CUTT

Program Spotlight

A variety of federal, state and local legislation mandates the reduction or elimination of chemical pesticide use in turfgrass management. Commercial landscapers, turfgrass managers, sports field managers, and golf course superintendents are therefore more interested in low-toxicity or "organic" products than ever before.

How Well Does Organic Weed Control Work?

A variety of federal, state and local leg islation (either proposed or recently enacted) mandates the reduction or elimination of chemical pesticide use in turfgrass management. Commercial landscapers, turfgrass managers, sports field managers, and golf course superintendents are therefore more interested in low-toxicity or "organic" products than ever before.

Professionals and homeowners constantly ask Cooperative Extension Educators about alternatives to pesticides for turfgrass management. A specific interest is in alternatives for the broad-spectrum herbicides, such as glyphosate (sold as "RoundUp" or other trade names). Broad-spectrum herbicides are used in a variety of turfgrass and landscape renovation projects, such as the removal of an existing turfgrass area to install new sod or seed, the removal of turfgrass for other landscaping projects, or general weed management in paved and graveled areas. While a new lawn or garden bed can be managed without pesticides, a broad-spectrum herbicide is generally needed to create a new bed or lawn, since the other alternatives (i.e., stripping the existing sod with a sod cutter, rototilling the existing sod into the soil, etc.) are often not practical or desirable.

Recently, a great deal of interest has been expressed in the use of acetic acid (vinegar) as a broad-spectrum herbicide. While anecdotal reports of success with vinegar have been published in the popular press and on the internet, research to substantiate these claims is limited. A keyword search on Michigan State's Turfgrass Information Center, a vast database of turfgrass abstracts, produced only five matches for acetic acid, none of which detailed its use as a herbicide. At least two acetic acid-based herbicides were commercially available for the 2001 grow-

Table 1. Treatments, Manufacturers and Treatment Schedules.

Treatment Number	Treatment Name and Active Ingredient	Manufacturer	Treatment Schedule
1	Nature's Glory Weed and Grass Killer (25% acetic acid)	Monterey Lawn and Garden Products	Sprayed once at 0 days
2	Nature's Glory Weed and Grass Killer (25% acetic acid)	See above	Sprayed 3 times (at 0, 7, and 14 days) or as per label directions
3	BurnOut Weed and Grass Killer (25% acetic acid)	St. Gabriel Laboratories	Sprayed once at 0 days
4	BurnOut Weed and Grass Killer (25% acetic acid)	See above	Sprayed 3 times (at 0, 7, and 14 days) or as per label directions
5	Scythe (57% pelargonic acid, 3% related fatty acids)	Mycogen, Inc.	Sprayed once at 0 days
6	Scythe (57% pelargonic acid, 3% related fatty acids)	See above	Sprayed 3 times (at 0, 7, and 14 days) or as per label directions
7	5% acetic acid	Mallinckrodt, Inc.	Sprayed once at 0 days
8	5% acetic acid	See above	Sprayed 3 times (at 0, 7, and 14 days)
9	10% acetic acid	See above	Sprayed once at 0 days
10	10% acetic acid	See above	Sprayed 3 times (at 0, 7, and 14 days)
11	20% acetic acid	See above	Sprayed once at 0 days
12	20% acetic acid	See above	Sprayed 3 times (at 0,7, and 14 days)
13	RoundUp (glyphosate)	Monsanto, Inc.	Sprayed once at 0 days
14	Check		

Table 2. Weed Populations for Three Replicate Plots

Replicate Number	Weed Population
1	70% quackgrass (*Elytrigia repens*), 20% crabgrass (*Digitaria sanguinalis*), 10% ground ivy (*Glechoma hederacea*)
2	90% ground ivy, 5% dandelion (*Taraxacum officinale*), 5% violet (*Viola sp.*)
3	60% plantain (*Plantago major*), 20% Kentucky bluegrass (*Poa pratensis*), 10% dandelion, 10% ground ivy

ing season. Numerous other "recipes" for acetic acid herbicides exist using store-bought vinegar (which contains about 5% acetic acid). This project addressed the lack of data by evaluating the broad-spectrum herbicidal activity of two new acetic acid type herbicides, one herbicidal soap (containing pelargonic acid), three treatments of commercially available acetic acid, and a traditional herbicide.

Objectives and Procedures

1. Observe and document the *initial damage* done to turfgrass species and lawn weed species by two new acetic acid type herbicides, one herbicidal soap (containing pelargonic acid), three treatments of commercially-available vinegar, and a traditional herbicide.

2. Observe and document the *long-term control* (with some use of repeated applications) of turfgrass species and lawn weed species by two new acetic acid type herbicides, one herbicidal soap (containing pelargonic acid), three treatments of commercially-available vinegar, and a traditional herbicide.

The treatments, manufacturers and treatment schedules are shown in Table 1.

The study was to be conducted at the City of Troy Golf Course on unirrigated rough areas. However, in 2001 the Capital District experienced prolonged dry weather starting in May, and turfgrass went into an early dormant period. Thus, the starting date for the study was delayed in the anticipation that rain would soon fall and turf would initiate growth. When this did not happen, the study was conducted in August on a partially irrigated lawn at the project leader's property in Castleton, NY.

Applications for each product were made either once (at 0 days) or three times (at 0, 7 and 14 days), except for glyphosate, which was applied only once. Each treated plot measured 3 ft. by 3 ft. Plots were arranged randomly within the block. Each treatment was replicated three times. Weed populations varied somewhat among the replicates (see Table 2). All treatments were evaluated at 6, 24, and 72 hours and one week after each application, then periodically thereafter. A 0-100% visual rating scale was used, with 0 appearing like the check plots (no injury) and 100% appearing as total injury. Visual symptoms of injury (i.e., twisted foliage, discoloration, necrosis, etc.) were noted for each plant species. Weed populations varied among the replicates, as described in Table 2. Since prolonged warm Fall weather encouraged plant growth, observations were continued until October 31.

Results and Discussion

Since the results for each set of replicate plots were so different, data for the three replicates is shown individually in Tables 3 and 4.

Initial Damage

All acetic acid treatments caused discoloration and damage (control) to the plots by the 6 hours posttreatment observation. Initial damage for all weed species was a dramatic discoloration and necrosis, with foliage quickly becoming blackened and water-soaked. No twisting or yellowing was seen for any treatment or species. Initial control was rated at 90 to 100% for all of the treatments containing acetic acid, except for the 5% treatments, where for the Replicate 2 plots damage was rated at 70 to 85%. Ground ivy was thus seen to be initially slightly more resistant to lower concentrations of acetic acid. By the 24 hours after treatment observation, however, the control in the Replicate 2 plots had increased to 95% (see Tables 3 and 4). By the 72 hours after treatment observation, control in all plots with an acetic acid product was 95 to 100% (data not presented).

Plots Sprayed With One Application (1x Plots)

Data for plots sprayed with one application are shown in Table 3. Nature's Glory and BurnOut performed similarly, giving an average control for all replicates well above 90% after 24 hours and at two weeks. At five weeks, good control was still seen except for one Replicate 3 plot where aggressive Kentucky bluegrass regrew. At nine weeks and beyond, control was significant only in Replicate 2 plots (with ground ivy). The 20% acetic acid performed

continued on page 14

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Organic Weed Control

continued from page 13

All treatments of acetic acid provided excellent control of crabgrass and broadleaf plantain

Ground ivy appears to be very susceptible to acetic acid. Virtually all treatments provided excellent initial and long-lasting control of this difficult-to-manage species.

Although all of the acetic acid treatments did a good job of initially controlling quackgrass, it regrew by the 9 week observation date for many treatments, and by 13 weeks, the percentage of quackgrass for many treatments increased beyond what was initially seen in the plots.

Table 3. Percent Control for Selected Dates for Plots Sprayed with One Application (1x Plots)

Product	Treatment	Replicate	24 Hours	2 Weeks	5 Weeks	9 Weeks	13 Weeks
Nature's Glory	1	1	100	90.0	80.0	15.0	10.0
		2	90	99.0	95.0	90.0	90.0
		3	98	95.0	85.0	40.0	30.0
		average	96.0	94.7	86.7	48.3	43.3
BurnOut	3	1	100	98.0	90.0	60.0	20.0
		2	95	100.0	95.0	85.0	80.0
		3	95	95.0	60.0	15.0	10.0
		average	96.7	97.7	81.7	53.3	36.7
Scythe	5	1	100	90.0	50.0	10.0	10.0
		2	98	99.0	95.0	80.0	80.0
		3	98	90.0	40.0	10.0	5.0
		average	98.7	93.0	61.7	33.3	31.7
5% Acetic Acid	7	1	100	40.0	5.0	5.0	5.0
		2	85	99.0	95.0	85.0	85.0
		3	95	85.0	40.0	10.0	10.0
		average	93.3	74.7	46.7	33.3	33.3
20% Acetic Acid	11	1	100	90.0	85.0	50.0	30.0
		2	95	100.0	98.0	98.0	98.0
		3	100	98.0	95.0	80.0	70.0
		average	98.3	96.0	92.7	76.0	66.0
Glyphosate	13	1	90	100.0	100.0	95.0	90.0
		2	0	98.0	100.0	100.0	100.0
		3	70	95.0	98.0	95.0	95.0
		average	53.3	97.7	99.3	96.7	95.0

slightly better than the commercial products, maintaining an average control of 92.7% at five weeks, and 76% at nine weeks. The 5% acetic acid treatment showed good control in Replicate 1 for less than two weeks, and for less than five weeks in Replicate 3, making it much less favorable than the higher concentration treatments. Scythe showed good weed suppression for less than five weeks in Replicates 1 and 3, with good control seen for 13 weeks in Replicate 2. Glyphosate, as expected, provided 90% or better control from two weeks to 13 weeks.

Plots Sprayed With Three Applications (3x Plots)

Data for plots sprayed with three applications are shown in Table 4. Nature's Glory and BurnOut again performed similarly, showing

Table 4. Percent Control for Selected Dates for Plots Sprayed with Three Applications (3x Plots)

	Treatment	Rep.	24 Hours	2 Weeks	5 Weeks	9 Weeks	13 Weeks
Nature's Glory	2	1	100	98.0	95.0	70.0	20.0
		2	90	100.0	100.0	98.0	90.0
		3	100	100.0	98.0	75.0	50.0
		average	96.7	99.3	97.7	81.0	53.3
BurnOut	4	1	100	98.0	90.0	60.0	20.0
		2	90	100.0	100.0	98.0	95.0
		3	100	100.0	100.0	95.0	80.0
		average	96.7	99.3	96.7	84.3	65.0
Scythe	6	1	100	98.0	98.0	20.0	5.0
		2	98	100.0	98.0	95.0	92.0
		3	98	98.0	90.0	40.0	40.0
		average	98.7	98.7	95.3	51.7	45.7
5% Acetic Acid	8	1	100	98.0	90.0	25.0	10.0
		2	70	100.0	100.0	98.0	98.0
		3	100	98.0	95.0	70.0	60.0
		average	90.0	98.7	95.0	64.3	56.0
20% Acetic Acid	12	1	100	98.0	98.0	85.0	60.0
		2	95	100.0	100.0	98.0	98.0
		3	100	100.0	98.0	92.0	85.0
		average	98.3	99.3	98.7	91.7	81.0
Glyphosate	13	1	90	100.0	100.0	95.0	90.0
		2	0	98.0	100.0	100.0	100.0
		3	70	95.0	98.0	95.0	95.0
		average	53.3	97.7	99.3	96.7	95.0

control at 90% or above for at least five weeks. By nine weeks, Kentucky bluegrass and quackgrass began to regrow, and average control slipped to just above 80%. After 13 weeks, control of 90% or above was seen only in the Replicate 2 plots on ground ivy. The 20% acetic acid treatments again showed slightly better control than the commercial products, with an average control of better than 90% maintained to nine weeks, and 81% after 13 weeks. Why there was better performance is unknown. The 5% acetic acid treatment showed surprisingly good control of 90% or better to five weeks, but proved much less effective at nine and 13 weeks. Scythe showed 90% or better control at the five week observation, but regrowth was significant thereafter, with only 20% and 40% control in the Replicate 1 and 3 plots, respectively, by the nine week observation.

Observation of Individual Weed Species

Crabgrass and Broadleaf Plantain: All treatments of acetic acid provided excellent control of crabgrass and broadleaf plantain, two annual weeds, with virtually no regrowth of these species during the 13 weeks and no new seedlings were observed. If this experiment took place earlier in the growing season, or under less droughty conditions, it is unknown if regrowth or seedling germination would have occurred.

Ground Ivy: Ground ivy appears to be very susceptible to acetic acid (see Replicate 2 data in Tables 3 and 4). Virtually all treatments provided excellent initial and long-lasting control of this difficult-to-manage species. Control with acetic acid in the Replicate 2 plots was still 80% or better for the 1x plots and 90% or better for the 3x plots. Pelargonic acid also performed well on ground ivy (80% control in the 1x plots and 92% control in the 3x plots after 13 weeks) as did glyphosate (100% control after 13 weeks).

Quackgrass and Kentucky Bluegrass: Although all of the acetic acid treatments did a good job of initially controlling quackgrass, it regrew by the 9 week observation date for many treatments, and by 13 weeks, the percentage of quackgrass for many treatments increased beyond what was initially seen in the plots (see Table 5). In most cases, the increases were less for the 3x plots than the 1x plots. One acetic acid treatment (20% acetic acid in the 3x plots) saw a dramatic decrease in quackgrass, however. Why this happened is unclear and the use of this type of treatment on quackgrass, bluegrass and other perennial, rhizomatous grasses should be investigated further.

Herbicide Costs

Cost per liter of some of the products used in this study as well as the cost to treat a 1,000 square foot area is in Table 6. Costs shown are for products purchased locally in the Troy, NY, area. The commercial acetic acid herbicide shown is more than three times as costly per square foot than glyphosate, and almost three times as costly as pelargonic acid. Acetic acid can be used at the 5% rate at an attractive price, but its effectiveness is limited. If 20% acetic acid or a commercial formulation must be sprayed three times to achieve effective control of most species, the cost per square foot increases accordingly.

Table 5. Percentage Change in Quackgrass and Kentucky Bluegrass After 13 Weeks

Treatment	Rep.	% change in quackgrass	% change in Kentucky bluegrass
Nature's Glory (1x)	1	20	
	3		36
Nature's Glory (3x)	1	6	
	3		30
BurnOut (1x)	1	-2	
	3		7
BurnOut (3x)	1	10	
	3		-2
Scythe (1x)	1	20	
	3		37
Scythe (3x)	1	15.5	
	3		28
5% acetic acid (1x)	1	25	
	3		61
5% acetic acid (3x)	1	15.5	
	3		20
20% acetic acid (1x)	1	0	
	3		4
20% acetic acid (3x)	1	-40	
	3		-6.5
Glyphosate	1	-64	
	3		-17.5

Future Research

This study showed that acetic acid is a useful herbicide. Acetic acid at 5% concentration (as would be found on the supermarket shelf) provided only short-term control of most perennial weeds, but did effectively control crabgrass and plantain. Three applications of acetic acid were seen to be much more effective than one application in most cases. Pesticide applicators following the advice of various gardening media who suggest vinegar as an herbicide should be aware that

continued on page 11

Table 6. Retail Cost Per Liter and Cost of Treating 1,000 Square Feet for Selected Herbicides

Product Name	Retail Cost/Liter	Cost/1,000 square feet
Nature's Glory Weed and Grass Killer (acetic acid)	$6.27	$38.87
Scythe (pelargonic acid)	$9.95	$19.90
17.4 M acetic acid (at 5% concentration)	$10.28	$10.28
17.4 M acetic acid (at 20% concentration)	$10.28	$41.12
RoundUp (glyphosate)	$51.85	$12.34

The final 2001 study field tested the prevention program identified in the growth chamber. Weekly applications of 0.25, 0.5, 1.0, 1.5 or 2.0 ounces of Junction at the 2 gallon spray volume were made to an area without moss. Similar to growth chamber findings the weekly 1 ounce application completely prevented moss establishment (see Figure 3). Plots treated with rates above 1 ounce developed the yellowing observed in the spray pH experiment. Again these were alleviated with applications of iron.

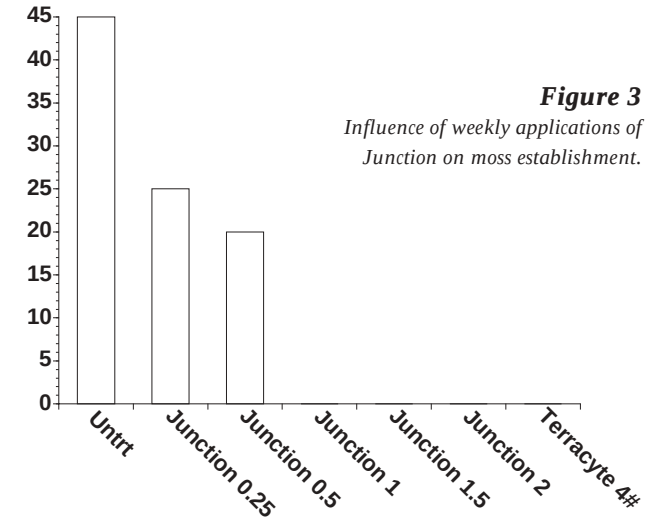

Figure 3
Influence of weekly applications of Junction on moss establishment.

A second series of experiments evaluated Terracyte, a sodium perchloride and lime based product for moss control. Spring applications were slightly less effective than Fall treatments for moss control (see Figure 4). This is consistent with observations of Junction efficacy on moss. Apparently moss begins an acclimation period in response to day-length and temperature. This acclimation either enhances susceptibility or reduces the recuperative ability of the moss.

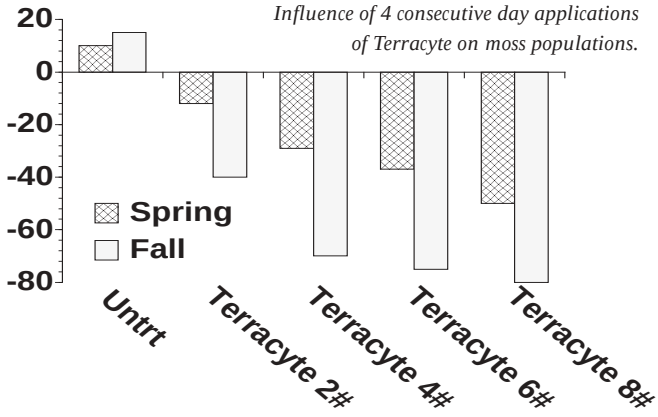

Figure 4
Influence of 4 consecutive day applications of Terracyte on moss populations.

This has been exceptionally productive research, building on initial observations. Follow up research more thoroughly refined application parameters and should result in excellent moss control programs. Financial support from Tri-State Research Foundation and Metropolitan Golf Course Superintendent Association, supplemented by Griffen LLC and the Hudson Valley Superintendents, helped make it possible. We are grateful for this support and look forward to further interaction with these outstanding organizations.

Frank S. Rossi

Interestingly, as spray solution pH decreased, bentgrass injury increased. We determined from tissue samples that iron uptake is reduced as compared to untreated tissue iron levels. A follow up application of iron sulfate seemed to reduce the yellowing and increase iron tissue levels.

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Organic Weed Control

continued from page 15

repeated applications may be necessary. The highest concentration of acetic acid (20%) gave better control than lower concentrations. Commercial formulations and the 20% acetic acid treatment provided better control than pelargonic acid in most cases in this study.

Glyphosate was the most effective herbicide, continuing to show excellent control of virtually all weed species at week 13. Acetic acid is quite costly compared to pelargonic acid or glyphosate, especially when three applications are needed to achieve good control. However, some pesticide applicators may opt to use acetic acid despite higher costs if legislation encourages the use of nontraditional pesticides, and acetic acid is seen as an environmentally-friendly alternative. Possible ways to improve the performance of acetic acid and thereby reduce cost per square foot should be examined. Although the plots where this study was conducted were irrigated, overall droughty conditions during the summer of 2001 may have influenced herbicide performance, making it desirable to repeat this work under conditions of "normal" rainfall and earlier in the year. Plots with more consistent weed species populations would also allow a meaningful statistical analysis to be generated.

David Chinery and Leslie Weston

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