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Can Roundup® Be Safely Used Over the Top of Nursery Crops?®

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Nine species of woody ornamentals in containers were treated over-the-top with Roundup Pro® at four rates: 0.29, 0.52, 1.2, and 2.3 kg ha⁻¹ (0.25, 0.5, 1.0, and 2.0 lb/acre a.i.) either once in June 2007, August 2007, or February 2008. A fourth group was treated on all three dates. Injury ratings were taken at multiple times after treatment. Dwarf mondo grass (*Ophiopogon japonicus* 'Nanus'), liriopie (*Liriope muscari* 'Cleopatra'), and variegated liriopie (*L. muscari* 'Variegata') were tolerant to all rates and application dates. Mondo grass (*O. japonicus*) showed no injury except for 139 days after treatment (DAT) after the February application. Blue Pacific juniper (*Juniperus rigida* subsp. *conferta* 'Blue Pacific') was also injured by February applications, but soon recovered. Asiatic jasmine (*Trachelospermum asiaticum*) and dwarf yaupon (*Ilex vomitoria* 'Stoke's Dwarf') showed injury 31 DAT after the June application, but showed no injury at the next evaluation. At 139 DAT after the February application, Asiatic jasmine and dwarf yaupon suffered considerable injury. Blue rug juniper (*J. horizontalis*) was tolerant in August but injured at ≥ 1.2 kg ha⁻¹ (≥ 1 lb/acre a.i.) for all other dates. Pink gumpo azalea (*Rhododendron* 'Gumpo Pink') was injured at all rates and application dates. Growth indices were taken on 3 March and 13 June 2008. Mondo grass, dwarf mondo grass, liriopie, variegated liriopie, and blue Pacific juniper were not affected by over-the-top Roundup Pro® applications except at 2.3 kg ha⁻¹ (2 lb/acre a.i.) applied three times. The remainder of the species had reduced growth as Roundup Pro® rates increased.

INTRODUCTION

Nursery crops must be weed-free when preemergent herbicides are applied. Such herbicides are typically applied three to six times per year, which means that the crops must be weeded three to six times as well. With labor shortages and higher costs, growers may face the prospect of spending more on hand weeding than what the plant is worth. Landscape companies may find themselves in a similar situation. With contracts signed a year in advance, they may not be able to find the laborers to fulfill their obligations.

Postemergence weed control in container-grown nursery crops is becoming more critical for economic profitability in the nursery industry. Roundup over the top of woody ornamental nursery crops is showing promise as a postemergent weed control. Between 1975 and 1980, Roundup was evaluated over the top of numerous container-grown crops. Self (1978) applied single, double, and triple treatments of Roundup at 0.5, 0.75, 1.0, and 1.5 lb/acre a.i., on 7, 14, and 21 April 1978 over 18 ornamentals. Total amounts of glyphosate applied ranged from 0.5 to 4.5 lb/acre a.i. Of the 18 species tested, eight were not injured, including blue Pacific juniper (*Juniperus rigida* subsp. *conferta* 'Blue Pacific'). Of the remaining species, 'Hinode-

giri' and 'Fashion' azaleas were the most sensitive, with injury occurring from as little as 2 applications of the 0.5 lb rate.

Perry and Knowles (1979) sprayed glyphosate at 0.25, 0.75, and 1.0 lb/acre a.i. over the top of 10 species once on 3 Aug. and again on 17 Aug. 1978. Following two applications, no phytotoxicity was observed on *Berberis xmentorensis*, *Camellia japonica*, *Forsythia xintermedia*, and *Ligustrum* 'Vicaryi' at all rates. Temporary slight yellowing was observed on *B. julianae*, *Euonymus japonicus*, and *Ilex cornuta* 'Dwarf Burford' (syn. 'Burfordi Nana') regardless of rate. Damage was more severe on the remaining species at ≥ 0.75 lb a.i./a. All species overwintered well, but evaluation of root systems in late February indicated slightly less root density with 1.0 lb a.i./a.

Neal and Skroch (1985) studied rates and timing of Roundup applications on 13 species of woody ornamentals. They applied Roundup at 0.73, 1.33, and 2.67 lbs a.i./acre at six different times throughout the season. They divided the plants and their responses to Roundup into four groups. Group 1 species: ajuga (*Ajuga reptans*), azalea [*Rhododendron obtusum* 'Kirin' (syn. 'Coral Bells')], and variegated liriope (*Liriope muscari* 'Variegata') were injured by all application times and rates. Group 2, 3, and 4 species showed tolerance to fall applications. Group 2; dwarf yau-pou, English ivy (*Hedera helix*), Helleri holly (*I. crenata* 'Helleri'), and ligustrum (*L. japonicum*) sustained the most injury from spring applications. Group 3; Andorra juniper (*J. horizontalis* 'Plumosa'), compacta holly (*I. crenata* 'Compacta'), Fraser's photinia (*Photinia xfraseri*), and green liriope (*Liriope spicata*) were most injured by summer applications. Group 4; blue Pacific juniper and blue rug juniper (*Juniperus horizontalis* 'Wiltonii') tolerated all but the highest rates with acceptable damage, which was considered to be $\leq 15\%$.

In a separate study, Neal et al. (1985) reported that ligustrum showed a linear decrease in susceptibility from March to November, while blue Pacific juniper sustained only temporary tip chlorosis from summer applications at high rates. Both species recovered by the end of the growing season. Neal stated that except for ligustrum treated on young expanding leaves, the time required for absorption of detectable levels of ^{14}C glyphosate into ligustrum and juniper was slow when compared to absorption rates for herbaceous weeds, but the time was similar for absorption rates for other woody species. Research by Ferreira and Reddy (2000) on *Erythroxylum coca* and *E. novogranatense* indicated the role of the leaf cuticle in the slow uptake of glyphosate by woody plants. This indicates a degree of selectivity with glyphosate applied over woody ornamentals and weeds growing in beds or pots. Under field conditions, timely rain or irrigation could remove unabsorbed herbicide and increase tolerance. Richardson et al. (2006) demonstrated the benefits of timely irrigation with their work on diuron for control of *Oxalis stricta*.

Altland et al. (2002) showed that Roundup at ≥ 0.4 lb/acre a.i. could be safely used as a cleanup treatment for control of spurge in *L. muscari* 'Big Blue' and 'Variegata'. Walsworth et al. (2006) showed that Roundup applied on 6 Sept. 2005 in a 1% solution (4 lb/acre a.i. in 100 gal) caused no injury on liriope and Asiatic star jasmine.

Recent work by Czarnota (2008) showed that minimal injury occurred on blue Pacific shore juniper, blue star juniper, and Parsonsii juniper [*Juniperus chinensis* (syn. *J. davurica*)] when Roundup Pro® was applied at up to lb/acre a.i. on 29 May 2004 and 13 May 2005. Walsworth et al. (2006) reported Roundup applied in a 1% solution (4 lb a.i./100 gal) on 6 Sept. 2005 caused no injury to Asiatic jasmine.

The objective of this research is to further evaluate the tolerances of individual container-grown species to various rates and application times of Roundup.

METHODS AND MATERIALS

Blue rug juniper, blue Pacific juniper, mondo grass, dwarf mondo grass, liriopse, variegated liriopse, Asiatic jasmine, pink gumpo azalea, and Stokes dwarf yaupon were potted in pinebark and peat moss (3 : 1, v/v) amended with $8.5 \text{ kg}\cdot\text{m}^{-3}$ (14 lbs/yd³) Osmocote 19–6–12 (N–P–K), $3.6 \text{ kg}\cdot\text{m}^{-3}$ (6 lb/yd³) dolomitic limestone, $1.2 \text{ kg}\cdot\text{m}^{-3}$ (2 lb/yd³) gypsum, and $0.9 \text{ kg}\cdot\text{m}^{-3}$ (1.5 lb/yd³) Micromax in 1-gal containers on 30 April 2007. Roundup Pro[®] was applied at four rates (0.25, 0.50, 1.0, and 2.0 lb/acre a.i.) in 30 GPA with a CO₂ backpack sprayer. Treatments were applied on 10 June 2007, 30 Aug. 2007, or 20 Feb. 2008 to separate groups of plants not previously treated. One group of plants was treated on all dates. There was one nontreated control group; 17 treatments in all. Plant injury ratings were taken throughout the study and final growth indices were taken on 13 June 2008. Plants were grouped by species in a completely randomized block design with 10 single-pot replications. Data was analyzed in a statistical software package (SAS Institute, Cary, North Carolina) using Waller-Duncan k ratio t tests ($P \leq 0.05$). Data was analyzed separately for each sampling date.

RESULTS

Dwarf mondo grass and blue Pacific juniper growth indices (Table 1) were similar compared to the non-treated control plants regardless of rate or application time. Mondo grass growth indices were similar among all treatments except with 2 lb/acre, a.i. three times. Growth suppression on liriopse was minimal. Growth of variegated liriopse was suppressed by 2.0 lb/acre, a.i. applied either in February or on all three dates. *Liriopse* 'Cleopatra' growth was suppressed only with 0.5 lb/acre, a.i. in August.

Blue rug juniper growth indices were smallest with 2 lb/acre a.i. in June, August, or on all three dates. The February application did not affect blue rug juniper growth. On the other hand, Asiatic jasmine was affected most by February application, where rates ≥ 0.5 lb/acre a.i. suppressed plant growth. A similar response occurred when applied on all three dates.

Pink gumpo azalea growth was suppressed with ≥ 1.0 lb/acre a.i. when applied in either June or February. August application resulted in growth indices similar to non-treated controls at all rates. Application on all dates resulted in severe growth suppression at 1.0 lb/acre a.i. and plant death at 2.0 lb/acre a.i.

Stokes dwarf holly growth was reduced by 74% when treated with Roundup at 2.0 lb/acre a.i. on all dates; by 21% with 1.0 lb ai/acre applied in Feb or June; and by 19% with 0.5 lb in June.

DISCUSSION

Research indicates that windows of opportunity exist for the use of Roundup over the top of container ornamentals with no injury or loss of growth. Dwarf mondo grass, and variegated and Cleopatra liriopse were tolerant of Roundup Pro[®] up to 2 lb/acre a.i. Mondo grass and blue Pacific juniper were tolerant up to 2 lb/acre a.i. applied in June and August. Asiatic jasmine was tolerant up to 2 lb/acre a.i. in August, and dwarf yaupon was tolerant up to 1 lb. Blue rug juniper was toler-

Table 1. Growth² indices taken on 13 June 2008 for ornamentals treated with Roundup Pro®.

Rate (lbs a.i./ acre)	Treatment date	dwarf mondo	mondo	liriope 'Cleopatra'	variegated liriope	blue Pacific juniper	blue rug juniper	Asiatic jasmine	dwarf yaupon holly	pink gumpo azalea
	nontreated	18.0 ab	35.4 ab	29.4 abc	36.9 abc	34.4 cde	44.2 abc	49.0abc	27.4 a	27.2 abc
0.25	2/20/2008	17.7 ab	35.9 ab	33.7 ab	37.6 ab	44.1 abc	39.8 bcd	44.3cd	25.5 ab	28.6 a
0.5		17.2 ab	38.0 a	33.5 ab	38.4 a	47.1 a	46.3 ab	36.2e	24.5 a-d	26.0 b-e
1		15.0 c	36.7 ab	29.8 abc	38.0 ab	45.2 ab	47.2 ab	25.9f	22.0 cde	23.8 efg
2		18.5 ab	32.7 b	26.8 bcd	33.2 d	46.6 a	45.4 ab	26.0f	17.1 g	22.0 g
0.25	6/10/2007	17.6 ab	35.3 ab	35.2 a	34.0 cd	38.3 a-d	44.4 abc	50.7abc	27.0 a	27.9 ab
0.5		17.8 ab	36.5 ab	27.5 abc	37.5 ab	46.2 a	45.7 ab	54.0a	21.8de	26.3 a-d
1		18.6 ab	34.9 ab	29.0 abc	35.5 a-d	42.2 abc	39.6 bcd	46.1bcd	20.6 ef	24.5 def
2		17.8 ab	34.7 ab	33.0 ab	37.6 ab	38.4 abc	35.4 de	44.2cd	18.9 fg	23.4 fg
0.25	8/30/2007	19 ab	35.0 ab	30.6 abc	36.4 a-d	42.5 abc	48.8 a	40.6de	27.2 a	28.0 ab
0.5		19.5 a	36.0 ab	20.7 d	35.3 a-d	38.2 a-d	44.5 abc	45.0cd	24.9 abc	27.8 ab
1		19.5 a	35.6 ab	32.7 ab	34.0 cd	42.7 abc	36.2 cde	52.4ab	26.3 a	26.9 abc
2		19.1 ab	37.1 a	34.0 ab	36.1 a-d	42.2 abc	12.6 g	46.5bcd	22.7 b-e	24.9 c-f
0.25	All dates	18.3 ab	34.0 ab	31.0 abc	35.4 a-d	30.5 de	46.0 ab	45.1cd	27.4 a	27.6 ab
0.5	shown	18.7 ab	36.6 ab	26.4 bcd	35.3 a-d	36.0 b-d	44 abc	35.6e	22.2 cde	25.1 c-f
1	above	18.0 ab	34.9 ab	29.3 abc	34.5 bcd	32.3 de	31.0 e	28.7f	16.1 g	17.2 h
2		17.0 b	16.6 c	23.0 cd	21.6 e	28.4 e	22.4 f	25.2f	7.2 h	0.0 i

²Growth indices [(height + width 1 + width 2)/3] presented in centimeters.

ant up to 2 lb/acre a.i. in February. Pink gumpo azalea was injured by all rates of 0.5 lb/acre a.i. and above and did not have a safe window. Growth indices taken the second season appear to be a much better indicator of overall effects than are injury ratings taken weeks or even months after treatment. June and August 2007 data were collected 12 and 10 months after treatment, well into the growing cycle, thus providing the opportunity to study long-term effects.

Our research indicates varied responses of individual species to applications of Roundup Pro. For example, there was a significant range of tolerance in junipers. Blue Pacific juniper showed injury 15 DAT in February, but recovered quickly. Growth indices were not significantly different for all rates and dates of application. Blue rug showed no injury or reduced growth from February treatments up to 2 lb/acre a.i., but was injured and growth was reduced by 1 and 2 lb/acre a.i. at all other application dates. Therefore, individual species should be tested for tolerance before large groups of plants are treated. Our research is intended to provide data for emergency measures for weed control when labor is unavailable or when it would cost more to weed the crop than it is worth. It should not replace a solid program of weed management consisting of monitoring, some hand weeding, and preemergent herbicides.

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