Performance of a new organic herbicide based on *d*-limonene

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Introduction

Natural product herbicides have the potential to play an important role in controlling weeds on organic farms by reducing reliance on tillage and cultivation and replacing expensive hand hoeing practices. In addition, cost effective natural products with high efficacy could replace more toxic pesticides currently in use on conventional farms.

Natural herbicides containing either vinegar (acetic acid) or clove oil (eugenol) are commercially available to organic growers, but only limited information is available on their effective use. Greenhouse and field trials have shown that vinegar applied in concentrations between 10 and 30% can effectively suppress multiple broadleaf weed species, but cannot consistently control grasses (Ferguson and Chase 2005). Clove oil at concentrations of 1 to 10 % has also been demonstrated to provide good control of several broadleaf weed species in some studies (Bainard et al. 2006; Tworkoski, 2002) but inconsistent control in others (e.g. Ferguson and Chase 2005).

A new OMRI-listed organic herbicide based on *d*-limonene (GreenMatch™ O, EPA Reg. No. 82052-1) has recently been introduced to the market by Marrone Organic Innovations, and a series of laboratory bioassays and field studies have been conducted to demonstrate its efficacy on some of the most common weeds in organic farming systems.

d-limonene

•***d*-limonene** ((4*R*)-1-methyl-4-(1-methylethenyl)cyclohexene or (*R*)-4-isopropenyl-1-methylcyclohexene) is a relatively stable monoterpene from orange peels and widely used as a cleaning agent.

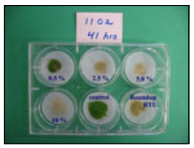
• the fast, non-selective herbicidal effect of *d*-limonene is based on the disruption of the leaf cuticle which leads to fast wilting of plants due to reduced chlorophyll fluorescence and stomatal functioning (Imrahim et al. 2004)

Bioassay set-up

• the phytotoxic effect of GreenMatch was tested in a laboratory bioassay on a 6-well plate using intact leaves of chickweed (*Stellaria media*) as a test subject
• the commercial product containing 70 % of *d*-limonene was diluted with DI water to the following concentrations: 0.5, 2.5, 5.0, 10.0 %. DI water and Roundup® RTU were used as control treatments
• a 0.5-mL aliquot of each solution was pipetted on a filter paper, and one leaf of chickweed was placed on the top of the filter paper
• the leaves were incubated for 2 days in a greenhouse with a 12-hr light/dark cycle, after which the leaves were evaluated for color change

Bioassay results

The results (on the right) show that:
• within 2-days, a direct contact with *d*-limonene at a concentration 2.5 % results in fast destruction of the chlorophyll which can be seen as a total bleaching of leaves.
• the effect of *d*-limonene, as a burndown, non-selective, non-systemic herbicide, is faster than that of systemic Roundup®.



Abstract

In organic farming, biological control of weeds using herbicides based on natural products or phytotoxic microbial metabolites is a potential alternative for hand hoeing and flaming. The herbicidal effects of plant extracts and essential oils have been acknowledged for decades but only recently have these products become commercially available for growers. One of the most promising organic herbicides is d-limonene, a monoterpene extracted from orange peels. It has previously been used as an insecticide in organic farming but recent field studies have shown that a *d*-limonene-product, GreenMatch™ O (70 % *d*-limonene), at 1:3 dilution controls most of the common broadleaved and grass weeds. The non-systemic burn-down effect is based on fast disruption of the leaf cuticle, which leads to wilting. The effect is dependent on temperature as well as the plant age and leaf structure but in most cases, one application of *d*-limonene controls more than 80 % of weeds for 3-4 weeks.

Field studies

A series of field studies have been conducted to test the efficacy of GreenMatch™ O on both broadleaf and grass weeds (see pictures below). Selected field study results are presented in Tables 1 and 2.

Table 2

Treatment	Application rate (% A.I.)	Spray volume (gpa)	Weed control (%) Mustard at 4-5 leaf stage (*Brassica juncea*)		
			1 DAT	13 DAT	34 DAT
Untreated	0.0	0	0.0 d	0.0 d	0.0 c
GreenMatch™O	10.0	140	16.2 b	85.0 a	57.5 a
GreenMatch™O	10.0	70	17.5 b	38.8 c	37.5 ab
GreenMatch™O	17.5	70	28.8 a	52.5 b	25.0 bc
Acetic acid	10 % dilution	70	8.8 c	13.8 d	7.5 c
Matran® EC	10 % dilution	35	17.5 b	36.2 c	25.0 bc
LSD (p≤ 0.05)			6.6	15.5	28.3

University of California, Davis, Jan 2007; Matran® and acetic acid were applied according to manufacturer's recommendations. Matran® is a registered trademark of EcoSmart Technologies, Inc.

Table 1

Treatment	Application rate (% A.I.)	Weed control (%) Common lambsquarters (*Chenopodium album*)			Weed control (%) Annual bluegrass (*Poa annua*)		
		1 DAT	8 DAT	15 DAT	1 DAT	8 DAT	15 DAT
Untreated	0.0	0.0 d	0.0 c	0.0 d	0.0 c	0.0 d	0.0 b
GreenMatch™ O	10.0	50.0 b	87.5 a	98.3 a	30.0 a	47.5 bc	45.0 a
GreenMatch™ O	17.5	63.8 a	98.0 a	97.8 a	28.8 a	68.8 a	56.3 a
Roundup®	4 qt/A	30.0 c	41.7 b	50.0 b	21.3 b	32.5 c	40.0 a
LSD (p≤ 0.05)		8.5	18.5	10.5	6.6	18.7	19.7

Study conducted by BioResearch, Fresno, CA; December 2006, spray volume 40 gpa; Roundup® is a registered trademark of Monsanto Company

Conclusions

- **an organic herbicide based on *d*-limonene (GreenMatch™ O) provides fast and effective control of both broadleaved and grass weeds**
- **the herbicidal effect of *d*-limonene decreases with decreasing temperature and increasing leaf cuticle thickness**
- **for optimal performance, GreenMatch™ O should be diluted 4–7x (17.5 – 10% A.I.) depending on temperature and the size of weeds**
- **good coverage (spraying volume of 60 gpa or higher) is required for best weed control especially at low temperatures and for large weeds**

References

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