Directed Application of Goal (Oxyfluorfen) to Container Grown Euonymus, to Minimize Phytotoxicity and Leaching[1]

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Abstract

Goal 1.6E (Oxyfluorfen) was applied to rooted cuttings of *Euonymus fortunei* 'Colorata' planted in a U.C. Mix (peat:sand, 1:1 by vol), in 3.8 l (#1) containers, either as a topical spray or mixed within the growth-medium to 2, 7 or 14 cm (0.8, 2.8, 5.6 in) depth. At comparable rates, phytotoxicity was much lower in layered treatments than when sprayed over-the-top. With an identical concentration of Goal in the growth medium, there was no difference in phytotoxicity between a shallow top layer, exposing all but the base of the root ball to treated soil, and planting the root ball into an entire container profile of treated soil. Incorporation slightly reduced the herbicidal activity—as assessed by oversown grass weeds—compared to surface application. The presence of herbicide in the effluent, collected under the containers, was determined 1 and 8 weeks after the application, by bioassay based on germinating bentgrass. In the first bioassay, no appreciable amount of Goal was detected from surface sprays up to 3 kg/ha (2.75 lb/A), nor from 2 and 7 cm (0.8, 2.8 in) layers containing up to 19 mg/kg (17 lb/A). In the second bioassay, no herbicide was detected from shallow layers containing up to 192 mg/kg (172 lb/A). Goal at 19 mg/kg incorporated 2 to 7 cm (0.8, 2.8 in) deep, at planting time, is suggested as an alternative to overall application on containers.

Index words: leachate, bioassay, container nursery production

Introduction

Weeds constitute a serious problem in nursery crops whether grown in containers, or kept in the field for one or two growing seasons. Herbicides used on container grown crops are generally applied as a broadcast spray or in a granule form. With topical application on round containers, part of the herbicide falls into the space between the units. This portion may reach 20% of the dose, even in compact spacing, and if it is not adsorbed to the soil it moves directly from the treatment site with the run-off water. Leaching may also be a problem because of the porosity of the growth-medium and the intensive watering, up to 450 cm (45,000 m^3)/ha/year (73 in/A). It is thus understandable that the potential pollution of drainage water by herbicides has become a concern to nurserymen, both for environmental reasons and because the water is recycled.

The objective of this study was to determine if a directed application could be used instead of a topical treatment by placing a herbicide treated layer on top of the container.

Technically, this can be achieved during the potting procedure, by incorporating the herbicide into the growth-medium or placing a herbicide-treated layer of growth medium on top of the container. The feasibility of the method requires the correct herbicide. The herbicide should be characterized, by: strong herbicidal activity and a marked persistence in the soil; a high tolerance to landscape plants; low water solubility; and, appropriate adsorption/desorption parameters to induce slow release and limited movement of the herbicide in the profile of organic growth media.

Four preemergence herbicides, meeting in part, the above criteria, are widely used in container nurseries: Devrinol (napropamide), Surflan (oryzalin), Ronstar 2G (oxadiazon) and Goal (oxyfluorfen) (2). Goal has the lowest solubility in water (0.1 ppm) in this group. It is strongly adsorbed on organic soil and on bentonite clay and desorbs very slowly; conversely, its leaching is very limited (3). The study reported deals with Goal, and its suitability for directed application to a container-grown nursery crop, using *Enonymous fortunei* 'Colorata' as a plant model.

Materials and Methods

The study was conducted with University of California (U.C.) Mix, a peat, sand media (1:1 by vol) in 3.8 l (#1) containers [surface area 175 cm^2, (28 in^2), soil depth 14 cm (5.6 in)] with drainage holes. Rooted cuttings of *E. fortunei* 'Colorata' were planted at the center of each pot. Goal (oxyfluorfen) as a 1.6E formulation was applied either in layers of treated soil placed in the container at planting or as a surface spray immediately after planting. Three concentrations of treated soil were prepared by mixing thoroughly adequate solutions of herbicide with U.C. Mix to contain 0.01, 0.1 or 1 ml of Goal 1.6E per kg soil (10, 100 or 1000 ppm, designated as series A, B and C, resp.). Treated soil of each concentration was layered in three depths: 1) a 2 cm (0.8 in) layer placed on the top of 12 cm (4.8 in) of untreated soil, exposing only the uppermost portion

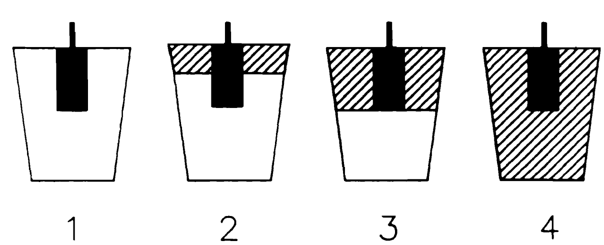

Fig. 1. Scheme of surface and layer application of Goal and euonymus cuttings. 1-surface application; 2-herbicide in layer 2 cm deep; 3-herbicide in layer 7 cm deep; 4-herbicide in full pot depth, 14 cm. For rates see Table 1.

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Table 1. Rates of herbicide applied in various treatments[z]

Herbicide application	Rate series	Goal 1.6E	Goal	
		L/ha	kg/ha	mg/pot
Surface	A	1.6	0.31	0.54
	B	16.0	3.1	5.4
	C	160.0	31.0	54.0
		ppm	mg/kg	mg/pot
2 cm layer	A	10	1.92	0.54
	B	100	19.2	5.4
	C	1000	192.0	54.0
7 cm layer	A	10	1.92	2.27
	B	100	19.2	22.7
	C	1000	192.0	227.0
14 cm full	A	. 10	1.92	5.05
	B	100	19.2	50.5
	C	1000	192.0	505.0

[z]Herbicide was applied on soil surface or incorporated in a layer 2, 7, or 14 cm (0.8, 2.8, 5.6 in) deep; 14 cm (5.6 in) is the full depth of the pot. Rates are given in formulated compound (Goal 1.6E) and in active matter on an area-basis for surface application, or in concentration for layered application (v of Goal or w of oxyfluorfen per w of soil). Average weight of soil in the treated layer (g/pot):2 cm—280, 7 cm—1180, 14 cm—2630.

of the root ball to treated soil; 2) a 7 cm (2.8 in) layer placed on untreated soil, exposing all but the base of the root ball to treated soil; 3) a 14 cm (5.6 in) layer filling the whole pot with treated soil (Fig. 1). The average weight of the treated layer was 280, 1180 and 2630 gm (0.6, 2.6, 5.8 lb) resp. Three doses of Goal were sprayed on the soil surface [in a water volume of 271 L/ha (29 gal/A)]; they were equivalent to the amount contained in the 2 cm (0.8 in) layers at the three concentrations. Further details of the treatments are given in Table 1. All treatments had 8 replicates, except completely-filled-pots which were made with 6 replicates.

Treatments were prepared and rooted cuttings were planted on November 18, 1987. Pots were placed in randomized blocks on the bench of a heated glasshouse on the U.C. Davis campus. They were sprinkled daily with approximately 3 mm (0.125 in) water (30 m^3/ha), which did not induce appreciable leachate. For leaching studies, 11 mm and 22 mm (110 and 220 m^3/ha) of water was applied on November 25, and January 12, 1988, resp., and the resulting leachate was collected under each pot for bioassay; the volume of effluent was not measured.

The bioassay was made with bentgrass (*Agrostis stolonifera* L., 'Seaside') sown in petri dishes moistened with 5 ml of test solution and kept in a 26/20°C (79/68°F) growth cabinet for 6 days; their shoot development was assessed visually.

Herbicidal activity was assessed by overseeding all pots with annual bluegrass (*Poa annua* L.) and annual ryegrass (*Lolium multiflorum* Lam.) at planting time, and again after removing these grasses, 5 weeks later. Development of *E. fortunei* plants was recorded and on January 13, 1988, all shoots were cut at ground level and weighed. Seeds of bentgrass were sown thereafter for assessment of the residual herbicidal activity at the end of the experiment.

Results and Discussion

Effect on E. fortunei *cuttings*. Spraying Goal over-the-top caused injury to the foliage and inhibited the growth of the transplanted cuttings. Plants sprayed with 0.31 kg/ha (0.28 lb/A) Goal did recover after one month, but higher doses produced stronger and longer damage. After two months, visual injury was apparent only on plants sprayed with 31 kg/ha (28 lb/A), and these plants had about five times more wrinkled and curled leaves than the average in all other treatments. At this time, however, the fresh weight of the shoots of all treatments, layered and surface applied, did not differ from the control indicating recovery from the initial damage (Table 2).

Incorporating the herbicide in the soil reduced markedly the phytotoxic symptoms on euonymus foliage. It is noticeable that with an identical concentration of herbicide in the soil, and increasing amounts per container according to the depth of the treated layer, there was no difference between shallow and deep incorporation (Fig. 2). The shoot development of *E. fortunei* was similar whether the roots of the cutting were partially placed in untreated soil or fully exposed in the treated soil (2 cm vs 7 cm and 14 cm). After an initial delay, (3–4 weeks), growth of plants in all soil-incorporated treatments became similar to the control.

Working with several landscape species, Skimina (7) reported greater phytotoxicity from an emulsifiable concentrate (EC) than from a granular formulation of Goal. Grabowski and Hopen (6) also recorded foliar damage caused by vapors of Goal, which were stronger from the EC than from granular formulation. Fayadomi and Warren (5) reported that the herbicidal activity of Goal on various legumes was 7 to 70 times stronger when applied on seedlings than when applied preemergence. More generally, they stated (4) that shoot application of Goal was more effective in reducing the growth of the test plant than root application. In another experiment (unpublished data), cuttings of *E. fortunei* 'Colorata' and 'Silver Queen' were treated with Goal 1.6E or a granular 1G formulation, and no phytotoxicity was observed by the granules broadcast on the soil at 2.2 kg/ha (2 lb/A), while the EC formulation sprayed over-the-top at half that rate, caused appreciable foliar damage. The present experiment confirms the foliar activity of the EC formulation of Goal, but stresses the considerable tolerance of the tested euonymus variety to soil-incorporated Goal, which overcame the effect of 192 mg/kg (172 lb/A) mixed within the whole container.

Table 2. Effect of surface and layered application of Goal on Euonymus fortunei cuttings

Treatment[z]		New growth[y]		Shoot fresh weight[x]
Rate -	Application	3 wks	5 wks	% control
A	Surface	3.6 bcd[w]	9.1 a	100 a
A	2 cm[v]	4.2 bcd	9.1 a	84 a
A	7 cm	4.6 abc	9.0 a	86 a
A	14 cm	4.6 abc	10.0 a	89 a
B	Surface	1.2 e	7.6 b	97 a
B	2 cm	4.0 bcd	9.8 a	79 a
B	7 cm	4.8 ab	9.9 a	80 a
B	14 cm	3.8 bcd	9.7 a	91 a
C	Surface	0.6 e	4.8 c	79 a
C	2 cm	2.8 d	9.5 a	92 a
C	7 cm	3.2 cd	9.9 a	101 a
C	14 cm	3.2 cd	9.5 a	90 a
C	Control	5.6 a	9.9 a	100 a

[z]For details see Table 1.
[y]Visual assessment 3 and 5 weeks after treatment, from 0 to 10 (10 = best growth).
[x]Shoots cut at soil level 2 months after treatment; transformed to % of control; fresh weight of control (100%) 17.7 g/pot.
[w]Means in a column followed by the same letter or letters are not significantly different at the 1% level using Duncan's multiple range test.
[v]Herbicide was incorporated in the surface 2 or 7 centimeter depth, or incorporated fully through the 14 centimeter depth of the container.

Fig. 2. Effect of Goal treatments of C rate series on euonymus. *From left to right*: surface-31 kg/ha, 54 mg/pot; layer 2 cm-192 mg/kg, 54 mg/pot; layer 7 cm-192 mg/kg, 227 mg/pot; full 14 cm-192 mg/kg, 505 mg/pot. Picture taken 5 weeks after application.

Herbicidal activity. The herbicidal activity was assessed by oversowing the pots with annual ryegrass and annual bluegrass, which are both only moderately sensitive to oxyfluorfen. Surface application gave insufficient control at the low rate, 0.31 kg/ha (0.28 lb/A), and good to very good control at the higher rates tested, 3.1 (2.8 lb/A) and 31 kg/ha (28 lb/A). Incorporating the dose applied on the soil surface in the upper 2 cm (0.8 in) resulted in a slight reduction of the grass control (Table 3). Fayadomi and Warren (5) indicated that incorporation of Goal had two opposite effects, dilution and protection from photodecomposition and vaporization.

Increasing the depth of the treated layer, from 2 to 7 and 14 cm (0.8, 2.8, 5.6 in) (maintained at the same concentration), did not alter the herbicidal activity. In the experiment, weed seeds were placed on the surface and the herbicide acted on the germinating seeds. In this case, and in nurseries where weeds are borne mainly by wind and water, there is no advantage in deepening the herbicidal layer, which would require higher doses of herbicides per unit area (for example, to prepare a 100 ppm concentration of Goal, 28 mg are needed per pot for the 2 cm (0.8 in) layer, and 263 mg for the whole pot).

At the end of the experiment, bentgrass, which is very sensitive to Goal, was sown on all pots. The bentgrass response indicated that 2 months after the application, the herbicidal activity was still appreciable, even at the lower dose.

No reduction occurred in the herbicidal activity of surface applications as compared to layered treatments, after approximately 200 mm (8 in) of water (2000 m^3/ha) given during the experiment (Table 3). Goal has a low solubility in water and its mobility in soil is very limited (3). The disappearance of the herbicidal activity from the upper layer is the result of downward leaching and degradation. A half life of 30 to 40 days has been reported for Goal (1). The duration of the present experiment, two months, was too short to address this aspect.

Leaching of herbicide. No appreciable leaching occurred with the regular daily watering, and in order to produce a sufficient volume of effluent for bioassay study, a 4 and 8 time greater water dose was applied in two occasions, 1 and 8 weeks after the treatment, (Table 4). In the preliminary trials, germinating bentgrass was found to be a sensitive indicator for Goal, its shoot-growth was significantly affected with 0.02 ppm, and was completely inhibited by 0.2 ppm.

At the first assessment, the bioassay response was similar to the control in all low-rate treatments, and among medium-rate treatments an appreciable amount of herbicide was detected only in the effluent from pots filled with 19 mg/kg (17 lb/A) Goal. All high-rate treatments, contained appreciable amounts of Goal, and the highest concentration (close to the upper limit of sensitivity of the bioassay) was recorded in effluents from pots filled with 192 mg/kg (172 lb/A) Goal.

Table 3. Effect of surface and layered application of Goal 1.6E on grass weeds.

Treatment[z]		Assessment of weeds[y] oversown at		
Rate -	Application	Treatment	5 wks after treatment	2 mos after treatment
A	Surface	4.8 cd[x]	6.2 cd	5.4 b
A	2 cm[v]	4.4 cde	3.2 f	4.8 bc
A	7 cm	4.4 cde	4.2 ef	4.0 c
A	14 cm	2.6 e	4.4 ef	5.2 bc
B	Surface	8.8 a	8.4 ab	9.8 a
B	2 cm	6.8 b	7.6 bc	9.8 a
B	7 cm	6.2 b	8.2 ab	9.8 a
B	14 cm	8.4 a	7.6 bc	10.0 a
C	Surface	9.8 a	9.2 ab	10.0 a
C	2 cm	9.6 a	9.0 ab	9.8 a
C	7 cm	9.2 a	9.4 a	10.0 a
C	14 cm	9.6 a	9.6 a	10.0 a
C	Control	2.6 e	5.2 de	2.4 d

[z]For details see Table 1.

[y]Seeds of annual bluegrass and annual ryegrass were sown at treatment time and 5 wks later; bentgrass was sown after 2 months. Visual assessment from 0 to 10 (10 = complete control) 2–3 wks after oversowing.

[x]Means in a column followed by the same letter or letters are not significantly different at the (1% level) Duncan's Multiple Range test.

[v]Herbicide was incorporated in the surface 2 or 7 centimeter depth, or incorporated fully through the 14 centimeter depth of the container.

Table 4. Bentgrass bioassay on leachate collected from surface and layered treatments of Goal.

Treatment[z]		Bioassay[y]		Bioassay[y]	
Rate -	Application	shoot (% control)	score (0–10)	shoot (% control)	score (0–10)
A	Surface	94 a[x]	0.8 d	98 a	1.0 b
A	2 cm[v]	92 a	0.2 d	109 a	1.0 b
A	7 cm	74 ab	1.6 d	93 a	1.6 b
A	14 cm	78 ab	1.0 d	102 a	1.2 b
B	Surface	89 ab	0.8 d	108 a	2.0 b
B	2 cm	79 ab	2.8 cd	102 a	1.6 b
B	7 cm	77 ab	1.6 d	102 a	1.8 b
B	14 cm	60 bc	4.0 bcd	100 a	2.6 b
C	Surface	27 de	7.4 ab	100 a	2.6 b
C	2 cm	44 cd	6.4 abc	103 a	1.6 b
C	7 cm	53 bc	4.8 bcd	103 a	2.2 b
C	14 cm	16 e	9.8 a	33 b	7.8 a
C	Control	100 a	9.6 a	100 a	1.2 b

[z]For details see Table 1.

[y]First and second bioassays were made 1 and 8 wks after treatment, respectively. The response of bentgrass was assessed by measuring the shoot length (transformed as % of control) and scoring its development from 0 to 10 (10 killed).

[x]Means in a column followed by the same letter or letters are not significantly different at the 1% level using Duncan's multiple range test.

[v]Herbicide was incorporated in the surface 2 or 7 centimeter depth, or incorporated fully through the 14 centimeter depth of the container.

At the second assessment, none of the treatments leached an appreciable amount of herbicide except from the pots filled with 192 mg/kg (172 lb/A) Goal.

Thus, even with watering in excess, no herbicide was detected in the effluents (i.e. their eventual level was below 0.02 ppm or 20 ppb of Goal) from surface spray at 3 kg/ha (2.7 lb/A) or from 19 mg/kg (17 lb/A) incorporated in the upper 2 or 7 cm (0.8, 2.8 in).

Significance to the Nursery Industry

Directed application of Goal (oxyfluorfen) to the growth medium is suggested as an alternative to broadcast or topical spray application, which cause phytotoxicity and potential run-off of herbicide from the soil applications into drainage water. In the experiment presented, with *Euonymus fortunei* 'Colorata' planted in UC Mix in 3.8 l (#1) containers, the optimal combination of rate and placement was 19 mg (0.00067 oz) of Goal 1.6E (0.1 ml) per kg (2.205 lb) of growth-medium placed in the upper 2 to 7 cm (0.8, 2.8 in) of the container. This treatment gave good herbicidal activity, was much less phytotoxic than a similar dose (16 L/ha Goal 1.6E) sprayed on the foliage, and no herbicide was detected in the effluent.

Restricting the herbicide-treated layer to the top of the container is safer (no appreciable leaching) than filling it completely with treated mix, and requires less herbicide. In practice, the application should be made during the potting and planting process, either by incorporating the herbicide in the upper soil, or by placing a treated layer on the top of the filling. This technique, applicable to nursery crops tolerant to Goal, will achieve adequate weed control within the containers, however, additional experimentation is still required to determine the persistance of the herbicidal activity.

(*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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Response of *Codiaeum variegatum* 'Gold Star' as Influenced by Slow-Release Fertilizer[1]

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Abstract

Codiaeum variegatum 'Gold Star' croton were grown at different nutritional levels of 3.3, 6.6, 9.9, 13.2, 16.5 and 19.8 g of slow-release 19N-3P-10K (19-6-12) per 12.5 cm (5 in) pot. Plant grade was highest with levels of 3.3–9.9 g per pot, with corresponding leachate electrical conductivity of approximately 200–1100 μmhos$\cdot$cm^{-1}.

Index words: croton, foliage plant, soluble salts, nutrient content

Introduction

Crotons are popular interior foliage plants because of their colorful foliage and tolerance of interior conditions. Research has been conducted in Europe to develop cultural procedures (1, 2, 3) under light intensities and temperatures lower, than that found in Florida.

Conover and Poole (4) produced *C. variegatum* 'Elaine' and 'Norma' cultivars under 30, 47 and 63% shade and found all acclimatized equally well to interior conditions, although 30% shade grown plants had slightly more leafdrop. Stock plants of 'Elaine' and 'Norma' grown in full sun produced slightly more cuttings than plants under 30% shade, but color was better on shade grown plants (5). In the same experiment, the highest fertilizer level of 16.8 kg N/ha-year (1500 lbs N/A-year) produced the highest number of cuttings.

Chemical composition of quality tropical foliage plants is described for some plants (7) but not croton. The work reported here was initiated to determine the best fertilization for crotons, optimum soluble salts of the growing medium and elemental concentration in tissues for producing croton.

Materials and Methods

Plants 8–12 cm (3–5 in) tall with 10 to 15 leaves each were obtained from commercial producers as rooted cuttings and planted in a potting medium consisting of Canadian peat and pine bark (1:1 by vol). The medium was steam-treated at 90°C (194°F) for approximately 1.5 hr prior to these additions and then amended with 2.7 kg/m^3 (7.5 lb/yd^3) kg dolomite and 0.5 kg/m^3 (1.5 lb/yd^3) Micromax (Sierra Chemical Co., Milpitas, CA 95035) per cubic meter. Plants were top-dressed at the beginning of each experiment with Osmocote 19N-3P-10K (19-6-12, 3 month release fertilizer from Sierra Chemical Co.) at 3.3, 6.6, 9.9, 13.2, 16.5 and 19.8 g/12.5 cm (5 in) pot. Recommended rate for crotons under these conditions is 4 g/12.5 cm (5 in) pot (6). Plants were irrigated by hand as needed. Ten single pot replicates were included for each treatment. Tests were conducted during 1986 and 1987 in a glasshouse at the CFREC-Apopka, Florida.

The first test was conducted from November 25, 1986 to January 16, 1987 with temperatures of 18–30°C (65–86°F) and light levels near 140 μmol$\cdot$m^{-2}s^{-1}. The second test was conducted from April 6 to May 27, 1987 at temperatures of 22–32°C (72–90°F) at a light level of near 200 μmol$\cdot$m^{-2}s^{-1}. The third test was conducted from September 9 to December 3, 1987 and temperatures between 22–32°C (72–90°F) at a light level near 170 μmol$\cdot$m^{-2}s^{-1}.

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