num moss peat (8). At the end of Expt. 1 (9 weeks), the average medium pH (saturation paste extract) was 5.4 in subirrigation treatments and 6.6 in drip fertigation treatments. At the end of Expt. 2 (12 weeks), the values were 5.5 and 6.3, respectively. The reason for fertigation effects on media pH are not clear. The subirrigation fertilizer had a slightly lower proportion of ammonium (34% of total N) than the drip irrigation fertilizer (37% of total N). Media samples from subirrigation treatments generally had higher levels of ammonium than samples from drip irrigation treatments (data not shown), suggesting higher rates of nitrification with drip irrigation. Nitrification would tend to acidify the media, so differences in nitrification are unlikely to account for the differences in pH. Another possibility is that drip fertigation, using fresh fertilizer solution at each irrigation, contributed more alkalinity to the medium than subirrigation with recycled fertilizer solution. Tap water used in these experiments contained 80 to 100 ppm alkalinity as $CaCO_3$ and had a pH of about 7.2.

Significant variation in urea hydrolysis rates among media substantiates previous observations (3), but, in contrast to them, length of cropping was not consistently associated with increased ureolytic activity.

The influence of media temperature on development of ureolytic activity may be inferred from the difference between heating treatments in Expt. 1. Although it was expected that root-zone heating would lead to higher rates than space heat, the reverse was observed (Fig. 1). This might be accounted for by the fact that temperatures were warmer in the space heat treatment (mean 23°C, range 11°–31°. cv 22%) than in the root-zone heat treatment (mean 20°, range 16°–28°, cv 15%). In addition, rates were much lower in Expt. 2 (Fig. 2) than in either treatment of Expt. 1 (Fig. 1). Media temperatures were also lower in Expt. 2 (mean 15°, range 6° to 23°, cv 23%). The possibility that plant species differentially affected development of ureolytic activity in the two experiments cannot be excluded, but seems unlikely in view of the observation that similar rates developed in sphagnum moss peat both with and without plants (8).

The results of this study illustrate the high degree of variability in ureolytic activity in soilless potting media under typical greenhouse conditions and typical cultural practices. Differences among media are not consistent from batch to batch, and cultural practices such as fertigation method and heating systems do not have consistent effects. Thus, it will be difficult to predict problems, such as ammonium or nitrite accumulation, associated with urea hydrolysis. Further investigations will be required to determine the contribution of different environmental factors and media characteristics to this variability.

The importance of uniform physical and chemical properties for potting media has long been recognized (2), but the importance of microbiological stability has been considered only recently (7). At this point, it seems warranted to investigate means of stabilizing biological and biochemical properties of soilless potting media.

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Paclobutrazol, Uniconazole, and Flurprimidol Influence Shoot Growth and Nut Yield of Young Pecan Trees

Bruce W. Wood[1]
Southeastern Fruit and Tree Nut Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, P.O. Box 87, Byron, GA 31008

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Abstract. **The problems of excessive vegetative growth and tree-size control of young pecan [*Carya illinoensis* (Wangenh.) C. Koch] trees prompted the evaluation of three tirazole analogs [paclobutrazol (PBZ), uniconazole (UCZ), and flurprimidol (FPD)] for their growth suppression efficacy and horticultural usefulness on pecan. A one-time soil application of these growth regulators at 132, 264, and 588 $\mu mol\cdot cm^{-2}$ trunk cross-sectional area suppressed shoot elongation by 50% to 90% for up to 3 years after treatment. Growth suppression greater than about 60% reduced nut yield; presumably due to drastically reduced leaf area and internal shading among leaves within compacted shoots. Relative efficacy in terms of shoot growth was UCZ > PBZ > FPD; however, all three chemicals exhibit commercial potential for controlling tree size. Chemical names used: β-[(4-chlorophenyl)methyl]-α-(1,1-dimethylethyl)-1*H*-1,2,4-triazole-1-ethanol (paclobutrazol); (E)-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol (uniconazol, name pending); α-(1-methylethyl)-α-[4-(trifluoromethoxy)phenyl]-5-pyrimidinemethanol (flurprimidol).**

Tree size of pecan is a major concern to pecan growers (6). The absence of dwarfing rootstocks or dwarf-like scion cultivars and the general inadequacy of mechanical pruning techniques as practical methods of size control have created a need for growth-suppressing chemicals. Paclobutrazol (PBZ; ICI Americas, Goldsboro, N.C.) is a trizole-type chemical that reduces shoot growth by interference with gibberellin metabolism (2). Several triazole analogs have also been observed to be highly effective as growth retardants. Two such analogs are uniconazole (name pending; XE-1019) (UCZ; Chevron Chemical Co., Richmond, Calif.) and flurprimidol (FPD; Eli Lilly and Co., Indianapolis, Ind.]. All three chemicals have been reported to control shoot growth of pecan (7–9); however, none of these chemicals are approved for use on pecan in the United States. PBZ has already proven to be an effective growth suppressant of trees in a commercial-like planting (1, 8, 9), whereas FPD (4) has reportedly reduced the growth of pecan seedlings in the greenhouse; however, the relative effectiveness of PBZ, UCZ, and FPD as pecan growth retardants in the field is unknown. This study reports an assessment of the response of trees in a commer-

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[1] Research Horticulturist.

Table 1. Effects of a single trunk-drench application of paclobutrazol (PBZ), uniconazol (UCZ), or flurprimidol (FPD) applied in Apr. 1984 on subsequent vegetative growth characteristics of young 'Cheyenne' and 'Desirable' pecan trees.

Treatment (μmol·cm^{-2} TCSA)[z]	Annual shoot growth (cm) 1984	1985	1986	Leaf area per terminal (cm^2) 1984	1985	Leaves per terminal (no.) 1984	1985
				'Cheyenne'			
No chemical	62	22	47	202	164	25	21
PBZ at 132	26	4	28	138	154	20	12
PBZ at 264	15	3	16	152	113	20	9
PBZ at 528	14	4	14	140	100	18	9
Significance:[y]	LQ	LQ	LQ	LQ	LQ	LQ	LQ
r^2	0.97	0.86	0.96	0.57	0.88	0.78	0.96
UCZ at 132	19	2	6	181	100	22	14
UCZ at 264	18	2	4	166	115	18	9
UCZ at 528	19	4	4	127	126	16	9
	LQ	LQ	LQ	LQ	LQ	LQ	LQ
r^2	0.83	0.83	0.90	0.60	0.54	0.85	0.66
FPD at 132	62	5	40	148	116	18	14
FPD at 264	40	4	39	160	126	18	12
FPD at 528	26	2	28	110	114	16	10
Significance:	LQ	LQ	LQ	LQ	LQ	LQ	LQ
r^2	0.69	0.88	0.80	0.70	0.55	0.81	0.65
				'Desirable'			
No chemical	70	26	18	301	271	20	15
PBZ at 132	30	4	8	202	173	12	10
PBZ at 264	18	3	6	185	189	12	11
PBZ at 528	14	4	3	190	169	10	6
Significance:	LQ	LQ	LQ	LQ	LQ	LQ	LQ
r^2	0.98	0.91	0.78	0.89	0.39	0.88	0.63
UCZ at 132	19	2	3	264	184	15	8
UCZ at 264	26	3	3	248	152	12	8
UCZ at 528	22	2	4	215	173	12	8
Signifcance:	LQ	LQ	LQ	LQ	LQ	LQ	LQ
r^2	0.81	0.85	0.89	0.78	0.81	0.88	0.75
FPD at 132	32	10	28	257	211	16	10
FPD at 264	19	2	12	225	168	14	10
FPD at 528	26	4	8	198	181	10	8
Significance:	LQ	LQ	LQ	LQ	LQ	LQ	LQ
r^2	0.89	0.88	0.38	0.39	0.93	0.57	0.61

[z] Chemicals applied as a basal-drench to the trunk–soil interface with rates based on trunk cross-sectional area (TCSA).

[y] Statistical significance levels were assessed at $P \leq 0.05$, NS represents nonsignificance while L and Q represent significant linear and quadratic terms, respectively. Coefficients of determination (r^2) of combined regression model.

cial-like orchard environment to treatment with equimolar levels of these three triazole compounds.

Growth regulators were evaluated on young pecan trees in a commercial-like planting growing at a 9.1 × 9.1 m spacing on a Faceville fine sandy loam (siliceous thermic Typic Paleudult) soil and with management of nutrition and pests in accordance to Georgia Cooperative Extension Service recommendations (3). Trees were drip irrigated as needed via emitters placed 0.61 m on two sides of the tree trunk. The experiment consisted of three growth regulators (PBZ, UCD, and FPD) at four equimolar levels [0, 132, 264, 528 μmol·cm^{-2} trunk cross-sectional area (TCSA)] applied to two scion cultivars (Cheyenne and Desirable). The experimental design was a randomized complete block consisting of three blocks with one tree per experimental unit. Chemicals were applied at budbreak (1 Apr. 1984) when trees were entering their fourth leaf. No chemicals were applied in subsequent years. All three growth regulators were wettable powder formulations and were applied in 1 iiter of water to a 4-cm-wide trench at the trunk–soil interface. Measurements of shoot length (10 terminals per tree), nut quality (100 nuts per treatment), total tree in-shell nut yield, and area per terminal shoot (10 terminals per tree) were taken annually for 3 years and statistically analyzed using SAS-GLM (5).

All three chemicals decreased vegetative growth for two to three growing seasons after treatment, depending upon rate (Table 1). Treatment at budbreak was sufficiently early to enable all three triazole compounds to substantially suppress vegetative growth the first growing season after treatment. Shoot growth suppression during this first growing season was in the sequence UCZ > PBZ > FPD.

Terminal shoot length reductions of both cultivars was proportional to mole concentration of all three triazoles (Table 1). Growth rate reductions were curvilinear with only 132 μmol·cm^{-2} TCSA, PBZ, or UCZ being required to suppress growth by 50% to 75%, while an additional 2- to 4-fold increase in concentration produced only an additional 10% growth suppression. By the third growing season post-treatment the two lowest mole rates of FPD did not suppress growth as much as did PBZ or UCZ. The ability of these growth regulators to reduce shoot growth on an equilmolar basis was UCZ > PBZ > FPD during all three seasons.

All three chemicals reduced the total number of leaves and their area per terminal (Table 1) as observed for PBZ on both young (9) and old (8) pecan trees. As with shoot growth, suppression was generally proportional to growth regulator level with leaf area and leaf number per terminal shoot being reduced by 30% to 60%. This reduction was insufficient to offset substantial compaction and shading of leaves.

In-shell nut yield was not decreased by these chemicals. There was a tendency to increase yield in 'Cheyenne' the first season after treatment with UCZ (Table 2). In-shell nut yield by 'Cheyenne', a precocious and prolific bearer, was also unaffected the second growing season post-treatment, but declined with increasing growth regulator levels during the third season. Nut yield by 'Desirable' was reduced by all three chemicals the second growing season post-treatment but was unaffected subsequently (Table 2). Such yield losses may be due to the loss of leaf area and increased leaf shading, because pecan nut production is highly sensitive to assimilate reserves (5, 9–11).

This study has demonstrated that in addition to PBZ (1, 8, 9) certain other triazole analogs are highly potent suppressors of pecan shoot growth. When applied as a trunk drench at the trunk–soil interface, relative efficacies were UCZ > PBZ > FPD. All three chemicals can potentially reduce nut yield of individual trees if rates are used that reduce shoot grwoth by more than about 60%. Such chemicals would, therefore, appear to be precluded from use in orchards if growth suppression ≥60% is required; however, all three analogs appear to be potentially useful on young pecan trees at the 132 μmol·cm^{-2} TCSA level. A concern common to all three chemicals is their long-term residual activity. This, potentially, could cause a problem with reduced nut yield if rates and/or frequency of application results in excessive growth suppression. While all three triazoles exhibit potential to control pecan tree size, much more information is needed before a commercially acceptable method can be developed. Since there were no significant cultivar interactions with triazole type or concentration, it would appear that such chemicals and their rates will not need to be tailored to pecan cultivars; especially since the two cultivars used in this study exhibit a rather diverse growth nature.

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Table 2. Effects of a single application of paclobutrazol (PBZ), uniconazole (UCZ), or flurprimidol (FPZ) applied in Apr. 1984 on in-shell nut production of young 'Cheyenne' and 'Desirable' pecans.

Treatment (μmol·cm^{-2} TCSA)[z]	In-shell nut yield (kg/tree) 1984	1985	1986
	'Cheyenne'		
No chemical	0.83	1.72	2.14
PBZ at 132	0.77	3.00	1.47
PBZ at 264	0.71	2.06	1.16
PBZ at 528	0.39	2.22	0.70
Significance:[y]	LQ	LQ	LQ
r^2	0.24	0.04	0.67
UCZ at 132	0.97	1.16	0.26
UCZ at 264	1.09	1.06	0.24
UCZ at 528	1.66	1.08	0.22
Significance:	LQ	LQ	LQ
r^2	0.53	0.10	0.89
FPD at 132	0.83	1.91	0.79
FPD at 264	1.44	1.71	0.92
FPD at 528	0.43	1.61	1.36
Significance:	LQ	LQ	LQ
r^2	0.65	0.27	0.80
	'Desirable'		
No chemical	0.45	0.68	2.97
PBZ at 132	0.48	0.04	2.84
PBZ at 264	0.57	0.07	2.20
PBZ at 528	0.47	0.04	1.70
Significance:	LQ	LQ	LQ
r^2	0.39	0.55	0.32
UCZ at 132	0.27	0.03	1.50
UCZ at 264	0.20	0.05	1.33
UCZ at 528	0.27	0.03	2.03
Significance:	LQ	LQ	LQ
r^2	0.10	0.41	0.48
FPD at 132	0.13	0.11	2.28
FPD at 264	0.07	0.15	2.39
FPD at 528	0.30	0.13	3.11
Significance:	LQ	LQ	LQ
r^2	0.18	0.04	0.79

[z] Chemicals applied as a basal-drench to the trunk–soil interface with rates based on trunk cross-sectional area (TCSA).

[y] Statistical significance levels were assessed at $P \leq 0.05$, NS represents nonsignificance while L and Q represent significant linear and quadratic terms, respectively. Coefficients of determination (r^2) of combined regression model.

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