of the problems associated with maturation of coconut somatic embryos.

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Proc. Fla. State Hort. Soc. 109:11-14. 1996.

EFFECT OF LATE GROWTH REGULATOR APPLICATIONS AT FLORAL BUD EMERGENCE AND STRETCH ON EASTER LILY DEVELOPMENT

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Additional index words. *Lilium longiflorum*, ancymidol, paclobutrazol, uniconazole, ornamental plants.

Abstract. **Easter lily cv. Nellie White (*Lilium longiflorum* Thunb.) bulbs (7/8 size), which had been stored at 40 F for 7 weeks, were planted in 6-inch diameter pots on 28 Dec. 1995. Plants were grown in a glasshouse with 40% light exclusion and ambient temp. to a minimum of 45F. Initial plant growth regulator (PGR) treatments of ancymidol, paclobutrazol or uniconazole were applied as a soil drench or foliar spray on 1 Feb. 1996 when plants were *ca.* 4 inches tall. Subsequent PGR applications were made at floral bud emergence (FBE) on 28 Feb. or at floral bud stretch (FBS) on 6 Mar. Plants drenched with ancymidol at 0.25, 0.375, or 0.5 mg ai/pot were 18.3, 17.8, and 16.3 inches tall, compared to 22.2-inch tall plants drenched with water. Plants drenched with paclobutrazol at 2, 3, or 4 mg ai were 18.0, 16.3, and 14.3 inch tall, while plants drenched with uniconazole at 0.05, 0.07, 0.09, or 0.11 mg ai were 19.0, 16.8, 16.1, and 14.5 inches tall, respectively. Optimum plant height would be 18 inches. Multiple applications of ancymidol had no effect on plant height. Paclobutrazol at 2.0 mg/pot at FBE yielded shorter plants than those plants given a single 2.0 mg/pot drench but had no effect at FBS. All second applications of uniconazole produced plants with shorter inflorescence than**

Florida Agricultural Experiment Station Journal Series No. N-01353.

those treated with a single drench of 0.05 mg/pot of this chemical.

Production of Easter lilies (*Lilium longiflorum*) in Florida during the warm ambient temperatures of the winter months is not as precise as in environmentally controlled greenhouses in the temperate areas of the United States (Miller, 1992). Variable temperatures, a floating holiday, the limited marketing duration and problems with plant height and uniformity discourage even the best Florida growers from producing this crop. In 1995, only 321,000 containerized Easter lily plants, with a wholesale value of $1.204 million, were marketed in Florida, compared to 9.378 million plants grown in the United States (U.S. Dept. Agr., 1996). Environmental conditions play a significant role on plant height and flower development in Easter lilies. Height is affected by both quantity and quality of light (Heins et al., 1982; Kohl and Nelson, 1963; Roh and Wilkins, 1977; Wilkins, 1980; Wilkins et al. 1986), warm day temperatures (Erwin et al., 1987; Roh and Wilkins, 1973; Wang and Roberts, 1983) and the difference between day and night temperatures (Erwin et al., 1987). Plants grown above 70F could lose their vernalization (Wang and Roberts, 1983; Wilkins, 1980). Growth regulators often are used to control plant height of Easter lilies, and are applied as soil drenches, foliar sprays, bulb dips, or incorporation in the potting media. Ancymidol (A-Rest®, ∝-cyclopropyl-∝-(p-methyxyphenyl)-5-pyrimidine-methanol) is the most commonly used growth regulator on Easter lilies and is effective as a soil drench of 0.25 to 0.75 mg ai/pot (Giafagna and Wulster, 1986; Johnson, 1973; Larson and Kimmons, 1971; Lewis and Lewis, 1982; Wilfret 1987, 1990), a foliar spray of 0.5 mg ai/plant (Larson and Kimmons, 1971; Lewis and Lewis, 1981; Wilfret, 1987; Wulster et al., 1987), or a preplant bulb soak of 0.25 mg ai/bulb (Lewis and Lewis, 1981, 1982; Wilfret, 1987, 1990; Wulster et al., 1987). Although ancymidol retards internode elongation, treated plants can have weak stems (Roh and Wilkins, 1977), hollow cavities in the pith area of the stems (Roh and Wilkins, 1977), a delay in flowering (White, 1972), or an increased yellowing of the basal leaves (Roh and Wilkins, 1973). Paclobutrazol (Bonzi® (2RS, 3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl) pentane-3-ol) has been inconsistent in height control of Easter lily (Giafagna and Wulster, 1986; Jiao et al., 1986; Larson, 1986; Shanks, 1983; Wilfret, 1987), but 2 to 4 mg ai/plant applied as a soil drench or foliar spray has been effective in Florida (Wilfret, 1987). Paclobutrazol caused a greater dead basal leaf zone than ancymidol (Menhenett et al. 1983). An analog of paclobutrazol, uniconazole (Sumagic®, (E)-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4 triazole-1-yl)-1-pentane-3-ol) has shown greater activity for inhibition of gibberellic acid synthesis. Levels of uniconazole as low as 0.06 mg ai/pot, applied as a foliar spray or a soil drench (Bailey and Miller, 1989; Wilfret, 1987) and as a bulb soak as low as 0.6 ppm, significantly retarded plant height (Wilfret, 1990).

Plant growth of Easter lilies not treated with growth regulators follows a typical sigmoid curve (Erwin and Heins, 1994; Miller, 1992; Wilfret, 1994) with increased elongation rates when the floral buds emerge above the leaves (Wilfret, 1994). Since winter temperatures in Florida are variable and cold weather slows stem elongation, the possibility exists that single applications of a growth regulator at the normal concentration may be excessive during an abnormally cold winter, with the results being plants that are too short to be marketable. Multiple applications of growth regulators could provide more control of plant height if applied when stem elongation is accelerated. The objective of this research was to determine the effect of single and multiple applications of growth regulators on Easter lily growth and development.

Materials and Methods

Easter lily cv. Nellie White bulbs (7/8 size) were case-cooled at 40F for seven weeks and planted on 28 Dec. 1995 with one bulb per 6-inch plastic pot, which contained a medium of Florida sedge peat, coarse vermiculite, coarse white sand, and perlite (6:3:2:1, v/v). The medium was amended with 12 lb Nutricote 13N-10.8P-5.6K (100 day), 15 lb dolomitic limestone, 4 lb hydrated lime, 10 lb granulated calcium carbonate, 2 lb superphosphate, and 1 lb Florikan Sec (a minor element mixture) per yd^3. Plants were spaced on 11-inch centers on raised benches in a glasshouse with 40% light exclusion and were watered manually as needed. Insects and diseases were controlled with pesticides as needed. Plants were arranged in a randomized complete block design with three replications per treatment and each replicate consisted of three plants. Data were analyzed using Least Significant Difference (LSD) with $\propto = 0.05$. Ancymidol, paclobutrazol, and uniconazole were applied as soil drenches (3.3 fluid oz/pot) or foliar sprays (2 qt/100 ft^2) when the plants were 4 to 4.5 inches tall. Initial applications were made on 1 Feb. 1996 and subsequent growth regulators were applied at floral bud emergence (FBE) on 28 Feb. or at floral bud stretch (FBS) on 6 March. Single ancymidol drench treatments were applied at 0.25, 0.375, or 0.5 mg ai/pot. Multiple ancymidol treatments consisted of an initial application of 0.25 mg ai/pot plus either 0.125 or 0.25 mg ai/pot at either the FBE or FBS stage of growth. Paclobutrazol drenches were applied singularly at 2.0, 3.0, or 4.0 mg ai/pot, and multiple applications consisted of 2.0 mg ai/pot plus 1.0 or 2.0 mg ai/pot at FBE or FBS. Uniconazole treatments included single drenches of 0.05, 0.07, 0.09, or 0.11 mg ai/pot, with multiple applications at 0.02, 0.04, or 0.06 mg ai/pot at FBE or FBS. Uniconazole sprays were applied once at 5.0 or 10.0 ppm or twice at 5.0 ppm initially, followed by 5.0 ppm at FBE or FBS. Plant height was recorded at time of initial treatment and weekly until flowering. Flowering date, vegetative height, overall height, flower length, and number of flowers were recorded at time of anthesis of the basal flower.

Results and Discussion

Glasshouse air temperature during the winter of 1995-96 ranged from 45 to 86F, with an average day temperature about 71F. This was a relatively cool winter, with temperatures generally 3 to 5 degrees below normal. Untreated plants during this season were about three inches shorter than the average untreated plants grown from 1988 through 1994 (Wilfret, 1994). All growth regulator treatments retarded overall plant height except the single uniconazole spray at 5 ppm, but multiple applications with this chemical yielded shorter plants (Table 1). Since the main objective of this research was to compare multiple applications of each chemical to single treatments, results of each chemical will be discussed separately.

Ancymidol. Although it appeared that increased concentrations of single applications of ancymidol affected overall plant height, the differences were not significant. Additional

Table 1. Effect of single and multiple growth regulator applications on height of Easter lilies.

	Plant height (inches)[y]		
Chemical treatment[z]	Inflorescence	Vegetative	Overall
Water control	8.3	13.9	22.2
Uniconazole Drench @ 0.05	8.4	10.6	19.0
Uniconazole Drench @ 0.05 + 0.02 FBE	7.3	9.6	16.9
Uniconazole Drench @ 0.05 + 0.04 FBE	6.8	10.0	16.8
Uniconazole Drench @ 0.05 + 0.06 FBE	6.1	9.0	15.1
Uniconazole Drench @ 0.05 + 0.02 FBS	7.4	10.1	17.5
Uniconazole Drench @ 0.05 + 0.04 FBS	6.8	9.7	16.5
Uniconazole Drench @ 0.05 + 0.06 FBS	6.6	9.1	15.7
Uniconazole Drench @ 0.05 + 0.07	7.5	9.3	16.8
Uniconazole Drench @ 0.05 + 0.09	7.4	8.7	16.1
Uniconazole Drench @ 0.05 + 0.11	6.8	7.7	14.5
Ancymidol Drench @ 0.25	7.6	10.7	18.3
Ancymidol Drench @ 0.25 + 0.125 FBE	7.1	10.6	17.7
Ancymidol Drench @ 0.25 + 0.25 FBE	6.8	9.9	16.7
Ancymidol Drench @ 0.25 + 0.125 FBS	7.4	10.6	18.0
Ancymidol Drench @ 0.25 + 0.25 FBS	7.1	11.1	18.2
Ancymidol Drench @ 0.375 mg	8.2	9.6	17.8
Ancymidol Drench @ 0.5 mg	7.4	8.9	16.3
Paclobutrazol Drench @ 2.0 mg	7.5	10.5	18.0
Paclobutrazol Drench @ 2.0 mg + 1.0 FBE	7.3	8.9	16.2
Paclobutrazol Drench @ 2.0 mg + 2.0 FBE	6.6	8.0	14.6
Paclobutrazol Drench @ 2.0 mg +1.0 FBS	7.6	8.8	16.4
Paclobutrazol Drench @ 2.0 mg + 2.0 FBS	6.9	9.1	16.0
Paclobutrazol Drench @ 3.0	7.6	8.7	16.3
Paclobutrazol Drench @ 4.0	7.4	6.9	14.3
Sumagic Spray @ 5.0	8.5	12.3	20.8
Sumagic Spray @ 5.0 + 5.0 FBE	5.9	7.9	13.8
Sumagic Spray @ 5.0 + 5.0 FBS	5.9	8.0	13.9
Sumagic Spray @ 10.0	7.5	7.5	15.0
LSD ($\propto = 0.05$)	0.9	1.6	2.4

[z]Drench (mg ai) applied at 3.3 oz/6" pot, spray (ppm) at 2 qt/100 ft^2, applied initially at ca. 4 inch height and at floral bud emergence (FBE) or floral bud stretch (FBS).
[y]Overall height measured from top of pot to top of terminal bud; vegetative height measured from top of pot to terminal leaf below inflorescence.

drenches of ancymidol at the FBE and FBS stages did not significantly affect overall plant height. No differences were observed in inflorescence and vegetative heights among any ancymidol treatments.

Paclobutrazol. Overall plant height was decreased with a 4.0 mg ai drench of paclobutrazol compared to the 2.0 mg drench, but the 3.0 mg treatment did not yield significantly shorter plants. When a second treatment of 2.0 mg paclobutrazol was applied at FBE, the plants were shorter than the once-treated plants. A second application of paclobutrazol at FBS had no effect on overall plant height. Multiple applications of paclobutrazol did not affect inflorescence length but plants drenched with 2.0 mg paclobutrazol at FBE had shorter vegetative growth.

Uniconazole. All plants drenched with uniconazole were shorter than the control plants. Single applications of uniconazole at 0.05, 0.07, 0.09, and 0.11 mg ai/pot yielded plants with overall heights of 19.0, 16.8, 16.1, and 14.5 inches tall, respectively, with the latter two treatments significantly different from the lowest concentration. When uniconazole was applied at FBE, only the 0.06 mg/pot rate yielded shorter plants. Overall plant height was shorter when a second drench application of uniconazole was provided at FBS with either 0.04 or 0.06 mg/pot. All multiple applications of uniconazole, regardless of when applied, yielded plants with shorter inflorescences than those treated with a single treatment, but multiple applications had no effect on vegetative growth. A uniconazole spray at 5 ppm had no effect on overall plant height, inflorescence length, or vegetative height. When the uniconazole concentration was increased to 10 ppm or a second 5 ppm spray was given, plants were significantly shorter than those treated with 5 ppm with respect to all parameters measured.

Chemical treatment had no affect on flowering date, number of flowers per inflorescence, or flower length (results not shown). The major effect of the late applications of growth regulators generally appeared to be on inflorescence rather than vegetative length, which was expected since the first of the multiple applications occurred when the floral buds emerged above the terminal leaf. Multiple applications of uniconazole were more effective than the other chemicals in retarding inflorescence length due to the rapid absorption and activity of this chemical.

Although the concentrations of the single applications of each growth regulator was selected from previous research so that a second application would be needed to produce plants 18 inches tall (Wilfret, 1994), the cool winter slowed plant growth. These lowest concentrations actually produced plants of the optimum height of 18 inches, and multiple applications were not necessary. Further research needs to evaluate reduced initial chemical concentration, increased second application concentration of ancymidol and paclobutrazol, and decreased concentration of the second application of uniconazole.

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Proc. Fla. State Hort. Soc. 109:14-16. 1996.

PRELIMINARY COMPARISON OF THREE FULL CIRCLE IMPACT SPRINKLERS FOR COLD PROTECTION IN SHADEHOUSES

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Additional index words. *Rumohra adiantiformis*, frost protection, irrigation.

Abstract. **Five combinations of sprinkler types and orifice sizes supplying water at rates from 4.4 to 6.2 mm·hr^{-1} [0.17 to 0.24 inches·hr^{-1}] were compared in shadehouses for effects on sprinkler rotation rates, temperatures at the crop canopy and leatherleaf fern [*Rumohra adiantiformis* (Forst.) Ching] yield. The post and cable shadehouses, located in Pierson, FL, were 29.3 m (96 ft) long, 29.3 m wide, 2.5 m (8 1/2 ft) high and covered with polypropylene shade fabric designed to exclude 73% of incoming radiation. Nine 0.9-m (3-ft) tall sprinkler risers were spaced 9.8 m (32 ft) apart in each shadehouse. Sprinkler rotation rates varied from 7.7 (Rain Bird L20VH with 0.32 cm [1/8-inch] orifice) to 0.9 rpm (Rain Bird SW2000 with 0.28 cm [7/64-inch] orifice), and were positively correlated (*r* = 0.79) with postfreeze yield. During the coldest part of the freeze, canopy temperatures were higher and fluctuated less in the shadehouses equipped with sprinklers with higher (>6 rpm) rotation rates than those with lower rates (≤1.5 rpm). Postharvest yield was also positively correlated (*r* = 0.91) with water application rate.**

Florida Agricultural Experiment Station Journal Series No. N-01309. The cooperation and donation of materials by TWC Distributors, Apopka, FL and Rain Bird Sales, Tampa, FL is appreciated.

Water, applied using overhead (over-the-crop) irrigation systems, has been used since the 1960s to protect crops in Florida from cold damage (Harrison et al., 1974). This cold protection technique has been a critical factor in enabling several of Florida's agricultural commodities to be produced during the winter. Research on reducing water application rates needed to cold protect crops in plastic fabric covered shadehouses was started in the early 1980s (Stamps and Chase, 1981; Stamps and Mathur, 1982). As new sprinkler designs become available, there is a need to test them to determine if they will perform adequately during freezes. Additionally, there is the possibility that new sprinkler designs will apply water more uniformly and/or efficiently than older designs and, thereby, allow the amount of water needed to be applied for cold protection to be reduced.