. The director as well as the staff members, especially Mr. VAN BIJLERT with whom I had the most contact, have shown the feeling and interest a foreigner usually longs for.

Within a couple of weeks after my arrival in The Netherlands, I found a refuge in the Laboratorium voor Tuinbouwplantenteelt where I played short roles as an orphan and that of a guest-worker before taking up the main role as "one of the staff members" which I still play as a "regular".

Professor WELLENSIEK, you, as the director of the laboratory, provided all the facilities and the material I needed. You, as the promotor, have always been interested in the progress of my work though my amateur ways of handling experimental work must have tried your patience several times. I consider myself fortunate that I have had an opportunity to observe your efforts to reach perfection in the research work from planning to presentation. Your perfectness is like a bright star far in the sky whose height is difficult to attain but its light guides one who seeks the direction of his voyage. I thought I know you for years, but no. I discovered you for myself only in the last weeks when we discussed the work for hours day after day.

Dr. DOORENBOS, you were the person whom I could approach any time with any problem. You were never too busy not to receive me. Dr. HARTSEMA, since our first discussion on the gladiolus in 1958, you have always put at my disposal your lifetime experience in bulb research. Dr. VERKERK, whenever I had a statistical problem it was you whom I could consult. Professor FERGUSON, Miss GARRETSEN, Mr. KAMMINGA and Ir. POST had often time in their busy schedules for the statistical advise on my results.

The experiments under controlled climatic conditions would not have been possible without the facilities provided by Dr. O. BANGA and Dr. W. VAN DOBBEN. My task was considerably lightened by the cooperation and help I received from Drs. BRAAK, Ir. SMEETS, Messrs v. D. VEEN and GMELIG-MEYLING.

Professor VAN DER WANT, I have always felt at home with you and among the staff members of your Laboratorium voor Bloembollenonderzoek at Lisse. Dr. KAMERBEEK, the respiration experiments could be completed in a short time only because you offered the experience in the method of measurement. Dr. SCHENK, I have learnt a great deal about gladiolus from the discussions and from the number of excursions you arranged for me in the bulb district.

Mr. van der Mark, the doors of your firm and home were always open for me through which I could pass without rapping. Because of your interest in the research work, I have received the cormels of any cultivar and in any quantity I wished – free of charge. Your son and the employees of the firm especially Messrs Bader, de Haas and Hoek were always available to explain me the various aspects of gladiolus growing.

My thesis could reach the printer in time only due to the efforts of Messrs Jansen and van Lent who prepared drawings and photographs by working extra hours. Miss Riekje van de Brink typed the manuscript very carefully and neatly in a short time. Mrs. Jeanne de Pauw, Mrs. Cis Blok and Miss Jansje van Voorthuizen have shared, with smile, the burden of the administrative work related to the thesis.

Miss Wolda, the proof-reading has given you and your assistant Miss Anke Meijer enough eye straining and throat drying. What is unforgettable is the frolic air of your room which rushes to level out the depression of spirits. It is not the coffee that attracts everyone to your room but perhaps the discussions on the subjects like "Beethoven", "birthday parties", "economic situation of the world" and "winter feeding of birds".

Mr. Sabarte Belacortu, nobody was perhaps so much a headache as I had been for you. I always wonder how your Spanish temper was never lost with me. The members of your section, especially of greenhouse 5 (Ultee group) and greenhouse 7 (van Welie group) have taken considerable pains to care for my plants.

The tedious jobs of counting, shelling and planting were shared mainly in the early stages by Mr. Pronk and in the later stages enthusiastically by Mr. Zevenbergen. Mr. v. d. Peppel and his colleagues have helped me in the regulation of electrical instruments and in the construction of structures used in the daylength treatments.

It was always a friendly atmosphere in the room with Wiëtze and Higazy, at the coffee club with Tetje, Suresh and Jan, and on weekends with Setty and Ramananda.

Mr. Veenman, because of your cooperation and the efficiency of your press, the printing of this thesis could get ready in a short time.

The editorial board of the "Mededelingen van de Landbouwhogeschool te Wageningen" was kind enough to publish this thesis.

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KIEMRUST EN KIEMING IN GLADIOLUS

by/*door*

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CONTENTS

CHAPTER I

GENERAL

1. *Introduction*

Gladiolus belongs to the 'flower-bulbs' which general term in the Dutch horticulture indicates material such as bulbs, corms, tubers, scales etc. of ornamental plants. In the Dutch flower-bulb industry, the position of gladiolus is second to none except tulips. This is evident from the fact that gladiolus occupies an average of 25% of the total area under flower-bulbs. Though references indicate that gladiolus has been known to Greeks and Romans (3, 1916),* the large flowering and summer-blooming gladiolus of to-day has a starting point as late as 1837, when BEDDINGHAUS of Belgium, as a result of an interspecific cross, obtained *Gladiolus gandavensis*. This hybrid was used by breeders like LEMOINE and LEICHTLIN who have a lion's share in the development of modern gladiolus. During the 18th and 19th centuries, in the Netherlands stress was laid mainly or perhaps entirely on the spring-flowering gladiolus and a remarkable Dutch contribution to this period came from SCHNEEVOOGT of Haarlem, who introduced *Gladiolus ramosus* (see KRELAGE 25, 1946, p. 689). After introduction of *Gladiolus gandavensis*, development of summer-flowering gladiolus continued at a tremendous rate and to-day, as a result, spring-flowering gladiolus occupies less than 1% of the total acreage under gladiolus. About 85% of the summerflowering cultivars that are grown in the Netherlands are of Dutch origin which is a great achievement in the light of the fact that the first Dutch cultivars were offered as late as 1905 by ALKEMADE of Noordwijk (see 31, 1961, p. 19). The rapid growth of the acreage under gladiolus can be seen from table 1 (31, 1961; 45, 1944 to 1962).

* Refers to number and year of publication of literature list on page 45.

TABLE 1. Growth of area under cultivation of gladiolus in the Netherlands, in comparison with tulips. Area of gladiolus both in hectares (ha) and in % of total area of flower-bulbs, tulips only in %.

Year	Gladiolus		Tulips
	ha	%	%
1910	250	–	–
1939	1117	15	49
1946	973	15	43
1950	1689	30	39
1955	2380	29	38
1960	3545	24	34

2. *Corm and cormel*

In the present investigations corms and cormels of gladiolus have been used as experimental material and various terms have been employed to describe the parts and the origin of them, for instance, 'outer hard shell of cormel', 'cormels originating from corms' or 'corms originating from cormels'. To avoid confusion, a short description of corm, cormel and of their role in the growth cycle of gladiolus is given. For detailed information see GEIGER (19, 1929), PFEIFFER (34, 1931) and HARTSEMA (20, 1937). The corm of gladiolus is a modified stem, bearing nodes, internodes and buds. It serves as 'mother corm' to produce a new corm and cormels which are referred to as 'originating from corm'. The cormels can, in a similar manner as the mother corm, produce corms and cormels which are, obviously, referred to as 'originating from cormels'. The corm or cormel which has been used for planting, shrivels and dies during the growth of the plant. This shrivelled mother corm or cormel can be, later, detached easily from the new corm due to the formation of an abscission layer. The corm and the cormel of gladiolus are ontogenetically different and, obviously, consideration of size should not be mistaken for a distinct line of separation between them. Cormels are borne on the stolons which originate from the axillary buds in the junction of the mother corm and the new corm. A mature cormel varies in size from a pin head to a hazel-nut. Its fleshy tissue is surrounded by a single hard shell which fits loosely to it. This shell, many times referred to as 'outer hard shell' may be naturally broken in certain cultivars.

3. *Dormancy*

Contrary to recent discoveries like photoperiodism, growth promoting and inhibiting substances etc., the phenomenon of dormancy was recognized much earlier. Failure of seeds to germinate or refusal of buds of deciduous trees or of bulbous plants to resume growth under conditions that are usually favourable for growth, is attributed to the stage of inactivity which is described by the general term 'dormancy'. As long as the regulation of cultivation of plants rested to nature's will and the human beings adapted themselves to it, the cycle of dormancy and resumption of growth was accepted without challenge. The possibility that the plants may be manipulated to recommence growth at will, was realized perhaps only in this century.

According to CROCKER (6, 1948), various workers between 1906 and 1913 demonstrated that the dormant rosaceous seeds can be made to sprout by removal of the seed coat and by the well known horticultural practice of low temperature stratification. After the establishment of the Boyce Thompson Institute in 1924, a research team intensively studied seed and bud dormancy in a number of plants and the mentioning of their results cannot be avoided, almost without exception, by anyone dealing with the subject of dormancy.

As far as gladiolus is concerned, the attention was drawn to the problem of dormancy as a side-issue in the attempts to obtain flowering in winter and, later, due to a controversy, which started around 1930, on the right temperature to break dormancy. To get a clear picture of this situation, events which occurred earlier than 1930 have also to be taken into account. WEINARD and DECKER (49, 1930) found, in the trials during 1922 and 1925 that the corms stored at temperature around 21° to 27°C sprouted earlier than those stored at 3°C. DENNY (7, 8, 1926) demonstrated the use of chemicals, especially ethylene chlorohydrin, in breaking the dormancy of potato tubers. After this discovery LOOMIS and EVANS (28, 1928) concluded that storage temperatures between 25°C (for 4 weeks) and 39°C (for 1 week) were equal in effectiveness and were superior to the treatment of ethylene chlorohydrin, in breaking the dormancy of corms. DENNY (9, 1930) repeated, with some modifications, the work of LOOMIS and EVANS and came to quite an opposite conclusion, namely, the treatment of ethylene chlorohydrin was effective in breaking the dormancy immediately after harvest as well as in the later stages of storage, while high temperature storage at 30°C was effective only in the latter case. During the next five years various reports were published indicating superiority of high temperature storage in breaking dormancy. EMSWELLER (14, 1930) used 3½°, 8°, 12° and 30°C and obtained the earliest flowering in the lots stored at 30°C. VOLZ and KEYES (48, 1933) showed that the corms stored at 30°C sprouted and flowered earlier than those stored at 10° to 18°C. In 1933 LOOMIS (27, 1933) published his second report and recommended again the use of high temperatures, from 20°C (8 to 10 weeks) to 40°C (for 1 week). FAIRBURN (17, 1934) obtained more vigorous growth and earlier flowering from corms stored at 32°C than from those stored at 10° or 21°C. Considering DENNY's lack of success with high temperatures in his previous work, DENNY and MILLER (12, 1935) used a wide range of temperatures from 3° to 35°C. They established that the corms stored at low temperatures of 3° or 10°C were sooner out of dormancy than those stored at room temperature (18° to 25°) or at 35°C. However, before even DENNY and MILLER in 1935 used low temperature for breaking the dormancy, it was a common practice in the Southern States of America to use refrigerated storage (26, 1934) for gladiolus to obtain better and uniform sprouting. It is often less emphasized that those workers who used a high temperature treatment for breaking dormancy (14, 1930; 27, 1933; 17, 1934) have, practically without exception, recommended it for only a short duration, while they were in favour of low temperatures for long storage. In the light of his results, DENNY's explanation (9, 1930; 10, 1936) was that high temperatures, being ineffective when applied to freshly dug corms which are in the early stages of dormancy, show a forcing effect only when these corms have reached the later stages of dormancy. The phenomena, (*a*) disappearance of dormancy slowly at high temperatures and rapidly at low temperatures, and (*b*) a pushing effect, as shown by early sprouting and flowering and realized by high temperatures, have been named 'dual effect of temperature' by MANN and LEWIS (30, 1956). This would be called 'thermoperiodicity' nowadays. Various other workers showed the beneficial effect of low temperature in breaking the dormancy of gladiolus (43, 1954; 37, 1955; 41, 1958; 46, 1960).

4. *Scope of the present investigations*

It is evident from the discussion of literature on dormancy of gladiolus that the physiologically interesting question remains whether dormancy disappears at high temperatures. A negative answer implies a doubt about the existence of dormancy at the harvesting time. As the information available on the conditions which are responsible for inducing the dormancy, is scant, it was decided to set the problem of dormancy in gladiolus on a more physiological basis. The experimental work carried out, in the first instance, established the role of environmental factors which existed during the formation of corms and cormels in inducing dormancy. Furthermore, the conditions which, during storage, favour the disappearance of dormancy have been studied with special reference to storage temperatures. While attacking these main aspects of the issue, a variety of secondary problems had to be investigated. They can be enumerated as follows: influence of soil temperature on disappearance of dormancy, effect of storage temperatures on growth of plants, respiratory behaviour during storage and, particularly, in relation to outer hard shell, etc. As the Dutch cultivars are used as experimental material, additional knowledge obtained about their behaviour is a great gain for a horticulturist.

CHAPTER II

MATERIAL AND METHODS

1. *Growth and selection of plant material*

During the four years of experimental work, the corms and cormels were obtained from a commercial firm in Noordwijk. Some cultivars had to be grown in the experimental garden of the Laboratory of Horticulture, Wageningen, because the firm discontinued to grow them. In most of the cases corms and cormels originating from corms were used, but under unavoidable situations those originating from cormels were also used.

Under the Dutch climatic conditions, gladiolus is grown during only one season per year. As soon as the temperatures begin to rise around March or April, the corms and cormels of summer-flowering hybrid gladiolus cultivars are planted and the crop is harvested in September or October. Some representative data are presented in table 2 so as to give some idea about the conditions during an average growing season (33, 1959; 45, 1962).

After the harvest, corms and cormels are air-dried for two weeks and then cleaned. The cormels were passed through different sieves to separate large and small sizes from an average medium size (70 to 90 cormels weigh 10 g) which, unless mentioned otherwise, has been used for the present experiments.

TABLE 2. Climatic conditions in the Netherlands during an average growing season of gladiolus.

Month / Condition	March	April	May	June	July	Aug.	Sept.	Oct.
Air (°C)	5.0	8.5	12.4	15.5	17.0	16.8	14.3	10.0
Soil (°C)	4.6	8.5	12.9	15.7	17.6	17.4	14.6	10.8
Rain (mm)	42	45	49	54	77	82	72	72
Sun (hours)	123	164	212	222	202	191	146	101
Day	12h 14′	14h 17′	15h 58′	16h 44′	16h 02′	14h 19′	12h 17′	10h 19′

2. *Storage and planting*

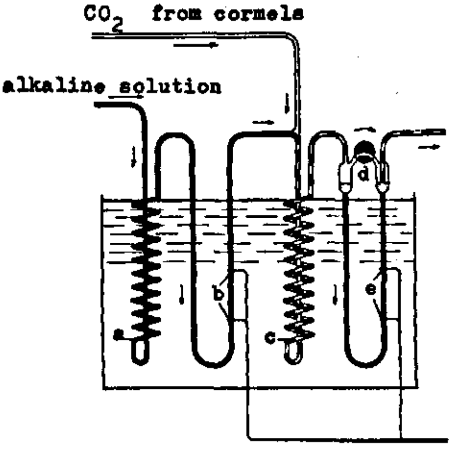
For storage at various temperatures between 6° and 27°, wooden thermostats, placed in a room cooled to 0°C, were used. The temperature fluctuated over 1°C for the thermostats between 6° and 20°C and over 2°C for those above 20°C. Experiments in relation to soil temperatures and with controlled growing conditions were carried out in growth rooms and greenhouses. For construction and working of these structures see BRAAK and SMEETS (5, 1956; 1962 in press). For long-day treatment the natural daylength was lengthened to 16 hours by using supplementary light, 4 incandescent lamps of 40 Watt each per square meter area, hung 50 cm above the plants and controlled automatically by an electric clock which could be set to give the desired extention of daylength. For shortday treatment, the plants are covered with black cloth from 4.30 p.m. to 8.30 a.m. to provide 8 hours of daylight and 16 hours of darkness. When growing conditions are not specified, the experiments were conducted in a greenhouse which was maintained between 18° and 22°C except on certain days, especially during summer, when outside temperature rose above 22°C. The corms and cormels were planted in a mixture of peat and sand (1:1 by volume) when only sprouting behaviour was studied, while on the occasions when the plants had to be grown to maturity a soil mixture was used of 30% peat-soil, 30% leaf mould, 20% farmyard manure and 20% sand, mixed and steam sterilized at 96°C for 1 hour.

3. *Respiration measurements*

The rate of respiration is expressed in terms of cubic centimeters of carbon dioxide evolved per hour per kilogram fresh weight and was measured by a 'Mikrogas' apparatus. The principle involved will be described briefly, while for details reference is made to KAMERBEEK (22, 1962) and KILBINGER (23, 1953).

Air, devoid of carbon dioxide, is passed over respiring cormels and the carbon dioxide evolved in the respiration is brought into contact with a specific reaction liquid (alkaline solution); the conductivity of the latter changes in proportion to the concentration of the reacting gas (carbon dioxide). The electrical reading of the variation in the conductivity will indicate directly the value of the carbon dioxide concentration. The alkaline solution and the carbon dioxide evolved in respiration, travel simultaneously and continuously through the reaction vessel. Thus the concentration of carbon dioxide can be measured at any moment. The parts of the reaction vessel (test cell) are shown in fig. 1 (51, 1958).

FIGURE 1.
Parts of test cell for respiration measurements.
From WÖSTHOFF (51).
Details in text.



An alkaline solution passes through a glass spiral *a*, where its temperature is ajdusted, to a glass spiral *c* in which it reacts with carbon dioxide. A gas separator *d* removes the residual carbon dioxide from the solution. The electrodes *b* and *e* are parts of a measurement circuit which measures the electrical conductivity of the alkaline solution before and after the uptake of CO_2. The pointer of a recording devise is coupled with the axis of the potentiometer of the measurement circuit and thus the value measured can be read from the scale.

CHAPTER III

EXPERIMENTS

1. DISAPPEARANCE OF DORMANCY DURING STORAGE

1.1. *Introduction*

As a practice of decades, the Dutch growers have been storing the cormels of gladiolus, after the harvest and during the winter months, in a room or a cellar which is protected from frost and the temperature of which is around 5 °C. Whether another storage temperature would be more beneficial for sprouting is not known. However, the results of a preliminary report (2, 1959) have shown that the cormels when stored, in the latter half of the winter months, at 3° to 9° sprouted better than those stored at 15° or 20 °C. The percentages of sprouting obtained after storage at 23° to 33° were either comparable to those of 15°C storage or the lowest among all the storage groups, depending on cultivars. To obtain a picture as complete as possible, various storage temperatures between 6° and 27 °C were used throughout the period which followed the harvesting. Besides, the influence of some morphological factors on sprouting, namely shell and size, has also been studied. Since the latter results will be used in our temperature studies we shall deal with them first.

1.2. *Shell and size of cormel*

It was observed that in certain cultivars a part of the cormels have a naturally cracked outer shell. As an illustration, the percentages of the cracked cormels in case of three cultivars will be given. In 'Friendship', 'Josephine' and 'Mecky', the total numbers of cormels produced by 16 corms of 10–12 cm size were 954, 331 and 390 respectively and the percentages of cracked cormels were 1, 17, 20 respectively. The percentages in the latter two cultivars are sufficiently high to justify a special attention.

The development of a crack in the shell of a cormel may possibly be due to the difference between the rates of growth of the inner soft tissues and the outer shell, the latter being slower. This conclusion is supported by the fact that in the cormels originated from the same mother corm, those which have cracked shell are, usually, larger in size than the rest of them. ROISTACHER *et al.* (36, 1957) reported that in case of cv. 'Margaret Beaton', the cormels with a naturally cracked shell showed a higher tetrazolium rating and gave better sprouting than those with intact shell. Unfortunately, the history of storage of the cormels has been unstated. The same workers also mention the unexpected finding that the tetrazolium rating was sometimes very low in case of freshly harvested cormels with cracked shells. This behaviour is difficult to understand since the freshly harvested cormels usually give a high tetrazolium rating.

Experiment 1. – In order to get a better knowledge of the sprouting of the cracked cormels, an experiment was planned. Immediately after the harvest 213 cormels, produced by 8 corms of cv. 'Mecky', were divided into 8 × 2 groups according to uncracked or cracked shell. One half of the cormels of both groups was planted immediately at 20°C while those of the second half were planted after a cold storage at 10° for 18 days. After 60 days from planting it was observed that none of the cormels without cold storage sprouted. In case of the cormels which received 18 days of cold storage, the sprouting percentages for uncracked and cracked cormels were 10 and 88 respectively. This shows that the naturally cracked cormels are earlier out of dormancy than the uncracked ones. The condition of the cormels, uncracked or cracked, has been included in following experiments and it will be discussed in more details later on.

It was further observed that the cormels exhibit a wide range in size. The interest in the morphological factor of size was aroused mainly due to two reasons. *a.* To justify the use of average medium size of cormels in the later series of trials. *b.* The findings of MAGIE (29, 1959) that the smaller cormels could stand a higher temperature in hot water treatment when compared with larger cormels. Since the effectiveness of disease control by hot water treatment is correlated with the temperature of the water bath, the smaller cormels could be used to obtain relatively more disease-free corms and cormels.

In literature several references, dealing with the factor of size of cormel in relation to sprouting, could be found but none of them is satisfactory for the following reasons. *a.* Lack of information on storage temperature (11, 1934). *b.* Conclusions drawn from a single planting (1, 1958; 39, 1961). *c.* Sprouting recorded for as long as 200 days while the soil temperature is unstated (11, 1934). In the light of these facts an experiment was planned using cormels of cv. 'Blauer Domino'.

Experiment 2. – At the harvesting time, each individual mother corm of 12–14 cm was bagged together with its own cormels. The bags were removed to a cold storage at 10°C and 8 corms with their cormels, 352 to 556 in number, were removed after 0, 35, 77, 102 or 136 days and planted at 20°C. At the planting time the cormels were graded after the following method. First of all, the cormels with naturally cracked shell, irrespective of size, were removed and grouped as 'cracked'. From the uncracked cormels, very small cormels were separated as 'pin-heads', while the rest of them passed through sieves of different sizes so that 3 groups could be formed, namely 'large', 'medium' and 'small'. The numbers of cormels per 10 g for the 3 latter groups averaged 27, 77, 166 respectively. The sprouting obtained after 60 days from planting was calculated as percentages of the cormels planted. The results are presented in table 3 which indicates that:

TABLE 3. *Experiment 2.* – The sprouting percentages after 60 days of the cormels of cv. 'Blauer Domino' with naturally intact or cracked shell. The cormels of the former group were further divided according to size as large, medium, small and pin-heads.

Cormels	Days in cold storage				
	0	35	77	102	136
Large	44	75	54	95	100
Medium	8	9	31	40	46
Small	8	8	0	12	12
Pin-heads	10	2	5	15	19
Cracked	100	100	100	100	100

a. The percentages of sprouting of the uncracked cormels from all the 4 groups in all cases, are lower than those of the cracked cormels, except that the large intact cormels after 136 days of cold storage also reached 100% sprouting.

b. In the uncracked cormels, the percentages of sprouting of the large ones are the highest among all groups at all instances.

c. For the first 35 days of the storage the medium, small and pin-head sized cormels sprout for 10% or less and hence are in deep dormancy. In the following periods of storage up to 136 days, the medium sized cormels show better sproutings than those of the small and pin-head sizes. The latter two groups rather continue to exhibit deep levels of dormancy, the pin-heads being slightly better than the small ones.

Experiment 3. – A year later an experiment in a similar manner was performed with cv. 'Josephine'. The modifications were that the mother corms were planted along with the different size groups from which the group of pin-heads was excluded, while the days of cold storage were 0, 22, 55 or 76. The sprouting percentages obtained for cormels are given in table 4 in which the percentages for the mother corms are not included because they reached, in all 4 plantings, 100% indicating that mother corms sprout better than the cormels they produced, including those with cracked shells. Since the results of table 3 have been described at length, those of table 4 may be given in brief as follows:

a. The percentages of sprouting of uncracked cormels are lower than those of the cracked ones.

b. In uncracked cormels of various sizes, the large ones sprout the best.

c. The medium sized cormels sprout better than the small ones with an exception at 22 days storage.

TABLE 4. *Experiment 3.* – The percentages of sprouting after 60 days of the cormels of 'Josephine' with naturally intact or cracked shell. The cormels of the former group were further divided according to size as large, medium or small.

Cormels	Days in cold storage			
	0	22	55	76
Large	23	37	53	59
Medium	5	25	28	50
Small	2	27	14	34
Cracked	67	83	93	96

1.3. *Storage temperature*

For nearly 40 years the subject of storage temperature has been attracting the attention of the scientists from various countries. Nevertheless, CROCKER (6, 1948, p. 240), while summarizing the work of his co-workers on gladiolus, stated, "Because of the great variation in behaviour of corms of different varieties, both as to depth of dormancy and factors that overcome dormancy, it is evident that each variety must be studied separately to determine the best forcing methods". Though in principle CROCKER's statement is endorsed, the application of it in the present experimental series had to be limited.

During three years, an extensive series of experiments was performed, using a number of cultivars. Considering the bulk of data at hand, it may be justified to discuss the representative data only, mainly with reference to 4 cultivars, namely 'Genoveva', 'Albert Schweitzer', 'Salome' and 'Rosenpolka'.

Immediately after the harvest, the cormels were removed to storages at 6°, 10°, 15°, 20° or 27°C. At various intervals samples of cormels were taken from each storage temperature and planted in a greenhouse maintained at 20°C. Just before the planting, the outer shells of the cormels were either left intact (uncracked) or completely removed (cracked). For each treatment 25 cormels of medium size were used. The plantings were continued throughout the storage period which was divided into two parts, 'primary' and 'secondary'. The primary period consists of approximately 130 days, counted from the beginning of November to the beginning of March. The secondary period consists of approximately one year counted from the beginning of March. This division of the storage period is based on the simple reasoning that the Dutch growers can plant at the end of either the primary or the secondary period.

1.3.1. Dormancy and primary period of storage

Experiment 4. – The sprouting percentages obtained in 11 plantings during the primary storage period for the cormels harvested in 1958, have been presented in fig. 2. Before we discuss the results in details a general trend of them may be described as follows.

For uncracked groups (fig. 2a, c, e, g):

a. The sprouting percentages obtained after the temperatures of 6° and 10°C are the best in all groups. In many instances the sprouting after 10°C is better than after 6°C.

b. The percentages of sprouting obtained after 15°, 20° and 27°C indicate that dormancy disappears in these groups either slowly and at an irregular rate or not at all.

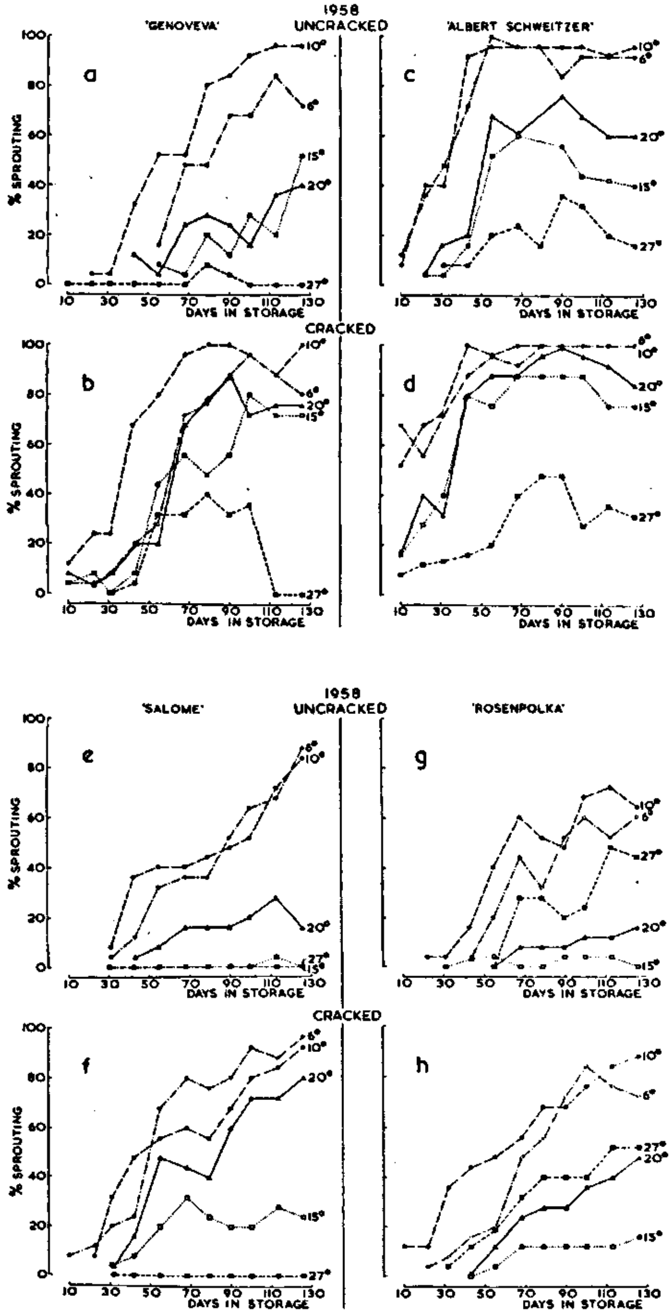


FIGURE 2. *Experiment 4.* – The percentages of sprouting of cormels of 4 cultivars of 1958 harvest, stored at 6°, 10°, 15°, 20° or 27° for 130 days. During the period of storage, the cormels were removed at various intervals and planted either uncracked or cracked. Cultivars: a, b = 'Genoveva'; c, d = 'Albert Schweitzer'; e, f = 'Salome'; g, h = 'Rosenpolka'.

For cracked groups (fig. 2b, d, f, g):

c. The levels of sprouting after 15° and especially 20° reach, in many instances, those levels of 6° and 10°C.

d. Except for 'Rosenpolka', the sprouting percentages obtained after 27° storage suggest that the dormancy disappears either at an irregular and slow rate or not in any degree.

For uncracked and cracked groups:

e. The percentages of sprouting are higher in the cracked group than in the uncracked ones.

From fig. 2a, b, c, d it will be seen that the cultivars 'Genoveva' and 'Albert Schweitzer', in main lines, fit in the general framework mentioned just now, though they differ from each other in the depth of dormancy. The numbers of days of storage at 6° or 10°C and for any condition of shell required to reach the 70% level of sprouting is smaller for 'Albert Schweitzer' than for 'Genoveva'. This means that the level of dormancy in 'Albert Schweitzer' is lower than in 'Genoveva'. After storage at 27°C there is nearly no sprouting response in 'Genoveva', while in 'Albert Schweitzer' it is irregular and at a particular instance as high as 35% sprouting was obtained, anyhow better than in 'Genoveva'.

On the basis of the same argument offered for the two previous cultivars as regards the depth of dormancy, it may be concluded that 'Salome' was at a deeper level than 'Genoveva'. A few striking points to be noted in fig. 2e, f are as follows:

a. The percentages of sprouting after storage at 15°C are nearly always 0% in uncracked cormels, while for cracked cormels they do not reach the levels of 6°, 10° or 20°C.

b. Even after cracking, the sprouting percentages after storage at 27°C remain at the 0% level.

As regards the depth of dormancy and the response of sprouting for storage temperatures of 6°, 10° and 15°C, the last cultivar, 'Rosenpolka', is comparable with 'Salome' (fig. 2g and h). The sprouting percentages after 20° storage are rather similar to those of 'Salome' in uncracked condition, while in cracked condition they do not rise as high as 'Salome'. A curious behaviour of 'Rosenpolka' is that the sprouting percentages obtained after 27°C storage were higher than those of 15° or 20° storage, planted either uncracked or cracked.

1.3.2. Dormancy and secondary period of storage

The plantings of experiment 4 as described in the preceding section, were continued in the same manner during the secondary storage period and the results are given in fig. 3.

In all the 4 cultivars either uncracked or cracked, the percentages of sprouting after 6° or 10°C storage continue to attain the high levels reached during the primary period, indicating that the condition of out of dormancy was maintained by these temperatures. However, in the cultivars 'Genoveva' and 'Albert Schweitzer' (fig. 3a, b, c, d) the sprouting percentages begin to show somewhat lower values after about 300 days of storage which may be perhaps due to partial loss of vitality.

The sprouting response, obtained after 15° or 20° with uncracked cormels, shows a very irregular pattern and except for 'Albert Schweitzer', the percent-

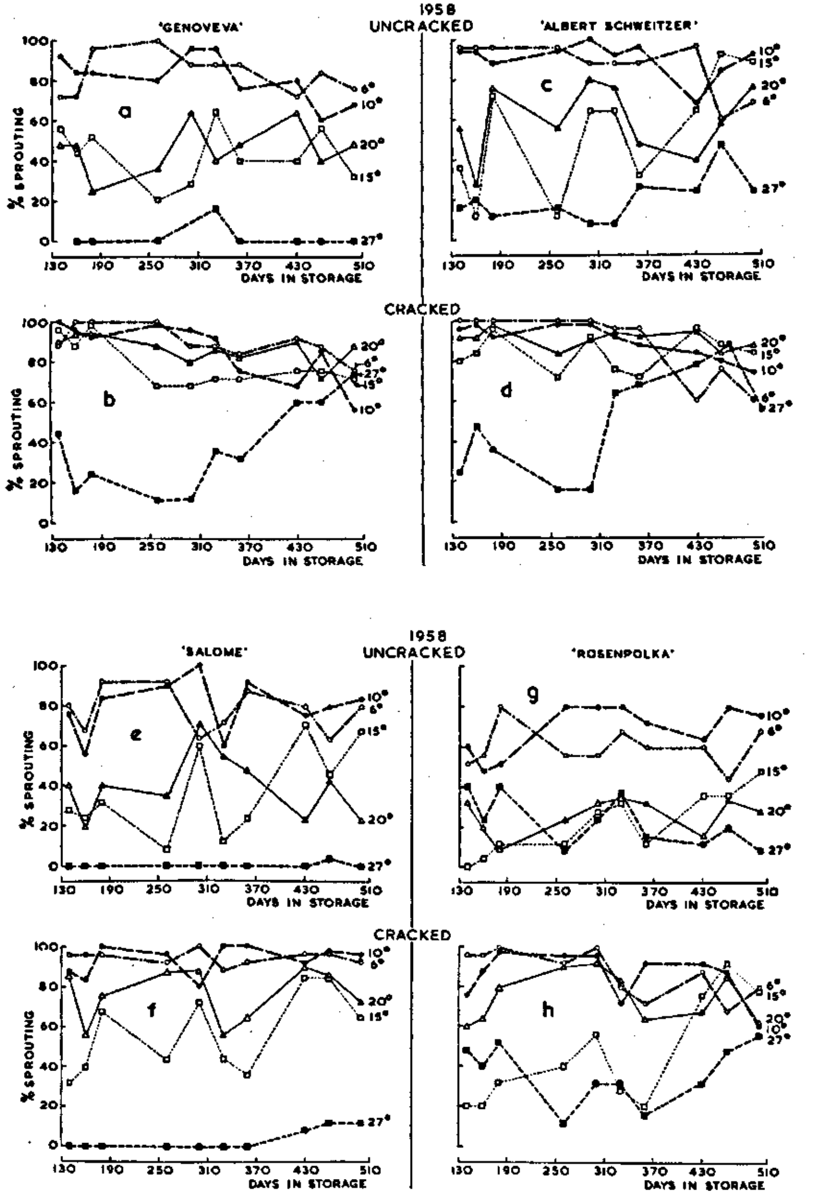


FIGURE 3. *Experiment 4.* – The percentages of sprouting of cormels of 4 cultivars of 1958 harvest, stored at 6°, 10°, 15°, 20° or 27°C for 510 days. During the storage period from 130 to 510 days the cormels were removed at various intervals and planted either uncracked or cracked. Cultivars: a, b = 'Genoveva'; c, d = 'Albert Schweitzer'; e, f = 'Salome'; g, h = 'Rosenpolka'.

ages are, as a rule, below the 50% level (fig. 3a, c, e, g). In 'Albert Schweitzer' the sprouting percentages are in most of the instances above the 50% level and in the latter part of the secondary storage they rise as high as those of 6° and 10°C. After cracking, the sprouting percentages for 'Genoveva' and 'Albert Schweitzer' (fig. 3b, d) during most of the secondary period and for 'Salome' and 'Rosenpolka' (fig. 3f, h), during the latter part of the period reach as high as those of 6° and 10°.

After 27°C storage and uncracked condition, the percentages of sprouting are nearly 0% for 'Genoveva' and 'Salome' (fig. 3a, e) while in 'Albert Schweitzer' and 'Rosenpolka' (fig. 3c, g) they are irregularly fluctuating. After cracking, all the cultivars except 'Salome' reach, in the latter part of the secondary period, levels as high as those of 6° and 10° indicating clearly that the dormancy had been broken.

1.3.3. Dormancy from year to year

Experiment 5. – Since the sprouting behaviour for the cormels harvested in 1958 was known, as described in experiment 4, plantings were carried out during the primary periods of storage, using the cormels of the 1959 and 1960 harvests. This was done to see whether dormancy and the influence of storage temperatures differ from year to year. The results of 'Genoveva' and 'Rosenpolka' for 1959 and 1960 are presented in fig. 4, in addition to the results of 1958 which have already been given in fig. 2a, b, g, h. A few salient features can be pointed out as follows:

a. In 'Genoveva' with uncracked cormels the storage temperatures of 6° or 10° proved to be the best during all the three years. After storage at 15° or 20°C the sprouting percentages were higher for 1958 than those of 1959 or 1960. With cracked cormels all the storage temperatures, except 27°C, behave more or less in a similar manner in different years. The percentages of sprouting after 27°C were lowest for 1958 and 1960, while for 1959 they were as high as the others.

b. In 'Rosenpolka' with uncracked cormels the level of dormancy differs from year to year, being highest for 1959, lowest for 1958, in intermediate position in 1960. However, after cracking, these differences were no longer so conspicuous. An exceptional dormancy breaking effect after 27° storage obtained in 1958 was not to be found for 1959 and 1960.

c. In both cultivars the response of cracking, after 15° or 20° storage, was less pronounced for 1958 than for 1959 and 1960.

1.3.4. Change in storage temperature

As seen from the foregoing experiments, the dormancy disappears sooner after storage at low temperatures than after high ones. To know how the sprouting response is influenced by changing a low storage temperature to a high one and vice versa, two experiments were planned.

Experiment 6. – Cormels of 'Salome', 'Genoveva' and 'Rosenpolka' stored for 27, 57 or 85 days at 6° or 27°C were either changed to a storage temperature of 27° or 6°C, or continued in the same storage for 42 more days. This makes the following treatments:

6° during 27 + 42, 57 + 42 or 85 + 42 = 69, 99 or 127 days.
6° during 27, 57 or 85 days, and followed by 27° during 42 days.

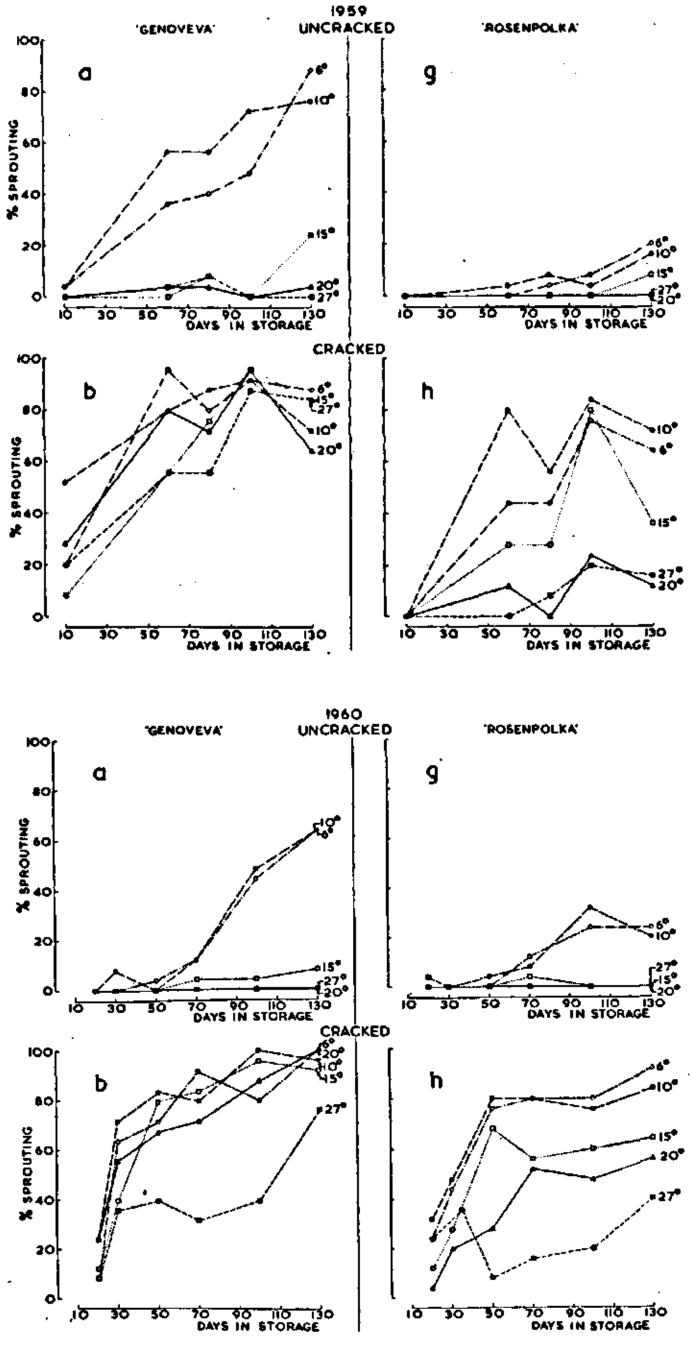


FIGURE 4. *Experiment 5.* – The percentages of sprouting of cormels of 2 cultivars of 1959 and 1960 harvest, stored at 6°, 10°, 15°, 20° or 27°C for 130 days. During the period of storage the cormels were removed at various intervals and planted either uncracked or cracked. Cultivars: a, b = 'Genoveva'; g, h = 'Rosenpolka'.

27° during 27 + 42, 57 + 42 or 85 + 42 = 69, 99 or 127 days.
27° during 27, 57 or 85 days, and followed by 6° during 42 days.

The material was planted, either uncracked or cracked. The sprouting percentages are given in table 5, the columns of which are numbered and abbreviated, while referring, as col. 1, col. 2 etc. The results indicate that:

a. The sprouting percentages obtained after 6° storage were considerably higher than those after a change from 6° to 27°C. The differences are larger for the uncracked cormels than for the cracked ones. (Compare col. 3 with 5, and 4 with 6).

b. The percentages of sprouting obtained after 27° storage were lower than those after a change from 27° to 6°C. (Compare col. 7 with 9, and 8 with 10).

c. The striking differences between col. 5 and 6 on the one hand and col. 9 and 10 on the other hand suggest that the temperature during the last part of the storage period has the greatest influence.

TABLE 5. *Experiment 6.* – The percentages of sprouting of the cormels stored at 6°, 6° followed by 27°, 27°, or 27° followed by 6°, and planted either uncracked (U) or cracked (C). Details of duration of storage periods in text.

1	2	3	4	5	6	7	8	9	10
	Storage	6°		6°→27°		27°		27°→6°	
	Shell	U	C	U	C	U	C	U	C
Cultivar	Days								
'Salome'	69	36	80	0	10	0	0	64	88
	99	64	92	4	76	0	0	84	96
	127	88	88	12	72	0	0	64	92
'Genoveva'	69	48	72	0	28	0	32	40	68
	99	68	80	8	60	0	36	44	60
	127	72	86	4	68	0	8	60	100
'Rosenpolka'	69	44	80	4	24	28	32	28	44
	99	60	84	8	20	24	40	60	64
	127	60	64	0	16	48	52	64	76

Experiment 7. – The cormels of cultivars 'Albert Schweitzer', 'Genoveva', 'Gustav Mahler' and 'Rosenpolka' were stored for 157 days or 188 days at 6° followed by 6°, 15°, 20° or 27°C for 42 days and planted either uncracked or cracked. The results are shown in fig. 5 and may be briefly stated as follows:

a. By the change in temperature, the sprouting percentages were influenced the least for 'Albert Schweitzer' and the most for 'Rosenpolka', while those for 'Genoveva' and 'Gustav Mahler' occupy an intermediate position.

b. As a rule, the percentages of sprouting decrease with the rise in storage temperatures from 6° to 27°C. This decrease is more pronounced for uncracked cormels than for cracked ones and with cracked cormels more for those percentages obtained after 165 days of storage than for those after 188 days storage.

1.3.5. Discussion

The cormels were in dormancy at the time of harvest. When they were stored at 6° or 10°C, the sprouting percentages increased with the duration of the

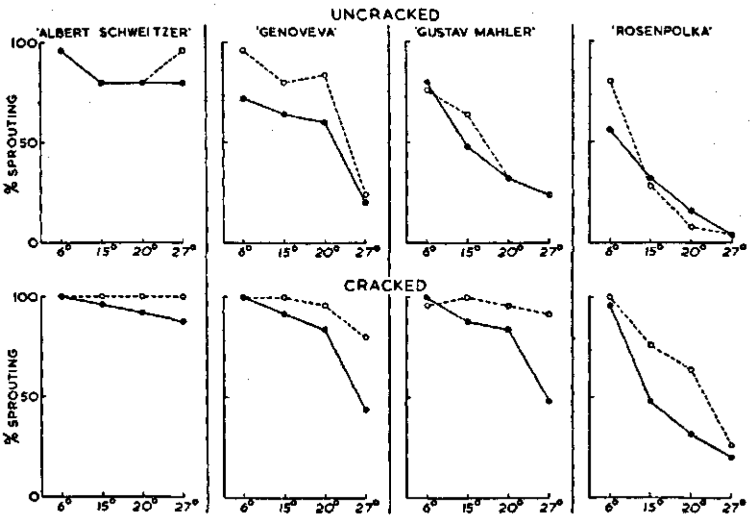


FIGURE 5. *Experiment 7.* – The percentages of sprouting of cormels stored at 6° for 157 days (unbroken lines) or 188 days (broken lines), changed to 6°, 15°, 20°, or 27°C for 42 days and planted either uncracked or cracked.

storage and they soon reached such high levels that the cormels were shown to be more or less completely out of dormancy. From the time this condition of out of dormancy was reached, the low temperatures maintained it at the same high level for a period of a year or so, at the end of which some cultivars began to show a somewhat lower level of sprouting, perhaps due to a partial loss of vitality.

When the higher storage temperatures of 15° or 20°C were used, an irregular pattern of sprouting was obtained, perhaps indicating a state of an unstable equilibrium for the processes involved in breaking the dormancy. In many cases the removal or cracking of the shell replaces the need of low temperature.

With the exception of one cultivar, the sprouting after storage at 27°C was considerably low which was somewhat improved by cracking during the primary period. However, at the end of the secondary period, the treatment of cracking could give high sprouting percentages, comparable to those of low temperatures. Thus, it is possible to break the dormancy without using low temperatures, when the storage lasts very long. However, low temperatures seem to be indispensable to maintain the condition of out of dormancy.

It is also worth mentioning that the control of dormancy was possible by changing high temperature to low and vice versa. Also, the depth of dormancy differs from year to year. This fact leads us to think of a possibility of a control of dormancy from the time it sets in in the cormels. This will be treated in section 5 of this chapter.

2. Soil temperature

2.1. *Introduction*

The results obtained with regard to the temperature requirements for the germination of seeds have indicated that not only from species to species or from cultivar to cultivar within the same species differences occur, but that also other factors such as storage conditions, age etc., have influence (24, 1955; 42, 1956). In comparison with the analogous case of seeds, little is known about the sprouting of gladiolus. In the controversial report of LOOMIS and EVANS (28, 1928) mention is made of the high soil temperatures for breaking the dormancy of gladiolus corms. EMSWELLER and TAVERNETTI (15, 1931) used electric cables to heat the soil (15,6° to 21,1°) and obtained earlier sprouting and flowering compared with those from unheated soil. The results of VEGA (46, 1960) suggest that temperatures between 13° and 30°C are favourable for sprouting of cormels, cultivar 'Picardy'.

Before describing our experimental results, some more discussion on certain aspects of this problem is necessary. Very shortly after the cormels are planted, imbibition starts and it is followed by a series of biochemical reactions resulting in sprouting as indicated by some visible signs of starting of growth. Failure of sprouting under favourable conditions may be considered as due to dormancy. From a quantitative aspect of this phenomenon, a sample of cormels which is completely in or out of dormancy would sprout for 0% or 100% respectively. If the above picture is accepted as valid, it would imply that the conditions preceding the planting determine the stage of dormancy, while the conditions following the planting express it by the degree of sprouting. In other words, the conditions under which sprouting occurs, would not be favourable for breaking the dormancy. In the experiments to follow, a range of soil temperatures is used to verify these assumptions.

2.2. *Soil temperature and sprouting*

Experiment 8. – The cormels of c.v. 'Josephine' which were stored at 10°C for 6 weeks after harvest, were planted at various soil temperatures. For each soil temperature 75 cormels were used. The sprouting percentages obtained after 60 days from planting are presented in table 6.

TABLE 6. *Experiment 8.* – Sprouting after 60 days from planting at various soil temperatures.

Soil temperature (in °C)	Sprouting %
6°	1
10°	21
14°	66
17°	65
20°	72
23°	74
26°	88

These results clearly indicate that the sprouting percentages increase with the rise of soil temperature. However, the duration of 60 days is not sufficient to complete the sprouting, especially at low soil temperatures. This will become clear from the next experiment.

Experiment 9. – The cormels of c.v. 'Albert Schweitzer' were stored for 5 months after harvest at 6°C. They were planted at various soil temperatures from 6° to 26°C, for each treatment 2 × 50 cormels. A period of 129 days was allowed to complete the sprouting. The results are illustrated in figure 6.

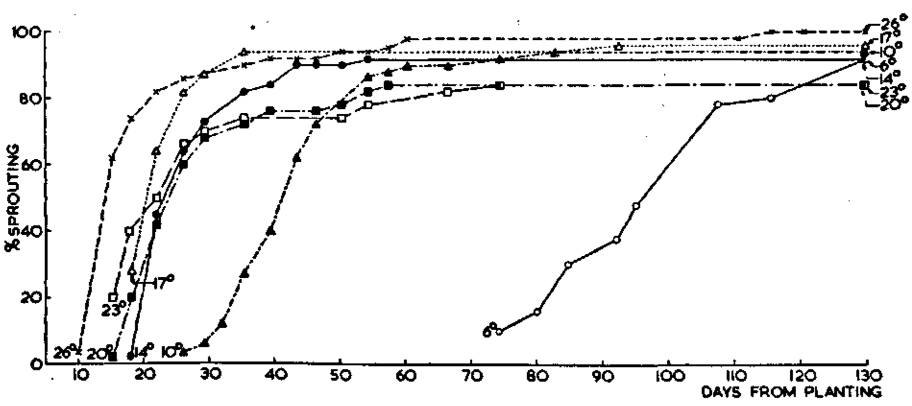


FIGURE 6. *Experiment 9.* – Sprouting percentages of the cormels of 'Albert Schweitzer' obtained in 130 days after planting at various soil temperatures, indicated at start and end of the lines.

These results may be summarized as follows:

a. At the soil temperature of 26 °C the sprouting started first and was completed in the shortest period of time.
b. The progress of sprouting was more or less similar for the cormels planted at soil temperatures between 14° and 23 °C.
c. The progress of sprouting was unfavourably effected at a soil temperature of 10 °C and considerably so at 6 °C.
d. The soil temperatures clearly influence the progress of sprouting, but when the time factor is omitted, final sprouting percentages between 85% and 100% are reached under all the temperatures between 6° and 26 °C.

After knowing a general pattern of response in case of cormels which were out of dormancy, it is interesting to see how the storage temperature – especially an unfavourable one for breaking the dormancy – and the condition of the shell influence the sprouting behaviour. In this respect two seperate experiments were performed.

Experiment 10. – In section 1 of this chapter it was demonstrated that the cormels stored at 6° or 10 °C sprout better than those stored at 20 °C. For the present experiment, 2 × 50 cormels of c.v. 'Leif Erikson', stored at 6° or 20 °C for 5 months after harvest, were planted at each of various soil temperatures between 6° and 26 °C. The results are given in table 7 and indicate:

a. The final percentages of sprouting obtained at the soil temperature of 26 °C is higher than those percentages obtained at various temperatures between 6° and 23 °C. An analysis of variance has revealed that sprouting percentage at 26° is significantly superior to the rest of the percentages which do not differ one among the other.
b. The progress of sprouting decidedly slows down at soil temperatures of 10° and 6 °C.
c. At any soil temperature between 6° and 26 °C, the percentage of sprouting was lower and the number of days required to complete sprouting was larger in case of storage at 20° than that of 6 °C.

TABLE 7. *Experiment 10.* – Sprouting percentages obtained after 129 days and average numbers of days required to complete sprouting of the cormels, cv. 'Leif Erikson', stored at 6° or 20 °C and planted at various soil temperatures.

Soil temperature	Storage temperature			
	6°		20°	
	%	days	%	days
6°	56	83.5	24	123.2
10°	58	43.8	24	87.7
14°	66	26.6	22	33.5
17°	54	24.9	18	33.7
20°	64	24.5	24	43.6
23°	60	23.7	28	40.9
26°	78	20.2	40	30.3

Experiment 11. – The soil temperatures of this experiment are slightly different from those which were used in the previous experiments. The cormels of cultivars 'Josephine', 'Africa' and 'Pall Mall' which were stored for 4 months after harvest at 10° or 20 °C, were planted at soil temperatures of 8°, 11°, 14°, 17° or 20 °C. For each of the soil temperature treatments, 160 cormels were used which, just before planting, were divided into two groups. One of the groups was planted with the shells of the cormels intact or 'uncracked', while in the second they were removed or 'cracked'. This treatment was included, because the removal of the shell has been, in many instances, proved to increase the sprouting percentage, as discussed in section 1 of this chapter. The observations were recorded for 104 days and the sprouting percentages obtained have been mentioned in table 8. From this table it can be noted that as a rule the sprouting

TABLE 8. *Experiment 11.* – Sprouting percentages after 104 days, obtained at various soil temperatures, of the cormels of three cultivars stored at 10° or 20°C and planted with the shell uncracked at planting time (U) or removed = cracked (C).

Cultivar / Treatment / Soil temperature	'Josephine'				'Africa'				'Pall Mall'			
	10°		20°		10°		20°		10°		20°	
	U	C	U	C	U	C	U	C	U	C	U	C
8°	90	88	48	70	55	98	0	63	15	48	0	30
11°	90	98	68	83	58	98	15	83	20	35	28	28
14°	93	95	68	85	53	95	8	70	8	40	8	35
17°	90	98	55	83	30	98	3	40	5	45	5	38
20°	100	98	55	100	78	95	0	55	5	28	0	38

percentages, obtained for any storage or for any shell condition, are not influenced by the soil temperatures. An overall analysis of variance supports this conclusion, and therefore, a special stress may not be given on a few exceptions of it. The cracked cormels sprout better than the uncracked ones, with very few exceptions of minor importance. Higher sprouting percentages are obtained in 'Josephine' and 'Africa' by storage at 10 °C than by storage at 20 °C. The average numbers of days required for sprouting of the cormels of experiment 11 have been presented in fig. 7. From this figure one can read the following.

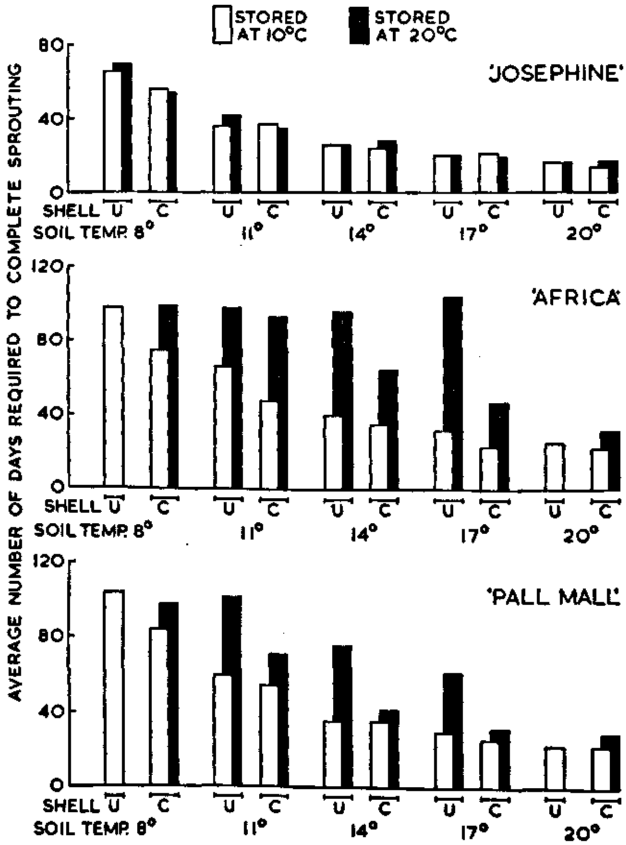


FIGURE 7. *Experiment II.* – Average numbers of days required to complete sprouting of the cormels which were stored at 10° or at 20 °C and planted, with shell uncracked (U) or cracked (C) at soil temperatures of 8°, 11°, 14°, 17° or 20°C.

a. 'Josephine' separates itself from the remaining two cultivars. The treatments of the storage or shell seem to have no influence on the number of days required for sprouting, except for soil temperature of 8 °C. Obviously, the following conclusions are drawn for 'Africa' and 'Pall Mall' only.

b. For the cormels stored at 10 °C, the number of days required for sprouting are smaller as the soil temperatures become higher from 8° to 20 °C. The cormels stored at 20 °C show irregular behaviour which may be, perhaps, due to the very low percentages of sprouting.

c. The cormels stored at 10 °C required lesser days to complete sprouting than those stored at 20 °C.

d. At any soil temperature and with storage of 20 °C, the uncracked cormels required more days for sprouting than the cracked ones. In case of cormels stored at 10 °C this conclusion holds true only for soil temperature of 8 °C.

2.3. *Soil temperature and dormancy*

It is evident from the earlier experiments that the dormancy is broken by storage at 6° or 10 °C in a dry condition. Whether it is possible to break the dormancy by providing the same low temperatures in moist condition, like in soil, is not known. To obtain more information on this point, two experiments were planned in which low temperature was provided in a moist condition either in one continuous period or in the form of diurnal alternation with high temperature.

Experiment 12. – Cormels of 'Leif Erikson' prestored at 20 °C for 5 months after harvest were used. These cormels were divided into 6 lots and two of them were planted at 10° or at 20° as controls. The remaining 4 lots were removed to 6 °C storage where the cormels of two lots were kept dry in paper bags and those of two other lots were covered with moist soil. Each of the lots represents 2 × 50 cormels. After 66 days of storage at 6 °C, the two lots which were in paper bags were planted at soil temperatures of 10° or 20 °C, while those two lots which were covered with moist soil, were transferred, in undisturbed condition with soil, to 10° or 20 °C, where the soil temperature reached the level of the air temperature within 8 hours. The results of sprouting of all the 6 lots were recorded for a period of 129 days. They are presented in table 9.

TABLE 9. *Experiment 12.* – Influence of storage at 6°C for 66 days in dry state or in moist soil on the sprouting percentages obtained during 129 days and on the average numbers of days required to complete the sprouting of the cormels of 'Leif Erikson', pre-stored at 20 °C for 5 months after harvest and planted at soil temperatures of 10° or 20°, compared with controls which were planted immediately after the pre-storage.

Storage at 6 °C for 66 days	Soil temperature	Sprouting %	Days
Control	10°	24	88
Dry	10°	92	55
In moist soil	10°	82	26
Control	20°	24	44
Dry	20°	82	28
In moist soil	20°	72	24

The results of table 9 clearly indicate that in case of cormels, which had received low temperature both in dry state or in moist soil, the sprouting percentages are higher and the average numbers of days required to complete sprouting are less than those obtained for the cormels which received no cold (control). As far as sprouting percentage is concerned, the effectiveness of the low temperature of 6 °C for 66 days, either in dry storage or in moist soil, is almost the same. For the cormels with low temperature storage in moist soil, the days required to complete sprouting were the least among all treatments, especially at a soil temperature of 10 °C, indicating a possibility that the processes involved in sprouting have already started without visible signs during storage at 6 °C.

Experiment 13. – The cormels of cultivars 'Friendship', 'Salome' and 'Josephine', stored at 20° or 27 °C for 6 months after harvest, were planted at soil temperatures of 10°, 22 °C or at a diurnal alternating temperature cycle of 16 hours at 10 °C and 8 hours at 22 °C. Per treatment 2 × 40 cormels were used. For the alternation of temperatures a simple method was used. The cormels were planted, as usual, in boxes containing soil. These boxes were put on a trolley which was allowed to stand in an air temperature of 10 °C from 4 p.m. to 8 a.m. (16 hours) and in an air temperature of 22 °C from 8 a.m. to 4 p.m. (8 hours). A single transfer of the trolley from one temperature to another required not more than a couple of minutes. Due to a regular alternation in the air temperatures, the cormels are actually exposed to a cyclic rise and fall of soil temperature which is shown in fig. 8.

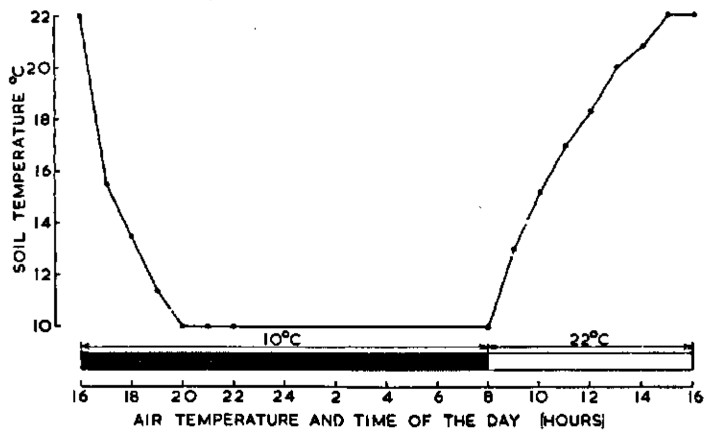


FIGURE 8. *Experiment 13.* – Soil temperature fluctuations due to a cyclic diurnal alternation of 16 hours at 10° and 8 hours at 22 °C in the air temperature.

The cormels were allowed to sprout during 118 days or during 236 cyclic alternations of temperature. The results obtained are presented in table 10.

TABLE 10. *Experiment 13.* – Influence of soil temperatures of 10°, 22° or a cyclic diurnal alternation of 16 hours at 10° and 8 hours at 22 °C on the sprouting percentages (%) and on the average numbers of days required to complete sprouting of the cormels of 3 cultivars stored at 20° or 27 °C.

Soil temperature	Cultivar / Storage / Sprouting	'Friendship'		'Salome'		'Josephine'	
		20°	27°	20°	27°	20°	27°
10°	%	23	30	0	0	13	23
	days	114	78	∞	∞	114	112
22°	%	37	25	3	0	5	3
	days	46	29	80	∞	41	51
10° ⇄ 22°	%	90	58	33	0	68	35
	days	97	83	115	∞	109	114

This table indicates that a diurnal cyclic alternation of temperature can break the dormancy. The effectiveness of this treatment is quite clear from the relatively high percentages of sprouting obtained in most cases. The only exception is 'Salome' of 27 °C storage which could point to a deep level of dormancy that has not been broken by the given number of cycles. The average numbers of days required to complete sprouting are considerably higher for alternating temperature than those required for soil temperature of 22 °C. This could perhaps be explained by the necessity of breaking dormancy in a part of the cormels, before sprouting can start, and this takes time.

2.4. *Maintenance of the dormancy*

It has been established from the results of the foregoing experiments that the sprouting can be obtained at any soil temperature from 6° to 23°C and that the sprouting percentages reach about the same level under all these temperatures provided a sufficient time is given. Applying these findings to an imaginary set of cormels which are in partial dormancy and are planted, we can expect a certain percentage of them to sprout during a period, the length of which is dependent on the soil temperature. A question can be asked about the unsprouted cormels in this particular case. How long can they lie in an unsprouted condition in moist soil? Or in other words, how long their dormancy will be maintained? The maximum period for sprouting, used so far, had been 129 days during which none of the constant temperatures between 6° and 23°C could break the dormancy. In the following experiments longer periods than 129 days have been used.

Experiment 14. – The cormels of the 7 cultivars were stored at various temperatures between 6° and 27°C for 9 or 42 days after harvest and then planted in a greenhouse maintained at about 20°C. For each cultivar 250 cormels were used. The sprouting was recorded for a period of 62 days from planting and for the following period of 197 days. In table 11 the percentages of sprouting are mentioned, totalized over the different storage groups. In this table we see that the two cultivars, 'Albert Schweitzer' and 'Leif Erikson' were in partial

TABLE 11. *Experiment 14.* – Sprouting percentages obtained after 62 days from planting and after the following 197 days at a soil temperature of 20°C, in 7 cultivars.

Cultivar \ Days	62	197
'Albert Schweitzer'	26	13
'Salome'	3	8
'Leif Erikson'	35	4
'Genoveva'	4	3
'Friendship'	3	<1
'Rosenpolka'	3	<1
'Gustav Mahler'	<1	<1

dormancy, while the remaining 5 cultivars were in nearly complete dormancy, sprouting for less than 12 percent. The very low sprouting percentages, obtained after 62 days and 62 + 197 = 259 days from planting, indicate that the dormancy of the unsprouted cormels is maintained in the moist condition at 20°C. This conclusion was supported by the results of an experiment carried out a year later under similar conditions with 5 cultivars.

To understand more about this phenomenon of maintaining the dormancy of the cormels in moist condition, two experiments were performed using low temperature interruption.

Experiment 15. – Due to the complicated nature of the method used in this experiment, it is necessary to explain it step by step and simultaneously with the table 12 in which the results are presented. The columns of this table are numbered and, while referring, abbreviated as 'col. 1', 'col. 2' etc.

TABLE 12. *Experiment 15.* – Sprouting percentages of the cormels of 4 cultivars, stored after harvest at 6°, 10°, 15°, 20° or 27° for 9 days or 42 days and planted at a soil temperature of 20°C. Col. 3, 5, 7, 9 give the sprouting percentages after 62 days (– cold). Col. 4, 6, 8, 10 give the percentages of sprouting after a cold treatment (+ cold).

1	2	3	4	5	6	7	8	9	10
	Cultivar	'Albert Schweitzer'		'Leif Erikson'		'Gustav Mahler'		'Rosenpolka'	
Storage Temp.	Cold / Days	–	+	–	+	–	+	–	+
6°	9	12	44	20	64	0	16	0	32
	42	64	96	28	96	0	20	0	52
10°	9	4	52	32	44	0	16	0	68
	42	88	96	56	92	0	32	0	68
15°	9	20	68	4	92	0	12	0	8
	42	4	76	16	72	0	20	1	36
20°	9	8	84	40	48	0	12	0	76
	42	4	84	12	92	0	32	0	48
27°	9	0	84	12	80	0	8	0	72
	42	4	56	4	80	0	48	0	80

a. The cormels of 4 cultivars, 25 cormels per treatment, were stored after harvest at 6°, 10°, 15°, 20° or 27°C for 9 days or 42 days and then planted at a soil temperature of 20°C.

b. The sprouting percentages obtained after 60 days from planting were recorded (col. 3, 5, 7, 9).

c. From the 61st day onward some sprouts came still up, but by the time the boxes were removed to low temperature (see *d*), most of the sprouted plants had died.

d. The boxes, in which the cormels were planted, were removed to the low temperature of 5°C, those of 9 days storage after 255 days, those of 42 days storage after 262 days. These boxes remained at 5°C for 42 days and were then brought back to the original greenhouse temperature of 20°C. The cormels were not disturbed during the transfer of the boxes.

e. The percentages of sprouting were recorded for 40 days after the end of the cold treatment. This is 337 days from planting for the cormels stored during 9 days, 344 days for the cormels stored during 42 days (col. 4, 6, 8, 10).

The results show that in all the 4 cultivars the sprouting percentages obtained for – cold are lower than those for + cold (compare col. 3, 5, 7, 9 with 4, 6, 8, 10). This indicates that the cold treatment of 5° for 42 days has broken the dormancy of the cormels.

A surprising fact which came out in this experiment is that the cormels, lying in moist soil in dormancy as long as 255 or 262 days, maintained the differences in the levels of dormancy which existed at the time of planting during the whole period in moist condition and exhibited them after exposure to the low temperature. This will be seen by comparing the figures of 9 days storage with those of 42 days storage in col. 4, 6, 8, 10, the figures from the latter storage being, as a rule, higher. It may be clarified that the use of the expression 'difference in the levels of dormancy at planting time' is based on the assumption that the level of dormancy after 9 days from harvest is higher than that after 42 days.

An objection may be raised, expecially in cases of cultivars 'Albert Schweitzer' and 'Leif Erikson', that the totals of the percentages obtained after 60 days and after cold treatment sometimes exceed 100 (col. 3 + 4, 5 + 6). This situation arises due to failure of removal of the cormels which had sprouted before the cold treatment and, later, resprouted along with those cormels which did not sprout at all. This objection, however, does not hold true for cultivars 'Gustav Mahler' and 'Rosenpolka' as they were in dormancy during all the period before cold treatment.

To verify the results in a more accurate way, the following experiment was planned, a year later, on rather similar lines except that the precaution was taken to remove all the sprouted cormels before the beginning of the cold treatment.

Experiment 16. – The method used can be described in the same way as in the previous experiment and simultaneously with table 13 in which the results are presented.

TABLE 13. *Experiment 16.* – Sprouting percentages of the cormels of 2 cultivars stored after harvest at various temperatures between 6° and 27°C for 10 or 57 days. Col. 3 and 5 give the sprouting percentages after 62 days (– cold). Col. 4 and 6 give the percentages of sprouting after a cold treatment (+ cold).

1	2	3	4	5	6
	Cultivar	'La Coruna'		'Africa'	
Storage	Cold	–	+	–	+
Temp.	Days				
6°	10	12	40	0	91
	57	56	37	8	96
10°	10	0	48	0	96
	57	60	15	32	95
15°	10	0	44	0	96
	57	0	59	0	96
20°	10	0	24	0	100
	57	0	52	0	100
27°	10	0	44	0	92
	57	0	67	0	100

a. The cormels of 2 cultivars, 'La Coruna' and 'Africa' were stored after harvest at various temperatures between 6° and 27° for 10 or 57 days. They were then planted at a soil temperature 20°C.

b. The sprouting percentages obtained after 62 days from planting were recorded (col. 3 and 5).

c. All the sprouted cormels, as recorded under *b* and a few more which came up after the 63rd day onward, were removed from the soil.

d. The boxes, in which cormels were planted, were removed to the low temperature of 5°C, those of 10 days storage after 229 days, those of 57 days storage after 182 days. These boxes remained at 5°C for 42 days and were then brought back to the original greenhouse temperature of 20°C.

e. The percentages of sprouting were recorded for 65 days after the end of the cold treatment. This is 336 days from planting for the cormels stored during 10 days, 289 days for the cormels stored during 57 days. The numbers of sprouts obtained, were converted into percentages of unsprouted cormels at the beginning of the cold treatment (col. 4 and 6).

With 2 exceptions the sprouting percentages under col. 3 and 5 are lower than those of col. 4 and 6, indicating that the dormancy was broken by the cold treatment. In col. 4 the sprouting percentages obtained at 15°, 20° and 27°C and 10 days storage were lower than those obtained at similar temperatures and 57 days storage. The sprouting percentages under col. 6 are above 91 indicating that the cold treatment was sufficient enough to remove the differences in the levels of dormancy.

A similar experiment was performed with 'Rosenpolka', but half of the cormels were cracked before planting. The sprouting percentages as well as the mean numbers of days required to complete sprouting are recorded in table 14.

TABLE 14. *Experiment 16.* – The percentages of sprouting of cv. 'Rosenpolka' recorded in the same manner as in table 13, and average numbers of days to complete sprouting which were calculated during 0 to 62 days and during the following 65 days after the cold treatment.

1	2	3	4	5	6	7	8	9	10
Storage	Treatments	– Cold				+ Cold			
		Uncracked		Cracked		Uncracked		Cracked	
Temp.	Days	%	days	%	days	%	days	%	days
6°	10	0	∞	0	∞	20	27	76	20
	57	0	∞	44	33	32	25	85	18
10°	10	0	∞	0	∞	32	23	91	18
	57	4	33	80	31	40	22	100	19
15°	10	0	∞	0	∞	32	27	71	19
	57	0	∞	28	33	32	23	100	19
20°	10	0	∞	0	∞	32	26	96	20
	57	0	∞	12	33	16	29	62	19
27°	10	0	∞	0	∞	36	24	88	16
	57	0	∞	0	∞	56	26	92	19

The results obtained are, in general lines, supporting the previous results. The main features can be listed as follows.

a. The sprouting percentages of col. 3 and 5 are lower than those of col. 7 and 9 respectively, indicating again that dormancy can be broken by low temperature for uncracked as well as for cracked cormels.

b. The sprouting percentages of col. 7 are lower than those of col. 9 suggesting that the cold treatment can break the dormancy more efficiently in cracked cormels than in uncracked ones. This is again supported by the average numbers of days required to complete sprouting which are larger in col. 8 than in col. 10.

c. With only few exceptions, in col. 7 and 9 the sprouting percentages for 10 days storage are lower than those for 57 days storage.

2.5. *Discussion*

In the beginning of this series of experiments, we started with the assumption that the conditions, under which sprouting occurs, do not induce the breaking of dormancy. However, it has become evident from the experimental results that an exposure to a low temperature of 6° in moist soil for 66 days or of 10 °C in a cyclic diurnal alternation with 22 °C, could break the dormancy (table 9, 10).

Obviously, a question arises whether the processes involved in breaking the dormancy and those involved in sprouting, could occur in the cormels at one constant temperature. In the light of the present limited results the answer is negative. This conclusion is supported in two different ways. Firstly by the fact that the levels of sprouting, reached during a maximum period of 129 days at all constant soil temperatures between 6° and 23 °C, are the same (table 7). Secondly by the evidence that a constant soil temperature of 20° could maintain the dormancy of the cormels, which are unable to sprout within 62 days from planting, up to a period of 262 days and perhaps even longer if these cormels had not been exposed to low temperature of 5 °C (table 12, 13, 14).

The surprising result that the different levels of dormancy existing at the planting time are maintained throughout a long period of moist condition at a constant temperature suggests two possibilities:

a. The levels of dormancy at planting time continue to exist unchanged.

b. An independent mechanism comes into play as soon as moist conditions are provided and this induces conditions similar to dormancy, the intensity of this induction being proportional to the level of the dormancy at the starting time of moist conditions.

3. Storage temperature and growth of plants

3.1. *Introduction*

In a commercial growing the ultimate goal is to obtain a good growth resulting in a high production of marketable plant parts. A satisfactory germination or sprouting becomes a starting point in a manoeuvre of commercial success. It has been established in the foregoing experiments that the storage temperatures greatly influence the sprouting behaviour of cormels (see sections 1 and 2 of this chapter). However, the success in manipulation of sprouting especially without low temperature storage, is shadowed when the resulting growth of plants and the production of corms and cormels are subnormal. Flemion and Prober (18, 1960) have quoted several references which demonstrated in various plants a stunted growth following the germination obtained in unchilled seeds by removal of seed coats. To study whether the storage temperatures influence the growth of plants of gladiolus, some experiments in the field and in the greenhouse were performed.

3.2. *Field experiments*

Experiment 17. – The cormels of cultivars 'Debonair' and 'Porter' were stored after harvest at room temperature of 20° to 25°C. After 5 months, one half of the cormels was removed to 5° for 6 weeks and then planted, along with the other half from the room temperature storage, either uncracked or cracked. For each treatment 4 × 50 cormels were used. The numbers of cormels produced per 50 cormels planted are given in table 15. The results show that in both cultivars the production of cormels after 5°C storage was higher than that for room temperature storage, both for uncracked and cracked cormels.

TABLE 15. *Experiment 17.* – The numbers of cormels produced per 50 cormels, stored at 5°C or 20°–25°C and planted in the field either uncracked or cracked.

Cultivar	Storage temperature	Shell condition	
		Uncracked	Cracked
'Debonair'	5°	352	371
	20°–25°	91	195
'Porter'	5°	246	321
	20°–25°	131	126

Experiment 18. – Since better storage facilities were available, the cormels of 3 cultivars were stored after harvest at 6°, 15° or 27°C for 4½ months and then planted. For each treatment 4 × 50 cormels were used. After the harvest, corms and cormels were separated and the former were graded as large, medium and small according to size 12 cm or above, 7 cm to 11 cm, and 6 cm or below respectively. The numbers and weights of corms and cormels are given in table 16. Besides a few exceptions of minor importance, the results show that the production of corms and cormels, both as number and as weight, was the highest for the cormels stored at 6° and the lowest for those after 27°C, while it was intermediate for those from 15° storage.

TABLE 16. *Experiment 18.* – The numbers and weights of corms and cormels produced per 50 cormels of 3 cultivars stored at 6°, 15° or 27°C for 4½ months and then planted in the field.

Cultivar	Storage temperature	Corms						Cormels	
		Large		Medium		Small			
		number	weight g	number	weight g	number	weight g	number	weight g
'Friendship'	6°	0	–	3	48	37	105	378	28
	15°	0	–	3	33	20	20	168	11
	27°	0	–	0	–	22	20	94	6
'Gustav Mahler'	6°	1	30	15	182	31	110	405	27
	15°	0	–	0	–	22	36	44	1
	27°	0	–	0	–	13	11	37	1
'Salome'	6°	0	–	3	33	49	94	286	18
	15°	0	–	0	–	48	59	220	9
	27°	0	–	0	–	30	17	56	3

The results of experiments 17 and 18 strongly lead us to draw the conclusion that the storage temperatures influence the production of corms and cormels. This is in accordance with STUART (40, 1954) and SCARCHUK (38, 1955) whose experiments were of a similar nature. However, this conclusion is subjected to several objections, based mainly on the fact, that the storage temperatures influence the sprouting behaviour of the cormels, which has been dealt with at length in sections 1 and 2 of this chapter. Some of these objections are as follows.

As a result of different percentages of sprouting:

a. The number of plants per treatment is not the same.

b. The spacing between the plants is not uniform.

As a result of different average numbers of days required to reach maximum sprouting:

c. The length of the growing period is not uniform for all treatments.

d. The growth of the plants is subjected to different combinations of daylength, temperature and other climatic factors.

Considering the above stated objections, experiments were carried out in the greenhouse at 17 °C, using a different method.

3.3. *Greenhouse experiments with uniform age and spacing*

Experiment 19. – The cormels of cultivar 'Josephine', stored after the harvest at 10°, 15° or 27 °C for about 4 months, were planted 3 times either uncracked or cracked, with an interval of 5 days between two plantings. Planting was done in earthen pots at a rate of 5 to 10 cormels per pot. At the end of 50 days after the first planting, the plants of as uniform a size as possible were selected from all the 3 plantings in such a way that one plant of a desired size per pot was available in an undisturbed condition, while all the other plants were removed. Care was also taken to remove the plants which sprouted later. In this way only plants were observed that grew under conditions as uniform as possible, especially regarding age and spacing. For each treatment 2 × 15 plants in 30 pots were used. The pots were buried to the rims in peat so that the roots, escaping through the bottom drainage hole, would not receive any nutrients of special importance. The plants were allowed to grow for 5 months from the time of selection and were then harvested. The height of plants and number of leaves were noted at the harvesting time, while the dry weights of leaves were determined immediately after the harvest. The weights of corms and cormels were determined after 8 days of air drying at 15 °C from the harvest. The data thus collected were calculated as averages per plant and presented in table 17. It was disclosed in the analyses of variance for all the 6 characters mentioned in the table that the differences due to the storage temperatures and the shell treatments were not significant.

Another experiment was conducted on exactly similar lines for the cultivars 'Albert Schweitzer' and 'Friendship'. The results confirmed the previous finding that in all the 6 characters the differences due to the storage temperatures were not significant at all. About the shell treatments, which as a matter of fact are of secondary importance in these particular experiments, it may be added that for both cultivars the uncracked cormels produced taller plants with a higher number of leaves than those of cracked ones, while for the remaining

TABLE 17. *Experiment 19.* – The data, expressed per plant, obtained from plants grown from the cormels of the cultivar 'Josephine' stored at 10°, 15° or 27 °C and planted either uncracked or cracked. See details about method of planting with uniform age and spacing and the collection of data in text.

Storage	Shell	Height of plant cm	Leaves		Corm	Cormels	
			number	dry weight × 10 mg	weight × 10 mg	number	weight × 10 mg
10°	Uncracked	57	5,4	163	455	17	59
	Cracked	55	4,5	118	383	15	58
15°	Uncracked	54	4,4	103	399	13	52
	Cracked	56	4,4	125	383	16	57
27°	Uncracked	58	5,1	152	553	14	47
	Cracked	53	4,4	123	486	14	46

4 characters the differences between uncracked and cracked cormels were not significant.

Experiment 20: Daylength. – One of the objections raised against the conclusion that the storage temperatures influence the growth of the plants, was that the plants of different storage treatments are subjected to different climatic factors as a consequence of the spreading of the sprouting over a long period. Though it was shown (table 17) that under the normal daylength conditions between March and October the storage temperatures did not influence the growth of the plants, an experiment was planned to see whether they do influence it under different daylengths.

The cormels of 'Josephine' and 'Pall Mall' stored for 8 months at 10°, 15° or 20° were planted in July 1960. The same methods for planting and selection were used as described in experiment 19 except that one half of the plants was given supplementary light to lengthen the natural daylength to 16 hours (LD), while the other half was exposed to the natural daylength (ND) which was about 16 hours in the beginning and about 8 hours at the end of the experiment. The results obtained for 3 characters were calculated per plant and are presented in table 18. The analyses of variance for all the 3 characters show that differences for the storage temperatures, either in LD or ND, were not significant. It may be interesting to point out that the weights of corm and cormels are significantly lower for LD than those for ND and this observation is in agreement with BORTHWICK and PARKER (4, 1949). The trend for the results with regard to height of the plants is just the opposite.

3.4. *Discussion*

In the field experiments 17 and 18 significant differences were found in the responses as regards production of corms and cormels of plants grown from cormels which were stored at high or low temperature. However, in the light of the greenhouse experiments 19 and 20 with uniform age and spacing these differences may not be attributed directly to the storage temperatures. It was revealed that the storage temperatures did not influence the growth of the plants as expressed by height of the plant, number and dry weights of the leaves, weights and numbers of corms and cormels.

TABLE 18. *Experiment 20.* – The data, expressed per plant, obtained from the plants of 2 cultivars grown from the cormels stored at 10°, 15° or 20°C. The plants were grown under 16 hour (LD) or natural daylength (ND) under uniform spacing. See details about methods of planting and growing in text sub experiment 19.

Storage	Daylength	'Josephine' Height of plant cm	'Josephine' Weight × 10 mg corm	'Josephine' Weight × 10 mg cormels	'Pall Mall' Height of plant cm	'Pall Mall' Weight × 10 mg corm	'Pall Mall' Weight × 10 mg cormels
10°	LD	63	146	40	74	135	53
	ND	56	224	63	66	225	81
15°	LD	62	144	46	82	155	57
	ND	53	250	72	70	230	87
20°	LD	59	138	36	79	146	61
	ND	56	219	60	64	207	80

It is concluded that the differences in the growth responses, as obtained in the field experiments, are due to various secondary conditions. These arise primarily from a single fact, namely that the sprouting behaviour of cormels after different storage temperatures results in different age and spacing.

As a side result, the far better production of corms and cormels at natural day than at long day certainly is worth while mentioning.

4. DORMANCY AND RESPIRATION

4.1. *Introduction*

Not long ago a hypothesis about the phenomenon of dormancy in gladiolus cormels was put up by ROISTACHER, BALD and BAKER (36, 1957). In main lines it assumes that the outer shells exclude the 'oxygen from the internal cormel tissues', resulting in the rise of the free auxin which is followed by a period of dormancy, the length of which depends on the 'thickness' of the outer shells or 'the rate of their deterioration'. The present author attempted to test partially the validity of this hypothesis by measurements of the respiration of the cormels with shell intact or broken. These measurements were also taken during the storage period of 220 days from harvest, in which period the corresponding lots were planted at 20°C for the determination of sprouting percentages. The methods of the measurement of the respiration have already been dealt with in the chapter on 'methods' (p. 6).

4.2. *Shell and respiration*

Experiment 21. – The cormels of cultivar 'Friendship' were stored after harvest in a room with a temperature between 15° and 20°C. After 7 months of storage 100 g of cormels were removed to the respiration tubes held at 20°C and the carbon dioxide evolved by the cormels was measured for 3½ hours. The cormels were then taken out and the outer shells were broken, at the pointed end only, by pressing every individual cormel gently between the fingers. Immediately after this, the cormels were placed again in the respiration tubes for the measurements which lasted for 66 hours. The cormels were then taken out to remove the shell completely. The measurements for the cormels with removed shell were carried out for 40 hours. The results are shown in fig. 9. Simultaneously with the measurements of the respiration, 4 × 50 cormels were planted at 20°C either with the shell intact or broken at the pointed ends and the sprouting percentages obtained after 60 days were 21 and 85 respectively. It is evident from fig. 9 that the rate of carbon dioxide production rose after breaking the shells at the pointed ends and considerably so after their complete removal. The maximum values reached by the rate in case of the cormels with broken or removed shells were 6 or 16 times the value, reached in case of cormels with intact shell.

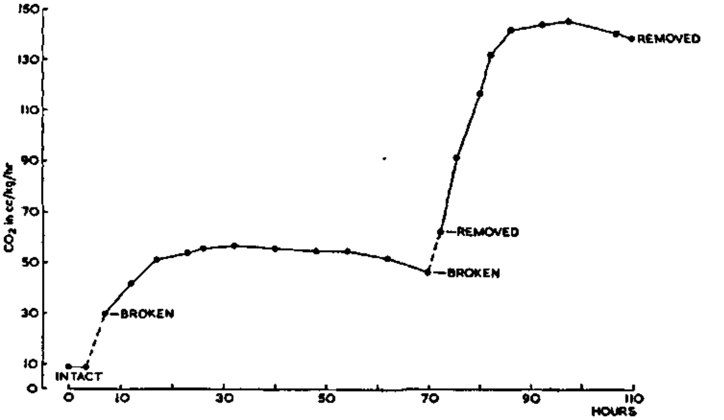


FIGURE 9. *Experiment 21.* – The rate of carbon dioxide production of the cormels with intact, broken and removed shells, cv. 'Friendship'.

4.3. *Storage temperature and respiration*

Experiment 22. – The cormels of the cultivars 'Salome' and 'Albert Schweitzer' were stored after harvest at 9° or 25°C for a period of 220 days during which the production of carbon dioxide was determined at various intervals. The temperature of the water-bath, in which the respiration tubes were suspended, was kept at 20°C for the first determination which was carried out after the harvest and just before the beginning of the storage period at controlled temperature. The later determinations were done in water-baths with the same temperatures as the storage, namely 9° or 25°C. Everytime on the day of carbon dioxide determination, 2 × 50 cormels were taken out of storage and planted, with the shells intact or removed, in a greenhouse at 20°C. The sprouting percentages were recorded for a period of 60 days. The results of the carbon dioxide determinations and of the sprouting are shown in fig. 10a, b. The results will be discussed in the following order: sprouting behaviour of individual cultivar, comparison between the cultivars for sprouting and for respiration, and the relation between sprouting and respiration.

Sprouting behaviour of individual cultivar

'Salome'. – a. After storage at 9°C the percentages of sprouting reached the level of 80% in 220 days for the cormels with intact shells, while a little higher level was already reached in 129 days by the cormels with removed shells.

b. After storage at 25°C the sprouting percentages for the cormels with intact

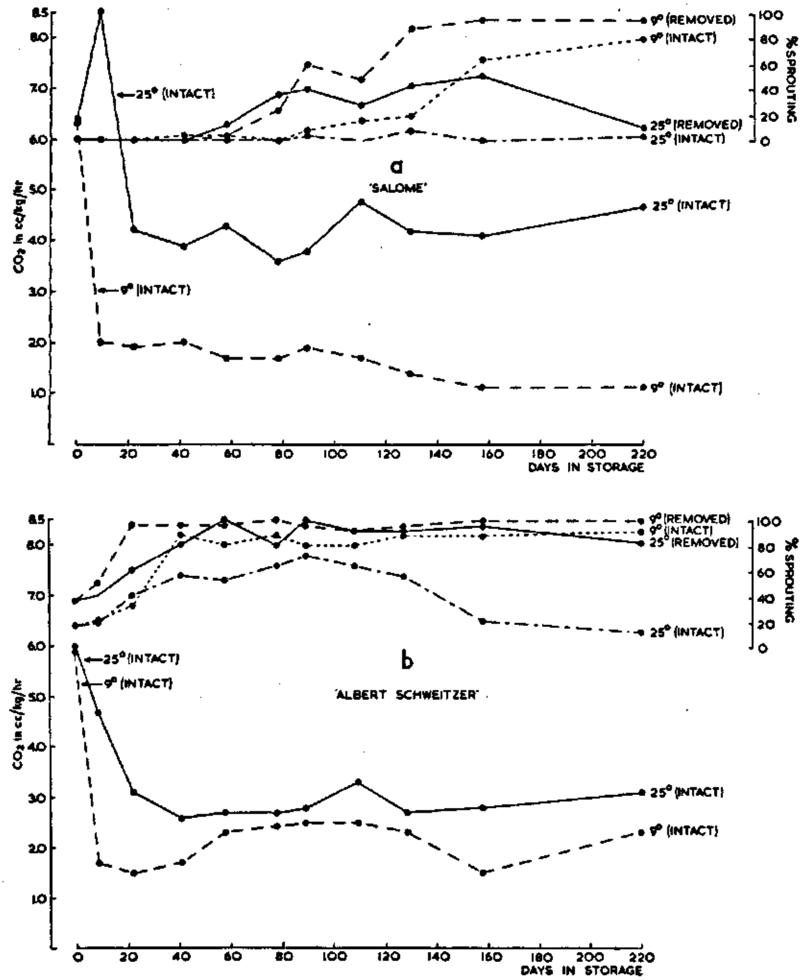


FIGURE 10. *Experiment 22.* – The relation between the production of CO_2 (left ordinate) and the percentages of sprouting (right ordinate) in the cormels, stored after harvest at 9° or 25 °C for 220 days. a = cv. 'Salome', b = cv. 'Albert Schweitzer'.

shells were nearly 0%, while those for the cormels with removed shells reached the 50% level and fell back to a low level.

'Albert Schweitzer'. – *c.* After storage at 9°C the percentages of sprouting for the cormels with intact shells exceeded the level of 80% in 40 days, while those for the cormels with removed shells already exceeded this level in 22 days.

d. After storage at 25°C the percentages of sprouting for the cormels with intact shells exceeded the level of 70% after 89 days, while those for the cormels with removed shells exceeded this level in 40 days.

Both cultivars: sprouting and respiration

e. It is evident from the comparison of conclusions *a.* and *b.* with *c.* and *d.* that 'Salome' was in a deeper dormancy than 'Albert Schweitzer'.

f. After comparing fig. 10a with fig. 10b it appears that the rate of carbon dioxide production, in all instances, for the cormels stored at 25° was higher for 'Salome' than the one for 'Albert Schweitzer'. However, except for 3 determinations following the first one, the situation is just the opposite for the cormels stored at 9 °C.

Relations between sprouting and respiration

This relation can be studied from part of the data of fig. 10a and b, namely those which give information about the change in the rate of CO_2-production during the period of disappearance of dormancy. For 'Salome' with intact shell and a storage temperature of 9°, the dormancy disappeared approximately from the 78th to the 220th day in storage. During this period the rate of CO_2-output decreased from 1.7 to 1.1 cc/kg/hr. Following this line of reasoning, for 'Albert Schweitzer' with intact shell during storage at 9° the change of CO_2-output was irregular, while during storing at 25° it decreased from 4.7 to 2.6.

No determinations of the respiration of cormels with removed shells were made. However, the removing of shells was not done before planting and this justifies to use the data for intact shells. If we use the data for the cormels with intact shells, the CO_2-output decreases in 2 cases, fluctuates in the other 2 cases.

Never did the CO_2-output increase during the period of disappearance of dormancy.

4.4. *Discussion*

The results of experiment 21 showed that the rate of respiration, after only a small crack at the pointed ends of the cormels, rose as much as 5 times the rate for the cormels with intact shells, while for the cormels with the shell completely removed, it rose as much as 16 times. These results clearly demonstrate the role played by the outer shell in limiting the rate of respiration of the internal cormel tissues. The cormels with broken shell sprouted for 85 % against 21 % for those with intact shells. However, it is premature to generalize that the rise in respiration results in breaking the dormancy, since the determination were not done in the early period of storage, during which the cormels do not respond to the treatment of shelling with regard to sprouting.

From the results of experiment 22 we have seen that in the period, during which the dormancy disappeared and during which the ability to respond to the treatment of shelling increased, the rate of respiration showed a decrease in 4 instances and irregular fluctuations in 3 instances.

We started to test the validity of the hypothesis that the length of the period of dormancy depends on the deterioration of the outer shell. It was found that a crack in the shell could greatly increase the rate of respiration. However, there was never a rise, but in fact sometimes a fall, in the rate of respiration during the period in which the dormancy disappeared. This evidence suggests that dormancy disappeared without involving the deterioration of outer shells and therefore the validity of the hypothesis is disputed.

5. Conditions during the growth of the plants and their influence on the dormancy of the resulting corms and cormels

5.1. *Introduction*

It is not improbable that the growers have observed different levels of dormancy exhibited by the corms grown in different seasons or imported from different countries. However, credit goes to EVENARI *et al.* (16, 1950) for pointing out a possibility that such differences in the levels of dormancy may be due to ecological factors, mainly temperature. They expressed doubt about the influence of daylength. Unfortunately, they could not proceed further for want of controlled experimental conditions. RYAN (37, 1955) partially succeeded in overcoming this situation ingeniously by using electric cables to heat the soil under the corms during the growth of the plants. Though growing had to be restricted to the winter season only, he still could demonstrate a somewhat deeper dormancy in the corms grown from heated soil than in those from an unheated one. Recently, TSUKAMOTO and YAGI (44, 1960) showed that when the plants were grown for 4½ or 5¼ months at a constant temperature of 20° and under short day (9 hr), the resulting corms exhibited a slightly lower level of dormancy than under natural long day (unspecified). However, this difference was not found, when the corms were harvested 3 or 6 weeks earlier than those previously mentioned.

Since no further data are available in the literature, two experiments were planned to see how temperature and daylength during the growing season of the plants would influence the level of dormancy in the resulting corms and cormels.

5.2. *Temperature and daylength*

Experiment 23. – The corms of cultivars 'Salome', 'Friendship' and 'Josephine' were harvested in the second half of October 1960. They were stored after the harvest at 10° and then at 15°C for 2 and 2½ months respectively. A selection was made of corms of a uniform size approaching 7 cm circumference. One corm per earthen pot was planted in a greenhouse at 12°C. After 4 weeks from planting, when sprouting had completed and the first foliage leaf was out, a rigorous selection of plants for a desired uniform size was made. The plants were transplanted, without disturbing the root system, in a special type of containers placed in controlled glasshouses or in the bench of an unheated greenhouse. For each treatment 15 to 20 plants were used. The controlled glasshouses were adjusted for constant temperatures of 14° or 23°C, while in the greenhouse the temperature was fluctuating parallel to outdoor conditions. After transplanting, the plants were allowed to grow for 6 months either under 16 hr (LD) or 8 hr (SD) daylength.

The observations regarding the influence of temperature and daylength on the growth of the plants are not presented, since they are out of the scope of our present investigations. After 7 months from planting, the plants at 14° or 23°C and from both daylengths, did not show any signs of maturity. In fact, plants from the short day treatment were greener than those from the long day one. From the greenhouse group some plants showed slight signs of maturity. This visual impression was confirmed when the unit surface areas of the 3rd and 4th leaves were extracted in 90% ethyl alcohol and the extracts compared colorimetrically. The plants were harvested and every corm with its cormels was bagged separately. Within 5 days from harvesting, the bags were removed to storage at 10°C and the contents planted after 0, 20, 53, 74 or 95 days of storage. For each planting 3 to 4 corms per treatment with their cormels were planted. The average numbers of days, required to complete the sprouting for corms, are given in table 19.

Before discussing the results, two points may be stated, namely that the corms in all instances sprouted for 100% and that the results of cormels are not given, because the plants did not produce enough of them due to low intensity of daylight, resulting from the construction of the glasshouses. This situation was better in the other experiment. The results of table 19 will be discussed for temperature and daylength separately.

TABLE 19. *Experiment 23.* – The average numbers of days required to complete sprouting of the corms of 3 cultivars which were obtained from plants grown for 6 months at constant temperatures of 14°, 23° or not controlled (Greenhouse) and under long day (LD) or short day (SD). The resulting corms were stored at 10° and after 0, 20, 53, 74 or 95 days of storage planted at a soil temperature of 18 °C.

1	2	3	4	5	6	7	8	9	10
Cultivar	During growth of plants		Days in storage at 10 °C					Average of columns 4 to 8	
	Temperature	Daylength	0	20	53	74	95	for daylength	for temperature
'Salome'	14°	LD	29	29	19	16	11	21	19
		SD	23	25	16	11	9	17	
	23°	LD	42	31	21	19	17	26	24
		SD	28	29	20	15	16	22	
	Greenhouse	LD	36	31	14	11	9	20	23
		SD	56	36	17	12	10	26	
'Friendship'	14°	LD	31	31	19	15	17	23	19
		SD	20	20	12	11	11	15	
	23°	LD	48	37	25	28	16	31	31
		SD	32	41	26	33	18	30	
	Greenhouse	LD	48	34	16	8	9	23	21
		SD	35	28	13	9	8	19	
'Josephine'	14°	LD	27	26	26	17	16	20	20
		SD	26	27	19	15	11	20	
	23°	LD	35	33	29	28	19	29	27
		SD	34	29	23	22	18	25	
	Greenhouse	LD	50	33	20	12	11	25	23
		SD	37	31	16	12	9	21	

Temperature. – *a.* In nearly all cases the average numbers of days required to complete the sprouting were lower for the corms from the 14° treatment than for those from the corresponding 23°. The only exception of minor importance was in cv. 'Friendship'.

b. If we attempt to compare the behaviour of the corms of the greenhouse group with those of either 14° or 23°, an interesting picture turns out. In the first two plantings, the results of the greenhouse group show a closeness to those of 23 °C, while for the remaining 3 plantings they appear to have been related to those of the 14 °C group. This behaviour implies that the dormancy of the corms of the greenhouse group, though originally on the same level as the one of the 23° group, disappears faster.

Daylength. – *c.* As a rule, the average numbers of days required to complete the sprouting were lower for short day treatment than those for the long day one. The important exceptions, leaving out 3 minor cases, were from 'Salome' the greenhouse group and 'Friendship' the group of 23 °C.

Experiment 24. – This experiment was simultaneously done with the previous one. The controlled glasshouses used in the present experiment were of a different design allowing satisfactory daylight intensities. The plants at 4 weeks age of cultivars 'Salome', 'Friendship' and 'Pall Mall' were prepared for transplanting in the same way as described in experiment 23. The plants were transplanted, either in the glasshouses at constant temperatures of 16° or 25 °C, or in the field. The treatments of daylengths were the same for the controlled glasshouses, while for the field only the natural daylength (ND) was used.

After 7 months from planting, the plants in the glasshouses did not show any signs of maturity yet. In fact, the plants from SD showed a greener colour than those from LD. The results of colorimetrical comparison, carried out in the same way as in experiment 23, confirmed the visual impression. A similar situation occurs in woody plants, as reviewed by NITSCH (32, 1957). Our observation about the maturity of the plants is not in agreement with BORTHWICK and PARKER (4, 1949), who observed that plants in SD matured earlier than those in LD.

The plants from the field started to turn yellow after 5½ months from planting and they were completely yellow after 6½ months.

The plants were harvested and stored in a similar manner as described earlier. The corms were planted along with their intact cormels of large, medium and small sizes only. Cormels with naturally broken shell and those with pin-head size were excluded. For each treatment 3 to 4 corms were planted, each one of them with a minimum of 20 cormels. The corms from all the treatments sprouted for 100 %. The average numbers of days required to complete sprouting followed the same main trends, namely these numbers were lower for corms from the 16° treatment than for those of 25 °C. The differences between the long day and short day were smaller, but still showed, as a rule, lower numbers for short day than for long day. The average numbers of days for the corms from the field group in all the 5 plantings showed a close relationship with those from the 16° group. The percentages of sprouting of the cormels in 60 days from the planting are given in table 20.

Surprisingly enough, the results of this table for the constant temperatures of 16° and 25° show two distinct trends according to cultivars:

a. In 'Salome' the percentages of sprouting are higher for 16° than for 25°, and are higher for LD than for SD.

b. In 'Friendship' and 'Pall Mall' the percentages of sprouting tend to be higher for 25° than for 16°, and tend to be higher for SD than for LD.

With one exception, the cormels from the field group exhibited a deep level of dormancy at all plantings.

5.3. *Discussion*

So far a very meager experimental evidence has been collected on the relation between the ecological factors, like temperature and daylength, prevailing during the growing season of the gladiolus and the level of dormancy in the resulting corms. As regards the cormels, nothing is known in this connection.

TABLE 20. *Experiment 24.* – The percentages of sprouting obtained 60 days after planting of the cormels developed on plants which were grown for 6 months at constant temperatures of 16°, 25° or not controlled (Field) and under long day (LD) or short day (SD). The resulting cormels were stored at 10° and after 0, 20, 53, 74 or 95 days of storage planted at a soil temperature of 18 °C.

1	2	3	4	5	6	7	8	9	10
Cultivar	During growth of plants		Days in storage at 10°C					Average of columns 4 to 8	
	Temperature	Daylength	0	20	53	74	95	for daylength	for temperature
'Salome'	16°	LD	0	0	16	22	36	15	11
		SD	0	0	0	12	18	6	
	25°	LD	0	0	4	9	13	5	3
		SD	0	0	0	0	0	0	
	Field	ND	0	0	0	<1	<1	<1	<1
'Friendship'	16°	LD	0	0	<1	2	7	2	6
		SD	0	5	16	14	14	10	
	25°	LD	<1	<1	5	23	25	11	11
		SD	0	0	0	18	33	10	
	Field	ND	<1	<1	<1	<1	13	3	3
'Pall Mall'	16°	LD	0	0	<1	0	2	<1	1
		SD	0	0	<1	8	2	2	
	25°	LD	0	0	10	16	23	10	11
		SD	0	0	13	18	34	13	
	Field	ND	0	0	0	0	0	0	0

The limited experimental data, presented in the foregoing pages, are certainly convincing. The corms, harvested from the plants grown under either high (23°, 25°) or low (14°, 16°) temperatures and under long day (16 hr) or short day (8 hr), sprouted in all instances for 100%. However, the average numbers of days required to complete sprouting clearly show the role of high temperature and long day in retarding the progress of sprouting. As it appears, the influence of the temperature is stronger than of the daylength.

The cormels were in a deeper level of dormancy than the corms. This fact has been already discovered in experiment 3. The results of experiment 24 show that also the dormancy of cormels is influenced by ecological factors during the preceding growing-season. However, conflicting results were obtained in different cultivars with regard to the precise action of the temperatures and the daylengths used. This may be due to varietal differences in dormancy between different cultivars, which could not be detected completely during the limited period of storage which had to be used and which for most cases resulted in rather low percentages of sprouting.

Contrary to the common experience and the one of BORTHWICK and PARKER (4, 1949), the plants in the present investigations did not go to maturity under short day given for a duration of 6 months. This behaviour may be attributed to the constancy of the temperature and to the relatively low light intensity in the glasshouses, since the plants in the field reached complete maturity. The extent, to which minor factors such as size of the corms, attack of insects, frequency of rain and cold waves, influence the onset of maturity, may not be underestimated.

CHAPTER IV

GENERAL DISCUSSION

So far, the problem of dormancy and sprouting has been mainly approached from a limited standpoint. The responses of corms and cormels were judged in the postharvest period and in many instances for short durations only. The possibility, that the environmental conditions during the growing season could influence the level of dormancy, was completely neglected. Furthermore, the interference of the diurnal and seasonal fluctuations of soil temperature on the level of dormancy was neither realized.

According to the literature (chapter I, section 3), gladiolus requires low temperatures for the disappearance of dormancy and high temperatures for producing a pushing effect as seen by accelerated sprouting and early flowering. This behaviour demonstrates 'seasonal thermoperiodicity' (WENT, 50, 1961).

The temperature requirements in the various stages of the life cycle of gladiolus follow from the results of individual experiments discussed in the previous chapter:

a. After the harvest the temperature of 10 °C in dry storage brought about the disappearance of dormancy and maintained the condition of out of dormancy (from experiment 4).

b. Sprouting could occur at any temperature between 6° and 26 °C. However, the minimum temperature, at which the sprouting occurred without being delayed, was 14 °C (from experiments 9 to 11).

c. At a constant day and night temperature of 14° for 6 months, the plants could grow without any visible signs of adverse effect and could produce flowers, corms and cormels in a normal way, irrespective of the daylength (from experiment 23 and part of unpresented data from this experiment).

d. The level of dormancy, as induced in the corms by temperature during the growing season, was very low when the environmental temperature for the growth of the plants was 14 °C. This very low level of dormancy did not inhibit, but perhaps only delayed the sprouting (from experiment 23).

The sequence of events mentioned in *a.* to *d.* would lead one to think of a possibility that gladiolus could pass through all stages of its life cycle within the very narrow range of temperatures between 10° and 14 °C. In such a case, the periodicity of the events would *no longer be controlled by temperature*, but by the other ecological factors, the most important among which is perhaps the moisture contents of the soil. The interception of a period of low moisture condition of soil (dry) after maturity of the plants is necessary for the disappearance of dormancy of corms and cormels. In the absence of such an interception, the dormancy would perhaps be maintained under moist conditions of the soil, since the temperature would be almost unfluctuating (see experiments 10, 11, 14 and 15).

At this stage we can revaluate, in the light of the idealized case just described, the whole problem of dormancy and sprouting from the view-point of ecological adaptability. The various responses of gladiolus to temperature, daylength, moisture etc. in relation to sprouting may be looked upon as the ways and means of spreading the sprouting which gives the plant a chance to reach maturity under favourable conditions of climate and to survive ultimately by reproduction. It is amazing to find the possibility of the regulation of sprouting in the preharvest history of corms and cormels. Since several ecological factors in different and variable combinations are working on the plant, it is extremely difficult even to estimate the total effect of them at the end of the growing season, the more so since different cultivars may react quite differently.

However, we can take the factor temperature to illustrate our case. Considering the temperature between 10° and 14° as ideal, it may be logical to think that the diurnal and seasonal fluctuations on either side of the ideal would induce dormancy, the depth of which will be, firstly, dependant on the size of the deviations and, secondly, on the interactions with other ecological factors. From this point of view it is considered erroneous to conclude that high temperatures alone are responsible for inducing the dormancy, as done by EVENARI *et al.* (16, 1950), RYAN (37, 1955) and VEGA (46, 1960).

In many respects the responses of cormels resemble those of seeds. Outer shells of cormels, like some seed coats, restrict the rate of respiration (experiment 21). In the primary storage period shelling would not help and low temperature is necessary. In the secondary storage period shelling has the same effect as cold (experiment 4). Somewhat on similar lines, for seeds, the germination responses in relation to cold requirement, to seed coats and to 'after-ripening' have been recorded (see CROCKER 6, 1948, pp. 85–96). Maintenance of dormancy in moist condition of soil has been observed in cormels and corms as well as in seeds (experiments 15, 16; see also CROCKER 6, 1948, pp. 39–41).

It is evident from this discussion that the gladiolus is equipped by nature in several ways with means to regulate the sprouting. An insight into this complex regulation is only possible if all phases of the life cycle are studied under controlled conditions.

SUMMARY*

I. GENERAL

Gladiolus occupies an important position in the flower-bulb industry of The Netherlands. The behaviour of corms and especially cormels in relation to dormancy was studied.

II. MATERIAL AND METHODS

Controlled conditions were used during the development and growth, the storage after the harvest, and the sprouting of corms and cormels. Respiration, in terms of carbon dioxide produced, was measured by a 'Mikrogas' apparatus.

* The Roman and Arabic figures in this summary refer to the corresponding chapters and sections.

III. Experiments

1. *Disappearance of dormancy during storage*

1.2. In the corms and cormels arising from the same plants, the level of dormancy was lower in the corms. The sprouting behaviour of the cormels varied with the natural conditions of the shell and the size.

1.3. Influences of storage temperature and of artificial removal of shell just before planting, (also referred to as 'cracking') were studied, using medium sized cormels during the primary period of 130 days and during the following secondary period of one year. As a rule, the dormancy disappeared after all storage temperatures between 6° and 27°C. However, the low temperatures of 6° or 10° were indispensable for maintaining the cormels in the out of dormancy condition. The removal of the shell improved the sprouting. The depth of dormancy varied from cultivar to cultivar and from year to year. The control of dormancy was possible by changing high temperature to low and vice versa.

2. *Soil temperature*

2.2. The soil temperatures influence the progress of sprouting, but when the time factor is omitted, the final sprouting percentages reached under all the soil temperatures between 6° and 23°C were the same. At a soil temperature of 26°C a dormancy breaking effect was observed. A reflection of the influences of the storage temperature and the treatment of the shell on the dormancy was seen on the progress of sprouting at various soil temperatures, especially the low ones.

2.3. Dormancy of the cormels was not broken at any constant soil temperature. An interruption of storage at 10° or 20°C with 6° during 66 days, or a diurnal cyclic alternation of 10° with 22°C, could break the dormancy.

2.4. The dormancy of the cormels could be maintained at a constant soil temperature of 20°C up to a period of 262 days and perhaps even longer, if the cormels had not been exposed to 5°C. The different levels of dormancy existing at the planting time were maintained throughout a long period of moist soil condition at a constant temperature of 20°C.

3. *Storage temperature and growth of plants*

3.2. In field experiments, differences were observed in the production of corms and cormels obtained from plants grown from cormels which were stored at high or low temperature.
3.3. When the plants were grown *with uniform age and spacing* in a greenhouse, no differences in the production of corms and cormels occurred.

4. *Dormancy and respiration*

4.2. The rate of respiration rose in the cormels with broken or removed shells to a level as high as 6 or 16 times the level reached in case of cormels with intact shells.

4.3. The validity of the hypothesis of Roistacher *et al.* (36, 1957) is disputed in the light of the results that the rate of respiration never rose, but in fact sometimes decreased, during the disappearance of dormancy.

5. *Conditions during the growth of the plants and their influence on the dormancy of the resulting corms and cormels*

The plants, 4 weeks old, were grown at constant day and night temperatures of 14°, 16°, 23° or 25°C under long day (16 hr) or short day (8 hr) for 6 months. The corms and cormels were harvested and tested for sprouting. The corms in all instances sprouted for 100%. However, the average numbers of days required to complete sprouting were lower for 14° or 16° and for short day than those for 23° or 25° and for long day. The trend for cormels was the same in one cultivar, but opposite in the other two. The cormels were in deeper level of dormancy than the corms.

IV. General discussion

From the review of literature gladiolus appears to represent a typical case of 'seasonal thermoperiodicity'. However, the experimental data collected in this work showed that it is possible for gladiolus to complete all phases of its life cycle in a very narrow range of temperatures between 10° and 14°C. The problem of dormancy was revaluated from the view-point of ecological adaptability, since the regulation of sprouting can be traced back to environmental factors.

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SAMENVATTING*

I. Algemeen

De gladiool neemt een belangrijke plaats in de bloembollencultuur van Nederland in. Het gedrag van knollen en speciaal van kralen met betrekking tot de kiemrust werd bestudeerd.

II. Materiaal en methoden

Beheerste omstandigheden werden gebruikt gedurende de groei en ontwikkeling, de bewaring na de oogst en de kieming van knollen en kralen. De ademhaling, uitgedrukt in eenheden geproduceerd koolzuur, werd gemeten met behulp van een 'Mikrogas'-apparaat.

* De Romeinse en Arabische cijfers in deze samenvatting verwijzen naar de betreffende hoofdstukken en paragrafen in de Engelse tekst.

III. EXPERIMENTEEL GEDEELTE

1. *Het verdwijnen van de kiemrust tijdens de bewaring*

1.2. Van knollen en kralen, afkomstig van dezelfde planten, was het niveau van de kiemrust lager in de knollen. De kieming van de kralen varieerde al naar de natuurlijke toestand van de huid en de grootte.

1.3. De invloed van de bewaartemperatuur en van het kunstmatig verwijderen van de huid vlak voor het planten werden bestudeerd aan kralen van middelmatige grootte, gedurende de primaire periode van 130 dagen en gedurende de daarop volgende secundaire periode van 1 jaar. In de regel verdween de kiemrust na alle bewaartemperaturen tussen 6° en 27°C. De lage temperaturen van 6° of 10° waren echter onmisbaar om de kralen te behouden in een toestand van afwezigheid van kiemrust. Het verwijderen van de huid verbeterde de kieming. De diepte van de kiemrust varieerde van cultivar tot cultivar en van jaar tot jaar. De beheersing van de kiemrust was mogelijk door de temperatuur te veranderen van hoog naar laag en vice versa.

2. *Bodemtemperatuur*

2.2. De snelheid van kieming wordt beïnvloed door de bodemtemperaturen, doch bij uitschakeling van de tijdsfaktor waren de uiteindelijke kiempercentages bij alle bodemtemperaturen tussen 6° en 23°C dezelfde. Bij een bodemtemperatuur van 26°C werd een rustverbrekend effekt waargenomen. Een afspiegeling van de invloeden van de bewaartemperatuur en de behandeling van de huid op de kiemrust werd waargenomen aan de snelheid van de kieming bij verschillende bodemtemperaturen, in het bijzonder de lage.

2.3. De kiemrust van de kralen werd niet verbroken bij enige constante bodemtemperatuur. Een onderbreking van de bewaring bij 10° of 20°C met 6° gedurende 66 dagen, of een dagelijkse wisseling van temperatuur van 10° naar 22°C en vice versa konden daarentegen de kiemrust wel verbreken.

2.4. De kiemrust van de kralen kon worden gehandhaafd bij een constante bodemtemperatuur van 20°C tot een periode van 262 dagen en misschien zelfs langer, wanneer de kralen niet waren blootgesteld aan 5°C. De verschillende niveaus van de kiemrust, die bestonden bij het uitplanten, werden gehandhaafd gedurende een lange periode met vochtige bodem bij een constante temperatuur van 20°C.

3. *Bewaartemperatuur en groei van de planten*

3.2. In veldproeven werden verschillen waargenomen in de produktie van knollen en kralen aan planten, die verkregen waren van kralen, bewaard bij hoge of lage temperatuur.

3.3. Wanneer echter de planten werden geteeld *met een gelijke leeftijd en een gelijke plantafstand* in een kas, werden geen verschillen in de produktie van knollen en kralen waargenomen.

4. *Kiemrust en ademhaling*

4.2. De mate van ademhaling in de knollen met een beschadigde of verwijderde huid steeg tot een hoogte van 6 of 16 keer de waarde, gevonden in kralen met onbeschadigde huid.

4.3. De juistheid van de hypothese van ROISTACHER *et al.* (36, 1957) wordt aangevochten op grond van de resultaten, dat de ademhaling nooit steeg, maar in feite soms daalde gedurende het verdwijnen van de kiemrust.

5. *Omstandigheden tijdens de groei van de planten en hun invloed op de kiemrust van hun knollen en kralen*

Planten van 4 weken oud werden gedurende 6 maanden geteeld bij constante dag- en nachttemperaturen van 14°, 16°, 23° of 25 °C onder lange dag van 16 uur of korte dag van 8 uur. Aan de geoogste knollen en kralen werd de kieming bepaald. De knollen kiemden in alle gevallen voor 100%. De gemiddelde aantallen dagen, die nodig waren om de kieming te completeren, waren echter lager voor 14° of 16° en voor korte dag dan die voor 23° of 25° en voor lange dag. Voor kralen gold hetzelfde resultaat met betrekking tot 1 cultivar, doch tegengestelde resultaten werden bereikt in de 2 andere cultivars. De kralen waren in een diepere kiemrust dan de knollen.

IV. ALGEMENE BESPREKING

Op grond van de literatuur stelt de gladiool een typisch geval voor van 'seizoensthermoperiodiciteit'. De experimentele gegevens, welke in de voorliggende publikatie werden vermeld, tonen echter aan, dat het bij de gladiool mogelijk is alle phasen van zijn levenscyclus binnen de zeer enge reeks van temperaturen tussen 10° en 14 °C te volbrengen. Het vraagstuk van de kiemrust werd bezien vanuit het standpunt van een ecologische aanpassing, hetgeen gemotiveerd is, omdat de regeling van de kieming kan worden teruggebracht tot uitwendige faktoren.

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