THE INFLUENCE OF PREPLANTING DIPS AND POSTPLANTING TEMPERATURES ON ROOT GROWTH AND DEVELOPMENT OF TULIPS, HYACINTHS, AND DAFFODILS

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ABSTRACT

THE INFLUENCE OF PREPLANTING DIPS AND POSTPLANTING TEMPERATURES ON ROOT GROWTH AND DEVELOPMENT OF TULIPS, HYACINTHS, AND DAFFODILS

By

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The rooting of 'Paul Richter' tulips, 'Explorer' daffodils, and 'Pink Pearl' hyacinths was conducted in dark, temperature controlled growth chambers. Tulip and daffodil bulbs were rooted at 5, 9, 13, 17, and 21°C whereas hyacinths were rooted at 9, 13, 17, 21, 25, 29, and 33°C. In 1973, each bulb species was sampled for root development at weekly intervals for five weeks. This was repeated in 1974 for tulips and daffodils, but the hyacinths were sampled at five day intervals for 25 days. Preplanting treatments of a 30 minute benomyl-ethazol dip in 1973 and 1974 and a 30 minute water dip in 1974 were conducted in conjunction with the time-temperature study. The parameters studied were number of bulbs rooted per pot, fresh root weight, and average root length.

It was determined that 17°C for three weeks and 17°C for three to four weeks were the optimal temperatures for root development of tulips and daffodils, respectively.

For hyacinths, a range from 17 to 25°C for 10 to 14 days was optimal. Under the above conditions, the root length was 70 mm or greater and the number of bulbs rooted per pot was 100% for each species. This growth is suitable for carrying the bulbs through the cold treatment.

It was also established that 9 and 13°C were sufficient for rooting tulips if four weeks were allowed for development. Temperatures 5 and 21°C remained suboptimal throughout the five week rooting period. Though yielding 100% rooted per pot, tulips at 5°C never obtained root growth near the optimal 70 mm. Bulbs at 21°C produced greater than 70 mm of root growth but they did not all root. There was also a problem with *Fusarium* at 21°C. The daffodils rooted well at 9 and 13°C but four to five weeks were needed instead of three weeks at 17°C. Three weeks were sufficient at 9 and 13°C for 100% rooting of bulbs per pot. Daffodils which rooted at 5°C did not produce roots longer than the optimal 70 mm during the five week period. In most cases at 21°C, daffodil root development was inhibited. Temperatures below 17°C and above 25°C were also adequate for root development of the hyacinth but development took from a week to 15 days longer than the optimal range of temperatures took. An increase in *Pythium* and *Fusarium* was observed at temperatures above 25°C.

The benomyl-ethazol and water preplanting dips were effective in stimulating root growth for the first two weeks for the tulips. This was not observed for hyacinths or daffodils. The benomyl-ethazol dip was also significantly better than the non-dipped control and water dip after five weeks of root growth for all bulb species. It was observed that this was due to disease protection.

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To my sister, Ruthie.

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TABLE OF CONTENTS

LIST OF TABLES

Table Page

Table | Page

Table | Page

LIST OF FIGURES

I. LITERATURE REVIEW

Introduction

Many bulbous species are commercially forced to produce high quality cut flowers and pot plants (De Hertogh, 1973). The first instance of scientific studies on forcing bulbs was in 1909, when Nicholas Dames developed the harvesting dates and a post harvest temperature sequence for very early forcing of hyacinths (Hartsema, 1961). Because each bulb species is morphologically and genetically different, Blaauw and his coworkers began to systematically investigate the environmental requirements for development of many of the important species (Hartsema, 1961). This work has been continued by Rees (1972), De Hertogh (1974), and others. Their research has demonstrated that almost all species can be forced by precise control of the environment, and in most instances, specifically temperature control.

De Hertogh (1974) organized bulb forcing principles into a three phase concept: production, programming, and greenhouse phases. The production phase encompasses all aspects related to field production of bulbs. The programming phase comprises all handling of the bulbs from harvest time until they are placed in the greenhouse. The greenhouse phase is continued until the plants are developed for marketing.

Rooting of bulbs is one of the prime factors in both the production and programming phases. In the production phase, bulbs are planted outdoors in October and November and a good root system must be developed prior to the onset of winter. In the programming phase of standard forcing, a series of controlled temperatures is necessary not only to root the bulbs but also to satisfy the cold requirement needed to obtain shoot elongation. Briggs (1972), de Pagter (1972), and De Hertogh (1973) have compiled the temperature sequences for satisfying the cold requirement for many cultivars of tulips, hyacinths, daffodils, and miscellaneous bulbs.

Beside temperature, there are several other environmental factors which influence the initiation and development of roots in bulbs. Among these are ethylene (Kamerbeek and de Munk, 1976), bulb size and shape (Schuurman, 1971), soil compaction in the field (de Haan, et al., 1971, and Wiersum, 1971), and the fungicide benomyl (Raabe, 1970, and Thomas, 1973), Current research on these and other factors will be summarized in this review on the physiology of bulb rooting.

Factors Influencing Root Initiation and Development

Temperature

Mulder and Luyten (1928) observed root formation between September and October at the basal plate of 'Pride of Haarlem', a Darwin tulip. When the bulbs were received in July, the basal plate, semi-circular in shape, had a slightly projected broad, smooth surface. After storing at 17°C, the basal plate underwent enlargement, growing out 4 to 6 mm. Roots subsequently emerged from this plate.

From 1920-27, Versluys (1927) conducted research on the periodicity of the formation and growth of roots of *Hyacinthus orientalis* L. 'Queen of the Blues'. Using temperatures of 12.5, 16.5, 19.5, 23.5, and 27°C, she determined that 23.5 and 27°C stimulated root initiation but were detrimental to root elongation. She concluded that 16.5°C was the best temperature for both root initiation and elongation.

White (1940) using temperatures ranging from 11 to 28°C observed that precooled *Lilium longiflorum* Thunb. 'Giganteum' rooted for six weeks produced the best root system in the range of 16 to 20°C. At higher or lower temperatures, a poorer root system was produced. Hartley (1968) observed that there was no root growth at -1°C and only limited growth at 4.5°C during the storage of 'Croft' and 'Ace' Easter lilies, but considerable growth occurred at 15.5, 21, and 27°C. Roots were found to be longest at 21°C, but they were not as fibrous as those at 15.5°C. De Hertogh and Blakely (1972) using temperatures of 5, 9, 13, 17, and 21°C found that nonprecooled 'Ace' lilies rooted most rapidly at 21°C. However, Miller and Kiplinger (1966) reported that temperatures above 20°C prior to cooling could delay flowering and therefore De Hertogh and Blakely (1972) concluded that a rooting temperature of 17°C should be used in commercial practice. For precooled 'Ace' lilies, the optimal rooting temperature was found to be 17 to 21°C, and temperatures above 20°C should be avoided.

Shoub and De Hertogh (1975) determined the amount of root growth at various stages in the forcing of 'Paul Richter' tulips. They showed that root development (mg/ bulb/day) was greatest at 17°C during the greenhouse phase. The next best root development was observed after the bulbs were planted and placed at 9°C during the programming phase. They felt that root growth in general was more optimal between 13 and 17°C but a definitive study of the affect of temperature at each stage of root growth was not conducted.

<u>The Fungicide 'Benomyl'</u>

Delp and Klopping (1968) reported that 1-(butyl-carbamoyl)-2-benzimidazole carbamic acid, methyl ester (benomyl) has the unique characteristic of being a preventative, a curative, and a systemic fungicide as well as being a mite ovicide. Benomyl has been demonstrated to be effective against *Botrytis* spp., *Fusarium* spp., and *Penicillium* spp. which are diseases affecting tulips, hyacinths, and daffodils. Edington, Knew, and Barron (1971) showed that *Botrytis*, *Fusarium*, and *Pencillium* were highly sensitive to 50 ppm of benomyl.

Raabe (1970) found that a mixture of benomyl and ethazol protected *L. longiflorum* roots from *Pythium*. With increased disease control, he found that there was a corresponding increase in root production. Lilies having a good root system will not only grow better in the greenhouse but will also have a better keeping quality in the home environment. Bald et al. (1973) reported that Easter lily bulbs which were dipped for five minutes in 150 ppm of benomyl before shipping, produced a healthier root system after planting.

Schuft (1970) and Becker (1971) observed the effects of benomyl on grapes which were not related to its fungicidal properties. The effects, which appeared beneficial to vine performance, included changes in bunch shape, fruit set, berry weight, leaf shape, and shoot vigor. Becker suggested that some of the changes resembled those induced by cytokinins. Schruft pointed out that there were certain chemical structural similarities between benomyl and cytokinins. Skene (1972) conducted tests of benomyl suspensions in two cytokinin bioassays: the soybean callus assay (Miller, 1968) and the radish cotyledon assay (Letham, 1968). Cytokinin-like activity of benomyl was thus confirmed by its positive effects in both assays.

Thomas (1973a) has reported that benomyl in combination with a mixture of the gibberellins $A_{4/7}$ caused the breaking of seed dormancy of four celery cultivars. Previously, Palevitch et al. (1971) had shown celery seeds to germinate under the influence of some cytokinins. Later, Thomas (1973b) showed that benomyl possessed both cytokinin-like and fungicidal activity. Skene (1972) suggested that the effectiveness of benomyl as a systemic fungicide was related in some way to its cytokinin properties. He found that fungicides showing the highest cytokinin activity were the most phytotoxic ones.

Ethylene

Radin and Loomis (1969) reported that low concentrations (0.01 ppm) of ethylene reduced growth of radish roots by 50% and that at a higher concentration (1.0 ppm) growth was completely inhibited. de Munk and de Rooy (1971) found that 'Apeldoorn' tulips infected with *Fusarium oxysporum f. tulipae* produced ethylene concentrations up to 10 ppm. They observed that tulips planted adjacent to the infected bulbs had reduced root growth and a high percentage of flower blasting. When they passed 6 ppm ethylene through the soil and in the air around the tulips which were not *Fusarium* infected the growth of shoots and roots were totally inhibited. Flower buds were blasted and the shoots were epinastic. The roots of the ethylene treated tulips were also epinastic and produced an abundant amount of protusions which were thought to be root hairs. Root hairs are not normally present on tulips roots in the absence of ethylene. There are many other anomalies observed in bulbs due to the presence of ethylene. These have been reviewed by Kamerbeek and de Munk (1976).

Soil Compaction

Wiersum (1971) has investigated the aeration requirements of tulip roots. He found that the rate of growth and penetration of the roots into compacted soils was impeded. The restricted root growth impaired nutrient uptake and lowered the supply of available moisture of the bulb and shoot and crop yield was reduced. The longest and healthiest roots were obtained in loose, well-aerated, moist soil. de Hann and van der Valk (1971) also studied root growth of several ornamental bulbs. They were concerned with the effects of increased mechanical cultivation and how it would influence crop yield. At pore-volume values less than 42%, root growth did not occur. They observed an increase in root penetration resistance. The water and air content of the soil did not prohibit the growth of roots and it was concluded that the decrease in root growth was due to increased compaction. Wiersum (1957) showed that from a mechanical point of view penetration was influenced not only by pore size but also by

rigidity of the pores. As long as the soil particles could be displaced easily, the root tip could penetrate without difficulty. They proposed that penetration resistance was very strongly related to structural rigidity.

Bulb Size and Shape

Schuurman (1971) reported that root weight and root length were linearly correlated to tulip bulb weight. He showed that bulbs, although being of the same size grade, gave different corresponding root weights. Normal shaped bulbs (dry weight, 12 mg) produced 225 mg (dry weight) of roots, while slighly flattened-radial shaped bulbs of the same weight had 190 mg of roots. Strong flattened-radial shaped bulbs had about 205 mg of roots. Since tulip roots do not branch, he felt that the increase in tulip root weight was due to number and length of the roots and that other increases were due to increases in root diameter or dry matter content.

Contractile Roots of Bulbous Species

It is a well established fact that the major function of the root is to anchor the plant to the soil so that water and nutrient uptake can occur (Esau, 1965). Another important aspect of the anchorage of the plant to the soil is by means of root contraction. Contraction takes place during a certain stage of development of the plant. The shoot apex is drawn near or below the ground level and is placed in an optimal environment for growth and for development of adventitous roots. Root contraction is a common phenomenon and is widely distributed among herbaceous perennial dictoyledons and monocotyledons (Arber, 1925; Gravis, 1926; Rimbach, 1929).

Contractile roots are formed by the longitudinal shortening and radial enlargement of the inner cortical parenchyma cells, while the outer cells including the cortical, exodermis, and epidermis are lifted over the surface of the contractile region to form large wrinkles (Chen, 1969). Contractile roots have been observed in many bulbous monocotyledons and function to draw the bulbs to considerable depths in the soil (Chan, 1952). The contractile region on Narcissus bulbs was found on the upper portion of the root near the basal plate and usually extended over more than 1 cm (Chen, 1969). Chan (1952) reported that roots of Narcissus in March which had attained a length of 3-7 cm were capable of contracting. In the course of 4 to 5 weeks the roots became 7 to 8 mm shorter.

According to Wilson and Honey (1966), who studied Hyacinth orientalis, the contraction of the inner cortical cells was a growth process in which the radial walls of the cells increased in area and thus the cells increased in volume. They explained the changing of the shape of the cells from a rectangle to a cuboid by means of active growth of the upper and lower transverse walls, which consequently extended the cell radially.

Chen (1969) reported that during the actual process of contraction the radial expansion of the inner cortex created a tension, tending to shorten both the outer cortex and the stele. The pulling force was evidently greater than the holding force and the rigidity of the outer cortex which had more free space in which to move towards the periphery of the root and thus was gathered into folds.

Sterling (1972), studying gladiolus roots, explains that the driving force for contraction was the differential compressive stress between atmospheric pressure and the negative pressure within the xylem.

II. INTRODUCTION

For the past sixty years, bulb research has focused mainly on floral development and the cold requirement needed for scape elongation and bulbing (Hartsema, 1961 and Rees, 1972). These physiological responses have been found to be mainly regulated by temperature. During the 1920s and '30s, Blaauw and co-workers studied these areas extensively. The area of root development, however, was observed mainly as a secondary effect to floral development. One major study was conducted by Versluys (1927) on *Hyacinthus orientalis* L. 'Queen of the Blues'. She observed that 23.5 and 27°C were favorable for root emergence from the basal plate but for root elongation lower temperatures between 15 and 17°C were more favorable. Another study by De Hertogh and Blakely (1972) on *Lilium longiflorum* Thunb. 'Ace' showed that temperatures between 17 and 21°C were optimal for root growth of this species.

Root development is a very important factor in the forcing of bulbs. The major objective of this study was to determine the optimal temperature requirements for root growth of tulips, hyacinths, and daffodils. A secondary goal was to determine if the fungicides, benomyl and ethazol, had a protective and/or stimulatory effect on the rooting of bulbs, especially at the higher temperatures.

III. METHODS AND MATERIALS

Bulbs of *Tulipa gesneriana* L. 'Paul Richter', *Hyacinthus orientalis* L. 'Pink Pearl' and *Narcissus pseudonarcissus* L. 'Explorer' were received from the Netherlands in mid-September 1973 and 1974. Upon arrival, the bulbs were stored and handled as outlined in the Holland Bulb Forcer's Guide (De Hertogh, 1973).

The following factors were common to the three bulb species during the experiments for 1973 and 1974. The pre-planting fungicidal treatment consisted of a 30 minute dip in a mixture of 0.2% benomyl and 0.4% ethazol. In 1974, another preplanting dip of 30 minutes in tap water was added. A steam sterilized planting medium consisting of soil, peat and sand (1:1:1 by volume) was used. After the initial postplanting watering, the bulbs were watered only as needed to maintain a moist, well aerated medium. All bulbs were rooted in dark, temperature controlled growth chambers. No fertilizers were used. At the respective sampling times, the soil was carefully washed from the roots and the following parameters were measured: (1) number of bulbs rooted per pot, (2) average root length (mm), and

(3) fresh root weight (g/bulb). The experiment was set up as a completely randomized design.

Tulip

1973

After removal of the tunic, 450 tulip bulbs were dipped in the fungicidal mixture and planted six per 15 cm pot. After planting, 30 pots each of the control (non-dipped) and fungicidal treated bulbs were placed at 5, 9, 13, 17, and 21°C. At weekly intervals for five weeks, three pots of bulbs from each temperature and preplanting treatment combination were sampled.

1974

The 1973 temperature and sampling time treatments were used, but another preplanting treatment consisting of the water dip was added. This study was conducted to determine if the fungicidal treatment was having a cytokinin-like effect on the bulbs, or if hydration was the major factor. The number of replications and parameters measured were the same as in 1973.

Hyacinth

1973

After the fungicidal dip, the hyacinths were planted three per 15 cm pot. After planting, 30 pots of each preplanting treatment were placed at 9, 13, 17, 21, 25, 29, or 33°C. Again, three pots from each temperature and preplanting treatment combination were sampled at weekly intervals.

1974

The 30 minute preplanting water dip was added and the sampling date was changed to every five days over a 25 day period instead of weekly.

Daffodil

1973

Small slabs and old roots were removed before planting three per 15 cm pot. Thirty pots each of the control and fungicidal dipped bulbs were placed at 5, 9, 13, 17 or 21°C. Three pots of bulbs from each temperature and preplanting treatment combination were sampled at weekly intervals.

1974

The 1973 temperature and sampling dates were used, and the 30 minutes preplanting water dip was added. A larger pot (20 cm) was used so that slabs did not have to removed. In the previous year it was observed that roots formed quickly in the area where slabs had been removed.

IV. RESULTS

The analyses of variance for all experiments are presented in the Appendix. Individual tables show results for 1973 and 1974 for the tulip (Appendix Tables 1 and 2), hyacinth (Appendix Tables 3 and 4), and daffodil (Appendix Tables 5 and 6). The analysis of variance was computed for the following parameters: (1) number of bulbs rooted per pot, (2) average root length (mm), and (3) fresh root weight (g). Only the significant first order interactions will be discussed. Tukey's omega-procedure was used for mean separation on the first order interactions at the 5% level of significance. These results are presented in Tables 1-37.

Tulip 'Paul Richter'

Number of Bulbs Rooted per Pot

1973. At 9, 13, and 17°C, 100% of the bulbs rooted within three weeks (Table 1). At 5°C, four weeks were required while 21°C remained suboptimal throughout the five week sampling period. The fungicidal dip resulted in an

Table 1.--The influence of temperature and sampling time treatments on number of 'Paul Richter' tulips rooted per pot, 1973.[x]

Time (weeks)	Temperature (°C)[y] 5	9	13	17	21	Week Means
1	1.5a e	3.5b e	1.8a e	2.8b e	1.8a ef	2.3
2	3.3b f	5.8d f	4.8c f	5.3cd f	1.3a e	4.1
3	5.7b g	6.0b f	6.0b g	6.0b f	2.3a fg	5.2
4	6.0b g	6.0b f	6.0b g	6.0b f	3.0a gh	5.4
5	6.0b g	6.0b f	6.0b g	6.0b f	3.3a h	5.5
Temperature Means	4.5	5.5	4.9	5.2	2.4	

[x]There were six bulbs per pot.

[y]Means in rows followed by the same letter (a to c) and means in columns followed by the same letter (e to h) are not significantly different at the 5% level.

increase in the number of bulbs which rooted only during the first two weeks (Tablė 2).

1974. At 9 and 13°C, 100% of the bulbs rooted within two weeks; whereas three weeks were required at 5 and 17°C (Table 3). Again, 21°C remained a suboptimal temperature throughout the five week growth period.

Average Root Length (mm)

1973. After two weeks, 17°C was the optimal temperature for root growth, but after three weeks, 9, 13, and 17°C were not significantly different (Table 4). At the five week sample period, 13°C produced the longest root system. The benomyl-ethazol dip increased root length at 21°C, and this was due to disease protection (Table 5). There was no significant difference between treated and untreated bulbs at the other temperatures. The fungicides did increase root length during the first three weeks when averaging all temperatures (Table 6). However, after three weeks, there were no significant differences.

1974. After the first week of rooting, tulip bulbs at 21°C produced the longest roots (Table 7). However, after three weeks 17°C was optimal and it remained so up to week five. The fungicides did not increase root elongation at the lower temperatures, but at 17 and 21°C they were stimulatory (Table 8). The water dip also helped root elongation at all temperatures except at 13°C. After five weeks, both the water and fungicidal dips were better than the control when averaging all temperatures (Table 9).

Table 2.--The influence of preplanting treatments and sampling time on number of 'Paul Richter' tulips rooted per pot, 1973.[x]

Preplanting Treatments	Time (Weeks)[y]					Temperature Means
	1	2	3	4	5	
Control	0.9a e	3.4b e	5.1c e	5.3c e	5.7c e	4.1
Fungicidal Dip	3.7a f	4.9b f	5.3b e	5.5b e	5.3b e	4.9
Week	2.3	4.1	5.2	5.4	5.5	

[x]There were six bulbs per pot.

[y]Means in rows followed by the same letter (a to c) and means in columns followed by the same letter (e to f) are not significantly different at the 5% level.

Table 3.--The influence of temperature and sampling time treatments on the number of 'Paul Richter' tulips rooted per pot, 1974.[x]

Time (Weeks)	Temperature (°C)[y] 5	9	13	17	21	Week Means
1	2.3a e	4.1b e	5.0b e	4.4b e	2.4a e	3.7
2	5.9b f	6.0b f	6.0b e	5.3b ef	3.1a ef	5.3
3	6.0b f	6.0b f	6.0b e	6.0b f	3.7a f	5.5
4	6.0b f	6.0b f	6.0b e	6.0b f	4.1a f	5.6
5	6.0b f	6.0b f	6.0b e	6.0b f	3.4a ef	5.5
Temperature Means	5.2	5.6	5.8	5.6	3.4	

[x]There were six bulbs per pot.

[y]Means in rows followed by the same letter (a to c) and means in columns followed by the same letter (e to h) are not significantly different at the 5% level.

Table 4.--The influence of temperature and sampling time treatments on the growth of roots (mm/bulb) for 'Paul Richter' tulip, 1973.

Time (Weeks)	Temperature (°C)[x]					Week Means
	5	9	13	17	21	
1	1a e	3a e	3a e	8a e	18a e	6.6
2	3a e	27b f	18ab e	47c f	26b f	24.2
3	12a ef	66c g	73c f	74c g	36b fg	52.2
4	28a fg	88c h	91c f	66b fg	47ab gh	64.0
5	40a g	108c i	130d g	95c h	66b h	81.4
Temperature Means	16.8	58.4	63.0	58.0	38.6	

[x]Means in rows followed by the same letter (a to c) and means in columns followed by the same letters (e to h) are not significantly different at the 5% level.

Table 5.--The influence of preplanting treatments and temperature on growth of roots (mm/bulb) for 'Paul Richter' tulip, 1973.

Preplanting Treatments	Temperature (°C)[x]					Preplanting Treatments Means
	5	9	13	17	21	
Control	17a e	60b e	61b e	54b e	28a e	44.0
Fungicidal Dip	17a e	57bc e	65c e	62bc e	50b d	50.2
Temperature Means	17.0	58.5	63.0	58.0	39.0	

[x]Means in rows followed by the same letter (a to c) and means in columns followed by the same letter (e to d) are not significantly different at the 5% level.

Table 6.--The influence of preplanting treatments and sampling time on the growth of roots (mm/bulb) for 'Paul Richter' tulip, 1973.

Preplanting Treatments	Time (Weeks)[x]					Preplanting Treatments Means
	1	2	3	4	5	
Control	1a g	17b g	48c g	63d g	89e g	43.6
Fungicidal Dip	12a h	31b h	56c h	65c g	87d g	50.2
Week Means	6.5	24.0	57.0	64.0	88.0	

[x]Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (g to h) are not significantly different at the 5% level.

Table 7.--The influence of temperature and sampling time treatments on the growth of roots (mm/bulb) for 'Paul Richter' tulip, 1974.

Time (Weeks)	Temperature (°C)[x]					Week Means
	5	9	13	17	21	
1	3a f	3a f	5a f	14b f	23 c f	9.6
2	8a f	13a g	26b g	50c g	42c g	27.8
3	20a g	29b h	62c h	84c h	59c h	50.8
4	37a h	56b i	81d i	93e j	70c i	67.4
5	58a i	79b j	93c j	109d j	72b i	82.2
Temperature Means	25.2	36.0	53.4	70.0	53.2	

[x]Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (f to j) are not significantly different at the 5% level.

Table 8.--The influence of preplanting treatments and temperature on the growth of roots (mm/bulb) for 'Paul Richter' tulip, 1974.

Preplanting Treatment	Temperature (°C)[x]					Preplanting Treatment Means
	5	9	13	17	21	
Control	25a ef	39b f	54d e	57d e	46c e	44.2
Water Dip	28a f	36b ef	53c e	76d f	54c f	49.4
Fungicidal Dip	22a e	33b e	53c e	77d f	59c f	48.8
Temperature Means	25.0	36.0	53.3	70.0	53.0	

[x]Means in rows followed by the same letter (a to d) and means in columns followed by the same letter (e to f) are not significantly different at the 5% level.

Table 9.--The influence of preplanting treatments and sampling time on the growth of roots (mm/bulb) for 'Paul Richter' tulip, 1974.

Preplanting Treatments	Time (Weeks)[x]					Preplanting Treatments Means
	1	2	3	4	5	
Control	9a f	24b f	47c f	62d f	79e f	44.2
Water Dip	9a f	27b fg	55c g	72d g	85e g	49.6
Fungicidal Dip	10a f	32b g	51c fg	68d g	83e fg	48.8
Week Means	9.3	27.7	51.0	67.3	82.3	

[x]Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (f to g) are not significantly different at the 5% level.

Fresh Root Weight (g/bulb)

1973. After three weeks, bulbs at 9, 13, and 17°C produced good root growth. Within the five week rooting period, 13°C was the optimal temperature with 9 and 17°C being slightly suboptimal. Temperatures 5 and 21°C were not conducive to good root growth (Table 10). When comparing the fungicide treatment with the control, over time, they were not significantly different until the fifth week (Table 11).

1974. The optimal temperature throughout the five week period was 17°C with 13°C being the next best temperature followed by 9°C (Table 12). Temperatures 5 and 21°C remained suboptimal for root growth throughout the five weeks. The fungicidal dip increased root growth at 17 and 21°C but did not increase it at the lower temperatures (Table 13). The water dip was effective only at 17°C.

Hyacinth 'Pink Pearl'

Number of Bulbs Rooted per Pot

1973. The fungicidal dip had varying effects on the number of hyacinths rooted per pot (Table 14). At 9, 25, and 33°C the fungicide increased the number rooted, whereas at 29°C the control gave better rooting.

1974. There was no temperature or preplanting dip effect on the number of bulbs rooted.

Table 10.--The influence of temperature and sampling time treatments on the growth of roots (g/bulb) for 'Paul Richter' tulip, 1973.

Time (Weeks)	Temperature (°C)[x] 5	9	13	17	21	Week Means
1	0.02a e	0.15a e	0.09a e	0.25a e	0.41a e	0.18
2	0.10a e	1.61ab e	0.92a f	3.05b f	1.05a e	1.35
3	0.74a ef	5.31b f	6.60b g	5.19b g	1.11a e	3.79
4	2.35a fg	7.21b g	9.64c h	6.95b h	1.79a e	5.59
5	2.97a g	9.90c h	12.07d i	9.63c i	4.99b f	7.91
Temperature Means	1.24	4.84	5.86	5.01	1.87	

[x]Means in rows followed by the same letter (a to d) and means in columns followed by the same letter (e to i) are not significantly different at the 5% level.

Table 11.--The influence of preplanting treatments and sampling time on root growth (g/bulb) for 'Paul Richter' tulip, 1973.

Preplanting Treatments	Time (Weeks)[x]					Preplanting Treatment Means
	1	2	3	4	5	
Control	.04a f	.95a f	3.90b f	5.50c f	8.6d g	3.80
Fungicidal Dip	.33a f	1.74b f	3.69c f	5.68d f	7.22e f	3.73
Week Means	0.19	1.35	3.80	5.59	7.91	

[x]Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (f to g) are not significantly different at the 5% level.

Table 12.--The influence of temperature and sampling time treatments on root growth (g/bulb) for 'Paul Richter' tulip, 1974.

Time (Weeks)	Temperature (°C)^{x}					Week Means
	5	9	13	17	21	
1	0.05a f	0.07a f	0.21a f	0.54a f	0.50a f	0.27
2	0.48a f	0.92ab fg	1.92abc g	3.29c g	1.95bc fg	1.71
3	1.40a f	2.14a g	5.35b h	7.52c h	2.84a gh	3.85
4	3.07a g	5.22b h	8.74c i	8.99c i	3.56a h	5.92
5	5.01b h	8.51c i	10.84d j	13.76e j	3.23a gh	8.27
Temperature Means	2.00	3.37	5.41	6.82	2.42	

^{x}Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (f to j) are not significantly different at the 5% level.

Table 13.--The influence of preplanting treatments and temperature on root growth (g/bulb) for 'Paul Richter' tulip, 1974.

Preplanting Treatments	Temperature[x] 5	9	13	17	21	Preplanting Treatments Means
Control	1.90a e	3.70b e	5.46c e	5.01c e	1.77a e	3.57
Water Dip	2.36ab e	3.28b e	5.34c e	7.51d f	2.18a e	4.13
Fungicidal Dip	1.74a e	3.14b e	5.45c e	7.94d f	3.30b f	4.31
Treatment Means	2.00	3.37	5.42	6.82	2.42	

[x]Means in rows followed by the same letter (a to d) and means in columns followed by the same letter (e to g) are not significantly different at the 5% level.

Table 14.--The influence of preplanting treatments and temperature on the number of 'Pink Pearl' hyacinth rooted per pot, 1973.[x]

Preplanting Treatments	Temperature (°C)[y]							Preplanting Treatments Means
	9	13	17	21	25	29	33	
Control	2.9b c	3.0b c	3.0b c	3.0b c	2.9b c	3.0b d	2.7a c	2.90
Fungicidal Dip	3.0a d	3.0a c	3.0a c	3.0a c	3.0a d	2.9a c	3.0a d	2.99
Temperature Means	2.95	3.0	3.0	3.0	2.95	2.95	2.85	

[x]There were 3 bulbs per pot.

[y]Means in rows followed by like letters (a to b) and means in columns followed by like letters (c to d) are not significantly different at the 5% level.

Average Root Length (mm)

1973. After three weeks, bulbs at 17, 21, and 25°C had the longest roots (Table 15). However, after four weeks, bulbs at 17°C had significantly longer roots. Root growth of bulbs at 9, 29, and 33°C remained suboptimal even after five weeks. The fungicidal dipped bulbs had increased root growth at all temperatures except 13 and 17°C. This effect could have been due to disease protection (Table 16). The fungicide treated bulbs produced longer roots over time. After the first week, the control and fungicide treated bulbs did not show a difference, but after the second week there was a significant difference (Table 17).

1974. After the first five days, 21 and 25°C were optimal growing temperatures. However, after ten days the optimal temperature range included 17°C (Table 18). Nine and 33°C remained suboptimal temperatures for root growth. The fungicidal treatment increased root growth only at 21°C and did not show a significant difference at the other temperatures (Table 19). The water dip was ineffective. The fungicide or water treated bulbs showed an increase in root growth only after 10 and 20 days when averaged across all temperatures (Table 20).

Fresh Root Weight (g/bulb)

1973. The best root growth occurred in the temperature range of 17-25°C for the first four weeks, however,

Table 15.--The influence of temperature and sampling time treatments on the root growth (mm/bulb) for 'Pink Pearl' hyacinth, 1973.

Time (Weeks)	Temperature (°C)[x]							Week Means
	9	13	17	21	25	29	33	
1	13a f	14a f	34b f	54c f	43bc f	42bc f	43bc f	34.7
2	36a g	34a g	78bc g	84c g	75bc g	67bc gh	63b g	62.4
3	70a h	82a h	114c hi	102c h	103c h	73a h	78a g	88.9
4	70ab h	96cd hi	128e i	99d gh	104d h	54a fg	78bc g	89.9
5	81a h	106b i	105b h	106b h	107b h	79a h	72a g	93.7
Temperature Means	54.0	66.4	91.8	89.0	86.4	63.0	66.8	

[x]Means in rows followed by the same letters (a to e) and means in columns followed by the same letters (f to i) are not significantly different at the 5% level.

Table 16.--The influence of preplanting treatments and temperature on the root growth (mm/bulb) for 'Pink Pearl' hyacinth, for 1973.

Preplanting Treatments	Temperature (°C)[x]							Preplanting Treatment Means
	9	13	17	21	25	29	33	
Control	48a e	67bc e	90d e	78cd e	82d e	50a e	59ab e	67.7
Fungicidal	60a f	66ab e	94c e	101c f	91c f	76b f	75b f	80.4
Temperature Means	54.0	66.5	92.0	89.5	86.5	63.0	67.0	

[x]Means in rows followed by the same letters (a to d) and means in columns followed by the same letters (e to f) are not significantly different at the 5% level.

Table 17.--The influence of preplanting treatments and sampling time on root growth (mm/bulb) for 'Pink Pearl' hyacinth, 1973.

Preplanting Treatments	Time (Weeks)^{x}					Preplanting Treatment Means
	1	2	3	4	5	
Control	32a d	55b d	84c d	82c d	85c d	67.6
Fungicidal	37a d	70b e	94c e	98c e	103c e	80.4
Week Means	34.5	62.5	89.0	90.0	94.0	

^{x}Means in rows followed by the same letters (a to c) are means in columns followed by the same letters (d to e) are not significantly different at the 5% level.

Table 18.--The influence of temperature and sampling time treatments on root growth (mm/bulb) for 'Pink Pearl' hyacinth, 1974.

Time (Days)	Temperature (°C)[x]							Day Means
	9	13	17	21	25	29	33	
5	3a g	6a g	20b g	42c g	41c g	35c g	15b g	23.2
10	11a h	23b h	70e h	79f h	76ef h	66d h	39c h	52.0
15	23a i	45b i	93de i	101e i	89cd i	84c i	52b i	69.6
20	34a j	65b j	111d j	114d j	107d j	81c j	60b j	81.7
25	52a k	87c k	125f k	119d j	109d j	93c j	66b j	93.0
Temperature Means	24.6	45.2	83.8	91.0	84.4	71.8	46.4	

[x]Means in rows followed by the same letter (a to f) and means in columns followed by the same letter (g to k) are not significantly different at the 5% level.

Table 19.--The influence of preplanting treatments and temperature on the growth of roots (mm/bulb) for 'Pink Pearl' hyacinth, 1974.

Preplanting Treatments	Temperature (°C)[x]							Preplanting Treatment Means
	9	13	17	21	25	29	33	
Control	26a f	42b f	81cd f	85d f	83d f	71c f	43b f	61.6
Water Dip	24a f	46b f	84cd f	91d fg	85cd f	76c f	48b f	64.9
Fungicidal Dip	25a f	47b f	87de f	96e g	85d f	69c f	48b f	65.3
Temperature Means	25.0	45.0	84.0	90.7	84.3	72.0	46.3	

[x]Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (f to g) are not significantly different at the 5% level.

Table 20.--The influence of preplanting treatments and sampling time on the growth of roots (mm/bulb) for 'Pink Pearl' hyacinth, 1974.

Preplanting Treatments	Time (Days)^x					Preplanting Treatment Means
	5	10	15	20	25	
Control	21a f	48b f	60c f	77d f	92e f	61.4
Water Dip	24a f	54b f	69c f	86d g	92e f	65.0
Fungicidal Dip	25a f	54b g	70c f	82d fg	96e f	65.4
Day Means	23.3	52.0	69.3	81.7	93.3	

^{x}Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (f to g) are not significantly different at the 5% level.

after the fifth week 21 and 25°C were optimal (Table 21). Temperatures 9, 29, and 33°C remained suboptimal for root growth. The fungicidal treatment enhanced root weight at the fourth and fifth weeks of growth when all temperatures were averaged (Table 22).

1974. After the first fifteen days of growth, bulbs growing at 17, 21, and 25°C had greater root weight than did bulbs at the other tempertures (Table 23). Bulbs at 17 and 25°C produced the best root growth after 25 days, while development at 21°C was slightly less. The fungicidal and water dips did not enhance root growth at any of the temperatures (Table 24).

Daffodil 'Explorer'

Number of Bulbs Rooted per Pot

1973. After two weeks, 100% of the bulbs rooted at 13°C (Table 25). Within three weeks, 9°C rooted bulbs obtained 100%. Bulbs at 17°C rooted rapidly but never achieved 100%. At 5°C, it took five weeks to obtain a high percentage of rooted bulbs. A high percentage of rooted bulbs was never obtained throughout the five week period at 21°C. The fungicidal dip increased the percent rooting only at 21°C (Table 26).

1974. After the first week, bulbs grown at 17°C exhibited 100% rooting and within three weeks all bulbs at 5, 9, and 13°C had rooted (Table 27). Bulbs at 21°C never exhibited a high percentage of rooting.

Table 21.--The influence of temperature and sampling time on root growth (g/bulb) for 'Pink Pearl' hyacinth, 1973.

Time (Weeks)	Temperature (°C)[x]							Week Means
	9	13	17	21	25	29	33	
1	0.83a e	0.73a e	2.94a e	4.51a e	2.37a e	2.33a e	0.93a e	2.09
2	3.88a e	4.22a e	10.81d f	10.45cd f	8.51bcd f	6.90abc f	5.34ab f	7.16
3	7.88a f	10.36ab f	17.70c gh	14.80c g	14.04bc g	7.28a f	8.72a fg	11.54
4	11.16a fg	16.54b g	20.63c h	17.88bc g	17.72bc h	8.72a f	7.77a fg	14.35
5	12.14a g	17.93bc g	16.14b g	21.60c h	20.94bc h	10.29a f	10.17a g	15.60
Temperature Means	7.18	9.96	13.64	13.85	12.72	7.10	6.59	

[x]Means in rows followed by the same letter (a to d) and means in columns followed by the same letter (e to h) are not significantly different at the 5% level.

Table 22.--The influence of preplanting treatments and sampling time on root growth (g/bulb) for 'Pink Pearl' hyacinth, 1973.

Preplanting Treatments	Time (Weeks) 1	2	3	4	5	Preplanting Treatment Means
Control	2.05a f	6.75b f	10.99c f	12.96d f	13.35d f	9.22
Fungicidal Dip	2.13a f	6.56b f	12.09c f	15.73d g	17.85e g	11.07
Week Means	2.09	7.16	11.54	14.35	15.60	

[x]Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (f to g) are not significantly different at the 5% level.

Table 23.--The influence of temperature and sampling time treatments on root growth (g/bulb) for 'Pink Pearl' hyacinth, 1974.

Time (Days)	Temperature (°C)[x]							Day Means
	9	13	17	21	25	29	33	
5	0.11a f	0.27a f	2.06ab f	3.98b f	3.76b f	1.88ab f	0.37a f	1.78
10	0.67a f	1.84a f	7.90bc g	9.49c g	9.51c g	6.42b g	2.05a fg	5.41
15	1.77a fg	4.50b g	12.50d h	14.76e h	12.59de h	9.03c h	3.20ab g	8.33
20	3.44a gh	7.22b h	15.57d i	14.63d h	14.41d hi	10.35c h	3.82a gh	9.92
25	4.95a h	10.26b i	16.38d i	14.66c h	16.03d i	12.40b i	5.62a h	11.47
Temperature Means	2.19	4.82	10.88	11.50	11.26	8.02	3.01	

[x]Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (f to i) are not significantly different at the 5% level.

Table 24.--The influence of preplanting treatments and temperature on root growth (g/bulb) for 'Pink Pearl' hyacinth, 1974.

Preplanting Treatment	Temperature (°C)[x]							Preplanting Treatment Means
	9	13	17	21	25	29	33	
Control	2.43a e	4.76b e	10.64d e	10.99d e	11.91d e	8.87c f	2.54a e	7.45
Water Dip	1.93a e	4.72b e	10.55d e	12.02d e	10.84d e	8.22d ef	3.34ab e	7.37
Fungicidal Dip	2.21a e	4.98b e	11.45d e	11.51d e	11.03d e	6.96c e	3.14a e	7.33
Temperature Means	2.66	4.82	10.88	11.51	11.26	8.02	3.01	

[x]Means in rows followed by the same letter (a to d) and means in columns followed by the same letter (e to f) are not significantly different at the 5% level.

Table 25.--The influence of temperature and sampling time treatments on number of 'Explorer' daffodils rooted per pot, 1973.[x]

Time (Weeks)	Temperature (°C)[y] 5	9	13	17	21	Week Means
1	1.2a d	2.0ab d	2.7b d	2.7b d	2.0ab d	2.1
2	1.0a d	2.8b d	3.0b d	2.5b d	2.3b d	2.3
3	2.0ab de	3.0b d	3.0b d	2.7b d	1.5a d	2.4
4	2.3ab ef	3.0b d	2.8b d	2.8b d	1.7a d	2.5
5	2.8ab f	3.0b d	3.0b d	2.8ab d	1.8a d	2.7
Temperature Means	1.9	2.8	2.9	2.7	1.9	

[x]There were 3 bulbs per pot.

[y]Means in rows followed by the same letter (a to b) and means in columns followed by the same letter (d to f) are not significantly different at the 5% level.

Table 26.--The influence of preplanting treatments and temperature on number of 'Explorer' daffodils rooted per pot, 1973.[x]

Preplanting Treatment	Temperature (°C)[y]					Preplanting Treatment Means
	5	9	13	17	21	
Control	2.0a e	2.9b e	2.9b e	2.7b e	1.5a e	2.4
Fungicidal Dip	1.7a e	2.7bc e	2.9c e	2.7bc e	2.2ab f	2.4
Temperature Means	1.9	2.8	2.9	2.7	1.9	

[x]There were 3 bulbs per pot.

[y]Means in rows followed by the same letter (a to c) and means in columns followed by the same letter (e to f) are not significantly different at the 5% level.

Table 27.--The influence of temperature and sampling time treatments on number of 'Explorer' daffodils rooted per pot, 1974.[x]

Time (Weeks)	Temperature (°C)[y]					Week Means
	5	9	13	17	21	
1	0.0a e	0.0a e	1.4b e	3.0c f	0.2a ef	0.9
2	2.4b f	3.0c f	2.8c f	3.0c f	0.2a ef	2.3
3	3.0b g	3.0b f	3.0b f	3.0b f	0.5a f	2.5
4	3.0b g	3.0b f	3.0b f	2.8b f	0.1a e	2.4
5	3.0b g	3.0b f	3.0b f	3.0b f	0.0a e	2.4
Temperature Means	2.9	2.4	2.6	3.0	0.2	

[x]There were 3 bulbs per pot.

[y]Means in rows followed by the same letter (a to c) and means in columns followed by the same letter (e to g) are not significantly different at the 5% level.

Average Root Length (mm)

1973. After the first week, bulbs at 17 and 21°C produced longer roots than at other temperatures (Table 28). By the third week, the optimal range shifted down to 13 and 17°C and remained at these temperatures up to week five. Five and 9°C were suboptimal temperatures for root growth. The effect of the fungicides on root growth varied with the temperature (Table 29). There was no difference between the control and fungicide treated bulbs at 5, 13, and 17°C. At 9°C, the control bulbs had better root development than the fungicide treated bulbs, but at 21°C the opposite effect was observed. The fungicide treatment increased root length during the five week sampling period (Table 30). Greater root development was observed for the fungicide treated bulbs after 2, 3, and 5 weeks.

1974. After each sampling period, it was determined that bulbs at 17°C had the longest roots (Table 31). Bulbs grown at 13°C exhibited satisfactory root growth but it was less than that at 17°C. Five and 21°C were suboptimal rooting temperatures. The fungicidal and water treatments had an effect only at 13°C (Table 32). Bulbs at other temperatures did not exhibit any difference between the control, and preplanting water and fungicidal dip treatments.

Table 28.--The influence of temperature and sampling time treatments on the growth of roots (mm/bulb) for 'Explorer' daffodil, 1973.

Time (Weeks)	Temperature (°C)[x]					Week Means
	5	9	13	17	21	
1	2a e	5a e	7a e	16ab e	23b e	10.6
2	2a e	10a ef	18ab e	31bc e	42c f	20.6
3	3a e	26b fg	50c f	55c f	19ab e	30.6
4	8a e	32b gh	67c g	66c fg	31b ef	40.8
5	15a e	43b h	80c g	72c g	46b f	51.2
Temperature Means	6.0	23.2	44.4	48.0	32.2	

[x]Means in rows followed by the same letter (a to c) and means in columns followed by the same letter (e to g) are not significantly different at the 5% level.

Table 29.--The influence of preplanting treatments and temperature on root growth (mm/bulb) for 'Explorer' daffodil, 1973.

Preplanting Treatment	Temperature (°C)[x]					Preplanting Treatment Means
	5	9	13	17	21	
Control	7a e	29c f	46d e	46d e	20b e	29.6
Fungicidal Dip	5a e	18d e	43c e	50c e	44c f	32.0
Temperature Means	6.0	23.5	44.5	48.0	34.0	

[x]Means in rows followed by the same letter (a to c) and means in columns followed by the same letter (e to f) are not significantly different at the 5% level.

Table 30.--The influence of preplanting treatments and sampling time on root growth (mm/bulb) for 'Explorer' daffodil, 1973.

Preplanting Treatments	Time (Weeks)					Preplanting Treatment Means
	1	2	3	4	5	
Control	13a e	18a e	28b e	40c e	48d e	29.4
Fungicidal Dip	9a e	23b f	33c f	41d e	54e f	32.0
Week Means	11.0	20.5	30.5	40.5	51.0	

[x]Means in rows followed by the same letter (a to d) and means in columns followed by the same letter (e to f) are not significantly different at the 5% level.

Table 31.--The influence of temperature and sampling time on root growth (mm/bulb) for 'Explorer' daffodil, 1974.

Time (Weeks)	Temperature (°C)[x] 5	9	13	17	21	Week Means
1	0a g	0a g	3ab g	17b g	5ab g	5.0
2	4a g	9ab gh	23b h	53c h	6a g	19.0
3	11a gh	22ab h	48c i	90d i	37bc h	41.6
4	19a hi	52b i	72c j	104d ij	11a g	51.6
5	28b i	72c j	89a k	117e j	0a g	61.2
Temperature Means	12.4	31.0	47.0	76.2	11.8	

[x]Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (g to k) are not significantly different at the 5% level.

Table 32.--The influence of preplanting treatments and temperature on root growth (mm/bulb) for 'Explorer' daffodil, 1974.

Preplanting Treatments	Temperature (°C)[x]					Preplanting Treatment Means
	5	19	13	17	21	
Control	13a e	28b e	38b e	74c e	16a e	33.8
Water Dip	12a e	29b e	50c f	74d e	9a e	34.8
Fungicidal Dip	12a e	36b e	52c f	81d e	11a e	38.4
Temperature Means	12.3	31.0	46.7	76.3	12.0	

[x]Means in rows followed by the same letter (a to d) and means in columns followed by the same letter (e to f) are not significantly different at the 5% level.

Fresh Root Weight (g/bulb)

1973. After one week, there was no significant difference between any of the temperatures (Table 33). After the third and fourth weeks, 13 and 17°C were optimal rooting temperatures. After the fifth week, 13°C became optimal. Temperatures 5, 9, and 21°C were suboptimal for rooting compared to the growth at 13 and 17°C. Fungicidal treated bulbs at 5, 9, and 17°C showed no increase in root growth as compared to the control (Table 34). At 9°C, the control bulbs had more growth than did the fungicide treated bulbs. At 21°C, the fungicidal treated bulbs exhibited better root growth. After the fifth week, the fungicidal treated bulbs had significantly better root growth than the untreated bulbs when all temperature treatments were averaged (Table 35).

1974. Throughout the five week period bulbs at 17°C exhibited the best root growth (Table 36). Five and 21°C were suboptimal rooting temperatures. The fungicidal treatment increased root growth at 9 and 13°C (Table 37). Water dipped bulbs also showed a significant difference compared to the control bulbs at 13°C.

Table 33.--The influence of temperature and sampling time treatments on root growth (g/bulb) for 'Explorer' daffodil, 1973.

Time (Weeks)	Temperature (°C)[x] 5	9	13	17	21	Week Means
1	0.00a e	0.02a e	0.08a e	0.28a e	0.10a e	0.12
2	0.01a e	0.58a ef	1.60a e	2.23a f	0.30a e	0.94
3	0.09a e	2.42a fg	5.21b f	6.39b g	1.57a e	3.14
4	0.78a e	4.17b gh	8.26c g	9.38c h	4.73b f	5.46
5	1.16a e	6.37b h	14.15d h	9.93c h	6.55b f	7.63
Temperature Means	0.51	2.71	5.86	5.64	2.65	

[x]Means in rows followed by the same letter (a to d) and means in columns followed by the same letter (e to h) are not significantly different at the 5% level.

Table 34.--The influence of preplanting treatments and temperature on root growth (g/bulb) for 'Explorer' daffodil, 1973.

Preplanting Treatment	Temperature (°C)[x]					Preplanting Treatment Means
	5	9	13	17	21	
Control	0.45a d	3.46b e	6.24c d	5.27c d	0.55a d	3.2
Fungicidal Dip	0.37a d	1.97b d	5.48c d	6.01c d	4.75c e	3.7
Temperature Means	0.41	2.72	5.86	5.64	2.65	

[x]Means in rows followed by the same letter (a to c) and means in columns followed by the same letter (e to d) are not significantly different at the 5% level.

Table 35.--The influence of preplanting treatments and sampling time on root growth (g/bulb) for 'Explorer' daffodil, 1973.

Preplanting Treatment	Time (Weeks)[x]					Preplanting Treatment Means
	1	2	3	4	5	
Control	0.06a e	0.84a e	3.24b e	5.07c e	6.75d e	3.19
Fungicidal Dip	0.13a e	1.06a e	3.03b e	5.86c e	8.51d f	3.72
Week Means	0.10	0.95	3.14	5.47	7.63	

[x]Means in rows followed by the same letter (a to d) and means in columns followed by the same letter (e to f) are not significantly different at the 5% level.

Table 36.--The influence of temperature and sampling time treatments on root growth (g/bulb) for 'Explorer' daffodil, 1974.

Time (Weeks)	Temperature (°C)[x] 5	9	13	17	21	Week Means
1	0.00a f	0.00a f	0.09a f	0.74a f	0.49a f	0.26
2	0.15a f	0.58a fg	2.41a f	6.31b g	0.15a f	1.92
3	0.84a f	2.87a g	8.18b g	20.24c h	2.66a f	6.96
4	2.18a fg	10.32b h	14.65c h	28.27d i	1.66a f	11.42
5	3.72b g	15.61c i	23.17d i	37.92e j	0.00a f	16.08
Temperature Means	1.38	5.88	9.70	18.70	0.99	

[x]Means in rows followed by the same letter (a to e) and means in columns followed by the same letter (f to j) are not significantly different at the 5% level.

Table 37.--The influence of preplanting treatments and temperature on root growth (g/bulb) 'Explorer' daffodil, 1974.

Preplanting Treatment	Temperature (°C)[x]					Preplanting Treatment Means
	5	9	13	17	21	
Control	1.60a e	5.43b e	7.63c e	18.14d e	1.57a e	6.87
Water Dip	1.51a e	4.87b e	10.30c f	18.68d e	0.64a e	7.20
Fungicidal Dip	1.01a e	7.33b f	11.17c f	19.27d e	0.76a e	7.91
Temperature Means	1.40	5.88	9.70	18.70	0.99	

[x]Means in rows followed by the same letter (a to d) and means in columns followed by the same letter (e to f) are not significantly different at the 5% level.

V. DISCUSSION

Van der Boon (1975) has demonstrated that tulip roots had to be at least 50 mm in length before nitrogen uptake could occur. Also, studies conducted here in indicated that when using a 15 cm diameter pot, 70 mm of root growth reached the bottom of the pot and subsequent growth occurred around the periphery of the soil ball leading to bound roots. Taking these facts into consideration, the results of this study are discussed based on the assumption that 70 mm of root growth is considered adequate for greenhouse forcing of tulips, hyacinths, and daffodils.

The optimal temperature range for root development of tulip and daffodil bulbs was found to be 13 and 17°C (Fig. 1 and 2). The same rooting results were obtained in 1973 and 1974; thus indicating a consistent response for two growing seasons. The tulip developed a minimum of 70 mm of roots in 21 days in both years; whereas, the daffodil required 35 days in 1973 and only twenty days in 1974 which is due to bulb variability from year to year. The number of bulbs rooted per pot was also 100% or slightly less at these optimal temperatures and time

Figure 1. Effects of preplanting treatments, temperature, and sampling time on root development of 'Paul Richter' tulips, 1974.

A. Fresh root weight (g/bulb) of the non-dipped bulbs (control).

B. Fresh root weight (g/bulb) of the 30 minute preplanting water dipping bulbs.

C. Fresh root weight (g/bulb) of the 30 minute preplanting benomyl-ethazol dipped bulbs.

D. Root length (mm/bulb) of the non-dipped bulbs (control).

E. Root length (mm/bulb) of the 30 minute preplanting water dipped bulbs.

F. Root length (mm/bulb) of the 30 minute preplanting benomyl-ethazol dipped bulbs.

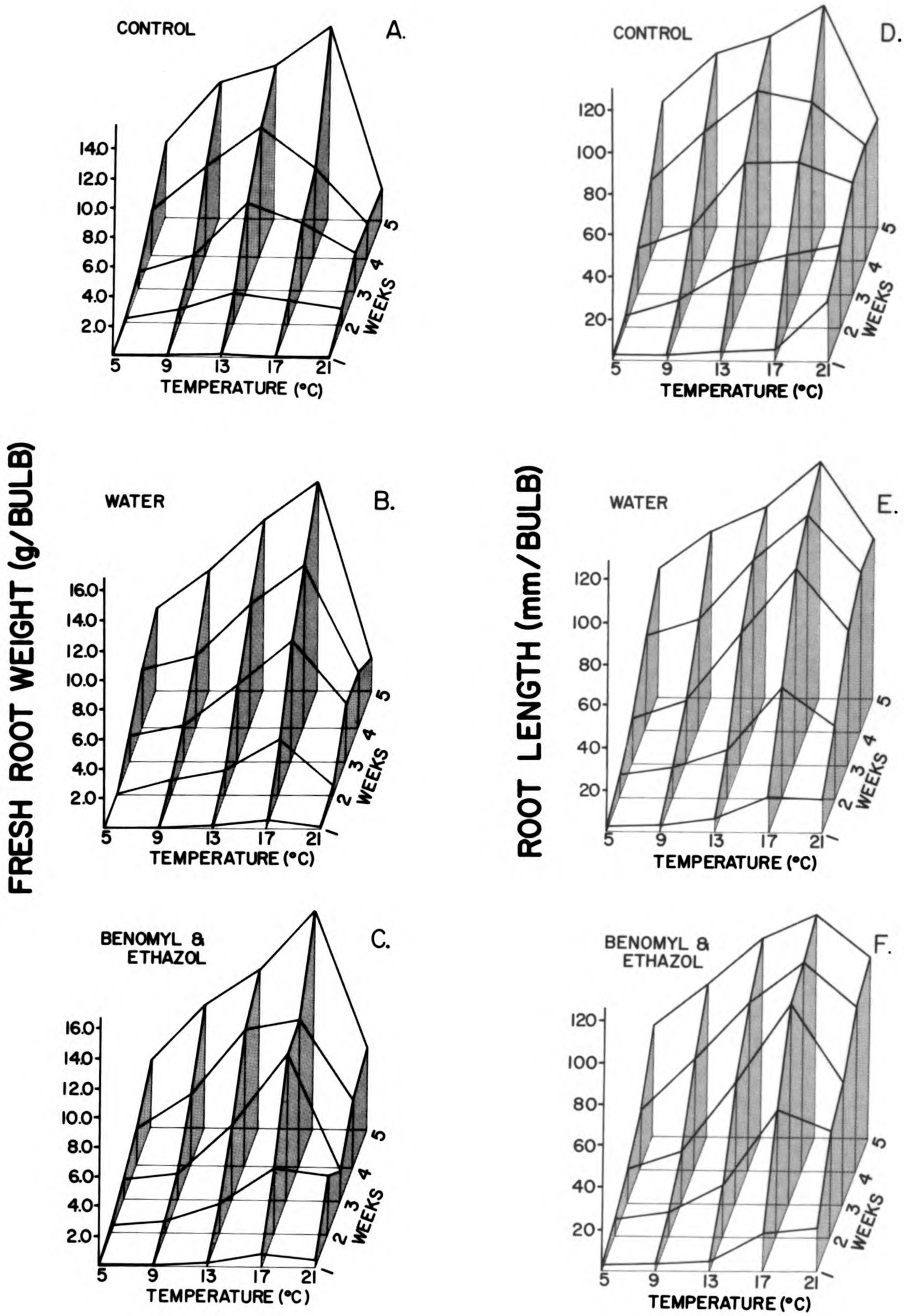

CONTROL
A.
FRESH ROOT WEIGHT (g/BULB)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
5
9
13
17
21
TEMPERATURE (°C)
1
2
3
4
5
WEEKS
WATER
B.
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
BENOMYL &
ETHAZOL
C.
CONTROL
D.
ROOT LENGTH (mm/BULB)
120
100
80
60
40
20
WATER
E.
BENOMYL &
ETHAZOL
F.

Figure 2. Effects of preplanting treatments, temperature, and sampling time on root development of 'Explorer' daffodils, 1974.

A. Fresh root weight (g/bulb) of the non-dipped bulbs (control).

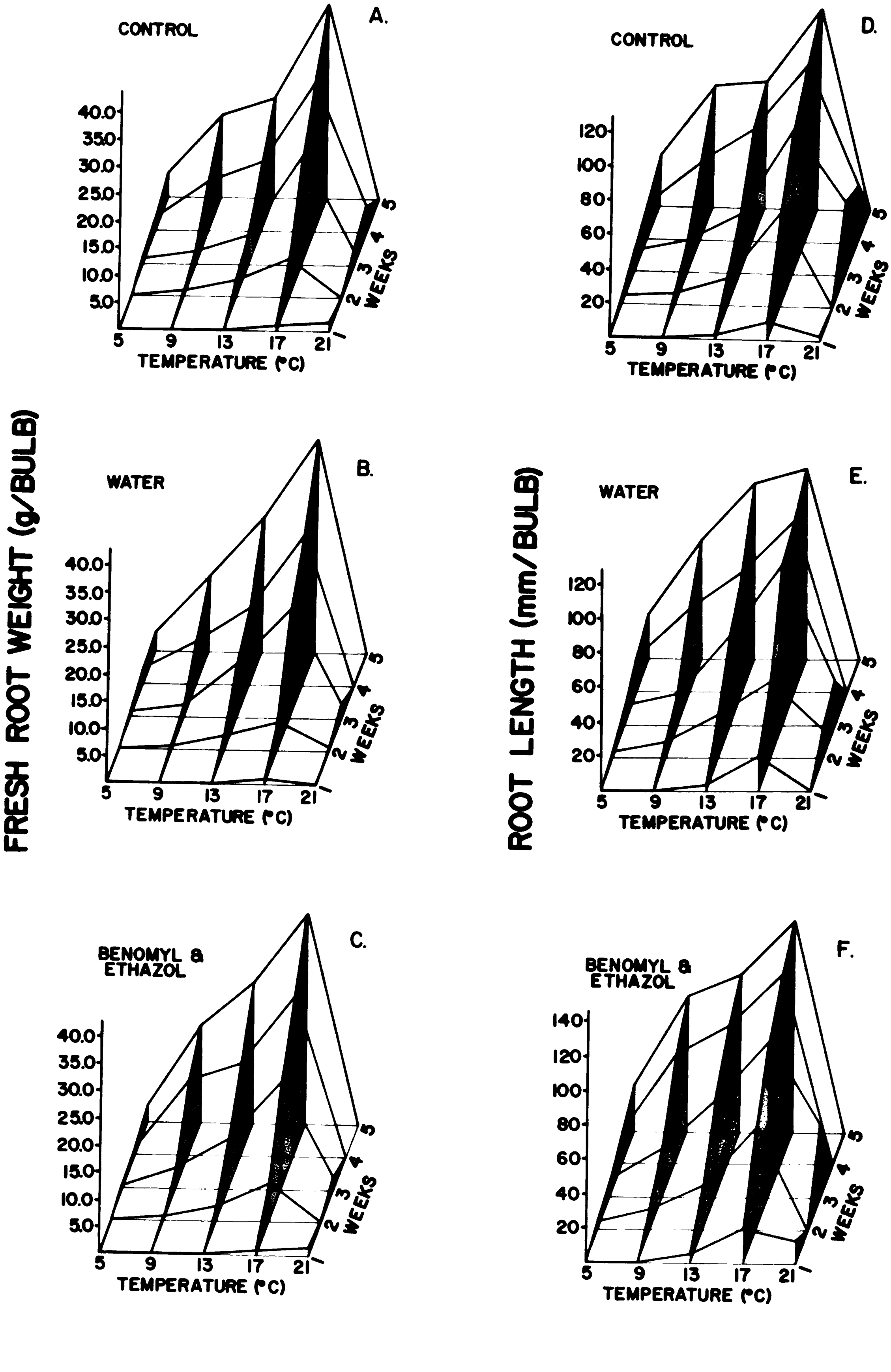
B. Fresh root weight (g/bulb) of the 30 minute preplanting water dipped bulbs.

C. Fresh root weight (g/bulb) of the 30 minute preplanting benomyl-ethazol dipped bulbs.

D. Root length (mm/bulb) of the non-dipped bulbs (control).

E. Root length (mm/bulb) of the 30 minute preplanting water dipped bulbs.

F. Root length (mm/bulb) of the 30 minute preplanting benomyl-ethazol dipped bulbs.


CONTROL
A.
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
5 9 13 17 21
TEMPERATURE (°C)
1 2 3 4 5
WEEKS
CONTROL
D.
120
100
80
60
40
20
5 9 13 17 21
TEMPERATURE (°C)
1 2 3 4 5
WEEKS
FRESH ROOT WEIGHT (g/BULB)
WATER
B.
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
5 9 13 17 21
TEMPERATURE (°C)
1 2 3 4 5
WEEKS
ROOT LENGTH (mm/BULB)
WATER
E.
120
100
80
60
40
20
5 9 13 17 21
TEMPERATURE (°C)
1 2 3 4 5
WEEKS
BENOMYL &
ETHAZOL
C.
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
5 9 13 17 21
TEMPERATURE (°C)
1 2 3 4 5
WEEKS
BENOMYL &
ETHAZOL
F.
140
120
100
80
60
40
20
5 9 13 17 21
TEMPERATURE (°C)
1 2 3 4 5
WEEKS

periods. For the hyacinth, however, a higher optimal temperature range of 17 to 25°C was required for rooting (Fig. 3). In 1973, the hyacinth bulbs rooted at the optimal temperature range produced 70 mm of roots within 14 days and in 1974 within 10 days. Also, 100% rooting of the bulbs per pot occurred in this temperature range within the 10 or 14 day period. The optimal temperatures for root growth found in these experiments were higher than those reported by Versluys (1927) for 'Queen of the Blues' hyacinth.

The optimal temperatures for root growth are similar to those for floral development for the respective bulb species. Luyten et al. (1925) found that 'Pride of Haarlem' tulip placed at 17°C for two weeks or 13°C for four weeks had optimal floral development. Huisman and Hartsema (1933) showed that the optimal temperature for 'King Alfred' daffodil for flower formation started at 20°C, but gradually dropped to 13°C. Hartsema (1961) reported that the optimal growth curve for both floral development and root development of the hyacinth is situated 4-5°C higher than the tulip. Luyten et al. (1932) found that 'L'Innocence' hyacinth formed flowers best when given a few days at 34°C and then seven weeks at 25.5°C. The optimal temperature for root development of the hyacinth, based on the studies conducted, appears to be 4-8°C higher than that of the tulip or daffodil.

Figure 3. Effects of preplanting treatments, temperature, and sampling time on root development of 'Pink Pearl' hyacinths, 1974.

A. Fresh root weight (g/bulb) of the non-dipped bulbs (control).

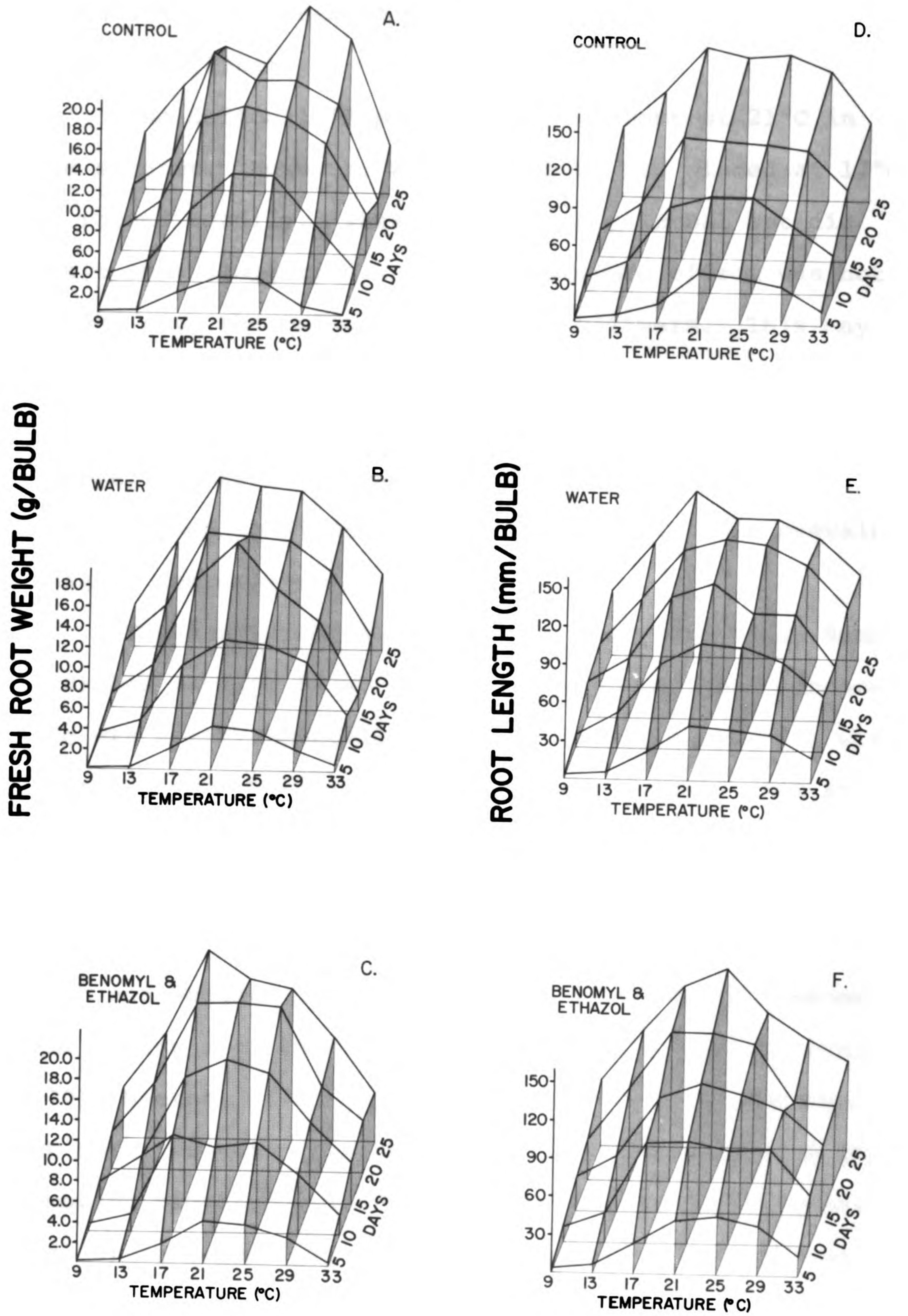
B. Fresh root weight (g/bulb) of the 30 minute preplanting water dipped bulbs.

C. Fresh root weight (g/bulb) of the 30 minute preplanting benomyl-ethazol dipped bulbs.

D. Root length (mm/bulb) of the non-dipped bulbs (control).

E. Root length (mm/bulb) of the 30 minute preplanting water dipped bulbs.

F. Root length (mm/bulb) of the 30 minute preplanting benomyl-ethazol dipped bulbs.

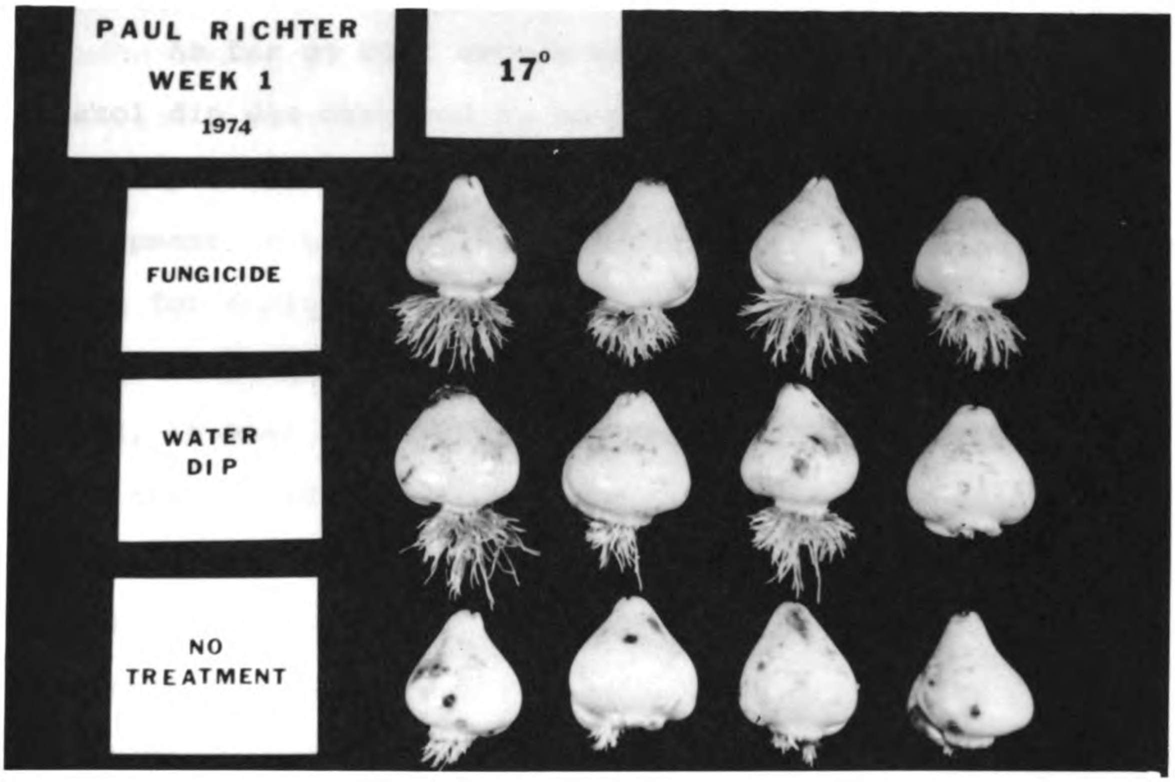

A.
CONTROL
B.
WATER
C.
BENOMYL & ETHAZOL
D.
CONTROL
E.
WATER
F.
BENOMYL & ETHAZOL
FRESH ROOT WEIGHT (g/BULB)
ROOT LENGTH (mm/BULB)
TEMPERATURE (°C)
DAYS
9 13 17 21 25 29 33
5 10 15 20 25
2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0
30 60 90 120 150

And, this is in agreement with the earlier investigations of Hartsema (1961).

The daffodil 'Explorer' did not root at 21°C in these studies. However, when replanted and placed at 17°C they rooted readily. Thus, 21°C was not lethal but did inhibit root elongation. This temperature effect was not observed with the tulip or hyacinth cultivars. This may also be a possible mechanism for the daffodil to be protected when grown out of doors. When temperatures are 21°C or above, the daffodil will not root and thus its roots will not be exposed to diseases which are usually more prevalent at higher temperatures.

The fungicidal pretreatments were used since Raabe (1970) had earlier found that as disease control increased there was a corresponding increase in root production with Easter lilies. With the tulip, it was observed that at 21°C the benomyl-ethazol preplanting dip promoted rooting of many of the bulbs. Subsequently, in the 1974 study a water dip was added to determine if the increase in root length and weight was possibly due to a hydration phenomenon or if it was a cytokinin-like effect as reported by Schuft (1970), Becker (1971) and Thomas (1973a,b). It was found that both the water and fungicidal dip were effective in promoting rooting of tulips. A closer look at the bulbs (Fig. 4) revealed that the fungicidal dip increased the uniformity of rooting during the first week. This could be useful when forcing special precooling tulips. For this

Figure 4. A comparison of the root development after one week of the preplanting treatments and the control of 'Paul Richter' tulips at 17°C, 1974.


PAUL RICHTER
WEEK 1
1974
17°
FUNGICIDE
WATER
DIP
NO
TREATMENT

particular type of forcing, tulip bulbs receive a dry cold treatment and subsequently when planted in the greenhouse they must undergo root and shoot elongation at the same time. As root development is very crucial to precooled forcing, use of the fungicidal dip to promote rooting and combat disease would be very beneficial.

As far as root growth was concerned, the benomyl-ethazol dip was observed to have the greatest effect on the tulip. However, it did slightly stimulate root development in the hyacinth and daffodil. The principle reason for employing a fungicide is to prevent disease. As these experiments were only conducted for a five week period, it must be kept in mind that in order to force bulbs they would have to receive a minimum of 14 cold weeks to satisfy the subsequent low temperature requirement for floral stalk elongation. With the extensive period of time that is needed to fully program the bulbs, the systemic fungicidal dip is bound to be effective for disease protection and thus result in overall higher quality plants. Further experimentation should be conducted on root development in regards to the long term effects of the fungicidal and water dips. The water dip was as effective as the fungicidal treatment for root promotion in daffodil and hyacinth bulbs, but after 15 weeks at the low temperature required for forcing the shoot would the water dip be as effective in disease control?

The results of this study are applicable in two areas of future research. First, it is possible that programs could be developed for tulips, hyacinths, and daffodils for very late forcing. The current forcing sequences use a 15 to 23 week period beginning with 9°C for rooting followed by 2-5°C for cooling and shoot retardation, depending on the desired date for flowering. If a bulb receives more than 18-20 weeks of cold, it becomes over-cooled and as a result stretching occurs which results in a low quality pot plant. Therefore, 9 and 5°C should be considered cooling temperatures. If the bulbs were initially rooted for four weeks at 17°C, a noncooling temperature, and then given a cold treatment of 18 weeks, a total of 22 weeks would be involved but only 18 weeks as cold exposure. A marketable pot plant for late spring sales could be produced using this method. Continued research is needed in this area to better formulate new schemes for late forcing taking advantage of optimal non-cooling rooting temperatures.

Secondly, since it is possible to root the bulbs at noncooling temperatures the cold requirement needed for scape elongation and bulbing could be studied apart from root development. Scape elongation and bulbing are under hormonal regulation. The gibberellins are a controlling class of hormones in the tulip (Aung and De Hertogh, 1971). They observed that rooted tulips contained more total GA's than did unrooted bulbs and also, that tulips rooted at

9°C (a cooling temperature) contained more GA's than did bulbs rooted at 17°C (a noncooling temperature). Further physiological studies should be undertaken to understand scape elongation and bulbing using 17°C as the rooting temperature because less hormones are produced.

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APPENDIX

TABLES

Table A-1.--Analysis of variance. Effects of temperature and fungicide over time on number of bulbs rooted per pot, root length, and fresh root weight. 'Paul Richter' Tulip, 1973.

Measurement	Analysis of Variance			
	Source	48	MS	F
No. Rooted				
	Total	149		
	Temp (T)	4	46.58	x
	Time-Weeks (W)	4	54.07	81.10***y
	T x W	16	3.11	4.66***
	Fungicide (F)	1	28.17	42.25***
	T x F	4	1.11	1.68
	W x F	4	11.57	17.35***
	T x W x F	16	2.23	3.38***
	Error	100	0.67	
Root Length				
	Total	149		
	Temp (T)	4	11188.28	-
	Time (W)	4	31059.79	193.30***
	T x W	16	1755.98	10.93***
	Fungicide (F)	1	1541.77	9.59***
	T x F	4	687.15	4.28***
	W x F	4	331.40	2.06*
	T x W x F	16	227.99	1.42
	Error	100	160.69	
Root Weight				
	Total	149		
	Temp (T)	4	128.25	-
	Time (W)	4	294.06	208.02***
	T x W	16	19.11	13.52***
	Fungicide (F)	1	0.15	0.11
	T x F	4	0.88	0.62
	W x F	4	5.03	3.55***
	T x W x F	16	1.42	1.00
	Error	100	1.41	

[x]The main effect, temperature, cannot be tested as it was not replicated.

[y] *Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

Table A-2.--Analysis of variance. Effects of temperature and fungicide over time on number of bulbs rooted per pot, root length, and fresh root weight. 'Paul Richter' Tulip, 1974.

Measurement	Analysis of Variance			
	Source	df	MS	F
No. Rooted				
	Total	224		
	Temp (T)	4	45.37	-[x]
	Time-Weeks (W)	4	30.29	40.33***[y]
	T x W	16	2.38	3.17***
	Fungicide (F)	2	3.20	4.27**
	T x F	8	1.17	1.56
	W x F	8	0.79	1.06
	T x W x F	32	0.73	0.97
	Error	150	0.75	
Root Length				
	Total	224		
	Temp (T)	4	1356.73	-
	Time (W)	4	38636.45	746.44***
	T x W	16	993.37	19.19***
	Fungicide (F)	2	612.87	11.84***
	T x F	8	535.70	10.35***
	W x F	8	83.56	1.61*
	T x W x F	32	118.41	2.29***
	Error	150	51.76	
Root Weight				
	Total	224		
	Temp (T)	4	189.48	-
	Time (W)	4	461.67	352.60***
	T x W	16	28.58	21.83***
	Fungicide (F)	2	11.41	8.71***
	T x F	8	9.60	7.33***
	W x F	8	1.29	0.99
	T x W x F	32	1.96	1.49*
	Error	150	1.31	

[x]The main effect, temperature cannot be tested as it was not replicated.

[y] *Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

Table A-3.--Analysis of variance. Effects of temperature and fungicide over time on number of bulbs rooted per pot, root length, and fresh root weight. 'Pink Pearl' Hyacinth, 1973.

Measurement	Analysis of Variance			
	Source	df	MS	F
No. Rooted				
	Total	209		
	Temp (T)	6	0.10	-[x]
	Time-Weeks (W)	4	0.04	1.50[y]
	T x W	24	0.04	1.31
	Fungicide (F)	1	0.17	6.00**
	T x F	6	0.12	4.44***
	W x F	4	0.03	1.00
	T x W x F	24	0.04	1.39
	Error	140	0.03	
Root Length				
	Total	209		
	Temp (T)	6	6727.24	-
	Time (W)	4	26749.48	198.25***
	T x W	24	1028.97	7.63***
	Fungicide (F)	1	8115.86	60.15***
	T x F	6	649.88	4.82***
	W x F	4	277.86	2.06*
	T x W x F	24	97.07	0.72
	Error	140	134.93	
Root Weight				
	Total	209		
	Temp (T)	6	316.58	-
	Time (W)	4	1293.11	259.38***
	T x W	24	33.11	6.64***
	Fungicide (F)	1	180.98	36.30
	T x F	6	6.70	1.34
	W x F	4	33.16	6.65***
	T x W x F	24	3.96	0.79
	Error	140	4.99	

[x]The main effect, temperature cannot be tested as it was not replicated.

[y] *Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

Table A-4.--Analysis of variance. Effects of temperature and fungicide over time on number of bulbs rooted per pot, root length, and fresh root weight. 'Pink Pearl' Hyacinth, 1974.

Measurement	Analysis of Variance			
	Source	df	MS	F
No. Rooted				
	Total	314		
	Temp (T)	6	0.14	-[x]
	Time-Days (D)	4	0.08	2.21*[y]
	T x D	24	0.02	0.65
	Fungicide (F)	2	0.07	1.75
	T x F	12	0.02	0.39
	D x F	8	0.05	1.33
	T x D x F	48	0.02	0.58
	Error	210	0.04	
Root Length				
	Total	314		
	Temp (T)	6	28517.26	-
	Time-Days (D)	4	47431.08	1198.23***
	T x D	24	827.28	20.90***
	Fungicide (F)	2	496.97	12.55***
	T x F	12	97.92	2.47***
	D x F	8	94.68	2.39**
	T x D x F	48	126.63	3.19***
	Error	210	39.58	
Root Weight				
	Total	314		
	Temp (T)	6	730.13	-
	Time-Days (D)	4	935.56	374.70***
	T x D	24	27.35	10.95***
	Fungicide (F)	2	0.41	0.16
	T x F	12	5.03	2.02**
	D x F	8	3.85	1.54
	T x D x F	48	3.55	1.42**
	Error	210	2.50	

[x]The main effect, temperature cannot be tested as it was not replicated.

[y] *Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

Table A-5.--Analysis of variance. Effects of temperature and fungicide over time on number of bulbs rooted per pot, root length, and fresh root weight. 'Explorer' Daffodil, 1973.

Measurement	Analysis of Variance			
	Source	df	MS	F
No. Rooted				
	Total	149		
	Temp (T)	4	7.81	-[x]
	Time-Weeks (W)	4	1.51	3.24**[y]
	T x W	16	1.03	2.20***
	Fungicide (F)	1	0.01	0.01
	T x F	4	1.06	2.26*
	W x F	4	0.42	0.91
	T x W x F	16	0.39	0.84
	Error	100	0.47	
Root Length				
	Total	149		
	Temp (T)	4	8625.69	-
	Time (W)	4	7666.41	142.92***
	T x W	16	990.14	18.46***
	Fungicide (F)	1	200.91	3.75*
	T x F	4	1318.74	24.59***
	W x F	4	132.47	2.47**
	T x W x F	16	162.94	3.04***
	Error	100	53.64	
Root Weight				
	Total	149		
	Temp (T)	4	157.85	-
	Time (W)	4	293.62	137.49***
	T x W	16	24.44	11.44***
	Fungicide (F)	1	10.32	4.83*
	T x F	4	36.90	17.27***
	W x F	4	4.53	2.12*
	T x W x F	16	9.10	4.26***
	Error	100	2.14	

[x]The main effect, temperature cannot be tested as it was not replicated.

[y] *Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

Table A-6.--Analysis of variance. Effects of temperature and fungicide over time on number of bulbs rooted per pot, root length, and fresh root weight. 'Explorer' Daffodil, 1974.

Measurement	Analyais of Variance			
	Source	df	MS	F
No. Rooted				
	Total	224		
	Temp (T)	4	53.36	-[x]
	Time-Weeks (W)	4	19.73	185.00***[y]
	T x W	16	4.09	38.33***
	Fungicide (F)	2	0.58	0.54
	T x F	8	0.15	1.42
	W x F	8	0.18	1.69*
	T x W x F	32	0.18	1.66**
	Error	150	0.11	
Root Length				
	Total	224		
	Temp (T)	4	32696.17	-
	Time (W)	4	24367.29	163.31***
	T x W	16	3259.84	21.85***
	Fungicide (F)	2	459.43	3.07**
	T x F	8	295.01	1.98**
	W x F	8	60.69	0.41
	T x W x F	32	141.57	0.95
	Error	150	149.21	
Root Weight				
	Total	224		
	Temp (T)	4	2390.86	-
	Time (W)	4	1942.40	435.87***
	T x W	16	354.94	79.65***
	Fungicide (F)	2	20.93	4.70*
	T x F	8	16.27	3.65***
	W x F	8	5.14	1.16
	T x W x F	32	4.43	0.99
	Error	150	4.46	

[x]The main effect, temperature cannot be tested as it was not replicated.

[y] *Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

Table A-7.--Analysis of variance. Effects of temperature and fungicide over time on shoot development. 'Paul Richter' Tulip, 1973.

Source	df	No. Shoots	Shoots (mm)	Scape & Flower (mm)	Scape (mm)	Flower (mm)
Temp (T)	4	0.09	424.42	88.70	43.17	12.15[x]
Fungicide (F)	1	0.67*	35.14*	17.07***	2.33	6.78**[y]
T x F	4	0.03	17.45	4.27*	1.50	2.11*
Time (W)	4	0.18	1147.96***	296.51***	83.81***	84.96***
T x W	16	0.13	63.63***	35.00***	10.30***	16.35***
F x W	4	0.15	4.21	10.34***	1.88*	3.63**
T x F x W	16	0.14	14.84**	1.80	0.79	0.89
Error	100	0.12	6.78	1.41	0.76	0.82

[x] The main effect, temperature, cannot be tested as it was not replicated.

[y] F - Test
* Significant at the 5% level.
** Significant at the 1% level.
*** Significant at the 0.1% level.

Table A-8.--Analysis of variance. Effects of temperature and fungicide over time on shoot development. 'Paul Richter' Tulip, 1974.

Source	df	No. Shoots	Shoots (mm)	Scape & Flower (mm)	Scape (mm)	Flower (mm)
Temp (T)	4	12.97	903.20	386.51	142.73	60.43[x]
Fungicide (F)	2	4.09***	156.32***	93.18***	17.74***	29.60***[y]
T x F	8	2.87***	154.54***	67.19***	16.47	18.71***
Time (W)	4	5.22***	1005.58***	410.80***	158.49***	78.34***
T x W	16	4.76***	573.32***	227.22***	64.99***	52.42***
F x W	8	1.62***	125.58***	54.19***	19.58***	9.90****
T x F x W	32	1.88***	134.41***	60.29***	13.78***	17.73***
Error	150	0.12	3.85	1.51	0.71	1.35

[x]The main effect, temperature, cannot be tested as it was not replicated.

[y]F - Test
* Significant at the 5% level.
** Significant at the 1% level.
*** Significant at the 0.1% level.

Table A-9.--Analysis of variance. Effects of temperature and fungicide over time on shoot development. 'Pink Pearl' Hyacinth, 1973.

Source	df	No. Shoots	Shoot (mm)	Flower (mm)
Temp (T)	6	0.04	144.91	163.97*
Fungicide (F)	1	0.02	1.77	10.39***
T x F	6	0.09	5.53	4.64
Time (W)	4	0.14	663.90***	743.37***
T x W	24	0.18	25.22***	26.96***
F x W	4	0.13	4.20	2.66
T x F x W	24	0.14	3.97	3.41
Error	140	0.14	3.43	2.34

[x]The main effect, temperature, cannot be teated as it was not replicated.

[y]F - Test * Significant at the 5% level.
** Significant at the 1% level.
*** Significant at the 0.1% level.

Table A-10.--Analysis of variance. Effects of temperature and fungicide over time on shoot development. 'Pink Pearl' Hyacinth, 1974.

Source	df	No. Shoots	Shoot (mm)	Flower (mm)
Temp (T)	6	0.07	171.23	128.97*
Fungicide (F)	2	0.08	2.14	3.74*
T x F	12	0.05	5.10	6.60
Time (W)	4	0.02	444.76***	86.45***
T x W	24	0.05	15.34***	14.66**
F x W	8	0.04	2.85	1.09
T x F x W	48	0.06	2.00	1.86
Error	210	0.05	2.87	7.00

[x]The main effect, temperature, cannot be tested as it was not replicated.

[y]F - Test * Significant at the 5% level.
** Significant at the 1% level.
*** Significant at the 0.1% level.

Table A-11.--Analysis of variance. Effects of temperature and fungicide over time on shoot development. 'Explorer' Daffodil, 1973.

Source	df	No. Shoots	Shoots (mm)	Scape & Flower (mm)	Scape (mm)	Flower (mm)
Temp (T)	4	0.84	433.75	100.52	44.78	18.32*
Fungicide (F)	1	0.17	381.13***	7.17	4.13	0.92*
T x F	4	0.27	134.75**	20.63	2.52	9.86
Time (W)	4	0.86*	2149.87***	287.74***	8.06*	336.11***
T x W	16	0.64**	56.15	21.05*	12.25***	8.35
F x W	4	0.48	115.00**	4.91	2.75	1.33
T x F x W	16	0.10	41.93	8.45	1.29	5.19
Error	100	0.28	34.49	11.50	2.89	6.86

[x]The main effect, temperature, cannot be tested as it was not replicated.

[y]F - Test * Significant at the 5% level.
** Significant at the 1% level.
***Significant at the 0.1% level.

Table A-12.--Analysis of variance. Effects of temperature and fungicide over time on shoot development. 'Explorer' Daffodil, 1974.

Source	df	No. Shoots	Shoots (mm)	Scape & Flower (mm)	Scape (mm)	Flower (mm)
Temp (T)	4	0.10	779.06	167.43	109.29	12.18*
Fungicide (F)	2	0.07	9.84	1.86	0.31	1.04*
T x F	8	0.18	13.15**	6.29**	1.73	2.36
Time (W)	4	0.10	1341.64***	444.38***	213.06***	55.00***
T x W	16	0.22	90.96***	25.93***	9.87***	6.67***
F x W	8	0.13	8.96*	3.63	1.82	1.14
T x F x W	32	0.14	4.04	1.83	1.50	1.66
Error	150	0.16	4.24	2.42	1.43	1.92

[x] The main effect, temperature, cannot be tested as it was not replicated.

[y] F - Test
* Significant at the 5% level.
** Significant at the 1% level.
*** Significant at the 0.1% level.