# THE INFLUENCE OF LOW TEMPERATURE TREATMENTS ON THE DEVELOPMENT OF TULIPA SP.

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# THE INFLUENCE OF LOW TEMPERATURE TREATMENTS ON THE DEVELOPMENT OF *TULIPA* SP.

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# INTRODUCTION

The process of bringing spring flowering bulbs into flower by use of controlled environmental conditions is called forcing.

By use of the proper sequences of high and low temperatures, the seasons of fall, winter and spring can be condensed into a shorter time period. As a result, bulbs can be made to flower at specified times.

To force tulips effectively, four different environmental regimes must be employed (12, 19). These are: (a) high temperatures after the bulbs have been harvested, (b) dry storage temperatures subsequent to flower formation, (c) low temperatures during the rooting and mobilization phase of development and (d) optimal greenhouse temperatures.

Much work has been done not only on the temperatures which influence flower formation (4,5,12,15,16,17,22), but also on the temperatures for storage after flower formation and prior to shipping (2,23). The temperatures to which the bulbs are exposed after harvesting are very critical since blind plants or blasted flowers may result if the flower is not properly formed.

Tulips which are grown in The Netherlands and are intended for use in the United States and Canada must be shipped. When transported by ship this normally takes three weeks. At the present time, temperatures during transport are being controlled only within broad limits. However, as modern transportation facilities become available this will change rapidly. It was because of this and other problems as well as the advent of many new cultivars of tulips that the need for more information on the precooling and rooting of tulips, as well as other techniques, became apparent.

For these investigations the flowering season was arbitrarily divided into five periods. These are:

(1) Very early (December 15 through January 15).

(2) Early (January 15 to February 5).

(3) Medium (February 5 to March 10).

(4) Late (March 10 to April 10).

(5) Very late (April 10 to May 15).

In this dissertation these periods are referred to as Classes I through V, however, only Classes I to IV were examined.

The experiments carried out for this dissertation were designed to develop cultural techniques in order to be able to program the forcing of tulips and improve quality. To do this three types of experimental variables were investigated utilizing several cultivars of tulips. These were:

(1) The use of various precooling temperatures and lengths of precooling to supplement the low temperature treatment during rooting.

(2) The use of different planting dates to vary the length of the low temperature treatment during rooting.

(3) The use of several rooting room temperature sequences to influence the development of the bulbs.

Through the implementation of these variables it was intended that information would become evident as to what effect each might have on: (a) sprout length, as an indicator of time to and/or easiness to flower (b) flower size (c) length of the first internode (d) total plant height and (e) the days to flower and spread date of flowering.

## LITERATURE REVIEW

Much of the research which has been done on spring flowering bulbs has been carried out in Europe (4, 10, 13). Among the areas which have been studied are: flower formation (4,5,12,15,16,17), dry storage problems (2,23), transportation (2), nutrition (26), and various flower disorders, e.g. blindness (11).

In addition to problems mentiond above there are other factors that play an important role in flower forcing. Growing conditions in the field, such as temperature, water and fertilization will be a determining factor in the quality of the bulb as well as the resulting flower. Harvesting conditions also play an effective part in greenhouse forcing.

Much of the early work with Tulipa sp. and their requirements for high and low temperatures, as well as other works have been reviewed by Purvis (18) and also by Went (24). A later review was published by Hartsema (9) who reviewed her own work as well as that of Dr. Blaauw, her co-worker. Of importance also is the review by Rees (19).

Flower Formation

Flower formation is of primary concern when forcing the tulip. The flower must be at stage VII in the scheme designed by Blaauw. He referred to the seven distinct stages of development within the bulbs as the stages I through VII, respectively. Stage VII is that stage which must be reached prior to the application of low temperature treatments

Beyer (1) reclassified the seven stages of development using alphabetical stages of development selected to correspond to the morphological stages of development. His seven stages are referred to as I, II, $P_1$, $P_2$, $A_1$, $A_2$, G. Beyer's "G" is comparable to Blaauw's stage VII.

Blaauw, Luyten and Hartsema (4) showed the effect of different temperatures on flower formation. They demonstrated that abnormally high temperatures as well as abnormally low temperatures had a deleterious effect on flower formation. The extreme result was no flowers formed. Luyten, Joustra and Blaauw (15) examined a wide range of different temperatures and found that by altering these temperatures that the speed of flower formation is affected.

Blaauw and Versluys (5) also showed the effect of different temperatures on flower formation, but showed further that even though certain temperatures resulted in faster flower formation that those flowers which formed first did not necessarily flower first under normal

conditions. The results of these studies showed the optimal temperature for flower formation to be 17-20°C.

## Flower Disorders

Some flower disorders were investigated by Hartsema and Luyten (11). They further substantiated that high temperatures can be used to destroy the flower before planting.

Hartsema and Waterschoot (13) also showed that extreme temperatures can be used to retard flowering of bulbs destined for planting and flowering in other countries, particularly the Southern hemisphere. For practical reasons the use of high temperatures to prevent flowering is not recommended for tulips as certain uncontrollable retardation can occur during shipping. This method has been suggested, however, for use with hyacinths and daffodils.

## Low Temperature Requirements

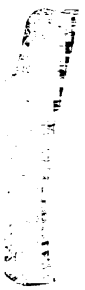
It was evident, however, that very little work had been done on *Tulipa sp.* when one considers temperature sequences, e.g. precooling and rooting room temperatures, and storage and planting dates, that relate to the proper forcing room temperatures, and storage and planting dates, that relate to the proper forcing of the many available cultivars.

It is important to note that when reference is made to various temperatures we are referring to temperatures in a controlled growth room and not those which are dependent on the severity or mildness of a particular fall or winter.

Attempts have been made through the years to determine optimum temperatures to be used for rooting and satisfying the cold requirement for early forcing periods (10).

Experimental evidence has shown that there was little effect of different curing temperatures on forcing performance of bulbs in lots precooled and rooted at 50°F. It was shown, however, that a curing temperature of 100°F delayed flower differentiation to the point that most bulbs were killed (20). It was also shown that various precooling temperatures produced plants of varying heights.

Stuart et al. (21) showed that precooling of bulbs at 40°F resulted in the production of longer stems and earlier flowering than the same length of storage at 50°F. They also showed that bulbs which were precooled at 50°F then planted or held dry at 60°F, resulted in flowering in the greenhouse which was not inhibited. The stems, however, were greatly shortened. They concluded that cool storage has more influence on factors which are responsible for stem elongation than on actual rooting. It is thought that these changes are enzymatic in nature, but there is little work at the present time which would verify this.



Rees (19), using the summary of Wood (25) says that,

> In general all cooling to promote early growth and flowering is detrimental to vegetative reproduction and flower quality. The two objectives, flower production and bulb increase are competitive and the storage temperatures adopted practically are those which are not optimal, but adjustments which give a greater margin of safety for flower quality.

Stuart and Gould (20) and Gill et al. (8) have carried out investigations in the United States and showed that precooling of tulip bulbs at 4°C followed by planting and a period of 6 weeks at 10°C gave longer stemmed plants than when a 9-10°C treatment employed for the same period of time. The 4° treatment was started at a later stage of development than is usually employed in normal precooling procedures. It might be worthy to note at this time that this 4°C treatment or 5°C bulbs as they are referred to today, is essential for normal blooming in southern climates where a gardener would encounter warmer soil temperatures.

Dickey (7), in Florida, has confirmed these observations of Stuart and his co-workers. He used storage sequences at 40°F for 60, 90, and 120 days and also 50°F for 90 and 120 days. He also stored bulbs for 90 days at 36°F. This particular treatment was reported as severely depressing flowering. He found that storage for 30 days was unsatisfactory at all temperatures. The bulbs stored as long as 120 days at 60°F also did not produce satisfactory growth and flowering. Toyoda and Nishii (22) also showed detrimental effects from such storage treatments.

Stuart et al. (21) showed that the rooting period at 10°C can be eliminated immediately after a precooling treatment. This was done using a precooling treatment of 4°C for 6 weeks. They further demonstrated that using the precooling method for 12 weeks at 4°C gave a reduced size and a greater percentage of "blasted" flowers. They showed that when bulbs were precooled at 4°C for 6 weeks followed by 4-6 weeks at 10°C, and then planted and forced at a temperature of 15.5°C good results could be obtained. The only objection to this method was that there was a slight reduction in overall plant size. They concluded that, "too short a period of cooling, or cooling at too high a temperature, results in short stems or in delayed blooming."

Hartsema, Luyten and Blaauw (12) determined what they considered a progressive stepping up of temperatures from planting to anthesis. They advocate 9°C until the sprouts are out of the bulbs. This is followed by an increase in temperature to 13°C for approximately two weeks or until the sprouts are 3 cm long, followed by 17°C for three weeks until 6 cm of sprouts are apparent, then place in light at 23°C to continue forcing.

Crossley (6) from British Columbia further substantiates the 9°C sequence but indicates better results are obtainable if after the flower begins to color the temperature is lowered.

Blaauw (3) concluded that 9°C was the most optimal temperature for cold storage. Luyten (14) also had excellent results using 9°C on the cultivar "Van der Neer."

Attempts have been made throughout the years to determine optimum temperatures to be used for rooting and supplying the necessary cold for early forcing periods.

Prior to these investigations most experimentation had been carried out on a limited number of cultivars. Due to the lack of information pertaining to newer cultivars, with reference to the correct procedures to be used in rooting and forcing, this dissertation came about.

## METHODS AND MATERIALS

During the period of fall 1966 to spring 1967 nine experiments were carried out.

For purposes of clarification the information necessary to explain each individual experiment and the treatment that the bulbs received prior to precooling, rooting and forcing were put in Tables 1 to 7.

### Inspection and Dry Storage of Bulbs Prior to Low Temperature Treatments

When each shipment of bulbs was received the packing crates were opened and an inventory taken.

Bulbs which were diseased or mechanically injured were discarded. The remaining bulbs were removed from the containers and placed in hardware screen racks. All bulbs were stored at 17°C prior to being placed in low temperature rooms. All temperature control rooms were maintained at the specified temperature ± 1°C. A close check was kept on the humidity to see that it did not get too high. This was done to reduce the potential of infection by disease.

### Planting Procedures

A soil mix consisting of sandy loam, peat and sand (2:1:1) was used. The forcing flats measured 8" X 8" X 4".

Just prior to planting, the bulbs were removed from storage and each individual bulb examined for mold and/or mechanical injury especially to the basal plate. Each bulb was mechanically peeled so as to expose the root plate.

Sixteen bulbs were placed in each flat so that the "nose" of the bulb was just even with or slightly above the top of the flat. Care was taken not to press the bulbs into the rooting medium. The flat side of the bulbs in two front rows faced the front of the flat and the back two rows faced the back side of the flat. Each cultivar within a treatment consisted of three replications of sixteen bulbs each.

After planting the flats were placed in the rooting rooms and thoroughly watered to run-off. This procedure was repeated for three consecutive days. Additional waterings were made as needed.

Light in the rooms was kept to a minimum. Once a week the rooms were aired to allow a complete change of air throughout the rooting room. Temperatures were observed twice daily, with each observation being recorded.

Shifting to Greenhouse

On predetermined dates the flats were removed from the rooting rooms and transported to the greenhouse for forcing. The treatments were placed in the greenhouse in a split block design.

The day temperature was maintained as close to 20°C as possible with the night temperature being held at 17°C.

The forcing flats were inspected each day and watered as needed. All watering was done in the morning in order to maintain a low humidity at night.

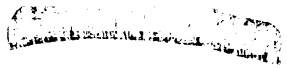
Data recorded

Sprout data were taken when the flats were removed from the rooting rooms. When the floral buds were beginning to show color, flowering data collection was started. Each flower was measured from the tip of the tepal to the base of the receptacle. At the same time the overall height of the plant to the nose of the bulb, as well as the length of the first internode (distance from nose of bulb to node of first leaf) was recorded. All measurements were recorded to the nearest 0.5 cm.

Class I--Very Early Forcing

Experiment I.--This experiment was designed to evaluate various precooling and planting sequences of tulips that were precooled at 9°C and forced for Christmas. Christmas forcing is considered to be very early forcing.

As indicated earlier the treatments the bulbs received is outlined in Table 1.



Experiment II.--This experiment dealt with various precooling temperatures and their effect on overall plant height, flower size, sprout size, length of the first internode and time of flowering.

The information regarding treatments and other pertinent information is found in Table 1.

Experiment III.--This experiment was designed to evaluate rooting room temperatures on the flowering of tulips for Christmas. Consult Table 1 for technical information.

Class II--Early Forcing

Experiment IV.--This experiment utilized ten cultivars in order to investigate the optimum planting date in conjunction with various rooting room temperature sequences for tulips forced in mid-January.

Details are explained in Table 2.

Experiment V.--This experiment was designed with ten different cultivars to study the effects of various rooting room temperatures on the flowering of tulips for Class II or mid-January forcing.

The shipping information as well as other storage temperatures and treatments can be observed in Table 3.

Class III--Medium Forcing

Experiment VI.--This experiment was designed to compare various rooting room temperatures. Information concerning treatments prior to, and after planting, are shown in Table 4.

Experiment VII.--This experiment was a planting date experiment in which five cultivars were used in three separate treatments.

The pertinent information is illustrated in Table 5.

Class IV--Late Forcing

The objectives were to try and determine which planting dates and rooting room temperature sequences are satisfactory to obtain properly timed plants.

Experiment VIII.--The first experiment used two planting dates in combination with specific rooting room temperature sequences to determine the best planting date for a late March (early Easter) flowering. Eleven cultivars were used.

The cultivars and their respective treatments are listed in Table 6.

Experiment IX.--The second experiment in this class was designed to compare various rooting room temperatures on the flowering of tulips for late March.

Five cultivars were used in each of three treatments. The initial rooting temperature, as in all experiments, was at 9°C. The temperature treatments before planting as well as those sequences given after are presented in Table 7.

TABLE 1.--Very Early Forcing.

| Expt. | Trt. | Cultivars | No. of Bulbs | Treatment prior to Shipment | Date of Shipping | Date of Arrival | Treatment prior to Precooling | Precooling Treatment | | Date of Planting | Rooting Room Temperatures | | | Total days at 5°C | Moved to greenhouse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Begin 9°C | Begin 5°C | | total days rooting at 9°C | Begin 5°C | Return to 9°C | | |
| I | 1 | Abodement<br>Christmas Marvel<br>Pax | 150 | All bulbs received 34°C for 1 week followed by 20°C till shipping | July 22 1966 | Aug. 8 1966 | All treatments stored at 17°C from Aug. 8 to Aug. 20 | Aug. 20-Sept. 24 | -- | Sept. 24 | 35 precooled<br>65 rooting @ 9°C | -- | -- | -- | Dec. 1 |
| | 2 | Ralph<br>Ruby Red | 150 | | | | | Aug. 20.-Oct. 1 | -- | Oct. 1 | 42 precooled<br>61 rooting @ 9°C | -- | -- | -- | " |
| | 3 | | 150 | | | | | Aug. 20-Oct. 8 | -- | Oct. 8 | 49 precooled<br>54 rooting @ 9°C | -- | -- | -- | " |
| II | 1 | Levant | 200 | " | " | " | All treatments stored at 17°C till precooling | Aug. 20 | -- | Oct. 1 | 42 precooled<br>60 rooting @ 9°C | -- | -- | -- | Dec. 1 |
| | 2 | Pink Trophy<br>Preludium | 200 | | | | | Aug. 20 | Sept. 10 | "<br>" | 21 precooled<br>60 rooting @ 9°C | -- | -- | -- | " |
| | 3 | Ranchi | 200 | " | " | " | | Sept. 10 | Aug. 20 | " | 21 precooled<br>60 rooting @ 9°C | -- | -- | -- | " |
| | 4 | Snowstar | 200 | " | " | " | | Sept. 10 | Aug. 20 | " | ?<br>60 rooting @ 9°C | -- | -- | -- | " |
| III | 1 | Dix's Favorite | 150 | " | " | " | All treatments stored at 17°C from Aug. 8 to Aug. 20 | Aug. 20 | -- | " | 12 precooled<br>61 rooting @ 9°C | -- | -- | -- | " |
| | 2 | Emmy Peeck<br>Gander | 150 | " | " | " | | Aug. 20 | -- | " | 12 precooled<br>47 rooting @ 9°C | Nov. 17 | -- | 14 | " |
| | 3 | Most Miles<br>Victor Mundy | 150 | " | " | " | | Aug. 20 | -- | " | 12 precooled<br>35 + 12 @ 9°C | Nov. 5 | Nov. 19 | 14 | " |

TABLE 2.--Early Forcing.

| Expt. | Trt. | Cultivars | No. of Bulbs | Treatment prior to Shipment | Date of Shipping | Date of Arrival | Treatment prior to Planting | Date of Planting | Rooting Room Treatments* | | | | Moved to Greenhouse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Begin 5°C | Return to 9°C | Total Days at 9° C | Total Days at 5°C | |
| IV | 1 | Cassini | 300 | 20°C until "G" stage followed by 17°C until shipping | Aug.26 1966 | Sept.20 1966 | All treatments were held at 17°C until Planting | Sept.20 | Oct.25 | -- | 35 | 65 | Dec. 29 1966 |
| | 2 | Demeter | " | | | | | Sept.20 | Oct.25 | Nov.?3 | (35+37) | 28 | |
| | 3 | Gander | " | | | | | Sept.30 | Nov.4 | -- | 35 | 55 | |
| | 4 | Madam Spoor | " | | | | | Sept.30 | Nov.4 | Dec.? | (35+27) | 28 | |
| | 5 | Most Miles | " | | | | | Oct. 10 | Nov.7 | -- | 28 | 52 | |
| | 6 | Paul Richter | " | | | | | Oct. 10 | Nov.7 | Dec.5 | (28+24) | 28 | |

*All treatments initially rooted at 9°C.

TABLE 3.--Early Forcing.

| Expt. | Trt. | Cultivars | No. of Bulbs | Treatment prior to Shipment | Date of Shipping | Date of Arrival | Treatment prior to Planting | Date of Planting | Rooting Room Treatments* | | | | Moved to Greenhouse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Begin 5°C | Return to 9°C | Total Days at 9°C | Total Days at 5°C | |
| V | 1 | Apricot Beauty | 300 | 20°C until "G" stage followed by 17°C until shipping | Sept. 2 1966 | Sept.26 1966 | All treatments stored for 4 days at 17°C | Sept. 30 | Oct.21 | -- | 21 | 69 | Dec. 29 |
| | 2 | Christmas Marvel | " | | | | | Sept. 30 | Nov. 4 | -- | 35 | 55 | |
| | 3 | Diorama | " | | | | | Sept. 30 | Nov.18 | -- | 49 | 41 | |
| | 4 | Merry Widow | " | | | | | Sept. 30 | Oct.21 | Nov.18 | (21+41) | 28 | |
| | 5 | Pax | " | | | | | Sept. 30 | Nov. 4 | Dec. 2 | (35+27) | 28 | |
| | 6 | Roland | " | | | | | Sept. 30 | Nov.18 | Dec.16 | (49+13) | 25 | |
| | 7 | van der Eerden | " | | | | | Sept. 30 | -- | -- | 90 | -- | |
| | 8 | Winter Queen | " | | | | | Sept. 30 | Sept.30 | -- | -- | 90 | |

*All treatments, except 8, rooted initially at 9°C.

TABLE 4.--Medium Forcing.

| Expt. | Trt. | Cultivars | No. of Bulbs | Treatment prior to Shipment | Date of Shipping | Date of Arrival | Treatment prior to Planting | Date of Planting | Rooting Room Treatments* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Begin 5°C | Return to 9°C | Total Days at 9°C | Total Days at 5°C | Moved to Greenhouse |
| VI | 1 | Bellona London Paris Pax Purple Star | 150 | 23°C until "G" stage followed by 17°C until shipping | Sept. 16 1966 | Oct. 7 1966 | All treatments held at 17°C for 13 days | Oct.20 1966 | Nov.24 | -- | 35 | 56 | Jan. 19 1967 |
| | 2 | " | " | " | " | " | " | " | Nov.24 | Dec.8 | (35+42) | 14 | " |
| | 3 | " | " | " | " | " | " | " | Nov.24 | Dec.22 | (35+28) | 28 | " |
| | 4 | " | " | " | " | " | " | " | Oct.20 | -- | -- | 91 | " |

*All treatments, except 4, initially rooted at 9°C.

TABLE 5.--Medium Forcing.

| Expt. | Trt. | Cultivars | No. of Bulbs | Treatment prior to Shipment | Date of Shipping | Date of Arrival | Treatment prior to Planting | Date of Planting | Rooting Room Treatments | | | | Moved to Greenhouse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Begin 5°C | Return to 9°C | Total Days at 9°C | Total Days at 5°C | |
| VII | 1 | Andes Apeldoorn Dreaming Maid | 150 | 23°C until "G" stage followed by 17°C until shipping | Sept.2 1966 | Sept.26 1966 | All treatments stored at 17°C until planting | Oct. 6 | Nov.10 | -- | 35 | 70 | Jan. 19 1967 |
| | 2 | Dutch Princess | " | | | | | Oct.20 | Nov.24 | -- | 35 | 56 | |
| | 3 | Gudoshnik | " | | | | | Nov.3 | Dec.8 | -- | 35 | 42 | |

TABLE 6.--Late Forcing.

| Expt. | Trt. | Cultivars | No. of Bulbs | Treatment prior to Shipment | Date of Shipping | Date of Arrival | Treatment prior to Planting | Date of Planting | Rooting Room Treatments* | | | | | Moved to Greenhouse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Begin 5°C | Begin 2°C | Total Days at 9°C | Total Days at 5°C | Total Days at 2°C | |
| VIII | 1 | Abe Lenstra<br>Aristocrat<br>Blizzard<br>Couleur Cardinal<br>Diplomate<br>Edith Eddy<br>Makassar<br>Orange Sun<br>Palestrina<br>Peerless Pink<br>Robina | 100 | 23°C until Sept. 1, 20°C until Oct. 1 followed by 17°C until shipping | Oct. 14 | Nov. 1 | Both treatments at 17°C until planting | Nov. 15 | Dec.6 | Jan.31 | 21 | 66 | 29 | |
| | 2 | | | | | | | Dec. 1 | Dec.22 | " | 21 | 40 | 29 | |

*All treatments initially rooted at 9°C.

TABLE 7.--Late Forcing.

| Expt. | Trt. | Cultivars | No. of Bulbs | Treatment prior to Shipment | Date of Shipping | Date of Arrival | Treatment prior to Planting | Date of Planting | Rooting Room Treatments* | | | | | Moved to Greenhouse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Begin 5°C | Begin 2°C | Total Days at 9°C | Total Days at 5°C | Total Days at 2°C | |
| IX | 1 | Dreaming Maid<br>Golden Eddy<br>Ornament<br>Paris<br>Utopia | 150 | 23°C until Sept. 1, 20°C until Oct.1, followed by 17°C until shipping | Oct. 14 | Nov. 1 | All treatments were stored at 17°C prior to planting | Dec. 1 | Dec.22 | Jan.31 | 21 | 40 | 29 | Mar. 1 1967 |
| | 2 | | | | | | | " | Jan.5 | Jan.31 | 35 | 26 | 29 | " |
| | 3 | | | | | | | " | Jan.19 | Jan.31 | 49 | 12 | 29 | " |

*All treatments initially rooted at 9°C.

# RESULTS

## Class I--Very Early Forcing

Experiment I.--This experiment was designed to evaluate various precooling and planting sequences of tulips forced for Christmas. The results of this experiment are shown in Table 8.

The data show that there were significant differences at the 5% level on sprout length when comparing treatments within the cultivar. Treatment 3 produced larger sprouts than treatments 1 and 2. There was little, or no significance, when comparing treatment 1 and treatment 2 in any of the five cultivars. Although treatment 3 exhibited a definite effect on sprout length none of the three treatments affected the time to flower (Table 9). These data suggest that sprout length, although affected by different treatments is not an indicator of the resulting quality, size of the flower, or ease of flowering.

No differences in flower size were apparent at the 5% level. No treatment effect was noted on flower color, shape or size. In addition there were no significant numbers of either "blind" or "blasted" flowers. This is shown by the high percentage of plants that flowered (Table 9).

Differences in overall total plant height did occur. Treatment 3, the longest time of precooling at 9°C, produced the tallest plants. The differences between treatments 1 and 3 were significant. In addition, there were significant differences when comparing cultivars within treatments.

Even though treatment 3 had less time at 9°C for rooting this appears to be offset by the longer time precooled at 9°C. It is apparent that increase in overall height is partly reflected in the length of the first internode or foot. This was observed in all cultivars with the exception of Pax. It appears then that longer periods of precooling at 9°C have affected the resulting overall height.

The only significant differences in foot length occurred between treatments 1 and 3 in the cultivars Abodement and Christmas Marvel.

The spread dates in the flowering of the cultivars can be attributed to a cultivar response and not the result of any of the treatments (Table 9).

Experiment II.--This experiment evaluated various precooling temperatures. The data from the four treatments are shown in Tables 10 and 11.

When treatments are compared the data show that there were no significant differences within cultivars in either sprout length or flower size. There were significant differences between cultivars within treatments. This is, however, to be expected.

When comparing cultivars within treatments one finds significant differences at the 5% level in all of the investigated categories.

There were significant differences at the 5% level when examining the total plant height as well as the length of the first internode, in treatments within cultivars.

There was no significance between treatments 2 and 3 in any cultivars with reference to total height. Treatment 4 is tall in each cultivar but significant only in the cultivar Snowstar. This indicates that longer periods of precooling at 5°C tends to give taller plants.

It is apparent that the treatments have had an effect on the days of flowering (Table 11). Some treatments promote earlier flowering while others delay flowering.

It should be pointed out that the only cultivars that would be saleable cut tulips for Christmas are, Levant, Preludium and Pink Trophy (Table 11).

The results of the four treatments on the five cultivars can be summarized as follows: Those plants which are designated for use as cut flowers should be precooled at 5°C for 6 weeks while those which are intended for use as pot plants should be precooled at 9°C for 6 weeks.

Experiment III.--This experiment was designed to evaluate various rooting room temperatures on the flowering of tulips for Christmas.

Data recorded in this experiment are shown in Table 12.

With four of the five cultivars, treatment 1 resulted in significantly longer sprout lengths than treatment 2. Like other experiments carried out in Part I sprout lengths, even though reduced in size, did not affect the resulting plant height, flower size or length of first internode. This coupled with other experiments is again suggestive that sprout height is not indicative of the ease or readiness to flower. Resulting flower sizes are also not indicated by sprout length.

There was no significant difference between treatments with reference to flower size.

No significant differences in total plant height resulted from any of the three treatments. There are significant differences though when comparing cultivars within treatments.

The shortest foot size in four out of five cultivars resulted from treatment 1. In three out of five cultivars treatment 2 produced the longest foot.

It should be noted that although three separate treatments were employed using various combinations of 5° and 9°C no one treatment was superior to the others. Treatment 1, however, enhanced flowering in most cases (Table 13). This seems to indicate that at some time during rooting the bulbs should be subjected to a temperature of 9°C. This is an area that needs further investigation because as indicated by the data in Table 13 one sees

the need to flower the plants 3 to 4 days earlier in order to have the plants available for the Christmas market.

Class II--Early Forcing

Experiment IV.--This experiment utilized ten cultivars while investigating the optimum planting date as well as the optimal rooting room sequence for tulips forced in mid-January.

Sprout lengths, as seen in Table 14 were significantly shorter in treatment 5. Treatment 2, unlike treatment 5, produced the tallest sprouts in all of the cultivars.

None of the treatments appeared to have any significant effect on flower size. Although differences occurred there appeared to be no definite trend.

When the dates of flowering are compared it is seen that treatments 5 and 6 flowered later than 3 and 4 which were later than 1 and 2 (Table 15). This is attributed to the fact that they were planted on later dates. Thus the length of the low temperature treatment can influence the days to flower. In addition it is seen that as the length of low temperature treatment is shortened the total plant height decreases. This could prove beneficial when programing plants for use as pot plants.

To further substantiate this, it was found that in the treatments which received 5°C for a longer duration of time the overall height was increased. Thus, the plants

could be used as cut flowers. This is in agreement with the work of Stuart et al. (21) where they found that storage for longer periods does result in a much taller plant. Genetically, however, there are limits as to the final height of the plant. Perhaps this would be of use in producing cut flowers from plants which are normally used as pot plants.

It is felt that the amount of cold which tulips required to perform satisfactorily as pot plants is acquired within 14.5 weeks. An interesting comparison can be seen with treatments 1 and 2 which were planted on September 20 and initially rooted at 9°C for 5 weeks. Both treatments were then stored at 5°C. Treatment 2 was subsequently returned to 9°C. This resulted in longer sprouts and taller plants. This difference was not however significant at the 5% level.

A point of reference is the fact that changes in the first internode length account for approximately 50% of the height change (Table 14).

As in previous experiments the intended use of the plants would delegate what treatment should be employed. The results of this experiment indicate that there is a definite relationship between planting time and rooting room temperatures on the eventual height of the plants.

Experiment V.--This experiment was designed to study the effect of various rooting room temperatures on the flowering of tulips for Class II or mid-January forcing.

This experiment consisted of eight rooting room temperatures (Table 3). The most noticeable and statistically significant results can be seen between treatments 7 and 8. These large differences are seen in the total overall plant height. The results are shown in Table 16. Treatment 7 consisted of 90 days of rooting at 9°C while treatment 8 was rooted at 5°C for 90 days. In these two treatments the extremes are experienced. Treatment 7 produced the longest sprouts while treatment 4, which had a return to 9°C after 28 days at 5°C, had second longest sprouts. Treatments 5 and 6, which had decreasingly shorter periods of 9°C at the end, gave shorter sprouts.

Treatments 1, 2 and 3 which rooted at 9°C and 5°C, with no return to 9°C produced sprouts that were shorter than treatments which were returned to 9°C. Some exposure to 9°C after 5°C gave sprouts that were longer than those that were not returned to 9°C. When the effect on the total plant height is impaired the same treatment effects are indicated.

These results are comparable to those of the previous experiment on planting time and rooting room temperatures. There is, however, an exception. With long periods of low temperatures (Table 14) a return at the end of the

rooting period to 9°C gave longer sprouts and taller plants. In this experiment treatment 8, which was rooted continuously at 5°C, gave the tallest plants with 50% of the difference again detected in the length of the first internode.

In reference to time to flower (Table 17). None of the treatments appeared to have any influence on the cultivars.

Class III--Medium Forcing

Two separate experiments were conducted. One experiment investigated the effect of planting dates while the second dealt with a series of rooting room temperature sequences.

Experiment VI.--This experiment compared various rooting room temperature sequences. Five cultivars were used in the four treatments.

In the majority of cases treatment 4 produced sprout lengths that were significantly longer than the other three treatments (Table 18). Here, as in the previous experiment a return to 9°C after an initial rooting sequence of 9°C and 5°C, produced sprout lengths longer than a rooting period of only 9°C and 5°C. Some 9°C after 5°C appears to have an accelerating effect.

Total plant height shows that treatment 4, or continuous 5°C produced significantly taller plants.

Treatment 1 produced the next tallest plants. In most cases, treatments 2 and 3 produced shorter plants.

Flower size appeared to be affected by treatment 4. In all cases this treatment had flowers that were smaller than the remaining three. Treatment 1 had slightly smaller flowers than treatments 2 and 3, but were still larger than treatment 4. This indicates that even though storage at 5°C produced significantly taller plants flower size was reduced. Some 9°C in the rooting sequence appears to be beneficial for a well proportioned plant.

Treatment 4 produced the largest first internode. Treatments 2 and 3 appear to have a direct affect on the length of the first internode. They produced shorter internodes.

Like earlier experiments, longer periods at 5°C during the rooting phase produced plants which would be more useful as cut flowers, while combinations of 9°C and 5°C gave plants that could be programed as pot plants.

In all cases treatment 4 accelerated flowering. Here a return to 9°C appears to delay flowering by a day (Table 19).

Experiment VII.--This experiment was a planting date experiment.

The sprout length of treatment 1 was significantly taller than in the other two treatments (Table 20). There appeared to be no significance between treatments 2 and 3.

Treatment effects were evident when examining flower sizes. Treatment 3, which consisted of less time at 5°C, gave the largest flowers. There was a significant difference between treatments 1 and 3. These results are in agreement with other experiments. We see, therefore, that a long period of time at 5°C gives smaller flowers.

The length of the first internode follows the pattern set up by the total height. There is a significant difference between each treatment. The treatment held longest at 5°C produced the longest first internode and this effect decreased as the length of time of rooting was decreased.

Class IV--Late Forcing

Our objective was to determine by trying various planting dates, as well as varying temperature sequences, just what methods are most satisfactory to obtain properly timed plants and yet maintain quality.

Experiments for this period necessitate the use of 2°C. This lower temperature becomes an integral part of the cold sequence because of the time of flowering.

Experiment VIII.--The first experiment was designed using two dates.

The most noticeable effect is the speed of flowering by the plants in treatment 1 (Table 23). This can be attributed to the fact that they were planted two weeks

earlier than those of treatment 2. The data in Table 22 show that treatment 1 was planted earlier and consequently flowered quicker, flower size was reduced significantly when compared with treatment 2. This was significant with all eleven cultivars. This reduction in the size of the flower in treatment 1 can be attributed to the extra time they remained in cold storage.

There appeared to be no treatment effect on overall plant height. The results tended to be erratic even though treatment 1 exhibited consistently larger sprouts than treatment 2. Again this is proof that sprout length is in no way indicative of resulting height or flower size.

It appears that the later one gets in the forcing season the less effect length of storage has on the resulting plants.

Experiment IX.--The second experiment for this Class IV period was designed to compare various rooting room temperatures on the flowering of tulips for late March.

The data for this experiment are presented in Tables 24 and 25.

One could summarize the results of this experiment by saying that there were not any differences that could be described as being significant. All cultivars flowered in a short period with three of the five flowering in the same period of time.

It appears that in this class the bulbs respond to varying treatments with similar results. This degree of freedom is lacking in the earlier Classes indicating that these early Classes are more responsive to low temperature treatments. The responses are not completely independent, however, but enough so that altering the length of storage does not significantly effect the resulting time to flower or quality of same. It is concluded that an alteration of the size of the plants for this class of forcing cannot be as easily accomplished as in earlier forcings due to lack of treatment response by the various cultivars.

TABLE 8.--Experiment 1: Length of sprouts, total plant heights, flowers and first internodes.

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Abodement | 1 | 4.6 | 5.0 | 17.6 | 2.1 |
| | 2 | 4.9 | 5.0 | 18.9 | 2.5 |
| | 3 | 3.1 | 5.2 | 21.2 | 3.5 |
| Christmas Marvel | 1 | 5.0 | 4.9 | 27.8 | 7.2 |
| | 2 | 4.8 | 5.0 | 28.7 | 7.6 |
| | 3 | 4.0 | 4.8 | 29.4 | 8.2 |
| Pax | 1 | 1.5 | 4.4 | 28.9 | 5.1 |
| | 2 | 1.6 | 4.5 | 30.6 | 5.6 |
| | 3 | 0.8 | 4.3 | 30.7 | 5.5 |
| Ralph | 1 | 3.2 | 5.2 | 23.3 | 5.7 |
| | 2 | 3.0 | 5.2 | 23.6 | 5.5 |
| | 3 | 2.5 | 5.0 | 25.3 | 6.2 |
| Ruby Red | 1 | 6.1 | 4.9 | 26.5 | 6.3 |
| | 2 | 6.3 | 4.8 | 25.4 | 6.1 |
| | 3 | 4.4 | 4.8 | 25.7 | 6.6 |
| To compare treatments within cultivar | | | | | |
| HSD 5% level | | 0.2 | N.S. | 1.1 | 0.5 |
| To compare cultivars within treatment | | | | | |
| HSD 5% level | | 0.4 | 0.2 | 2.6 | 1.1 |

TABLE 9.--Experiment I: Flowering dates.

| Cultivar | Trt. | % Flowering by Dates (December) | | | | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 13-15 | 16-18 | 19-21 | 22-24 | 25-27 | 28-30 | | | |
| Abodement | 1 | 19 | 75 | 6 | -- | -- | -- | 100 | 16 | 16 |
| | 2 | 17 | 83 | -- | -- | -- | -- | 100 | 17 | 17 |
| | 3 | -- | 65 | 31 | -- | -- | -- | 96 | 17 | 17 |
| Christmas Marvel | 1 | -- | 31 | 69 | -- | -- | -- | 100 | 19 | 19 |
| | 2 | -- | 2 | 90 | 8 | -- | -- | 100 | 20 | 20 |
| | 3 | -- | 8 | 75 | 11 | -- | -- | 94 | 20 | 20 |
| Pax | 1 | -- | -- | -- | 34 | 42 | 24 | 100 | 26 | 26 |
| | 2 | -- | -- | -- | 38 | 58 | 4 | 100 | 26 | 26 |
| | 3 | -- | -- | -- | 14 | 44 | 42 | 100 | 27 | 27 |
| Ralph | 1 | -- | -- | 46 | 52 | -- | -- | 98 | 22 | 22 |
| | 2 | -- | 21 | 54 | 25 | -- | -- | 100 | 21 | 21 |
| | 3 | -- | -- | 50 | 44 | -- | -- | 94 | 21 | 21 |
| Ruby Red | 1 | -- | -- | 100 | -- | -- | -- | 100 | 19 | 19 |
| | 2 | -- | 40 | 56 | -- | -- | -- | 96 | 19 | 19 |
| | 3 | 4 | 29 | 65 | -- | -- | -- | 98 | 19 | 19 |

TABLE 10.--Experiment II: Length of sprouts, total plant height, flowers, and first internodes.

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Levant | 1 | 5.2 | 5.2 | 22.6 | 4.3 |
| | 2 | 5.3 | 5.4 | 24.8 | 5.8 |
| | 3 | 5.2 | 5.2 | 24.2 | 5.2 |
| | 4 | 5.3 | 5.0 | 25.7 | 4.9 |
| Pink Trophy | 1 | 4.9 | 5.0 | 30.0 | 7.7 |
| | 2 | 4.4 | 5.1 | 30.6 | 7.4 |
| | 3 | 4.5 | 5.2 | 32.6 | 8.3 |
| | 4 | 3.9 | 5.1 | 33.2 | 7.9 |
| Preludium | 1 | 2.6 | 4.9 | 27.0 | 9.2 |
| | 2 | 2.6 | 4.8 | 29.8 | 9.7 |
| | 3 | 2.6 | 5.0 | 29.4 | 9.7 |
| | 4 | 2.7 | 4.9 | 30.4 | 9.9 |
| Ranchi | 1 | 5.6 | 4.8 | 30.1 | 3.9 |
| | 2 | 5.4 | 4.7 | 31.3 | 4.9 |
| | 3 | 5.7 | 4.8 | 32.1 | 4.8 |
| | 4 | 5.9 | 4.7 | 32.2 | 4.7 |
| Snowstar | 1 | 3.8 | 5.2 | 26.2 | 7.2 |
| | 2 | 3.6 | 5.2 | 29.4 | 9.1 |
| | 3 | 4.0 | 5.1 | 28.5 | 8.7 |
| | 4 | 4.1 | 5.1 | 30.9 | 8.8 |
| To compare treatments within cultivar | | | | | |
| HSD 5% level | | N.S. | N.S. | 1.7 | 0.6 |
| To compare cultivar within treatment | | | | | |
| HSD 5% level | | 0.4 | 0.2 | 1.8 | 0.8 |

TABLE 11.--Experiment II: Flowering dates.

| Cultivar | Trt. | % Flowering by Dates (December) | | | | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 16-17 | 18-19 | 20-21 | 22-23 | 24-25 | 26-27 | | | |
| Levant | 1 | -- | 19 | 79 | -- | -- | -- | 98 | 20 | 20 |
| | 2 | -- | -- | 98 | -- | -- | -- | 98 | 21 | 21 |
| | 3 | 15 | 21 | 62 | 2 | -- | -- | 100 | 20 | 20 |
| | 4 | 9 | 26 | 54 | 5 | -- | -- | 94 | 20 | 20 |
| Pink Trophy | 1 | 15 | 33 | 46 | 6 | -- | -- | 100 | 20 | 20 |
| | 2 | -- | 2 | 50 | 48 | -- | -- | 100 | 21 | 21 |
| | 3 | -- | -- | 73 | 27 | -- | -- | 100 | 21 | 21 |
| | 4 | 2 | 13 | 29 | 48 | -- | -- | 92 | 22 | 22 |
| Preludium | 1 | 13 | 38 | 49 | -- | -- | -- | 100 | 19 | 19 |
| | 2 | -- | 4 | 77 | 19 | -- | -- | 100 | 21 | 21 |
| | 3 | -- | 15 | 81 | 4 | -- | -- | 100 | 20 | 20 |
| | 4 | 17 | 21 | 60 | -- | -- | -- | 98 | 20 | 20 |
| Ranchi | 1 | 2 | -- | 10 | 31 | 42 | 9 | 94 | 24 | 24 |
| | 2 | -- | 15 | 23 | 44 | 6 | 4 | 92 | 22 | 22 |
| | 3 | -- | 4 | 38 | 29 | 23 | 4 | 98 | 22 | 22 |
| | 4 | -- | 2 | 31 | 42 | 15 | 4 | 94 | 22 | 22 |
| Snowstar | 1 | -- | -- | 31 | 65 | 2 | -- | 98 | 22 | 22 |
| | 2 | -- | 10 | 88 | -- | -- | -- | 98 | 21 | 21 |
| | 3 | -- | 13 | 85 | 2 | -- | -- | 100 | 21 | 21 |
| | 4 | 2 | 15 | 64 | 19 | -- | -- | 100 | 21 | 21 |

TABLE 12.--Experiment III: Length of sprouts, total plant height, flowers and first internodes.

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Dix's Favourite | 1 | 4.1 | 5.1 | 31.3 | 9.2 |
| | 2 | 4.0 | 4.8 | 33.9 | 10.0 |
| | 3 | 4.0 | 5.0 | 32.9 | 10.3 |
| Emmy Peeck | 1 | 4.9 | 4.7 | 33.0 | 6.4 |
| | 2 | 4.0 | 4.8 | 35.6 | 7.6 |
| | 3 | 4.3 | 4.9 | 34.8 | 7.5 |
| Gander | 1 | 4.6 | 5.2 | 37.5 | 9.0 |
| | 2 | 3.6 | 5.0 | 37.5 | 8.5 |
| | 3 | 4.4 | 5.1 | 38.3 | 8.0 |
| Most Miles | 1 | 5.3 | 5.1 | 43.9 | 9.3 |
| | 2 | 4.2 | 5.1 | 41.0 | 9.8 |
| | 3 | 5.7 | 5.2 | 40.0 | 9.4 |
| Victor Mundy | 1 | 6.2 | 5.1 | 31.6 | 5.3 |
| | 2 | 4.6 | 4.9 | 32.6 | 6.0 |
| | 3 | 5.5 | 5.0 | 32.6 | 5.6 |
| To compare treatments within cultivars | | | | | |
| HSD 5% level | | 0.2 | N.S. | N.S. | 0.5 |
| To compare cultivar within treatment | | | | | |
| HSD 5% level | | 0.5 | 0.2 | 2.4 | 1.0 |

TABLE 13.--Experiment III: Flowering dates.

| Cultivar | Trt. | % Flowering by Dates (December) | | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|---|
| | | 19-20 | 21-22 | 23-24 | 25-26 | | | |
| Dix's Favourite | 1 | 6 | 77 | 17 | -- | 100 | 22 | 22 |
| | 2 | -- | 17 | 73 | 6 | 96 | 23 | 23 |
| | 3 | -- | 8 | 88 | 2 | 98 | 22 | 22 |
| Emmy Peeck | 1 | 44 | 35 | 6 | -- | 85 | 21 | 21 |
| | 2 | 13 | 60 | 23 | -- | 96 | 22 | 22 |
| | 3 | 39 | 57 | 2 | -- | 98 | 21 | 21 |
| Gander | 1 | 4 | 60 | 32 | -- | 96 | 21 | 21 |
| | 2 | -- | 13 | 87 | -- | 100 | 23 | 23 |
| | 3 | -- | 2 | 92 | -- | 94 | 24 | 24 |
| Most Miles | 1 | -- | 31 | 65 | -- | 96 | 23 | 23 |
| | 2 | -- | 2 | 73 | 15 | 90 | 24 | 24 |
| | 3 | -- | 44 | 42 | 8 | 94 | 23 | 23 |
| Victor Mundy | 1 | -- | 31 | 67 | 2 | 100 | 23 | 23 |
| | 2 | -- | 4 | 58 | 38 | 100 | 24 | 24 |
| | 3 | -- | 19 | 72 | 9 | 100 | 24 | 24 |

TABLE 14.--Experiment IV: Length of sprouts, total plant heights, flowers and first internodes.

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Cassini | 1 | 6.0 | 5.3 | 29.6 | 9.0 |
| | 2 | 6.6 | 5.3 | 30.5 | 9.7 |
| | 3 | 5.9 | 5.4 | 29.7 | 9.2 |
| | 4 | 6.3 | 5.3 | 28.1 | 8.3 |
| | 5 | 5.0 | 5.2 | 26.0 | 7.4 |
| | 6 | 6.5 | 5.3 | 24.1 | 6.6 |
| Demeter | 1 | 6.3 | 4.8 | 40.8 | 11.5 |
| | 2 | 8.2 | 4.9 | 41.1 | 10.0 |
| | 3 | 5.4 | 5.0 | 37.8 | 9.3 |
| | 4 | 6.8 | 5.0 | 36.1 | 8.7 |
| | 5 | 3.8 | 5.0 | 33.4 | 7.8 |
| | 6 | 5.8 | 4.9 | 30.5 | 6.2 |
| Dr. Plesman | 1 | 5.2 | 5.0 | 29.3 | 5.3 |
| | 2 | 6.2 | 5.2 | 28.7 | 5.4 |
| | 3 | 4.7 | 5.2 | 28.0 | 4.8 |
| | 4 | 5.5 | 5.1 | 24.6 | 3.9 |
| | 5 | 4.2 | 5.2 | 25.2 | 4.0 |
| | 6 | 5.1 | 5.3 | 22.9 | 3.2 |
| Gander | 1 | 5.8 | 5.1 | 39.6 | 11.3 |
| | 2 | 7.3 | 5.0 | 40.2 | 11.7 |
| | 3 | 5.5 | 5.1 | 39.0 | 11.0 |
| | 4 | 6.5 | 5.2 | 37.3 | 10.3 |
| | 5 | 3.9 | 5.1 | 35.1 | 9.9 |
| | 6 | 5.2 | 5.1 | 32.0 | 7.7 |
| Madame Spoor | 1 | 3.8 | 5.5 | 32.4 | 8.8 |
| | 2 | 4.7 | 5.5 | 33.7 | 10.4 |
| | 3 | 3.7 | 5.7 | 32.0 | 10.0 |
| | 4 | 4.4 | 5.7 | 26.4 | 7.1 |
| | 5 | 2.3 | 5.8 | 34.9 | 9.3 |
| | 6 | 3.2 | 5.3 | 28.1 | 7.9 |
| To compare treatments within cultivar | | | | | |
| HSD 5% level | | 1.2 | 0.3 | 3.7 | 1.9 |
| To compare cultivars within treatment | | | | | |
| HSD 5% level | | 1.3 | 0.5 | 8.3 | 3.1 |

TABLE 14.--Continued.

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Most Miles | 1 | 7.0 | 5.2 | 35.1 | 10.0 |
| | 2 | 8.4 | 5.3 | 37.2 | 9.6 |
| | 3 | 6.2 | 5.5 | 36.8 | 9.6 |
| | 4 | 6.5 | 5.3 | 35.4 | 8.7 |
| | 5 | 4.4 | 5.2 | 35.8 | 10.0 |
| | 6 | 7.2 | 5.6 | 34.4 | 8.7 |
| Paul Richter | 1 | 5.5 | 4.6 | 27.8 | 6.0 |
| | 2 | 6.7 | 4.6 | 27.4 | 6.1 |
| | 3 | 5.0 | 4.7 | 26.4 | 5.6 |
| | 4 | 6.6 | 4.7 | 27.1 | 5.6 |
| | 5 | 4.4 | 4.5 | 23.8 | 4.5 |
| | 6 | 6.2 | 4.6 | 23.5 | 4.1 |
| Prominence | 1 | 2.6 | 4.8 | 23.1 | 8.1 |
| | 2 | 3.0 | 4.9 | 24.2 | 8.0 |
| | 3 | 2.5 | 4.7 | 23.5 | 8.0 |
| | 4 | 2.9 | 4.8 | 21.3 | 6.7 |
| | 5 | 2.1 | 4.8 | 20.4 | 6.4 |
| | 6 | 2.7 | 4.8 | 20.5 | 6.1 |
| Ralph | 1 | 4.0 | 4.9 | 24.2 | 6.0 |
| | 2 | 4.8 | 5.0 | 22.5 | 5.3 |
| | 3 | 3.5 | 5.0 | 21.8 | 4.9 |
| | 4 | 4.2 | 5.0 | 20.0 | 3.7 |
| | 5 | 3.1 | 5.3 | 21.3 | 4.9 |
| | 6 | 3.8 | 5.3 | 16.7 | 3.1 |
| Snowstar | 1 | 5.3 | 5.0 | 26.7 | 7.6 |
| | 2 | 5.8 | 4.9 | 28.8 | 7.5 |
| | 3 | 3.4 | 5.0 | 24.7 | 7.0 |
| | 4 | 4.4 | 4.9 | 23.4 | 6.4 |
| | 5 | 3.4 | 4.9 | 22.7 | 6.1 |
| | 6 | 4.0 | 5.0 | 23.6 | 6.1 |
| To compare treatments within cultivar | | | | | |
| HSD 5% level | | 1.2 | 0.3 | 3.7 | 1.9 |
| To compare cultivars within treatment | | | | | |
| HSD 5% level | | 1.3 | 0.5 | 8.3 | 3.1 |

TABLE 15.--Experiment IV: Flowering Dates.

| Cultivar | Trt. | % Flowering by Dates (January) | | | | | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12-14 | 15-17 | 18-20 | 21-23 | 24-26 | 27-29 | 30 | | | |
| Cassini | 1 | -- | 58 | 42 | -- | -- | -- | -- | 100 | 17 | 20 |
| | 2 | -- | 52 | 48 | -- | -- | -- | -- | 100 | 17 | 20 |
| | 3 | -- | 35 | 61 | 4 | -- | -- | -- | 100 | 18 | 21 |
| | 4 | -- | 52 | 48 | -- | -- | -- | -- | 100 | 17 | 20 |
| | 5 | -- | 13 | 65 | 18 | -- | -- | -- | 96 | 19 | 22 |
| | 6 | -- | 15 | 54 | 29 | -- | -- | -- | 98 | 19 | 22 |
| Demeter | 1 | 40 | 58 | -- | -- | -- | -- | -- | 98 | 15 | 18 |
| | 2 | 83 | 17 | -- | -- | -- | -- | -- | 100 | 14 | 17 |
| | 3 | 13 | 85 | -- | -- | -- | -- | -- | 98 | 15 | 18 |
| | 4 | 77 | 23 | -- | -- | -- | -- | -- | 100 | 14 | 17 |
| | 5 | -- | 71 | 27 | -- | -- | -- | -- | 98 | 17 | 20 |
| | 6 | 12 | 88 | -- | -- | -- | -- | -- | 100 | 16 | 19 |
| Dr. Plesman | 1 | 35 | 50 | 15 | -- | -- | -- | -- | 100 | 15 | 18 |
| | 2 | 43 | 36 | 13 | -- | -- | -- | -- | 92 | 15 | 18 |
| | 3 | 17 | 50 | 10 | -- | -- | -- | -- | 77 | 16 | 19 |
| | 4 | 13 | 54 | 25 | -- | -- | -- | -- | 92 | 16 | 19 |
| | 5 | 8 | 38 | 39 | -- | -- | -- | -- | 85 | 18 | 21 |
| | 6 | 23 | 50 | 21 | -- | -- | -- | -- | 94 | 16 | 19 |
| Gander | 1 | 4 | 63 | 18 | -- | -- | -- | -- | 85 | 17 | 20 |
| | 2 | 18 | 78 | 4 | -- | -- | -- | -- | 100 | 16 | 19 |
| | 3 | 4 | 48 | 46 | 2 | -- | -- | -- | 100 | 17 | 20 |
| | 4 | -- | 79 | 21 | -- | -- | -- | -- | 100 | 16 | 19 |
| | 5 | -- | 10 | 58 | 22 | -- | -- | -- | 100 | 20 | 23 |
| | 6 | 2 | 8 | 31 | 32 | -- | -- | -- | 73 | 21 | 24 |
| Madame Spoor | 1 | -- | -- | 2 | 58 | 34 | -- | -- | 94 | 23 | 26 |
| | 2 | -- | -- | -- | 78 | 18 | -- | -- | 96 | 23 | 26 |
| | 3 | -- | -- | 2 | 27 | 71 | -- | -- | 100 | 24 | 27 |
| | 4 | -- | -- | 13 | 48 | 37 | -- | -- | 98 | 23 | 26 |
| | 5 | -- | -- | -- | 4 | 50 | 44 | -- | 98 | 26 | 29 |
| | 6 | -- | -- | 2 | 36 | 44 | 10 | -- | 92 | 25 | 28 |

TABLE 15.--Continued.

| Cultivar | Trt. | % Flowering by Dates (January) | | | | | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12-14 | 15-17 | 18-20 | 21-23 | 24-26 | 27-29 | 30 | | | |
| Most Miles | 1 | 8 | 90 | -- | -- | -- | -- | -- | 98 | 16 | 19 |
| | 2 | 5 | 95 | -- | -- | -- | -- | -- | 100 | 16 | 19 |
| | 3 | -- | 55 | 38 | -- | -- | -- | -- | 93 | 17 | 20 |
| | 4 | -- | 83 | 15 | -- | -- | -- | -- | 98 | 16 | 19 |
| | 5 | -- | 10 | 78 | 10 | -- | -- | -- | 98 | 19 | 22 |
| | 6 | 2 | 37 | 57 | -- | -- | -- | -- | 96 | 18 | 21 |
| Paul Richter | 1 | 8 | 29 | 46 | 17 | -- | -- | -- | 100 | 19 | 22 |
| | 2 | 21 | 23 | 43 | 13 | -- | -- | -- | 100 | 18 | 21 |
| | 3 | 13 | 17 | 50 | 20 | -- | -- | -- | 100 | 18 | 21 |
| | 4 | 11 | 31 | 52 | 4 | -- | -- | -- | 98 | 18 | 21 |
| | 5 | -- | 13 | 46 | 33 | -- | -- | -- | 92 | 20 | 23 |
| | 6 | 2 | 21 | 54 | 23 | -- | -- | -- | 100 | 19 | 22 |
| Prominence | 1 | -- | 71 | 29 | -- | -- | -- | -- | 100 | 17 | 20 |
| | 2 | -- | 48 | 39 | 11 | -- | -- | -- | 98 | 18 | 21 |
| | 3 | -- | 25 | 46 | 29 | -- | -- | -- | 100 | 18 | 21 |
| | 4 | -- | 43 | 38 | 17 | -- | -- | -- | 98 | 18 | 21 |
| | 5 | -- | -- | 60 | 40 | -- | -- | -- | 100 | 20 | 23 |
| | 6 | -- | -- | 46 | 54 | -- | -- | -- | 100 | 21 | 24 |
| Ralph | 1 | 2 | 90 | 6 | -- | -- | -- | -- | 98 | 16 | 19 |
| | 2 | 19 | 75 | 6 | -- | -- | -- | -- | 100 | 16 | 19 |
| | 3 | 2 | 71 | 25 | -- | -- | -- | -- | 98 | 16 | 19 |
| | 4 | 19 | 69 | 12 | -- | -- | -- | -- | 100 | 16 | 19 |
| | 5 | -- | 69 | 19 | -- | -- | -- | -- | 88 | 17 | 20 |
| | 6 | -- | 25 | 58 | 2 | -- | -- | -- | 85 | 18 | 21 |
| Snowstar | 1 | 8 | 90 | -- | -- | -- | -- | -- | 98 | 16 | 19 |
| | 2 | 33 | 65 | 2 | -- | -- | -- | -- | 100 | 15 | 18 |
| | 3 | 6 | 56 | 38 | -- | -- | -- | -- | 100 | 17 | 20 |
| | 4 | 21 | 60 | 13 | -- | -- | -- | -- | 94 | 16 | 19 |
| | 5 | -- | 13 | 77 | 10 | -- | -- | -- | 100 | 19 | 22 |
| | 6 | -- | 6 | 88 | 6 | -- | -- | -- | 100 | 19 | 22 |

TABLE 16.--Experiment V: Length of sprouts, total plant heights, flowers and first internodes.

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Apricot Beauty | 1 | 6.2 | 5.8 | 31.8 | 6.3 |
| | 2 | 7.9 | 6.1 | 30.6 | 5.9 |
| | 3 | 5.7 | 5.8 | 32.0 | 6.3 |
| | 4 | 9.5 | 5.7 | 30.0 | 5.7 |
| | 5 | 8.2 | 5.8 | 30.1 | 5.6 |
| | 6 | 6.8 | 5.8 | 31.3 | 6.4 |
| | 7 | 9.3 | 5.8 | 27.4 | 4.6 |
| | 8 | 8.3 | 5.7 | 33.1 | 6.9 |
| Christmas Marvel | 1 | 5.2 | 4.9 | 27.7 | 7.6 |
| | 2 | 6.8 | 4.9 | 28.6 | 8.0 |
| | 3 | 5.5 | 4.8 | 27.5 | 7.4 |
| | 4 | 8.5 | 4.4 | 29.0 | 7.4 |
| | 5 | 7.9 | 4.9 | 28.3 | 7.8 |
| | 6 | 7.1 | 4.8 | 29.2 | 8.2 |
| | 7 | 8.4 | 4.8 | 25.4 | 6.4 |
| | 8 | 6.9 | 4.8 | 29.1 | 8.0 |
| Diorama | 1 | 3.0 | 4.8 | 32.1 | 7.0 |
| | 2 | 3.0 | 5.1 | 35.2 | 7.4 |
| | 3 | 2.9 | 5.2 | 34.7 | 7.2 |
| | 4 | 3.9 | 5.1 | 33.1 | 6.2 |
| | 5 | 3.4 | 5.1 | 33.0 | 6.7 |
| | 6 | 3.0 | 5.3 | 36.8 | 7.6 |
| | 7 | 4.5 | 5.0 | 33.1 | 6.1 |
| | 8 | 3.8 | 4.8 | 35.9 | 7.7 |
| Merry Widow | 1 | 3.6 | 4.6 | 24.5 | 8.1 |
| | 2 | 3.8 | 4.6 | 25.8 | 7.8 |
| | 3 | 3.2 | 4.8 | 23.9 | 7.3 |
| | 4 | 5.3 | 4.6 | 22.0 | 6.4 |
| | 5 | 4.4 | 4.7 | 23.2 | 7.3 |
| | 6 | 3.9 | 4.6 | 23.8 | 7.4 |
| | 7 | 4.6 | 4.7 | 21.7 | 5.8 |
| | 8 | 4.1 | 4.5 | 26.8 | 8.2 |
| Pax | 1 | 3.2 | 4.2 | 27.4 | 7.3 |
| | 2 | 3.5 | 4.3 | 28.1 | 7.5 |
| | 3 | 2.5 | 4.2 | 26.5 | 6.8 |
| | 4 | 3.8 | 4.3 | 24.5 | 5.7 |
| | 5 | 2.7 | 4.3 | 25.3 | 5.6 |
| | 6 | 3.2 | 4.3 | 27.7 | 7.0 |
| | 7 | 3.4 | 4.2 | 26.1 | 5.8 |
| | 8 | 3.2 | 4.1 | 28.3 | 7.4 |
| To compare treatments within cultivar | | | | | |
| HSD 5% level | | 1.3 | 0.4 | 3.3 | 1.4 |
| To compare cultivars within treatment | | | | | |
| HSD 5% level | | 1.2 | 0.7 | 7.9 | 4.6 |

TABLE 16.--Continued.

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Roland | 1 | 3.1 | 4.6 | 22.2 | 7.7 |
| | 2 | 3.6 | 4.5 | 21.0 | 7.1 |
| | 3 | 3.5 | 4.8 | 21.7 | 8.2 |
| | 4 | 4.2 | 4.7 | 20.0 | 6.0 |
| | 5 | 3.7 | 4.6 | 20.4 | 6.7 |
| | 6 | 3.6 | 4.7 | 19.7 | 6.5 |
| | 7 | 4.5 | 4.6 | 16.9 | 4.4 |
| | 8 | 4.1 | 4.5 | 25.6 | 10.5 |
| Topscore | 1 | 3.6 | 4.8 | 24.0 | 8.2 |
| | 2 | 4.1 | 4.9 | 25.8 | 8.9 |
| | 3 | 4.0 | 4.9 | 25.2 | 8.7 |
| | 4 | 5.1 | 5.0 | 23.0 | 7.3 |
| | 5 | 4.5 | 5.0 | 24.6 | 8.1 |
| | 6 | 3.9 | 5.2 | 25.9 | 9.5 |
| | 7 | 5.6 | 5.0 | 24.9 | 7.7 |
| | 8 | 4.7 | 4.9 | 26.7 | 9.5 |
| Trance | 1 | 5.0 | 4.7 | 25.9 | 6.3 |
| | 2 | 5.4 | 4.8 | 24.8 | 5.8 |
| | 3 | 4.6 | 4.8 | 25.3 | 6.2 |
| | 4 | 8.0 | 5.1 | 23.9 | 5.3 |
| | 5 | 6.6 | 4.8 | 23.2 | 4.9 |
| | 6 | 6.5 | 5.0 | 26.2 | 6.2 |
| | 7 | 6.9 | 5.0 | 24.5 | 5.2 |
| | 8 | 6.6 | 4.8 | 26.8 | 7.2 |
| van der Eerden | 1 | 4.4 | 4.9 | 32.6 | 9.7 |
| | 2 | 4.9 | 5.0 | 32.0 | 9.8 |
| | 3 | 4.6 | 4.8 | 33.9 | 10.4 |
| | 4 | 5.4 | 5.1 | 31.9 | 8.9 |
| | 5 | 4.1 | 5.1 | 30.9 | 8.6 |
| | 6 | 4.6 | 5.0 | 32.4 | 10.1 |
| | 7 | 5.7 | 4.9 | 27.3 | 7.0 |
| | 8 | 5.7 | 5.0 | 36.8 | 11.4 |
| Winter Queen | 1 | 6.1 | 5.5 | 18.8 | 5.0 |
| | 2 | 6.7 | 5.5 | 20.7 | 5.3 |
| | 3 | 5.8 | 5.3 | 19.4 | 5.1 |
| | 4 | 7.8 | 5.6 | 18.9 | 4.6 |
| | 5 | 6.6 | 5.6 | 16.9 | 3.4 |
| | 6 | 6.3 | 5.6 | 20.9 | 5.2 |
| | 7 | 7.0 | 5.4 | 14.9 | 2.7 |
| | 8 | 6.3 | 5.5 | 19.7 | 5.1 |
| To compare treatments within cultivar | | | | | |
| HSD 5% level | | 1.3 | 0.4 | 3.3 | 1.4 |
| To compare cultivars within treatment | | | | | |
| HSD 5% level | | 1.2 | 0.7 | 7.9 | 4.6 |

TABLE 17.--Experiment V: Flowering Dates.

| Cultivar | Trt. | % Flowering by Dates (January) | | | | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 10-12 | 13-15 | 16-18 | 19-21 | 22-24 | 25 | | | |
| Apricot Beauty | 1 | -- | 39 | 55 | -- | -- | -- | 94 | 16 | 19 |
| | 2 | -- | 15 | 73 | 3 | -- | -- | 91 | 16 | 19 |
| | 3 | -- | -- | 85 | 6 | -- | -- | 91 | 18 | 21 |
| | 4 | -- | 67 | 30 | -- | -- | -- | 97 | 15 | 18 |
| | 5 | -- | 21 | 55 | 9 | -- | -- | 85 | 17 | 20 |
| | 6 | -- | 15 | 71 | 5 | -- | -- | 91 | 15 | 20 |
| | 7 | -- | 9 | 73 | 15 | -- | -- | 97 | 17 | 20 |
| | 8 | -- | 58 | 42 | -- | -- | -- | 100 | 15 | 18 |
| Christmas Marvel | 1 | -- | 33 | 63 | -- | -- | -- | 96 | 15 | 18 |
| | 2 | -- | 64 | 31 | 3 | -- | -- | 98 | 15 | 18 |
| | 3 | -- | 58 | 42 | -- | -- | -- | 100 | 15 | 18 |
| | 4 | 7 | 89 | 4 | -- | -- | -- | 100 | 14 | 17 |
| | 5 | 2 | 92 | 4 | -- | -- | -- | 98 | 14 | 17 |
| | 6 | -- | 80 | 18 | -- | -- | -- | 98 | 15 | 18 |
| | 7 | 11 | 87 | -- | -- | -- | -- | 98 | 14 | 17 |
| | 8 | -- | 89 | 11 | -- | -- | -- | 100 | 15 | 18 |
| Diorama | 1 | -- | -- | -- | 38 | 56 | -- | 94 | 22 | 25 |
| | 2 | -- | -- | -- | 2 | 84 | 2 | 88 | 23 | 26 |
| | 3 | -- | -- | -- | 9 | 85 | -- | 94 | 23 | 26 |
| | 4 | -- | -- | -- | 25 | 73 | -- | 98 | 22 | 25 |
| | 5 | -- | -- | -- | 17 | 83 | -- | 100 | 23 | 26 |
| | 6 | -- | -- | -- | 6 | 88 | 2 | 96 | 23 | 26 |
| | 7 | -- | -- | -- | 23 | 67 | 6 | 96 | 23 | 26 |
| | 8 | -- | -- | 2 | 63 | 29 | -- | 94 | 21 | 24 |
| Merry Widow | 1 | -- | 4 | 73 | 21 | -- | -- | 98 | 17 | 20 |
| | 2 | -- | -- | 21 | 77 | -- | -- | 98 | 19 | 22 |
| | 3 | -- | -- | 25 | 73 | -- | -- | 98 | 19 | 22 |
| | 4 | -- | 17 | 75 | 4 | -- | -- | 96 | 16 | 19 |
| | 5 | -- | 4 | 58 | 36 | -- | -- | 98 | 16 | 21 |
| | 6 | -- | 2 | 67 | 31 | -- | -- | 100 | 18 | 21 |
| | 7 | -- | -- | 56 | 42 | -- | -- | 98 | 18 | 21 |
| | 8 | -- | 6 | 75 | 15 | -- | -- | 96 | 17 | 20 |
| Pax | 1 | -- | -- | 44 | 48 | -- | -- | 92 | 19 | 22 |
| | 2 | -- | -- | 23 | 77 | -- | -- | 100 | 19 | 22 |
| | 3 | -- | -- | 10 | 90 | -- | -- | 100 | 20 | 23 |
| | 4 | -- | 2 | 25 | 73 | -- | -- | 100 | 19 | 22 |
| | 5 | -- | -- | 6 | 79 | 13 | -- | 98 | 20 | 23 |
| | 6 | -- | -- | 13 | 85 | -- | -- | 98 | 20 | 23 |
| | 7 | -- | -- | 13 | 71 | 14 | -- | 98 | 21 | 24 |
| | 8 | -- | -- | 50 | 50 | -- | -- | 100 | 18 | 21 |

| Cultivar | Trt. | % Flowering by Dates (January) | | | | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 10-12 | 13-15 | 16-18 | 19-21 | 22-24 | 25 | | | |
| Roland | 1 | -- | 37 | 59 | 2 | -- | -- | 98 | 16 | 19 |
| | 2 | -- | 18 | 59 | 8 | -- | -- | 85 | 16 | 19 |
| | 3 | -- | 2 | 93 | -- | -- | -- | 95 | 17 | 20 |
| | 4 | 2 | 46 | 39 | -- | -- | -- | 87 | 16 | 19 |
| | 5 | -- | 39 | 61 | -- | -- | -- | 100 | 16 | 19 |
| | 6 | -- | 4 | 79 | -- | -- | -- | 83 | 17 | 20 |
| | 7 | -- | 36 | 58 | 4 | -- | -- | 98 | 16 | 19 |
| | 8 | -- | 38 | 51 | -- | -- | -- | 89 | 16 | 19 |
| Topscore | 1 | -- | 25 | 75 | -- | -- | -- | 100 | 16 | 19 |
| | 2 | -- | 6 | 88 | 6 | -- | -- | 100 | 17 | 20 |
| | 3 | -- | -- | 96 | 2 | -- | -- | 98 | 17 | 20 |
| | 4 | -- | 33 | 65 | -- | -- | -- | 98 | 16 | 19 |
| | 5 | -- | 13 | 83 | 2 | -- | -- | 98 | 16 | 19 |
| | 6 | -- | -- | 92 | 6 | -- | -- | 98 | 17 | 20 |
| | 7 | 2 | 46 | 48 | -- | -- | -- | 96 | 16 | 19 |
| | 8 | -- | 10 | 88 | -- | -- | -- | 98 | 16 | 19 |
| Trance | 1 | -- | 46 | 52 | -- | -- | -- | 98 | 16 | 19 |
| | 2 | -- | 50 | 50 | -- | -- | -- | 100 | 15 | 18 |
| | 3 | 2 | 33 | 63 | -- | -- | -- | 98 | 16 | 19 |
| | 4 | -- | 98 | 2 | -- | -- | -- | 100 | 14 | 17 |
| | 5 | -- | 83 | 15 | -- | -- | -- | 98 | 15 | 18 |
| | 6 | -- | 71 | 29 | -- | -- | -- | 100 | 15 | 18 |
| | 7 | -- | 60 | 40 | -- | -- | -- | 100 | 15 | 18 |
| | 8 | -- | 100 | -- | -- | -- | -- | 100 | 14 | 17 |
| van der Eerden | 1 | -- | -- | 44 | 56 | -- | -- | 100 | 19 | 22 |
| | 2 | -- | -- | 17 | 73 | 2 | -- | 92 | 19 | 22 |
| | 3 | -- | -- | 17 | 73 | 2 | -- | 92 | 21 | 24 |
| | 4 | -- | -- | 54 | 38 | -- | -- | 92 | 18 | 21 |
| | 5 | -- | 2 | 35 | 44 | -- | -- | 81 | 20 | 23 |
| | 6 | -- | -- | 44 | 50 | -- | -- | 94 | 20 | 23 |
| | 7 | -- | 2 | 31 | 63 | 2 | -- | 98 | 19 | 22 |
| | 8 | -- | -- | 46 | 44 | -- | -- | 90 | 19 | 22 |
| Winter Queen | 1 | -- | 92 | 4 | -- | -- | -- | 96 | 15 | 18 |
| | 2 | 4 | 90 | -- | -- | -- | -- | 94 | 15 | 18 |
| | 3 | 2 | 94 | 4 | -- | -- | -- | 100 | 15 | 18 |
| | 4 | 8 | 88 | -- | -- | -- | -- | 96 | 13 | 16 |
| | 5 | 2 | 85 | 6 | -- | -- | -- | 93 | 15 | 18 |
| | 6 | 4 | 94 | 2 | -- | -- | -- | 100 | 14 | 17 |
| | 7 | 21 | 65 | 8 | -- | -- | -- | 94 | 15 | 18 |
| | 8 | -- | 94 | -- | -- | -- | -- | 94 | 14 | 17 |

TABLE 18.--Experiment VI: Length of sprouts, total plant heights, flowers and first internodes.

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Bellona | 1 | 3.2 | 5.3 | 27.2 | 8.3 |
| | 2 | 5.2 | 5.4 | 23.8 | 6.2 |
| | 3 | 4.8 | 5.5 | 25.2 | 7.1 |
| | 4 | 4.8 | 5.2 | 26.9 | 8.2 |
| London | 1 | 2.8 | 5.2 | 30.8 | 5.4 |
| | 2 | 3.8 | 5.6 | 26.0 | 3.3 |
| | 3 | 3.9 | 5.4 | 29.5 | 4.2 |
| | 4 | 4.5 | 4.8 | 28.1 | 6.0 |
| Paris | 1 | 3.4 | 4.4 | 23.1 | 4.6 |
| | 2 | 5.0 | 4.5 | 23.2 | 4.0 |
| | 3 | 4.5 | 4.5 | 20.7 | 3.5 |
| | 4 | 5.1 | 4.3 | 22.1 | 4.0 |
| Pax | 1 | 2.9 | 4.1 | 22.6 | 4.6 |
| | 2 | 5.2 | 4.0 | 19.0 | 3.4 |
| | 3 | 5.1 | 4.0 | 17.7 | 3.0 |
| | 4 | 5.5 | 4.1 | 26.1 | 6.1 |
| Purple Star | 1 | 4.1 | 4.6 | 33.9 | 11.1 |
| | 2 | 5.7 | 4.4 | 29.1 | 9.9 |
| | 3 | 6.1 | 4.5 | 29.4 | 10.0 |
| | 4 | 5.6 | 4.2 | 31.9 | 11.8 |
| To compare treatments within cultivar | | | | | |
| HSD 5% level | | 0.4 | 0.2 | 1.7 | 1.1 |
| To compare cultivars within treatment | | | | | |
| HSD 5% level | | 0.3 | 0.2 | 2.5 | 0.7 |

TABLE 19.--Experiment VI: Flowering dates.

| Cultivar | Trt. | % Flowering by Dates (February) | | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|---|
| | | 3-5 | 6-8 | 9-11 | 12-14 | | | |
| Bellona | 1 | -- | 75 | 23 | -- | 98 | 8 | 20 |
| | 2 | -- | 77 | 23 | -- | 100 | 8 | 20 |
| | 3 | -- | 98 | 2 | -- | 100 | 8 | 20 |
| | 4 | 29 | 71 | -- | -- | 100 | 6 | 18 |
| London | 1 | -- | -- | 88 | 2 | 90 | 10 | 22 |
| | 2 | -- | 8 | 67 | 19 | 94 | 10 | 22 |
| | 3 | 6 | 82 | -- | -- | 88 | 9 | 21 |
| | 4 | 19 | 73 | 8 | -- | 100 | 7 | 19 |
| Paris | 1 | -- | -- | 4 | 94 | 98 | 13 | 25 |
| | 2 | -- | -- | 2 | 98 | 100 | 13 | 25 |
| | 3 | -- | -- | 15 | 85 | 100 | 12 | 24 |
| | 4 | -- | 4 | 46 | 50 | 100 | 11 | 23 |
| Pax | 1 | 8 | 82 | 10 | -- | 100 | 8 | 20 |
| | 2 | 88 | 12 | -- | -- | 100 | 5 | 17 |
| | 3 | 69 | 27 | 4 | -- | 100 | 5 | 17 |
| | 4 | 96 | 4 | -- | -- | 100 | 5 | 17 |
| Purple Star | 1 | -- | 6 | 80 | 8 | 94 | 10 | 22 |
| | 2 | -- | 23 | 65 | 4 | 92 | 10 | 22 |
| | 3 | -- | 31 | 65 | -- | 96 | 9 | 21 |
| | 4 | 6 | 63 | 27 | -- | 96 | 8 | 20 |

TABLE 20.--Experiment VII: Length of sprouts, total plant heights, flowers and first internodes.

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Andes | 1 | 7.7 | 5.1 | 32.2 | 6.8 |
| | 2 | 6.6 | 5.1 | 27.7 | 4.5 |
| | 3 | 7.4 | 5.2 | 25.5 | 3.3 |
| Apeldoorn | 1 | 3.9 | 5.2 | 31.4 | 4.1 |
| | 2 | 3.0 | 5.5 | 26.4 | 1.9 |
| | 3 | 3.2 | 5.5 | 19.2 | 1.0 |
| Dreaming Maid | 1 | 7.5 | 4.8 | 35.0 | 8.2 |
| | 2 | 7.0 | 4.6 | 25.1 | 4.0 |
| | 3 | 6.4 | 4.9 | 29.7 | 4.9 |
| Dutch Princess | 1 | 6.3 | 5.0 | 35.4 | 5.6 |
| | 2 | 5.3 | 4.9 | 31.4 | 4.6 |
| | 3 | 4.8 | 5.3 | 27.9 | 2.8 |
| Gudoshnik | 1 | 1.9 | 5.0 | 42.2 | 8.9 |
| | 2 | 1.3 | 5.1 | 31.1 | 6.0 |
| | 3 | 1.9 | 5.3 | 25.3 | 4.4 |
| To compare treatments within cultivar | | | | | |
| HSD 5% level | | 0.5 | 0.2 | 1.6 | 0.6 |
| To compare cultivars within treatment | | | | | |
| HSD 5% level | | 0.6 | 0.1 | 2.3 | 1.3 |

TABLE 21.--Experiment VII: Flowering dates.

| Cultivar | Trt. | % Flowering by Dates (February) | | | | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 5-7 | 8-10 | 11-13 | 14-16 | 17-19 | 20-22 | | | |
| Andes | 1 | 52 | 34 | -- | -- | -- | -- | 86 | 7 | 19 |
| | 2 | -- | 70 | 21 | -- | -- | -- | 91 | 10 | 22 |
| | 3 | 13 | 56 | 23 | -- | -- | -- | 92 | 10 | 22 |
| Apeldoorn | 1 | -- | 23 | 75 | 2 | -- | -- | 100 | 11 | 23 |
| | 2 | -- | -- | 6 | 77 | 15 | -- | 98 | 15 | 27 |
| | 3 | -- | -- | 2 | 76 | 22 | -- | 100 | 16 | 28 |
| Dreaming Maid | 1 | -- | 15 | 77 | -- | -- | -- | 92 | 11 | 23 |
| | 2 | -- | -- | 13 | 31 | -- | -- | 44 | 14 | 26 |
| | 3 | -- | -- | 49 | 45 | -- | -- | 94 | 14 | 26 |
| Dutch Princess | 1 | -- | 83 | 17 | -- | -- | -- | 100 | 10 | 22 |
| | 2 | -- | -- | 77 | 21 | -- | -- | 98 | 13 | 25 |
| | 3 | -- | -- | 32 | 66 | -- | -- | 98 | 14 | 26 |
| Gudosnik | 1 | -- | -- | 17 | 44 | 35 | -- | 96 | 15 | 27 |
| | 2 | -- | -- | -- | 35 | 37 | 24 | 96 | 17 | 29 |
| | 3 | -- | -- | -- | -- | 23 | 71 | 94 | 20 | 32 |

TABLE 22.--Experiment VIII: Lengths of sprouts, total plant heights, flowers and first internode

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Abe Lenstra | 1 | 6.6 | 4.8 | 36.2 | 5.9 |
| | 2 | 5.5 | 5.2 | 33.9 | 6.4 |
| Aristocrat | 1 | 10.1 | 4.7 | 32.9 | 6.5 |
| | 2 | 8.7 | 5.0 | 35.7 | 8.6 |
| Blizzard | 1 | 8.2 | 4.9 | 18.5 | 2.1 |
| | 2 | 6.9 | 5.3 | 23.7 | 3.7 |
| Couleur Cardinal | 1 | 7.1 | 4.8 | 18.6 | 2.8 |
| | 2 | 6.3 | 4.9 | 19.0 | 3.2 |
| Diplomate | 1 | 5.5 | 5.5 | 27.7 | 2.9 |
| | 2 | 4.2 | 5.8 | 27.1 | 2.0 |
| Edith Eddy | 1 | 5.9 | 4.3 | 25.1 | 5.5 |
| | 2 | 4.5 | 4.5 | 25.6 | 6.8 |
| Makassar | 1 | 6.7 | 4.6 | 33.1 | 5.0 |
| | 2 | 5.4 | 5.1 | 30.8 | 4.8 |
| Orange Sun | 1 | 9.6 | 5.4 | 29.2 | 5.6 |
| | 2 | 7.7 | 5.6 | 27.8 | 5.2 |
| Palestrina | 1 | 8.0 | 5.1 | 27.5 | 4.5 |
| | 2 | 6.5 | 5.5 | 29.6 | 5.4 |
| Peerless Pink | 1 | 7.6 | 6.1 | 27.3 | 2.8 |
| | 2 | 6.1 | 6.2 | 28.1 | 4.3 |
| Robinea | 1 | 6.2 | 5.2 | 24.4 | 5.5 |
| | 2 | 5.4 | 5.4 | 24.7 | 6.4 |
| To compare treatments within cultivar | | | | | |
| HSD 5% level | | 0.2 | 0.1 | 0.7 | 0.4 |
| To compare cultivars within treatment | | | | | |
| HSD 5% level | | 0.8 | 0.6 | 3.8 | 1.8 |

TABLE 23.--Experiment VIII: Flowering dates.

| Cultivar | Trt. | % Flowering by Dates (March) | | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|---|
| | | 14-16 | 17-19 | 20-22 | 23-25 | | | |
| Abe Lenstra | 1 | -- | -- | 98 | -- | 98 | 20 | 20 |
| | 2 | -- | -- | 39 | 61 | 100 | 23 | 23 |
| Aristrocrat | 1 | 6 | 35 | 49 | -- | 90 | 20 | 20 |
| | 2 | -- | -- | 88 | 8 | 96 | 21 | 21 |
| Blizzard | 1 | -- | 69 | 19 | -- | 88 | 18 | 18 |
| | 2 | -- | 10 | 90 | -- | 100 | 20 | 20 |
| Couleur Cardinal | 1 | 17 | 83 | -- | -- | 100 | 17 | 17 |
| | 2 | -- | 54 | 46 | -- | 100 | 19 | 19 |
| Diplomate | 1 | 2 | 98 | -- | -- | 100 | 17 | 17 |
| | 2 | -- | 67 | 33 | -- | 100 | 19 | 19 |
| Edith Eddy | 1 | 77 | 23 | -- | -- | 96 | 15 | 15 |
| | 2 | 6 | 90 | -- | -- | 96 | 18 | 18 |
| Makassar | 1 | -- | 2 | 90 | 4 | 96 | 22 | 22 |
| | 2 | -- | -- | -- | 94 | 94 | 23 | 23 |
| Orange Sun | 1 | -- | 67 | 33 | -- | 100 | 19 | 19 |
| | 2 | -- | 67 | 31 | -- | 98 | 19 | 19 |
| Palestrina | 1 | -- | 32 | 62 | -- | 94 | 20 | 20 |
| | 2 | -- | -- | 100 | -- | 100 | 21 | 21 |
| Peerless Pink | 1 | -- | 10 | 78 | 8 | 96 | 21 | 21 |
| | 2 | -- | -- | 31 | 67 | 98 | 23 | 23 |
| Robinea | 1 | 2 | 67 | 27 | -- | 96 | 19 | 19 |
| | 2 | -- | 2 | 90 | -- | 92 | 21 | 21 |

TABLE 24.--Experiment IX: Length of sprouts, total plant heights, flowers and first internodes.

| Cultivar | Trt. | Length (cm) | | | |
|---|---|---|---|---|---|
| | | Sprout | Flower | Total plant height | First Internode |
| Dreaming Maid | 1 | 10.9 | 4.8 | 28.3 | 3.0 |
| | 2 | 11.2 | 5.1 | 29.4 | 3.8 |
| | 3 | 10.3 | 5.0 | 28.7 | 3.7 |
| Golden Eddy | 1 | 5.9 | 4.5 | 26.7 | 7.2 |
| | 2 | 6.7 | 4.5 | 28.0 | 6.8 |
| | 3 | 6.5 | 4.7 | 27.7 | 7.4 |
| Ornament | 1 | 6.0 | 5.1 | 20.2 | 1.5 |
| | 2 | 6.0 | 5.0 | 18.9 | 1.3 |
| | 3 | 6.0 | 5.0 | 18.9 | 1.1 |
| Paris | 1 | 6.4 | 4.5 | 21.2 | 3.2 |
| | 2 | 6.2 | 4.5 | 24.6 | 4.5 |
| | 3 | 6.4 | 4.7 | 25.6 | 5.2 |
| Utopia | 1 | 7.2 | 4.7 | 30.8 | 6.7 |
| | 2 | 7.6 | 5.0 | 31.8 | 6.9 |
| | 3 | 7.2 | 4.9 | 30.9 | 6.6 |
| To compare treatments within cultivar | | | | | |
| HSD 5% level | | 0.3 | 0.2 | 0.9 | 0.4 |
| To compare cultivars within treatment | | | | | |
| HSD 5% level | | 0.5 | 0.4 | 1.4 | 0.7 |

TABLE 25.--Experiment IX: Flowering dates.

| Cultivars | Trt. | % Flowering by Dates (March) | | | % of plants flowering | Average date of flowering | Average days to flower |
|---|---|---|---|---|---|---|---|
| | | 14-16 | 17-19 | 20-22 | | | |
| Dreaming Maid | 1 | 10 | 74 | 8 | 92 | 18 | 18 |
| | 2 | 8 | 58 | 17 | 83 | 18 | 18 |
| | 3 | 25 | 58 | 2 | 85 | 17 | 17 |
| Golden Eddy | 1 | 50 | 50 | -- | 100 | 16 | 16 |
| | 2 | 48 | 50 | -- | 98 | 17 | 17 |
| | 3 | 44 | 54 | -- | 98 | 17 | 17 |
| Ornament | 1 | 19 | 77 | -- | 96 | 17 | 17 |
| | 2 | 23 | 65 | -- | 88 | 17 | 17 |
| | 3 | 47 | 42 | -- | 89 | 16 | 16 |
| Paris | 1 | 2 | 35 | 61 | 98 | 20 | 20 |
| | 2 | -- | 17 | 79 | 96 | 20 | 20 |
| | 3 | -- | 19 | 79 | 98 | 20 | 20 |
| Utopia | 1 | -- | 83 | 17 | 100 | 18 | 18 |
| | 2 | 4 | 79 | 15 | 98 | 18 | 18 |
| | 3 | -- | 94 | 2 | 96 | 18 | 18 |

# DISCUSSION

The effects of various temperatures on the resulting sprout heights, plant heights and length of the foot, although significant at times, were variable from cultivar to cultivar. That is to say that not all cultivars follow the same pattern. The length of storage time did, however, significantly affect the overall eventual height of the plants, a phenomenon already noted by Stuart et al. (21). In their work it was determined that the longer the time in cold storage the taller the plants. The data reported here agree with this conclusion. This duration of cold had an effect not only on plant height but also showed significant correlations in some cases to foot length as well as sprout height. Correlations existed also between length of time in storage and flower size.

For dicsussion purposes the author has singled out one experiment that contains the necessary variables. Generally the other experiments reacted much the same as the one to be described. This experiment was designed to determine the optimum planting date for rooting room storage for a medium forcing period. This medium forcing period includes Valentine's Day.

Five cultivars were used: Andes, Apeldoorn, Dreaming Maid, Dutch Princess and Gudoshnik.

To determine their response to length of cold storage the cultivars were evaluated separately.

Storage on Total Height

Pertinent statistical information relevant to the effect of length of storage on total height on the cultivars involved is shown in Appendix Table 6.

In the cultivars Dutch Princess, Apeldoorn, Gudoshnik and Andes there is a highly significant correlation between the total plant height and the length of time in storage (Appendix Tables 1,2,3,4). With Dreaming Maid there appears to be no correlation (Appendix Table 5). Apparently there is a direct cultivar response with Dreaming Maid.

These same results were experienced in preliminary experiments where the majority of cultivars responded to a treatment, while a small percentage did not.

There was a negative correlation to plant height as storage times are altered or shortened. The less time in storage the shorter the plants. These two extremes in storage are beneficial when it is desirable to have either a pot plant or a cut flower.

Storage Time on Sprout Height

Pertinent statistical data are shown in Table 7. In the cultivars Dreaming Maid and Dutch Princess there is a highly significant correlation between sprout height and the length of time in storage. The longer the storage duration

the longer the sprouts (Appendix Tables 1,5). Because only these two responded this way, with longer sprouts, and the remaining three did not, it is possible to assume then that this could be attributed to a cultivar reaction and not a treatment effect. It is interesting to note that even though these two responded with longer sprouts than did the remaining three, this increase in height appeared to have no effect on the resulting overall height. This is also borne out when comparing Gudoshnik with a sprout length of 1.9 cm to the cultivar Andes that had 7.7 cm. The mean total plant height for Andes three replications was 32.2 compared to Gudoshnik with the shorter sprout having a total plant height of 42.2 cm. It is felt then that even though longer times at cold storage may possibly affect sprout height, in most instances they have no relationship to the overall plant height.

In earlier years of bulb forcing many growers relied strictly on sprout height as an indicator of "readiness to force." It is shown in this dissertation that this is not always the case.

Storage Effect on Foot Length

In four of the five cultivars there was a significant correlation between the length of time in storage and the foot length. These correlations are shown in the tables of Simple Correlations (Appendix Tables 1-5). Pertinent statistical data are shown in Appendix Table 8.

It appears that storage has an effect on foot length. To further prove this it was observed by the author and co-workers that significant changes in total plant height are actually reflected in the foot length and to a lesser degree from the first node to the top of the flower. If then storage times, and the temperatures, are altered enough to seriously effect foot length one can assume that the total plant height is also going to be directly affected.

The overall increase in total plant height which is visible as an increase in foot length substantiates the work of Stuart (21). He showed that longer storage time is reflected in a taller plant. He does not indicate however whether the increase in height is principally in the length of the foot.

Total Height and Foot

As discussed previously, increases in foot length give an increase in total plant height. The actual increase in total plant height is reflected in the plants as an elongation of the foot itself and not so much an elongation of the plant above the foot.

This phenomenon is proven by examining the five cultivars under consideration as significance between total plant height and foot with total height being the dependent variable. The direct simple correlations are shown in Appendix Tables 1-5.

With storage time being the independent variable, we can see that total plant heights are also going to be altered or determined by storage durations. Explanation of variations due to storage are shown in Appendix Table 9.

It can be hypothesized then by altering time of storage we are altering resulting foot lengths which in turn determine significant increases or decreases in total plant height.

Sprout Height on Total Height

Only in the cultivar Dutch Princess is there a significant correlation between sprout height and total plant height (Appendix Table 1). This response is best explained as a direct cultivar response and not one indicative of any external treatment. This type of response should not be a contributing factor in determining length of storage for other bulbs in a forcing program. Pertinent statistical information regarding this response is shown in Appendix Table 10.

Sprout Height on Foot Length

Only with the cultivar Dutch Princess was there any significance between foot length and sprout height (Appendix Table 1). This also can be best explained as a direct cultivar response and not one dependent on external factors. Explanation of variations due to storage length are shown

in Appendix Table 11. This is further proven when remembering that this cultivar was the only one that sprout height and total height were correlated.

Flower Size and Storage

Flower size is apparently genetically determined and not readily altered by varying durations of storage. In the cultivar Gudoshnik there was apparent the only significance and this was a negative one (Appendix Table 3). As total height increased flower size had a tendency to decrease. This decrease in size although related possibly to total plant height is not as drastic as can be encountered when improper temperatures are given to the bulbs either in dry or wet storage. In these cases complete abortion or blindness occurs.

General Discussion

In a bulb forcing program the control of storage time and temperature is a very useful tool. Through proper manipulation of length of time and temperatures the process of forcing bulbs will involve less guesswork.

Stuart et al. (21) showed that storage time definitely influenced the resulting height of the flowering plants. This investigation not only confirms their findings but also shows that many cultivars, can be quite precisely regulated for use either as a pot plant or cut flower. There are however cultivars that are genetically destined

to be a certain size so that if alteration of this innate trait is tried the plant will retort by either aborting the flower or having some other undesirable characteristic.

In earlier work, by Hartsema, Luyten and Blaauw (12) much emphasis was placed on emerging sprouts. They advocated moving the bulbs to another temperature when the sprouts were of a certain size and then subsequently moving them again when the sprouts were longer. However, from the results of these present experiments, there was no statistically significant correlation between sprout length and total plant height, as was there no difference in foot or flower size. Therefore these data are not in agreement with the proposed scheme of Hartsema et al. (12).

In the experiments that were described in the results section much evidence was accumulated to add strength to the preceding discussion. These results also show that it was the treatment after planting that determines what the resulting plant height will be. As indicated these experiments deal not only with various planting dates but also included different temperature schemes. Included in the investigation were precooling and planting combinations.

These planting date experiments although having some effect on foot heights, flower size, etc. exhibited exactly what has been borne out in this latter work. That of course is, for taller plants the length of storage time at 5°C should be increased. This period should be at least 15

weeks for cut flowers and 13 weeks for pot plants. Therefore, cut flowers need the longer time, while a shorter treatment is satisfactory for pot plants.

By using the 13 week cold instead of the 15 week it is expected then that varieties previously grown only as cut flowers could be grown as pot plants. It is felt that 9°C in combination with 5°C is far superior as far as pot plants are concerned.

It is concluded that by combining proper storage temperatures with proper storage times the forcer can determine final plant size.

In addition to proper storage temperatures and durations there are many other conditions that can interfere with forcing. These are improper dry storage times and temperatures, disease infection, insect infestation, a lack of moisture and/or poor temperature control during rooting.

Important also are the temperatures in the greenhouse during forcing. By controlling these variable conditions, through programming and monitoring them periodically, the use of storage durations and lower temperatures (5°C) can be used as an effective means of producing quality plants.

## SUMMARY

The results of this investigation show that guidelines can be developed to control with a great deal of accuracy the performance of forced tulips.

Cultural techniques were investigated as well as correct sequences of rooting room temperatures and precooling treatments.

To illustrate, what each experiment clearly indicated in the data, one experiment was chosen that contained all the variables that the remaining experiments consisted of. Each independent variable was analyzed. The results were:

(1) In most cases sprout length was in no way an indicator of the plants' final height or readiness to be forced.

(2) Flower size is not affected by varying durations of storage and therefore appears to be genetically determined.

(3) Total plant height is directly affected by the length of time in storage. This duration should be 15 weeks for cut flowers and 13 weeks for pot plants. The less time in storage the shorter the plants.

(4) Storage duration has a direct effect on foot length. Significant changes in total plant height are reflected in changes in foot length. At times this change can be 50% or better of the overall change in total height.

(5) Days to flower and spread dates of flowering were not seriously affected by treatments that closely paralleled each other.

(6) By using a forcing scheme containing 13 weeks of cold instead of 15 weeks, varieties previously grown only as cut flowers could be grown as pot plants. It is felt that 9° C in combination with 5°C is far superior when considering pot plants.

By the use of proper temperature sequences and durations of temperatures not only overall plant heights are controlled but other factors as well which contribute to the final product, a quality plant.

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# APPENDIX

APPENDIX TABLE 1.--Simple correlations--Dutch Princess.

| | Sprout Height | Total Height | Flower Size | Foot | Storage |
|---|---|---|---|---|---|
| Sprout Height | 1.000 | | | | |
| Total Height | 0.900 | 1.000 | | | |
| Flower Size | -0.322 | -0.465 | 1.000 | | |
| Foot | 0.860 | 0.957 | -0.555 | 1.000 | |
| Storage | 0.886 | 0.935 | -0.577 | 0.919 | 1.000 |

APPENDIX TABLE 2.--Simple correlations--Apeldoorn

| | Sprout Height | Total Height | Flower Size | Foot | Storage |
|---|---|---|---|---|---|
| Sprout Height | 1.000 | | | | |
| Total Height | 0.551 | 1.000 | | | |
| Flower Size | -0.531 | -0.481 | 1.000 | | |
| Foot | 0.650 | 0.912 | -0.549 | 1.000 | |
| Storage | 0.633 | 0.942 | -0.617 | 0.910 | 1.000 |

APPENDIX TABLE 3.--Simple correlations--Gudoshnik.

| | Sprout Height | Total Height | Flower Size | Foot | Storage |
|---|---|---|---|---|---|
| Sprout Height | 1.000 | | | | |
| Total Height | 0.157 | 1.000 | | | |
| Flower Size | 0.079 | -0.731 | 1.000 | | |
| Foot | 0.141 | 0.973 | -0.799 | 1.000 | |
| Storage | -0.000 | 0.976 | -0.757 | 0.966 | 1.000 |

APPENDIX TABLE 4.--Simple correlations--Andes.

| | Sprout Height | Total Height | Flower Size | Foot | Storage |
|---|---|---|---|---|---|
| Sprout Height | 1.000 | | | | |
| Total Height | 0.214 | 1.000 | | | |
| Flower Size | 0.192 | 0.024 | 1.000 | | |
| Foot | 0.159 | 0.978 | -0.122 | 1.000 | |
| Storage | 0.123 | 0.921 | -0.235 | 0.961 | 1.000 |

APPENDIX TABLE 5.--Simple correlations--Dreaming Maid.

| | Sprout Height | Total Height | Flower Size | Foot | Storage |
|---|---|---|---|---|---|
| Sprout Height | 1.000 | | | | |
| Total Height | 0.484 | 1.000 | | | |
| Flower Size | -0.048 | 0.523 | 1.000 | | |
| Foot | 0.631 | 0.951 | 0.439 | 1.000 | |
| Storage | 0.816 | 0.474 | -0.231 | 0.634 | 1.000 |

.666--5% level

.798--1% level

APPENDIX TABLE 6.--Storage on total height: Pertinent statistical information relevant to the effect of days in cold storage on total height with the five cultivars.

| Cultivar | Equation | Regression coefficient squared ($R^2$) | Level of significance | Error mean square |
|---|---|---|---|---|
| Andes | $\hat{Y}=6.59+0.24X$ | 0.849 | <0.0005 | 1.718 |
| Apeldoorn | $\hat{Y}=-14.07+0.44X$ | 0.888 | 0.0005 | 4.032 |
| Dutch Princess | $\hat{Y}=6.98+0.27X$ | 0.874 | 0.0005 | 1.767 |
| Dreaming Maid | $\hat{Y}=0.36+4.25X$ | 0.235 | 0.186 | 20.22 |
| Gudoshnik | $\hat{Y}=-22.03+0.60X$ | 0.952 | 0.0005 | 3.040 |

APPENDIX TABLE 7.--Storage on sprout length: Pertinent statistical information relevant to the effect of days of storage on sprout height with the five cultivars.

| Cultivar | Equation | Regression coefficient squared ($R^2$) | Level of significance | Error mean square |
|---|---|---|---|---|
| Andes | $\hat{Y}=6.26+0.81X$ | 0.023 | 0.694 | 0.803 |
| Apeldoorn | $\hat{Y}=0.88+0.03X$ | 0.400 | 0.067 | 0.188 |
| Dutch Princess | $\hat{Y}=0.49+0.05X$ | 0.785 | 0.001 | 0.138 |
| Dreaming Maid | $\hat{Y}=3.60+0.04X$ | 0.667 | 0.007 | 0.114 |
| Gudoshnik | $\hat{Y}=1.71+-0.0X$ | 0.000 | 1.000 | 0.104 |

APPENDIX TABLE 8.--Storage on foot length: Pertinent statistical information relevant to the effect of days in cold storage on foot length with the five cultivars.

| Cultivar | Equation | Regression coefficient squared ($R^2$) | Level of significance | Error mean square |
|---|---|---|---|---|
| Andes | $\hat{Y}$=-6.37+0.12X | 0.925 | 0.0005 | 0.208 |
| Apeldoorn | $\hat{Y}$=-7.73+0.11X | 0.827 | 0.001 | 0.430 |
| Dutch Princess | $\hat{Y}$=-4.56+0.09X | 0.845 | <0.0005 | 0.292 |
| Dreaming Maid | $\hat{Y}$=-5.03+0.11X | 0.403 | 0.066 | 3.456 |
| Gudoshnik | $\hat{Y}$=-7.98+0.15X | 0.934 | <0.0005 | 0.296 |

APPENDIX TABLE 9.--Total height on foot length: Pertinent statistical information relevant to the effect of total height on foot length with the five cultivars.

| Cultivar | Equation | Regression coefficient squares ($R^2$) | Level of significance | Error mean square |
|---|---|---|---|---|
| Andes | $\hat{Y}$=-8.85+0.48X | 0.957 | <0.0005 | 0.119 |
| Apeldoorn | $\hat{Y}$=-3.80+0.24X | 0.832 | 0.001 | 0.417 |
| Dutch Princess | $\hat{Y}$=-6.78+0.35X | 0.917 | <0.0005 | 0.157 |
| Dreaming Maid | $\hat{Y}$=-7.64+0.44X | 0.905 | <0.0005 | 0.547 |
| Gudoshnik | $\hat{Y}$=-2.05+0.26X | 0.947 | <0.0005 | 0.238 |

APPENDIX TABLE 10.--Sprout height on total height: Pertinent statistical information relevant to the effect of sprout height on total height with the five cultivars.

| Cultivars | Equation | Regression coefficient squared ($R^2$) | Level of significance | Error mean square |
|---|---|---|---|---|
| Andes | $\hat{Y}=22.69+0.79X$ | 0.046 | 0.579 | 10.90 |
| Apeldoorn | $\hat{Y}=5.80+5.90X$ | 0.303 | 0.124 | 25.13 |
| Dutch Princess | $\hat{Y}=8.50+4.21X$ | 0.811 | 0.001 | 2.642 |
| Dreaming Maid | $\hat{Y}=0.36+4.25X$ | 0.234 | 0.186 | 20.225 |
| Gudoshnik | $\hat{Y}=26.20+3.91X$ | 0.024 | 0.686 | 62.650 |

APPENDIX TABLE 11.--Sprout height on foot length: Pertinent statistical information relevant to the effect of sprout height on foot length with the five cultivars.

| Cultivars | Equation | Regression coefficient squared ($R^2$) | Level of significance | Error mean square |
|---|---|---|---|---|
| Andes | $\hat{Y}=2.76+0.29X$ | 0.025 | 0.681 | 2.713 |
| Apeldoorn | $\hat{Y}=-3.81+1.82X$ | 0.422 | 0.058 | 1.437 |
| Dutch Princess | $\hat{Y}=-3.77+1.47X$ | 0.7409 | 0.003 | 0.490 |
| Dreaming Maid | $\hat{Y}=-12.36+2.59X$ | 0.399 | 0.068 | 3.477 |
| Gudoshnik | $\hat{Y}=4.84+0.92X$ | 0.019 | 0.717 | 4.418 |

# GLOSSARY

# GLOSSARY

Basal Plate: The raised basal portion of the bulb from which the roots emerge.

Blasting: Failure of the bulb to produce a marketable flower after the flower has been formed. There are several stages of blasting. It may occur as early as immediately after flower formation or as late as the day the flower colors in the greenhouse.

Blindness: Failure of the bulb to form a flower.

Bulb Cellar: See rooting room.

Cool Room: Controlled temperature room used for storage.

Cultivar: A variety or race that has originated and persisted under cultivation. Usually propogated asexually.

Dry Storage: The storage of bulbs before planting. Sometimes used to refer to the storage of flowers after cutting.

Flat: Wcoden container used to grow bulbs for cut flower production.

Forcing: The flowering of a bulb or plant using other than naturally occurring climatic conditions.

Precooling: Dry storage of bulbs at 48°F or lower prior to planting.

Rogueing: Selective removal of diseased plants to prevent the spread of pathogens.

Root Plate: See basal plate.

Rooting Room: Controlled temperature facility used to satisfy the rooting and cold requirement of bulbs.

Shoot: An organ bearing both vegetative and floral parts.

Sprout: See shoot.

Uncooled Bulbs: Bulbs which have received no precooling.