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EFFECTS OF UNICONAZOLE ON GROWTH AND FLOWERING ON SIX SELECTED BEDDING PLANT SPECIES, CHRYSANTHEMUMS, POINSETTIAS, AND EASTER LILIES

A Thesis

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ABSTRACT

The experimental growth retardant, uniconazole, Sumagic™ [(E)-(p-chlorphenyl)-4,4,-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol] was evaluated for growth control on several bedding plant species, chrysanthemum, poinsettia, and Easter lily cultivars. Uniconazole was compared against chlormequat [(2-chloroethyl)trimethylammonium chloride], daminozide [succinic acid-2,2-dimethylhydrazide], or ancymidol [α-cyclopropyl,α-4-methoxypropyl,α-5-pyrimidine methanol] for effectiveness in controlling height on the various test species.

Uniconazole foliar spray concentrations of 5-60 mg/l severely retarded growth of several bedding plant species, especially geranium and coleus. Optimum growth control was at 4 mg/l or below. Delay in flowering occurred in all bedding plants tested, except for geranium and coleus, which exhibited earlier flowering.

Soil drenches of uniconazole were more active than foliar sprays for 'Annette Hegg Dark Red' and 'Gutbier V-14 Glory' poinsettias, and 'Bonnie Jean' chrysanthemum. Best growth control was achieved by foliar sprays at 5 mg/l or below. Higher concentrations of uniconazole severely retarded plant growth regardless of application methods.

Uniconazole as bulb soaks prior to cooling severely reduced growth of 'Ace' and inhibited shoot emergence of 'Nellie White'

Easter lilies. Postemergence soil drenches and foliar sprays were less effective in controlling growth than were bulb-soaks. Best finished plants for both of these cultivars were observed at 5-10 mg/l sprays and 2-3 mg/pot drenches. All soak treatments (2-10 mg/l) retarded growth severely, especially for 'Nellie White'. There was a trend toward delayed emergence and flowering with increasing uniconazole concentrations when applied as bulb-soaks. However, no significant delays in flowering occurred either from soil drench or foliar spray treatments. Severe leaf phytotoxicity was observed in all foliar spray treatments of uniconazole, but this was not observed on drench and soak treated plants.

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LIST OF ABBREVIATIONS

1. Uni. = Uniconazole
2. Chl. = Chlormequat
3. Da. = Daminozide
4. An. = Ancymidol
5. mg/p = mg/pot

CHAPTER I

INTRODUCTION

Floriculturists use growth retardants to modify the plant growth habits into habits not existing in the genotype. Ideally, plant growth habits should be determined by the plant breeders so growers need not be concerned about chemical growth control. Plant breeders modify genetic expression and develop seed lines which respond to different environments, as well as customer's preferences. New varieties, therefore, are constantly produced. However, perfection of specific characteristics in the natural genetic system often progresses very slowly or may be impossible due to lack of transmissable variation.

With the great emphasis on uniformly controlled production and quality, the floriculture industry has become habitually dependent on growth controlling chemicals for several crops. The change of growing situations from "dig and wrap" to the modern growing cells and containers has caused plants to require greater modification to constrain rooting and plant spacing. Coupled with the application of constant liquid feeding which force plants to produce rapid growth in very restricted space, the plants need to be short and well-branched, which contradicts their genetic constitutions. Therefore, growth habits, especially height and internode length, are modified chemically. The ultimate aim is to produce uniformly compact attractive plants in limited greenhouse space.

Over the past 20 years, a number of growth retardants have been studied and released to the commercial market. Chlormequat, daminozide, and ancymidol are the most commonly used retardants in the commercial market today. The newly released paclobutrazol is still being tested by floriculturists. Most recently, uniconazole (Sumagic^{TM}, XE-1019, 0.05% EC) formulated by the Chevron Chemical Company has been developed as a growth retarding chemical. This chemical is reported to be highly active at very low concentrations and may offer possibilities for use in floricultural production.

The purpose of this study was to investigate the effects of uniconazole on growth and flowering of selected bedding plants, poinsettias, chrysanthemums, and Easter lilies, as compared with chlormequat, daminozide, or ancymidol.

CHAPTER II

LITERATURE REVIEW

Background

Controlled chemical retardation of plant growth controls plant sizes and maintains desirable plant form and symmetry. Intermode elongation, specifically, is suppressed without disrupting the physiological activity of the apical meristem. Apical dominance is maintained (56), and leaf and flower initiation are not affected in major ways when the retardant chemical is applied according to researched recommendations. The subapical meristem is the morphological site where the effect on internode elongation occurs (9,54). Reduced gibberellin synthesis is the outstanding physiological effect of growth retardants (17,56,66). Other effects are interference with auxin synthesis (9,36) CO_2 assimilation in young and old leaves (33), and possibly other metabolic processes (37).

Growth retardants have been defined as chemicals which slow cell division and cell elongation in shoot tissues and regulate plant height physiologically without formative effects (10). All types of the growth retardants thus far used in the commercial market have been synthetically produced (11). Today the most commonly used growth retardants are chlormequat, daminozide, and ancymidol (4). Paclobutrazol (PP-333 or Bonzi^{TM}) was recently introduced to the commercial market and has proven to be effective

on poinsettias (64,65), chrysanthemums (47,49), and other ornamentals (29). These chemicals and the newest experimental growth retardant, uniconazole, are structurally unrelated but they are grouped as gibberellin inhibitors (16,48).

Chlormequat

The growth retarding activity of this chemical was first mentioned in 1960 (10). A product of American Cyanamid Inc. (Cycocel^{TM}), this compound was originally labelled for height control of azaleas and poinsettias (56). Later it was found to be effective on other ornamentals including some bedding plant species (11). Temporary chlorosis of foliage may be induced (10,29), but this can be reduced by the addition of a surfactant (9).

Chlormequat has become an important growth retardant for seed geraniums used as bedding plants. The effects of chlormequat on geranium were well documented (3,4,12,13,30,55,57,62), and included reduced height with shortened internodes (stockier plants), earlier flowering, and increased number of basal shoots resulting in greater numbers of flowers. Combined treatments of chlormequat and high light intensity caused severe dwarfing and premature flowering (3). Flowering was accelerated in geranium regardless of number of applications, or the time of application of chlormequat (50).

Chlormequat is the most commonly used growth regulator on poinsettia due to cost, ease of application, and consistent

effectiveness. It can be applied to poinsettias either as foliar spray or soil drench. Soil application has provided greater height control than spray application (60). Foliar application of chlormequat even at an optimum concentration of 177 mg/l (Cycocel 1500 mg/l) caused chlorosis of leaves. Height control with foliar sprays was unsatisfactory at concentrations that did not cause foliar phytotoxicity (14). Phytotoxicity increased with increased temperature and light intensity (15). Foliar sprays of chlormequat at 295 mg/l (Cycocel 2500 mg/l) caused temporary leaf chlorosis, while chlormequat 590 mg/l (Cycocel 5000 mg/l) caused permanent chlorosis and necrosis (38). Soil drenched chlormequat at 354 mg/15 cm pot (Cycocel 3000 mg/15 cm pot) was the most effective chemical method of poinsettia height control (31,63). Date of flowering was unaffected by this chemical (46). Whitefly infestation was reduced by chlormequat in 'Annette Hegg Lady' and 'Eckespoint C-1' poinsettias (20,21,22).

Daminozide

This compound is a product of UniRoyal Inc. sold under several trade names: Alar™, B-Nine™, and SADH. Daminozide retards growth of legumes, vines, potatoes, and ornamentals (10). Label recommendations are available for petunia, marigold, zinnia, aster, cosmos, and salvia (1). Height control of impatiens has been reported (41).

Daminozide was most effective when used as foliar spray (10). Foliar spray of daminozide controlled internode elongation

of marigold, impatiens, petunia, and other ornamentals (11) on any daylength without delaying flowering (4). Foliar spray with daminozide was very effective while soil drench was ineffective on chrysanthemum (10). Plant size and number of flowers were suppressed on chrysanthemum treated with daminozide (52). Single or repeated applications of daminozide suppressed low temperature injury (increased winter hardiness) in chrysanthemums (7). Number of flowers and nodes were unaffected by daminozide treatment (40). Foliar spray of daminozide effectively controlled plant height of chrysanthemum compared with drench of ancymidol or paclobutrazol in media with and without pine bark (5). Chrysanthemum 'Wanda' cuttings dipped momentarily in a solution of daminozide produced significantly greater fresh weight and number of adventitious roots as compared with untreated controls (54).

Ancymidol

Ancymidol was introduced in the commercial market in 1970 by Elanco Products Inc. under several trades names: EL-531™, Quel™, A-Rest, and Ancymidol (58). Ancymidol has been proven more active in retarding plant growth than other growth retardants (11,18,26). Nevertheless, label clearance is established only for use for chrysanthemums, Easter lilies, and poinsettias (2).

Ancymidol was effective as foliar spray at 25-200 mg/l on geranium, marigold, scarlet sage, vinca, zinnia, and celosia (11). A higher concentration (100-200 mg/l) of Ancymidol was required to retard growth of coleus, snapdragon, and impatiens. Petunia,

pansy, verbena, and gomphrena were not responsive to these concentrations. However, other researchers (18,23,50,59) found Ancymidol to be effective on petunia either by soil drench or foliar spray. Soil application was more effective than foliar spray in controlling height of petunia and other bedding plant species (11,19). Delay in flowering was reported (2,26).

Ancymidol is the most commonly used growth retardant in controlling height of Easter lilies (24,27,32,34,35,39,61). Soil drench at 0.25 or 0.5 mg/pot Ancymidol gave excellent height control in 'Ace' Easter lilies (39,61) while higher concentrations were injurious. Other researchers (27,28) have shown that foliar application was less injurious than either preplant soil incorporation or soil drench. However, spray application was phytotoxic under certain environmental conditions while soil drenches gave better results in terms of predictability, reduced chances of phytotoxicity, and therefore increased quality of plants (61). Bulb-dip treatment prior to planting was more effective in controlling height of 'Ace' Easter lilies than soil drench or foliar spray (44,45). This method of application had no effect on number of flowers and no phytotoxic reactions, but flowering was delayed (44,45). Other investigations, however, have reported no delay in flowering by either foliar spray or soil drench (32,61). Others reported slight delays in flowering (24,28,43).

Uniconazole

This product of Chevron Chemical Company also is designated by three other names: Sumagic™, Prunit™, and XE-1019. Uniconazole is an experimental growth retardant and has no commercial label clearance. Grouped as a gibberellin inhibitor, this compound was recently reported to be effective on height control of citrus, bedding plants, poinsettias and other floricultural crops (6,16,25). Uniconazole drenched at 0.5 mg/pot gave shortest plant heights and smallest bract diameters on 'Annette Hegg Dark Red' poinsettias compared to nontreated controls and Cycocel™ combined with B-Nine™ (42). To date, the effects of uniconazole on earliness of flowering, phytotoxic reactions, and number of buds and flowers are not known for floricultural crops.

CHAPTER III

MATERIALS AND METHODS

Bedding Plants

Experiment I

Several rates of uniconazole [(E)-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol] were tested to determine the growth controlling activity and the effects on growth and flowering of six selected bedding plant species. They were: Tagetes erecta L. 'Yellow Climax', Petunia hybrida Vilm. 'Blue Joy', Impatiens sultana Hook. 'Futura Red', Pelargonium x hortorum Bailey 'Sprinter Scarlet', Coleus blumei Benth. 'Rose Wizard', and Celosia cristata L. 'Plumosa Brush Fire'. Each variety was selected on the basis of commercial use and requirement for height control. The experiment was conducted in a plastic greenhouse in mid-summer, 1986, at The University of Tennessee, Knoxville.

Bedding plants were grown according to commercial standards. The germination medium consisted of sphagnum:vermiculite (1:1 by volume). Shortly after the emergence of the first true leaves, uniform seedlings were transplanted to standard cell-packs in flats. A night temperature of 70°F was maintained but day temperature was not controlled and ranged from 70°F-90°F. The transplanting medium consisted of peat:vermiculite:perlite (1:1:1 by volume). The flat provided uniform 6-packs, with 36 individual cells of 6.67 cm x 5.93 cm x 6.35 cm (depth). Each cell held a

working volume of 250 cm^3. This cell pack was selected because it may be divided into 6 equal units/flat of 6 cells each to serve as replications.

Treatments were applied to the seedlings when the foliage canopy had expanded to a 2-inch diameter (approximately 6 weeks after sowing). All chemical treatments were by foliar spray with a hand-held pump action sprayer. Uniconazole 0.05% (Sumagic) was applied to each species at the following rates: 0, 5, 10, 15, 30, 40, or 60 mg/l. This was equivalent to 0, 10, 20, 30, 60, 80, or 120 ml of Sumagic/liter of water. Surfactant (Triton B-1956) at 0.65 ml/l was added to the spray solution to ensure proper wetting of foliage. Plants were sprayed until surface run-off and held for 18 hours before irrigation was begun. Fertilizer at 200 mg/l (20N-8.8P-16.6K) was applied at each irrigation to plants at early growth stages, and then increased to 300 mg/l. Insect and disease control practices were followed throughout the course of the experiment.

Commercial standards of either chlormequat [Cycocel™; (2-chloroethyl)-trimethylammonium chloride], daminozide [B-995™, (succinic acid 2,2-dimethyl hydrazide)], or ancymidol [A-Rest™, (α-cyclopropyl,α-4-methoxyphenyl,α-5-pyrimidine methanol] were used for comparisons with uniconazole rates. Chlormequat at 236 mg/l (Cycocel at 2000 mg/l) was applied to geranium 3 weeks following transplanting. Daminozide was applied to petunia, marigold, and impatiens at 2125 mg/l (B-Nine at 2500 mg/l) 3 weeks following transplanting, and coleus and celosia were treated with ancymidol

at 47.5 mg/l (A-Rest at 190 mg/l) when seedlings were well-rooted in the transplanting packs, i.e., approximately 6 weeks after sowing. The experiment was assembled in a completely randomized design with 8 chemical treatments, 6 replications, and 6 plants per replication for each of the six species tested.

When plants had attained a suitable maturity and were saleable, the following parameters were measured for each species; plant height, foliar spread, bloom diameter, date of first bloom, and total number of buds and flowers produced. In addition to these data, pack uniformity, flower color intensity, and phytotoxic reactions to chemicals were evaluated visually.

Experiment II

This experiment was conducted in a manner similar to Experiment I except the rates of uniconazole used were greatly reduced. They were 0.25, 0.5, 1, 2, or 4 mg/l of uniconazole, which were equivalent to 0.5, 1, 2, 4, or 8 ml of Sumagic/liter of water. The same species of bedding plants were tested and collected as in Experiment I. The experiment was begun in early March 1987.

Chrysanthemum

Evaluation of the effects of uniconazole was conducted with the tall growing Chrysanthemum morifolium Ramat. 'Bonnie Jean'. Different application methods and several rates of uniconazole were compared with daminozide applied according to commercial recommendation.

Five rooted cuttings of 'Bonnie Jean' chrysanthemum were placed individually in 15 cm plastic pots on October 3. The growth medium consisted of peat:vermiculite:perlite (1:1:1 by volume). Pots were spaced at 36 cm x 36 cm on a bench. When the plants were well established in the pot, shoot terminals were pinched on October 21. Four weeks after potting, chemical treatments were applied in the morning (0830-1000 hr). All plants were irrigated 1 hour prior to treatment applications. Fertilizer at 250 mg/l (15N-6.6P-24.9K) was applied to plants at each irrigation throughout the experiment. Irrigation was done 1-3 times daily depending on environmental conditions. Standard greenouse pest control practices were followed.

Treatments consisted of uniconazole soil drenches at 0, 2, 3, or 5 mg/pot, foliar sprays at 0, 5, 10, or 25 mg/l, or daminozide soil drench and foliar spray at 4250 mg/l (B-Nine, 5000 mg/l). Each treatment consisted of 10 replications with 5 plants per replication arranged in a completely randomized design. Even though daminozide is not reported to be effective in growth control of chrysanthemum when used as soil drench, this method of application was used in this experiment to compare the drench effect of daminozide with uniconazole.

When the mature flowers were fully expanded, the following parameters were measured in each treatment: plant height, plant spread, bloom diameter, date of first bloom, and numbers of buds and flowers produced. In addition to these data, height uniformity,

flower color intensity, and phytotoxic reactions to chemicals were evaluated visually.

Poinsettia

The effects of uniconazole on poinsettia, Euphorbia pulcherrima Willd. 'Annette Hegg Dark Red' and "Gutbier V-14 Glory' were evaluated in the fall of 1986. Several application methods and rates of uniconazole were used. These were compared with chlormequat at standard commercial rates.

Poinsettia cuttings were rooted under mist in Oasis™ strips beginning on July 31, 1986. Well-rooted cuttings were placed individually in 15 cm pots with peat:vermiculite:perlite (1:1:1 by volume) as the potting medium. Each pot was spaced at 36 cm x 36 cm on a bench in a plastic greenhouse. When cuttings had rooted to the bottom of the pot, the terminal shoot was pinched to 7 leaves. Pinching was uniform for all plants. Chemical treatments were applied when breaks from the pinch were 2.5 cm in length. Treatments to each cultivar consisted of uniconazole soil drenches at 0, 2, 3, or 5 mg/l, foliar sprays at 0, 5, 10, or 25 mg/l, and chlormequat at 354 mg/l (Cycocel at 3000 mg/l) applied as a soil drench or foliar spray. All plants were irrigated 1 hour prior to the chemical treatment applications. Treatments were applied in the late afternoon (1600-1800 hr). Standard greenhouse insect and disease control practices were followed. Fertilizer at 250 mg/l (15 N-7P-14K) was applied to the plants at early growth stages and

increased to 300 mg/l as plants grew older. The experiment was conducted under natural light.

The experiment was conducted in a completely randomized design with 2 cultivars, 10 chemical treatments, and 10 replications with 1 plant per replication. In mid-December, when bracts were well colored and plants were saleable, the following parameters were measured: plant height, plant spread, days to anthesis, days to full bract color, inflorescence (bracts and cyathium) numbers, and diameter of inflorescences. Height uniformity, bract color intensity, and phytotoxic reactions to chemicals were evaluated visually.

Easter Lily

Methods and rates of application of uniconazole and ancymidol were compared on Lilium longiflorum Thunb. 'Ace' and 'Nellie White'. The application methods were bulb-dip, soil drench, and foliar spray. For the bulb-dip treatment, bulbs were immersed for 1 hour in uniconazole solutions at 0, 2, 3, or 5 mg/l or ancymidol at 47.5 mg/l (A-Rest at 190 mg/l) at room temperature prior to cooling. Excess solution was drained thoroughly from the bulbs before potting. All bulbs were potted in 15 cm pots, cooled at 4.4°C (40°F) in November 1986 for 6 weeks, and then the pots were placed in a glass greenhouse maintained at a minimum temperature of 70°F.

Soil drenches and foliar spray applications were made when shoots were 5-10 cm high. Uniconazole drench concentrations were

0, 2, 3, or 5 mg/pot, and foliar spray concentrations were 0, 5, 10, 25, or 50 mg/l. Ancymidol was applied as soil drench at 47.5 mg/l (A-Rest at 190 mg/l) and as foliar spray at 95 mg/l (A-Rest at 380 mg/l) as comparisons with rates of uniconazole. Treatments were applied in mid-morning (0900-1030 hr), and irrigation was begun 18 hours later. Fertilizer at 200 mg/l (25N-0P-20.8K) was applied at the beginning of shoot emergence and increased to 300 mg/l as plants grew older, i.e., approximately 4 weeks following cooling. Natural daylength and light intensities were used. Standard pest control practices were performed.

The experiment was assembled in a completely randomized design with 11 chemical treatments, 9 replications, and 1 plant per replication for 'Ace', and 11 treatments, 4 replications, and 1 plant per replication for 'Nellie White'. When plants started to bloom and most flowers were fully expanded, the following measurements were taken: plant height, foliar spread, date of first bloom, numbers of buds and flowers produced. Flower color intensity and phytotoxicity to the foliage were evaluated visually.

CHAPTER IV

RESULTS AND DISCUSSION

Bedding Plants

Geranium

Experiment I. Uniconazole rates tested in this experiment were too high for geranium. All rates tested severely retarded growth, with most plants being too short with diminished foliage (Table 1).* Height was limited to 53% of controls (14.4 cm) in plants treated with uniconazole at 5 mg/l (6.7 cm) (Figure 1a). Plants treated at rates between 5 mg/l to 60 mg/l were not significantly different in height compared with one another. Chlormequat-treated geraniums were significantly taller than all uniconazole-treated plants; and also were significantly shorter than control plants. Thus, chlormequat at 236 mg/l was less effective than uniconazole at 5 mg/l in controlling height of geranium.

Uniconazole-treated plants flowered up to 2 weeks earlier than controls or chlormequat-treated plants (Plate 1, Figures 12-13). Leaves were darker green and smaller with uniconazole treatments. No foliar abnormalities were observed on plants treated with either the lower rates of uniconazole or chlormequat. However, foliar chlorosis was observed at the highest rates of uniconazole,

*All tables, figures and plates may be found in the Appendix.

i.e., 30 mg/l and above. Chlormequat-induced leaf chlorosis also was noted.

Experiment II. The reduced rates of uniconazole used in this experiment improved plant form and symmetry. Final heights of plants treated with all uniconazole rates were significantly shorter than the controls, but were taller than plants treated at high rates of uniconazole in Experiment I (Figure 1a-b). Heights of geraniums were the same for uniconazole at 0.25 mg/l (9.5 cm) and chlormequat at 236 mg/l (9.0 cm) (Figure 1b). However, significant height differences resulted from uniconazole rates of 2 mg/l or higher.

A 21% decrease in plant spread was observed with uniconazole rates of 0.25 mg/l or higher (Table 1). Flowering was more than 2 weeks earlier than non-treated controls and chlormequat-treated plants, even at the lowest rates of uniconazole. This suggests that uniconazole affected floral bud initiation in geranium. A deeper green foliage coloration was observed in uniconazole-treated plants and the foliar chlorosis noted in Experiment I was not observed. However, chlormequat-induced chlorosis was observed again in this experiment.

Petunia

Experiment I. Petunia heights were 50% shorter over control plants (11.1 cm) with all uniconazole rates tested (4.2-4.7 cm) (Figure 2a) and by more than 20% when compared with daminozide-

treated plants (5.9 cm). Plants treated with uniconazole rates at 5 mg/l or higher did not differ significantly in height. Plant spread was significantly limited by all uniconazole treatments compared to controls or daminozide-treated plants. Control plants and daminozide-treated plants attained more foliage spread (Table 2). Reduction of bloom diameter by uniconazole was progressive as concentrations increased. Numbers of buds and flowers on control plants were significantly greater than on plants treated with uniconazole or daminozide. Plants treated with daminozide produced the same number of buds and flowers as plants treated with uniconazole. Flowering was delayed up to 4 days in uniconazole-treated plants. This delay is significantly less than from daminozide-treated plants, which were delayed up to 14 days. Uniconazole shortened internodes so that the plants appeared more stocky and darker green than controls. There were no abnormalities in shape of leaves and no phytotoxic reactions.

Experiment II. The lower rates of uniconazole used in this experiment produced taller plants when compared with the rates used in Experiment I (Figures 2a-b). Uniconazole at 0.25 and 0.50 mg/l did not limit plant spread (Table 2). No significant differences were observed in plant diameters from uniconazole rates between 1 and 4 mg/l. Blooms produced by plants treated with uniconazole rates at 0.25 to 1 mg/l (Table 2) did not differ in diameter. However, with increased rates of uniconazole beyond these levels, bloom diameters were reduced. Daminozide-treated plants produced

significantly smaller blooms than did control plants, but did not differ much in size when compared with uniconazole-treated plants (Table 2).

There were no differences in the number of buds and flowers produced by control plants and uniconazole-treated plants at all rates tested. Daminozide-treated plants produced 30% more flowers than other treatments (Table 2). A delay in flowering for 2-7 days were observed in all uniconazole-treated plants. Most delay in flowering was observed in daminozide-treated plants.

Leaf coloration was greener and internodes were shorter with increasing rate of uniconazole. No foliage phytotoxicity was detected.

Marigold

Experiment I. A significant reduction in height was observed on plants treated with uniconazole (Figure 3a). Plant height was limited as the amount of uniconazole increased (Plate 2, Figures 14-15). Daminozide at 2125 mg/l produced significantly taller plants (57.0 cm) than plants treated with any rate of uniconazole (26.6-41.3 cm), but were significantly shorter than controls (70.4 cm) (Figure 3a). While growth was reduced progressively as the amount of uniconazole increased, rates of 40 mg/l or higher produced plants having similar heights (Table 3). Bloom diameters were significantly less on all uniconazole-treated plants when compared with controls and daminozide-treated plants, but there were no significant differences in bloom diameters of control

plants and those treated with daminozide. Also, as the amount of uniconazole used increased, the number of flowers were reduced (Table 3) and flowering was up to 10 days later than control plants and daminozide-treated plants. Greener foliage and stockier stems were produced by increasing uniconazole concentrations. No foliage damage by either chemical was observed.

Experiment II. Plant height was reduced by at least 30% by uniconazole treatments (Figure 3b). Uniconazole rates of 0.25 and 0.50 mg/l produced significantly taller plants than did daminozide at 2125 mg/l (Figure 3b). This suggests that these rates of uniconazole are not as effective as daminozide at 2125 mg/l. Growth was significantly limited at the lowest uniconazole rate used (0.25 ml/l) when compared with the controls. Plants treated with daminozide were 22% shorter than those treated with the lowest rate of uniconazole used in the experiment (Table 3).

No progressive suppression in bloom diameter was observed as the concentrations of uniconazole increased (Table 3). Control plants and daminozide-treated plants did not differ in diameter of blooms, but they were significantly larger in comparison with uniconazole-treated plants at rates above 0.50 mg/l. At all treatment levels petunia plants were not significantly different in numbers of flowers, except for the uniconazole treatment of 4 mg/l which significantly reduced floral bud production. Date of flowering was delayed up to 7 days by uniconazole treatments, while daminozide delayed flowering up to 4 days.

Greener foliage and shorter internodes were observed in direct proportion to uniconazole rates used. No phytotoxicity to the foliage was observed. The better quality plants were from uniconazole treatments at the rates of 0.25 to 0.50 mg/l.

Coleus

Experiment I. Plant heights were at least 53% shorter for all uniconazole treatments (Figure 4a). Heights of plants treated with uniconazole between 5 to 60 mg/l (5.3-6.6 cm) and ancymidol at 47.5 mg/l (6.1 cm) were similar (Table 4).

Abnormalities in the shape of young foliage was observed with the higher rates of uniconazole. Young leaves became twisted and crinkled at higher chemical rates. This effect was not observed on ancymidol-treated plants. Flowering was 7-10 days earlier for all uniconazole-treated plants, and was 4 days earlier than ancymidol-treated plants. Visual evaluation showed uniconazole did not cause phytotoxicity to coleus. Higher rates of uniconazole caused leaf color to be darker green with fewer variegations.

Experiment II. Height suppression of coleus was less pronounced using the lower rates of uniconazole (0.25 to 4 mg/l) (Figure 4b). Uniconazole-treated plants at 0.25 to 0.50 mg/l (14.7 and 12.9 cm) did not differ in height when compared with ancymidol-treated plants at 47.5 mg/l (13.3 cm). Plant spread was reduced by uniconazole treatments. Uniconazole application at 0.25 and 0.50 mg/l caused plants to be significantly taller

compared with other higher rates (1-4 mg/l). Control plants produced the largest spread and longest internodes, causing plants to be lanky.

Earlier flowering was observed with uniconazole-treated plants. Foliage color appeared to be greener as uniconazole rates increased. Uniconazole at 0.25 and 0.50 mg/l caused plants to have more variegations than those treated with higher uniconazole rates.

Celosia

Experiment I. Plants treated with uniconazole at all rates tested (9.9-12.7 cm) were significantly shorter than control plants (21.6 cm) and ancymidol-treated plants (17.4 cm) (Figure 5a). These results suggest that all rates of uniconazole were too high for use in height control of celosia.

Growth was severely limited (up to 83%) by uniconazole at 60 mg/l. Ancymidol limited growth by 27% from controls (Table 5). No significant differences were observed between the uniconazole rates tested. These results suggest that all uniconazole rates tested were beyond the tolerance of celosia growth. Inflorescences were significantly shorter at uniconazole rates of 10 mg/l and higher (Table 5). A 5 mg/l treatment resulted in relatively the same inflorescence lengths as ancymidol at 47.5 mg/l. Flowering was delayed up to 3 weeks by uniconazole.

Foliage color was deeper green in all uniconazole-treated plants than controls. No phytotoxicity was observed throughout

the experiment. Best finished plants were from uniconazole treatment rates of 30-60 mg/l. At uniconazole rates of 15 mg/l and lower, plants were less compact.

Experiment II. The lower uniconazole rates used in this experiment resulted in less severe height limitation of celosia (Figure 5b). All plants with uniconazole treatments were significantly shorter than controls (37.3 cm), but rates of 0.25 and 0.50 mg/l (30.0 cm and 29.4 cm) produced plants that were significantly taller than those treated with ancymidol at 47.5 mg/l (25.9 cm).

Plant spread was not affected by either uniconazole or ancymidol treatments (Table 5). Inflorescence lengths were significantly suppressed by uniconazole and ancymidol treatments (Table 5). The suppression was inversely proportional to the amount of uniconazole used. A delay in flowering of up to 16 days was observed in all uniconazole-treated plants. Darker green foliage color was observed in this experiment with the lower uniconazole rates tested. Uniconazole rates from 0.25-4 mg/l tested produced plants with less compact forms than 5 mg/l and above.

Impatiens

Experiment I. Height of impatiens was 58% shorter with uniconazole treatment at 60 mg/l (5.5 cm) and 13% shorter with daminozide treatment at 2125 mg/l (13.5 cm) than were control

plants (15.6 cm) (Figure 6a). Therefore, the uniconazole rates tested were too concentrated for producing the desired height control of impatiens.

Plant spreads were more than 50% smaller with uniconazole-treated plants than daminozide-treated plants and controls. There were no significant differences in spread between all uniconazole-treated plants (Table 6). Flowering was delayed in all uniconazole-treated plants. At uniconazole rates of 30, 40, and 60 mg/l very few buds and no open blooms were observed.

The high rates of uniconazole caused contorted stems having deep green, small, crinkled foliage. No leaf chlorosis was observed throughout the experiment, but blooms on plants treated with uniconazole at 5, 10, and 15 mg/l produced a faded red color in comparison with blooms of controls. Finished plants were increasingly more compacted and stunted as the concentration of uniconazole increased.

Experiment II. The lower rates of uniconazole tested produced plants that were not as short as in Experiment I (Figure 6a-b). However, plant spread was significantly less as concentrations of uniconazole increased (Table 6). Plant spread sizes were predictable in direct proportion to concentration of uniconazole used. Flower delay was observed in all uniconazole-treated plants. Darker green foliage color resulted from increasing amounts of uniconazole. Shorter internodes were produced and stems were contorted, but the degree of twistedness and compactness was not as

severe as from the higher rates of uniconazole used in Experiment I.

'Bonnie Jean' Chrysanthemum

Foliar spray applications of uniconazole at 5-25 mg/l produced chrysanthemum heights up to 60% shorter and soil drench applications up to 61% shorter at lower rates (2-5 mg/pot) of uniconazole (Figure 7a-b). The uniconazole spray rate of 5 mg/l (23.4 cm) produced taller plants than other uniconazole treatments (17.7-20.8 cm). There were no height differences between plants given uniconazole soil drenches at 2-5 mg/pot or between foliar sprays at 10-25 mg/l.

Plants treated with uniconazole were significantly shorter than daminozide-treated plants (Figure 7a-b). Plant spread was significantly smaller from both soil drench or foliar spray applications of uniconazole (Table 7). However, uniconazole sprays at 5, 10, or 25 mg/l and drenches at 2, 3, and 5 mg/pot produced similar plant spread. Uniconazole sprays at 5 mg/l and daminozide spray at 4250 mg/l produced similar spread, but uniconazole drenches at 5 mg/pot produced significantly smaller plants than did daminozide drenches at 4250 mg/pot.

Bloom diameters were suppressed by uniconazole treatments. However, the degree of suppression was unpredictable (Table 7). Uniconazole soil drench application rates of 2, 3, and 5 mg/pot caused smaller bloom diameters. No significant differences were observed in numbers of buds and flowers between treatments (Table

7). Flowering was delayed up to 5 days for uniconazole-treated plants, and 3 days for daminozide-treated plants (Plate 3, Figures 16-17). Foliage colors were more intense green and stem internodes were shorter as the concentration of uniconazole increased. Phytotoxic reactions were not detected in these treatments.

Poinsettias

Annette Hegg Dark Red

Height was limited up to 65% by uniconazole sprays and up to 69% by soil drenches (Figure 8a-b). Uniconazole soil drenches at all rates tested produced plants that were excessively short and stunted. However, the spray rates of uniconazole at 10 and 25 mg/l produced equally undesirable plants. Only the 5 mg/l spray rate of uniconazole provided acceptable finished plants (Plate 4, Figures 18-19). These results indicated that all of the rates of uniconazole tested, either as soil drenches or foliar sprays, were beyond the tolerance of Dark Red poinsettia.

Foliar spray was suppressed significantly with increasing uniconazole concentrations, regardless of application method (Table 8). This trend was not observed with soil drench applications. Soil drenches caused greater plant compactness than did spray treatments of uniconazole.

Bloom diameters were significantly reduced by uniconazole treatments. Spray applications of uniconazole gave larger bloom diameters than did soil drench applications (Table 8). With 5 mg/l uniconazole sprays, the average bloom diameter was 21 cm, but 5 mg/pot uniconazole soil drenches produced an average bloom diameter of 6.3 cm which was 70% smaller. All uniconazole-treated plants were delayed in flowering from controls. Spray applications caused flowering delays up to 7 days and drench applications caused delays up to 11 days. Chlormequat-treated plants flowered 2-3 days earlier than uniconazole-treated plants. Numbers of inflorescences produced were slightly lower on uniconazole spray and drench application treatment plants (Table 8). Deeper green foliage color and shorter internodes were observed on all uniconazole-treated plants in proportion to uniconazole concentrations. Young shoots were more abnormal in shape, crinkled, and twisted as the amount of uniconazole increased.

Gutbier V-14 Glory

Plant heights of Glory poinsettia were suppressed up to 65% by uniconazole spray applications and 64% by soil drench applications (Figure 9a-b). These results indicated that the rates of uniconazole tested in Glory poinsettia were beyond the optimum level for this cultivar's tolerance. Uniconazole spray applications of 5 mg/l produced plants that were slightly taller than

those provided higher chemical rates. However, drenches of uniconazole at 2, 3, and 5 mg/pot produced plants that did not differ significantly in height between one another. Plants given uniconazole spray or drench treatments were significantly shorter than those treated with chlormequat.

Uniconazole applied as either soil drenches or foliar sprays produced significantly smaller plants than either non-treated controls or chlormequat-treated plants (Table 8). As the concentration of uniconazole increased, the plant spread was increasingly suppressed. A significant suppression of bloom diameter was caused by uniconazole treatments compared to controls and chlormequat treatments (Table 8). Both soil drenches and foliar sprays resulted in progressively smaller blooms as the amount of uniconazole increased. Numbers of inflorescences were fewer for uniconazole treatments (Table 8). Plants treated with either uniconazole or chlormequat produced relatively smaller bloom diameter than control plants. Flowering was delayed up to 1 week by uniconazole spray treatments and up to 9 days by soil drenches. Chlormequat-treated plants flowered slightly earlier than those receiving uniconazole treatments. Flower color intensity did not differ between treatments. Young foliage was slightly crinkled and twisted, and more severely so as the concentrations of uniconazole increased. Greener leaves with shorter internodes but no phytotoxic reactions were noted on uniconazole-treated plants.

Easter Lilies

Ace

Plant heights of 'Ace' Easter lily were significantly limited by all uniconazole or ancymidol treatments (Figure 10, Plates 5-6, Figures 20-23). All uniconazole-treated plants were of similar heights. Bulb-soak treatments produced the shortest plants (Figure 10a-c). Plant heights of 'Ace' lilies were significantly suppressed by ancymidol, but not as much as by uniconazole. Among ancymidol treatments, the drench application produced the shortest plants (Table 9).

Plant spread was not significantly reduced by uniconazole (Table 9) suggesting that uniconazole at the lower rates tested does not affect the foliar spread of 'Ace' Easter lily. Ancymidol, regardless of application method, did not affect plant spread of lilies.

Numbers of buds and flowers of uniconazole-treated plants were limited in a predictable manner for both foliar spray and soil drench application methods. As the amount of uniconazole increased, the number of buds and flowers produced decreased (Table 9). Lilies given the bulb-soak application of uniconazole initiated fewer buds and flowers than did those treated with soil drenches. At the 10 mg/l bulb-soak treatment level, no bud formation was observed. At the 10 mg/pot drench treatment level, an average of 3.3 buds were observed. At the 10-50 mg/l spray treatment levels, an average of 0-0.7 buds were noted. These results indicated that

drench application of uniconazole promoted development of more buds and flowers. No delay in flowering was observed for plants treated with uniconazole foliar sprays and soil drenches in comparison with control plants. However, a delay in flowering was observed for all plants given uniconazole bulb-soaks or ancymidol applications.

Slightly deeper green foliage color was observed with plants treated with both uniconazole and ancymidol. Foliage phytotoxicity was most severe with uniconazole spray applications at the higher concentrations, with some of the plants dying before flower bud initiation. Uniconazole soil drench applications caused some leaf phytotoxicity of older foliage at the base of stem, but the effect was not as severe as with foliar spray applications. Bulb-soak applications greatly retarded plant growth, and hence caused plants to be stunted.

Nellie White

Plant heights were significantly suppressed by uniconazole foliar spray and soil drench treatments, but heights were not significantly different between treatment rates (Figure 11a-b, Plate 7, Figure 24). Shoot emergence was inhibited by bulb-soak application. Very little growth was observed on bulbs soaked in uniconazole at the high rates (5-10 mg/l). Shoot growth was inhibited at the very early stages of development of soaked bulbs, as evidenced by the zero increment in height as shown in Figure 11c and Plate 7, Figure 25. Plant spread was not significantly

reduced by either foliar spray or soil drench application, but the soak method severely suppressed plant spread (Table 10).

Uniconazole-treated plants significantly suppressed the number of buds and flowers (Table 10). More flower buds were present on plants treated with the uniconazole soil drenches than those treated with foliar sprays. Little or no growth occurred on plants given the bulb-soak treatment, and no buds were observed when data were collected. Flowering was not delayed on plants treated with uniconazole foliar sprays or soil drenches. Foliar chlorosis on this cultivar was not as severe as on 'Ace' lily, but several plants died before data were taken. This was especially true for plants treated with uniconazole foliar sprays.

CHAPTER V

SUMMARY AND CONCLUSIONS

Bedding Plants

The results from both experiments indicated that geranium, coleus, and impatiens were very responsive to uniconazole foliar spray treatments at very low concentrations (5 mg/l or below). Higher concentrations of this chemical caused plants to be stunted, overly compact, and undesirable in appearance. Petunia and marigold apparently can tolerate slightly higher rates of uniconazole (5-10 mg/l), and uniconazole rates up to 15 mg/l may be applied to celosia for producing finished plants. Uniconazole treatments beyond these levels are not recommended for producing these bedding plant species. Future study should concentrate on lower rates of uniconazole (0.25-5 mg/l) for obtaining the best growth control of each species of bedding plant for use in the commercial market.

All six species of bedding plants tested were responsive to all uniconazole rates tested, with plant heights being significantly shorter. Greater degree of height limitation was achieved as the amount of uniconazole rate used increased. The rates of 5-60 mg/l severely limited heights of geranium and coleus. Other species exhibited less severe height suppression. At 15 mg/l and lower, celosia plants were lanky and less compact. The findings suggest that for celosia slightly higher rates of uniconazole may be required for producing compact plants. Low rate of uniconazole

foliar spray treatments (0.25-0.50 mg/l) were less effective in controlling plant height of celosia, but these rates were more effective than ancymidol at 47.5 mg/l for height control of celosia.

Foliar spreads of all species tested were lower with increasing concentrations of uniconazole. However, low rates of uniconazole (0.25-4 mg/l) and a high rate (40 mg/l) produced plant widths similar to those of non-treated control plants. Increasing the uniconazole concentrations resulted in progressively fewer floral buds on finished plants. However, lower rates of uniconazole used on petunia and marigold did not alter the number of buds and flowers produced. This fact was also true for daminozide-treated marigold.

All bedding plant species tested exhibited smaller bloom diameter as the amount of uniconazole used increased; but the lower uniconazole rates (0.25-4 mg/l) did not affect bloom diameter of marigold. Uniconazole treatments delayed flowering of all bedding plant species tested except for geranium and coleus, which exhibited earlier flowering. The results showed that uniconazole at all rates tested (0.25-60 mg/l) induced slightly earlier floral bud initiation. Marigolds treated with either daminozide or uniconazole flowered almost at the same time but later than the non-treated control plants.

Flower color intensities of the bedding plant species tested were not altered by the uniconazole treatments, except that impatiens plants produced a more faded red color in comparison with

blooms of the non-treated controls. Various degrees of contortion in young leaves of coleus increased as the concentrations of uniconazole increased suggesting that this chemical may have affected the normal development of leaves. Foliage of other species of bedding plants were normal in shape.

'Bonnie Jean' Chrysanthemum

Chrysanthemum growth was limited by uniconazole applied either as a foliar spray or as a soil drench. High rate of uniconazole (25 mg/l) produced severely retarded plants having very short internodes and caused a delay in flowering, resulting in poorly finished plants. Increasing rates of uniconazole reduced plant spread but not in a progressive manner. Soil drench applications of uniconazole were more effective in controlling height and spread of chrysanthemum than foliar spray applications. Bloom diameters were slightly smaller with uniconazole treatments, but numbers of buds and flowers were not affected by uniconazole treatments.

Poinsettias

Both poinsettia cultivars responded very positively to uniconazole treatments. Soil drenches caused plants to be more severely suppressed in height, with less spread and closer internodes than plants treated with uniconazole foliar spray. Most control plants of Annette Hegg Dark Red cultivar had many broken limbs at maturity. Those plants treated with uniconazole did not exhibit

this problem since they were less lanky than controls. Control plants of the Gutbier V-14 cultivar did not have many broken limbs. This was probably a result of cultivar differences. Limb-breakage was not a problem for either cultivar when treated with chlormequat.

Plants treated with uniconazole at rates of 5 and 10 mg/l foliar sprays attained the most desirable height and best overall appearance for both poinsettia cultivars. Soil drench applications at all uniconazole rates did not result in well finished plants of either cultivar. No phytotoxic reactions were observed on foliage of the two poinsettia cultivars from uniconazole treatments. Both of these cultivars exhibited darker green foliage and shorter internodes as the amount of uniconazole used increased. A foliar spray application at low rates of uniconazole (5 to 10 mg/l) can be recommended for best growth control on poinsettia. Soil drench application of uniconazole even at very low rates cannot be recommended.

Easter Lilies

The lily cultivars 'Ace' and 'Nellie White' were suppressed in height by all uniconazole rates and methods. Bulb-soak application of uniconazole caused 'Nellie White' to be severely retarded. The bulb-soak method of application caused an inhibition of shoot growth in the early stages of development and very little growth occurred thereafter. The concentrations of uniconazole tested in these experiments were definitely too high for producing saleable compact lilies. More research using lower rates of

uniconazole needs to be conducted before the bulb-soak method could be used to produce satisfactory plants of Easter lilies. Spray applications may not be useful for treating lilies with uniconazole because this chemical caused severe foliar phytotoxicity. The soil drench method of application might be useful in obtaining good growth control; however, the rates of uniconazole used must be at very low levels and a safe level must be established in further experiments.

Uniconazole appears to be a broad-spectrum and highly active chemical. Different species of plants react differently to the concentration of uniconazole. High rates (above 5-10 mg/l) are not recommended for foliar spray application to florists' crops. Soil drenches and bulb-soaks require very low rates (0.50 mg/pot or lower). Optimum rates of uniconazole for each plant species will need to be investigated in future studies, using much lower concentrations.

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APPENDIX

TABLE 1

EFFECTS OF UNICONAZOLE AND CHLORMEQUAT ON GROWTH OF 'SPRINTER SCARLET' GERANIUM

Application Rate (mg/l)		Finish Ht (cm)	Growth[a] (cm)	Plant Spread (cm)	No. of Blooms
Experiment I					
Uniconazole	0	14.4	10.0	--	--
	5	6.7	2.7	--	--
	10	7.2	1.4	--	--
	15	6.4	1.3	--	--
	30	5.6	0.6	--	--
	40	5.9	0.4	--	--
	60	5.6	0.6	--	--
Chlormequat	236	11.4	6.6	--	--
HSD[b]		1.8	1.5	--	--
Experiment II					
Uniconazole	0	12.0	--	15.7	0.0
	0.25	9.5	--	12.2	0.4
	0.50	6.6	--	9.8	1.0
	1	8.5	--	11.6	0.3
	2	6.5	--	9.6	0.7
	4	8.4	--	10.8	0.4
Chlormequat	236	9.0	--	10.7	0.5
HSD[b]		1.3	--	1.4	0.4

[a]Finish Ht - Ht at treatment application.

[b]Tukey's studentized range test, $\alpha = 0.05$.

TABLE 2

EFFECTS OF UNICONAZOLE AND DAMINOZIDE ON GROWTH OF 'BLUE JOY' PETUNIA

Application Rate (mg/l)		Plant Ht (cm)	Plant Spread (cm)	Bloom Diameter (cm)	No. of Buds and Flowers
Experiment I					
Uniconazole	0	11.1	11.4	5.9	19.5
	5	4.4	9.7	5.1	9.5
	10	4.6	9.8	4.8	11.2
	15	4.7	9.5	4.7	10.8
	30	4.6	9.1	4.3	10.5
	40	4.7	8.9	4.3	10.3
	60	4.2	8.1	4.0	8.8
Daminozide	2125	5.9	11.3	4.8	9.2
HSD[a]		1.4	4.7	0.7	9.6
Experiment II					
Uniconazole	0	16.5	15.1	6.7	19.1
	0.25	8.8	16.0	6.5	20.6
	0.50	8.4	14.3	6.3	20.3
	1	7.7	13.4	6.5	18.8
	2	6.5	13.6	6.1	19.8
	4	5.3	12.9	5.8	17.9
Daminozide	2125	8.0	14.2	5.9	25.6
HSD[a]		1.8	2.4	0.5	2.8

[a]Tukey's studentized range test, $\alpha = 0.05$.

TABLE 3

EFFECTS OF UNICONAZOLE AND DAMINOZIDE ON GROWTH OF 'YELLOW CLIMAX' MARIGOLD

Application Rate (mg/l)		Finish Ht (cm)	Growth[a] (cm)	Bloom Diameter (cm)	No. of Buds and Flowers
Experiment I					
Uniconazole	0	70.4	57.7	9.9	8.2
	5	41.3	27.9	2.2	4.5
	10	37.8	25.5	4.2	3.4
	15	32.0	19.6	3.0	3.4
	30	30.7	18.4	0.8	2.9
	40	27.6	14.4	0.0	2.2
	60	26.6	15.0	0.0	2.0
Daminozide	2125	57.0	44.4	8.1	6.7
HSD[b]		10.2	10.7	3.5	1.8
Experiment II					
Uniconazole	0	46.3	32.9	8.8	4.5
	0.25	32.3	19.0	8.7	4.5
	0.50	30.0	17.0	8.4	3.8
	1	26.9	15.1	8.2	3.6
	2	27.0	14.7	7.9	3.3
	4	24.9	12.0	8.0	2.9
Daminozide	2125	27.5	14.8	8.5	4.3
HSD[b]		2.7	3.0	0.6	1.8

[a]Finish Ht - Ht at treatment application.

[b]Tukey's studentized range test, $\alpha = 0.05$.

TABLE 4

EFFECTS OF UNICONAZOLE AND ANCYMIDOL ON GROWTH OF 'ROSE WIZARD' COLEUS

Application Rate (mg/l)		Plant Ht (cm)	Plant Spread (cm)
Experiment I			
Uniconazole	0	14.7	18.0
	5	6.6	11.5
	10	6.2	11.3
	15	5.8	10.7
	30	6.0	11.2
	40	5.5	10.8
	60	5.3	10.6
Ancymidol	47.5	6.1	10.4
HSD[a]		1.5	1.8
Experiment II			
Uniconazole	0	17.5	18.6
	0.25	14.7	16.9
	0.50	12.9	14.4
	1	9.3	12.5
	2	10.2	13.0
	4	8.5	12.1
Ancymidol	47.5	13.3	14.7
HSD[a]		2.7	1.5

[a]Tukey's studentized range test, $\alpha = 0.05$.

TABLE 5

EFFECTS OF UNICONAZOLE AND ANCYMIDOL ON GROWTH OF 'PLUMOSA BRUSH FIRE' CELOSIA

Application Rate (mg/l)		Finish Ht (cm)	Growth[a] (cm)	Plant Spread (cm)	Length of Inflorescence
Experiment I					
Uniconazole	0	21.6	13.0	--	8.2
	5	12.7	4.6	--	7.5
	10	11.5	3.9	--	6.0
	15	10.9	3.1	---	5.9
	30	10.2	2.6	--	5.2
	40	10.1	2.7	--	4.8
	60	9.9	2.2	--	5.1
Ancymidol	47.5	17.4	9.5	--	6.9
HSD[b]		3.5	3.0	--	1.4
Experiment II					
Uniconazole	0	37.3	30.6	17.2	8.2
	0.25	30.0	22.7	17.4	7.6
	0.50	29.4	23.6	16.3	6.9
	1	27.0	22.4	16.9	5.1
	2	20.9	16.3	16.1	4.7
	4	17.7	12.7	17.4	5.2
Ancymidol	47.5	25.9	20.7	17.8	4.7
HSD[b]		3.0	1.9	2.4	3.1

[a]Finish Ht - Ht at treatment application.

[b]Tukey's studentized range test, $\alpha = 0.05$.

TABLE 6

EFFECTS OF UNICONAZOLE AND DAMINOZIDE ON GROWTH OF 'FUTURA RED' IMPATIENS

Application Rate (mg/l)		Plant Ht (cm)	Plant Spread (cm)
Experiment I			
Uniconazole	0	15.6	24.2
	5	5.7	10.8
	10	6.2	12.4
	15	6.4	11.8
	30	5.9	12.5
	40	6.5	11.4
	60	5.5	10.8
Daminozide	2125	13.5	22.0
HSD[a]		2.5	4.5
Experiment II			
Uniconazole	0	17.6	21.3
	0.25	11.6	17.3
	0.50	8.8	14.4
	1	8.1	13.8
	2	6.6	12.5
	4	6.8	11.0
Daminozide	2125	14.0	20.0
HSD[a]		2.9	2.6

[a]Tukey's studentized range test, $\alpha = 0.05$.

TABLE 7

EFFECTS OF UNICONAZOLE AND DAMINOZIDE ON GROWTH OF 'BONNIE JEAN' CHRYSANTHEMUM

Application Method and Rate		Plant Ht (cm)	Plant Spread (cm)	Bloom Diameter (cm)	No. of Buds and Flowers
Spray (mg/liter)					
Uniconazole	0	44.7	74.2	7.8	133.3
	5	23.4	44.5	6.8	202.5
	10	20.8	39.9	3.9	110.1
	25	17.7	36.3	5.7	92.9
Daminozide	4250	28.4	50.6	5.7	130.2
HSD[a]		3.4	8.2	2.8	118.1
Drench (mg/pot)					
Uniconazole	0	44.4	80.7	7.3	140.2
	2	18.5	40.9	4.7	89.0
	3	18.6	38.2	2.0	90.6
	5	17.4	38.8	3.8	88.7
Daminozide	4250	40.5	66.3	7.7	121.2
HSD[a]		3.4	8.2	2.8	118.1

[a]Tukey's studentized range test, $\alpha = 0.05$.

TABLE 8

EFFECTS OF UNICONAZOLE AND CHLORMEQUAT ON GROWTH OF TWO POINSETTIA CULTIVARS

Application Method and Rate		Plant Ht (cm)	Plant Spread (cm)	Bloom Diameter (cm)	No. of Inflorescences
			Annette Hegg Dark Red		
Spray (mg/liter)					
Uniconazle	0	55.8	68.2	30.3	6.1
	5	28.0	45.6	21.0	6.9
	10	20.9	32.1	17.3	6.5
	25	19.4	26.9	10.3	5.0
Chlormequat	354	40.9	63.1	26.3	6.8
HSD[a]		7.6	19.0	3.9	1.7
Drench (mg/pot)					
Uniconazole	0	59.8	48.6	27.2	6.8
	2	19.9	26.3	11.4	5.1
	3	19.6	27.5	7.1	4.2
	5	18.6	27.3	6.3	4.3
Chlormequat	354	47.0	54.7	26.3	4.3
HSD[a]		7.6	19.0	3.9	1.7

TABLE 8 (CONTINUED)

Application Method and Rate		Plant Ht (cm)	Plant Spread (cm)	Bloom Diameter (cm)	No. of Inflorescences
			Gutbier V-14 Glory		
Spray (mg/liter)					
Uniconazole	0	41.3	62.4	25.3	6.5
	5	22.5	40.2	19.4	5.5
	10	20.6	32.9	15.7	5.3
	25	14.5	21.4	7.2	3.6
Chlormequat	354	30.9	52.9	20.3	5.8
HSD[a]		4.2	16.4	6.3	2.2
Drench (mg/pot)					
Uniconazole	0	39.6	53.7	27.3	6.4
	2	16.0	25.3	9.1	3.9
	3	14.4	23.4	6.8	4.0
	5	14.3	24.3	5.2	3.8
Chlormequat	354	35.1	47.0	18.7	5.0
HSD[a]		4.2	16.4	6.3	2.2

[a]Tukey's studentized range test, $\alpha = 0.05$.

TABLE 9

EFFECTS OF UNICONAZOLE AND ANCYMIDOL ON GROWTH OF 'ACE' EASTER LILY

Application Method and Rate		Finish Ht (cm)	Growth[a] (cm)	Plant Spread (cm)	No. of Buds and Flowers
Folinar Spray (mg/liter)					
Uniconazole	0	33.8	19.6	23.7	5.7
	5	18.2	1.3	18.9	4.0
	10	17.8	0.9	15.0	0.7
	25	18.7	1.2	12.0	0.6
	50	16.9	0.4	9.0	0.0
Ancymidol	95	17.4	2.1	19.1	5.4
HSD[b]		10.0	8.0	11.2	3.4
Soil Drench (mg/pot)					
Uniconazole	0	49.1	32.1	24.1	6.3
	2	23.2	5.3	23.5	7.1
	3	20.6	4.1	23.0	5.9
	5	18.6	2.4	23.6	5.8
	10	18.2	1.3	21.1	3.3
Ancymidol	47.5	15.7	1.8	17.7	4.7
HSD[b]		10.0	8.0	11.2	3.4
Bulb-Soak (mg/liter)					
Uniconazole	0	40.8	40.8[c]	28.0	7.0
	2	14.6	14.6	19.5	3.9
	3	20.4	20.4	25.9	4.7
	5	14.4	14.4	20.2	0.2
	10	14.4	14.4	20.6	0.0
Ancymidol	47.5	19.3	19.3	25.1	0.0
HSD[b]		10.0	8.0	11.2	3.4

[a]Finish Ht - Ht at treatment application.

[b]Tukey's studentized range test, $\alpha = 0.05$.

[c]Growth for bulb-soaks treatments was equal to finish height because no growth had occurred when treatments were made to bulbs.

TABLE 10

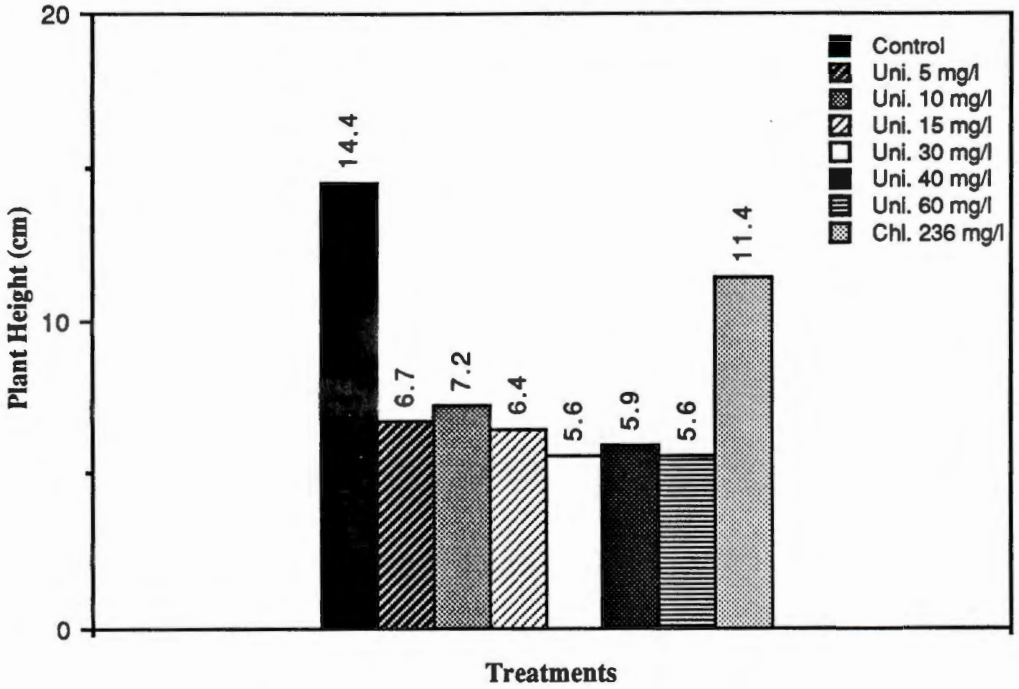
EFFECTS OF UNICONAZOLE AND ANCYMIDOL ON GROWTH OF 'NELLIE WHITE' EASTER LILY

Application Method and Rate		Finish Ht (cm)	Growth[a] (cm)	Plant Spread (cm)	No. of Buds and Flowers
Spray (mg/liter)					
Uniconazole	0	49.9	29.0	28.2	7.2
	5	20.7	2.5	22.4	2.5
	10	17.4	1.7	16.7	0.3
	25	16.5	0.0	21.4	0.0
	50	17.4	0.0	21.4	0.0
Ancymidol	95	18.1	1.1	22.2	5.8
HSD[b]		7.6	6.6	13.8	3.5
Drench (mg/pot)					
Uniconazole	0	40.2	23.4	29.8	6.8
	2	19.9	3.2	21.3	3.5
	3	20.8	3.6	20.9	3.3
	5	17.5	2.3	22.4	3.5
	10	14.9	1.2	21.0	0.0
Ancymidol	47.5	14.4	2.0	14.8	4.0
HSD[b]		7.6	6.6	13.8	3.5
Dip (mg/liter)					
Uniconazole	0	35.9	35.9[c]	29.7	5.8
	2	6.0	6.0	11.8	0.0
	3	11.9	11.9	22.1	0.0
	5	0.0	0.0	8.1	0.0
	10	0.0	0.0	6.9	0.0
Ancymidol	47.5	15.4	15.4	0.0	0.0
HSD[b]		7.6	6.6	13.8	3.5

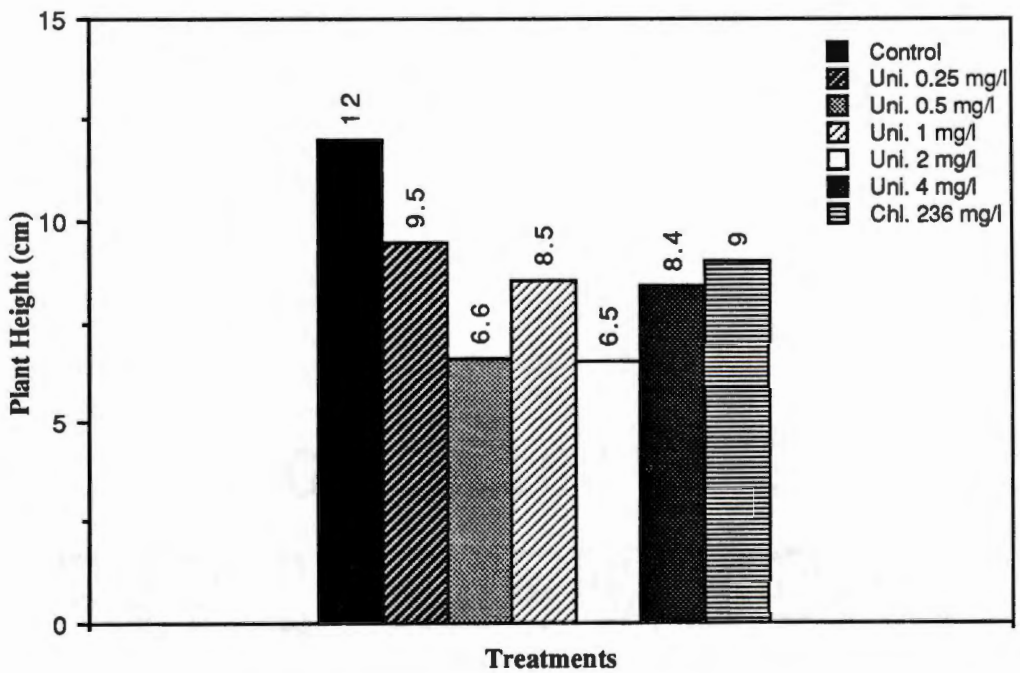
[a]Finish Ht - Ht at treatment application.

[b]Tukey's studentized range test, $\alpha = 0.05$.

[c]Growth for bulb-soaks treatments was equal to finish height because no growth had occurred when treatments were made to bulbs.

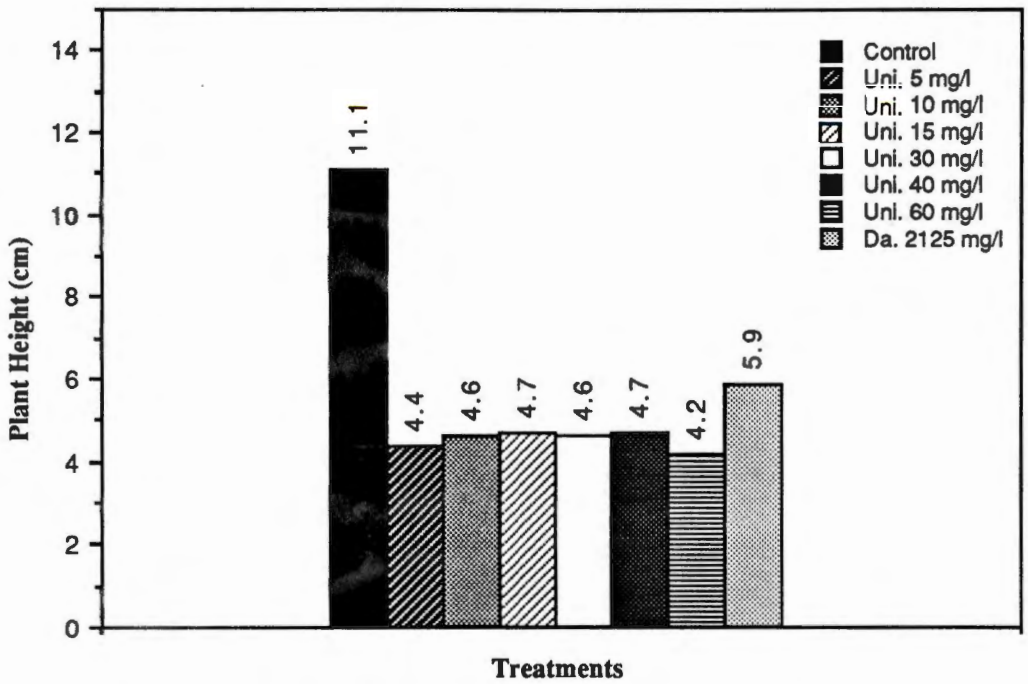


a. Uniconazole Foliar Sprays at 5 - 60 mg/l.

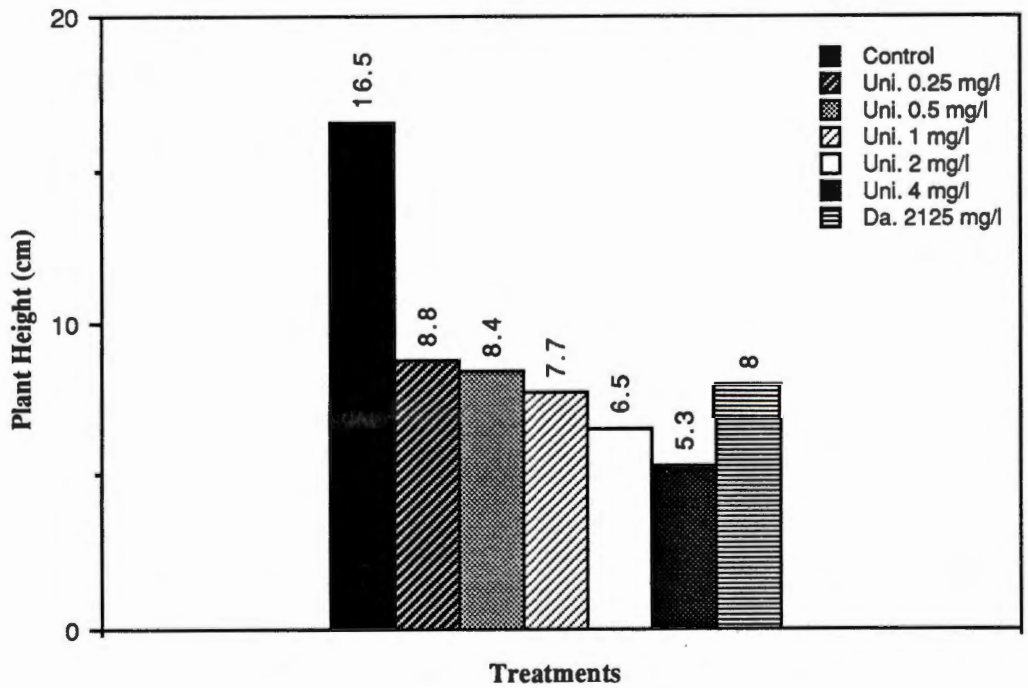


b. Uniconazole Foliar Sprays at 0.25 - 4 mg/l.

Figure 1. Effect of Uniconazole Foliar Sprays on Height on 'Sprinter Scarlet' Geranium.

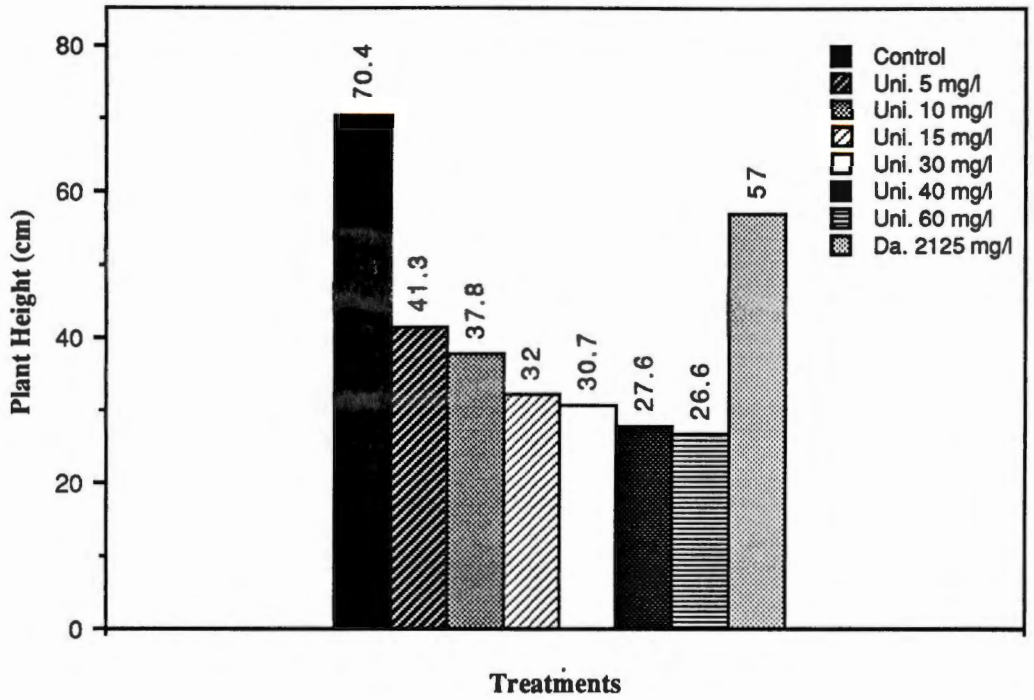


a. Uniconazole Foliar Sprays at 5 - 60 mg/l.

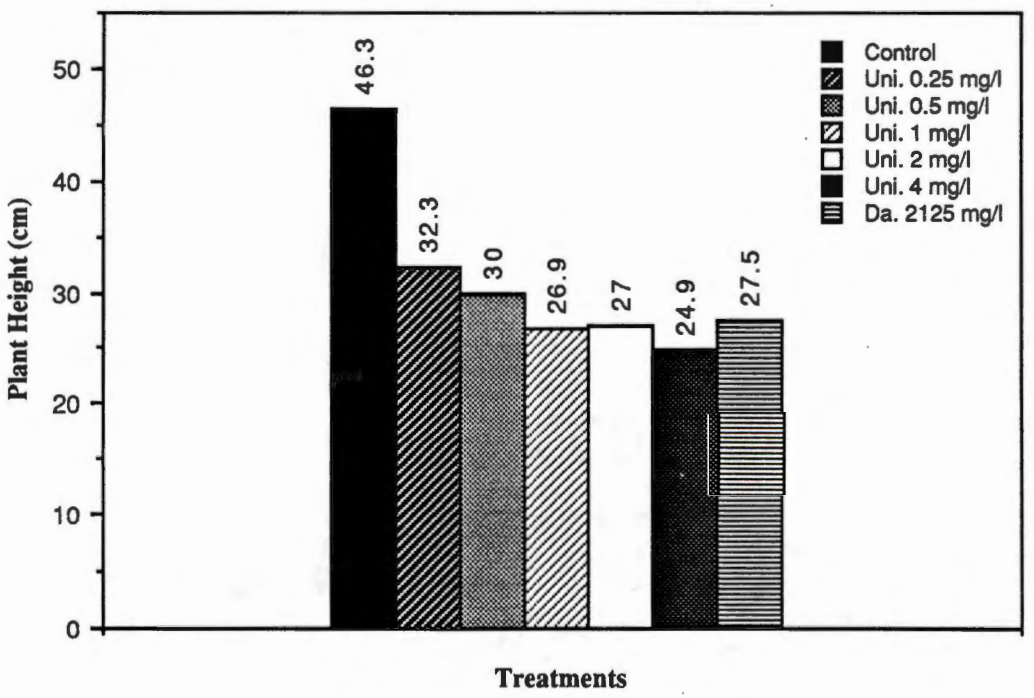


b. Uniconazole Foliar Sprays at 0.25 - 4 mg/l.

Figure 2. Effect of Uniconazole Foliar Sprays on Height on 'Blue Joy' Petunia.

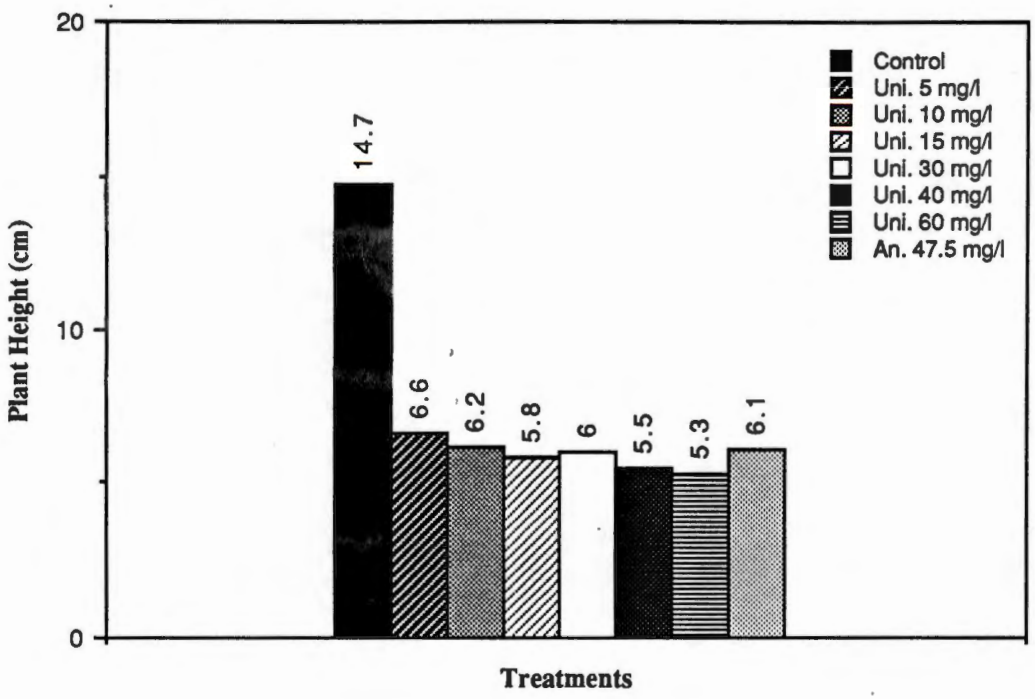


a. Uniconazole Foliar Sprays at 5 - 60 mg/l.

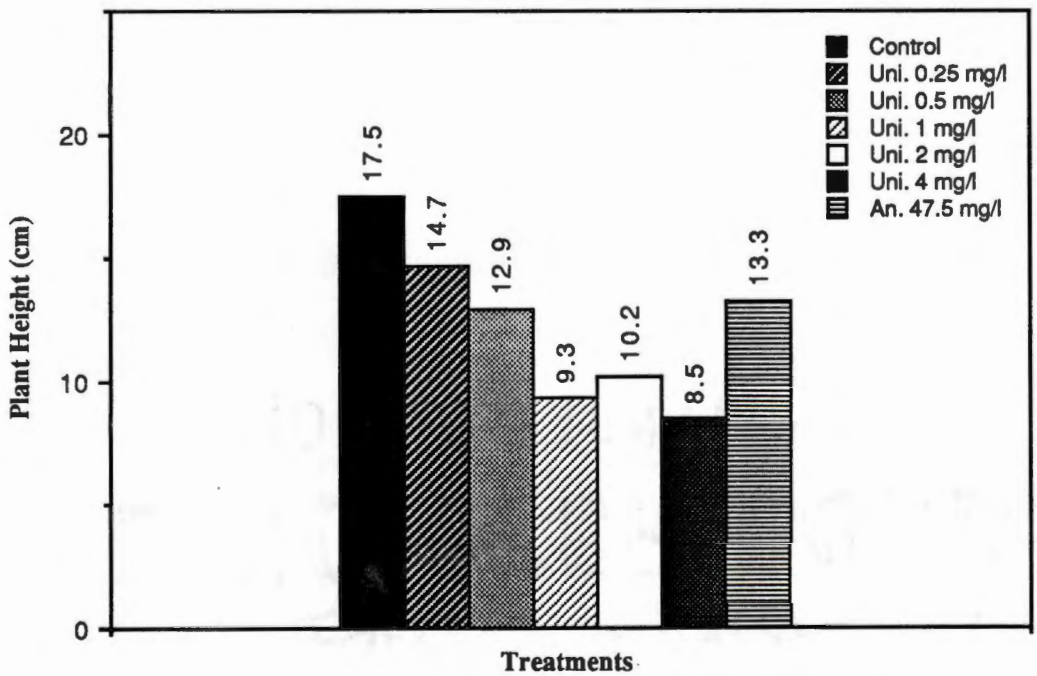


b. Uniconazole Foliar Sprays at 0.25 - 4 mg/l.

Figure 3. Effect of Uniconazole Foliar Sprays on Height on 'Yellow Climax' Marigold.

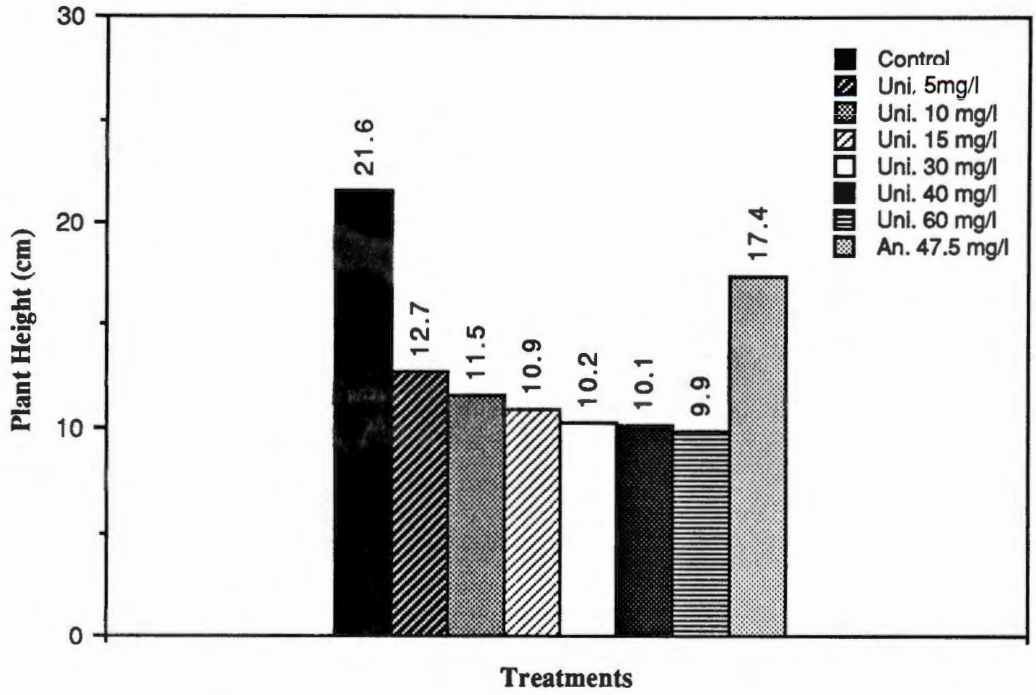


a. Uniconazole Foliar Sprays at 5 - 60 mg/l.

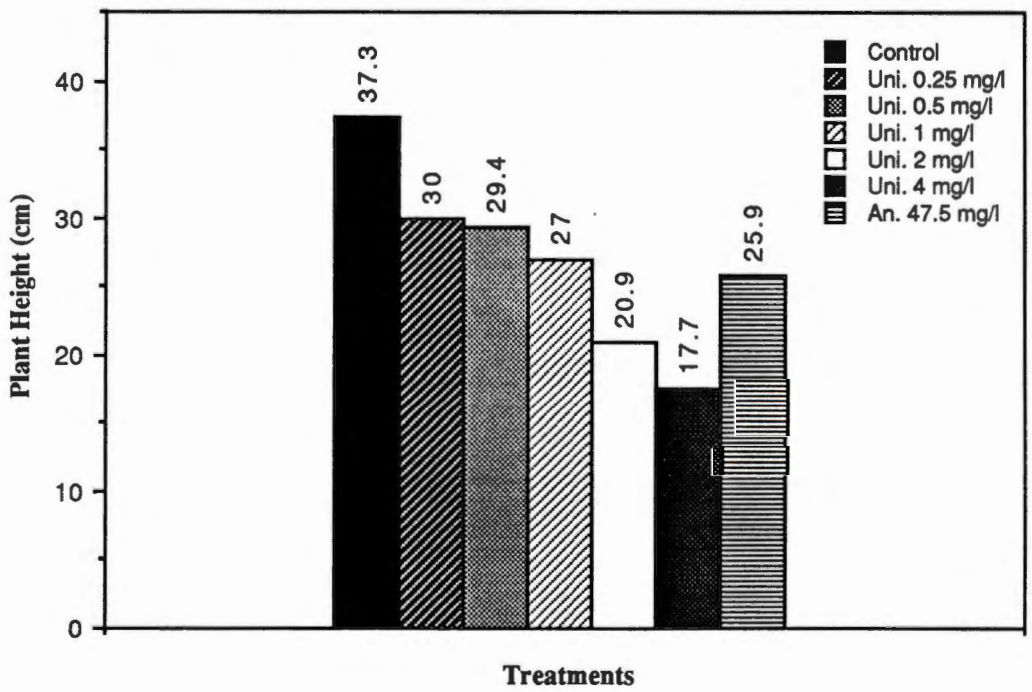


b. Uniconazole Foliar Sprays at 0.25 - 4 mg/l.

Figure 4. Effect of Uniconazole Foliar Sprays on Height on 'Rose Wizard' Coleus.

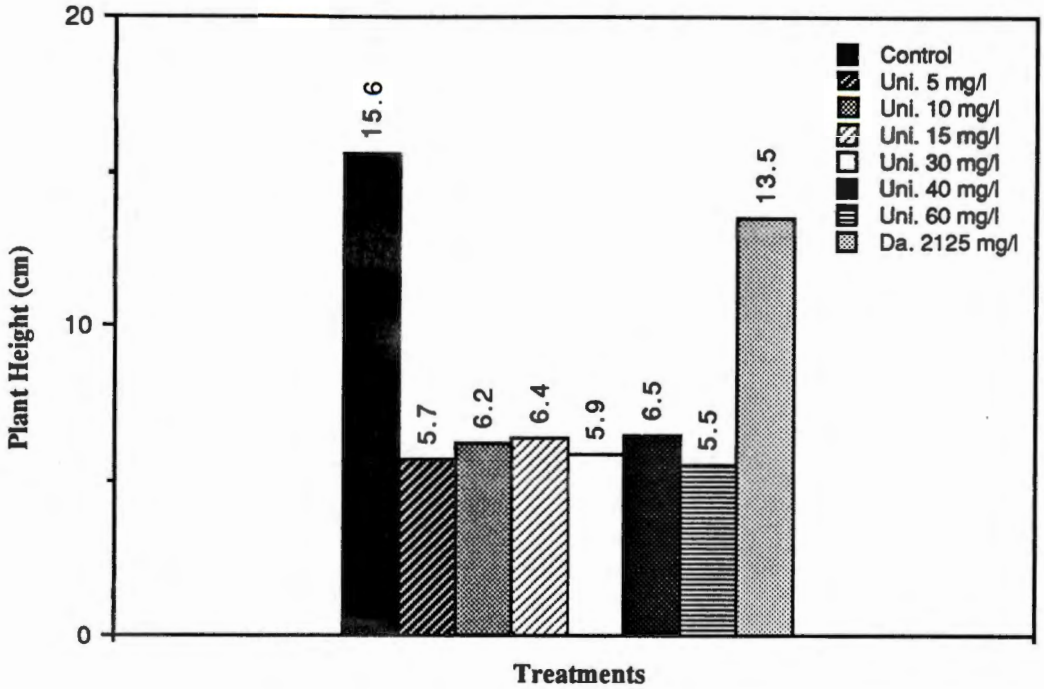


a. Uniconazole Foliar Sprays at 5 - 60 mg/l.

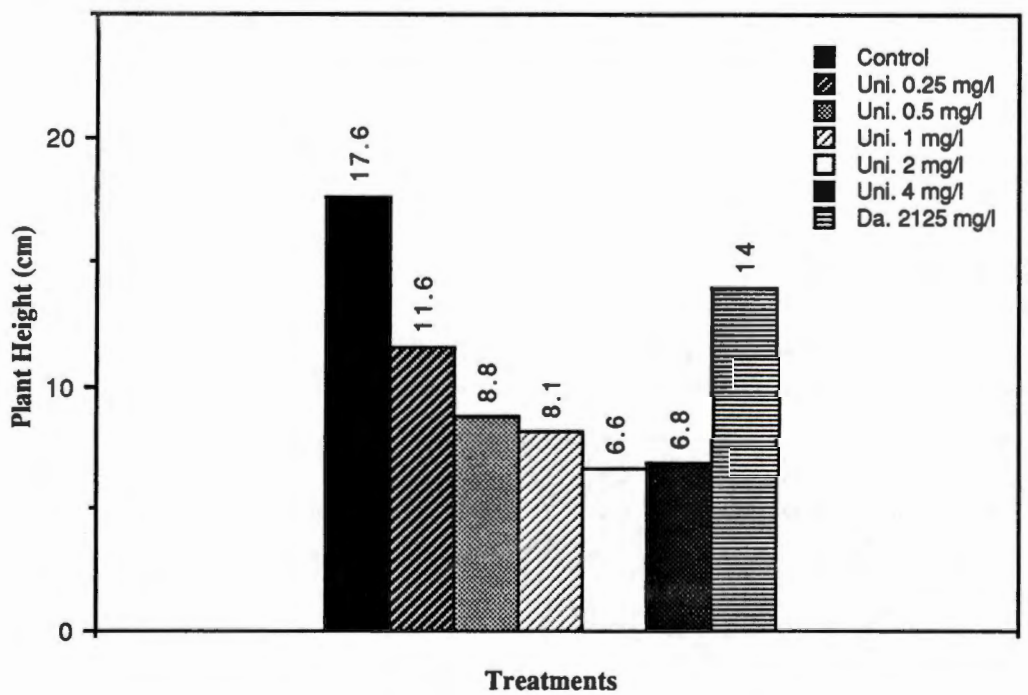


b. Uniconazole Foliar Sprays at 0.25 - 4 mg/l.

Figure 5. Effect of Uniconazole Foliar Sprays on Height on 'Plumosa Brush Fire' Celosia.

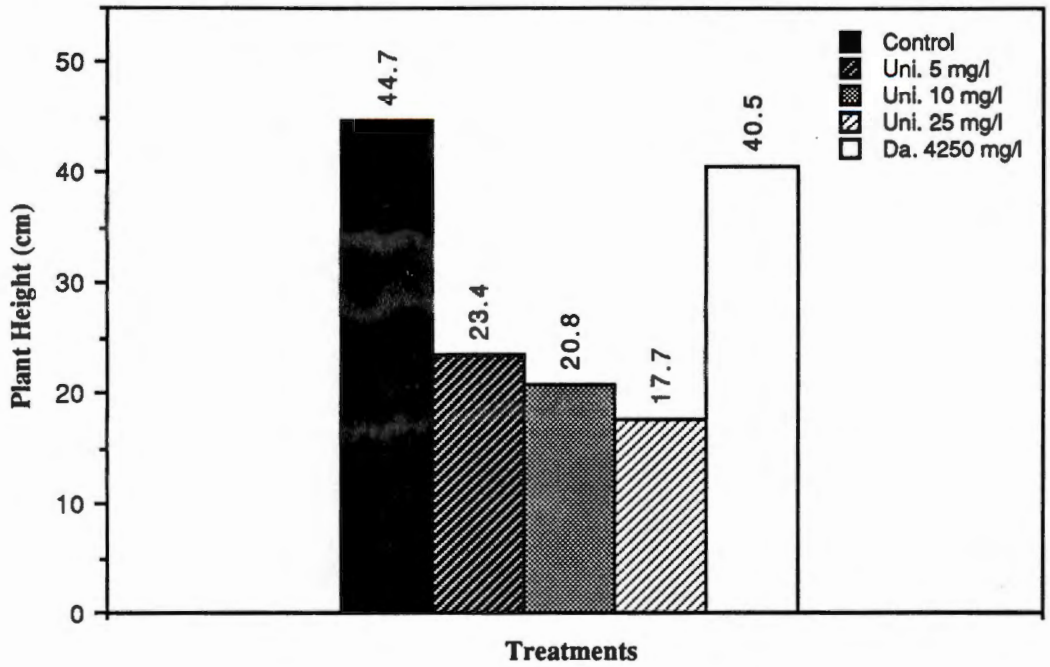


a. Uniconazole Foliar Sprays at 5 - 60 mg/l.

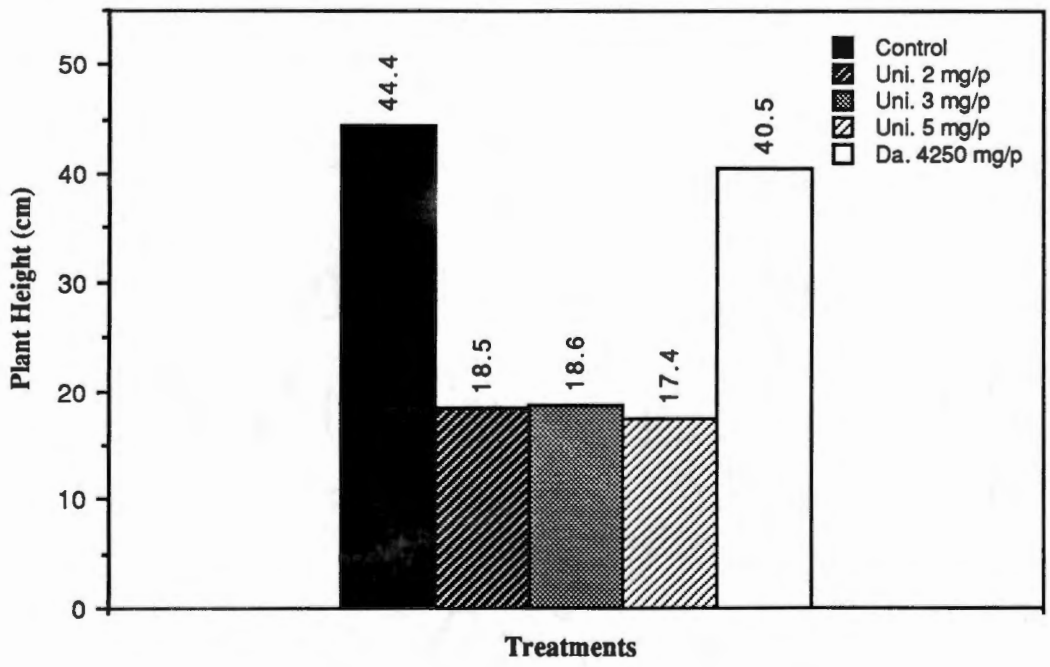


b. Uniconazole Foliar Sprays at 0.25 - 4 mg/l.

Figure 6. Effect of Uniconazole Foliar Sprays on Height on 'Futura Red' Impatiens.

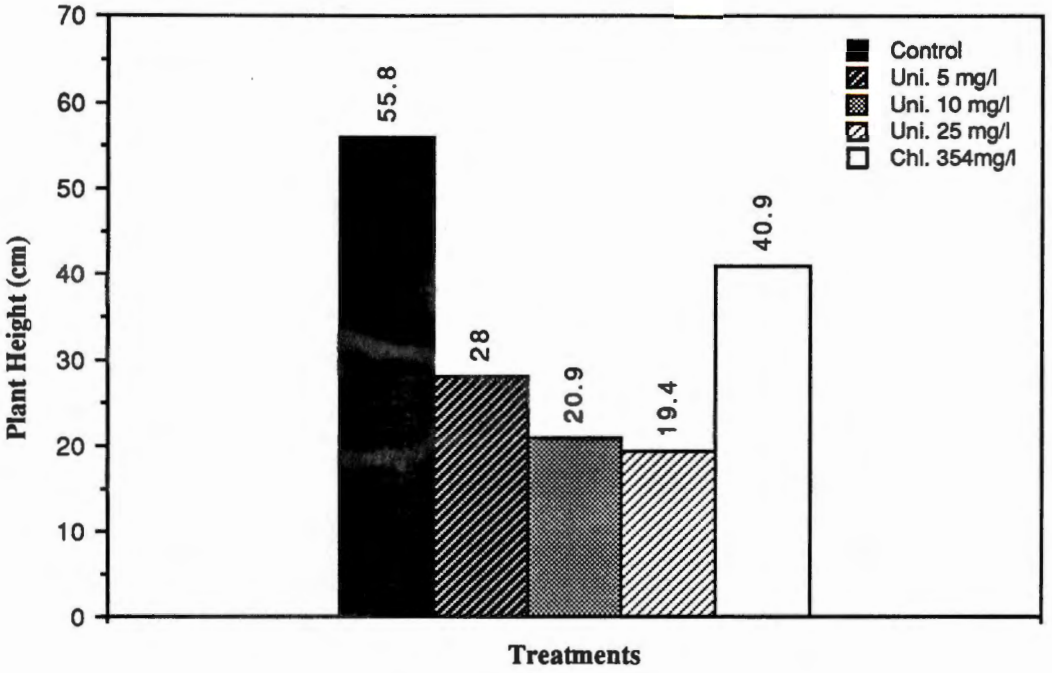


a. Uniconazole Foliar Sprays at 5 - 25 mg/l.

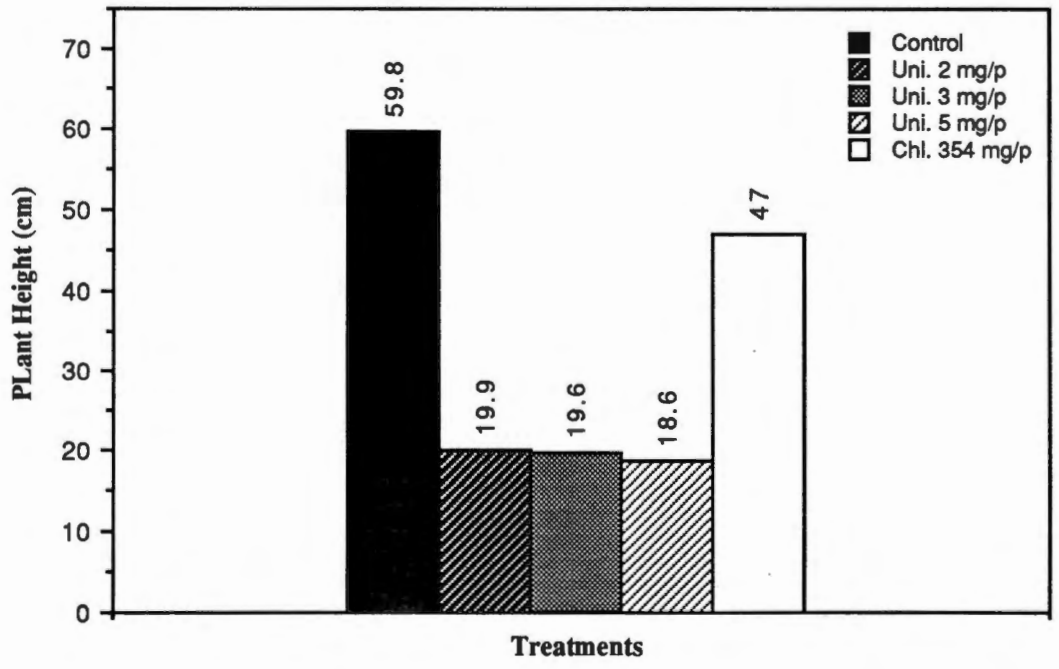


b. Uniconazole Soil Drenches at 2 - 5 mg/pot.

Figure 7. Effects of Uniconazole Foliar Sprays and Soil Drenches on Height on 'Bonnie Jean' Chrysanthemum.

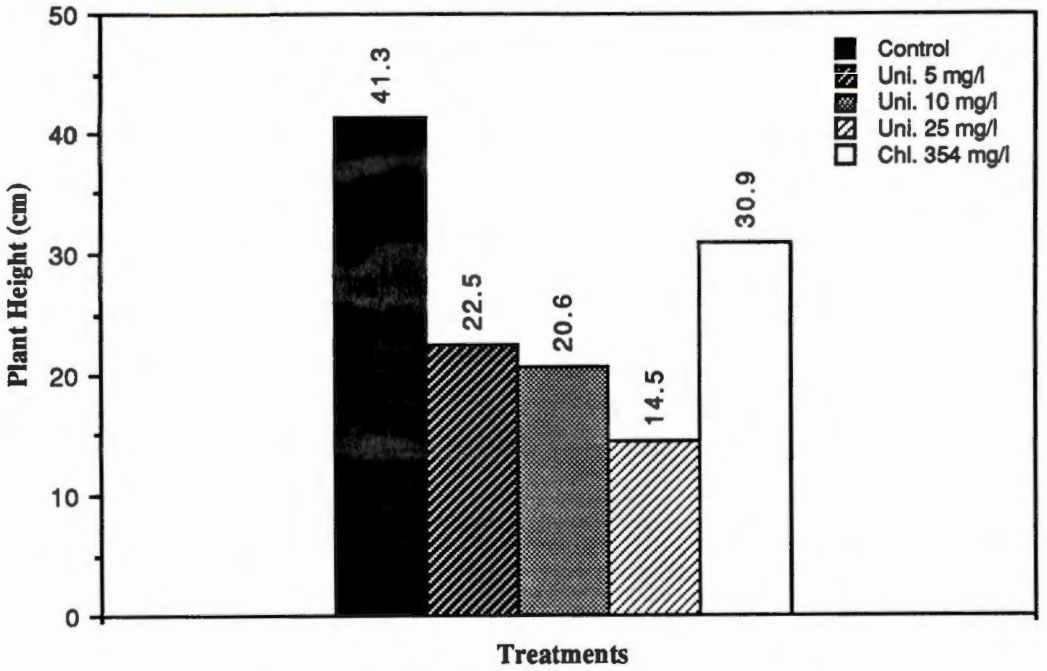


a. Uniconazole Foliar Sprays at 5 - 25 mg/l.

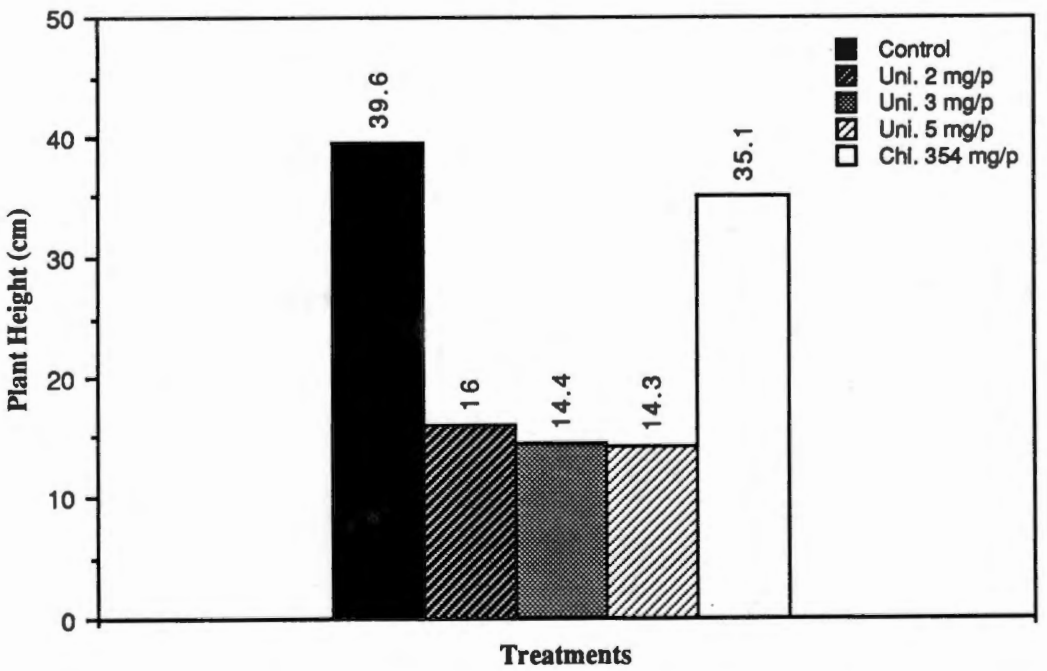


b. Uniconazole Soil Drenches at 2 - 5 mg/pot.

Figure 8. Effects of Uniconazole Foliar Sprays and Soil Drenches on Height on 'Annette Hegg Dark Red' Poinsettia.

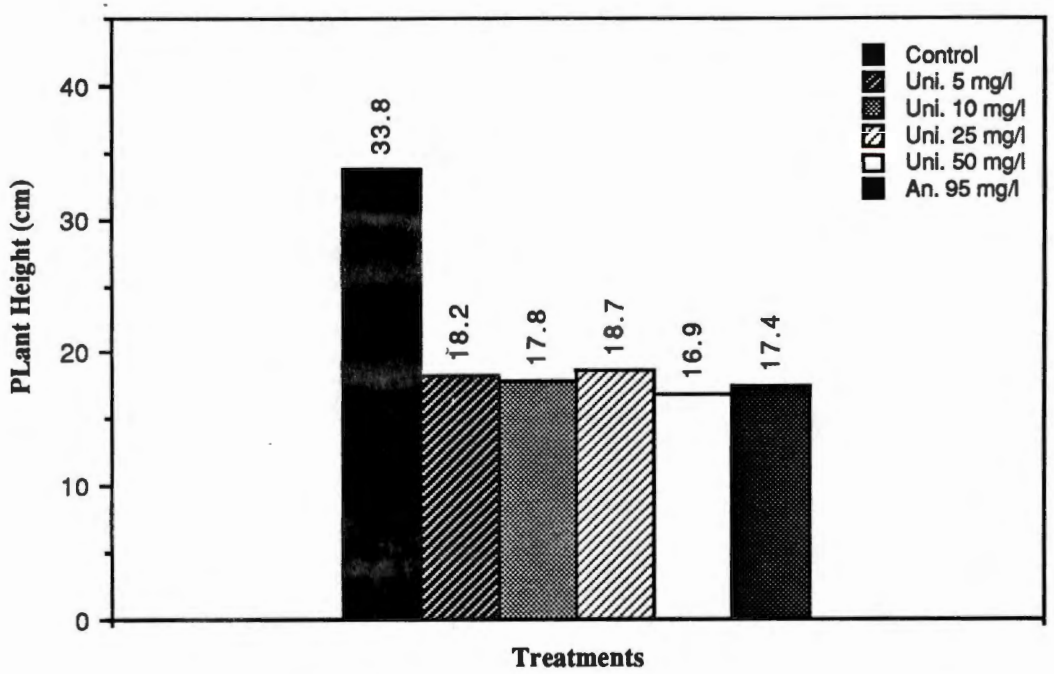


a. Uniconazole Foliar Sprays at 5 - 25 mg/l.

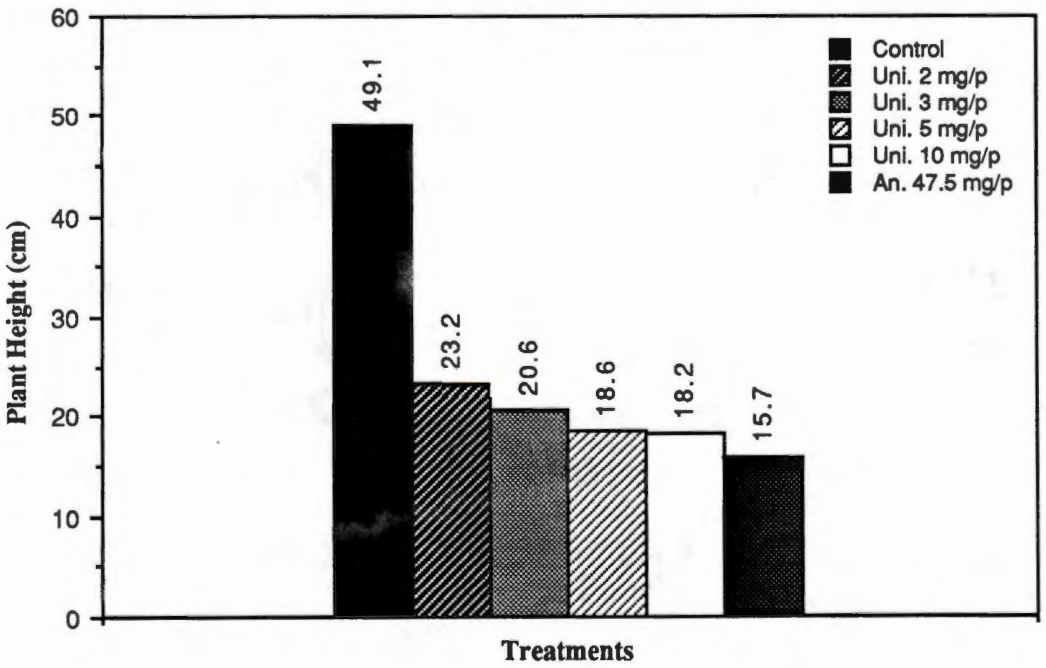


b. Uniconazole Soil Drenches at 2 - 5 mg/pot.

Figure 9. Effects of Uniconazole Foliar Sprays and Soil Drenches on Height on 'Gutbier V-14 Glory' Poinsettia.

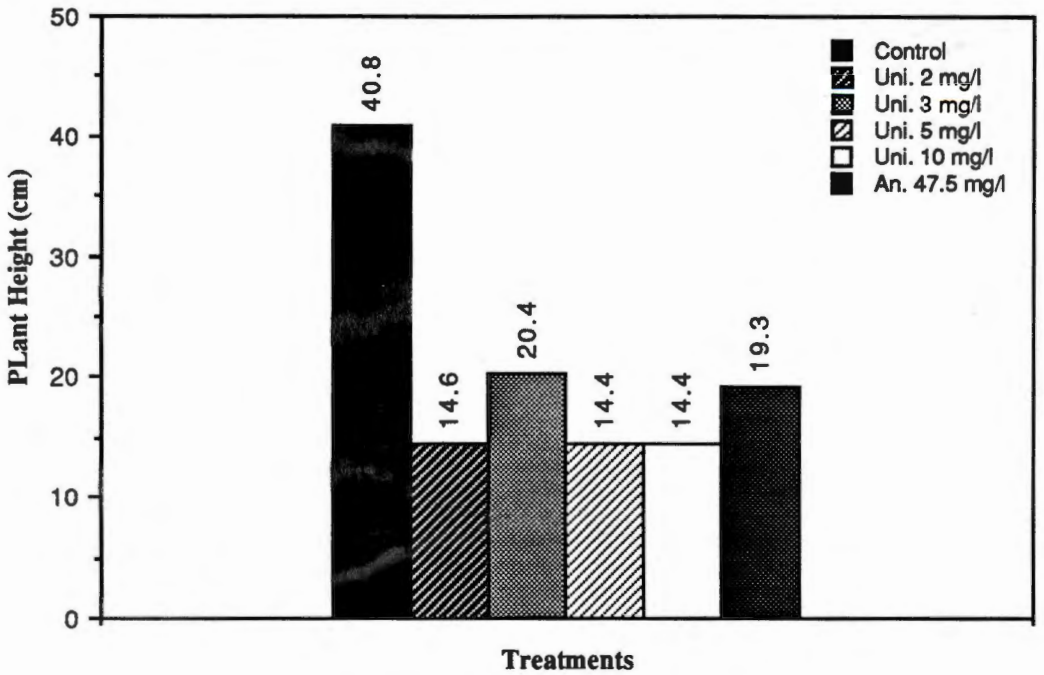


a. Uniconazole Foliar Sprays at 5 - 50 mg/l.



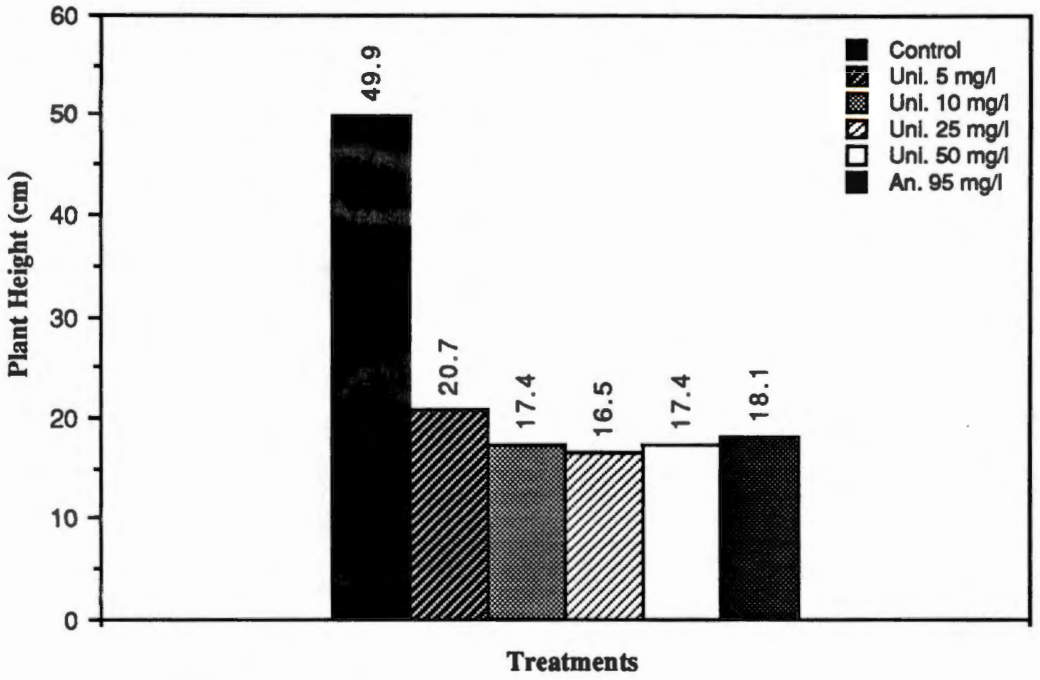
b. Uniconazole Soil Drenches at 2 - 10 mg/pot.

Figure 10. Effects of Uniconazole Foliar Sprays, Soil Drenches, and Bulb-Soaks on Height on 'Ace' Lily.

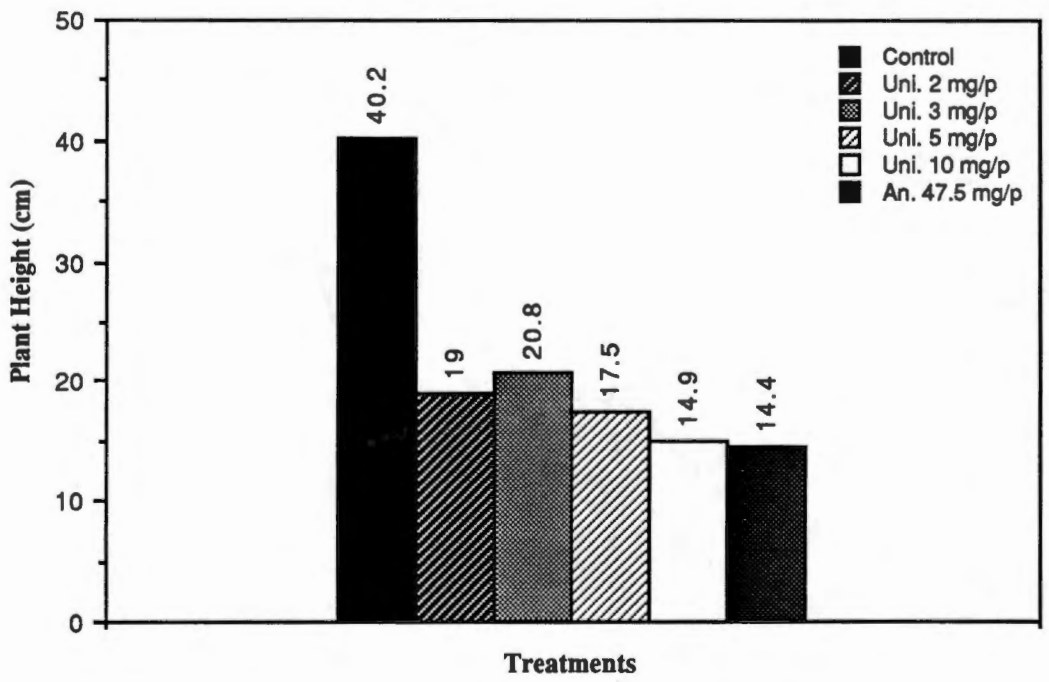


c. Uniconazole Bulb-Soaks at 2 - 10 mg/l.

Figure 10. (Continued).

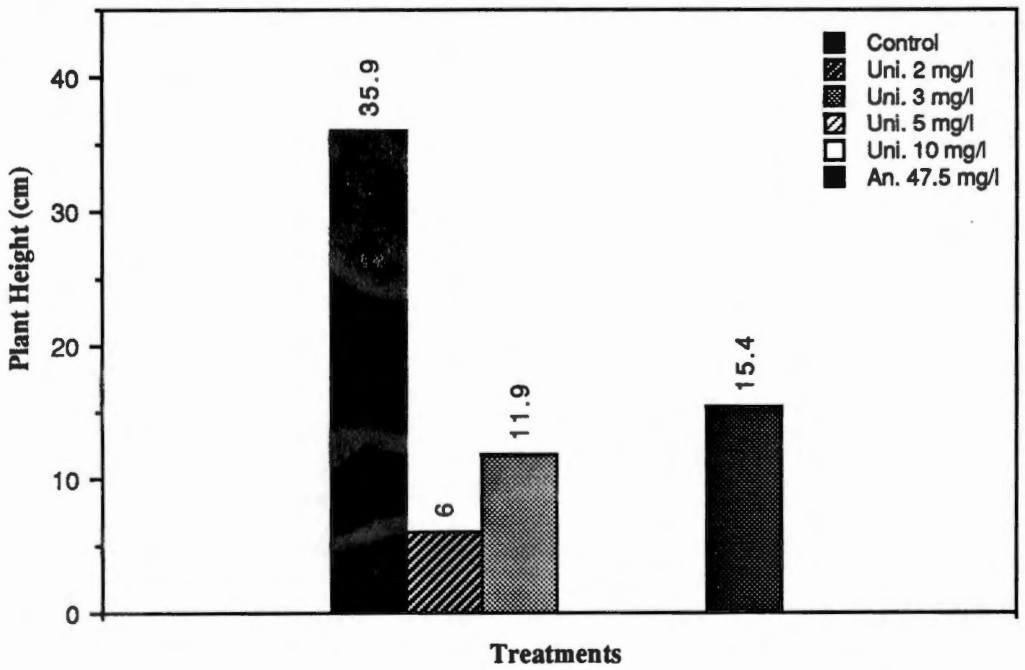


a. Uniconazole Foliar Sprays at 5 - 50 mg/l.



b. Uniconazole Soil Drenches at 2 - 10 mg/pot.

Figure 11. Effects of Uniconazole Foliar Sprays, Soil Drenches, and Bulb-Soaks on Height on 'Nellie White' Lily.



c. Uniconazole Bulb-Soaks at 2 - 10 mg/l.

Figure 11. (Continued).

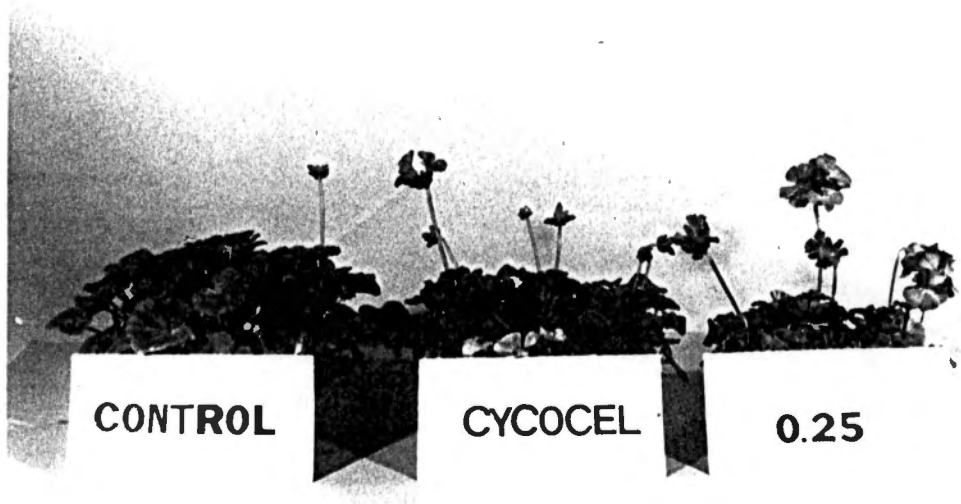
PLATE 1

EFFECT OF UNICONAZOLE AND CHLORMEQUAT ON FLOWERING OF 'SPRINTER SCARLET' GERANIUM

Figure 12. Uniconazole at 0.25 mg/l Caused Earlier Flowering than Chlormequat at 236 mg/l (Cycocel at 2000 mg/l) and Control Plants in Geranium.

Figure 13. Uniconazole at 4 mg/l Caused Geranium to Flower Up to 2 Weeks Earlier than Control Plants.

12



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PLATE 2

INCREASING UNICONAZOLE CONCENTRATIONS INCREASED THE SUPPRESSIONS OF HEIGHT ON 'YELLOW CLIMAX' MARIGOLD

Figure 14. Daminozide at 2125 mg/l (B-995 at 2500 mg/l) Provided Shorter Plant Height than Uniconazole at 0.25 mg/l.

Figure 15. Increasing Uniconazole Concentrations from 0.25 to 4 mg/l Caused Increased Limitations in Height on Marigold.

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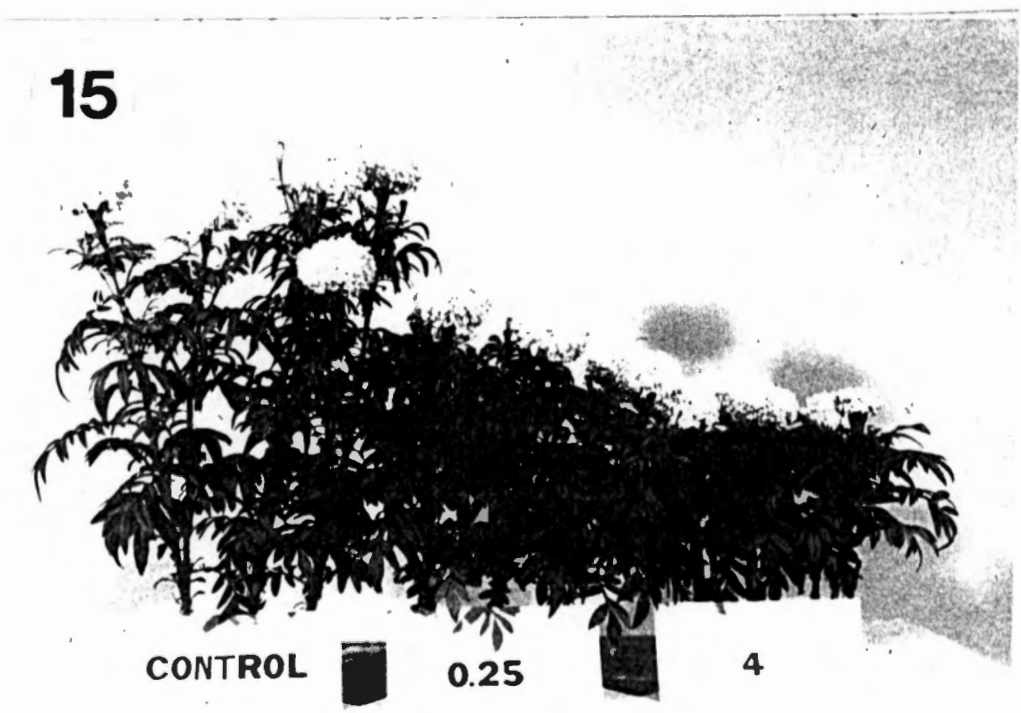


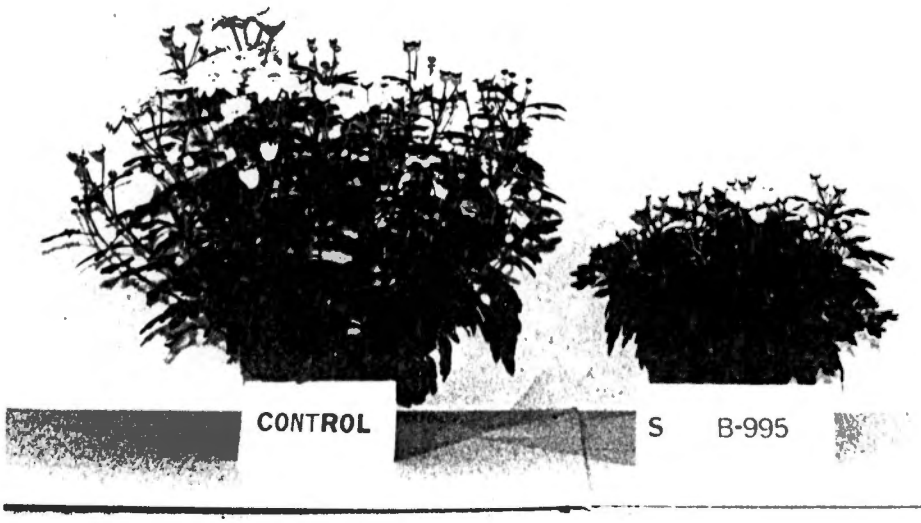
PLATE 3

EFFECTS OF UNICONAZOLE AND DAMINOZIDE ON FLOWERING OF 'BONNIE JEAN' CHRYSANTHEMUM

Figure 16. Daminozide Foliar Sprays at 4250 mg/l (B-995 at 5000 mg/l) Delayed Flowering up to 3 Days in 'Bonnie Jean' Chrysanthemum.

Figure 17. Uniconazole Foliar Sprays at 5 mg/l Delayed Flowering up to 5 Days Compared to Control Plants in 'Bonnie Jean' Chrysanthemum.

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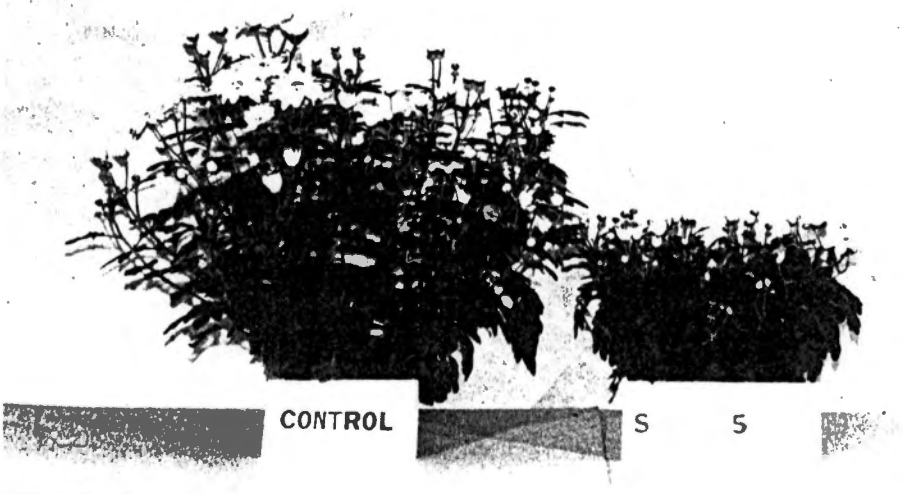


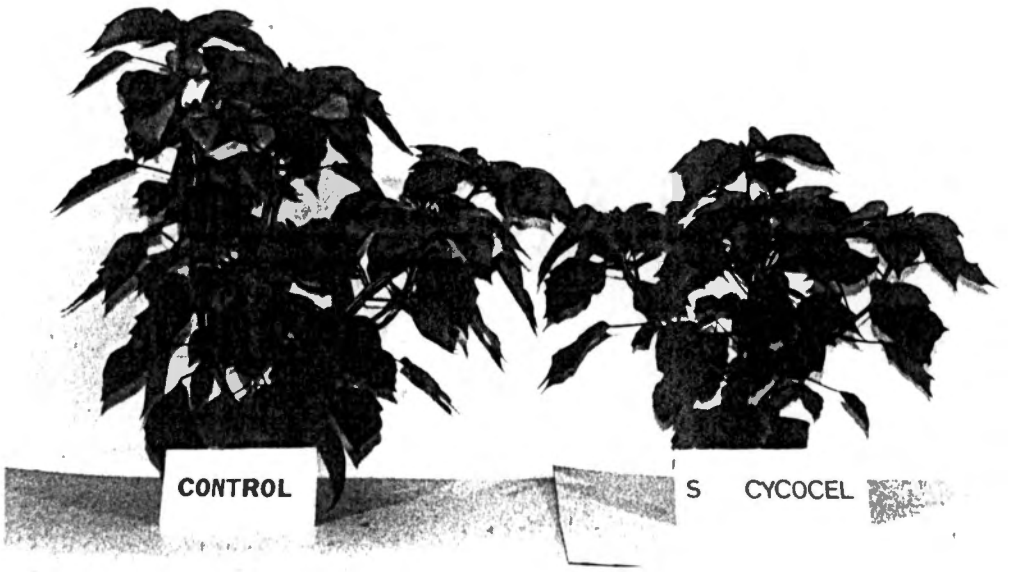
PLATE 4

LOW UNICONAZOLE CONCENTRATIONS PROVIDED ACCEPTABLE FINISHED 'ANNETTE HEGG DARK RED' POINSETTIA

Figure 18. Chlormequat Foliar Sprays at 354 mg/l (Cyclocel at 3000 mg/l) Provided Slightly Compact Poinsettia.

Figure 19. Uniconazole Foliar Sprays at 5 mg/l Provided Compact Poinsettia.

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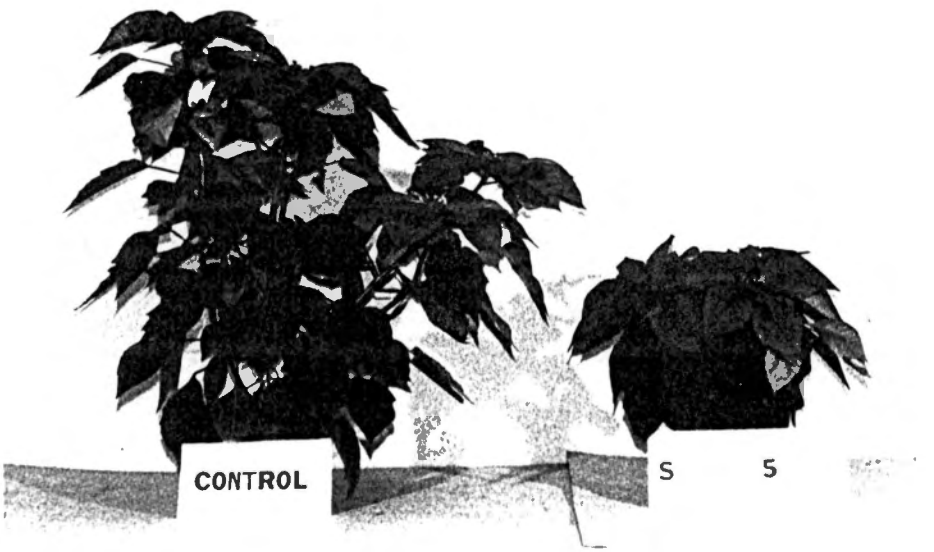


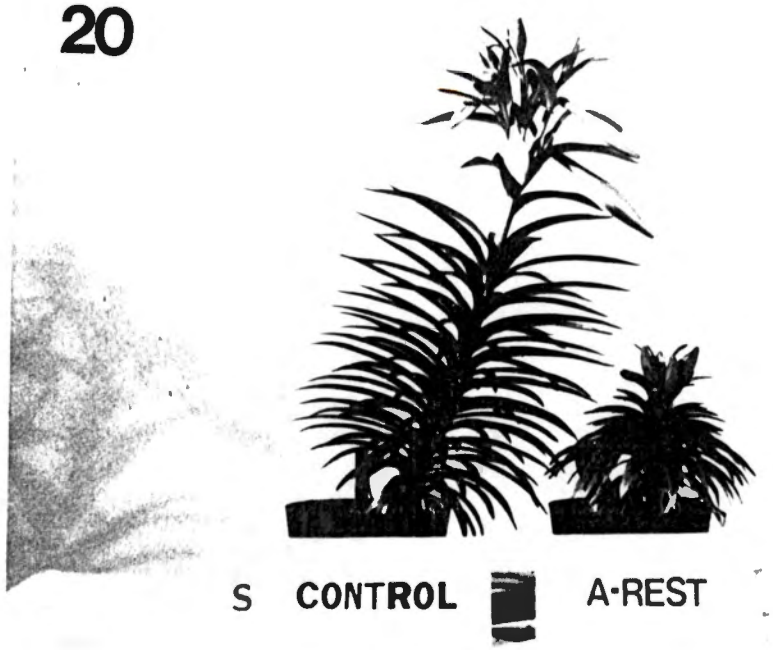
PLATE 5

EFFECT OF ANCYMIDOL ON HEIGHT ON 'ACE' LILY

Figure 20. Ancymidol Foliar Sprays at 95 mg/l (A-Rest at 380 mg/l) Limited Height of Lily Significantly.

Figure 21. Plant Height of Lily was Significantly Suppressed by Ancymidol Soil Drenches at 47.5 mg/pot (A-Rest at 190 mg/pot).

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S CONTROL A-REST

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D CONTROL A-REST

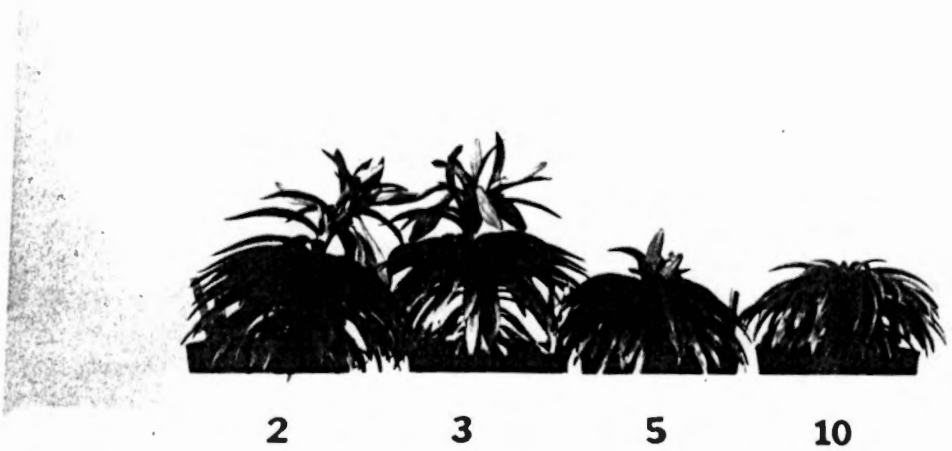
PLATE 6

EFFECT OF UNICONAZOLE ON HEIGHT ON 'ACE' LILY

Figure 22. Uniconazole Soil Drenches at 2, 3, 5 and 10 mg/pot Suppressed Height of Lily Significantly.

Figure 23. Uniconazole Foliar Sprays at 5, 10, 25 and 50 mg/l Suppressed Height of Lily Significantly.

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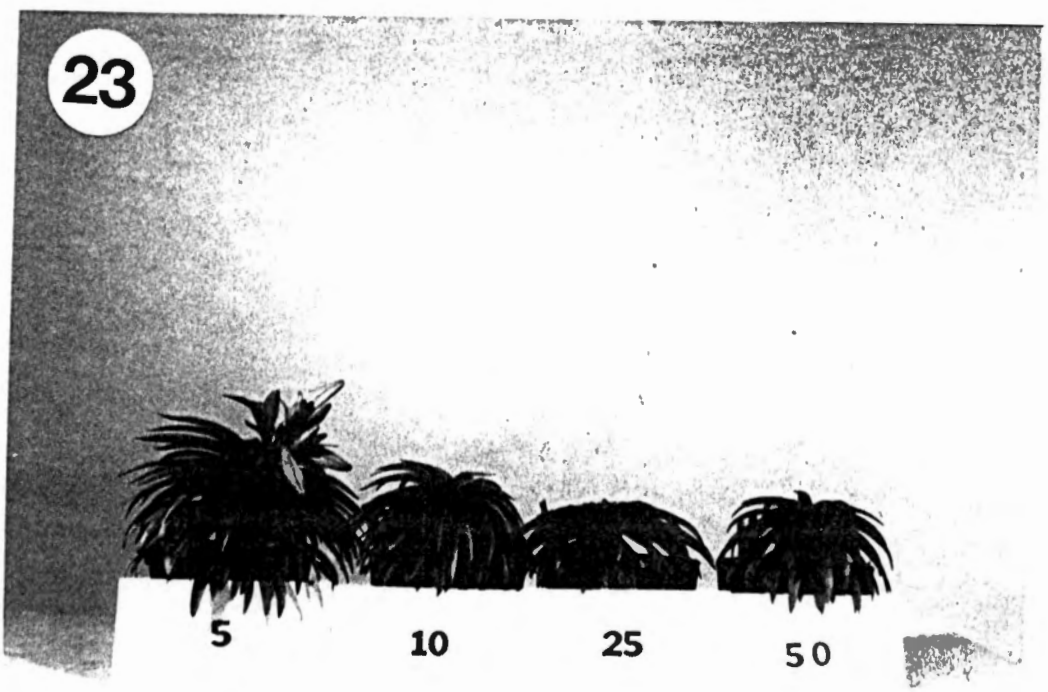
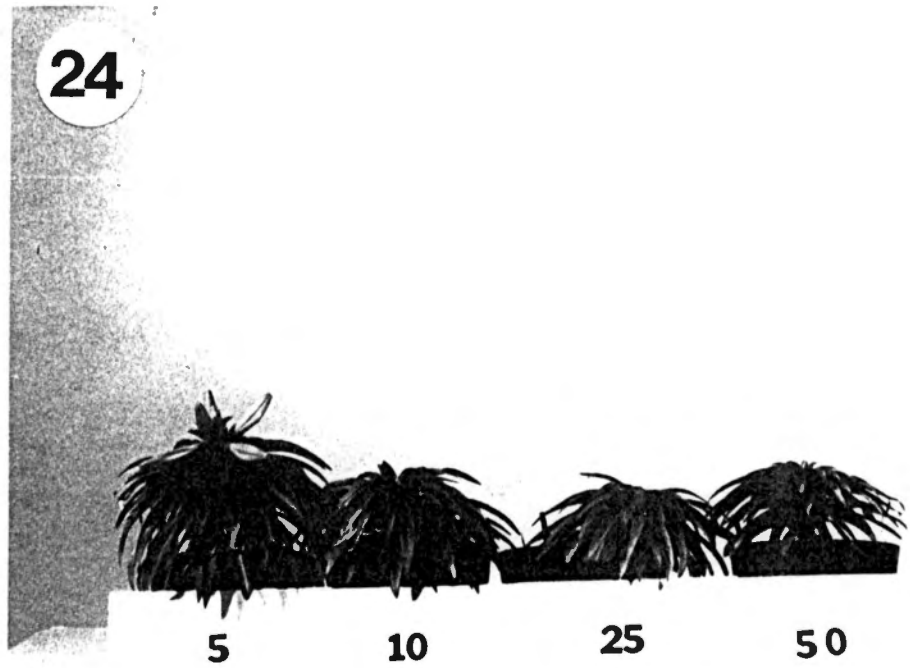


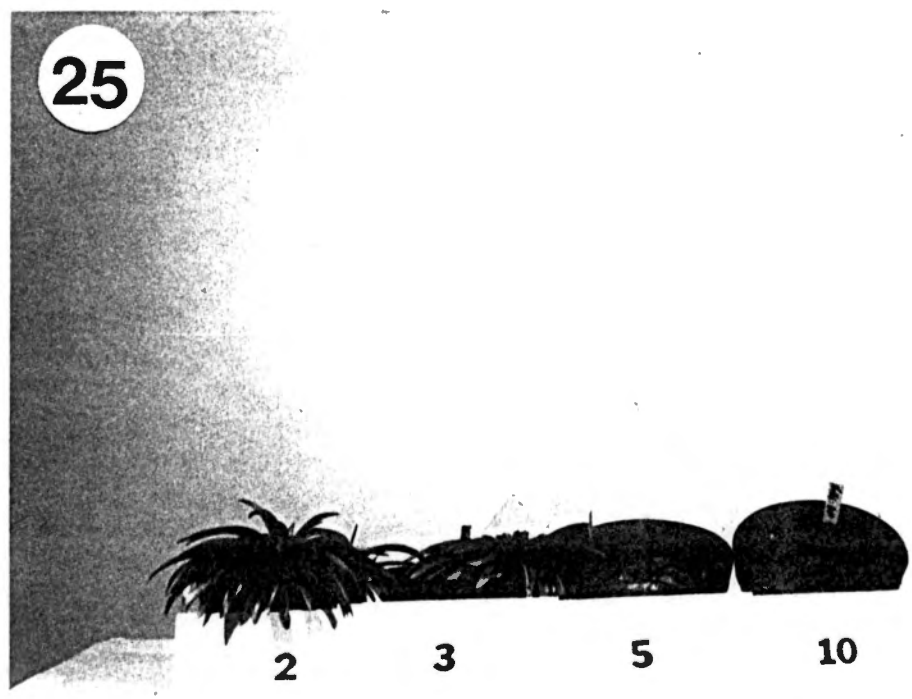
PLATE 7

EFFECT OF UNICONAZOLE ON HEIGHT ON 'NELLIE WHITE' LILY

Figure 24. Uniconazole Foliar Sprays at 5, 10, 25 and 50 mg/l Showed No Significant Differences when Compared Between Treatment Rates.

Figure 25. Uniconazole Bulb-Soaks at 2, 3, 5 and 10 mg/l Provided Very Little or No Growth on Lily.


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10
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50


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2
3
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VITA

Gok Yin Yeow was born in Negeri Sembilan, Malaysia on September 9, 1959. She was graduated from Pulau Sebang Secondary School, Malacca in 1977. In 1983, she received the Bachelor of Science degree in Agriculture with Education from the Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia.

In April 1986, the author came to the United States and enrolled into graduate school in the Department of Ornamental Horticulture and Landscape Design. She was granted the Master of Science degree from The University of Tennessee, Knoxville with a major in Ornamental Horticulture and Landscape Design in March 1988. While working toward this degree, she was employed as a Graduate Research Assistant for the Department by The University of Tennessee Agricultural Experiment Station.

The author is a member of Gamma Sigma Delta, the Agriculture Honor Society, and Pi Alpha Xi, the Floriculture and Ornamental Horticulture Honor Society.