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Paclobutrazol Inhibits Growth of Woody Landscape Plants[1]

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Abstract

Paclobutrazol, applied as a spray or drench, suppressed growth of 8 woody landscape species. Magnitude of growth inhibition was directly correlated with application rate, whereas both magnitude and duration of growth inhibition was influenced by application method. Generally, paclobutrazol when applied as a drench suppressed growth to a greater degree than did spray applications. Flowering or fruiting of 3 species was generally promoted with paclobutrazol, while phytotoxicity symptoms were observed on 4 species.

Index words: Growth retardant, Bonzi, Clipper, growth inhibition
Growth regulators used in this study: Bonzi (paclobutrazol) (2*RS*, 3*RS*)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1*H*-1,2,4-triazole-1-yl)pentan-3-ol
Species used in this study: Japanese euonymus (*Euonymus japonica* 'Microphylla' H. Jaeg.); dwarf Burford holly (*Ilex cornuta* Lindl. & Paxt. 'Burfordii Nana'); compacta Japanese holly (*Ilex crenata* Thunb. 'Compacta'); shore juniper (*Juniperus conferta* Parl. 'Blue Pacific'); Hino Crimson azalea (*Rhododendron obtusum* Planch 'Hino Crimson'); Formosa azalea (*Rhododendron indicum* L. 'Formosa'); photinia (*Photinia* × *fraseri* Dress); privet (*Ligustrum japonicum* Thunb. 'Aureo-marginatum')

Significance to the Nursery Industry

Paclobutrazol is an effective growth retardant on a wide range of woody landscape plants when applied as either a drench or spray. This may offer growers an additional management tool; for example, it's use offers the ability to retard growth during a depressed market or avoid transplanting. Due to the magnitude and persistence of growth suppression, drench applications during production are probably not practical and spray rates should be carefully chosen. Drench and spray application methods have potential for the landscape industry, however established plants may respond differently than container-grown plants to paclobutrazol rate and application method due to differences in growth medium or other factors. Sensitivity to paclobutrazol varied greatly among species, and appropriate rates are likely to be highly species-dependent; hence, paclobutrazol should first be tested on a small group of plants before committing to large scale application.

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Introduction

Mechanical pruning to control excessive vegetative growth and improve plant form is a major expense in the production and maintenance of woody landscape plants. Over time, numerous compounds have been used to retard woody plant growth, but most remain uneconomical or cause undesirable side effects (1,5,11). Currently, chemical growth inhibitors are being actively evaluated by the electric utility industry, which spends an estimated $800 million per annum on tree trimming (12). Paclobutrazol, registered as Clipper, is an inhibitor of gibberellin biosynthesis and is used to suppress regrowth of pruned trees along utility rights-of-way. Clipper is labeled for trunk injection of trees; this method of application avoids chemical contact with nontarget plants and reduces environmental residues. Paclobutrazol also is labeled as Bonzi® for use on poinsettias, bedding plants, chrysanthemums, geraniums, and potted freesias. Little published research is available on the potential uses of paclobutrazol in the production and maintenance of woody landscape plants (2,6,10). The objectives of this research were to evaluate the magnitude and duration of growth inhibition by media- and foliar-applied paclobutrazol for 8 woody landscape species.

Materials and Methods

Eighty uniform liners per species were potted March 27, 1986, in a 100% milled pine bark growth medium amended with 3.6 kg/m^3 (6 lb/yd^3) dolomitic limestone, 1.2 kg/m^3 (2 lb/yd^3) gypsum, 0.9 kg/m^3 (1.5 lb/yd^3) Micromax micronutrient fertilizer, and 7.1 kg/m^3 (12 lb/yd^3) Osmocote 17N-3P-10K (17-7-12). Plant species and container sizes included *Euonymus japonica* 'Microphylla' (euonymus), *Ilex cornuta* 'Burfordii Nana' (dwarf Burford holly), *Ilex crenata* 'Compacta' (compacta Japanese holly), *Juniperus conferta* 'Blue Pacific' (juniper), and *Rhododendron obtusum* 'Hino Crimson' (kurume azalea) in 2.8 l (#1 trade gal) containers; *Photinia* × *fraseri* (photinia) and *Rhododendron indicum* 'Formosa' (indica azalea) in 3.8 l (#1 gal) containers; and *Ligustrum japonicum* 'Aureo-marginatum' (privet) in 11.4 l (#3) containers. Plants were placed outdoors in full sun or under 47% shade (euonymus and azaleas) and maintained following typical nursery cultural practices. On July 23, 1986, the following treatments were applied: paclobutrazol sprays of 0, 250, 500, 1000, and 2000 ppm in a volume of 204 ml/m^2 (2 qt/100 ft^2) and paclobutrazol drenches of 6.3 (0.1), 25 (0.4), and 100 mg (1.5 grains) ai in a volume of 250 ml (8.5 oz)/container. A surfactant, Nufilm 17, at 0.6 ml/l (0.08 oz/gal) was added to spray solutions. Environmental conditions at time of application were 32.2°C (90°F) and 59% relative humidity. Rainfall occurred 3½ hours after treatments were applied. Growth indices (height + width + width/3) were taken at time of treatment. There were 10 single-plant replicates completely randomized within species.

On November 19, 1986, seventeen weeks after treatment (WAT), growth indices and foliar color ratings (1 = light green; 3 = medium green; 5 = dark green) were determined for all species. On November 25, 1986, five single-plant replicates each of euonymus, photinia, and privet were completely randomized within species and planted 1 m (1.1 yd) apart in a loamy sand bed with 5.1 cm (2 in) of pine bark tilled into the upper 15 cm (6 in). Plants in the ground bed received spring and fall applications of 12N-3P-5K (12-6-6) fertilizer broadcast at 97.6 g/m^2 (2 lb/100 ft^2). Plants in containers were topdressed in March 1987 with Osmocote

Table 1. Growth indices[z] of 8 woody landscape species drenched or sprayed with paclobutrazol, November 19, 1986 (17 WAT).

Paclobutrazol treatment		Species							
Method of application	Concentration	*Euonymus japonica* 'Microphylla'	*Ilex crenata* 'Compacta'	*Ilex cornuta* 'Burfordii Nana'	*Juniperus conferta* 'Blue Pacific'	*Ligustrum japonicum* 'Aureo-marginatum'	*Photinia* × *fraseri*	*Rhododendron indicum* 'Formosa'	*Rhododendron obtusum* 'Hino Crimson'
Drench	mg ai·pot^{-1}								
	0.0	44.3	45.5	28.1	52.2	100.5	78.2	62.6	41.8
	6.3	33.8	42.4	24.0	44.5	76.0	50.8	49.8	38.8
	25.0	32.8	39.7	25.6	42.9	75.2	47.0	53.8	37.7
	100.0	30.4	38.5	25.8	36.6	68.5	43.5	49.9	38.8
Significance[y]		C**	Q**	C*	C**	C**	C**	C**	C**
Spray	(ppm)								
	0	44.3	45.5	28.1	52.2	100.5	78.2	62.6	41.8
	250	45.1	46.9	25.0	47.5	91.3	63.3	56.7	38.5
	500	45.0	41.5	24.1	50.0	89.5	56.0	55.3	38.7
	1000	41.5	42.3	24.7	45.9	82.6	55.4	54.1	39.4
	2000	40.7	40.3	27.1	44.5	74.9	50.7	53.4	38.5
Significance		C*	L**	Q**	L**	L**	C**	Q**	C*
Drench		32.3 b[x]	40.2 b	25.1	41.3 b	73.2 b	47.1 b	51.1 b	38.4
Spray		43.1 a	42.8 a	25.2 NS	47.0 a	84.6 a	56.4 a	54.9 a	38.8 NS

[z]Growth index = (height + $width_1$ + $width_2$)/3 in cm, where $width_1$ = width at the widest point and $width_2$ = width at a right angle to $width_1$.
[y]Significant at the 5% (*) or 1% (**) level; L = linear, Q = quadratic, C = cubic. Zero rate included in regression analysis.
[x]Significant or not significant (NS) at the 5% level; zero rate not included in mean determination.

17N-3P-10K (17-7-12) at 12 g/2.8 l (2 tsp./#1 trade gal.) container, 18 g/3.8 l (1 Tbsp./#1 full gal.) container, and 90 g/11.4 l (5 Tbsp./#3) container. Plants were topdressed again in February 1988 with 12N-3P-5K (12-6-6) at 6 g/2.8 or 3.8 l (1 tsp./gal) container and 18 g/11.4 l (1 Tbsp./#3) container.

On March 27, 1987 (35 WAT), flowers on 5 single-plant replicates of Formosa azalea were counted and the diameter of 10 flowers per plant for 4 single-plant replicates of Hino Crimson azalea was measured. Due to a delay in flowering, flower number and flower diameter of drench-treated plants were not determined until April 20. Growth indices were taken again on June 19 (48 WAT) and December 1, 1987 (71 WAT); foliar color was rated on December 9, 1987 (72 WAT), and fruit of dwarf Burford holly was counted on January 18, 1988 (78 WAT). On March 8, 1988 (84 WAT), root systems of all species were rated for density (1-5 = 0, 25, 50, 75, 100% of rootball surface covered, respectively), foliage color was rated, and shoots were severed at container surface for dry weight determination.

On June 30, 1987 (50 WAT), fifty 8.9 cm (3.5 in) cuttings of compacta holly and privet were taken from plants in each treatment and given a 3-second quick dip of 1% K-IBA in water. Compacta holly cuttings were placed in 72-cell packs of unamended peat:perlite:vermiculite (1:1:1, by vol.). Photinia cuttings were placed in 8.3 cm (3.3 in) containers of the same amended 100% pine bark growth medium that the stock plants were grown in. Cuttings were placed in a glass greenhouse under intermittent mist. Rooting was evaluated August 11, 1987, and in September compacta holly plants were transplanted into 8.3 cm (3.3 in) containers of amended 100% pine bark growth medium. Liners were placed in a heated, double polyethylene greenhouse, and heights were measured on January 25 (79 WAT) and March 8, 1988 (84 WAT).

Results and Discussion

By November 19, 1986, seventeen WAT, significant differences in growth indices had occurred in response to both rate and application method (Table 1). In general, growth indices of all species decreased with increasing drench and spray rates. Drench treatments were more active than spray treatments for 6 species, while 2 species (dwarf Burford holly and Hino Crimson azalea) responded similarly, regardless of the application method.

Subsequent growth measurements of euonymus, photinia, and privet were not influenced by whether plants were growing in containers or a ground bed; hence, data were combined for analysis. Similar trends in growth indices to those on November 19 were observed on June 19, 1987 (48 WAT), and December 1, 1987 (71 WAT) (data not shown). Growth indices for all species decreased with increasing paclobutrazol rates except for spray-treated euonymus (both dates) and juniper (June date only). Drenches again were more effective than sprays in suppressing growth indices for all species on both sampling dates.

For most species, foliar color ratings taken November 19, 1986 (17 WAT), were not influenced by treatment, however foliar color ratings for euonymus and photinia did increase with increasing paclobutrazol rates (data not shown). Ratings were higher for spray-treated euonymus than for drenched plants; the inverse was true for photinia. By December 9, 1987 (72 WAT), foliar color ratings of most species were influenced by paclobutrazol (Table 2). Foliar color ratings for 6 of 8 species drenched and 4 of 8 species

Table 2. Foliar color[z] of 8 woody landscape species drenched or sprayed with paclobutrazol, December 9, 1987 (72 WAT).

Paclobutrazol treatment		Species							
Method of application	Concentration	*Euonymus japonica* 'Microphylla'	*Ilex crenata* 'Compacta'	*Ilex cornuta* 'Burfordii Nana'	*Juniperus conferta* 'Blue Pacific'	*Ligustrum japonicum* 'Aureo-marginatum'	*Photinia* × *fraseri*	*Rhododendron indicum* 'Formosa'	*Rhododendron obtusum* 'Hino Crimson'
Drench	mg ai·pot^{-1}								
	0.0	3.5	4.0	3.6	3.8	3.9	3.5	3.5	3.3
	6.0	4.1	4.1	4.3	3.9	3.9	3.8	4.4	3.9
	25.0	4.2	4.3	3.7	4.0	4.3	4.3	4.8	3.8
	100.0	4.6	4.9	3.6	4.5	4.4	4.8	5.0	3.6
Significance[y]		C**	L**	C**	L**	L*	Q*	C**	C**
Spray	(ppm)								
	0	3.5	4.0	3.6	3.8	3.9	3.5	3.5	3.3
	250	3.6	3.9	4.3	3.9	3.8	3.5	4.0	3.6
	500	3.6	4.1	4.6	3.8	4.1	3.6	4.1	4.1
	1000	3.6	4.0	4.1	3.7	4.1	3.6	4.1	4.1
	2000	3.8	4.0	4.5	3.7	4.1	4.0	4.1	4.3
Significance		NS	NS	C**	NS	NS	L*	C**	C*
Drench		4.3 a[x]	4.4 a	3.9 b	4.1 a	4.2	4.3 a	4.7 a	3.7 b
Spray		3.7 b	4.0 b	4.4 a	3.8 b	4.0 NS	3.7 b	4.1 b	4.0 a

[z]Foliar color rating: 1 = light green, 3 = medium green, 5 = dark green.
[y]Significant or not significant (NS) at the 5% (*) or 1% (**) level; L = linear, Q = quadratic, C = cubic, Zero rate included in regression analysis.
[x]Significant at the 1% level; zero rate not included in mean determination.

sprayed with paclobutrazol improved while foliar color ratings of drench-treated dwarf Burford holly and Hino Crimson azalea increased at the lower rates but decreased at higher rates. Foliar color ratings were higher for drenched treatments as compared to sprays with 5 species, lower with 2 species (dwarf Burford holly and Hino Crimson azalea) and similar for the other species (privet), regardless of application method.

In addition to effects on magnitude of growth and foliar color, paclobutrazol also influenced axillary bud development of several species (Table 3). Axillary shoot development in response to application method varied with species. Axillary shoot number for privet and photinia receiving either a spray or drench and spray-treated euonymus increased with increasing rates of paclobutrazol.

Flower number for Formosa azalea increased dramatically in response to paclobutrazol, with as much as a 360% and 238% increase in flower number with sprays and drenches, respectively (Table 4). Flower diameter of Hino Crimson azaleas drenched or sprayed was reduced as much as 46% and 11%, respectively, compared with the control. Flowering of drench-treated plants of both cultivars was delayed about 3 weeks; a similar delay in flowering was observed with florist azaleas (8) and chrysanthemum (9). Fruit number of dwarf Burford holly increased with increasing spray rates, while drench-treated plants increased in fruit number at the lowest rate and decreased to essentially zero at the highest rate. Other cases of increased fruit number with paclobutrazol application have been reported (5).

Terminal data collected on March 8, 1988 (84 WAT), were root density and shoot dry weight. Roots of most species covered the entire rootball surface and were densely matted, regardless of treatment. However, differences among treatments were evident with the two azalea species and dwarf Burford holly (data not shown). Root density of Formosa azaleas treated with the highest drench rate was less than plants in other treatments, whereas root density of Hino Crimson azalea decreased with increasing drench rate. Root coverage of sprayed and control plants was similar for both azalea cultivars. Root coverage of dwarf Burford holly was highest for nontreated plants and decreased with increasing paclobutrazol rates, with drenches suppressing root growth more than sprays.

Shoot dry weight was suppressed 20 months after paclobutrazol was applied with all species drenched and with 6 of 8 species sprayed (Table 5). Only dry weight of spray-treated dwarf Burford holly and juniper was not affected by treatment. Growth retardation was greater for 7 of 8 species drenched compared to sprayed. Reduced shoot dry weight of paclobutrazol-treated plants agrees with previously reported research (2,6).

Eleven months after treatments were applied (June 30, 1987), 50 cuttings per treatment were taken from compacta holly and privet to determine if rooting and subsequent growth of the liner would be affected by paclobutrazol. All cuttings for both species rooted. Liner growth varied with treatment, species, and sampling date (Table 6). Height of compacta holly liners decreased with increasing drench rate on both sampling dates, January 25 (78 WAT) and March 7, 1988 (84 WAT), whereas spray-treated plants were not affected by treatment at either date. Liners from drench-treated compacta holly plants also were shorter than liners from sprayed plants. Height of privet was not affected by paclobutrazol rate or method of application on either sampling date. The duration of the growth inhibition to compacta holly liners indicates the persistence of drench-applied paclobutrazol in the treated plants. The length of time that paclobutrazol inhibits shoot growth in various species has

Table 3. Axillary shoot number[z] of 3 woody landscape plants drenched or sprayed with paclobutrazol, April 20, 1987 (39 WAT).

Paclobutrazol treatment				
Method of application	Concentration	*Euonymus japonicus* 'Microphyllus'	*Liqustrum japonicum* 'Aureo-marginatum'	*Photinia × fraseri*
Drench	mg ai·pot^{-1}			
	0.0	39.5	14.9	14.5
	6.3	36.5	22.7	35.3
	25.0	34.0	25.9	33.8
	100.0	34.2	32.4	34.9
Significance[y]		NS	C*	C**
Spray	(ppm)			
	0	39.5	14.9	15.5
	250	38.8	12.8	34.1
	500	40.9	17.7	33.7
	1000	42.3	20.5	30.8
	2000	46.1	23.2	33.7
Significance		L*	L**	C**
Drench		34.9 b[x]	27.0 a	34.7
Spray		42.0 a	18.6 b	33.1 NS

[z]Axillary shoots 1 cm or longer.
[y]Significant or not significant at the 5% (*) or 1% (**) level; L = linear, Q = quadratic, C = cubic. Zero rate included in regression analysis.
[x]Significant or not significant (NS) at the 1% level; zero rate not included in mean determination.

Table 4. Flowering or fruiting of 3 woody landscape species drenched or sprayed with paclobutrazol.

Paclobutrazol treatment: Method of application	Paclobutrazol treatment: Concentration	*Rhododendron indicum* 'Formosa' Flower no.[z]	*Rhododendron obtusum* 'Hino Crimson' Flower diameter[y] (cm)	*Ilex cornuta* 'Burfordii Nana' Fruit no.[x]
Drench	mg ai·pot^{-1}			
	0.0	79.2	3.5	40.2
	6.3	—	2.9	239.6
	25.0	189.1	2.1	73.0
	100.0	153.0	1.9	1.5
Significance[w]		Q**	Q**	C**
Spray	(ppm)			
	0	79.2	3.5	40.2
	250	119.2	3.3	208.4
	500	238.6	3.2	159.5
	1000	287.6	3.1	272.5
	2000	274.4	3.3	275.0
Significancc		Q**	Q**	Q**
Drench		171.1 b[v]	2.3 b	104.7 b
Spray		230.0 a	3.2 a	228.9 a

[z]Means of 5 single-plant replicates, March 27, 1987. Due to a delay in flowering, data on drench-treated plants were taken April 20, 1987. Data for the 6.3 mg ai drench not available.

[y]Means of 10 flowers per plant, 4 single-plant replicates, March 27, 1987. Due to a delay in flowering, data on drench-treated plants were taken April 20, 1987.

[x]Means of 10 single-plant replicates, January 18, 1988.

[w]Significant at the 1% level; Q = quadratic, C = cubic. Zero rate included in regression analysis.

[v]Significant at the 1% level.

Table 5. Shoot dry weight (g) of 8 woody landscape species drenched or sprayed with paclobutrazol, March 8, 1988 (84 WAT).

Paclobutrazol treatment: Method of application	Paclobutrazol treatment: Concentration	*Euonymus japonica* 'Microphylla'	*Ilex crenata* 'Compacta'	*Ilex cornuta* 'Burfordii Nana'	*Juniperus conferta* 'Blue Pacific'	*Ligustrum japonicum* 'Aureo-marginatum'	*Photinia* × *fraseri*	*Rhododendron indicum* 'Formosa'	*Rhododendron obtusum* 'Hino Crimson'
Drench	mg ai·pot^{-1}								
	0.0	83.8	119.2	63.4	171.2	277.9	164.0	242.6	102.6
	6.3	52.2	82.6	45.0	161.9	172.2	111.4	129.6	67.9
	25.0	47.9	81.0	26.0	182.4	181.1	95.2	116.7	46.2
	100.0	37.0	63.9	21.7	112.9	144.5	43.9	32.4	27.3
Significance[z]		C**	C*	Q**	Q*	C**	C**	C**	C**
Spray	(ppm)								
	0	83.8	119.2	63.4	171.2	277.9	164.0	242.6	102.6
	250	77.2	127.9	65.8	164.3	232.3	162.5	248.3	96.3
	500	82.3	106.7	70.6	151.5	235.5	128.0	255.8	74.8
	1000	78.7	102.5	57.0	166.1	182.8	110.6	213.9	69.4
	2000	67.3	88.4	61.3	170.6	200.6	92.9	174.1	64.2
Significance		L**	L**	NS	NS	Q**	L**	C*	Q**
Drench		45.7 b[y]	75.8 b	30.9 b	152.4	165.9 b	83.5 b	128.4 b	47.1 b
Spray		76.4 a	106.4 a	63.7 a	163.1 NS	212.8 a	123.5 a	223.0 a	76.2 a

[z]Significant or not significant at the 5% (*) or 1% (**) level; L = linear, Q = quadratic, C = cubic. Zero rate included in regression analysis.

[y]Significant or not significant (NS) at the 5% level; zero rate not included in mean determination.

Table 6. Liner height (cm) of cuttings[z] taken from stock plants treated with paclobutrazol drenches or sprays.

Paclobutrazol treatment		*Ilex crenata* 'Compacta'		*Liqustrum japonicum* 'Aureo-marginatum	
Method of application	Concentration	January 25, 1988	March 7, 1988	January 25, 1988	March 7, 1988
Drench	mg ai·pot^{-1}				
	0.0	13.8	18.6	22.1	25.1
	6.3	12.4	16.5	22.5	24.2
	25.0	13.3	17.3	22.3	25.6
	100.0	9.2	12.5	25.5	27.2
Significance[y]		L**	C*	NS	NS
Spray	(ppm)				
	0	13.8	18.6	22.1	25.1
	250	13.4	18.0	20.7	24.1
	500	13.2	18.8	18.6	22.1
	1000	14.9	20.1	22.1	25.6
	2000	14.3	19.2	26.4	26.9
Significance		NS	NS	NS	NS
Drench		11.6 b[x]	15.4 b	23.4	25.7
Spray		14.0 a	19.0 a	22.0 NS	24.6 NS

[z]Cuttings taken June 30, 1987 (50 WAT); liner heights measured 78 and 84 WAT.

[y]Significant or not significant at the 5% (*) or 1% (**) level; L = linear, C = cubic. Zero rate included in regression analysis.

[x]Significant or not significant (NS) at the 1% level; zero rate not included in mean determination.

not been studied in detail, but this work and other research (8,13) indicate that the compound is very persistent.

In addition to quantitative differences among treatments, visual or aesthetic changes were observed with paclobutrazol-treated plants. Generally, plants responded to increasing drench and spray rates by producing shorter internodes and smaller leaves. Axillary buds began to develop on several species (Table 3) but these buds seldom elongated more than 2–4 cm (0.8–1.6 in). Foliage of some species was darker green when treated with paclobutrazol; with other species, treatment had no affect on foliar color. Relatively high rates of paclobutrazol generally do not cause phytotoxicity (4). However, in our test several species exhibited phytotoxicity symptoms in response to the higher paclobutrazol rates; for example, foliage of dwarf Burford holly developed tip and marginal chlorosis while new foliage of photinia and the two azalea cultivars curled downward. As a result of excess internode suppression, other species developed dense clusters of leaves closely adpressed along the stems. Similar symptoms of phytotoxicity have been reported (3,6).

Paclobutrazol is a powerful inhibitor of internode elongation. Growth inhibition was detected as early as 4 months after paclobutrazol was applied and persisted for at least 20 months. Generally, the magnitude and duration of growth suppression was greater when paclobutrazol was applied as a drench than as a spray, as exemplified by the growth indices (Table 1), shoot dry weight (Table 5), and liner height (Table 6) data. Foliar color ratings generally increased when paclobutrazol was applied as a drench; response to sprays varied among species (Table 2). Paclobutrazol promoted axillary shoot growth (Table 3), flowering, and fruiting (Table 4) of several species. Increased flowering of azaleas may have implications in florist azalea production and concurs with recent findings of Keever and Foster (8).

(**Ed. note:** This paper reports the results of research only, and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and/or federal authorities.)

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