primary roots at the same radial distance from the stem of trees grown directly in the field. Soluble and structural carbohydrates were determined using procedures described by Stamps (3).

Production systems did not influence the change in height or stem diameter or shoot fresh weight for the *Magnolia, Ulmus, Lagerstroemia,* and *Pinus* (Table 1). Fabric container-grown or field-grown *Quercus* were taller than *Quercus* produced in containers. *Quercus* root dry weights were significantly greater inside the 36-cm-diameter fabric root-restricting containers than inside the 36-cm-diameter harvest zone of field-grown trees. There was no difference in total *Quercus* roots due to production system.

Liquidambar trees were 50% taller, with 43% greater stem diameter, 54% more shoot weight, and 56% more total root weight if grown in fabric Field-Gro containers or directly in the field than if grown in above-ground plastic containers (Table 1). There was 29% more sweet gum root dry weight harvested from within the fabric container than from the comparable harvest zone for field-grown trees without root restriction. Fifty percent of the *Liquidambar* trees produced one to four roots that penetrated the polyethylene bottom of the fabric containers. Some of these roots were ≥1.5 cm in diameter. Ninety-one percent and 87% of total *Liquidambar* root weights were in the inside harvest zone for the fabric container-grown and field-grown trees, respectively. However, many *Liquidambar* trees had a few roots that grew deeper than the harvest zone, including some of those planted in fabric containers.

Production systems did not influence shoot growth or total root dry weight of 'East Palatka' holly, but did affect root distribution (Table 1). The percentage of 'East Palatka' holly root weight in the fabric container or comparable harvest zone was greater for trees in the fabric containers (91%) than for field-grown (82%) trees. The percentage of roots in the inside harvest zone for fabric container-grown and field-grown trees did not differ for *Pinus, Magnolia, Ulmus,* or *Lagerstroemia.* There were 88%, 91%, 71%, 78%, and 94% of total root weights in the inside harvest zone averaged across both production systems for *Quercus, Magnolia, Ulmus, Lagerstroemia,* and *Pinus,* respectively.

Total carbohydrate content of primary root samples was greater in the *Quercus* and *Magnolia* if the roots had been restricted by the fabric containers than if grown directly in the field (Table 2). Total carbohydrate content of *Liquidambar* root samples was increased if trees had been grown directly in the field. An increased carbohydrate level in primary root tissue could accelerate root development after transplanting, assuming other environmental and physiological factors were not limiting. The primary contributor to these differences in total carbohydrate levels was the level of soluble sugars for *Magnolia* and *Liquidambar,* whereas starch was the major contributor in *Quercus.*

The effects of fabric containers for field production on growth and the portion of the total root system harvested appeared to be species-dependent. The fabric containers did not result in a growth advantage or increase the percent of roots harvested for *Magnolia, U. parvifolia* 'Drake', *Lagerstroemia,* or *Pinus,* compared to production directly in the field under the conditions described, but *Liquidambar* and *Quercus* responded positively. Producers must decide between these production systems based primarily on economic and marketing strategy factors or any differences in rate of establishment after transplanting. It was clear that container production, following management practices in this experiment, was inferior to either of the field production systems tested for *Quercus* and *Liquidambar.*

Literature Cited

1. Hartman, H.T. and D.E. Kester, 1983. Plant propagation : Principles and practices. 4th ed. Prentice-Hall, Englewood Cliffs, N.J.
2. Reiger, R. and C.E. Whitcomb. 1983. A root control system for growing trees in the field. Proc. SNA Res. Conf. 28:100–102.
3. Stamps, R.H. 1984. Production temperature effects on anatomy, morphology, physiology and postharvest longevity of leatherleaf fern (*Rumorha adiantiformis* Forst. Ching). PhD Diss. Univ. of Florida, Gainesville.
4. van de Werken, H. 1982. Effects of four root barrier fabrics on penetration and self pruning of roots. Proc. SNA Res. Conf. 27:292–293.
5. Whitcomb, C.E. 1985. Innovations and the nursery industry. J. Env. Hort. 3(1):33–38.

HORTSCIENCE 22(6):1287–1289. 1987.

Efficacy of Ancymidol, Daminozide, Flurprimidol, Paclobutrazol, and XE-1019 when Followed by Irrigation

James E. Barrett, Carolyn A. Bartuska, and Terril A. Nell
Department of Ornamental Horticulture, University of Florida, Gainesville, FL 32611

Additional index words. *Chrysanthemum morifolium*

Abstract. **Vegetative *Chrysanthemum morifolium* Ramat. 'Nob Hill' plants were treated with foliar sprays of ancymidol, daminozide, flurprimidol, paclobutrazol, or XE-1019 and then overhead-irrigated 0.5, 1, 2, 4, 8, or 24 hr later. Irrigation prior to 4 hr reduced the efficacy of daminozide but did not alter efficacy of other chemicals. Efficacy was not affected when similar plants were treated with a medium drench of the same chemicals, except daminozide, and followed with irrigation at 1, 24, or 48 hr. Chemical names used: α-cyclopropyl-α-(4-methoxyphenyl)-5-pyrmidinemethanol (ancymidol), butanedioic acid mono-(2,2-diemthylhydrazide) (daminozide), α-(1-methylethyl)-α-[4-(trifluoromethoxy)phenyl]-5-pyrimidinemethanol (EL-500) (flurprimidol), (±)-(*R**,*R**)-beta-((4-chlorophenyl)methyl)-α-(1,1-dimethylethyl)-1*H*-1,2,4-triazole-1-ethanol (PP-333) (paclobutrazol), and (E)-(*p*-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol (XE-1019).**

Concern is often expressed by commercial growers about the reduced efficacy of growth-retardant chemicals when applications are followed by overhead irrigation or rain. Labels of two commercial growth retardants (B-Nine and Cycocel) indicate that overhead irrigation should be avoided for several hours after foliar application. Cathey (5) reported that the efficacy of ancymidol was not reduced by washing treated plants 5 min after foliar application, but that daminozide efficacy was reduced when treated plants were washed 1 hr after application compared to 24 hr. Very little is known about the effect of irrigation on efficacy of medium drench applications.

Paclobutrazol (1, 3, 6, 7) and XE-1019 (4, 8) are active on a broad range of container-grown ornamental species. Flurprimidol is an analog of ancymidol and is effective on several species (1, 2, 6). This study was designed to evaluate the effects of irrigation on the efficacy of growth retardants applied as a foliar spray or medium drench.

Rooted cuttings of *Chrysanthemum morifolium* 'Nob Hill' were planted one per 12.5-cm plastic container in Vergro Klay Mix (Verlite Corp., Tampa, Fla.). Plants were not pinched and were maintained vegetative by the use of incandescent lights from 2200 to 0200 HR daily. Normal irrigation was applied as needed through a tube system that delivered water to the medium surface without wetting the foliage. Plants were fertilized at each irrigation with a 20N–4.4P–16.6K

Received for publication 4 Dec. 1986. Florida Agricultural Experiment Station Journal Series no. 7772. This research was supported by Chevron Chemical Company, Eli Lilly and Company, Sandoz Crop Protection, Uniroyal Chemical, and Yoder Brothers. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

Table 1. Stem elongation for chrysanthemums given overhead irrigation at intervals after growth retardant spray.[z]

Irrigation time[y] (hr)	Stem elongation (cm) Paclobutrazol (100 mg·liter^{-1})	XE-1019 (50 mg·liter^{-1})	Chemical Ancymidol (100 mg·liter^{-1})	Daminozide (5000 mg·liter^{-1})	Flurprimidol (75 mg·liter^{-1})
0.5	11	9	4	17	16
1	12	9	4	10	15
2	11	8	4	7	15
4	14	8	4	6	13
8	14	8	3	4	13
24	12	8	3	5	15
None	10	8	4	5	14
Significance:					
HSD (5%)		5	2		NS
Chemical (C)		**	**		---
Irrigation (I)		NS	**		---
C × I		NS	**		---
Nontreated plants		38	21		42

[z]Data are from three separate experiments. Plants were single-stem 'Nob Hill' in 12.5-cm pots.
[y]Overhead irrigation (1.5 cm) was applied at indicated time after spray treatment or no irrigation was applied.
*, **Significant at $P = 0.05$ and 0.01, respectively.

Table 2. Stem elongation of chrysanthemums irrigated at intervals after application of growth retardant as a medium drench.[z]

Chemical	Concentration (mg/pot)	Stem elongation (cm) Irrigation time (hr)[y] 1	24	48	Mean
Ancymidol	0.2	6	6	6	6
Flurprimidol	0.1	3	4	4	4
Paclobutrazol	0.2	10	10	12	11
XE-1019	0.1	10	10	10	10
None		26	26	26	26
Time mean		11	11	12	
HSD 5%					3
1%					4

[z]Chemical × time interaction was nonsignificant.
[y]One-hundred fifty milliliters of water applied to medium surface per 12.5-cm pot at indicated time after chemical application.

with N at 300 mg·liter^{-1}. Growth-retardant treatments were applied 7 to 14 days after planting. Data are presented as difference in stem length at time of treatment and 21 to 28 days later. Each experiment was repeated two or three times and experiments were in a randomized complete block design with four replications and two plants per experimental unit.

Spray applications. Three experiments were conducted. The first was a factorial with two chemicals, pacobutrazol at 100 mg·liter^{-1} and XE-1019 at 500 mg·liter^{-1}, and seven irrigation treatments. These treatments were 1.5 cm of water applied through an overhead mist system in a 30-min period starting 0.5, 1, 2, 4, 8, or 24 hr after spray treatments, and a control that received only normal irrigation. The second experiment was a factorial with two chemicals, ancymidol at 100 mg·liter^{-1} and daminozide at 5000 mg·liter^{-1} and the same seven irrigation treatments. The third experiment included plants treated with flurprimidol at 75 mg·liter^{-1} and then receiving the seven irrigation treatments. Also, each experiment included plants not treated with a chemical and receiving normal irrigation to indicate degree of reduction in stem elongation caused by the treatments. However, these nontreated plants were not included in data analysis (Table 1).

Irrigation at different times had little effect on stem elongation of plants treated with flurprimidol, paclobutrazol, or XE-1019, and there was no interaction between the paclobutrazol and XE-1019 treatments and the irrigation treatments. However, there was an interaction between irrigation and the ancymidol and daminozide treatments in the second experiment. Stem elongation in plants receiving daminozide was greater when overhead irrigation occurred within 2 hr of treatment compared to later applications, but irrigation did not affect ancymidol-treated plants.

Drench applications. A factorial experiment was conducted with five chemical treatments and three irrigation times. Chemical treatments were medium drench with ancymidol, flurprimidol, paclobutrazol, or XE-1019 at 0.2, 0.1, 0.2, and 0.1 mg/pot, respectively, and a no-chemical control. These were applied in 90 ml of water. Then, 150 ml (1.25 cm) of water was applied to the medium surface at 1, 24, or 48 hr after chemical drench treatments. Normal irrigation was resumed 4 days after chemical treatment.

There was no interaction between chemical treatment and irrigation time (Table 2). All chemicals reduced stem elongation compared to controls. However, time of irrigation did not influence stem elongation, indicating that it did not reduce chemical efficacy. Flurprimidol resulted in the least elongation, whereas elongation was similar in XE-1019- and paclobutrazol-treated plants, even though XE-1019 was applied at one-half the paclobutrazol concentration.

These results indicated that paclobutrazol, flurprimidol, and XE-1019 are similar to ancymidol in that overhead irrigation does not reduce their efficacy, whether applied as a foliar spray or a medium drench. This persistence may be because they are only slightly soluble in water, similar to ancymidol, in contrast to daminozide, which is completely soluble in water. Also, similar to ancymidol, the efficacy of paclobutrazol and flurprimidol are reduced in drench applications when the medium contains pine bark as a component. This reduction probably is related also to their hydrophobic character (1).

Literature Cited

1. Barrett, J.E. 1982. Chrysanthemum height control by ancymidol, PP333, and EL-500 dependent on medium composition. HortScience 17:896–897.
2. Barrett, J.E. 1983. Comparison of growth retardant activities of EL-500 with ancymidol, chlormequat, and daminozide on flowering ornamentals. Plant Growth Regulator Bul. 11(4):8–10.
3. Barrett, J.E. and C.A. Bartuska. 1982. PP333 effects on stem elongation dependent on site of application. HortScience 17:737–738.
4. Barrett, J.E. and T.A. Nell. 1986. Evaluation of XE-1019 and paclobutrazol for height control of flowering annuals. Proc. Plant Growth Regulator Soc. Amer. 13:63–64.
5. Cathey H.M. 1975. Comparative plant growth-retarding activities of ancymidol with ACPC, phosfon, chlormequat, and SADH on ornamental plant species. HortScience 10:204–216.
6. McDaniel, G.L. 1986. Comparison of paclobutrazol, flurprimidol, and tetcyclacis in controlling height of poinsettia. HortScience

21:1161–1163.
7. Shanks, J.B. 1980. Chemical dwarfing of several ornamental greenhouse crops with PP333. Proc. Plant Growth Regulator Working Group 7:46–51.
8. Wilfret, G.J. 1986. Growth retardation of poinsettia and chrysanthemum with XE-1019. Proc. Plant Growth Regulator Soc. Amer. 13:65. (Abstr.)

HortScience 22(6):1289–1290. 1987.

Influence of Fall Planting Dates on the Survival and Growth of *Taxus*, *Thuja*, and *Viburnum* Species

John Ball
Horticultural Technology, University of Minnesota Technical College, Waseca, MN 56093

Additional index words. transplanting, soil temperatures, Tauntonii yew, Techny arborvitae, American cranberrybush viburnum

Abstract. **The influence of soil temperature on the survival and growth of fall transplanted Tauntonii yew (*Taxus* ×*media* Rehd., 'Tauintonil') Techny arborvitae (*Thuja occidentalis* L. 'Techny') and American cranberrybush viburnum (*Viburnum trilobum* Marsh.) was investigated. Soil temperature appears to be a critical factor in the success of yew plantings, but less so for arborvitae and viburnum. Planting should be made ≈4 weeks before soil temperatures in the root zone reach 7°C.**

In northern areas of the United States, spring has been the primary season consumers buy and plant woody nursery stock. Warm spring day generally induce a surge of nursery stock sales, which slows considerably during the summer. Unfortunately, the return of the cool fall weather does not result in increased sales. Despite the nursery industry's fall planting campaign, the consumer still has a fear of losing the plant due to the rigors of winter, which follows fall transplanting (2). This fear is not entirely unfounded. Several studies have documented the poor survival of some species when fall-planted. Swanson (9) observed that fall planting of many woody plants resulted in excessive mortality during the cold, dry winters of Colorado. Some plants, such as Magnolia (*Magnolia* spp.), have a fleshy root system that does not withstand fall transplanting (1). Other trees that are difficult to transplant, such as birch (*Betula* spp.) and walnut (*Juglans* spp.) usually are listed for spring transplanting (3).

A major consideration in the success of fall transplanting may be the time of favorable soil temperatures. Root elongation decreases but continues until late fall for many species (7). Roots may continue growing until soil temperatures reach 4° to 7°C (2, 4). Early fall transplanting should be done soon enough to allow root growth, since moisture stress is usually significant as the result of transplanting (4). Further, moisture stress induced in the fall may increase the risk of winter injury (8).

The objective of this study was to determine the influence of time of planting and subsequent soil temperatures on the survival and growth of three species of fall-planted containerized nursery stock.

The study was conducted at the Univ. of Minnesota Technical College nursery in Waseca, located in zone 4 of the USDA hardiness map. The nursery soil is a Webster clay loam (mixed, mesic, typic haplaquolis). Container size no. 2 Tauntonii yew, Techny arborvitae, and American cranberrybush viburnum were planted on 27 Sept., 21 Oct., and 13 Nov. 1984. Twenty plants of each species were planted on each date without the addition of any soil amendments or mulch. Soil temperatures were measured 10 cm below the soil surface from 27 Sept. until 6 Dec. 1984. The plants were placed in four north–south oriented rows with a spacing of 50 cm within the row and 75 cm between the rows. Plants were blocked by planting date.

All plants were watered at planting. Additional irrigation was not necessary, since Waseca had above average amounts of precipitation. Rainfall totals for September, October, and November were 6.1, 11.8, and 5.6 cm, respectively.

On 24 May 1985, the shrubs were evaluated for survival, extent of dieback, and foliage condition. Current season stem growth was measured on 18 Aug. 1985.

The daily maximum soil temperature was >16°C for 2.5 weeks and >10° for 4 weeks following the first transplanting. Soil temperature was 7° at the time of the 21 Oct. planting. Within 2 weeks, soil temperature fell below 4°. The soil temperature had dropped below 4° at the 13 Nov. planting and varied from 0° to 6° in the following 3 weeks.

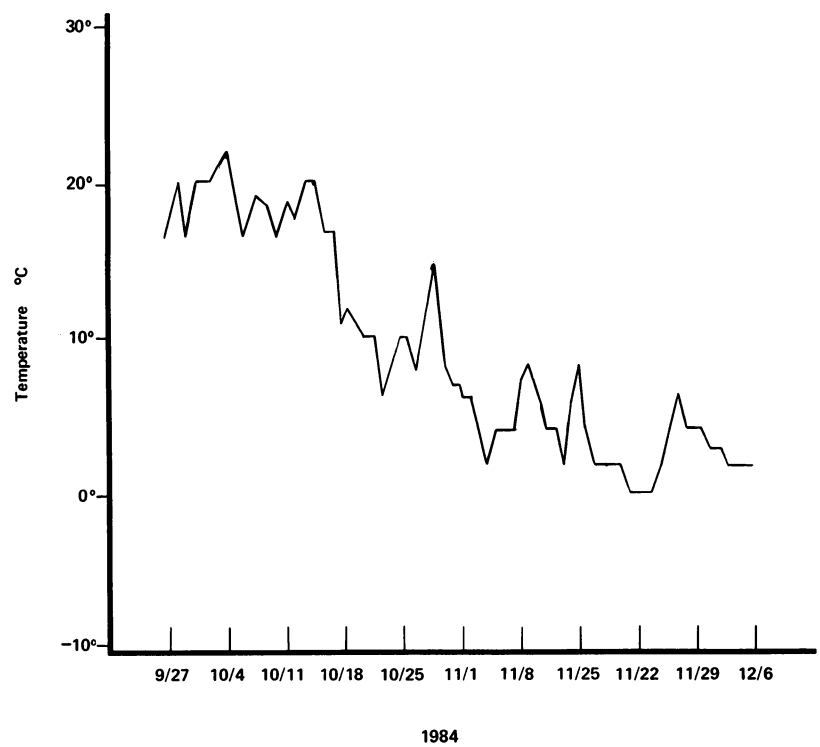

Fig. 1. Daily maximum soil temperature at a depth of 10 cm. Data collected at Waseca, Minn. during Fall 1984.

Received for publication 12 Sept. 1986. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.