SECTION 7
GROWTH REGULATORS

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Paclobutrazol Efficacy on Poinsettias Grown in Waste Tire Rubber Amended Media

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Nature of Work: Many waste materials such as rice hulls, nut husks, and sewage sludge have been used in container production. When used in the correct proportions, acceptable plant material has been produced in these waste materials (Nash and Hegwood, 1978). About 242 million tires are discarded annually in the United States. Only about 7% of these are recycled and the rest are stockpiled. Current estimate of the total volume of discarded tires is 2 billion (Riggle, 1992). Research has been conducted on using waste tire rubber as a growing media component. Chrysanthemums grown in media containing waste tire rubber contained high zinc levels in the foliage. Plants were of smaller size, but some still were of marketable quality (Bowman, Evans, and Dodge 1994). Zhao (1995) grew several bedding plant species in media containing waste tire rubber at various proportions. Results showed that plants grown in media with 25% or less rubber were of acceptable quality, but some growth reduction did occur. Plants grown in media containing 50% rubber exhibited chlorosis due to zinc toxicity. Young leaves of these plants did not recover from this chlorosis.

Previous research with Bonzi shows that the base organic materials and particle size of the media influence the activity of this plant growth regulator (Barrett, 1982; Quarrels and Newman, 1994). A study was conducted to evaluate the efficacy of paclobutrazol (Bonzi, Uniroyal Chemical Company, Middlebury, CT) applied as a drench to media containing waste tire rubber. Poinsettias, *Euphorbia pulcherrima*, were grown in the amended media, and the effects on growth and quality were observed.

The control medium used was 2 pine bark: 1 peat moss: 1 sand (by volume). Two additional media were formulated using 1/4 inch shredded waste tire rubber where the rubber was used to replace the pine bark at 25 or 50%. Dolomitic limestone was added at 1 lb/ft^3 of peat moss. Micromax (Grace/Sierra Corp, Foglesville, PA) was added at 1.5 lb/yd^3. Two cultivars 'Gutbier V-14 Glory' and 'Angelika Red' were planted in six inch pots containing the three media. Four ounces of Bonzi per pot at three rates, 0 ppm, 1 ppm, and 2 ppm (0 mg a.i./pot, 0.125 mg a.i./pot, and 0.250 mg a.i./pot) were used. The experimental design was 3 x 2 x 3 factorial completely randomized with ten replications. Plants were pinched to 5 to 7 nodes when the root growth progressed to the edge of the pot. Bonzi was applied when new growth was 1.5 to 2.0 inches in length. Plants were fertilized at 200 ppm N every irrigation with Excel 15-5-15 Cal/Mag (Grace/Sierra Corp, Foglesville, PA). Data collected included plant height, width, visual quality rating, branch length, bract surface area, dry weight of stems and dry weight of roots.

Results and Discussion: Plant height was affected by a combination of the percent rubber in the media and rate of Bonzi applied. However, plant height was more strongly influenced by increasing rates of Bonzi than by percent rubber.

Angelika branch length was affected by both percent rubber in the media and the rate of Bonzi applied. V-14 average bract size and branch length were not affected by the percent rubber in the media but were affected by the rate of Bonzi applied as was bract size in Angelika.

Plant dry weight was also affected by both the percent rubber in the media and the rate of Bonzi applied. Bonzi reduced dry weight in plants over the control. There was no significant difference in plant dry weight between rates of Bonzi applied for either cultivar. Plants grown in the 25% waste tire rubber media had greater dry weights than those grown in 50% waste tire rubber media. There was no difference in plant dry weight between control media and either media containing waste tire rubber.

Visual quality was affected by both the percent waste tire rubber in the media and the rate of Bonzi applied. The highest visual quality rating was for those plants grown in 25% waste tire rubber and with no (0 ppm) Bonzi applied. Plants grown in 50% waste tire rubber and at the 2 ppm rate of Bonzi had the lowest quality rating. All other combinations of media and growth regulator treatments were comparable to the control treatments.

Significance to the Industry: Results of this study show that waste tire rubber may be a viable component of growing media for poinsettias. The quality of poinsettias grown in waste tire rubber was lower only at the highest rate of Bonzi and percent rubber in the media. Those plants grown in 25% of the pine bark replaced with waste tire rubber had the highest visual quality rating. The rate of Bonzi applied was more influential on plant growth parameters than the percent waste tire rubber in the media.

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Growth Responses of Honeylocust to Pre-Germination Seed and Post-Germination Foliar Applications of DCPTA

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Nature of Work: The synthetically produced tertiary amine bioregulator, DCPTA (2-(3,4-dichlorophenoxy) triethylamine) improved growth of blue spruce (*Picea pungens* var. *glauca*), radish (*Raphanus sativus*), heliconias (*Heliconia stricta*), and various genera of orchids following seed (5, 6) or tissue (1, 4) treatments. However, these studies were all conducted under controlled greenhouse conditions. Studies in more commercial settings, field or shade structures, with guayule (*Parthenium argentatum*) (2), tomato (*Lycopersicon esculentum*) (3), pepper (*Capsicum annuum*) (3) and amaryllis (*Hippeastrum hybridum*) (7) have failed to confirm the growth promotive effects of DCPTA applications. If responses to DCPTA on container nursery crops are similar to those on forest trees, such as blue spruce (5), then the chemical could be useful to nurserymen. The objectives of this study were to determine the effects of DCPTA seed soaks and foliar sprays on the growth of *Gleditsia triacanthos* L. var. *inermis* Willd. during container nursery production.

On March 16, 1992, scarified (90 min. in concentrated sulfuric acid) *Gleditsia triacanthos* var. *inermis* seeds (Sheffield's Seed Co., Locke, NY) were soaked at 20 C (68(F) for 6 hr. in water containing 0.1 % Tween 80 and 0, 1, 10, or 100 ppm DCPTA (courtesy Dr. Henry Yokoyama, USDA, Pasadena, CA). After soaking, seeds were rinsed in running water for 5 min. and planted in a 3 pine bark : 1 sand : 1 peat moss (by vol.) media in propagation flats. Flats were placed in a greenhouse set at 24/18 C (75/65(F) day/night with natural photoperiods. On April 3, 30 seedlings of each DCPTA treatment were transplanted to #1 (3.2 liter) black plastic nursery pots (Zarn, Reidsville, NC) containing a 3 pine bark : 1 sand (by vol.) media amended with 3.5 kg dolomite/m^3 (6 lb./$yd.^3$), 1.7 kg 0N-20P-0K/m^3 (3 lb./$yd.^3$), and 0.68 kg Micromax (Sierra Chemical Co., Milpitas, CA)/m^3 (1.5 lb./$yd.^3$). Thirty seedlings from each DCPTA seed treatment were divided into two groups of 15. One group received no more DCPTA treatments. The other group received additional foliar applications of the same concentration of DCPTA as in their respective seed soak on April 20, May 18, June 13, and July 13. Seedlings were returned to the greenhouse and arranged in a randomized complete block statistical design(4 seed treatments + 4 foliar treatments x 3 blocks with 5 plant replications/block, total of 120 plants). An application of 16 g (0.56 oz.) 18N-3.1P-8.3K-1Fe (18-7-10-1) Sierrablen Nursery Mix 8-9 month slow release fertilizer (Sierra Chemical Co., Milpitas, CA) was applied to the media surface of each container.

Seedlings were transferred from the greenhouse to an open-air shade structure (55 % light exclusion) on May 13 and transplanted to #3 (15 liter) black plastic containers and an additional 16 g (0.56 oz.) of slow release fertilizer was placed on the media surface. Seedling height and trunk caliper (6 cm (2 in.) above the container) were recorded. After two weeks, seedlings were placed at 0.5 m (21 in.) spacings in a gravel covered outdoor growing area in full sun (Cookeville, TN). Daily overhead irrigation

(3 cm (1 in.)), when rainfall < 3 cm (1 in), and weekly fertigations of 200 ppm N from a 20N-8.7P-16.7K (20-20-20) water soluble fertilizer (W.R. Grace Co., Fogelsville, PA) were applied. On October 5, all seedlings were harvested to determine height, caliper, shoot, and root fresh and dry (4 days at 70 C (158(F)) weights. Total plant fresh and dry weights were calculated. Data were analyzed using analysis of variance.

Results and Discussion: No significant (*P* (0.05) effects of DCPTA seed soaks or foliar sprays were found for any growth parameter measured (data not presented). A similar lack of improvement in growth was reported for tomato, pepper and amaryllis and guayule (2, 3, 7). A slight cupping and yellowing of leaflet margins was evident on some seedlings treated with 100 ppm DCPTA foliar sprays. Dierig and Backhaus (2) also reported phytotoxicity symptoms when 400 ppm DCPTA was applied to guayule in the field.

Significance to Industry: Data from this study indicates that DCPTA seed soaks or foliar sprays did not improve the growth of thornless common honeylocust during container nursery production.

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The Use of Ethephon (Florel) to Prevent the Formation of Gum Balls on Sweetgum Trees

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Nature of Work: Sweetgum (Liquidambar szyraciflua L.) is native throughout the south and up to Connecticut and southern Illinois (4). It is planted throughout the West and South as well as Europe (2). The Sweetgum is a large columnar tree that exhibits fall color tones of red, yellow and purple. The short lived monoecious flowers bloom from March to May. The pistillate flowers ate borne in axillary globose heads, forming one and one half inch diameter multiple heads of small twocelled capsules (4). These fruiting capsules remain on the tree over winter falling sporadically through spring of the following year. The "Gum balls" remain on the ground which make walking difficult. Most homeowners remove these fruiting structures from the landscape. Even though a fruitless variety is available in the trade, existing landscape trees provide beautiful fall coloration and shade for many years. Research was conducted to examine the effects of ethephon (Florel) on eliminating the formation of gum balls on sweetgum trees. Ethephon has been used for thinning of apple fruit, cherry fruit abscission and uniform shuck dehiscence of pecans (1,5,6).

Ethephon was sprayed on three sweetgum trees, located on the Mississippi State University campus; at the rate of 1 qt. per 10 gallons of water. The trees, approximately 30 - 40 feet in height, were sprayed to the point of runoff. One treatment was made to one tree on March 15, 1994 and the other two bees were sprayed on March 17, 1994. A commercial sprayer utilizing a piston pump and an adjustable spray nozzle was used to apply the ethephon as a fine spray throughout the canopy of the trees. The timing of application coincided with the development of the pistillate flowers. These trees had produced “gum balls” for several years!

Results and Discussion: The March 15, 1994 treatment was evaluated throughout the growing season with no visual adverse symptoms observed. Fruit formation was significantly reduced (greater than 95%) when compared to untreated trees. The March 17, 1994 treatment was abandoned because approximately 1 “ of rain fell shortly after the application of ethephon. For best results, the flowers should remain dry for several hours after application of ethephon. Also, timing of application to coincide with the development of the pistillate flowers seems to be very crucial in preventing the development of sweetgum balls..

Significance to Industry: Where such fruit is objectionable in newly planted landscapes, fruitless Sweetgum trees can be planted. However, where established trees exist, ethephon has potential to eliminate unsightly and objectionable fruit on sweetgum. Its use in the ornamental industry could possibly provide uniform leaf drop on Shumardii oaks & other trees that tend to shed leaves throughout the dormant season, as well as preventing undesirable fruit formation on ornamental plants.

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Promotion of Flower Bud Development on *Kalmia latifolia* with Growth Retardants

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Nature of Work: *Kalmia latifolia* (Mountain Laurel) is a popular broadleaf evergreen shrub with exceptionally beautiful spring flowers. It is, however, slow to begin flower bud development during production, often taking more than 3 years to produce a significant floral display. The growth retardants, paclobutrazol (Bonzi) and uniconazole (Sumagic), have shown promise in promotion of flowering on some shrub species, including Rhododendron and Kalmia (1,2; also Dick Bir, Martin Gent, personal communication). However, responses to rate and application methods in these studies have varied greatly. In this study, we evaluated spray applications of several rates of Bonzi and Sumagic on the Kalmia cvs. 'Carol', 'Freckles', and 'Bullseye' during nursery container production.

Three Kalmia cvs. were selected for treatment. 'Freckles' and 'Carol' were in 1 gallon containers, in their second season of growth. These two cvs. had not flowered previously. 'Bullseye' was in 3 gallon containers, beginning the third season of growth. Some of the 'Bullseye' plants had a few scattered blooms. All of the plants were in a pine bark medium. Treatments were applied on May 20, 1994. All of the plants had just completed their first flush of growth. The new growth was sheared back lightly on 'Freckles' and 'Bullseye', just prior to treatment. 'Carol' was not sheared. Spray treatments of Bonzi (paclobutrazol) ranging from 0 to 600 ppm, or Sumagic (uniconazole) ranging from 0 to 300 ppm (Table 1) were applied. Five plants per treatment of each cv. were utilized in a completely randomized design. The treatments were applied to wet foliage and stems with a CO_2-pressurized sprayer set at 30 psi. Weather was cloudy; air temperature about 60F. On October 6, 1994, the treatments were evaluated by counting the number of flower bud clusters. Effects on growth were also evaluated by measuring longest shoot lengths from the point of shearing on 'Freckles' and 'Bullseye', and by measuring total plant height of 'Carol' (unsheared cv.). To evaluate long-term effects on growth, shoot lengths were again determined on May 15, 1995, following the first growth flush of the year after treatment.

Results and Discussion: The Bonzi treatments appeared to have a marginal effect on flower bud promotion. With some plants, there appeared to be an increase but the results were variable and in only one case (600 ppm Bonzi on 'Freckles'), statistically significant (Table 1). Sumagic, however, significantly increased number of flower buds on 'Freckles' and 'Bullseye' with all treatment levels from 50 to 300 ppm (Table 1). With 'Bullseye', there was approximately a 10-fold increase in the number of buds for treatments of 100 to 300 ppm. There was a significant increase in flower buds on 'Carol' at 200 ppm. The higher rates of Sumagic also reduced shoot length of the second flush of growth (Table 1). If not excessive, some reduction in shoot length can be desireable in that the flower buds are not obscured by foliage as they begin to enlarge and open the following spring.

Sumagic rates of 50 ppm and above also caused a reduction in shoot growth for the following spring (Table 2). Sumagic rates of 200 and 300 ppm resulted in residual growth retardation that would generally be considered excessive.

Significance to the Industry: Spray treatments of Sumagic in the range of 50 to 100 ppm promoted flower bud development on the Kalmia cvs. ‘Freckles’ and ‘Bullseye’ without causing excessive shoot growth inhibition. This preliminary study indicates possibilities for determining growth retardant spray rates and timing for promotion of early flowering of certain cultivars of Kalmia.

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Table 1. Flower bud and growth response of *Kalmia* to spray treatments of Bonzi and Sumagic.

	Kalmia ‘Carol’		Kalmia ‘Freckles’		Kalmia ‘Bullseye’	
Treatment	Bud Clusters	Height	Bud Clusters	Longest Shoot Length	Bud Cluster	Longest Shoot Length
Bonzi 0 ppm	2.6 b[z]	44.4 bc	7.0 d	26.0 ab	17.7 c	22.3 abc
Bonzi 10 ppm	0.0 b	48.4 ab	15.6 bcd	16.0 c	22.0 bc	26.7 a
Bonzi 100 ppm	0.0 b	51.2 a	13.4 cd	18.4 bc	16.7 c	22.0 abc
Bonzi 200 ppm	1.6 b	41.6 c	8.8 d	20.0 bc	23.0 bc	21.7 abc
Bonzi 400ppm	0.0 b	44.2 bc	20.4 abcd	14.4 c	35.0 bc	20.7 abc
Bonz 600 ppm	0.8 b	43.4 bc	33.6 a	3.2 d	18.3 c	21.7 abc
Sumagic 0 ppm	0.2 b	40.2 cd	13.4 cd	31.6 a	8.7 c	14.7 cd
Sumagic 10 ppm	0.6 b	35.4 de	7.2 d	21.0 bc	25.7 bc	21.3 abc
Sumagic 50 ppm	5.2 ab	30.2 ef	28.2 ab	14.4 c	48.7 b	23.7 ab
Sumagic 100 ppm	9.4 ab	24.0 g	28.0 ab	5.4 d	89.3 a	16.3 bcd
Sumagic 200 ppm	14.6 a	28.2 fg	26.8 abc	3.6 d	82.7 a	8.7 de
Sumagic 300 ppm	7.2 ab	23.6 g	28.8 ab	5.2 d	94.3 a	6.0 e

[z]Mean separation within columns by LSD, P <0.05.

Table 2. Spring shoot growth response of *Kalmia* to spray treatments of Bonzi and Sumagic applied the previous growing season.

Treatment	Kalmia 'Carol' Shoot growth	Kalmia 'Freckles' Shoot Growth	Kalmia 'Bullseye' Shoot Growth
Bonzi 0 ppm	13.0 ab[z]	14.6 a	15.0 ab
Bonzi 10 ppm	13.0 ab	14.4 a	14.6 ab
Bonzi 100 ppm	14.2 a	12.8 a	15.6 a
Bonzi 200 ppm	14.0 a	13.4 a	13.8 ab
Bonzi 400 ppm	11.8 ab	9.0 b	14.0 ab
Bonzi 600 ppm	11.0 b	5.0 c	12.0 bc
Sumagic 0 ppm	13.6 ab	14.6 a	12.2 b
Sumagic 10 ppm	12.6 ab	13.2 a	14.6 ab
Sumagic 50 ppm	7.2 c	9.0 b	8.8 cd
Sumagic 100 ppm	2.5 d	8.0 b	7.0 de
Sumagic 200 ppm	0.5 d	2.2 d	3.8 e
Sumagic 300 ppm	0.5 d	0.7 d	4.0 e

[z]Mean separation within columns by LSD, P <0.05.

Influence of Paclobutrazol on Growth of Lantana 'New Gold'

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Nature of Work: Shrub lantana (*Lantana camara* L.) is a vigorous growing small shrub which is often used as an annual in the eastern United States for its continuous bloom period through the summer months. When grown in containers, lantana requires frequent pruning to maintain plant shape and marketability. The cultivar ‘New Gold’ is a prostrate form which produces numerous golden-yellow flowers. The popularity of ‘New Gold’ lantana has increased in recent years and the plant was recently selected by the Georgia Plant Selections Committee as a Gold Medal winner for 1995.

Paclobutrazol (Bonzi) is labelled for application as a foliar spray or as a root-medium drench (Uniroyal Chemical Co., Middlebury, Conn.). Granular (4) and spike formulations (2,3) are also effective methods for applying paclobutrazol. The purpose of this study was to evaluate the effectiveness of paclobutrazol applied as a foliar spray, root-medium drench or impregnated spike on the growth control and flowering of ‘New Gold’ lantana.

Research was conducted at Wight Nurseries in Cairo, Ga. Fifty-four plants were grown in #1 pots and pruned to a height of 5 in. on 13 June 1993. The potting medium consisted of a 4 pine bark : 1 sand (v/v) mixture. Liquid fertilizer (10N-1.5P-8.5K) was applied with each irrigation at the rate of 100 ppm N. Plants were grown in full sun and irrigated as needed at 1/2 in./irrigation using solid set sprinklers.

Paclobutrazol was applied on 14 June 1993 at the rates of 0, 0.5, and 1.0 mg a.i./pot as a foliar spray, medium drench, or impregnated spike. Foliar sprays (1/6 oz./plant) and medium drenches (4 oz./plant applied to the surface of the container medium) were applied using Bonzi (0.128%, Uniroyal Chemical Co.). Spikes (0.02% paclobutrazol) were identical to Jobe Fertilizer Spikes (Weatherly Consumer Products, Lexington, KY) with paclobutrazol impregnated in the spikes instead of fertilizer. Spikes were positioned vertically in the container medium with the top of the spike even with the surface of the container medium. Spikes were placed equal-distant from each other on opposite sides of the plant approximately 2 in. from the edge of the pot. The experiment was arranged as a completely randomized design with six replicate plants per treatment.

The experiment was terminated on 27 July 1993 when untreated control plants required pruning to remain marketable. Measurements taken at the termination of the study were plant height, growth index [(height + width 1 + width 2 (perpendicular to width 1))/3], shoot dry weight, root dry weight, number of flower heads, and number of heads with open florets. Data were evaluated by analysis of variance and mean separations where appropriate.

Results and Discussion: For all measured variables, spike applications of paclobutrazol reduced plant growth and flowering compared to sprays. Growth indices were reduced by 22%, shoot dry weight (19%), root dry weight (50%), biomass (33%), number of flower heads (48%), and number of flower heads with open florets (41%) when plants were treated with spikes versus spray applications. Drench applications were not different from spike applications for root dry weight, biomass, and number of flower heads with open florets. Compared to spray applications, drenches reduced root dry weight by 32% and biomass by 18%.

For rate of application, there were no differences between 0.5 and 1.0 mg a.i./pot. When rates were combined and compared to the control, all growth and flowering parameters were reduced by application of paclobutrazol. Growth indices were reduced by 36%, shoot dry weight decreased 40%, root dry weight decreased 72%, biomass was reduced 54%, number of flower heads decreased 35%, and number of flowers with open florets decreased 50% per plant.

Using drench and spike applications of paclobutrazol, Deneke and Keever (3) found that method of application had no effect of the height of potted tulips (*Tulipa gesneriana* L.). In agreement with the results of our study, Barrett et al. (2) found no interactions between method of application and rate on several floricultural crops.

In a pine bark-based medium such as the one used in this study, spikes impregnated with paclobutrazol generally reduced plant size and flowering to a greater degree than spray or drench applications. Previous research with spikes has been conducted with floricultural media which contained no pine bark (2, 3). The efficacy of paclobutrazol applied as a drench was reduced when applied to media containing pine bark (1). Further work is needed to determine if spikes will be more effective than drenches in pine bark-based media on a variety of container-grown crops.

Significance to Industry: Paclobutrazol was applied as a foliar spray, root-medium drench, and impregnated spike to ‘New Gold’ lantana grown in #1 pots. All growth and flowering measurements were reduced by method of application and paclobutrazol. Impregnated spikes reduced plant size and flowering to a greater degree than spray or drench applications. These results suggest that impregnated spike formulations of paclobutrazol have the potential to provide good control of growth in pine bark-based media.

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