Growth and Landscape Establishment of *Pyracantha* and *Juniperus* after Application of Paclobutrazol

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Abstract. The long-term effects of paclobutrazol applied to container-grown 'Mojave' pyracantha (*Pyracantha* x) and 'San Jose' juniper (*Juniperus chinensis* L.) were investigated. Paclobutrazol was applied as a drench to container-grown (2.8 liter) plants at the rates of 0, 5, 10, 20, and 40 mg a.i./pot in June 1991, and plants were transplanted to the field in Feb. 1992. *Pyracantha* plant height, shoot and root dry weight, and total biomass (shoot dry weight + root dry weight) decreased quadratically as rate of paclobutrazol increased during nursery production. Paclobutrazol had no effect on plant height or shoot dry weight of *Juniperus*, although width indices were reduced. Ratings for root quality for *Juniperus* in containers increased as rate of paclobutrazol increased. After 9 months in the landscape, paclobutrazol still influenced plant height, width, and shoot dry weight for *Pyracantha* but had no effect on *Juniperus*. As rate of application increased, fruit retention on *Pyracantha* increased. Paclobutrazol applied as a container medium drench at 5 mg a.i./pot was excessive during nursery production of *Pyracantha* and *Juniperus*. Chemical name used: [(2RS, 3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-yl)penten-3-ol] (paclobutrazol).

Paclobutrazol is a triazole plant growth regulator known to inhibit the growth of woody landscape plants (Keever et al., 1990; Owings and Newman, 1993; Ruter, 1992; Ruter and Martin, 1994). Previous reports on the use of paclobutrazol drenches for nursery production indicated rates of 0 to 100 mg a.i./pot (Keever et al., 1990), 0 to 400 mg a.i./pot (Wilkinson and Richards, 1991), and 0 to 40 mg a.i./pot (Ruter, 1992) were used. Recommended trial rates for container-grown woody landscape plants were not available to nursery operators until 1993 (Uniroyal Chemical Co., Middlebury, Conn.).

The known effects of triazole plant growth regulators on the growth of plants in the landscape are limited (Keever and West, 1992; Norcini and Knox, 1989). It is not known if paclobutrazol applied during nursery production would continue to retard plant growth in the landscape. Norcini and Knox (1989) found that the effects of [(E)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-yl)penten-3-ol] (uniconazole), a triazole growth regulator similar to paclobutrazol, applied to container-grown plants had diminished effects 17 months after

transplanting. While paclobutrazol may be useful during nursery production, it is important that plants resume normal growth after planting in the landscape. The studies presented here evaluated the effects of a paclobutrazol potting-medium drench on growth retardation during nursery production and growth after transplanting.

Methods and Materials

Growth in containers (1991). Forty plants each of *Pyracantha* x 'Mojave' and *Juniperus chinensis* 'San Jose' were grown in 2.8-liter pots and pruned on 26 June 1991. The potting medium consisted of 4 pine bark : 1 sand (v/v). Liquid fertilizer (10N–1.5P–8.5K) was applied with each irrigation at 100 mg N/liter. Plants were grown in full sun and irrigated as needed at 20 mm/irrigation using overhead sprinklers.

Paclobutrazol at 0, 5, 10, 20, or 40 mg a.i./pot (Clipper 2SC; ICI Americas, Richmond, Calif.) was applied to the container medium surface as a single 100-ml liquid drench on 28 June 1991. The experiment was terminated on 30 Sept. 1991. Terminal measurements included height, a width index $\{[\text{width } 1 + \text{width } 2 (\text{perpendicular to width } 1)]/2\}$, and shoot and root dry weight. Root dry weight for *Juniperus* could not be determined due to our inability to separate the root mass from the potting medium. Therefore, a root quality rating was used (1 = less than 20% of the rootball covered with white roots, 2 = greater than 20% but <40%, 3 = greater than 40% but <60%, 4 = greater than 60% but <80%, and 5 = greater than 80% coverage). The design was completely randomized with eight replicate plants

per treatment; four of the eight were harvested for shoot and root dry weights.

Growth in field (1992). Four replicate plants of each species from 1991 were planted in a Tifton loamy sand (fine-loamy, siliceous, thermic Plinthic Paleudult) on 12 Feb. 1992 in a completely randomized design. Planting holes were augered (30-cm width) to a depth of 30 cm. Plants were spaced 1.8 m apart within rows with 3.8 m between rows and were fertilized at planting with 13.6 g of granular 12N–2.6P–5.0K (Tri-State Plant Food, Dothan, Ala.) per plant. Drip irrigation was provided at the rate of 3.8 liters/week per plant when <25 mm of rain had fallen during the previous week. Weeds were removed during the experiment.

Growth measurements (height and width indices) were taken on 17 July and 16 Nov. 1992; at the latter date, a fruit retention rating (1 = no fruit retention, 3 = moderate fruit retention, and 5 = heavy fruit retention) was recorded for *Pyracantha*. Shoot dry weights were determined for both species. Data for both phases were evaluated by analysis of variance and regression analysis (SAS Inst., Cary, N.C.).

Results and Discussion

Growth in containers. Paclobutrazol rate curvilinearly influenced most plant growth characteristics measured for *Pyracantha* (Table 1), although additional decreases in growth were minimal as rate increased above 5 mg a.i./pot; at this, the lowest rate used, plant heights were reduced by 36%. Width indices decreased linearly as rate increased (Table 1). Inhibition of shoot growth of *Pyracantha* in containers was excessive even at the lowest rate used. Shoot dry weight was reduced 18% at this rate, with no further decreases as rate increased. Root dry weight of *Pyracantha* was reduced ~40% by all rates of paclobutrazol. Application of paclobutrazol reduced total biomass by ~30% when averaged across rate of application. Foliar phytotoxicity was absent at all rates of application, but treated plants had darker green leaves than control plants.

Paclobutrazol had no effect on height of *Juniperus*, a prostrate-growing plant (Table 2). Width growth decreased curvilinearly as rate of application increased. In contrast to *Pyracantha*, paclobutrazol had no effect on shoot dry weight of *Juniperus* (Table 2). A reduction in width growth coupled with no reduction in shoot dry weight for plants treated with paclobutrazol resulted in compact plants with shorter internodes.

Root quality ratings for *Juniperus* increased as rate of paclobutrazol application increased. Keever et al. (1990) noted roots of most species covered the entire rootball surface when treated with paclobutrazol. At rates >5 mg a.i./pot, live roots were found on the south and west container sides. During the summer, roots are generally absent from these solar container quadrants due to lethal, high root-zone temperatures (Ingram et al., 1989; Martin and Ingram, 1988). Uniconazole increased the thermotolerance of roots (Upadhyaya et al.,

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Table 1. The effect of rate of paclobutrazol (Pac.) application on the growth of *Pyracantha* x 'Mojave' in 2.8-liter containers.

Pac. rate (mg a.i./ pot)	Growth response				
	Ht (cm)	Width index ^z	Shoot dry wt (g)	Root dry wt (g)	Total biomass
0	69	41	83.7	118.3	201
5	46	39	68.4	70.5	139
10	49	38	67.2	66.3	133
20	48	36	64.5	67.3	132
40	45	35	67.0	77.0	144
Significance					
Linear	**	**	**	*	**
Quadratic	**	NS	**	**	**

^zWidth index: (width 1 + width 2)/2.

NS, *, ** Nonsignificant at $P > 0.05$ or significant at $P \leq 0.05$ or 0.01, respectively.

Table 2. Effect of rate of paclobutrazol (Pac.) application on the growth of *Juniperus chinensis* 'San Jose' in 2.8-liter containers.

Pac. rate (mg a.i./ pot)	Growth response			
	Ht (cm)	Width index ^z	Shoot dry wt (g)	Root quality ^y
0	20	55	133.1	2.5
5	20	32	138.0	3.3
10	19	27	128.3	4.3
20	19	25	140.9	4.3
40	18	28	141.1	4.3
Significance				
Linear	NS	**	NS	**
Quadratic	NS	**	NS	**

^zWidth index: (width 1 + width 2)/2.

^yRoot quality rating: 1 = less than 20% of the rootball covered with white roots, 2 = greater than 20% but less than 40%, 3 = greater than 40% but <60%, 4 = greater than 60% but <80%, and 5 = greater than 80% coverage.

NS, ** Nonsignificant at $P > 0.05$ or significant at $P \leq 0.01$, respectively.

1990), while paclobutrazol protected seedlings of *Pinus banksiana* Lamb. from lethal, high-temperature damage (Marshall et al., 1991).

Growth in field. When averaged across treatments, *Pyracantha* plant height was reduced by 38% in July (Table 3). Change in plant height between Nov. 1991 and July 1992 was characterized by a curvilinear response. Rate of application had no effect on width indices or change in width indices when measured in July (Table 3).

At the conclusion of the study, in November, height and width indices of *Pyracantha* had been reduced by 16% and 9%, respectively, at the 5-mg a.i. application rate relative to the control (Table 3). Similarly, final shoot dry weights decreased 23%, 38%, 36%, and 19%, respectively, as application rates increased. Decreased shoot dry weights coupled with decreased width indices indicated paclobutrazol effects on shoot growth of *Pyracantha* were evident 17 months after treatment.

Fruit retention on treated *Pyracantha* plants increased as rate of application increased (Table 3). An increase in fruit count on container-grown *Ilex cornuta* Lindl. 'Burfordii Nana' appeared to be related to rate and method of paclobutrazol application (Keever et al., 1990). In studies with apples (*Malus domestica* L.), paclobutrazol application resulted in increased fruit set (Curry and Williams, 1983; Williams and Edgerton, 1983). As *Malus* and *Pyracantha* are in the same subfamily, Pomoidae, it is logical that fruit retention was also improved by paclobutrazol.

Paclobutrazol application had no effect on height (range 20 to 24 mm, July; 25 to 28 mm, November) or width indices of *Juniperus* in July (range 52 to 56) or Nov. (range 67 to 74) 1992. Paclobutrazol had no effect on final shoot dry weight of *Juniperus* 17 months after application (range 534 to 641 g).

Growth regulators have produced variable results on conifers (Hare, 1982; Keever and West, 1992; Weston et al., 1980; Wheeler, 1987). Keever and West (1992) found uniconazole effective on x *Cupressocyparis leylandii* in 3.8-liter containers but not on mature plants treated after landscape establishment. Growth of seedling loblolly pine (*Pinus taeda* L.) and Douglas fir [*Pseudotsuga*

menziesii (Mirbel) Franco] was reduced by paclobutrazol application but had no effect on 3- to 9-year-old plants (Wheeler, 1987). Differences in gymnosperm and angiosperm vascular systems have been suggested as a reason for conifers' lack of response to growth regulator applications (Wheeler, 1987).

Consistent with previous studies, paclobutrazol was less effective in reducing the growth of the gymnosperm *Juniperus* relative to the angiosperm *Pyracantha*. However, paclobutrazol may have potential for increasing the stress tolerance of container-grown plants, as evidenced by the increased root ratings for *Juniperus*. Improved root system development through the use of triazole growth regulators may prove to be a useful management tool for producers of container-grown plants in the southeastern United States. Further research on rate of application for various species is required before paclobutrazol can be widely used in nursery crop production.

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Table 3. Effect of rate of paclobutrazol (Pac.) application to container-grown *Pyracantha* plants in 1991 on growth in the landscape in 1992. Plants were set out in Feb. 1992.

Pac. rate (mg a.i./ pot)	July 1992				Nov. 1992			
	Ht (cm)	Width index ^z	ΔHt ^y	ΔWidth index ^y	Ht (cm)	Width index ^z	Shoot dry wt (g)	Fruit retention ^x
0	84	81	17	32	137	166	931	2.0
5	51	74	6	42	115	152	719	2.3
10	54	62	6	44	102	138	574	2.3
20	50	62	2	37	103	148	596	3.8
40	53	71	7	42	108	159	754	4.5
Significance								
Linear	**	NS	**	NS	**	**	**	NS
Quadratic	**	NS	**	NS	*	**	*	NS
Cubic	**	NS	NS	NS	*	*	*	*

^zWidth index: (width 1 + width 2)/2.

^yMeasured from Nov. 1991 to July 1992.

^xFruit retention: 1 = no fruit retention, 3 = moderate fruit retention, 5 = heavy fruit retention.

NS, *, ** Nonsignificant at $P > 0.05$ or significant at $P \leq 0.05$ or 0.01, respectively.

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