



Environmental Horticulture Program Research Project Sheet

<https://www.ir4project.org/ehc/ehc-registration-support-research/env-hort-extension-resources/>

Project Name: Liverwort Efficacy

New		Ongoing		Completed	X	Duration if ongoing or completed:	2006, 2010-2013, 2018 - 2021
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Project Description:

Liverworts are among the most serious weeds of container grown environmental horticulture crops, particularly undercover in greenhouses or overwintering covered hoopouses. Classified as bryophytes these simple plants thrive on water and nitrogen for reproduction but can also survive long dry periods. Herbicides effective for other weeds often may not have activity for liverworts, plus most herbicides are not labelled for use within greenhouses or other covered growing structures.

Research Project Abstract (if available):

Abstract from 2015 Liverwort Efficacy Summary

Data in this report were generated to evaluate several products for post-emergent control of liverworts (*Marchantia sp.*). Liverworts are among the most serious weeds of container grown ornamentals. Classified as bryophytes these simple plants thrive on water and nitrogen for reproduction but can also survive long dry periods. During the 2004 and 2009, IR-4 Ornamental Horticulture Workshops, a project was prioritized to screen for efficacious products to manage post-emergent liverwort in container grown ornamentals grown primarily under cover in greenhouses or hoop houses, use sites with very few registered herbicides. This research was conducted across the United States in 1976, 2005, 2006, and 2009 through 2011 to evaluate several registered products for liverwort control.

Treatments with proven effectiveness in multiple trials include Bryophyter (oregano oil) at 2% v/v, Greenmatch (d-limonene) at 20% v/v, Racer (ammonium nonanoate) at 5% v/v, Scythe (pelargonic acid) at 5-10% v/v, SureGuard (flumioxazin) at 0.375 lb ai/A, Terracyte Pro (sodium carbonate peroxyhydrate) at 10 lb/1000 sq. ft., V-10233 (flumioxazin) at 10 fl oz/A, and WeedPharm (acetic acid) 10- 20% v/v. In limited experiments, Broadstar 0.25G (0.25 lb/A), indaziflam (0.065 lb ai/A), Ronstar 2G (4.0 lb ai/A) and EC (2 lb ai/A) and Showcase 2.5G (2.5 lb ai/A) also demonstrated good control. Contact type treatments such as Scythe and Bryophyter were fast acting but generally required more than one application to remain effective (>80% control) during the trial period. Treatments with unacceptable or inconsistent liverwort control include Champ, FlowerPharm, Freehand, Junction, M-Pedi, Quicksilver, Sporan, Sporatec, and Xeroton. In a single trial the following products were effective in controlling bittercress and crabgrass, as well as, liverwort: Bryophyter, GreenMatch, Scythe, SureGuard, and WeedPharm. Silwett alone also controlled these weeds but was ineffective in controlling liverwort.

The results from this study successfully identify several options for postemergent control of liverwort. Further research should focus on products that can be safely applied as a conventional application or as a dormant treatment to container grown ornamentals which provide residual control of liverwort, as well as, other weeds.

Target Species (Phytotoxicity, or common and Latin name of arthropod, pathogen, weed):

Liverwort (*Marchantia sp.*)

Target Crops (list tested crops if ongoing or completed project)

<i>Asimina triloba</i>	<i>Gymnocladus dioicus</i>	<i>Quercus palustris</i>
<i>Berberis thunbergii</i>	<i>Hosta sp.</i>	<i>Rosa sp.</i>
<i>Buxus microphylla</i>	<i>Hydrangea macrophylla</i>	<i>Salix sp.</i>
<i>Buxus sp.</i>	<i>Hydrangea quercifolia</i>	<i>Sambucus sp.</i>
<i>Cladrastis sp.</i>	<i>Hydrangea sp.</i>	<i>Vinca sp.</i>
<i>Gardenia sp.</i>	<i>Matteuccia struthiopteris</i>	<i>Weigela florida</i>
<i>Gleditsia sp.</i>	<i>Pachysandra terminalis</i>	<i>Weigela sp.</i>

Target Product(s)(list tested products or numbered compounds if ongoing or completed project)	
Avenger Ag (d-limonene)	Oxyfluorfen 2G (Oxyfluorfen)
Baking soda (sodium bicarbonate)	Pendulum 2G (Pendimethalin)
Basagran T&O Herbicide (Bentazon)	Pendulum 3.3 EC (Pendimethalin)
BroadStar 0.25G (Flumioxazin)	QuickSilver T&O (Carfentrazone-ethyl)
BroadStar 0.25G VC1604 (Flumioxazin)	Racer Herbicide (Ammonium nonanoate)
Bryophyter (Oregano oil)	Ronstar G (Oxadiazon)
BW133 (BW133)	Scythe (Pelargonic acid)
Champ DF (Copper Hydroxide)	Showcase (Trifluralin + Isoxaben + Oxyfluorfen)
Chipco Ronstar 2G (Oxadiazon)	Sporan (Plant Essential Oils)
FlowerPharm (Cinnamon oil + rosemary oil)	Sporotec (Clove oil + Rosemary oil + Thyme oil)
Freehand G (Dimethenamid-p + pendimethalin)	SureGuard 51WDG (Flumioxazin)
Gentry (Quinoclamine)	Terracyte (Sodium carbonate peroxyhydrate)
Goal 2E (Oxyfluorfen)	Terracyte Pro (PerCarb, GC Pro, GreenClean Max)
Junction (SePro) (Mancozeb + copper hydroxide)	(Sodium carbonate peroxyhydrate)
Marengo 74SC (Indaziflam)	Tower (Dimethenamid-p)
Marengo G (Indaziflam 0.0224%)	V-10233 76WG (Flumioxazin + pyroxasulfone)
M-Pede (Horticulture Soap)	V-10336 61.5WG (Flumioxazin + pyroxasulfone)
Neudorff's Granular Moss Killer (Pelargonic acid)	Weed Pharm (Acetic acid)
Oryzalin 75WP (Oryzalin)	Xeroton (Peroxyacetic acid)

Product Registration and Research Status			
	Fully Screened (also includes standards)	Partially Screened through IR-4 ¹	Need Data Across Species?
Labeled Generally & Commercialized	Racer Scythe TerraCyte WeedPharm		
Labeled Generally But NOT Commercialized			
Labeled Specifically & Commercialized		SureGuard Tower	
Labeled Specifically but NOT Commercialized			
Not yet registered or Labeled		Baking soda Bryophyter (labeled for moss) V-10233	
No longer available for development	Gentry		
* IR-4 Data contributed to registration decision – either adding pest to label or not pursuing further research			
1 At least one species screened fully			

PROS	CONS
Weed Pharm and Racer exhibited no to commercially acceptable injury on 50% of crops tested while Bryophyter exhibited no to commercially acceptable injury on 25% of crops tested	Avenger Ag and Scythe exhibited commercially unacceptable injury on all crops tested



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Outdoor liner production needed on labels: Tower, Sureguard & Marengo	Many of these products already have liverwort efficacy listed and have open labels, so growers can use without changes in labeling
Valent would consider dormant applications for Broadstar/Suregard for outdoor use	Broadstar/Suregard – no indoor use, even for dormant applications.
Broadstar for woodies within in structures, no volatility	Tower not labeled for indoor
Freehand for pre-emergent (vs liquid)	

Scope of Project: screen liquids and granulars of same ais; look at lower rates; preemergent and early post efficacy
Comments: several products are registered generally that can be used as directed post-emergent tools that demonstrate good to excellent control; Freehand as preventing new liverwort growth was not as successful as Tower in work during 2009. Additional results have not been received. Marengo liquid and granular formulations were variable.
 Potential label changes for use of Broadstar, Sureguard, and Tower may not need efficacy data. Liner stage may need crop safety data.

IR-4 Efficacy Trials to Date

Average rating on a scale of 1 – 5 with 1 = 0 to about 50% efficacy (not effective) and 5 = 95 to 100 efficacy (very effective); minimum to maximum rating; number of trials (See table on next page). For product/insect combinations that are blank, IR-4 has not screened this combination.

‘Labeled’ indicates that this insect species or genera is listed on the label. A rating of 2 or lower is considered unacceptable efficacy (*red text*). A rating of 3 or higher is considered commercially acceptable (black text). Non-labeled, completed product/insect combinations (3 or more trials) with an average rating of 3 or higher are highlighted with *green text*. For insect/product combinations that are blank, IR-4 has not screened this combination.

Products (Active Ingredients)	MOA	Liverwort (<i>Marchantia sp</i>)
Avenger Ag (d-limonene)	unknown	4.1 (1 - 5) n9 Labeled
Baking soda (sodium bicarbonate)	FRAC NC	5.0 (5 - 5) n3
Basagran T&O Herbicide (Bentazon)	WSSA 6	1.3 (1 - 2) n4
BroadStar 0.25G (Flumioxazin)	WSSA 14	2.0 (2 - 2) n3
BroadStar 0.25G VC1604 (Flumioxazin)	WSSA 14	1.0 (1 - 1) n1
Bryophyter (Oregano oil)	unknown	3.7 (1 - 5) n23
BW133 (BW133)	FRAC NC	1.0 (1 - 1) n2
Champ DF (Copper Hydroxide)	FRAC M1	1.1 (1 - 2) n12
Chipco Ronstar 2G (Oxadiazon)	WSSA 14	2.6 (1 - 5) n5
FlowerPharm (Cinnamon oil + rosemary oil)	unknown	1.0 (1 - 1) n2
Freehand G (Dimethenamid-p + pendimethalin)	WSSA 15 + WSSA 3	1.0 (1 - 1) n1
Gentry (Quinoclamine)	unknown	5.0 (5 - 5) n7
Goal 2E (Oxyfluorfen)	WSSA 14	4.0 (4 - 4) n1
Junction (SePro) (Mancozeb + copper hydroxide)	FRAC M3 + FRAC M1	1.0 (1 - 1) n4
Marengo 74SC (Indaziflam)	WSSA 29	2.7 (1 - 5) n3
Marengo G (Indaziflam 0.0224%)	WSSA 29	1.7 (1 - 3) n3
M-Pede (Horticulture Soap)	FRAC P07	1.0 (1 - 1) n1
Neudorff's Granular Moss Killer (Pelargonic acid)	WSSA 17	2.7 (1 - 4) n3
Oryzalin 75WP (Oryzalin)	WSSA 3	2.0 (2 - 2) n1
Oxyfluorfen 2G (Oxyfluorfen)	WSSA 14	4.0 (3 - 5) n2
Pendulum 2G (Pendimethalin)	WSSA 17	1.0 (1 - 1) n2
Pendulum 3.3 EC (Pendimethalin)	WSSA 3	1.0 (1 - 1) n2
QuickSilver T&O (Carfentrazone-ethyl)	WSSA 14	1.3 (1 - 2) n8
Racer Herbicide (Ammonium nonanoate)	unknown	3.0 (1 - 5) n18 Labeled
Scythe (Pelargonic acid)	WSSA 17	4.5 (1 - 5) n17 Labeled
Showcase (Trifluralin + Isoxaben + Oxyfluorfen)	WSSA 3 + WSSA 21 +WSSA 14	1.0 (1 - 1) n3
Sporan (Plant Essential Oils)	FRAC NC	1.0 (1 - 1) n1
Sporotec (Clove oil + Rosemary oil + Thyme oil)	FRAC NC	1.0 (1 - 1) n3
SureGuard 51WDG (Flumioxazin)	WSSA 14	4.2 (1 - 5) n19 Labeled
Terracyte (Sodium carbonate peroxyhydrate)	unknown	1.0 (1 - 1) n1 Labeled
Terracyte Pro (PerCarb, GC Pro, GreenClean Max) (Sodium carbonate peroxyhydrate)	unknown	2.5 (1 - 5) n22 Labeled
Tower (Dimethenamid-p)	WSSA 15	3.1 (1 - 5) n20 Labeled
V-10233 76WG (Flumioxazin + pyroxasulfone)	WSSA 14 + WSSA 15	3.6 (1 - 5) n5
Weed Pharm (Acetic acid)	unknown	4.2 (1 - 5) n14 Labeled
Xeroton (Peroxyacetic acid)	unknown	2.5 (1 - 4) n2