EXPERIMENTS ON THE RETARDATION OF DUTCH IRISES

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INTRODUCTION

The normal market of Dutch bulbs lies in the Northern Hemisphere since the successful growing of these bulbs is only possible in those countries where the temperature during winter is not too high. In tropical regions it is not possible to grow normal flowers, unless a low temperature can be provided after planting by artificial means; e.g. by planting the bulbs in pots or boxes and keeping them in cold storage for some months at a temperature in the region of 10°C. (BEIJER 1948)

Formerly this same need for a low temperature following planting seemed to prevent the exportation to the Southern Hemisphere, for when sent at the normal time, in September or October, on their arrival in South Africa, South America or Australia the bulbs had to withstand the very high summer temperature prevailing. Planting during this summer period nearly always resulted in failure to flower, and was often followed by total loss of the bulbs.

It became evident later that if it should prove possible to retard the development of the bulbs until March, planting either in this month or early in April would enable them to use the lower soil-temperature which prevails at this time of the year. After a long series of experiments (BLAAUW, LUYTEN en HARTSEMA 1930, BEIJER en VAN SLOGTEREN 1933, VAN SLOGTEREN 1947, BEIJER 1938, 1948) it was proven possible to retard hyacinths, daffodils and tulips until March, or later in the year. For a better understanding of the experiments with irises, the treatments practised in retarding hyacinths, daffodils and tulips will be discussed briefly.

Hyacinth bulbs due to be sent to the Southern Hemisphere are treated as follows: (VAN SLOGTEREN en BEIJER 1947).

The bulbs are lifted at the normal time, early in July, and kept at a temperature of 30° C. till the middle of October. During this period of high-temperature treatment the flower primordium inside the bulb is slowly developing so that at the end all flowers of the inflorescence are formed. During the following period, from mid-October until the end of December, the temperature is kept at — ½° C. i.e. just below freezing point. In this temperature the development is morphologically practically stopped. One would think now that it would be best to maintain this temperature until planting-time, but it has been proven that bulbs treated in this way, and having been planted in March or April, failed to develop both roots and shoots. Experiments have shown that after the low-temperature treatment a period at a high temperature is again necessary. A temperature of 25½° C. for about 6 weeks or somewhat longer, proved to be optimum. This whole retardation treatment can be indicated briefly as the 30; — ½; 25½-treatment, thus giving the three successive differing temperatures.

The same treatment holds for daffodils (BEIJER 1938).

For tulips another combination of temperatures proved to be necessary and is indicated as the — ½; — ½; 25½ treatment; here we have a long period at a low temperature, ranging from lifting-time in early July until the end of December. During this period the growing point inside the bulb remains dormant. From January onwards at a temperature of 25½° C. this growing point starts developing the flower primordium, and so in the tulip, the flower formation takes place after the low-temperature period; in the hyacinth bulb the flower is formed before the low-temperature treatment.

Late in February, or early in March, the retarded bulbs can be sent to the Southern Hemisphere. They have to be planted as soon as possible after arrival, preferably early in April. They are adapted now to the new climatic conditions and will flower in July or August.

As a matter of course only the southern parts of South Africa, South America and Australia are suitable for the growing of bulbs, for the northern parts of these countries, even during the winter season, have a prevailing temperature, which is too high.

After successful experiments, especially with hyacinths and daffodils, which were followed by their practical application the question arose whether it was also possible to retard bulbs of the Dutch iris. It seemed, however, unrational to apply the retardation treatment used for hyacinths and tulips directly to irises; for iris bulbs behave quite differently from other flower bulbs. In hyacinths and tulips the flower is formed during the time the bulbs are out of the soil, and thus occurs during summer when the bulbs are stored; in daffodils this occurs even earlier, while they are still in the ground, so that after lifting the bulbs the flower formation is nearly completed. In these three bulbous plants, all parts of the flower or inflorescence are present inside the bulb at planting time. After planting it is only a question of growth in length and thickness. This extension growth is greatly influenced by the temperature during the preceding storage-period and, after planting, by the soil temperature. The changing of these temperatures provides us with a means of hastening or retarding the date of flowering.

In the iris, however, the flower formation does not take place during the storage period. In Holland the iris-bulbs are normally lifted in August and planted in October. At that time there is no visible sign of a flower primordium inside the bulb, the growing point being still in the vegetative phase and only splitting off foliage leaves. It is long after planting time, during the winter (November-March) that development of the flower starts. This development thus takes place at a temperature of about 5° C. It is stated (v. D MEULEN and LUYTEN 1936) that during this period temperatures below the freezing point may temporarily arrest the flower formation, without harming later development. The flowering time of the Dutch iris in Holland is strongly influenced by climatic conditions during the spring, but normally the bulbs are blooming at the end of May or early in June.

It seemed questionable whether it would be possible to retard the development of irises in a similar way to hyacinths, daffodils or tulips, since the periodicity of these two groups of bulbs differs so much.

I. PRELIMINARY EXPERIMENTS (1946/47)

The retardation experiments with Dutch irises were started in 1946 with the varieties *White Excelsior* and *Imperator*. The material consisted of first sized bulbs (9 cms in circumference), which were lifted at the end of August. Just as in previous experiments in retarding flower bulbs it proved desirable to divide the whole retardation period into three parts, the first extending from lifting time until the middle of October, the second from mid-October until the end of December or the beginning of January, and the third from the end of December to the middle of February, or somewhat later.

The results obtained with *White Excelsior* will be discussed first. Table I gives the five temperature treatments used. The first treat-

TABLE I

Iris "*White Excelsior*". 1946/47. Application of the five temperature treatmenıs.

No.	Aug. 30—Oct. 16	Oct. 16—Jan. 6	Jan. 6—March. 6
1	— ½	— ½	25½
2	— ½	— ½	— ½
3	25½	— ½	— ½
4	25½	— ½	25½
5	30	— ½	25½

ment is the same as proved satisfactory for tulips; a long period of — ½° C. from lifting time until the beginning of January, followed by 25½° C. during the ensuing six weeks. No. 2 is a continuous storage of the bulbs at — ½° C.

Previous experiments for other purposes had shown that low-temperature treatment of iris bulbs often inhibits later flower-formation. The subjection of the bulbs to a high temperature immediately after lifting time proved to be very satisfactory in preventing this inconvenience, and therefore in No. 3 a temperature of 25½° C. is maintained during the first period, and this is followed by — ½° C.

during the two succeeding periods. No. 5, the 30; — ½; 25½ treatment is the same used for the retarding of hyacinths and daffodils. Fearing a detrimental effect of the long period at 30° C. in No. 4, a treatment was added with a temperature of 25½° C. in place of 30° C.

On March 6th, at the end of the third period, the bulbs of all five treatments were kept for four weeks at 17° C. In the experiments with hyacinths, daffodils and tulips, this temperature proved to be very favourable for the resultant quality of the flowers. The bulbs were planted in the open on April 3rd '47 in the experimental fields of our laboratory.

In table II and fig. 2 the flowering results are given, the numbers of the treatments corresponding to those in table I. The photograph clearly shows the total failure of the treatments 1, 2 and 3 and the

TABLE II

White Excelsior 1946/47. Flowering results after temperature treatments 1—5. The bulbs were planted on April 4, 1947; they were stored at 17° C. during the 4 weeks prior to planting.

No.	Treatment	Flowering date	Plants	Flowers	Flower quality	n
1	— ½; — ½; 25½	July 22	18 %	12 %	very poor	50
2	— ½; — ½; — ½	—	0 %	0 %	—	50
3	25½; — ½; — ½	June 6	6 %	6 %	very poor	50
4	25½; — ½; 25½	July 1	86 %	76 %	excellent	50
5	30; — ½; 25½	July 1	100 %	90 %	excellent	50

The two rows of percentages in this and subsequent tables all refer to the total number of bulbs planted. Thus, 6 % in no. 3 indicates that only 6 per cent of the bulbs came up and that all these plants flowered.

good flowering results of nos. 4 and 5. Of these two treatments, 30; — ½; 25½ has given 45 flowers out of 50 bulbs or 90 %; and the 25½; — ½; 25½ treatment only 76 %.

From these experiments it seemed clear that only treatment 30; — ½; 25½ could promise good retardation results in sending iris bulbs to the Southern Hemisphere. Moreover, the condition of these bulbs at the end of the treatment early in March, was excellent. They were quite firm and showed neither signs of shooting nor swelling of the root initials.

Some test-shipments to South America gave good results especially with the varieties *Imperator* and *White Excelsior*, but this means of retarding iris bulbs soon turned out not to be the trustworthy method we had expected. In the first place in our trials the method proved suitable for only some varieties of iris, such as *Imperator* and *White Excelsior*, whilst well known varieties, such as *Wedgwood* and *Blue Triumphator*, gave very poor results (see table III, lower part). Secondly after being retarded the variety *White Excelsior* sometimes showed the same abnormal development as *Wedgwood*.

As already mentioned, the preliminary trials of 1946/'47 were also made with *Imperator*. Just as with *White Excelsior* treatments no. 1, 2 and 3 on table I gave almost total failures; no. 4 (25½; — ½; 25½) was worse, while no. 5 (30; — ½; 25½) proved even better than with *White Excelsior*. The results of the latter two treatments are given in table III.

It is seen from this table that a further modification in the method of retardation was added. In this treatment no low temperature was used, but during the whole storing period from September 5th 1946 to March 1947 a constant temperature of 25½° C. was maintained. Just as after the 30; — ½; 25½ treatment the percentage and the quality of the flowers were very good. The date of flowering, moreover was 10 days later, which showed that an even better retardation of the bulbs had been attained.

It seemed desirable to continue the experiments with this treatment and to compare it with the 30; — ½; 25½ treatment. It was also thought necessary to follow the morphological development during the process of retardation to discover at which time eventual abnormalities originated.

TABLE III

Flowering results of some varieties of Dutch iris following various retardation treatments. *Imperator* was planted on April 3, 1947, the two other varieties on April 6, 1948.

Treatment	Flowering date	Plants	Flowers	Flower quality	n
Imperator					
25½; — ½; 25½	July 5	37.5 %	32.5 %	medium	80
30 ; — ½; 25½	July 4	100 %	98 %	excellent	50
25½; 25½; 25½	July 14	100 %	96 %	excellent	50
Wedgwood					
30 ; — ½; 25½	July 4	44 %	12 %	poor	50
Blue Triumphator					
30 ; — ½; 25½	July 14	34 %	18 %	poor	50

The percentages refer to the total number of bulbs planted.

II. The high-temperature retardation treatment (25½° C.) as compared with the combined high- and low-temperature treatment (30; — ½; 25½)

In order to understand the morphological changes occurring during the retardation treatment it is necessary to know something of the normal structure of the iris-plant (see also Blaauw 1935). A first sized bulb e.g. of the variety *Imperator*, is surrounded by three thin brown-coloured tunics. The greater part of the bulb consists usually of 4 white coloured very thick fleshy bulb scales. At flowering time 2 or 3 scale leaves or sheating leaves, surrounding the underground part of the stem, are emerging from within the innermost bulb scale, generally just reaching the ground level. Normally this stem is bearing 9—11 foliage leaves, the phyllotaxis being distichous. The two uppermost leaves, differentiated as the valves of the spathe, envelop the flower bud.

The experiments were started as soon as possible after the bulbs had been lifted and cleaned. In these freshly harvested bulbs the sheath leaves and 4 or 5 of the leaf primordia were already split off by the growing point.

Table IV shows the length of the outermost leaf and the number of foliage leaves (in brackets) at successive dates during the retardation treatment. The variety *Wedgwood* was chosen for giving consistently bad results after the 30; — ½; 25½ treatment, when compared with *Imperator*. First sized bulbs were used.

When retarded for flowering in the Southern Hemisphere, the retardation is stopped at the beginning of March, but in this experiment the bulbs were left at 25½° C. much longer in order to find out how long the temperature of 25½° C. could be maintained without it causing damage to the young growing plant inside the bulb.

TABLE IV

Length of the outermost foliage leaf in mm and the total number of leafprimordia formed (in brackets). n = 5.

Wedgwood 1948/49	Sept. 11	Jan. 12	March 7	Apr. 13	May 13
30 ; — ½; 25½	7.9(5.0)	8.8(5.8)	19.6(8.2)	**25.0(9.8)***	**33.6 ***
25½; 25½; 25½	7.9(5.0)	17.0(6.6)	21.1(6.6)	31.1(8.0)	34.1(8.0)
Imperator 1948/49	Sept. 13	Jan. 14	March 7	Apr. 14	July 14
30 ; — ½; 25½	2.7(4.6)	5.9(5.8)	10.4(7.0)	11.7(6.8)	**21.7(9.3)**
25½; 25½; 25½	2.7(4.6)	8.8(6.4)	11.1(7.0)	14.5(7.8)	17.5(8.8)
Wedgwood 1947/48		Febr. 25			
30 ; — ½; 25½		**25.8(6.8)**			
Imperator 1947/48		Febr. 20		Apr. 13	July 27
30 ; — ½; 25½		8.3(5.6)		**19.2(7.8)**	**20.3(10.4)***
25½; 25½; 25½		10.6(6.2)		13.1(7.0)	20.5 (8.5)

1948 : — ½° C. from Oct. 18 until Dec. 29.
1947 : — ½° C. from Oct. 16 until Dec. 29.
* flower formation started.
Figures in bold-faced type: morphological development abnormal.

As shown in table IV, on September 11th, the date of the commencement of the experiment with *Wedgwood*, the average length of the outermost foliage leaf was 7.9 mm, and there were 5 leaf primordia. Four months later, on January 12th, the length of the leaf after the 30; — ½ treatment, was 8.8 mm, after the 25½ treatment it was 17.0 mm; the number of leaf primordia being 5.8 against 6.6; and the retarding-power of the 30; — ½; 25½ treatment would seem to be the greater. Two months later, however, on March 7th, the difference in length was reduced to only 1.5 mm, whereas the numbers of leaf-primordia were 8.2 and 6.6; so that now the activity of the growing point would seem to be more retarded after the 25½ treatment.

On April 13th all bulbs looked quite normal after the 25½ treatment, but the combined high-low temperature retardation had given rise to an abnormal development of the foliage leaves in many of them, which is indicated in the table by figures in bold-faced type. The growing point, moreover, had stopped the formation of foliage leaves and had passed into the flower-forming phase, which is indicated by an asterisk.

The abnormal morphological structure was characterized by a scale-like swelling of the lower part of the foliage leaves. Later on the tops of these leaves turned brown and became shrivelled, the basic parts developing like true bulb scales, while the young flower primordium perished early. It is evident that such bulbs failed to flower and very often did not sprout at all.

On May 13th the bulbs of the 25½; 25½; 25½ treatment still looked quite normal and even on August 13th, which is not mentioned in table IV, after an eleven month retardation period at 25½° C., although somewhat shrivelled, they showed a normal development, no sign of shoots or root development being visible externally. On this date the length of the outermost leaf was 39.4 mm. and the average number of leaves was 8.8.

In table IV the dates referable to *Imperator* (1948/49) are also given. It seems superfluous to follow step by step the development of this variety after the two retarding treatments. The following conclusions can be drawn from the data of this table. First of all the length of the first foliage leaf on the different dates of examination is much shorter than on the corresponding dates for *Wedgwood*. Secondly, the internal morphology on April 14th after the 30; — ½; 25½ treatment is still quite normal, whereas *Wedgwood* on that date already showed an abnormal structure. Yet *Imperator* in the long run was also damaged by this treatment; for on July 14th some of the bulbs showed the same abnormal development as *Wedgwood* had done, while the 25½; 25½; 25½ retarding showed no damaging influence.

The lower part of table IV gives some interesting data of the same two varieties, though the year is now 1947/1948. After the 30; — ½; 25½ treatment *Wedgwood* as early as February 25th showed an abnormal morphological development in most of the bulbs; *Imperator* as early as April 13th in some of the bulbs only, in both cases much earlier than in 1948/49. The 25½; 25½; 25½ treatment in 1947/48, applied only to *Imperator*, caused no abnormalities in this generally unfavourable year and even on July 27th the morphological development was quite normal.

The main conclusion to be drawn from the data of table IV is that continuous storage of the bulbs at 25½° C. has a much greater retarding effect than the 30; — ½; 25½ treatment. This is particularly due to the absence of any tendency to abnormal morphological development, even in an early flowering variety like *Wedgwood.*

From most of the treatments in table IV samples of about 100 bulbs were planted in the experimental field at Lisse early in April, after having been stored at 17° C. for one month. This planting date was chosen as being about the same planting time as for bulbs sent to the Southern Hemisphere; in addition bulbs from some of the treatments were planted early in May and June. The flowering results of these different lots of bulbs are given in table V.

After the 25½ treatment all samples of *Wedgwood* and *Imperator* flowered very well. The quality of the flowers produced could be classed as either very good or excellent.

The 30; — ½; 25½ treatment, however, proved to be very detrimental for *Wedgwood*; when planted early in April the result was a total failure in 1947/48, with only 12 % flowers of poor quality. This was to be expected for on February 25th (on table IV) the morphological development had already shown abnormal symptoms. In the following season, 1948/49, 92 % of the bulbs planted gave flowers but they were of poor quality.

This accordance between the findings of the morphological examination and the flowering results was also evident in the variety

TABLE V

Flowering results of *Wedgwood* and *Imperator* following various retardation treatments, and different planting dates. All groups were stored at 17° C. for the month prior to planting. n = ± 100.

Wedgwood 1948/49	Date of Planting		
	April 5	May 4	June 1
30 ; — ½; 25½	June 27 (92 %) †		
25½; 25½; 25½	July 3 (100 %) *	July 15 (98 %)	Aug. 1 (100 %)
Imperator 1948/49	April 5	May 4	June 1
30 ; — ½; 25½	July 17 (100 %) *		
25½; 25½; 25½	July 19 (100 %) *	Aug. 7 (100 %) *	Sept. 5 (92 %)
Wedgwood 1947/48	April 6		
30 ; — ½; 25½	July 4 (12 %) †		
Imperator 1947/48	April 6	May 7	June 3
30 ; — ½; 25½	July 17 (95 %) *	July 26 (57.5 %) †	— (0.0 %)
25½; 25½; 25½	July 27 (93.8 %) *	Aug. 3 (100 %) *	Aug. 20 (78 %)

† flowers medium or poor.
* flowers excellent.
otherwise the flowers were good or very good.

Imperator 1947/48, where the abnormal development was first observed on April 13th. The bulbs, stored at 17° C. on March 3rd and planted on April 6th, produced 95 % flowers the quality of which was excellent. Bulbs, however, planted after April 13th, on May 7th, produced only 57.5 % flowers of poor quality, whilst those planted on June 3rd produced no shoots at all.

These flowering results thus provided confirmation of the conclusion already drawn from the morphological examination, viz. that a continuous storage of the bulbs at 25½° C. produces a much better retardation effect than the 30°; — ½; 25½ treatment.

III. The significance of the retardation at 25½° C. for the export of Dutch irises to the Southern Hemisphere

During the years 1948, '49 and '50 retardation treatment at 25½° C. of approximately six months duration, was tested on several varieties of Dutch irises by planting them early in April in the experimental fields of our laboratory; samples of these lots were sent to South America, South Africa and Australia.

For the month prior to planting the bulbs in Holland, a temperature of 17° C. was maintained. Data concerning the well known varieties *Wedgwood, White Superior, White Excelsior, H. C. van Vliet* and *Imperator* are given in table VI, in which the flowering date is given as the time at which most of the flowers were open. The percentage

TABLE VI

Date of flowering and percentage of flowering plants (in brackets) of different varieties of Dutch iris after a six months retardation period at 25½° C. During the last month before planting a temperature of 17° C. was maintained. n = 50 or 100.

Year	Planting date	*Wedgwood*	*White Superior*	*White Excelsior*	*H. C. v. Vliet*	*Imperator*
1948/49	5-4	3-7(100%)*	—	15-7 (98%)*	17-7 (98%)*	19-7(100%)*
1949/50	3-4	28-6 (96%)*	10-7(100%)*	11-7(100%)*	16-7(100%)*	17-7 (96%)*
1950/51	2-4	1-7 (99%)*	14-7 (99%)*	14-7 (98%)*	16-7(100%)*	21-7 (97%)*

* Flowers excellent.

of bulbs planted which produced a normal flower is also mentioned. From the data given it appears that in all cases 96—100 % of the bulbs flowered very well. In the foreground of Fig. 3 *White Excelsior* is shown flowering on July 16, 1949, while behind other groups of flowering irises can be seen. It is remarkable that in the succeeding years the differences between the flowering dates for each variety are rather small.

Apart from the varieties mentioned in table VI some yellow varieties were also tested, but although the flowering results were good, too many bulbs were lost early, actually during the retardation treatment.

This loss in bulbs during the high temperature treatment in itself decides whether a variety will be suitable for export to the Southern

Hemisphere or not. Table VII shows the percentages of loss for several varieties in the years 1949, '50 and '51, which were determined early in March about the date of shipping. In most cases the loss remained at a rather low percentage, seldom exceeding 5 %. An exception to this was found with *Yellow Queen*, for here the loss was

TABLE VII
Percentage loss in bulbs of Dutch irises early in March after a six months retardation treatment at 25½° C.

Variety	1948/49	1949/50	1950/51
Imperator	1.7 % (1200)	5.6 % (1100)	0.5 % (2000)
H. C. v. Vliet	2.1 % (1500)	2.9 % (375)	0.9 % (2000)
White Excelsior	0.9 % (1000)	10.8 % (1000)	1.3 % (2000)
Wedgwood	0.1 % (1500)	0.1 % (1000)	0.2 % (1000)
White Superior	—	—	1.7 % (1000)
Yellow Queen	± 60 % (750)	—	—
Golden Emperor	—	—	2.1 % (1000)

The total number observed is given in brackets.

in the region of 60 %. This variety was unable to stand the long storage at 25½° C., the bulbs drying out too much and the root initials swelling too early. *Golden Emperor* seemed much better, sustaining a loss of only 2.1 %but this yellow variety also proved to be less suitable owing to too great a degree of shrinkage and a too early root development. The bulbs of the other varieties remained quite firm without showing any sign of root growth. The relatively higher losses in 1950 of *Imperator* and *White Excelsior*, are noteworthy, with 5.6 and 10.8 % respectively.

Since the shipping of iris bulbs to the Southern Hemisphere is the principal aim of these investigations, samples of retarded bulbs were sent to South America, South Africa and the southern part of Australia. Just as in our previous experiments with hyacinths and daffodils, the bulbs were placed in the holds under the waterline to avoid too high a temperature in transit. It soon appeared, however, that the shipping of retarded iris bulbs provided a difficult problem, for, particularly after long sea passages, the bulbs often arrived in a bad condition with both shoots and roots already sprouting. As a matter of course such bulbs either failed to grow at all, or produced only stunted plants with poor flowers.

In order to determine the influence of different temperatures in transit some bulbs from March 1 were kept for six weeks at 25½°, 17°, 9° and 1° C.; the trial was made with *Wedgwood*, this variety being most susceptible to temperature influences at that time. Figure 1 shows the morphological development during the different temperature treatments. On January 12th, after 4 months storage at 25½° C. the average length of the first foliage leaf was 17.0 mms, and on March 1st 21.1 mms, on which date one group of bulbs was left at 25½°, while three other groups were stored for 6 weeks at 1°, 9° and 17° C. respectively. At the end of this period the length of the first leaf at 1° was 28.1 mms, at 25½°, 31.1 mms, at 17°, 41.1 mms, and at

9°, 51.1 mms. Thus storage at 9° or 17° C. caused an extension growth of the leaves to such an extent that after six weeks the shoot had already grown out of the top of the bulb, flower formation had started and the roots had developed too much; and this in dry, well-ventilated storage rooms. It is obvious that the results would have been worse were the bulbs exposed to the same temperature in a damp atmosphere, which possibly occurs during transit.

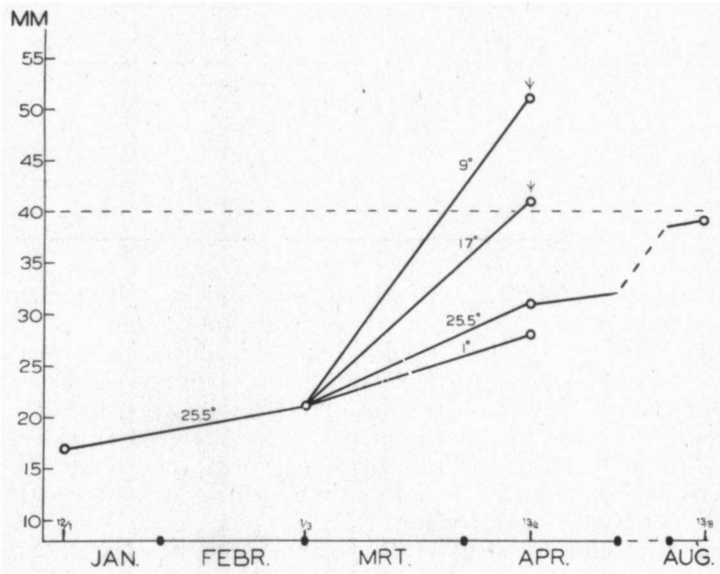

Fig. 1. Iris "*Wedgwood*" 1949. Length of the outermost foliage leaf inside the bulb in mms. Bulbs retarded at 25½° C. from September 11, 1948 until March 1, 1949. Influence of different storage temperatures from March 1, until April 13.
↓ Flower formation started.
The dotted line indicates the average height of the bulb.

It can be seen in Fig. 1 that on August 13th, after a further 4 months storage at 25½° C. the shoot was still within the bulb, its length being only 39.4 mms.

Of the two temperatures ensuring the best conditions for bulbs during transit, that of 25½° C. will not be so easily realised in practice, especially since storage of bulbs at a high temperature necessitates the existence of good ventilation. For this reason 1° C. seemed more promising, whilst retarding the extension growth even more adequately. The bulbs of these two treatments, planted in Holland early in April, flowered excellently, the 25½° bulbs on July 8th, the 1° bulbs on July 4th, both sets bearing 100 % flowers. It remains to be emphazised however, that the flower quality can be affected unfavourably by too long a storage at 1° C. (see also p. 282).

As a result of these trials an attempt was made to have the bulbs shipped in cold storage, but two difficulties now arose. Firstly a temperature of 1° C. was not available, so we had to make do with one which fluctuated between 1—3° C. Secondly, bulbs shipped in this way have to be unloaded and unpacked as soon as possible after arrival, for cooled bulbs once exposed to a higher temperature will become moist, and during later transport, e.g. by rail, are very susceptible to damage by the development of mould.

In 1949 and 1950 many samples of retarded irises were sent to different countries in the Southern Hemisphere.

A survey of the flowering results for both years is given in table VIII, and the results of the four varieties *H. C. van Vliet*, *White Excelsior*, *Imperator* and *White Superior*, were added to simplify matters. The dates of flowering and the percentages of flowering plants produced by the total numbers of bulbs shipped, are given in this table. Flowering results higher than 70 % are in bold-faced type. The shipments are numbered 1—14 [1], partly loaded in cold storage (C), partly under the waterline (W).

The date of arrival and the number of days of transit (in brackets) proved to be very important. All shipments arriving in May (1, 2, 4, 7, 14) being 60—87 days on the way, gave bad results; all except one of the shipments (3) arriving in March or April (5, 6, 8, 9, 10, 11, 12, 13), transit taking 36—58 days gave good results. The shortest transit time with the earliest arrival (11) gave the best results (97.0 %) the longest transit time and the latest arrival (7) gave total failure (3.0 %).

From these facts it is clear that the best results in the Southern Hemisphere are to be obtained by planting the bulbs early in April, and they therefore have to be shipped from Holland about the middle of February. It is also of great importance to ensure that the passage is the shortest possible.

Some shipments were loaded partly in cold storage, and partly under the waterline. Comparison of nos. 8 and 9, and of nos. 12 and 13 shows no great difference between the two sites of loading; both gave excellent results, though the quality of the flowers and the length of the flower stems of the cooled shipments were somewhat better in those bulbs carried in cold storage. After too long a passage, especially with cold storage bulbs which were not immediately unloaded but were kept for some time at higher temperatures or taken by rail to more distant destinations, the results were very bad (1, 7, 14). The bulbs of such shipments were generally damp on arrival, and mouldy, showing long shoots and roots.

In both years the flowering dates in South Africa fell in August, in South America and in Australia in September. The quality of the

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[1] We are very grateful to Mrs A. de Winter–Ferguson (1, 2, 8, 9) at Hurlingham (near Buenos Aires) for all the trouble she has taken with the trial shipments, and for sending us elaborate reports of great value.

The same applies to the following persons: Mr Dr A. J. Louw (3, 11) Stellenbosch, Mr F. A. Vlag (4, 12, 13) Immerpan, Mr F. M. Read (5) Melbourne, Mr R. W. Turner (6, 14) Warburton, Mr K. C. Hockey (7) Palmerston and Mr. Ir J. Roberts (10) Buenos Aires in connection with a shipment to Tucuman.

The numbers in brackets refer to table VIII.

flowers of the shipments 5, 6 and 8 up to and including 13 was excellent.

Apart from the four varieties already mentioned, trials were also made with *Wedgwood* and *Golden Emperor*, but these varieties proved to be less suitable, for both developed shoots and roots too easily during transit. This agrees with the data of Fig. 1 which shows the development of a strong extension growth as soon as the temperature

TABLE VIII

Flowering results of retarded irises in the Southern Hemisphere. The data refer to the varieties *Imperator*, *H. C. van Vliet*, *White Excelsior* and *White Superior*.

No.	1949		Date of arrival	% Flowers	Date of flowering	n
1	Am.	C.	13-5 (63)	10.0 %	24/9 — 4/10	150
2	Am.	W.	13-5 (63)	48.0 %	9/10—16/10	150
3	Af.	W.	8-4 (41)	40.0 %	18/8 —25/8	250
4	Af.	W.	9-5 (72)	36.5 %	7/8	200
5	Au.	C.	4-4 (44)	**89.6** %	12/9 —20/9	250
6	Au.	C.	6-4 (46)	**80.0** %	12/9 —15/9	350
7	N.Z.	C.	20-5 (87)	3.0 %	—	350
No.	1950					
8	Am.	C.	19-4 (40)	**91.0** %	22/8 —23/9	200
9	Am.	W.	19-4 (40)	**90.0** %	10/9 —30/9	300
10	Am.	W.	24-4 (43)	**71.0** %	15/8	200
11	Af.	C.	30-3 (36)	**97.0** %	2/8 —15/8	200
12	Af.	C.	21-4 (58)	**93.7** %	6/8	300
13	Af.	W.	21-4 (58)	**92.8** %	10/8 —14/8	400
14	Au.	C.	11-5 (60)	28.0 %	10/10—21/10	300

Am. South America N. Z. New Zealand
Af. South Africa C. loaded in cool store
Au. Australia (southern part) W. under the waterline

The number of days in transit after arrival (in brackets) is mentioned.

The percentages refer to the number of flowering plants produced by the total number of bulbs shipped.

happened to sink too far below 25½° C. or to rise considerably above 1° C. *Wedgwood* has occasionally given good flowering results in Australia and South America, but only after a very favourable passage.

One further point of interest remains. Apart from the retarding treatment 25½; 25½; 25½ the combination 30; 25½; 25½ was also applied to all the varieties used. Neither here in Holland, nor in the Southern Hemisphere was any definite difference to be found in the quality of the blooms, the date of flowering or the loss of bulbs. Figure 4 shows flowers of iris "*Imperator*", retarded in this way and planted in Holland on May 4th after one month's storage at 17° C.

IV. The application of the retardation treatment to obtain flowering irises from May until December

The flowering period of the different varieties of Dutch iris is not normally a long one. The retardation experiments, aiming at the export to the Southern Hemisphere, suggested a means of producing flowering irises over a much longer period both in Holland and abroad. The normal planting time of bulbous irises is October or November. The possibility of retarding iris bulbs at 25½° C. for a rather long time makes it possible to delay this planting date until after the winter period. Planting early in April, May or June, as already mentioned in table V, may give flowering plants in July, August and September.

It soon appeared possible to obtain irises flowering continually throughout the entire summer, as is shown in table IX for iris "*Imperator*". The bulbs of this trial were retarded at 25½° C.

From November 7th 1949 until June 6th 1950 3 lots of 50 bulbs were planted each month in the open, after one month's treatment at 9°, 17° and 25½° C. Furthermore early in October, November and

TABLE IX

Flowering dates of iris "*Imperator*" retarded from Sept. 6, 1949 at 25½° C.

Date of planting		Temperature during last month before planting		
		9° C.	17° C.	25½° C.
12-10	I	**1-5**	**7-5**	11- 5
7-11	I	12-5	**13-5**	16- 5
6-12	I	20-5	**21-5**	23- 5
7-11	II	4-6	**6-6**	8- 6
6-12	II	8-6	**10-6**	13- 6
6- 1	II	13-6	**15-6**	20- 6
6- 2	II	20-6	**22-6**	27- 6
6- 3	II	2-7	**4-7**	12- 7
6- 4	II	13-7	**14-7**	22- 7
6- 5	II	31-7	**5-8**	25- 8
6- 6	II	26-8	**28-8**	14-10

I. planted in an unheated greenhouse
II. planted in the open.
Figures in boldfaced type: the best flower quality of the three lots planted on the same date.

December 1949 3 lots were again planted in each month in a non-heated glasshouse. From the blooming dates of table IX, indicating the opening of the first flowers of each lot, it can be concluded that there was a practically uninterrupted period of flowering from May 1st until the end of August. The average number of flowers produced was about 95 % with the temperature at 25½° C. and 97 % with the two other temperatures.

From the three temperatures used during the last month prior to planting, 9° resulted in the earliest flowering, and 25½° in the latest. Although very good flowers were produced following all three treatments, the quality of the flowers of 17° nearly always looked somewhat better; and so we find the simplest way in which to obtain a continuous flowering of retarded irises during summer is to plant them about every two weeks, after one month's storage at 17° C. Under normal climatic conditions in Holland the following varieties proved to be suitable for this purpose: *Wedgwood*, *Imperator*, *H. C. van Vliet*, *White*

Excelsior, *White Superior* and if not dried out too much during the 25½° treatment, *Golden Harvest* and *Golden Emperor* can also be included in this list.

The latest possible time for planting in the open in Holland is at the end of June or the beginning of July, with a flowering period in the first part of October. Fig. 5 shows *White Superior* planted on July 3rd and flowering outdoors on October 13th. During this late flowering time damp weather conditions will often stain the blooms, although this may be prevented by the timely use of glass covering. Planting still later in July, results in too late a development, and the plants during autumn are badly damaged by cold and bad weather conditions, without reaching the blooming period. Planting in a glasshouse in July or August proved to be very unsuccessful. The temperature of both soil and air was too high apparently during these months and prevented a normal development of the plants. Only a small number of the bulbs planted reached the flowering stage, and these produced only poor blooms of an inferior quality.

Probably the only way in which to obtain good flowers of retarded iris bulbs after September will be to plant them in forcing boxes; and until now only a few preliminary experiments have been undertaken. The best results were obtained with *Wedgwood*. In 1950 bulbs of 10 cms circumference, retarded at 25½° C., from August 24th 1949 until one month prior to boxing, and kept at 9° C. during this latter month, were boxed in the open on August 13th 1950; and after having been taken to the glasshouse (± 11° C.) on October 31st, they were flowering on November 18th, with 95 % flowers. The following year in 1951, having been treated in a similar way, but taken earlier to an unheated glasshouse, on October 12th, they flowered on October 22nd producing excellent blooms. (n = 200).

As has already been mentioned on page 278 the extension growth of retarded iris bulbs is so intensely stimulated by storing them at 9° or 17° C. that the leaves are early found to be growing out of the top of the bulb and this is especially true of *Wedgwood*. When these bulbs have to be planted on the spot it will not be very dangerous, but when they have to be sent elsewhere, such bulbs will be badly damaged during transit; and in such a case a temperature of 1° C. may be used in place of 9° or 17°. Some data are given in table X, which shows the influence of these temperatures on the blooming date of retarded irises.

It is clear that the earliest flowering is produced after 1 month's storage at 9°, and the latest after one month 1°, but even after late planting (*White Superior* on July 2nd) the difference between the 17° and 1° treatments is not very great. The quality of the flowers with both was excellent, only the flowers of *Wedgwood* planted on June 1st and flowering early in August were somewhat smaller, probably in consequence of the high summer temperature.

This same table (X) shows a very remarkable difference between one month's and two months' storage at 1° C. Bulbs of the iris *H. C. van Vliet* planted on May 1st. flowered with excellent blooms on

August 5th after 1 month 1° C. but when planted on the same date after 2 months at 1°, they flowered as early as July 16th about 3 weeks earlier and with very small and poor flowers. Planting on June 1st gave similar results. A too long storage at 1° C. must be avoided, as it accelerates flowering and produces tenuous plants with poor blooms.

TABLE X

Flowering dates of retarded irises after being treated for one month at 9° C. and 17° C.; or after one and two months at 1° C.

Variety	Date planted	Temperature before planting:			
		1 month 9° C.	1 month 17° C.	1 month 1° C.	2 months 1° C.
Wedgwood '49	5-4	30-6 (98%)*	3-7(100%)*	5-7(100%)*	—
,, ,,	4-5	13-7 (98%)*	15-7 (98%)*	19-7 (98%)*	—
,, ,,	1-6	28-7 (98%)*	1-8(100%)	8-8 (98%)	—
White Superior '50	1-5	23- 7(100%)*	27-7 (100%)*	31- 7(100%)*	—
,, '51	2-7	1-10 (92%)*	13-10 (90%)*	17-10 (96%)*	—
H. C. v. Vliet '50	1-5	—	—	5-8 (96%)*	16-7(98%) †
,, ,,	1-6	—	—	13-8 (100%)*	5-8(94%) †

In brackets: percentage of flowering plants.
Quality of unindicated flowers was good: quality * was excellent: and quality † indicates that flowers were small and poor, and plants spindly.
n in most cases 50 or 60 bulbs.

As mentioned above, it is possible to retard irises long enough to have them in flower till early in November, but on the other hand, bulbs which are lifted in summer can be forced in January after being subjected to a special temperature treatment. Perhaps it will prove possible in future to bridge the remaining period of November and December, and with this in view, the following trials with the irises *H. C. van Vliet* and *White Superior* are worthwhile mentioning. The bulbs of *H. C. van Vliet* were kept at 25½° C. from September 8th, 1949 until August 30th, 1950 and thereafter for one month at 1° C. They were then planted in forcing boxes on September 30th, 1950 and taken to an unheated glasshouse, where the temperature soon became too low; the flowering was thus delayed until May 1951, when 39 bulbs out of 40 produced excellent flowers. (see Fig. 6)

Still more promising were the results obtained with *White Superior*, shown in Fig. 7 flowering on December 12th, 1951, during the final preparation of this publication.

SUMMARY AND CONCLUSIONS

Normally the saleable bulbs of the different varieties of Dutch iris are lifted in August and planted again in October or November. During the time the bulbs are out of the soil they are stored at a temperature of about 23—25½° C. during the first weeks, which is lowered to about 17° in the last weeks before planting.

During this storage period, in contrast to other flower bulbs such as hyacinths and tulips there is no flower formation. After planting, the growing point inside the bulb continues to split off leaf primordia, and it is during the winter at a rather low temperature that the flower formation is started and accomplished.

The flowering period of these irises is rather short, the earliest, such as *Wedgwood*, normally flowers at the end of May, the later varieties in the first part of June.

All experiments on the retardation of irises in the same way as for hyacinths, daffodils or tulips, i.e. by applying low (— ½° C.) or combined high and low temperature treatments (30; — ½; 25½° C.), failed to give satisfying results.

It proved possible, however, to retard iris bulbs excellently by storing them at a constant temperature of 25½° C. This temperature has to be applied as soon as possible after the normal lifting and cleaning of the bulbs.

During this temperature treatment the growing point only continues very slowly to split off leaf primordia, while the growth in length of the foliage leaves is strongly retarded. Iris bulbs retarded in this way are suitable for export to the Southern Hemisphere. Shipped in February-March and planted early in April the bulbs, which are now adapted to the reversed climatic conditions, will flower in August or September.

Temperatures between about 7° and 17° C. must be avoided as far as possible during transport; for these temperatures greatly stimulate the growth of both shoots and roots. Shipping in cold storage at + 1° C. is to be recommended, provided the bulbs are unloaded and unpacked as soon as possible after their arrival.

It must be emphasized that planting early in April will guarantee the best results, which necessitates the bulbs being forwarded in time; moreover the duration of the transport is preferably not longer than six weeks.

Very good results were obtained with trial shipments to South America, South Africa and Australia, which included first sized bulbs of *Imperator*, *H. C. van Vliet*, *White Superior* and *White Excelsior*.

The retardation at 25½° C. could be continued over a still much longer period. Even an early variety such as *Wedgwood* could be retarded from August until September of the following year, when the bulbs were seen to be somewhat shrivelled, but still showed no shoot development externally. Internally the first leaf had just reached the top of the bulb, but the flower formation had not started even yet.

On any given day of this long retardation period it proved possible to plant the bulbs and have them in flower after about three months, or even later depending on the climatic conditions prevailing at the time.

Instead of planting immediately from storage at 25½° C. a better quality of flower could be obtained by storing the bulbs at a temperature of 17° C. for one month before planting.

By planting retarded bulbs in Holland at repeated intervals it has been proven possible to obtain flowering irises in the open from May until October; success being achieved with the varieties *Wedgwood*, *Imperator*, *H. C. van Vliet*, *White Excelsior* and *White Superior*.

Some preliminary experiments have shown the possibility of having flowering irises even later, e.g. in November and December. Retarded bulbs were boxed therefore in August (after 12 months storing at 25½° C.) and transferred later on to a glasshouse, where they were forced at 10—13° C.

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Fig. 2. Iris "*White Excelsior*" on July 2 1947. Flowering results after the temperature treatments No. 1—5 (see table II)
1. — ½; — ½; 25½ 2. — ½; — ½; — ½ 3. 25½; — ½; — ½
4. 25½; — ½; 25½ 5. 30; — ½; 25½
Only Nos. 4 and 5 have produced flowers.

Fig. 3. Iris "*White Excelsior*" flowering on July 16, 1949. Immediately after lifting time, on August 16, the bulbs were stored at 25½° C. until March 1. After four weeks storing at 17° C. they were planted in the open on April 5.

Fig. 4. Iris "*Imperator*", grown outofdoors, flowering on August 6, 1949. Retardation temperature 30° C. from September 8, 1948 until October 18 and 25½° C. until April 4, 1949. Planted on May 4 after one month's storage at 17° C.

Fig. 5. Iris "*White Superior*", grown outofdoors, flowering on October 13, 1950. Bulbs lifted in August 1949 and retarded at 25½° C. Planted on July 3, 1950 after one month storing at 1° C.

Fig. 6. Iris "*H. C. van Vliet*". Bulbs lifted in September 8, 1949, retarded at 25½° C. until August 30, 1950. After one month storing at 1°, boxed on September 30 and put in an unheated glasshouse. The flowering started on May 6, 1951.

Fig. 7. Iris "*White Superior*", flowering at December 12, 1951. Bulbs retarded at 25½° C. from September 13, 1950 until July 4, 1951. Boxed on August 9 after one month storing at 9°. Boxes put outofdoors until October 12; in an unheated glasshouse until November 12. From this date forced at 10—13° C.

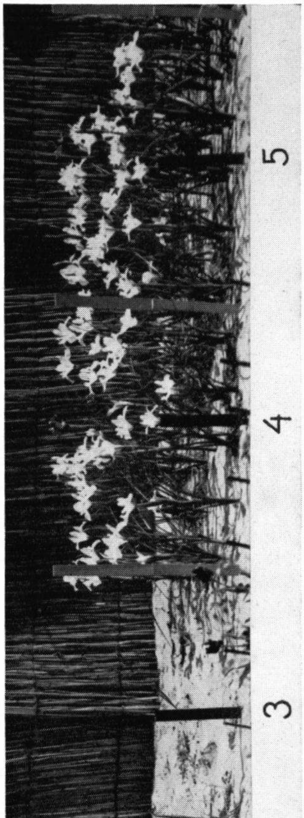

Fig. 2

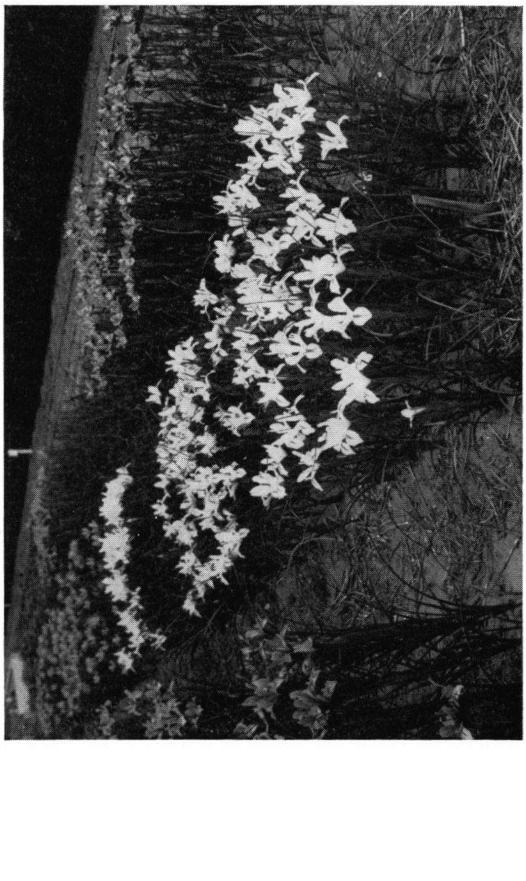

Fig. 3

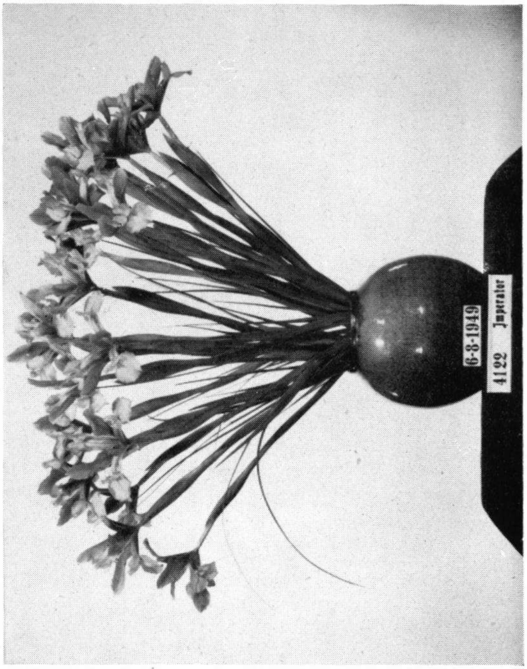

Fig. 4

PLATE VIII

Fig. 5

Fig. 7

Fig. 6