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Postemergence *Oxalis* Control in Container-grown Nursery Crops[1©]

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Experiments were conducted to evaluate the tolerance of abelia to over-the-top spray applications of diuron and to quantify the foliar absorption of diuron on oxalis. Rates ≥0.56 kg a.i./ha (0.5 lb a.i./acre) provided excellent (100%) oxalis control regardless of the time of year the treatment was made. Diuron applications ≤1.12 kg a.i./ha (1.0 lb a.i./acre) in fall and spring caused slight to no injury to dormant abelia. Plants leafed out normally in the spring after application and there was no difference in growth 180 days after treatment (DAT). Application at 2.24 kg a.i./ha (2.0 lb a.i./acre) caused slight to no injury on abelia by the following spring. Spring application to actively growing abelia caused slight to moderate injury from which plants treated with ≤0.56 kg a.i./ha completely recovered by 90 DAT. Abelia treated with 1.12 kg a.i./ha (1.0 lb a.i./acre) were slightly injured 90 DAT. Abelia treated with 2.24 kg a.i./ha (2.0 lb a.i./acre) were severely injured with many dead plants 60 DAT. Absorption and translocation of foliar-applied diuron by oxalis was evaluated using radiotracer techniques. After 24 h, 86% of the applied diuron had been absorbed, and 76% of amount applied remained in the treated leaflet, indicating minimal translocation.

INTRODUCTION

Consumers demand weed-free container grown plants. Labor for hand weeding of containers is expensive and increasingly difficult to find. With increasing costs and declining profit margins, growers have been forced to search for nontraditional weed

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control methods to reduce costs and produce an economically competitive weed-free crop. In the past, growers demanded that herbicides have broad-spectrum control and crop safety. However, many growers now accept herbicides that have tolerance in a few crops or that control a single weed species, i.e., bittercress (*Cardamine hirsuta* L.) (Altland et al 2002), spurge (*Chamaesyce prostrata* Ait.), or oxalis (*Oxalis* sp. L.) (Gilliam et al., 1990; Simpson et al., 2003). With postemergence herbicides in particular, many growers are willing to accept limited crop injury. Eliminating a hand weeding process may be an acceptable (cost effective) trade for limited crop injury from which the crop recovers in a short time period.

One area where postemergence-applied herbicides have potential is when nursery crops are emerging from over-wintering. Frequently, conditions in late winter favor development of winter weeds, such as oxalis and bittercress (Cross and Skroch, 1992), while the nursery crop is still dormant, but the winter weed is actively growing. A postemergence herbicide with selective tolerance could provide growers economic relief from a crop situation that requires hand weeding. Recent research has demonstrated success with postemergence weed control in container-grown nursery crops. Studies by Altland et al. (2000) evaluated Gallery (isoxaben) for postemergence control of bittercress. Bittercress control was influenced by Gallery rate and bittercress size, where control was greater on smaller, non-flowering bittercress. Gallery at 1.12 kg a.i./ha (1.0 lb a.i./acre) was required for excellent control of small and intermediate size bittercress, and a rate of 2.24 kg a.i./ha (2.0 lb a.i./acre) was required for excellent control of larger, flowering bittercress. Other research demonstrated Roundup (glyphosate) and Finale (glufosinate) could control prostrate spurge (*Chamaesyce prostrata* Ait.) when applied at 1.8 kg a.i./ha (1.6 lb a.i./acre) and 1.12 kg a.i./ha (1.0 lb a.i./acre) respectively, with minimal injury to two liriope cultivars.

Limited research evaluating postemergence control of *Oxalis stricta* has been conducted in the Southeastern United States. Oxalis is generally considered to be a cool season weed but may occur throughout the entire growing season under overhead irrigation in many parts of the United States. A 1990 survey of nurserymen reported that oxalis was considered to be among the most difficult to control weeds in container-grown nursery crops (Gilliam et al., 1990). While preemergence herbicide applications provide adequate control of oxalis and other weeds, no method is 100% effective (Berchielli et al., 1988; Marshall, 1987). Control via hand weeding is difficult due to prolific seeding characteristics and optimal growing conditions for weeds in container nurseries (Gilliam et al., 1990). Research by Holt and Chism (1988) reported napthaleneacetic acid (NAA) could be used to control *O. corniculata* L. Several landscape crops had tolerance to NAA applications; however, impractical rates of 8.4 kg a.i./ha (7.5 lb a.i./acre) were required to provide adequate control. Another herbicide with potential to provide postemergence oxalis control is diuron (Hill et al., 1965; Kumar and Singh, 1988). A Georgia grower (Mark Crawford of Griffin LLC) found that over the top applications of diuron provided excellent oxalis control with slight to no injury on camellia. Diuron and other photosynthesis inhibiting herbicides are widely used and labeled for use on winter dormant alfalfa (Cary and Stritzke 1979; Vencill, 2002). Data from prior work showed that diuron provided excellent oxalis control with slight to no injury on dormant camellia and liriope (Simpson et al., 2003). We speculated that no injury was observed because the plants were dormant at the time of treatment. The objective of this study was to evaluate nursery crop tolerance to diuron based on the time of year and plant growth stage and to quantify foliar absorption of diuron on oxalis.

MATERIALS AND METHODS

Four experiments were conducted at Auburn University, Alabama to evaluate diuron (Direx 4L) (Griffin L.L.C., Valdosta, Georgia) for nursery crop tolerance based on time of application. Experiments were conducted on 28 Nov. 2001, 15 Mar. 2002, 15 Oct. 2002, and on 12 Mar. 2003. Treatments for all experiments were applied with a CO_2 backpack sprayer equipped with an 8004 flat fan nozzle. Applications were made with a pressure of 1.41 $kg{\cdot}cm^{-2}$ (20 psi) and calibrated to deliver 340 $L{\cdot}ha^{-1}$ (40 gal /acre). The substrate used in all experiments consisted of 7 pine bark : 1 sand (v/v) amended per m^3 (yd^3) with 8.3 kg (14 lb) of Osmocote 17N–3.1P–10K (17N–7P–12K Scotts Co., Marysville, Ohio), 2.9 kg (5.0 lb) of dolomitic limestone, and 0.9 kg (1.5 lb) of Micromax (Scotts Co.). Treatments included diuron at 0.28, 0.56, 1.12, and 2.24 kg a.i./ha (0.25, 0.5, 1.0, and 2.0 lb a.i./acre) and a non-treated control. Non-ionic surfactant (X-77, Loveland Industries, Greely, Colorado) at 0.25% (v/v) was also included. All plants were grown in full sun. Unless otherwise noted, all experiments had eight replications per treatment arranged in a completely randomized design (CRD) with nursery crop species grouped separately. Data collected included visual nursery crop injury ratings at 15, 21, 30 days after treatment (DAT), and then monthly thereafter until 150 DAT. The visual rating scale used was from 1 to 10, where 1 equaled no injury and 10 equaled plant death (Frans et al 1986). Growth indices [(height+ widest width+ perpendicular width)/3] were taken at 180 DAT. All data were analyzed with regression analysis and Dunnett's test where appropriate.

Foliar Absorption and Translocation of Diuron by Oxalis. This study was conducted in a glass-glazed greenhouse, equipped with evaporative cooling. Day/night temperatures were set to 28/22 °C (87/72 °F). Relative humidity averaged 40% to 50%. The first and second repetitions of this experiment were conducted in August and September of 2002, respectively. The photoperiod from natural light was 13:30 and 12:50 HR for the two repetitions, respectively. The greenhouse was equipped with an automatically activated shade cloth so light intensity did not exceed 10,500 lux. Oxalis plants were approximately 15 cm tall, and flowering at the time of treatment. A 0.5-ml subsample of spray solution (1.0 a.i./acre 40 gal/acre) was spiked with ^{14}C-diuron. Final concentration of diuron and radioactivity was 3000 mg·L and 0.2 MBq/2 µL, respectively. A recently formed, fully expanded leaf of an individual plant was selected, and a single 2-µl drop of the radiolabled spray solution was applied to the middle leaflet of the selected leaf using a microapplicator.

Treated plants were harvested at either 24 or 48 h after treatment. At harvest, the treated leaf was detached from the central stalk of the plant. The leaflet that received the herbicide was excised and washed with a 1 water : 1 methanol solution (v/v). A single milliliter of this wash solution had been previously added into a 20-ml scintillation vial. The treated leaflet was placed into this vial and agitated with a swirling motion for 30 sec; then removed from the vial and 10 ml of scintillation fluid was added in preparation for counting. Remaining portions of the treated leaf, i.e., the two adjacent, non-treated leaflets and the leaf petiole, were also collected. Plant tissue sections were dried at 45 °C (113 °F) [24 h], combusted in a biological tissue oxidizer, and recovered radioactivity quantified through scintillation spectrometry. A completely random design with six single-plant replicates was used, and the experiment was repeated once. Fisher's protected LSD values ($\alpha = 0.05$) were used to separate treatment means.

Table 1. Treatment date and growth stage influence abelia tolerance to diuron.

	15 Oct. 2002, not actively growing				Gl
Rate kg a.i./ha	21 DAT [z]	30 DAT	60 DAT	120 DAT	180 DAT
0.28	1.0 y	1.0	1.0	1.0	68.2 [w]
0.56	1.0	1.0	1.0	1.0	67.6
1.12	1.1	1.3	1.3	1.0	61.2
2.24	1.3	1.6 [x]	1.8 [x]	1.0	66.1 [x]
Non treated	1.0	1.0	1.0	1.0	64.5
Significance	Q*	Q***	Q***	NS	Q*
	12 March 2003, actively growing				
Rate kg a.i./ha	15 DAT	21 DAT	30 DAT	60 DAT	90 DAT
0.28	1.7	1.2	1.2	1.1	1.2
0.56	2.3	1.3	1.2	1.3	1.2
1.12	3.6 [x]	3.2 [x]	3.4 [x]	3.1 [x]	2.0 [x]
2.24	4.8 [x]	5.6 [x]	6.6 [x]	7.3 [x]	7.6 [x]
Non treated	1.0	1.0	1.0	1.0	1.0
Significance	L***Q*	L***	L***	L***	L***

[z] DAT and GI represent days after treatment and growth indices, respectively.

[y] Where 1 = no injury and 10 = death.

[x] Injury rating significantly higher than non-treated or GI significantly lower than non-treated (Dunnett's Test: alpha=0.05).

[w] Growth indices in cm (height+ widest width+ perpendicular width/3).

[v] NS, L, and Q represent not significant, linear and quadratic responses, respectively.

*,**,*** indicates significance at the 0.05, 0.01,and 0.001 level, respectively.

RESULTS AND DISCUSSION

Diuron applied to dormant abelia in November 2001, (Exp. 1) and abelia in March 2002, prior to active growth (Exp. 2) caused no injury or any effects on growth indices at 180 DAT (Data no shown). Applications of diuron in October 2002 to abelia at the end of a growth flush caused only slight injury with a quadratic rate response at 21, 30, and 60 DAT (Table 1). Injury to abelia was characterized by a slight chlorosis on terminal leaves, possibly caused by the leaves' tendency to cup upward and hold the spray solution. This was only observed at the 2.24 kg a.i./ha (2.0 lb a.i./acre). However, the following spring there was no observable injury on any abelia plants. Abelia growth indices responded in a quadratic manner however, growth indices were similar among all diuron treated plants to non-treated plants. Diuron application to actively growing abelia treated in March 2003, caused slight injury at 0.56 kg a.i./ha (0.5 lb a.i./acre) and was characterized by terminal leaf chlorosis. Plants treated with the two lowest rates recovered and were not different from non-treated abelia 60 DAT. Rates of 1.12 kg a.i./ha (1.0 lb a.i./acre) and higher caused moderate injury throughout the test which was characterized was characterized by extensive chlorosis and some leaf senescence. Injury to abelia treated with 2.24 kg a.i./ha (2.0 lb a.i./acre) was moderate (4.8) 15 DAT; however by 60 and 90 DAT injury ratings had increased to severe injury (7.3 and 7.6, respectively). Severe injury was characterized by extensive necrosis (die back) and death. The resultant injury to abelia is consistent with research conducted with substituted ureas and alfalfa that showed alfalfa that were dormant were not injured and plants that were actively growing at the time of treatment were injured (Cary and Stritzke 1979). These data suggest that dormant plants have a greater tolerance to diuron than actively growing plants.

Foliar Absorption and Translocation of Diuron by Oxalis. Preliminary statistical analysis also revealed that absorption and translocation was not influenced by exposure time. Consequently, data were pooled across the 24 and 48 h exposure times for further analysis and presentation. Only 14% of the amount of applied diuron was recovered in the leaf wash; indicating that 86% of applied diuron had been absorbed. Amounts recovered in the treated leaflet, the two adjacent leaflets, and the leaf petiole were 76%, 6%, and 4% of that applied, respectively. These data indicate that diuron is rapidly absorbed by oxalis foliage. However, subsequent translocation is minimal. The foliar activity of diuron against oxalis is predominately contact in nature. A similar conclusion was reached by Bayer and Yamagugchi (1965).

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