INFLUENCE OF GREENHOUSE ENVIRONMENTAL FACTORS ON THE FORCING OF DAHLIA VARIABILIS WILLD.

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ABSTRACT

INFLUENCE OF GREENHOUSE ENVIRONMENTAL FACTORS ON THE FORCING OF *DAHLIA VARIABILIS* WILLD.

By

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Dutch-grown tuberous-roots of 'Park Princess' and 'Kolchelsee' were forced under various greenhouse conditions during February, March, and April of 1975 and 1976. The basic factors investigated were (a) fertilization, (b) temperature, (c) light intensity, (d) photoperiod, and (e) hydrogel. In all experiments, ancymidol was applied for height control two weeks after the respective planting dates at the rate of 0.5 mg per 15 cm pot. Except for the fertilization experiments, Osmocote (14-14-14) was either incorporated at a rate of 169 g per cubic foot or top dressed at a rate of 9 g per pot. Unless the objective was to evaluate the individual factor, full sunlight, natural daylength, and a minimum night temperature of 17°C were used.

The statistical parameters were days to flower, flower diameter, flower longevity, plant height, the number of flowers and buds per plant, and the number of shoots per plant.

Applications of various formulations of Osmocote or 20-20-20 as a soluble fertilizer produced high quality plants which flowered in approximately 70 days. This was an average of 20 days earlier than non-fertilized plants. More importantly, the number of plants flowering was increased. Without fertilization, many plants either failed to flower or produced only a few abnormal flowers. Over the two year period, with 'Kolchelsee', the number of plants flowering was increased from 25% to 100% and with 'Park Princess' the increase was from 85% to 100%.

The earliest flowering (59 days) was obtained with a day/night temperature of 29/22°C. As day/night temperatures were lowered to 29/17 and 27/12°C, the days to flower increased to 63 and 90 days, respectively. Plants grown at 27/16°C averaged 78 and 86 days to flower for 'Kolchelsee' and 'Park Princess', respectively. The best height control was obtained at 27/16°C with heights of 34 and 30 cm for 'Kolchelsee' and 'Park Princess', respectively. Plants at 29/17°C were approximately 4 cm taller and at 27/12°C plants were 9 cm taller. At 29/22°C they were stunted and chlorotic, and averaged 27 cm. It was concluded that dahlias responded to both day and night temperatures. The optimum day/night temperature combination appeared to be 27/16°C.

When light intensity was reduced by 50%, the plants were 11 cm taller than those receiving either 100 or 75% light levels. All other parameters were not significantly affected. Apparently when dahlias are forced in a greenhouse they require very high light intensities.

Plants given an eight hour photoperiod were 17 days earlier in flowering than all other treatments, but only 40% of the plants flowered. At anthesis, the flowers which did develop were abnormal. They had 'open-eye' centers. Under natural photoperiods flowering averaged 69 days. Long day treatments of either the 16 hour photoperiod or the 4 hour night break caused a delay of 6 days. Plant heights were satisfactory for all treatments except under the eight hour photoperiod. 'Kolchelsee' averaged 26 and 33 cm and 'Park Princess' averaged 29 and 30 cm in 1975 and 1976, respectively. Other parameters were not consistently affected by the treatments. Therefore, dahlias should never be forced under an 8 hour photoperiod. Forcing under an increasing natural daylength of 10 to 14 hours provided the best results.

Hydrogel did not influence flowering or developmental rates and all plants were of satisfactory quality.

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INTRODUCTION

Dahlias (*Dahlia variabilis* Willd.) grown from tuberous-roots are popular with amateur flower growers and home gardeners (James, 1963). The use of dahlias could be increased by marketing them as flowering plants at Easter and Mother's Day. Initially, the plants would be used as house plants and later they could be transplanted into outdoor flower beds, or large containers where they would continue flowering until the first killing frost.

The production of greenhouse crops is based on controlling the major environmental factors which influence plant growth and development. Light is an important factor because of its influence on plant growth and development and because it is required for photosynthesis. The effects of light intensity and duration (photoperiod) vary with the species and many times even the cultivar. Maximum, minimum, and optimum levels have been established for many crops (Einert and Box, 1967, Smith and Langhans, 1962b).

Temperature affects plant quality and flower development of many plant species (Smith and Langhans, 1962a, Roh and Wilkins, 1973). Since night temperature generally affects growth more than day temperature, minimum night temperatures have been established for many greenhouse crops (Cathey, 1954, Langhans and Larson, 1960).

Because the production of plants in pots restricts root development to a finite soil volume, fertilization requirements for a crop are also quite specific (Ball, 1972, Gortzig, 1974).

Forcing schedules must integrate these factors so that the crop will flower uniformly within a pre-determined number of days and at a specific plant height. The number of flowers per plant and flower life and diameter also must fall within desired ranges.

Chemical growth retardants have been utilized to reduce the height of many crops, including _Chrysanthemum_, _Lilium_, and _Euphorbia_ (Gortzig, 1974). Ancymidol has been effective on a wide range of crops (Einert, 1971, Larson and Kimmins, 1972, Cathey and Heggestad, 1973) and its effects on tuberous-rooted dahlias have been demonstrated (De Hertogh, Blakely, and Szlachetka, 1976). With appropriate application procedures, heights of 30-40 cm have been achieved with selected cultivars. Thus, the potential for forcing dahlias as potted plants has been established.

The objective of this study was to determine the effects of fertilization, greenhouse temperature, photoperiod, and light intensity on the forcing of two tuberous-rooted cultivars, and to integrate them into a basic greenhouse program for forcing pot dahlias.

REVIEW OF LITERATURE

Introduction

Several studies have been conducted on the effects of environmental factors on the growth of dahlias. The objectives of the studies varied widely and the cultivars were always different. They were primarily designed to evaluate tuberization effects, cut flower production, or outdoor growing conditions. Responses of the different cultivars indicated that this was a major source of variability. In addition, the plant materials used included seedlings, stem cuttings, and tuberous-rooted plants.

The effects of photoperiod treatments were first reported (Garner and Allard, 1923, Zimmerman and Hitchcock, 1929) on the tuberization process. Effects on flowering were reported later (Maatsch and Rünger, 1954, Yasuda and Yokoyama, 1960). Most experiments included a natural daylength treatment. Since the research had been conducted in Germany, the Netherlands, England, Japan, and the United States, seasonal conditions of temperature, daylength, and light intensity varied greatly. Planting and harvesting dates were likewise different.

There are few reports available on the effects of other environmental factors on the growth of dahlias. The effect of light intensity was determined on stock plants used for cutting production but not on forced flowering plants (Biran and Halevy, 1973a). Experiments to determine the response to different temperatures during the forcing period have not been conducted. Fertilization requirements have never been evaluated in a forcing program.

The basic responses of dahlias as well as some analogous bulbous plants to environmental factors are the subjects of this review of literature. For clarity, the botanical history, production cycle, and a summary of the development stages of the dahlia are also included.

Botanical History

Dahlias are native to the high plateau regions of Mexico and Guatemala (James, 1963). They are half-hardy, herbaceous, tuberous-rooted perennials. The genus *Dahlia*, named for Andreas Dahl, is a member of the Compositae family, forming both disc and ray florets. Leaves are opposite.

As early as 1580, Hernandez described cultivated dahlias in Mexico using the Aztec names of Acocotli, Cocoxochitl, and Acocoxochitl which referred to the hollow stem characteristic. He described several different forms of dahlias having variations in petal color and plant heights.

In 1789, seeds from Mexico were introduced to Spain and in 1798 subsequently to England. Because of the Mexican origin, dahlias were assumed to be subtropical, but they did not respond accordingly. By 1804, D. coccinea, D. crocea, D. purpurea, and D. rosea were recognized as species and hybrid forms were listed in the Annual Dahlia Register in 1836. In 1872, the first cactus dahlia, later named Dahlia Juarezii was sent from Mexico to M. J. J. VanderBerg near Utrecht, the Netherlands (Baumgardt, 1970, James, 1963).

Dahlias are now produced in England, The Netherlands, and in several areas of The United States.

Production Cycle

To produce tuberous-rooted dahlias (Krabbendam, 1967) mother plants of each cultivar are planted in 15-20 cm deep benches in 15°C greenhouses in late January or February. As shoots develop from the base of the previous year's stem (crown), cuttings are removed when they are 7 to 10 cm long. It is essential that each cutting include a portion of the crown or otherwise the plant will not produce shoots in the second growing season. Cuttings are taken through early May. The cuttings are rooted in sand under greenhouse conditions and are subsequently placed in cold-frames until planting into the field in early June. Throughout the summer months, shoot growth occurs and tuberization is induced by the ensuing short days of fall. After the first frost, normally October, all shoot portions of the plants are cut off and the tuberous-roots are harvested. They are kept in high humidity, nonventilated storage rooms at 9-11°C. Prior to shipping, they are graded, washed, and packed in peat or some similar material.

Developmental Stages

Only one study (Krijthe, 1938) has been carried out on the formation and development of leaves and flowers of the dahlia roots during and after the storage period. She found that no flowers had been initiated in Mignon dahlia 'L'Innocence' by May 8, the date of planting of the tuberous-roots in the field. After two and a half weeks and the formation of seven pairs of leaves, flower initiation occurred. Flowering occurred some ten weeks after planting. Tuberous-roots planted in a greenhouse in early March and grown at 15-16°C started flower initiation after the formation of only five pairs of leaves. When the temperature was raised to 20°C on March 25, flowering also occurred about ten weeks after planting (about mid-May). Krijthe (1938) also observed that height at flowering was dependent upon the length of the internodes. The control of the length of the internodes is the important key in producing dahlias as pot plants.

Fertilization

Fertilization has been recommended for dahlias grown in the garden from tuberous-roots, cuttings, or seedlings. Baumgardt (1970) and Vance (1974) have proposed using liquid feed applications every two weeks or dry formulations of (2-10-6) or (8-20-12) at the rate of 453 g per 9.2 square meters.

Specific fertilizer recommendations for greenhouse forced dahlias have not been established. De Hertogh, Blakely, and Szlachetka (1976) used liquid applications of 30 ppm (20-20-20) every three weeks in their growth regulator trials. In evaluating the effects of growth regulators on tuberization, rooted cuttings of 'Nita' were fertilized weekly with a 12% solution of (20-8.6-16.6) NPK (Read, Dunham, Fieldhouse, 1972).

Some bulbous plants have variable fertilizer requirements during forcing. *Tulipa*, *Hyacinthus* and *Narcissus* are not normally fertilized during the forcing period (De Hertogh, 1973) but regular fertilization has been recommended for forcing *Lilium longiflorum* (Kiplinger and Langhans, 1967). Constant liquid feed applications at the rates of 150 ppm nitrogen throughout the greenhouse forcing period or weekly applications of 90 g per 38 liters of water of potassium nitrate alternated with calcium nitrate have been suggested (Kiplinger and Langhans, 1967). Osmocote (12-0-41) or (26-0-0) incorporated into the planting media at the rates of 97.6 or 131 g per cubic foot caused rapid emergence and earlier maturity in forced 'Ace' lilies although bud initiation and bud counts were only minimally affected (Hasek and Sciaroni, 1970).

Corms of Gladiolus 'Spotlight' pot-forced in sand from May to August flowered about five days earlier when treated with nitrogen at rates of 100 or 200 ppm nitrogen and phosphorus at 50 ppm, while plants not receiving nitrogen flowered later (Kosugi, 1960).

Temperature

Temperature is an important factor both in the storage of bulbous plant materials and during forcing (De Hertogh, 1973).

For dahlias, studies were conducted to determine the optimal temperatures for the over-wintering of the tuberous-roots for later use in the garden. Tuberous-roots of three dahlia cultivars were stored satisfactorily from November to May at temperatures of 1.7-10°C (Zimmerman and Hitchcock, 1932). Dahlias stored at 0°C were infected with soft rot while at 21-32°C, roots became desiccated and only 50% were viable when planted in the spring. Allen (1937) confirmed these findings with seven other cultivars. He found that the ideal temperature for a six month storage period was 4.5-7.0°C with a relative humidity of 80 to 85%. Peat moss with a moisture of 50% was an ideal packing material to prevent desiccation. Higher moisture content of the peat promoted disease development.

Temperature has a major influence in the forcing of both bulbous and non-bulbous plant material (Hartsema, 1961, De Hertogh, 1973). Its primary effect has been to accelerate or delay the flowering process but other growth parameters are also affected.

To date, there has not been a study on the effects of greenhouse temperatures on forced dahlias. In their experiments De Hertogh, Blakely, and Szlachetka (1976) used the day/night temperature sequence of 16-17/18-20°C for forcing several cultivars of tuberous-rooted dahlias from February or March to May. Under these conditions, 'Kolchelsee' and 'Park Princess' flowered in 81 and 71 days, respectively.

Flowering of dahlia seedlings (Botacchi, 1958) of 'Coltness' was reported in 141, 150, 149, 168, and 177 days at 10°C under photoperiods of 9, 13½, 14½, 10½-16, 17½, and 24 hours respectively, while at 15.5°C flowering under the same photoperiods was reported in 125, 120, 174, 134, and 155 days. Seedlings of 'Unwin' flowered in 138, 149, and 158 days at 10°C and 127, 135, and 135 days at 15.5°C under photoperiods of 13½, 14½, and 17½ hours, respectively. For both cultivars, plant heights at the 15.5°C treatment were increased approximately 6 cm. At 21.1°C, 'Unwin' flowered in 91 and 104 days with 9 and 14½ hour photoperiods while 'Coltness' averaged 80 and 101 days at the same temperature and photoperiods.

The effects of greenhouse temperatures on the days to flowering and plant height at flowering have been reported for a number of bulbous greenhouse crops.

Smith and Langhans (1962a) showed that both night and day temperatures affected the number of days from planting to flowering of precooled 'Croft' lily bulbs but concluded that night temperature had the greatest influence. Plants at 10.0, 15.6, 18.3 21.1, and 26.7°C minimum night temperatures flowered in 141, 110, 106, 95, and 82 days respectively, with a 15.6°C day temperature, and they flowered in 135, 102, 106, 86, and 81 days respectively with a 21.1°C day temperature. The optimum continuous forcing combination was the 21.1 day/15.6°C night temperature. Plant height was also modified by the temperature regimes. Heights were 35.6, 40.4, 39.3, 47.5 and 58.9 cm for constant day/night temperatures of 10, 15.6, 18.7, 21.1 and 26.7°C, respectively (Smith and Langhans, 1962a). With different day/night temperatures, heights varied but the plants tended to be tallest in treatments combining both high day and high night temperatures and shortest with low day/night temperatures.

Day and night temperatures during forcing from the visible bud stage to anthesis affected the number of days to flower in 'Ace' lilies (Roh and Wilkins, 1973). With constant temperatures of 15.6, 21.1, 26.7 and 32.2°C, flowering occurred in 45, 28, 25 and 24 days, respectively. With a day temperature of 21.1°C flowering occurred in 40, 28, 26, and 28 days with night temperatures of 15.6, 21.1, 26.7 and 32.2°C, while with a day temperature of 26.7°C flowering was obtained in 30, 26, 25, and 23 days with the same night temperatures. The forcing temperatures also affected the plant heights at flowering. With a day temperature of 26.7°C, heights were 26.9, 23.5, 23.7 and 23.2 cm for the respective night temperatures of 15.6, 21.1, 26.7, and 32.3°C. Thus, plant height increased with the combined high day and low night temperature.

Following pretreatments at 31°C and preparation treatment at 13°C (Hartsema, 1961), bulbs of Iris hollandica 'Wedgewood' flowered in 58, 48, 35, and 31 days when forced at constant temperatures of 15, 17, 20, and 23°C, respectively. Flowering of Iris hollandica 'Dominator', 'Professor Blaauw', and 'Imperator' was accelerated by forcing at increasing temperatures in the range of 9-18°C (Fortanier and Zevenbergen, 1973). At 9°C, 50% flowering of the first bud was seen in 142, 152, and 160 days, for the respective cultivars while at 15°C the numbers of days decreased to 70, 85, and 111. At 18°C, 50% flowered in 59, 65, and 86 days while further decreases to 49, 50, and 73 days were seen at 24°C. In forcing Iris hollandica 'Wedgewood' at 21, 18, and 15°C, stem lengths were increased from 12 to 19 and 34 cm, respectively under a 12 hour photoperiod while with a 16 hour photoperiod at the same temperatures heights were 26, 27, and 54 cm (Fortanier and Zevenbergen, 1973). Thus, for cut flower production it is important to select a temperature which gives the most rapid flowering but with a satisfactory length.

Light Intensity

The effect of light intensity on the stimulation of rooting of dahlia cuttings was investigated by Biran and Halevy (1973a). They found that the rooting percent of cuttings from 'Orpheo' stock plants grown continuously under only 50 or 28% of natural daylight was increased, but there were 40% fewer cuttings per plant. Rooting was not enhanced when stock plants were shaded only during the noon hours. These treatments also affected the internodal lengths of the cuttings. With 100, 50, and 28% light treatments, the lengths of the second internodes were 1.8, 3.6, and 6.7 cm, respectively.

The elongating effect of low light intensities during the greenhouse forcing phase of *Lilium longiflorum* has been established (Kohl and Nelson, 1963, Einert and Box, 1967). Under 500 ft. candles, 'Ace' lilies at full bloom were significantly longer (79 cm) than those obtained with a light intensity level of 1,000 ft. candles (65.7 cm). This increase in height was due to internode length and not the number of nodes (Kohl and Nelson, 1963).

Similarly, plants of the Harson strain of 'Georgia' lilies forced under 100% light intensity were 38.6 cm in height, while with 75 and 50% light, the height increased to 44.5 and 47.5 cm, respectively (Einert and Box, 1967). Flowering was also affected by these treatments. The flower buds formed per plant numbered 13.3, 12.7, and 11.9 for the 100, 75, and 50% light intensities, respectively.

During outdoor summer forcing of <u>Gladiolus</u> 'Sans Souci' (Shillo and Halevy, 1976a), a 25% light treatment increased flower stalk length by 18 cm but decreased the percent flowering to 64 and decreased the florets per spike by 53%. With a 20% light treatment during winter forcing the flowering of 'Dr. Fleming' was similarly decreased to 25% and the number of florets was decreased by 54%.

<u>Photoperiod</u>

Tuber and tuberous-rooted plants progress through a series of developmental stages. Normally, the sequence is vegetative growth, then flower initiation and flowering, and then tuber formation and enlargement. Photoperiod treatments have been shown to induce or retard the onset of the different stages (Garner and Allard, 1923). Several reports have established that the tuberization process in dahlias is under short day control (Garner and Allard, 1923, Zimmerman and Hitchcock, 1929). These results were also seen by Moser and Hess (1968) who concluded that at least five inductive cycles were needed to initiate the responses.

Similar short day treatments have been shown to enhance tuberization in other tuberous plants. Weights of tubers formed by 'Mc Cormack' potatoes under a 10 hour photoperiod were 8 times greater than those formed under a 13 hour photoperiod (Garner and Allard, 1923). Three to four weeks of an 8 1/2 hour photoperiod applied from late July increased the root weights in tuberous-rooted begonias (Wasscher, 1955).

The effects of photoperiod conditions on the stages of vegetative growth and flower formation and development in several dahlia cultivars have also been reported. These reports have greater implications regarding greenhouse forcing.

During their tuberization experiments, Zimmerman and Hitchcock (1929) also made observations on the flowering of plants under different daylengths. They reported that both cuttings and tuberous-rooted plants of 'Jersey's Beauty', 'Trentonian', 'Mrs I. de Ver Warner', and 'Insulinda' flowered only with 7-9 hour photoperiods, and that a 16 photoperiod delayed flowering of 'John Erlich'.

During their tuberization experiment, Moser and Hess (1968) found that vegetative growth was promoted by photoperiods of 12 hours or longer. They concluded that photoperiod treatments regulated a competitive relationship between vegetative growth and tuberization. They did not, however, evaluate the flowering stage.

During a tuberization study (Yasuda and Yokoyama, 1959) with 'Hanagasa', the total number of flowers formed from April 15 to September 1 was 446 for plants with a 13 hour photoperiod while the number of flowers decreased to 235 and 158 with 10 and 7 hour photoperiods, respectively.

The flowering response of tuberous-rooted plants of 4 dahlia types (Yasuda and Yokoyama, 1960) single, decorative, cactus, and pompon was determined using an 8 hour photoperiod, natural daylength (Japan-April to June) and incandescent night lighting. After three weeks of treatment, the 8 hour photoperiod produced the highest number of buds recording 34, 22, 22, and 34 buds per the respective flower types. Plants under the natural daylength had 32, 16, 12, and 24 buds while night lighting reduced the number of buds per plant to 20, 0, 0, and 25. Although the tuberous-roots were planted on April 15, the controlled light conditions were not initiated until June 1. Since floral bud initiation has been shown to be completed within three weeks after planting (Krijthe, 1938) and these treatments were started 6 weeks after planting, the effect of daylength would primarily be on flower development.

The effects of photoperiod on the tuberous-rooted dahlias 'Broeder Justinus' and 'Finesse Anversoise' were reported for continuous photoperiods of 10, 11, 12, 13, and 14 hours and natural daylength conditions from late May to September 1 (Germany), (Maatsch and Rünger, 1954). Plants of 'Broeder Justinus' flowered earliest with the 12 hour photoperiod while delays of 5, 15, and 22 days were seen with 13 or 14 hour photoperiods or under the natural daylength conditions. Plants of 'Finesse Anversoise' flowered earliest with the 11 hour photoperiod and were delayed 7, 11, 25, and 35 days with 12, 13, or 14 hours or under the natural day conditions. With the 11 hour photoperiod, flowers of 'Finesse Anversoise' were abnormally formed, having single rows of ray florets and 'open-eye' centers.

For 'Broeder Justinus' the number of flowers at the 10, 11, 12, 13, and 14 hour and natural daylength treatments was 0, 1.3, 6.3, 42.6, 28.9, and 19.1, while 'Finesse Anversoise' had 3.4, 10.7, 20.7, 55.4, 17.6 and 3.4 flowers. They found maximum flower number with the 13 hour photoperiod and reduction in flower numbers at treatments of 14 hours or more. Flowering was severely affected by the 10 and 11 hour photoperiods.

In 'Broeder Justinus' plant heights were 15, 25, 40, 55, and 50 cm for 8-11, 12, 13, and 14 hours and natural daylength conditions, respectively. Shoot weights were 50, 100, 500, 1,400, and 1,800 g for 'Broeder Justinus' and 150, 300, 1,000, 1,500, and 2,200 g for 'Finesse Anversoise' with 11 or less, 12, 13, and 14 hour photoperiods and natural day conditions. Vegetative growth was severely retarded with 11 hour or shorter photoperiods and increased with the longer photoperiods. This is in agreement with the findings of Moser and Hess (1968). The increase in plant weight at the 14 hour photoperiod or natural daylength conditions was seen as an indicator of increased vegetative growth while flowering was delayed and flower numbers were reduced. The critical daylength of 12-13 hours was the most conducive for flowering these cultivars.

In a study to determine the optimum daylength for cut flower production in Japan in autumn, the percent flowering of cuttings of 'Akane' and 'Futurishizaka' was 0 and 35% with an 11 hour photoperiod, 20 and 57% with a 12 hour photoperiod, and 87 and 100% with a 13 hour photoperiod (Konishi and Inaba, 1964). In the spring, the percent flowering was 5, 70 and 100 for the 11, 12, and 13 hour photoperiods with 'Akane'. Similarly, the fresh weights of the vegetative shoots of these plants increased from 5 and 7 g at 11-12 hours to 45 and 20 g with a 13 hour photoperiod. Lengths of stems were 5 and 15 cm at 11 and 12 hour photoperiods, while at 13 hours the lengths were 83 and 78 cm for the respective cultivars. The critical daylength was determined to be 12 hours, with both vegetative and floral growth suppressed by shorter photoperiods while longer photoperiods enhanced both stages.

For cut flower production in England (Canham, 1969), a two hour night break treatment with fluorescent lights through January and February induced normal flower formation 10 and 8 weeks earlier than natural day plants of 'Newby' and 'Chorus Girl' respectively. Flowers of plants grown under natural daylengths were abnormally formed, having 'open-eye' centers and vegetative growth of the plants was suppressed.

Photoperiod treatments have also affected both the dates of flowering and the flower number in *Lilium longiflorum*. With an 18 hour photoperiod applied from the date potting, flowering of 'Croft' lilies was 111 days, while plants under a 9 hour photoperiod flowered in 119 days with a constant temperature regime of 15.6°C (Smith and Langhans, 1962b). The number of flowers under the 18 hour photoperiod was reduced, however, to 4.0, 3.4 and 2.0 at constant temperatures of 15.6, 18.3 and 21.1°C, while with a 9 hour photoperiod, plants averaged 4.5, 4.1 and 2.9 flowers.

The stem length of *Lilium longiflorum* has been modified by the use of photoperiod treatments during the forcing period (Kohl and Nelson, 1963, Smith and Langhans, 1962b, Wilkins, Waters, Widmer, 1968). With a 9 hour photoperiod applied from potting, plant heights of 'Croft' lilies averaged 32.2 cm while with an 18 hour photoperiod, heights increased to 67.5 cm (Smith and Langhans, 1962b). Heights of 'Ace' lilies forced with an 8 hour photoperiod were 60 cm while with a 16 hour photoperiod they were 84.8 cm (Kohl and Nelson, 1963). The increased heights at flowering were a result of increased internodal length.

During outdoor winter forcing of *Gladiolus* 'Sans Souci' (Shillo and Halevy, 1976b) plants under the natural daylength (10-12 hours) flowered in 123 days while flowering of plants receiving 10-19 foot candles under either an 18 hour photoperiod or a 4 hour night break treatment was delayed by 4 days. With these respective treatments, stalk lengths were 155.1, 161.9 and 162.8 cm. Shortening the natural daylength during summer forcing (13 1/2-14 1/2 hours) to a 6 hour photoperiod reduced the flowering by 68%.

Also during summer forcing, 82, 71, 57, and 22% of 'Dr. Fleming' flowered with natural day (11-13 hours), 8 hour, 6 hour, and 4 hour photoperiods, respectively.

Growth Regulators

Exogenous applications of growth regulators on dahlias have been used primarily to investigate their effects on the rooting of cuttings or on the tuberization process.

Applications of indolebutyric acid alone (Biran and Halevy, 1973c) or in combination with abscissic acid (Biran and Halevy, 1973b) have increased the average number of roots per cutting. The number of tuberous-roots, root diameters, and root fresh weights were increased by daminozide and chlormequat (Read, Dunham, Fieldhouse, 1972) and tuberization was promoted by abscissic acid (Biran, Gur, Halevy, 1972) while GA_3 (Moser and Hess, 1968) and ethephon (Biran, Gur, and Halevy, 1972) suppressed tuberization.

Ancymidol, daminozide, and chlormequat are widely used to regulate plant height on many greenhouse crops such as *Chrysanthemum morifolium*, *Euphorbia pulcherrima*, and *Lilium longiflorum* (Gortzig, 1974). Soil drench applications have had longer-lasting effects than foliar sprays (Cathey and Heggestad, 1973). However, responses have been modified by cultivar sensitivity, growing conditions, dose rates, stages of plant development, and time of application.

Recently, De Hertogh, Blakely, and Szlachetka (1976) reported on the effectiveness of growth regulators on controlling the height of forced tuberous-rooted dahlias. For spring forcing of 'Park Princess', soil drenches of ancymidol at the 0.5 mg rate per pot reduced plant heights to 31.2 or 28.8 cm for 8 February or 9 March planting dates, respectively, while heights of untreated plants were 46.0 cm. Soil drenches of chlormequat at 270 or 540 mg per pot and foliar sprays of daminozide at the 2,500 or 5,000 ppm rate per plant were not effective. Soil drenches of ancymidol at the 0.5 mg rate reduced plant heights of 'Kolchelsee' to 27.4 cm at the 8 February planting date while heights of untreated plants, chlormequat-treated (270 mg, soil drench) and daminozide-treated (2,500 ppm foliar spray) were 30.8, 34.4, and 41.5 cm, respectively. Application made two weeks after the planting dates were more effective than those made 4 weeks after planting. Flower diameter and the number of shoots per plant were not affected while flowering was delayed by ancymidol in 'Kolchelsee' at the early planting date but not at the later date.

MATERIALS AND METHODS

Tuberous-roots were used and they were grown in the Netherlands. They were harvested in October 1974 and 1975, stored at 9 to 11°C, graded as size number II, washed just prior to shipping, and then packed in cardboard cartons with airdried peat to prevent drying. They were shipped on December 23 and 17 in 1974 and 1975, respectively. They arrived in East Lansing on January 13, 1975 and January 9, 1976. On arrival, the tuberous-roots were stored in the shipping containers at 5°C until the dates of planting. Prior to planting, shoot and root development was minimal. Two cultivars had been selected for evaluation in all experiments. 'Kolchelsee', a red semi-decorative type had rather large tuberous-roots with four to five elongated storage organs eight to ten cm long. 'Park Princess' a pink semi-cactus flowered cultivar, had four to five spherical storage organs which were three to four cm long.

In 1975, the tuberous-roots, washed free of packing material, were dipped for thirty minutes in a solution containing 44.8 g each of benomyl (50% WP) and ethazol (50% WP) per 90 liters of water prior to planting. This pre-plant dip was eliminated in 1976.

The tuberous-roots were planted one per 15 cm clay pot with the crown region approximately one to two cm above the level of the planting medium (Figure 1). The medium consisted of sterilized soil, sand, peat, and Perlite (equal volumes). The saturated soil extract test (Rieke and Warncke, 1975) gave a soluble salts conductivity reading of 150 MHOS X 10^{-5} or 1050 ppm and a pH of 6.7.

Except in the fertilization experiments, Osmocote (14-14-14) was incorporated into the planting medium at the rate of 169.8 g per cubic foot, in 1975. In 1976, Osmocote (14-14-14) was top dressed at the rate of 9 g per pot one week after planting.

Two weeks after planting ancymidol was applied as a soil drench to all plants at the rate of 0.5 mg per 15 cm pot in 100 ml of solution.

In all of the experiments, each treatment consisted of five pots in three blocks. Pots were placed on the benches in blocks which were designed to minimize the effects of the peripheral heat source. Initially, spacing was pot to pot and this later was increased to 35 cm centers when shoot growth dictated it. All pots were thoroughly watered immediately after planting and were subsequently watered as needed to maintain adequate moisture. Treatments in the individual experiments are described in the following pages.

Figure 1. A tuberous-root of 'Kolchelsee' planted in the 15 cm pot.

A. Old Stem

B. New Shoots

C. An Individual Enlarged Tuberous-Root

D. Fibrous Roots

Fertilizer Experiments

In 1975, seven fertilization formulations were evaluated (Tables 6 and 7). All tuberous-roots were planted on 4 February. In 1976, only four fertilization formulations were evaluated (Tables 8 and 9) and a February 6 planting date was used.

All plants received natural daylength and full sunlight conditions with a minimum night temperature of 17°C. The specific fertilizer treatments were as follows:

1. No fertilizer was incorporated into the planting medium prior to planting and no fertilizer was subsequently applied.
2. Osmocote (14-14-14), a 3-4 month formulation was incorporated into the planting medium prior to planting at the rate of 169.8 g per cubic foot of medium.
3. (1975) Osmocote (18-9-13), a 3-4 month formulation was incorporated into the planting medium prior to planting at the rate of 169.8 g per cubic foot. (1976) Osmocote (14-14-14) was top dressed one week after planting at the rate of 9 g per pot.
4. Osmocote (18-6-12), an 8-9 month formulation was incorporated into the planting medium prior to planting at the rate of 169.8 g per cubic foot.

5. Osmocote (18-6-12) and Osmocote (14-14-14) were both incorporated into the planting medium prior to planting at the rate of 84.9 g each per cubic foot of medium.
6. Osmocote (18-9-13) and Osmocote (18-6-12) were both incorporated into the planting medium prior to planting at the rate of 84.9 g each per cubic foot.
7. (1975) No fertilizer was incorporated into the planting medium. Plants received 200 ppm (20-20-20) in 300 ml of solution per pot weekly.

Treatments 1 and 2 were the same in 1975 and 1976. Treatment 7 in 1975 was treatment 4 in 1976. The other treatments were not repeated.

Temperature Experiments

In 1975, (Tables 10 and 11) three maximum day/minimum night temperature treatments were evaluated using two planting dates, January 30 and February 20. In 1976, (Tables 1, 12 and 13) a fourth temperature treatment was included. The planting dates remained the same. All plants received natural daylength and full sunlight intensity.

Light Intensity Experiments

In 1975 and 1976 light intensity treatments giving 100, 75, and 50% of natural daylight were evaluated. Plastic mesh was used to reduce the light intensity. Two planting dates, January 30 and February 20 were used. Foot candle measurements (Table 2) were determined with a direct reading GE Type 213 light meter.

Table 1.--Mean day/night temperatures during the 1976 forcing period.

Month	°C			
February	25/11	23/16	28/16	29/20
March	26/14	25/15	26/16	29/22
April	28/12	28/16	30/17	28/22
May	27/13	32/17	32/17	28/22
Seasonal Average	27/12	27/16	29/17	29/22

Table 2.--Foot candle measurements of the three light intensity levels under different weather conditions and dates, 1976.

DATE, CONDITION AND TIME OF READING	% LIGHT INTENSITY 100	75	50
February 2 Clear AM	5000	3500	2500
February 5 Overcast AM	2000	1500	650-600
February 19 Clear AM	4000	3200	2000
February 26 Rainy AM	260	220	150
March 11 Clear AM	5000+	5000+	4000
March 17 Overcast PM	1500	1000	500-400
March 23 Partly Cloudy AM	2700	1800	1000-700
April 5 Cloudy PM	1500	1000	600-500
April 18 Clear PM	5000+	4000+	4000+

Table 3.--Solar radiation in calories/cm^2/day at East Lansing, Michigan.[a]

WEEK	MEAN RADIATION
01/31-02/06	191.1
02/21-02/27	251.8
03/08-03/14	292.4
03/15-03/21	326.0
04/05-04/11	378.0
04/26-05/02	423.6
05/10-05/16	465.1

[a](Baker and Klink, 1975).

Table 4.--Calories/ cm^2/day determinations under three weather conditions at East Lansing, Michigan.[a]

Month	100% cloud cover	50% cloud cover	0% cloud (clear)
January	50	150	215
February	100	250	380
March	120	380	480
April	150	480	500
May	200	550	700

[a](Baker and Klink, 1975).

Photoperiod Experiments

In 1975, four photoperiod treatments (Tables 18 and 19) were evaluated using two planting dates, January 30 and February 20.

In 1976, four combination treatments were included (Tables 20 and 21), and only one planting date, February 9 was used. These treatments evaluated long day and night-break regimes with natural daylengths. Transfers from the initial photoperiod to the finishing photoperiod took place on March 15, five weeks after planting. The minimum night temperature was 17°C. The specific photoperiod treatments were as follows:

1. The natural daylength treatment received sunlight available in a greenhouse at 42° 42' N. latitude. The daylength varied from 10 to 14 hours by the termination of the experiment (Table 5).
2. The 8 hour photoperiod treatment had black cloth applied daily from 1630 to 0830 hours until termination of the experiment.
3. The 16 hour photoperiod, an extended day treatment, was supplied by four cool-white 110 fluorescent tubes suspended 92-102 cm above the bench surface with 150-200 foot candles supplied to supplement the natural daylength (Table 5). At the time of flowering, the lights were approximately 60 cm above the plants.
4. The four hour night break treatment was provided using eight 60 watt incandescent bulbs with reflectors suspended 56 cm apart and 92 cm above the bench. Lights supplied 60-100 foot candles nightly between

2200 and 0200 hours. At the time of flowering, lights were approximately 60 cm above the plants.

Table 5.--Number of daylight hours and times of photoperiod treatments for dates during the 1976 forcing season at East Lansing, Michigan, 43° north latitude.

Date	Number of Daylight hours	Natural Daylength[a] EST	Black cloth applied	16 Hour lights applied from	4 Hour lights applied
February 1	10.0	0750-1750	1630-0830	0200 hr.	2200-0200
February 9	10.5	0745-1800	"	0200 hr.	"
February 20	11.25	0730-1815	"	0230 hr.	"
March 6	11.5	0700-1830	"	0230 hr.	"
March 12	11.5	0700-1830	"	0230 hr.	"
March 26	12.5	0630-1900	"	0300 hr.	"
April 15	13.5	0600-1930	"	0330 hr.	"
April 30	14.0	0630-2000	"	0430 hr.	"
May 1	14.2	0630-2040	"	0430 hr.	"
May 11	14.7	0615-2100	"	0500 hr.	"

[a]Daylight savings time went into effect on April 30 and continued throughout the experiment.

Hydrogel Experiment

In 1975, three rates of the soil amendment hydrogel (Viterra) were evaluated (Tables 22 and 23). The tuberous-roots were planted on February 4. Plants received natural daylength with full sunlight intensity and the minimum night temperature was 17°C. Specific treatments were applied as follows:

1. No hydrogel was incorporated.
2. Hydrogel at the rate of 339.6 g per cubic foot was incorporated into the planting medium prior to planting.
3. Hydrogel at the rate of 226.4 g per cubic foot of planting medium was incorporated prior to planting.

Pots were thoroughly watered immediately after planting and were subsequently watered as needed to maintain adequate moisture levels. These requirements varied with the rate of hydrogel incorporated.

Pesticide Usage

In 1975, plants in all experiments received a soil drench of ethazol at the rate of 22.2 g per 45 liters of water with 200 ml of solution applied per pot on March 17. Plants were sprayed with 'Malathion' to runoff on March 18. Aldicarb was applied to the soil surface at the rate of 0.1 g per pot, worked and watered in on March 20.

In 1976, Aldicarb was applied at the same rate and in the same manner on March 19.

In 1975, many plants of 'Kolchelsee' regardless of the treatment or soil moisture level became wilted. To aerate the planting medium, plants were removed from the pots and the root clumps were given a quarter turn before being replaced into the pots on March 26. All pots were then heavily leached weekly and allowed to drain. Soil samples from wilted plants were tested and the results indicated that the main cause of the wilting was high soluble salts and overwatering. The soft rot bacteria *Pectobacterium sp*. was reported as present in root tissue, although it was not a causal agent of wilting.

Removal of Failures

For all treatments, tuberous-roots which did not produce shoots 4-6 weeks after planting were removed. These losses were low, from 3 to 5%.

Data Collection

For all experiments, specific parameters were measured as indices of the plant response to the treatments.

The number of days to flower for the first, second, and third flowers per plant was determined from each planting date to the date when the flower was fully opened.

The promotion or delay of flowering was determined by comparing the mean number of days when 100% of the plants in a treatment had flowered. In some treatments of the fertilizer and photoperiod experiments some of the plants failed to flower. Therefore, the mean of the maximum percent which did flower was determined and compared.

The height of the flower stalks of the first, second, and third flowers was measured from the crown of the tuberous-root to the base of the fully open flower head.

The longevity (flower life) of the first, second, and third flowers per plant was determined by recording the number of days from flower opening to the senescence.

The diameter of the first, second, and third flowers per plant was measured from the distal ends of the florets through the center of the flower on the day each flower was fully opened.

The number of major and minor shoots which arose from the crown of the tuberous-root was also recorded. The major shoots were the vigorous shoots which flowered earliest while the minor shoots were those less vigorous and delayed in flowering. The total number of shoots which arose from the crown was determined by summing the values obtained for both types of shoots.

Statistical Analysis

The experiments were conducted as randomized complete block designs with 2 x 2 factorial analyses conducted on the data.

Means in rows were compared using the Tukey omega-procedure to determine the treatment significance on each parameter, for each planting date, and for each cultivar. Means in columns were separated by the omega-procedure for each parameter, for each cultivar at one treatment level to determine the significance of the planting dates (Steele and Torrie, 1960).

In determining the treatment effects on the forcing parameters, it is important to note the limitations under which the experiments were conducted. The error variance in the experiments is likely to be overestimated if the effects of the blocks interacted with those of the treatments or planting dates. Thus, the tests of significance of the treatment levels and planting dates were conservative. Although the level of significance may have been inexactly determined, the large differences were primarily caused by the treatment levels, cultivars, and planting dates with consistent responses seen for the two years of data.

RESULTS AND DISCUSSION

Forcing Criteria

The forcing of dahlias as a commercial greenhouse crop depends upon the use of environmental factors which will produce high quality plants. The specific criteria for dahlias satisfactory as pot plants include the following:

1. Forcing time should not exceed 84 days.
2. Ninety-five percent of the plants should flower within a 10 day period.
3. Plant height from the crown to the base of the first fully opened flower should range from 30-40 cm when planted in a 15 cm pot.
4. Flower diameters should range from 10 to 15 cm when fully opened.
5. Plants should have 2-4 flowers open at the same time and there should be 10 or more floral buds initiated and developed.
6. Plants should have dense and well-formed foliage with an attractive color.
7. Plants should have an indoor keeping quality of 2-4 weeks, with good transplanting characteristics and continued flowering.

These criteria were used as guidelines to judge satisfactory plant quality in the following discussion of the experimental results and an example of a high quality plant is illustrated in Figure 2.

Effects of Fertilization

In both years, fertilizer treatments markedly affected plant growth characteristics (Tables 6, 7, 8 and 9). With 'Kolchelsee', the fertilizer treatments increased the percent of plants flowering from 0 to 100% in 1975, and from 53, 26, and 0% for the first, second, and third flowers, respectively, to 100% in 1976. With 'Park Princess', fertilizer treatments also increased the percent flowering of first, second, and third flowers from 73, 40, and 30% to 100% in 1975, while in 1976 it increased from 33 and 0% for second and third flowers to 100%. The higher percent flowering of both cultivars without fertilization from 1975 to 1976 reflects year to year variation during production and forcing periods.

On the average, applications of fertilizer promoted earlier flowering by 20 days. Plant heights, flower diameters and flower longevity, and the total number of shoots and flowers per plant were also increased. Thus, fertilization is essential in the production of high quality plants forced from tuberous-roots.

In both years, there were differences in some of the forcing parameters among the fertilizer treatments. But the

Figure 2. A high quality plant of 'Park Princess' after forcing.

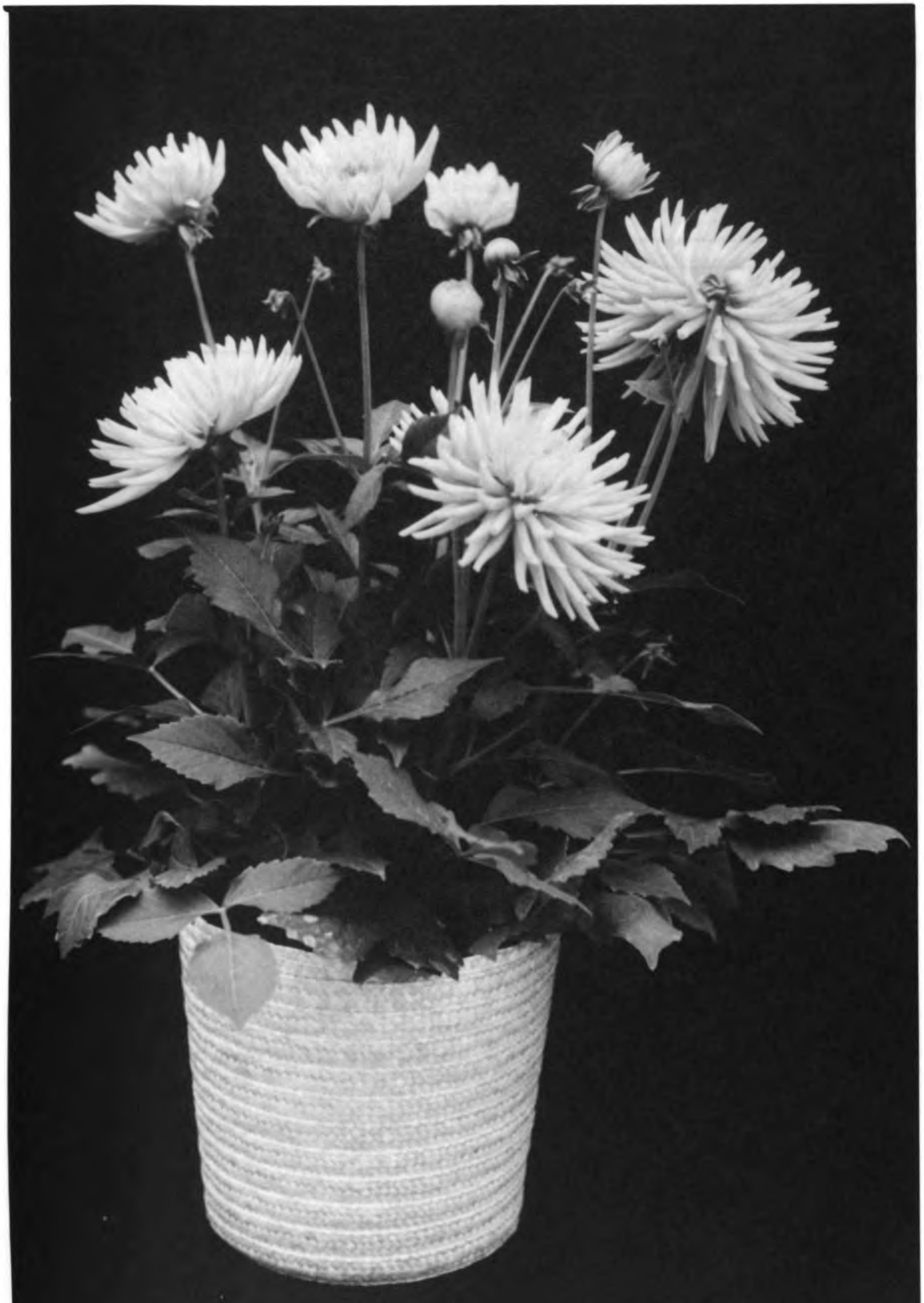

Table 6.--Effect of fertilizer treatments on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Kolchelsee'. Tuberous-roots were planted on 4 February, 1975.

PLANT ORGAN EVALUATED	FERTILIZER TREATMENTS[x]						
	None[y]	14-14-14	18-9-13	18-6-12	18-6-12 14-14-14	18-9-13 18-6-12	20-20-20 Liquid
	Days to Flower						
First Flower	-	65a	70b	72b	70b	72b	70b
Second Flower	-	77a	78a	82ab	81ab	80ab	84b
Third Flower	-	86a	85a	86a	90ab	87ab	92b
	Plant Height (cm)						
First Flower	-	26.1bc	25.3abc	29.0c	22.2a	26.5bc	23.6ab
Second Flower	-	31.4a	29.5ab	36.9c	28.2ab	31.1a	26.2b
Third Flower	-	34.1cb	31.4c	38.9a	31.9c	36.1ab	27.9d
	Flower Longevity (Days)						
First Flower	-	7.4a	7.2a	7.3a	7.2a	6.2b	6.7ab
Second Flower	-	6.5a	7.3a	6.8a	6.7a	7.0a	6.9a
Third Flower	-	6.9bc	6.9bc	7.6c	5.9a	6.3ab	6.8bc
	Diameter (cm)						
First Flower	-	5.8a	5.8a	6.3b	5.9ab	6.0ab	5.9ab
Second Flower	-	5.7a	5.7a	5.8a	5.9a	5.8a	5.5a
Third Flower	-	5.5a	5.8a	5.6a	5.8a	5.7a	5.3a
	Number of Shoots Per Plant						
Major Shoots	1.0a	1.8bc	2.0b	1.1a	1.5c	1.5c	1.1a
Minor Shoots	0.3a	0.9b	0.6ab	0.5ab	0.3a	0.5ab	0.5ab
Total Shoots	1.3a	2.7b	2.6b	1.6ac	1.8c	2.0c	1.6ac

[x]Means followed by the same letter (a,b,c,d) are not significantly different by Tukey's test at .05 for single rows (each organ per parameter determined separately).

[y]None of the plants flowered.

Table 7.--Effect of fertilizer treatments on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Park Princess'. Tuberous-roots were planted on 4 February, 1975.

PLANT ORGAN EVALUATED	FERTILIZER TREATMENTS[x]						
	None[y]	14-14-14	18-9-13	18-6-12	18-6-12 14-14-14	18-9-13 18-6-12	20-20-20 Liquid
	Days to Flower						
First Flower	88(73%)a	72b	74bc	76c	75bc	74bc	75bc
Second Flower	98(40%)a	78b	79bc	82bc	82bc	78b	84c
Third Flower	105(30%)a	82b	83b	89cd	86bc	85bc	93d
	Plant Height (cm)						
First Flower	23.9(73%)a	28.8bc	34.3d	31.8cd	29.9bc	29.8bc	26.4ab
Second Flower	29.5(40%)a	32.6ab	35.9b	35.2b	30.4a	30.6a	30.8a
Third Flower	30.7(30%)a	34.8bc	37.9b	37.5b	35.3bc	34.9bc	32.7ac
	Flower Longevity (Days)						
First Flower	6.8(73%)a	7.5ab	7.5ab	7.6ab	7.8b	7.7b	8.3b
Second Flower	6.9(40%)a	6.9a	8.1b	6.5a	6.9a	8.1b	7.0ab
Third Flower	6.3(30%)ac	7.0ab	7.3b	6.8ab	6.5abc	6.3ac	5.8c
	Diameter (cm)						
First Flower	11.0(73%)a	12.0b	11.9b	12.3b	12.2b	12.3b	12.2b
Second Flower	9.7(40%)a	11.7b	12.0bc	11.9bc	12.1c	11.7b	11.6b
Third Flower	7.3(30%)a	11.8b	11.6b	11.8b	11.6b	11.7b	10.8c
	Number of Shoots Per Plant						
Major Shoots	1.4a	2.2bc	2.0bc	1.8b	2.2bc	2.4c	1.9b
Minor Shoots	1.0ab	1.4b	1.3ab	0.8a	1.2ab	0.9a	1.1ab
Total Shoots	2.4a	3.6c	3.3bc	2.6a	3.4c	3.3bc	3.0b

[x]Means followed by the same letter (a,b,c,d) are not significantly different by Tukey's test at .05 for single rows (each organ per parameter determined separately).

[y]Maximum percent of plants flowering is given.

Table 8.--Effect of fertilizer treatments on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Kolchelsee'. Tuberous-roots were planted on 6 February, 1976.

PLANT ORGAN EVALUATED	FERTILIZER TREATMENTS[x]			
	None[y]	14-14-14 Incorporated	14-14-14 Top dressed	20-20-20 Liquid
	Days to Flower			
First Flower	84(53%)a	65b	69bc	74c
Second Flower	109(26%)a	71b	76b	77b
Third Flower	- (0%)	80a	77a	81a
	Plant Height (cm)			
First Flower	27.1(53%)a	30.8a	31.8a	38.9a
Second Flower	30.3(26%)a	34.2a	35.6a	41.4a
Third Flower	- (0%)	38.9a	41.4a	44.5a
	Flower Longevity (Days)			
First Flower	7.7(53%)a	6.0b	5.9b	5.9b
Second Flower	8.0(26%)a	5.8b	7.2ab	5.8b
Third Flower	- (0%)	7.3a	7.3a	6.6a
	Diameter (cm)			
First Flower	5.5(53%)a	6.1a	5.8a	5.9a
Second Flower	4.3(26%)a	5.5b	5.8b	5.8b
Third Flower	- (0%)	5.6a	5.6a	5.6a
	Number of Shoots Per Plant			
Major Shoots	1.0a	1.5a	1.5a	1.8a
Minor Shoots	0.4a	1.0a	0.9a	0.9a
Total Shoots	1.4a	2.5b	2.4b	2.7b
	Number of Flowers and Buds Per Plant			
Total Flowers and Buds	1.3a	8.5b	8.2b	8.7b

[x]Means followed by the same letter (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per parameter determined separately).

[y]Maximum percent of the plants flowering is given.

Table 9.--Effect of fertilizer treatments on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Park Princess'. Tuberous-roots were planted on 6 February, 1976.

PLANT ORGAN EVALUATED	FERTILIZER TREATMENTS[x]			
	None[y]	14-14-14 Incorporated	14-14-14 Top dressed	20-20-20 Liquid
	Days to Flower			
First Flower	90a	73b	74b	76b
Second Flower	98(33%)a	74b	77b	80b
Third Flower	-(0%)	81a	81a	86a
	Plant Height (cm)			
First Flower	32a	41a	45a	38a
Second Flower	35(33%)a	43a	46a	42a
Third Flower	-(0%)	44a	48a	43a
	Flower Longevity (Days)			
First Flower	9.0a	8.4a	9.0a	8.1a
Second Flower	8.8(33%)a	8.4a	7.7a	8.0a
Third Flower	-(0%)	8.1a	7.7a	8.1a
	Diameter (cm)			
First Flower	10.3a	12.1b	12.2b	12.4b
Second Flower	8.3(33%)a	11.4b	11.6b	11.6b
Third Flower	-(0%)	11.7a	11.9a	11.3a
	Number of Shoots Per Plant			
Major Shoots	1.2a	1.8a	1.9a	1.4a
Minor Shoots	0.4a	0.4a	0.7a	0.7a
Total Shoots	1.6a	2.2b	2.6b	2.1b
	Number of Flowers and Buds Per Plant			
Total Flowers and Buds	1.9a	7.5b	9.1c	6.4b

[x]Means followed by the same letter (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per parameter determined separately).

[y]Maximum percent of the plants flowering is given.

data indicated that balanced formulations of Osmocote (14-14-14) or soluble fertilizers (20-20-20) were satisfactory. Also, the higher nitrogen formulations, (18-6-12) or (18-9-13), did not delay flowering and are not required.

These results are consistent with recommendations that dahlias should be fertilized when grown in the garden (James, 1963, Vance, 1974, Baumgardt, 1970). There have been no previous studies on fertilizer requirements for greenhouse forced tuberous-rooted dahlias. De Hertogh, Blakely, and Szlachetka (1976) used 30 ppm liquid feed applications in their study on the effects of growth regulators on forced tuberous-rooted dahlias and this would appear to be on the low side.

In its basic responses to fertilizer treatments, the dahlia is similar to *Lilium* and *Gladiolus* in their levels of fertilizer recommended during forcing (Kiplinger and Langhans, 1967, Kosugi, 1960). It differs greatly, however, from the bulbous materials such as *Tulipa*, *Hyacinthus*, and *Narcissus* which do not normally require fertilization during forcing (De Hertogh, 1973).

Effects of Temperature

In 1975, (Tables 10 and 11), flowering was promoted with an increase in the day/night temperatures from 26/11 to 23/16 and 27/18°C from 103 to 84 and 64 days and from 93 to 74 and 68 days for 'Kolchelsee' and 'Park Princess' respectively. Comparing planting dates, flowering was accelerated

Table 10.--Effect of temperature on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Kolchelsee'. Tuberous-roots were planted in 1975.

PLANT ORGAN EVALUATED	PLANTING DATE	DAY/NIGHT TEMPERATURES °C[x] 26/11	23/16	27/18
		Days to Flower		
First Flower	30 Jan	103a/d	84b/d	63c/d
	20 Feb	91a/e	62b/e	59b/d
Second Flower	30 Jan	111a/d	99b/d	71c/d
	20 Feb	98a/e	69b/e	64b/d
Third Flower	30 Jan	116a/d	104b/d	74c/d
	20 Feb	97a/e	73b/e	67b/e
		Plant Height (cm)		
First Flower	30 Jan	35.7a/d	24.9b/d	31.1ab/d
	20 Feb	38.0a/d	21.7b/d	32.4a/d
Second Flower	30 Jan	40.7a/d	30.4b/d	35.7ab/d
	20 Feb	41.9a/d	26.2b/d	38.4b/d
Third Flower	30 Jan	41.2a/d	35.2a/d	37.4a/d
	20 Feb	46.8a/d	28.4b/d	41.3a/d
		Flower Longevity (Days)		
First Flower	30 Jan	5.9a/d	6.9a/d	7.2b/d
	20 Feb	5.2a/d	6.9a/d	7.0b/d
Second Flower	30 Jan	5.2a/d	5.7a/d	7.3b/d
	20 Feb	5.7a/d	7.3b/e	7.2b/d
Third Flower	30 Jan	6.9a/d	7.0a/d	7.3a/d
	20 Feb	5.3a/d	7.0a/d	6.9a/d

Table 10.--Continued.

PLANT ORGAN EVALUATED	PLANTING DATE	DAY/NIGHT TEMPERATURES °C[x] 26/11	23/16	27/18
		Diameter (cm)		
First Flower	30 Jan	5.4a/d	5.8a/d	5.8a/d
	20 Feb	5.9a/d	6.3a/d	6.2a/d
Second Flower	30 Jan	5.8a/d	5.5a/d	5.7a/d
	20 Feb	6.1a/d	6.0a/d	5.9a/d
Third Flower	30 Jan	5.5a/d	5.7a/d	5.6a/d
	20 Feb	5.5a/d	5.9a/d	5.9a/d
		Number of Shoots Per Plant		
Major Shoots	30 Jan	1.7a/d	1.5a/d	1.7a/d
	20 Feb	1.4a/d	1.5a/d	1.6a/d
Minor Shoots	30 Jan	0.6a/d	0.6a/d	0.3a/d
	20 Feb	0.4a/d	0.5a/d	0.4a/d
Total Shoots	30 Jan	2.3a/d	2.1a/d	2.0a/d
	20 Feb	1.8a/d	2.0a/d	2.0a/d

[x]Means followed by the same letter preceding the slash (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per date and parameter determined separately). Means followed by the same letter following the slash (d,e) are not significantly different by Tukey's test at .05 for pairs in columns (each organ per treatment and parameter determined separately).

Table 11.--Effect of temperature on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Park Princess'. Tuberous-roots were planted in 1975.

PLANT ORGAN EVALUATED	PLANTING DATE	DAY/NIGHT TEMPERATURES °C[x] 26/11	23/16	27/18
		Days to Flower		
First Flower	30 Jan	93a/d	74b/d	68b/d
	20 Feb	89a/d	67b/d	63b/d
Second Flower	30 Jan	100a/d	79b/d	73b/d
	20 Feb	94a/d	74b/d	69b/d
Third Flower	30 Jan	105a/d	85b/d	77b/d
	20 Feb	97a/e	78b/e	72b/d
		Plant Height (cm)		
First Flower	30 Jan	36.4a/d	32.3a/d	35.1a/d
	20 Feb	34.9a/d	30.1a/d	27.1a/e
Second Flower	30 Jan	38.7a/d	32.1b/d	36.9ab/d
	20 Feb	37.7a/d	37.1a/d	31.9a/d
Third Flower	30 Jan	39.0a/d	45.5a/d	38.5a/d
	20 Feb	39.6a/d	38.1a/d	34.8a/d
		Flower Longevity (Days)		
First Flower	30 Jan	6.5a/d	7.9a/d	9.9b/d
	20 Feb	7.5a/d	7.8a/d	6.8a/e
Second Flower	30 Jan	7.1a/d	7.7a/d	8.9a/d
	20 Feb	7.9a/d	7.7a/d	6.9a/e
Third Flower	30 Jan	7.0ab/d	6.2a/d	8.3b/d
	20 Feb	9.9a/e	8.3a/e	8.0a/d

Table 11.--Continued.

PLANT ORGAN EVALUATED	PLANTING DATE	DAY/NIGHT TEMPERATURES °C[x] 26/11	23/16	27/18
		Diameter (cm)		
First Flower	30 Jan	12.3a/d	12.4a/d	11.2b/d
	20 Feb	13.2a/e	12.4a/d	12.7a/e
Second Flower	30 Jan	11.0a/d	12.1b/d	11.2ab/d
	20 Feb	11.8a/d	11.6a/d	11.4a/d
Third Flower	30 Jan	11.4a/d	12.2a/d	11.5a/d
	20 Feb	11.2a/d	11.4a/d	11.6a/d
		Number of Shoots Per Plant		
Major Shoots	30 Jan	1.7a/d	2.3a/d	1.9a/d
	20 Feb	1.6a/d	1.5ab/e	2.2a/d
Minor Shoots	30 Jan	1.4a/d	1.0a/d	1.6a/d
	20 Feb	1.2a/d	0.7a/d	0.4a/e
Total Shoots	30 Jan	3.1a/d	3.3a/d	3.5a/d
	20 Feb	2.8a/d	2.2a/d	2.6a/d

[x]Means followed by the same letter preceding the slash (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per date and parameter determined separately). Means followed by the same letter following the slash (d,e) are not significantly different by Tukey's test at .05 for pairs in columns (each organ per treatment and parameter determined separately).

for all temperatures with the second planting. The range was from 4 to 31 days. The cultivars differed with 'Park Princess' flowering 2-11 days earlier than 'Kolchelsee' under comparable treatments.

At 26/11°C, plant heights were significantly increased, averaging 40 and 37 cm for 'Kolchelsee' and 'Park Princess' while heights at 23/16°C averaged 28 and 36 cm and at 27/18°C heights were 35 and 34 cm for the respective cultivars. Flower longevity, flower diameter, and the number of shoots per plant were not affected by temperature or planting date.

Since the upper temperature limit for forcing was not established in 1975, an additional day/night temperature treatment was included in the 1976 study. Again, the data showed that flowering was promoted by increasing temperatures (Tables 12 and 13). The higher temperature permitted the earliest initiation and floral development but adverse affects on overall plant quality were noted.

Cultivars again differed in their response. 'Kolchelsee' flowered a maximum of 16 days earlier than 'Park Princess'. Year to year variation was reflected by the average promotion of flowering by 6 days from 1975 to 1976 for comparable treatments.

The 29/22°C treatments produced the earliest flowering with both cultivars. With the 29/17°C treatments flowering was delayed to 62 and 64 days for 'Kolchelsee'

Table 12.--Effect of temperature on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Kolchelsee'. Tuberous-roots were planted in 1976.

PLANT ORGAN EVALUATED	PLANTING DATE	DAY/NIGHT TEMPERATURES °C[x] 27/12	27/16	29/17	29/22
		Days to Flower			
First Flower	30 Jan	81a/d	71b/d	59c/d	55c/d
	20 Feb	84a/d	75b/d	57c/d	54c/d
Second Flower	30 Jan	88a/d	76b/d	63c/d	62c/d
	20 Feb	91a/d	82a/d	61b/d	59b/d
Third Flower	30 Jan	94a/d	81b/d	67c/d	66c/d
	20 Feb	96a/d	84b/d	66c/d	59c/d
		Plant Height (cm)			
First Flower	30 Jan	37.6a/d	31.6a/d	34.4a/d	19.5b/d
	20 Feb	38.1a/d	30.7b/d	32.1ab/d	29.4b/e
Second Flower	30 Jan	42.0a/d	32.7b/d	38.7b/d	24.7c/d
	20 Feb	47.3a/e	37.5bc/e	39.3b/d	31.5c/e
Third Flower	30 Jan	45.2a/d	35.6bc/d	40.7ab/d	29.5c/d
	20 Feb	50.4a/d	37.5b/d	39.4b/d	36.7b/e
		Flower Longevity (Days)			
First Flower	30 Jan	5.8a/d	6.1a/d	6.5a/d	5.9a/d
	20 Feb	6.9a/d	7.3a/d	6.2a/d	5.3a/d
Second Flower	30 Jan	7.9a/d	6.1b/d	6.5ab/d	5.7b/d
	20 Feb	7.3a/d	7.3a/d	6.3ab/d	5.2b/d
Third Flower	30 Jan	8.2a/d	6.3ab/d	6.2ab/d	5.1b/d
	20 Feb	7.8a/d	6.5ab/d	6.3ab/d	5.4b/d

Table 12.--Continued.

PLANT ORGAN EVALUATED	PLANTING DATE	DAY/NIGHT TEMPERATURES °C[x] 27/12	27/16	29/17	29/22
		Diameter (cm)			
First Flower	30 Jan	6.0a/d	6.0a/d	6.3a/d	5.7a/d
	20 Feb	6.3a/d	6.0a/d	6.0a/d	5.7a/d
Second Flower	30 Jan	5.7a/d	5.5a/d	6.2a/d	5.7a/d
	20 Feb	6.2a/e	5.9a/d	5.7a/d	5.5a/d
Third Flower	30 Jan	5.7a/d	5.3a/d	5.9a/d	5.5a/d
	20 Feb	5.7a/d	5.5a/d	5.7a/d	5.2a/d
		Number of Shoots Per Plant			
Major Shoots	30 Jan	1.5a/d	1.7a/d	1.5a/d	1.8a/d
	20 Feb	1.3a/d	1.2a/e	1.4a/d	1.8a/d
Minor Shoots	30 Jan	0.9a/d	0.8a/d	0.5a/d	0.7a/d
	20 Feb	0.7a/d	0.8a/d	0.7a/d	0.1a/d
Total Shoots	30 Jan	2.3a/d	2.5a/d	1.9a/d	2.5a/d
	20 Feb	1.9a/d	2.0a/d	2.1a/d	1.9a/d
		Number of Flowers and Buds Per Plant			
Total Flowers and Buds	30 Jan	9.4a/d	7.4ab/d	8.0ab/d	6.2b/d
	20 Feb	7.3ab/d	5.7a/e	10.0b/e	8.1b/e

[x]Means followed by the same letter preceding the slash (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per date and parameter determined separately). Means followed by the same letter following the slash (d,e) are not significantly different by Tukey's test at .05 for pairs in columns (each organ per treatment and parameter determined separately).

Table 13.--Effect of temperature on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Park Princess'. Tuberous-roots were planted in 1976.

PLANT ORGAN EVALUATED	PLANTING DATE	DAY/NIGHT TEMPERATURES °C[x] 27/12	27/16	29/17	29/22
		Days to Flower			
First Flower	30 Jan	87a/d	82a/d	61b/d	54b/d
	20 Feb	88a/d	76b/d	60c/d	56c/d
Second Flower	30 Jan	93a/d	89a/d	64b/d	58b/d
	20 Feb	94a/d	87a/d	66b/d	60b/d
Third Flower	30 Jan	96a/d	97a/d	67b/d	59b/d
	20 Feb	96a/d	94a/d	69b/d	60b/d
		Plant Height (cm)			
First Flower	30 Jan	36.8a/d	28.9b/d	39.3a/d	21.4c/d
	20 Feb	37.2a/d	27.0b/d	34.6a/d	21.8b/d
Second Flower	30 Jan	38.4a/d	31.6b/d	43.5a/d	29.2b/d
	20 Feb	39.8a/d	30.1b/d	38.5a/e	25.2b/d
Third Flower	30 Jan	37.5a/d	35.2a/d	47.8b/d	30.2a/d
	20 Feb	38.6a/d	29.3b/e	38.7a/e	28.3b/d
		Flower Longevity (Days)			
First Flower	30 Jan	8.9a/d	8.6ab/d	7.3ab/d	6.7b/d
	20 Feb	9.1a/d	10.7a/e	8.7ab/d	6.9b/d
Second Flower	30 Jan	8.7a/d	9.1a/d	7.8ab/d	6.2b/d
	20 Feb	8.7a/d	9.0a/d	8.7a/d	7.6a/e
Third Flower	30 Jan	7.5a/d	10.3b/d	7.4a/d	6.4a/d
	20 Feb	7.2a/d	9.3b/d	9.2b/e	7.6ab/d

Table 13.--Continued.

PLANT ORGAN EVALUATED	PLANTING DATE	DAY/NIGHT TEMPERATURES °C[x] 27/12	27/16	29/17	29/22
		Diameter (cm)			
First Flower	30 Jan	11.8ab/d	12.2a/d	12.4a/d	11.2b/d
	20 Feb	12.4a/e	13.0a/e	11.0b/e	10.6b/e
Second Flower	30 Jan	11.4a/d	12.6b/d	11.3a/d	10.4a/d
	20 Feb	12.3a/e	11.3b/e	10.2c/e	9.9c/d
Third Flower	30 Jan	11.5ab/d	12.2a/d	10.9b/d	10.6b/d
	20 Feb	11.7a/d	10.6b/e	10.1b/e	9.6b/e
		Number of Shoots Per Plant			
Major Shoots	30 Jan	1.3a/d	1.5ab/d	2.0ab/d	1.9ab/d
	20 Feb	1.3a/d	1.4a/d	1.3a/e	1.6a/d
Minor Shoots	30 Jan	1.4a/d	0.6a/d	0.6a/d	0.6a/d
	20 Feb	1.6a/d	0.8a/d	0.7a/d	0.7a/d
Total Shoots	30 Jan	2.7a/d	2.1a/d	2.6a/d	2.6a/d
	20 Feb	2.9a/e	2.2a/d	1.9a/d	2.3a/d
		Number of Flowers and Buds Per Plant			
Total Flowers and Buds	30 Jan	6.6a/d	6.3a/d	10.5b/d	10.0b/d
	20 Feb	6.7a/d	3.3b/e	5.1ab/e	7.3a/e

[x]Means followed by the same letter preceding the slash (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per date and parameter determined separately). Means followed by the same letter following the slash (d,e) are not significantly different by Tukey's test at .05 for pairs in columns (each organ per treatment and parameter determined separately).

and 'Park Princess', respectively due to the lower night temperature since the day temperatures were approximately equal.

The delaying effects of the lowered night temperature was demonstrated by the 27/16°C treatment in which flowering averaged 78 and 86 days for 'Kolchelsee' and 'Park Princess', respectively. The greatest delay in flowering occurred with the 27/12°C treatment. This showed the retarding effect of the lowest minimum night temperature since the average day temperature approximately equalled that of two other treatments. Since there was no effect of planting date, the minimum days to flower at each temperature was probably due to the higher day temperature.

Plant heights of 'Park Princess' at 27/16°C averaged 30.3 cm. This was significantly less than 39.2 cm at 27/12°C or 34 cm at the 29/17°C treatment. Likewise, plant heights of 'Kolchelsee' at 27/16°C averaged 34 cm and this was significantly less than 43.4 cm at 27/12°C or 37 cm at the 29/17°C treatments.

Flower diameters, flower longevity, and the number of shoots, flowers and buds per plant were only minimally affected by these temperatures or planting dates.

The 29/22°C treatment was suboptimal for forcing both cultivars because of the adverse effects noted. The flower diameters were decreased, plant heights and leaf areas were reduced, and the foliage had a chlorotic condition.

Since the dahlia, like the Easter lily and bulbous *Iris*, does not have differentiated flower parts at planting time, temperature treatments applied from the data of potting to flowering would affect the rates of differentiation, development of floral organs and the rate of vegetative growth. The promotion of flowering in the dahlia by increasing day and/or night temperatures has been similarly demonstrated with both the 'Ace' and 'Croft' Easter lilies as well as with several cultivars of *Iris hollandica*. In practice, temperatures could be temporarily raised or lowered to either accelerate or delay crop development in order to meet the market demand.

In dahlias, the best height control was produced with the 27/16°C treatment. With the 29/17°C treatment, plants were too tall to be acceptable. This response had been similarly reported with 'Ace' lilies (Roh and Wilkins, 1973) and *Iris* 'Wedgewood' (Fortanier and Zevenbergen, 1973).

The increases in height of dahlias at flowering may be due to more rapid vegetative growth at the higher day and night temperatures prior to the application of ancymidol. Thus, regardless of planting date, it appears that ancymidol must be applied before shoots exceed 3 cm if good height control is to be obtained.

Effects of Light Intensity

Light intensity treatments markedly affected the height of plants of both cultivars in 1975 and 1976 (Tables 14, 15, 16, and 17). Plants grown under 50% of the natural light intensity were 10 and 11 cm taller than those grown under the 75 or 100% levels, respectively.

In both years, heights of 'Kolchelsee' of the second planting date averaged 10 cm taller than those of the first planting date. Heights of 'Park Princess' however, were not significantly different with the two planting dates.

In 1975, the 50 and 75% light intensity treatments promoted the opening of first flowers of 'Kolchelsee' by 13 and 10 days earlier than the 100% light intensity treatment of the first planting date. However, in 1976, there were no differences due to treatments or planting dates. The 50% light intensity treatment also delayed the opening of first flowers of 'Park Princess' by 8 and 4 days at the respective planting dates in 1975, but in 1976 delayed opening by 5 days only of the first planting date.

With 'Park Princess' flower longevity was increased under the 50% light intensity level in 1976. Also, in 1976, longevity was increased of the second planting date for both cultivars.

At the 50% level, 'Park Princess' had a reduced number of flowers and buds, but an increased number of shoots. Flower diameter was unchanged by treatments.

Table 14.--Effect of light intensity on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Kolchelsee'. Tuberous-roots were planted in 1975.

PLANT ORGAN EVALUATED	PLANTING DATE	LIGHT INTENSITY TREATMENTS %[x] 100	75	50
		Days to Flower		
First Flower	30 Jan	86a/d	76b/d	73b/d
	20 Feb	68a/e	69a/e	64a/e
Second Flower	30 Jan	94a/d	89a/d	87a/d
	20 Feb	75a/e	76a/e	73a/e
Third Flower	30 Jan	101a/d	97a/d	96a/d
	20 Feb	78a/e	80a/e	78a/e
		Plant Height (cm)		
First Flower	30 Jan	28.9a/d	37.6a/d	37.8b/d
	20 Feb	39.9a/e	43.3a/e	43.2a/d
Second Flower	30 Jan	36.9a/d	34.0a/d	51.5b/d
	20 Feb	44.3a/e	48.5ab/e	52.7b/d
Third Flower	30 Jan	37.5a/d	39.2a/d	58.7b/d
	20 Feb	46.5a/e	51.7ab/e	54.4b/d
		Flower Longevity (Days)		
First Flower	30 Jan	7.0a/d	6.7a/d	8.2a/d
	20 Feb	7.4a/d	6.4a/d	7.0a/d
Second Flower	30 Jan	6.3a/d	6.8a/d	7.1a/d
	20 Feb	7.0a/d	6.9a/d	7.6a/d
Third Flower	30 Jan	6.3a/d	7.1a/d	7.4a/d
	20 Feb	6.8a/d	7.0a/d	7.3a/d

Table 14.--Continued.

PLANT ORGAN EVALUATED	PLANTING DATE	LIGHT INTENSITY TREATMENTS %[x]		
		100	75	50
		Diameter (cm)		
First Flower	30 Jan	5.7a/d	5.8a/d	5.9a/d
	20 Feb	6.3a/d	6.6a/d	5.8a/d
Second Flower	30 Jan	5.5a/d	5.8a/d	5.6a/d
	20 Feb	5.9a/d	6.0a/d	5.8a/d
Third Flower	30 Jan	5.7a/d	5.6a/d	5.6a/d
	20 Feb	6.2a/d	6.0a/d	5.6a/d
		Number of Shoots Per Plant		
Major Shoots	30 Jan	1.5a/d	1.3a/d	1.3a/d
	20 Feb	1.8a/d	1.3a/d	1.4a/d
Minor Shoots	30 Jan	1.3a/d	0.5a/d	0.6a/d
	20 Feb	0.5a/d	0.2a/d	0.4a/d
Total Shoots	30 Jan	2.8a/d	1.7a/d	1.9a/d
	20 Feb	2.3a/d	1.5a/d	1.8a/d

[x]Means followed by the same letter preceding the slash (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per date and parameter determined separately). Means followed by the same letter following the slash (d,e) are not significantly different by Tukey's test at .05 for pairs in columns (each organ per treatment and parameter determined separately).

Table 15.--Effect of light intensity on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Park Princess'. Tuberous-roots were planted in 1975.

PLANT ORGAN EVALUATED	PLANTING DATE	LIGHT INTENSITY TREATMENTS %^{x} 100	75	50
		Days to Flower		
First Flower	30 Jan	69a/d	69a/d	77b/d
	20 Feb	67a/d	74b/d	71ab/d
Second Flower	30 Jan	77a/d	75a/d	83a/d
	20 Feb	75a/d	81a/d	80a/d
Third Flower	30 Jan	80a/d	79a/d	91b/d
	20 Feb	78a/d	83a/d	86a/d
		Plant Height (cm)		
First Flower	30 Jan	30.3a/d	32.6a/d	40.9b/d
	20 Feb	30.1a/d	31.5a/d	42.8b/d
Second Flower	30 Jan	32.3a/d	35.2a/d	46.7b/d
	20 Feb	37.1a/d	36.4a/d	48.7b/d
Third Flower	30 Jan	36.5a/d	38.7a/d	52.1b/d
	20 Feb	38.1a/d	37.8a/d	52.5b/d
		Flower Longevity (Days)		
First Flower	30 Jan	7.1a/d	7.7a/d	7.9a/d
	20 Feb	7.7a/d	8.7a/d	6.9a/d
Second Flower	30 Jan	6.7a/d	7.2a/d	7.4a/d
	20 Feb	7.7a/e	8.2a/e	7.9a/d
Third Flower	30 Jan	7.5a/d	6.1a/d	7.6a/d
	20 Feb	8.3a/d	7.4a/d	7.7a/d

Table 15.--Continued.

PLANT ORGAN EVALUATED	PLANTING DATE	LIGHT INTENSITY TREATMENTS %[x] 100	75	50
		Diameter (cm)		
First Flower	30 Jan	12.1a/d	11.8a/d	12.1a/d
	20 Feb	12.4a/d	12.2a/d	12.2a/d
Second Flower	30 Jan	11.3a/d	11.1a/d	11.3a/d
	20 Feb	11.6a/d	11.5a/d	11.7a/d
Third Flower	30 Jan	11.6a/d	11.6a/d	11.7a/d
	20 Feb	11.4a/d	11.9a/d	11.6a/d
		Number of Shoots Per Plant		
Major Shoots	30 Jan	2.1a/d	1.7a/d	1.9a/d
	20 Feb	1.5a/d	2.0ab/d	2.3b/d
Minor Shoots	30 Jan	1.3a/d	0.7a/d	1.1a/d
	20 Feb	0.7a/d	1.2a/d	1.4a/d
Total Shoots	30 Jan	2.3a/d	1.5a/d	1.8a/d
	20 Feb	2.2a/d	3.2ab/d	3.7b/d

[x]Means followed by the same letter preceding the slash (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per date and parameter determined separately). Means followed by the same letter following the slash (d,e) are not significantly different by Tukey's test at .05 for pairs in columns (each organ per treatment and parameter determined separately).

Table 16.--Effect of light intensity on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Kolchelsee'. Tuberous-roots were planted in 1976.

PLANT ORGAN EVALUATED	PLANTING DATE	LIGHT INTENSITY TREATMENTS %[x] 100	75	50
			Days to Flower	
First Flower	30 Jan	65a/d	66a/d	66a/d
	20 Feb	66ab/d	64a/d	68b/d
Second Flower	30 Jan	70a/d	72a/d	73a/d
	20 Feb	72a/d	70a/d	73a/d
Third Flower	30 Jan	74a/d	74a/d	80a/d
	20 Feb	75a/d	72a/d	78a/d
			Plant Height (cm)	
First Flower	30 Jan	29.8a/d	34.5ab/d	40.4b/d
	20 Feb	35.2a/d	35.7a/d	52.6b/e
Second Flower	30 Jan	34.9a/d	38.1a/d	47.2b/d
	20 Feb	43.3a/e	40.3a/d	52.3b/d
Third Flower	30 Jan	38.1a/d	41.9ab/d	47.4b/d
	20 Feb	46.6a/e	45.5a/d	62.8b/e
			Flower Longevity (Days)	
First Flower	30 Jan	6.6a/d	7.3a/d	6.6a/d
	20 Feb	7.0a/d	6.8a/d	7.9a/e
Second Flower	30 Jan	6.0a/d	6.6a/d	6.3a/d
	20 Feb	7.8a/e	8.0a/e	7.7a/e
Third Flower	30 Jan	6.1a/d	6.1a/d	6.6a/d
	20 Feb	8.0a/e	8.1a/e	8.2a/e

Table 16.--Continued.

PLANT ORGAN EVALUATED	PLANTING DATE	LIGHT INTENSITY TREATMENTS %[x] 100	75	50
		Diameter (cm)		
First Flower	30 Jan	6.3a/d	6.3a/d	6.2a/d
	20 Feb	6.1a/d	6.0a/d	5.9a/d
Second Flower	30 Jan	6.1a/d	5.7a/d	5.6a/d
	20 Feb	5.8a/d	5.6a/d	5.9a/d
Third Flower	30 Jan	6.0a/d	5.9a/d	5.6a/d
	20 Feb	5.8a/d	5.6a/d	5.8a/d
		Number of Shoots Per Plant		
Major Shoots	30 Jan	1.7a/d	1.4a/d	1.3a/d
	20 Feb	1.3a/e	1.7a/d	1.5a/d
Minor Shoots	30 Jan	0.8a/d	0.9a/d	1.0a/d
	20 Feb	0.4a/d	0.4a/d	0.2a/e
Total Shoots	30 Jan	2.6a/d	2.3a/d	2.4a/d
	20 Feb	1.7a/d	2.0a/d	1.7a/d
		Number of Flowers and Buds Per Plant		
Total Flowers and Buds	30 Jan	7.5a/d	7.0a/d	8.0a/d
	20 Feb	9.0a/d	8.5a/d	6.9a/d

[x]Means followed by the same letter preceding the slash (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per date and parameter determined separately). Means followed by the same letter following the slash (d,e) are not signigicantly different by Tukey's test at .05 for pairs in columns (each organ per treatment and parameter determined separately).

Table 17.--Effect of light intensity on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Park Princess'. Tuberous-roots were planted in 1976.

PLANT ORGAN EVALUATED	PLANTING DATE	LIGHT INTENSITY TREATMENTS %[x] 100	75	50
		Days to Flower		
First Flower	30 Jan	70a/d	70a/d	75b/d
	20 Feb	66a/e	66a/e	68a/e
Second Flower	30 Jan	74a/d	74a/d	79a/d
	20 Feb	71a/d	73a/d	74a/d
Third Flower	30 Jan	76ab/d	75a/d	82b/d
	20 Feb	73a/d	76a/d	78a/d
		Plant Height (cm)		
First Flower	30 Jan	41.4a/d	38.7a/d	56.5b/d
	20 Feb	32.4a/e	38.4a/d	57.9b/d
Second Flower	30 Jan	44.8a/d	43.7a/d	58.8b/d
	20 Feb	36.5a/e	42.8a/d	60.0b/d
Third Flower	30 Jan	47.9a/d	45.4a/d	62.4b/d
	20 Feb	37.9a/e	44.3b/d	65.4c/d
		Flower Longevity (Days)		
First Flower	30 Jan	6.9a/d	6.1a/d	8.2b/d
	20 Feb	7.8a/d	8.9ab/e	9.3b/e
Second Flower	30 Jan	6.6a/d	6.5a/d	7.6a/d
	20 Feb	7.7a/e	8.3ab/e	9.1b/e
Third Flower	30 Jan	6.9a/d	7.0a/d	7.7a/d
	20 Feb	7.4a/d	8.4a/e	8.3a/e

Table 17.--Continued.

PLANT ORGAN EVALUATED	PLANTING DATE	LIGHT INTENSITY TREATMENTS %[x] 100	75	50
		Diameter (cm)		
First Flower	30 Jan	12.3a/d	12.5a/d	12.3a/d
	20 Feb	12.4a/d	12.7a/d	12.3a/d
Second Flower	30 Jan	11.8a/d	11.9a/d	11.8a/d
	20 Feb	11.5a/d	11.7a/d	11.7a/d
Third Flower	30 Jan	11.0a/d	11.7a/d	11.5a/d
	20 Feb	11.5a/d	11.4a/d	11.5a/d
		Number of Shoots Per Plant		
Major Shoots	30 Jan	1.9a/d	2.2a/d	1.9a/d
	20 Feb	1.5a/d	1.3a/e	1.6a/d
Minor Shoots	30 Jan	0.5a/d	0.5a/d	0.6a/d
	20 Feb	0.6a/d	0.4a/d	0.8a/d
Total Shoots	30 Jan	2.4a/d	2.7a/d	2.6a/d
	20 Feb	2.0a/d	1.6a/e	2.4a/d
		Number of Flowers and Buds Per Plant		
Total Flowers and Buds	30 Jan	9.4a/d	10.1a/d	7.3b/d
	20 Feb	8.3a/d	5.7b/e	6.8ab/d

[x]Means followed by the same letter preceding the slash (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per date and parameter determined separately). Means followed by the same letter following the slash (d,e) are not significantly different by Tukey's test at .05 for pairs in columns (each organ per treatment and parameter determined separately).

The increased heights of forced dahlias with lowered light intensities confirms the findings of Biran and Halevy (1973a) who reported increased internodal length of stock plants of 'Orpheo' with 50 and 28% light levels. Similarly, plant heights of both 'Ace' and 'Georgia' Easter lilies have been increased with lowered light levels (Kohl and Nelson, 1963; Einert and Box, 1967). Heights of 'Ace' lilies had been increased 14 cm by a 500 ft candle level while heights of 'Georgia' lilies were increased 5.9 and 8.9 cm with 75 and 50% light levels.

The height increase of 'Kolchelsee' due to the second planting date had also been noted by De Hertogh, Blakely and Szlachetka, (1976) and may reflect the seasonal increase in solar radiation and calories (Tables 3 and 4). Thus, for a later planting date of 'Kolchelsee' the application of ancymidol may be needed earlier to achieve proper height control or the rate may have to be increased.

In other crops, the number of flowers per plant has also been affected by lowered light levels. With a 50% light level, the reduced number of flowers and buds as seen in 'Park Princess' (Table 17) was similar to that reported by Einert and Box (1967) with 'Georgia' lilies. In _Gladiolus_ 'Sans Souci' and 'Dr. Fleming' decreases in flowering to 64 and 25% were reported with 25 and 20% light levels (Shillo and Halevy, 1976a).

The delay in flowering at the 50% light level (Table 14, 15, and 17) probably reflects an overall reduction in the photosynthetic rate of these plants. The promotion of flowering in both cultivars during the 1976 forcing period was an indicator of the yearly variation in light and temperature conditions at the forcing location as well as the year to year variation in plant material due to production conditions. Obviously, these conditions will interact.

Increases in flower longevity of the second planting date may reflect seasonal promotion of vigorous growth (Tables 15, 16 and 17).

The increase in the number of shoots at the 50% light level would have no commercial value since plant height was unacceptable (Table 15).

Effects of Photoperiod

The greatest significant differences in all plant parameters were obtained with the continuous treatments of natural daylength, 4 hour night break, or 16 hour photoperiods in both 1975 and 1976 (Tables 18, 19, 20 and 21) as well as with the combination treatments in 1976 (Tables 20 and 21). In all these treatments, 100% of the plants flowered.

With the 8 hour photoperiod in 1975 (Table 18) 0 and 40% of 'Kolchelsee' flowered of the first and second planting dates respectively, while in the one planting date in 1976, 0% flowered (Table 20). Flowering of 'Park Princess' was affected to a lesser extent by the eight hour treatment (Table 19) with 26 and 60% forming flowers of the

Table 18.--Effect of photoperiod on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Kolchelsee'. Tuberous-roots were planted in 1975.

PLANT ORGAN EVALUATED	PLANTING DATE	PHOTOPERIOD TREATMENTS[x] Natural Day	8 Hour[y]	16 Hour	4 Hour Night Break
		Days to Flower			
First Flower	30 Jan	68a/d	-	72a/d	74a/d
	20 Feb	64a/d	88.3b(40%)	67ac/d	73c/d
Second Flower	30 Jan	75a/d	-	81ab/d	84b/d
	20 Feb	69a/e	-	72a/e	82b/d
Third Flower	30 Jan	79a/d	-	86a/d	82a/d
	20 Feb	72a/d	-	78ab/d	85b/d
		Plant Height (cm)			
First Flower	30 Jan	25.8a/d	-	26.2a/d	26.3a/d
	20 Feb	32.6a/e	16.5b(40%)	31.4a/e	28.7a/d
Second Flower	30 Jan	29.5a/d	-	31.9b/d	32.9b/d
	20 Feb	35.7a/e	-	33.0ab/d	30.9b/d
Third Flower	30 Jan	33.5a/d	-	35.4a/d	34.8a/d
	20 Feb	38.0a/e	-	37.1a/d	33.2b/d
		Flower Longevity (Days)			
First Flower	30 Jan	6.9a/d	-	7.7a/d	8.3a/d
	20 Feb	6.3a/d	4.2b(40%)	6.3a/d	6.6a/e
Second Flower	30 Jan	6.9a/d	-	7.6a/d	6.7a/d
	20 Feb	6.0a/d	-	7.5a/d	7.1a/d
Third Flower	30 Jan	6.9a/d	-	7.2a/d	7.4a/d
	20 Feb	6.9a/d	-	7.4a/d	6.8a/d

Table 18.--Continued.

PLANT ORGAN EVALUATED	PLANTING DATE	PHOTOPERIOD TREATMENTS[x] Natural Day	8 Hour[y]	16 Hour	4 Hour Night Break
		Diameter (cm)			
First Flower	30 Jan	5.9a/d	-	5.8a/d	5.9a/d
	20 Feb	6.3a/d	5.2b(40%)	6.2a/d	6.2a/d
Second Flower	30 Jan	5.6a/d	-	5.7a/d	5.9a/d
	20 Feb	5.9a/d	-	5.9a/d	5.9a/d
Third Flower	30 Jan	5.6a/d	-	5.9a/d	5.8a/d
	20 Feb	5.6a/d	-	5.9a/d	5.8a/d
		Number of Shoots Per Plant			
Major Shoots	30 Jan	1.6a/d	1.2a/d	1.7a/d	1.6a/d
	20 Feb	1.5a/d	1.8a/d	1.6a/d	1.7a/d
Minor Shoots	30 Jan	1.1a/d	0.8a/d	1.1a/d	0.9a/d
	20 Feb	0.5a/d	0.5a/d	0.3a/d	0.3a/d
Total Shoots	30 Jan	2.7a/d	1.8a/d	2.8a/d	2.5a/d
	20 Feb	2.0a/d	2.3a/d	1.9a/d	2.0a/d

[x]Means followed by the same letter preceding the slash (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per date and parameter determined separately). Means followed by the same letter following the slash (d,e) are not significantly different by Tukey's test at .05 for pairs in columns (each organ per treatment and parameter determined separately).

[y]Maximum percent of the plants flowering is given.

Table 19.--Effect of photoperiod on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Park Princess'. Tuberous-roots were planted in 1975.

PLANT ORGAN EVALUATED	PLANTING DATE	PHOTOPERIOD TREATMENTS[x]			
		Natural Day	8 Hour[y]	16 Hour	4 Hour Night Break
		Days to Flower			
First Flower	30 Jan	71a/d	54b/d(26%)	82c/d	82c/d
	20 Feb	68a/d	51b/d(60%)	75c/d	74c/d
Second Flower	30 Jan	78a/d	-	89b/d	88b/d
	20 Feb	75a/d	63b(60%)	83c/e	83c/e
Third Flower	30 Jan	82a/d	-	90ab/d	99b/d
	20 Feb	78a/d	-	90a/d	89a/d
		Plant Height (cm)			
First Flower	30 Jan	31.2a/d	24.3b/d(26%)	27.0ab/d	27.2ab/d
	20 Feb	30.1ab/d	29.0ab/e(60%)	31.9a/e	25.7b/d
Second Flower	30 Jan	34.1a/d	-	32.9a/d	32.6a/d
	20 Feb	37.1a/d	34.0a/b(60%)	35.7a/d	29.6b/d
Third Flower	30 Jan	36.3a/d	-	34.3a/d	35.0a/d
	20 Feb	38.1a/d	-	40.7a/e	33.7b/d
		Flower Longevity (Days)			
First Flower	30 Jan	9.4a/d	6.2b/d(26%)	7.9ac/d	7.3c/d
	20 Feb	7.7ab/e	6.6a/d(60%)	8.3ab/d	8.7b/d
Second Flower	30 Jan	7.9a/d	-	7.7a/d	8.2a/d
	20 Feb	7.7a/d	7.0a(60%)	8.2a/d	8.9a/d
Third Flower	30 Jan	7.0a/d	-	8.3a/d	8.3a/d
	20 Feb	8.3a/d	-	6.5a/e	6.4a/e

Table 19.--Continued.

PLANT ORGAN EVALUATED	PLANTING DATE	PHOTOPERIOD TREATMENTS[x] Natural Day	8 Hour[y]	16 Hour	4 Hour Night Break
		Diameter (cm)			
First Flower	30 Jan	11.7a/d	10.1b/d(26%)	13.4c/d	14.3c/d
	20 Feb	12.4a/e	11.1b/e(60%)	13.6c/d	13.0ac/d
Second Flower	30 Jan	11.4a/d	-	13.3b/d	13.4b/d
	20 Feb	11.6a/d	10.3b(60%)	12.5ac/d	13.2c/d
Third Flower	30 Jan	11.3a/d	-	12.7b/d	13.0b/d
	20 Feb	11.4a/d	-	12.4b/d	12.1ab/e
		Number of Shoots Per Plant			
Major Shoots	30 Jan	1.9a/d	1.5a/d	2.0a/d	1.9a/d
	20 Feb	1.5ab/d	1.0b/d	1.9a/d	1.9a/d
Minor Shoots	30 Jan	1.0a/d	0.5a/d	0.8a/d	1.0a/d
	20 Feb	0.7a/d	0.6a/d	2.3b/e	0.8a/d
Total Shoots	30 Jan	2.9a/d	2.0a/d	2.8a/d	2.9a/d
	20 Feb	2.2ab/d	1.6b/d	3.2a/d	2.7a/d

[x]Means followed by the same letter preceding the slash (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per date and parameter determined separately). Means followed by the same letter following the slash (d,e) are not significantly different by Tukey's test at .05 for pairs in columns (each organ per treatment and parameter determined separately).

[y]Maximum percent of the plants flowering is given.

Table 20.--Effect of photoperiod of the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Kolchelsee'. Tuberous-roots were planted on 9 February, 1976.

PLANT ORGAN EVALUATED	PHOTOPERIOD TREATMENTS[x]							
	Natural Day (ND)	8 Hour[y]	16 Hour	4 Hour Night Break	4 HR-ND	16 HR-ND	ND-4HR	ND-16HR
	Days to Flower							
First Flower	65ab	-	67ab	72b	69ab	64a	64a	65ab
Second Flower	72a	-	75a	78a	76a	70a	72a	72a
Third Flower	74ab	-	81ab	84a	79ab	72b	75ab	78ab
	Plant Height (cm)							
First Flower	31.3a	-	32.6a	32.2a	36.3a	35.4a	35.1a	33.4a
Second Flower	36.3a	-	37.5a	35.2a	40.3a	38.9a	35.8a	39.9a
Third Flower	30.0a	-	39.8a	40.3a	43.6a	40.2a	41.8a	42.9a
	Flower Longevity (Days)							
First Flower	5.8a	-	6.3ab	7.6b	6.9ab	6.0a	6.0a	5.6a
Second Flower	6.0a	-	7.7a	7.4a	6.6a	5.9a	6.2a	6.4a
Third Flower	5.6a	-	8.7a	8.2a	7.4a	6.4a	6.9a	7.5a

Table 20.--Continued

PLANT ORGAN EVALUATED	PHOTOPERIOD TREATMENTS[x] Natural Day (ND)	8 Hour[y]	16 Hour	4 Hour Night Break	4 HR-ND	16 HR-ND	ND-4HR	ND-16HR
	Diameter (cm)							
First Flower	5.9a	-	6.0a	6.2	5.9a	6.1a	6.1a	6.3a
Second Flower	5.8a	-	5.7a	6.0a	5.8a	5.7a	5.6a	5.7a
Third Flower	5.8a	-	5.6a	5.7a	5.7a	5.8a	5.8a	5.6a
	Number of Shoots Per Plant							
Major Shoots	1.7ab	1.7ab	1.5ab	1.7ab	1.7ab	1.8a	1.6ab	1.1b
Minor Shoots	0.9a	0.6a	0.8a	1.3a	1.3a	0.6a	1.1a	0.9a
Total Shoots	2.7a	2.3a	2.4a	3.0a	3.0a	2.4a	2.7a	2.1a
	Number of Flowers and Buds Per Plant							
Total Flowers and Buds	8.6a	-	7.8a	7.1a	9.3a	8.0a	7.9a	8.4a

[x]Means followed by the same letter (a,b,c,d) are not significantly different by Tukey's test at .05 for single rows (each organ per parameter determined separately).

[y]None of the plants flowered.

Table 21.--Effect of photoperiod on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Park Princess'. Tuberous-roots were planted on 9 February, 1976.

PLANT ORGAN EVALUATED	PHOTOPERIOD TREATMENTS[x]							
	Natural Day (ND)	8 Hour[y]	16 Hour	4 Hour Night Break	4 HR-ND	16 HR-ND	ND-4HR	ND-16HR
	Days to Flower							
First Flower	68a	56(78%)b	70a	71a	71a	72a	69a	71a
Second Flower	74a	60(57%)b	75a	79a	77a	74a	74a	79a
Third Flower	77a	64(7%)b	80a	84a	80a	79a	79a	83a
	Plant Height (cm)							
First Flower	30.8a	34.0(78%)a	29.1a	32.8a	30.7a	30.9a	31.7a	32.9a
Second Flower	34.3a	35.5(57%)a	32.9a	37.5a	35.8a	33.9a	36.8a	37.7a
Third Flower	37.8a	34.0(7%)a	36.1a	39.1a	36.9a	37.6a	41.0a	40.7a
	Flower Longevity (Days)							
First Flower	8.5a	5.8(78%)b	9.0a	9.4a	8.2a	8.9a	9.0a	8.4a
Second Flower	8.9a	5.0(57%)b	9.9a	9.5a	8.8a	9.7a	9.2a	8.8a
Third Flower	8.3a	3.0(7%)b	9.4a	9.2a	8.4a	9.1a	8.7a	8.7a

Table 21.--Continued.

PLANT ORGAN EVALUATED	PHOTOPERIOD TREATMENTS[x]							
	Natural Day (ND)	8 Hour[y]	16 Hour	4 Hour Night Break	4 HR-ND	16 HR-ND	ND-4HR	ND-16HR
	Diameter (cm)							
First Flower	12.5ab	12.0(78%)a	13.7b	13.4b	13.5b	13.4b	13.2ab	13.1ab
Second Flower	12.7a	10.4(57%)b	12.6a	12.5a	12.6a	12.9a	12.9a	12.3a
Third Flower	12.2a	11.0(7%)b	12.3a	12.8a	12.4a	11.9a	12.1a	12.5a
	Number of Shoots Per Plant							
Major Shoots	1.5a	1.4a	2.2b	2.1b	1.9ab	1.9ab	1.8ab	1.7ab
Minor Shoots	0.5a	0.8a	0.3a	0.4a	0.6a	0.7a	0.5a	0.5a
Total Shoots	2.0a	2.2a	2.5a	2.5a	2.5a	2.6a	2.3a	2.2a
	Number of Flowers and Buds Per Plant							
Total Flowers and Buds	7.3a	1.6b	8.2a	7.5a	7.7a	8.6a	7.7a	7.5a

[x]Means followed by the same letter (a,b,c,) are not significantly different by Tukey's test at .05 for single rows (each organ per parameter determined separately).

[y]Maximum percent of the plants flowering is given.

respective planting dates in 1975. In 1976 (Table 21) 78, 57, and 7% of the plants formed first, second, and third flowers respectively. The increases in percent flowering from the first to second planting date and from 1975 to 1976 reflect variation in forcing conditions and/or plant material.

Under the 8 hour photoperiod, flowers opened 17 days earlier than under natural daylength conditions but were abnormal, having a single row of ray florets with 'open-eye' centers. Plant height, flower longevity, flower diameter, and the number of flowers and buds per plant were significantly decreased by this treatment and vegetative growth was severely retarded.

Plants of 'Kolchelsee' and 'Park Princess' under the natural daylength treatment flowered in 68 and 71 days in 1975 (Tables 18 and 19) and in 1976 (Tables 20 and 21) in 65 and 68 days for the respective cultivars.

Flowering was delayed in plants grown under the 16 hour photoperiod, 4 hour night break, and some of the treatments which combined these regimes with the natural daylength photoperiod. The mean delay in flowering was six days for 'Kolchelsee' and seven days for 'Park Princess'. Flower longevity was also increased in both cultivars but flower diameters of only 'Park Princess' were increased. Means for plant height, the number of shoots, and the number of flowers and buds per plant were not different.

Previous investigators had reported that photoperiods of natural daylength, short days, and long days affected the flowering stage of dahlias (Zimmerman and Hitchcock, 1929, Maatsch and Rünger, 1954, Yasuda and Yokoyama, 1959). However, since the locations of the experiments and the particular seasonal conditions prevailing had altered the natural daylength in each experiment, it is difficult to make direct comparisons of the results. Their experiments showed however, that there were great cultivar differences in responses to the various photoperiods. Also, since their plants had originated from seeds, cuttings, or tuberous-roots, this factor affected the responses.

Since flower initiation is completed within three weeks after the planting of the tuberous-roots (Krijthe, 1938), effects of photoperiod on bud initiation and development were determined using continuous treatments from the time of planting. Photoperiod conditions applied after the first three weeks of growth and continued until flowering would primarily affect floral development. Since 'Kolchelsee' and 'Park Princess' formed floral buds under all the photoperiod treatments, it was apparent that the critical daylength for bud initiation in these cultivars must be less than eight hours. Floral development, however, was primarily affected by the photoperiod treatments.

The adverse effects of the eight hour photoperiod on the flowering stage of 'Kolchelsee' and 'Park Princess' with reduced flowering, abnormal floral development, and retarded vegetative growth has been similarly reported with tuberous-rooted dahlias of 'Broeder Justinus' and 'Finesse Anversoise' with 8-11 hour photoperiods (Maatsch and Rünger, 1954).

The increased percent of flowering of the second planting date during the 8 hour photoperiod reflected the seasonal increase in light and energy levels during the restricted hours (Tables 3 and 4). Konishi and Inaba (1966) reported a similar increase from 35% flowering in 'Akane' with a 12 hour photoperiod in the autumn compared to 70% flowering in the spring with the same photoperiod. The role of short day conditions in promoting tuberization of many dahlia cultivars has been well established (Zimmerman and Hitchcock, 1929, Moser and Hess, 1968), and it is directly antagonistic to the vegetative growth stage (Moser and Hess, 1968). Similarly the flowering stage is greatly affected.

Abnormal flower development in 'Park Princess' seen with the 8 hour photoperiod was similarly reported in 'Newby' and 'Chorus Girl' with short day conditions in January and February (Canham, 1969) and in 'Finesse Anversoise' receiving photoperiods of 11 hours or shorter (Maatsch and Rünger, 1954). For 'Park Princess' the critical daylength for normal flower development must exceed 8 hours.

The delayed flowering of 'Kolchelsee' and 'Park Princess' under long day type treatments has been reported for 'John Erlich' grown under a 16 hour photoperiod (Zimmerman and Hitchcock, 1929). Flowering of seedlings of 'Unwin' and 'Coltness' were similarly delayed by daylengths exceeding 14 1/2 hours (Botacchi, 1958), while 'Broeder Justinus' and 'Finesse Anversoise' were delayed an average of 20 days with a 14 hour photoperiod (Maatsch and Rünger, 1954).

Although cultivar response varied, treatments of natural daylength exceeding at least 10 hours at planting appear adequate for forcing. Adequate vegetative growth and rapid flowering can be obtained.

Effects of Hydrogel

For both cultivars, forcing parameters were not greatly affected by the hydrogel treatments (Tables 22 and 23) and there were no adverse effects. At maturity, the plants required increased amounts of water and both rates of hydrogel were adequate to prevent the afternoon wilting that was normally observed.

Perhaps, hydrogel could be effective in increasing the shelf life of plants during shipping and marketing. Treatments could increase the amount of time between applications of water by consumers, but these effects were not determined.

Table 22.--Effect of hydrogel on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Kolchelsee'. Tuberous-roots were planted on 4 February, 1975.

PLANT ORGAN EVALUATED	HYDROGEL TREATMENTS (GRAMS PER CUBIC FT.)[x]		
	0	339.6	226.4
	Days to Flower		
First Flower	65a	68a	66a
Second Flower	72a	79b	73ab
Third Flower	80a	86b	81ab
	Plant Height (cm)		
First Flower	26.2a	25.2a	27.3a
Second Flower	29.8a	29.5a	31.2a
Third Flower	33.8a	32.7a	34.1a
	Flower Longevity (Days)		
First Flower	7.0a	7.1ab	7.6b
Second Flower	6.9a	7.7b	7.3ab
Third Flower	6.3a	7.2a	6.9a
	Diameter (cm)		
First Flower	6.0a	5.9a	6.1a
Second Flower	5.7a	5.7a	6.0a
Third Flower	5.9a	5.8a	6.0a
	Number of Shoots Per Plant		
Major Shoots	1.5a	1.7a	1.5a
Minor Shoots	0.7a	1.1a	0.7a
Total Shoots	2.1a	2.7a	2.2a

[x]Means followed by the same letter (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per parameter determined separately).

Table 23.--Effect of hydrogel on the number of days to flower, plant height, flower longevity, and diameter of the first three flowers and number of shoots produced per plant of 'Park Princess'. Tuberous-roots were planted on 4 February, 1975.

PLANT ORGAN EVALUATED	HYDROGEL TREATMENTS (GRAMS PER CUBIC FT.)[x]		
	0	339.6	226.4
	Days to Flower		
First Flower	76a	72a	74a
Second Flower	80ab	76a	83b
Third Flower	85ab	82a	88b
	Plant Height (cm)		
First Flower	31.4a	32.0a	31.1a
Second Flower	32.8a	34.6a	36.2a
Third Flower	34.1a	37.3b	37.6b
	Flower Longevity (Days)		
First Flower	7.9a	7.9a	7.7a
Second Flower	6.2a	7.8b	7.3b
Third Flower	6.8a	6.6a	6.5a
	Diameter (cm)		
First Flower	12.5a	12.4a	12.1a
Second Flower	12.3a	12.1ab	11.9b
Third Flower	11.5a	12.6b	11.8a
	Number of Shoots Per Plant		
Major Shoots	2.5a	2.2a	2.3a
Minor Shoots	1.8a	1.7a	2.5a
Total Shoots	4.4a	3.9a	4.8a

[x]Means followed by the same letter (a,b,c) are not significantly different by Tukey's test at .05 for single rows (each organ per parameter determined separately.

CONCLUSIONS

1. Cultivars differed in their response to the various environmental factors tested.
2. The parameters: shoot number, flower diameter, and flower longevity were minimally affected by the treatments and were mainly a cultivar characteristic.
3. Year to year variation due to variation in production and forcing conditions was reflected in data for 1975 and 1976 for comparable treatments and cultivars.
4. Fertilization of tuberous-roots during forcing promoted earlier flowering and plant development. Precise levels for fertilization were not determined but an application of Osmocote (14-14-14), (18-6-12), and (18-9-12) or (20-20-20) as a soluble fertilizer were satisfactory.
5. Light intensity levels of 100 or 75% gave good height control and promoted rapid flowering with no other adverse effects. At 50% light levels, plant heights exceeded acceptable ranges and flowering was delayed.

6. The 8 hour photoperiod severely retarded vegetative growth, reduced the percent of plants flowering, and caused abnormal flowering. Natural daylengths of at least 10 hours at planting and increasing to 14 hours produced good quality plants. Long day treatments of either 16 hours or a 4 hour night break delayed flowering.
7. Responses to both day and night temperatures were demonstrated. The 27/16°C treatment promoted rapid flowering with satisfactory height control. Higher temperatures accelerated flowering but were deleterious for satisfactory growth and development. Lower temperatures delayed flowering and increased plant height.
8. By controlling the interaction of these greenhouse factors, the production of high quality pot plants from tuberous-rooted cultivars for spring markets is feasible.

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