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Liverwort Control in Propagation: Challenges and Opportunities©

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INTRODUCTION

The primary limitation for weed control in propagation is lack of chemical options. Weed management programs in nursery crop production rely heavily on herbicides. This reliance on chemical weed control becomes a liability in propagation because most herbicides are not labeled for greenhouse use. Several postemergence herbicides can be used including Roundup, Diquat, and Scythe. Roundup can only be used in empty greenhouses (without plants). And while Diquat and Scythe can be used in greenhouses with plants, none of these postemergence herbicides can be applied within propagation flats where weed control is most critical.

Preemergence herbicides cannot be used inside closed structures. This includes glass houses, poly-covered hoop houses, gutter-connected houses, etc. Since most propagation occurs inside closed structures, preemergence herbicides are generally not an option.

The primary fear of labeling preemergence herbicides for use in propagation is volatilization and co-distillation of the herbicide. Also, many of the herbicides used in nursery crop production contain dinitroaniline (DNA) herbicides as one of its components. Dinitroaniline herbicides are a class of herbicide that function by inhibiting cell division in root meristems. The goal in propagation, by seed or cutting, is to grow roots. If DNA herbicides are applied to generally coarse and porous media used in propagation, large volumes of water applied through mist systems are likely to move herbicide through the media into proximity of the root system. If preemergence herbicides contact root tips, root initiation and/or growth would be inhibited. Research has shown that DNA-containing herbicides are generally more injurious in propagation than those that do not contain DNAs (Thetford et al., 1988).

Growers and researchers have reported trials in which herbicides were used in propagation with success (Langmaid, 1987; Thetford et al., 1988). However, every herbicide labeled for nursery crops clearly states that they may not be used in closed structures. It is illegal to recommend or use any pesticide in a manner not consistent with the label. Herbicide manufacturers are not likely to change labels for indoor use due to the reasons stated above. Therefore, regardless of how much research is conducted, currently labeled herbicides will not likely be labeled for indoor production or propagation.

Liverwort (*Marchantia polymorpha*) is one of the most difficult to control weeds in propagation. Liverworts thrive in low light, high relative humidity, high nutrition, and moist substrates (Svenson, 2002). Liverwort are primitive plants that lack a vascular system. They are more closely related to ferns and mosses than more common seed-bearing plants. Liverworts spread sexually by spores and asexually by splashing gemmae. Spores are microscopic and airborne, and thus are impossible to exclude from propagation areas. Gemmae are small asexually produced clonal fragments that accumulate in specialized structures on liverwort thalli (leaves) called gemmae cups. Gemmae allow liverwort colonies to spread quickly from a single plant.

Pre-emergence herbicides are not labeled for indoor use, and are thus not an option for liverwort control in propagation. Quinoclamine is an algaecide used for algae and moss control in rice paddies (in Japan). The Crompton Uniroyal Company is evaluating the market potential of labeling the product for indoor greenhouse and nursery production in the U.S.A. and Canada. In order to expedite the label registration process, Crompton Uniroyal has requested research at several universities throughout the U.S.A., including Oregon State University.

TerraCyte is a granular form of sodium carbonate peroxyhydrate. Upon contact with water, it breaks down into sodium carbonate and hydrogen peroxide. Hydrogen peroxide oxidizes cell membranes of some organisms, thus killing them. It is currently labeled for greenhouse and nursery crops as an algaecide and fungicide. It helps prevent liverwort, moss, and algae infestations by killing spores of these organisms. It has demonstrated postemergence activity on liverwort in several pilot studies (data not published).

Flumioxazin is a new herbicide that should be labeled for nursery crops (not in closed structures) by the end of the year, pending EPA decision. It is similar to Goal in its activity, mode of action, and crop tolerances. However, unlike Goal, it is available as a granular herbicide. Although Goal is a component of several granular herbicides, the concentration in those products was not high enough to provide postemergence liverwort control in pilot studies (data not published).

The objective of this research was to compare efficacy of quinoclamine, Terracyte, and flumioxazin for postemergence liverwort control.

MATERIALS AND METHODS

Three experiments were conducted at the Oregon State University North Willamette Research and Extension Center. Sprayable herbicides were applied with a CO_2 backpack sprayer at a pressure of 35 psi and calibrated to deliver 100 gal/A. Granular herbicides were applied with a hand-held shaker. In all experiments, plants were grown under a retractable roof greenhouse, with the roof open at all times. Plants were irrigated overhead with $^1/_2$ inch of irrigation daily, split in two equal cycles.

Experiment 1. Products were applied on 6 June 2003 to #1 containers of actively growing PJM rhododendron (*Rhododendron* PJM Group), 'Rose Glow' barberry (*Berberis thunbergii* f. *atropurpurea* 'Rose Glow'), and 'Goldsturm' rudbeckia (*Rudbeckia fulgida* var. *sullivantii* 'Goldsturm'). Quinoclamine was mixed at rates of 1 or 2 oz/gal and applied at 100 gal/A. TerraCyte was applied at 15 lb/1000 ft^2 (650 lb/A), and flumioxazin at 200 lb/A. Irrigation was withheld for 24 h after herbicide application. Data collected included injury ratings for each species at 7, 14, 30, 60, and 90 days after treatment (DAT), growth index on PJM rhododendron and 'Rose Glow' barberry 90 DAT, and shoot dry weight (SDW) on 'Goldsturm' rudbeckia 90 DAT.

Table 1. Postemergence liverwort (*Marchantia polymorpha*) control in containers.

		Experiment 2 (juvenile liverwort)			Experiment 3 (mature liverwort)		
Herbicide	Rate	2 DAT[Z]	14 DAT	45 DAT	2 DAT	14 DAT	45 DAT
Quinoclamine	1 oz./gal	99 a[Y]	98 a	92 c	89 a	84 b	49 a
Quinoclamine	2 oz./gal	100 a	100 a	98 b	94 a	97 ab	78 a
Quinoclamine	4 oz./gal	100 a	100 a	99 a	96 a	99 a	94 a
TerraCyte	650 Ib/acre	67 b	79 b	69 d	66 b	56 c	29 b
Broadstar	200 Ib/acre	20 c	39 c	65 e	3 c	5 d	3 b
Control	-	2 d	3 d	31 e	0 c	3 d	3 c

[Z] Days after treatment.
[Y] Means separated within a column using Duncan's Multiple Range Test (alpha = 0.05).

Experiment 2. Herbicides were applied on 22 July 2003 to #1 containers of actively growing PJM rhododendron, 'May Night' salvia [*Salvia* × *sylvestris* 'Mainacht' (syn. *S. nemorosa* 'May Night')], and 'Pink Mist' scabiosa (*Scabiosa* 'Pink Mist'). Containers were inoculated with liverwort using a method described by Svenson (1998). Herbicides were applied to liverwort that covered approximately 25% of the container surface and had no gametangiophores present at the time of application. Quinoclamine was mixed at 1, 2, or, 4 oz/gal and applied at 100 gal/A. Terracyte and Broadstar were applied at the same rates as Experiment 1. Data collected included visual ratings of liverwort control at 2 and 14 DAT and estimation of the percent container surface coverage by liverwort 45 DAT.

Experiment 3. Experiment 3 was conducted similarly and simultaneous to Experiment 2, with the following exception. Herbicides were applied to #1 containers of actively growing liverwort, which covered approximately 60% of the container surface with gametangiophores present.

RESULTS

Experiment 1. Quinoclamine caused no visual injury to 'Goldsturm' rudbeckia, PJM rhododendron, or 'Rose Glow' barberry. TerraCyte caused slight injury to 'Goldsturm' rudbeckia.

Experiment 2. Quinoclamine provided 99% to 100% liverwort control by 2 DAT (Table 1). Control was relatively unchanged by 14 DAT; however, by 45 DAT recolonization had occurred in containers treated with 1 oz/gal.

Terracyte and Broadstar provided poor to moderate control throughout the experiment. This and previous research suggests that Terracyte and flumioxazin provided acceptable postemergence liverwort control early in the growing season (March), but control declined throughout the year (data not published).

Experiment 3. By 2 DAT, Quinoclamine provided 89% to 96% liverwort control, with control increasing with increasing rate. Terracyte provided poor control and Broadstar provided almost no control. By 14 DAT, control declined for the low quinoclamine rate (1 oz/gal) while control was excellent in containers treated with 2 or 4 oz/gal. At this time, the only living remnants of the liverwort were female gametangiophores. The entire thallus (leaf-like structures) were dead. By 45 DAT, control began to decline in containers treated with 1 and 2 oz/gal while control was still high among containers treated with 4 oz/gal.

It has been noted that some postemergence herbicides provide 100% control of the liverwort thallus, but poor control of gemmae (Sven Svenson, pers. comm.). It is uncertain whether liverwort in containers treated with 1 or 2 oz/gal regenerated from gemmae that remained viable after herbicide application, or if they were formed by subsequently introduced spores. If recolonization of liverwort in these containers are from germinating spores, lack of recolonization in containers treated with 4 oz/gal might indicate residual preemergence control at higher rates.

No injury was observed on any of the nursery crops evaluated.

DISCUSSION

Quinoclamine provides excellent post-emergence liverwort control with no detrimental effects on the ornamentals tested. Further studies are necessary to determine tolerance of cuttings without roots, plants from tissue culture, and lower plant types (ferns, for example). It is also not certain if the product provides residual or pre-emergence liverwort control.

Traditional weed control in container production relies heavily on pre-emergence herbicides applied prior to weed emergence. Pre-emergence herbicides are not likely to be labeled for use in propagation. However, periodic applications of quinoclamine can be used to kill liverwort as they reach a level of minor infestation.

Integrated pest management (IPM) uses the concept of economic thresholds to govern pesticide applications. That is, under an IPM system, growers wait until a pest reaches a certain level before treating. Because pre-emergence herbicides have to be applied prior to weed emergence and post-emergence herbicides cannot be used in containers, IPM has limited application in container weed control programs. Killing liverwort with spray-applied quinoclamine once it reaches an economic threshold will be a powerful tool for propagation managers.

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