ORGANIC FARMING RESEARCH FOUNDATION

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This is a final project report submitted to the Organic Farming Research Foundation.

General topic: Weed management in organic vegetables

Project Title:

On-farm testing of organic weed control strategies in Indiana

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Project summary

The purpose of this project was to substantiate and measure the effectiveness of various organic strategies for creating a weed free 'stale seedbed'. Using these techniques for salad greens and other short-lived and close-growing crops to save weeding time and facilitate weed-free harvesting greatly reduces labor time.

The strategies tried were several different organic herbicides and flaming. Growing beds in spring, summer and fall were prepared for seeding and then allowed to germinate weeds for 1-2 weeks. Applications of the treatments were then made to kill weeds. Several days after weed kill the areas were hand weeded to determine the extent of weed kill.

Of the organic herbicides trialed, all of them supplied a very good measure on control of non-grassy weeds when compared to the untreated areas. LP Gas flaming produced better results than any of the herbicides, is the most convenient to use, but also is a non-renewable resource. It is the only approach that kills grasses and some hardy natives.

On our farm we will in the future use sprays of Vinegar, Matran 5 and use some flaming. The protocol is that for areas with no grasses and low weed pressure in the spring and fall we will use vinegar to create our stale seedbeds. In areas with heavier weed pressures we will use Matran 5. In areas with grasses or summertime flushes of purslane we will use flaming. Matran was in a new formulation and was not used in heavy enough concentrations. New recommendations from the manufacturer call for higher percentages and subsequent trials have shown Matran capable of killing seeding grasses.

Introduction

The problem we are addressing is improving farm profitability through the use of organic weed management strategies that have only been recently developed or for which there is not widely distributed information. There have been few studies made of these techniques and none in testing them against each other.

At Rhoads farm we grow specialty lettuces, salad greens, other leafy greens, herbs and tomatoes. Before testing some of these herbicides we prepared beds for planting and did hand and mechanical weeding for the first two weeks of growth. After the greens are growing well they shade the area, preventing weed seeds from germinating. Weeding of salad green beds was our most time consuming and least desirable farm task. Using the organic herbicides has reduced our weeding time by 75%. The importance of this is obvious in terms of time, money and frustration saved.

After initially being leery of the benefits to be gained from these products we have seen that not only is there the easy-to-see benefit of labor saved, but also this labor saving allows crops to be grown profitably in harder to grow season or makes less profitable crops profitable due to a reduction in weeding time.

Description of Study Location

Rhoads Farm is located in Brown County, Indiana, near Nashville, Indiana. There are three acres of mixed fruit and vegetable production. The growing areas of the farm are located on a hillside in a series of five terraces with fruit tree plantings on borders and in between the terraces of vegetable production. The main vegetables grown are salad greens and leafy greens like kale and basil. The main fruit crop is Asian Pears. The produce is sold to local restaurants and a food co-op. The farm has been in operation since 1993. It has been organic for all of those years and certified organic by OEFFA since 2000.

The soil is a Berks-Wellston-Trevlac association, which is a moderately deep, moderately sloping well drained soil formed in loess and weathered shale siltstone and sandstone. The land had been clear-cut and corn farmed 100 years ago, then used as a horse pasture. When we cleared for farming it was covered with broom sedge and brushy clumps of 'reclamation' trees and shrubs like sumac, white poplar, sassafras trees and multiflora rose. We had made significant soil improvements over the years through additions of manures, rotted sawdust and cover crops.

The farm located in Central Indiana is in growing zone 5. The yearly average temperature is 52 degrees F with summertime highs in the 90's to occasional 100 degrees and winter time lows into -10 with occasional -20 degrees F. Our average precipitation is between 35-45 inches per year. We typically farm from March through November out of doors. Typical frost free dates are from May 4- Oct 19. We irrigate with both drip and overhead watering from our pond.

Typically we deal with four weeds here having over the years virtually eliminated lambsquarters, pigweed, smartweed and some other commonly seen weeds. While some of those weeds appeared in our trial plots, the percentages of those weeds that are seen are low. Our problem weeds are chickweed, hairy galinsoga, purslane and various grasses. While we have not identified the specific grass that we have the most of, it is a very short season grass being able to produce seed from seedling to maturity in 2 months. Seventy-five percent of our weed problem is from hairy galinsoga, which kills easily with the organic herbicides.

Objectives Statement

There are two primary objectives in this project and at least one secondary objective. The first of these primary objectives is to compare in replicated field trials the effectiveness and cost of a number of organic weeding strategies. The second objective is to inform other organic farmers of weeding options. The one known secondary objective is planned continuing trials similar to these and continuing efforts to advance these techniques by Dr. Maynard at Purdue.

Materials and Methods

A stale seedbed for the planting of salad greens was prepared three times in the year. The seed beds were tilled, leveled, watered and allowed to sit for one to two weeks to germinate weed seeds. Each bed was 3' feet wide and 90' long. Each of these beds had 18 equal 3'x 5'sized sections that received the different treatments or methods to be tested, with three replications of each treatment. Treatments were assigned randomly to each section. Treatments were made on May 18th, June 15th and August 28th. Weed counts to determine effectiveness were made about one week after treatment. Some weeds like grass and purslane can be defoliated but not killed by some of these treatments and will re-grow about 5 days after application.

The different methods are listed here.

1. No treatment.

2. The organic herbicide Matran 5 was applied at a 3% dilution.

3. A vinegar solution was applied as an organic herbicide at a 10% dilution rate.

4. In the original plans we were going to test the organic herbicide Xpress, even though we had experienced poor results with it. Xpress was pulled from the market. We substituted a vinegar solution at a 13% dilution rate to compare with the other herbicides and specifically to see if 13% vinegar demonstrated greater killing power than 10% vinegar.

5. A hand held 'flaming unit' that burns germinated weeds to the ground was used on the last of the 20'sections

6. The organic herbicide Burnout II which we later discovered is not allowed in certified organic production due to a mineral carrier.

In the proposal we had the following as the sixth treatment. "After tilling, leveling and watering, a sheet of clear greenhouse-weight UV protected plastic will be secured on the ground to test weed killing possibilities." In our last year and this year's early season pre-trials it became evident that a treatment using plastic would not give any results due to the small size of the treatment areas. Our standard procedure in the spring is to till and cover areas with a 10' by 100' sheet of plastic to speed soil warming and weed germination. We also use this size plastic sheeting in other seasons to help protect our 'crusty soils' from forming a crust due to hard rainfall. At times we have noticed significant weed kill from the plastic, especially in the summertime. (Other weeds like purslane love growing under the plastic.) We think this technique is well worth exploring some more, but had to drop it from these trials as ineffective due to the small size of the plots (3'x5'). Our experience with plastic has shown that good weed kill starts a foot or more from the edge of the plastic. Burnout II was substituted for plastic.

After the treatments were made, within a day or so the areas were planted to salad greens and within one week the areas were hand weeded with the amount of time spent in each area recorded. We felt like while recording weeding time was less accurate than counting the numbers of weeds, time to weed gives a figure directly accessible to farmers in figuring profitability. Effort was made to weed at a uniform speed with taking short breaks in between each plot to try to make perceived effort and physical strain the same for each plot.

These organic herbicides are contact herbicides made of essential oils and other organic substances that have to come in contact with a weed to kill it. For more information on the herbicides see the later section of this report under the "What Would you do Differently" Section.

Quantitative data was recorded and analyzed using standard statistical methods, including analyses of variance and mean separation.

Field Notes

Trial #1: First Application

Application was on May 18, 2005, 65 degrees F, sunny, 10 am
Weed counts on May 29, 2005
Each plot is 3'x5'. We measured the time it took to weed after application of materials. This plot was very weedy, had uncomposted manure put on it year before. The area had been covered with a sheet of clear plastic for two weeks before application of materials to germinate weeds. Plastic was removed 10 days before application and a light frost had damaged some of the leafy annuals. There were 700 weeds counted in one of the untreated plots.

All sprayed applications had ½ gallon of mix applied per 3'x5' area.
Matran 5 was applied at 3% dilution.
Vinegar was at 10% and 13% dilutions.
Burnout 2 was applied at 33% dilution. (Note: Burnout has a mineral carrier and is not OMRI approved. Using it would violate Organic Standards.)
Flaming took approximately 45 seconds per 3'x5' plot. Used 15 ounces of LP gas for each of the flaming plots.

#	Treatment	Time in minutes to hand weed	Any comments or notes
1	Vinegar 13%	25	Killed all except grass and rye
2	Burnout 2	9	Killed 85% of grass, killed everything else
3	Burnout 2	10	
4	Vinegar 10%	27	Killed all except for grass and rye left from tilling
5	Flaming	19	Only killed 50% of grass
6	Vinegar 10%	29	
7	Matran 5	24	Killed everything except 50% of grass
8	Flaming	19	Killed 60% of grass
9	Vinegar 13%	23	Did not kill grass
10	Burnout 2	10	
11	Untreated	40+	40 minutes was the cut off on measuring
12	Vinegar 13%	22	
13	Flame	19	Killed 50% of grass
14	Untreated	40+	
15	Matran 5	23	Did not kill the smart weed
16	Untreated	40+	
17	Vinegar 10%	25	
18	Matran 5	20	

Trial #2: Second Application

Application made June 15, 2005, 75 degrees F, 10 am
Weed counts on June 21, 2005.

Note: due to inconsistent weed germination across the different plots, a weed coverage percentage of each plot was made before materials application. That percentage is recorded in the notes for each plot.

This plot differed from the springtime trials in terms of different kinds of weeds. There was not nearly as much hairy galinsoga, more grass, considerable purslane and small amounts of pigweed, lambsquarters and ragweed. Also I allowed the weeds to get a little bigger in this set of trials to demonstrate killing power with larger weeds. Here weeds were 4”-8” tall. This area has been allowed three weeks to germinate weeds. We generally kill at the 2”-3” size at about 2 weeks after bed preparation.

As the purslane and grass is much harder to kill, all sprayed applications had 1 gallon of mix applied per 3’x 5’ area (as opposed to ½ gallon used in trials #1 and #3) and 2 lbs of LP gas was used in flaming the plots. Dilution rate of all spray materials was the same as in trial #1 listed above.

Plot	Treatment	Time in minutes to hand weed	Percentage of area covered by weeds	Height of weeds	Any notes or comments
1	Vinegar 13%	20 min	90% covered in weeds	4-6”	Burned but did not kill grasses, defoliated claytonia (clay) but did not kill it, 100% kill on everything else
2	Untreated	40+	100%	4-8”	
3	Matran 5	15 min	90%	4-8”	Defoliated all claytonia, killed 50% claytonia, did not kill grass
4	Vinegar 13%	21	100%	4-6”	similar to plot 1
5	Burnout 2	5 minutes	90%	4-8”	Killed 90% claytonia and 95% grass
6	Burnout 2	4 minutes	90%	4-8”	Similar to plot 5
7	Flame	0 minutes	80%	4-6”	80% total kill all weeds. Flame approx. 1 min/plot
8	Untreated	35	70%	4-6”	
9	Matran 5	4 minutes	70%	4-5”	Defoliated 70% and killed 50% claytonia, did not kill grass, killed all else
10	Burnout 2	1 minute	60%	4-5”	97% kill
11	Vinegar 10%	8 minutes	70%	4-6”	Defoliated 70% claytonia, did not kill claytonia, did not kill grass, killed everything else
12	Vinegar 13%	5 minutes	70%	4-6”	Defoliate 75% claytonia, no grass kill
13	Flame	0	60%	4-6”	100% kill
14	Vinegar 10%	7 minutes	65%	4-6”	Similar to plot 11
15	Vinegar 10%	6 minutes	60%	4-6”	Similar to plots 11 and 14
16	Flame	- 1 minute	60%	4-6”	Two grass seedlings survived
17	Matran 5	5 minutes	70%	4-5”	Defoliated claytonia but only kill 50%, did not kill grasses
18	Untreated	35 min	80%	4-5”	

Trial #3: Third Application

Application made August 28, 2005, 75 degrees F and sunny, 11 am
Weed counts on September 2, 2005

In these trials there were fewer weeds than in any of the other two trials, particularly Trial #1 in spring that was conducted on ground on which uncomposted manure had been applied the fall prior to testing. The majority of the weeds were hairy galinsoga (starting to germinate with slightly cooler temperatures), with fewer numbers of purslane and some grass. These beds had been tilled, prepared for planting and let sit for two weeks to germinate weeds. There were 250-400 weeds per plot in the untreated plots.

Because of the lower weed populations before application and less of the hard-to-kill purslane in these trials, ½ gallon of each liquid spray material was used to cover each of the three replications. One pound three ounces of LP gas was used to the flaming plots in

this trial. Fifteen ounces was used in the spring trial #1 (this was too little, flame not held long enough to kill growing tips of the grasses) and two pounds were used in trial #2 when there was heavy claytonia and grass populations. There was some kill on grass with all the treatments, probably due to dry soil and high temperatures.

Plot	**Treatment**	**Time in minutes to hand weed**	**Notes**
1	Vinegar 13%	1 minute	1 pigweed and 8 grasses
2	Flame	30 seconds	2 grasses
3	Untreated	30 minutes	400 weeds of which 45 were grasses
4	Matran 5	1 minute	8 grasses
5	Flame	0 minutes	100% kill
6	Burnout 2	0 minutes	100 kill
7	Vinegar 10%	1 minute	10 grasses
8	Burnout 2	0 minutes	100 % kill
9	Untreated	20 minutes	250 weeds of which 15 were grass seedlings
10	Flame	0	100% kill
11	Vinegar 10%	1 minute	8 grasses
12	Matran 5	1 minute	10 grasses
13	Vinegar 13%	1 minute	5 grasses
14	Untreated	15 minutes	225 weeds in this plot
15	Vinegar 13%	1 minute	10 grasses
16	Vinegar 10%	1 minute	10 grasses
17	Matran 5	30 seconds	1 Purslane, 1 grass
18	Burnout 2	0 minutes	100% kill

Project Results

Results Averaged over the Three Trials

Product used- listed in order farmer thinks is most effective	Average weeding time in minutes for Trial #1	Adjusted average weeding time in minutes for Trial #2	Average weeding time in minutes for Trial #3	Average weeding time in minutes for all trials
LP Flaming	19- ^	1	0.4	6.8
Burnout II #	10	4	0	4.6
Matran EC *	22	11	0.8	11.2
Vinegar 13%	23	17	1	13.6
Vinegar 10%	27	11	1	13
Untreated $	40	40	22	34

^ - In Trial #1 flaming was applied at too short of an interval for best weed control.
# - Burnout II is not approved for USDA certified organic use due to a mineral carrier.
* - **Matran EC was used at 3% dilution rate and is now recommended by manufacturer to be used at 5-8% which would greatly increase its effectiveness.**
$ - Untreated areas weeding time was stopped at 40 minutes.

Comments on the Results Averaged over the Three Trials

The farmer thinks these results are skewed somewhat by various factors, some of which are explained in the footnotes of the above table. From using these products and methods in these trials and in the field outside of these trials, we think in order of efficiency LP Flaming does the most complete job, Burnout was next, Matran, Vinegar 13% and then Vinegar 10%. All of the methods dramatically reduced weeding time. We think that Matran EC (at the time of these trials it was called Matran formulation 5) at the now recommended concentration would do as well as Burnout II. In the trials Vinegar at 13% appeared to perform better than Vinegar at 10%. While we did not notice much difference between Vinegar 10% and 13%, at times it appeared to us that the 13% killed a few more weeds and common sense would support that. In future trials we are going to try Vinegar at 15% instead of 13%.

Further Results Graphs

The last four pages of the report are statistical data on the results done by Elizabeth Maynard, Phd. of Purdue University.

Conclusions and Discussion

All of the test materials and methods reduce weeding time by at least 32% when used to create a stale seedbed. In many situations these methods and materials will reduce weeding time by 75% or more (in the August trials weeding time was reduced by 200%). (Note: We have heard of a number of farmers and university researchers trying these

materials and flaming with larger weeds bigger than 1'- 2' in height and mature grasses as if these products were the conventional herbicide Roundup. They had no or little success, claiming these products do not work. These spray materials and flaming are intended for use on *emerging weed seedlings*.)

From the farmer perspective the materials in ranking of effectiveness is as follows:
1. Flaming
(2. Burnout- but it is not certifiable and cost prohibitive)
2. Matran 5
3. Vinegar at 13%
4. Vinegar at 10%

Flaming is the only organically approved option that dealt with young grasses. (Note: Matran EC in a higher dilution rate than used in these trials is thought to kill young grasses.)

The LP flaming is the most convenient to use, but the least favorite due to it being a non-renewable resource. We have had some problems with the herbicides eating sprayer seals and gaskets. Care must be used to add all the water before adding the herbicides and a good washing afterwards. Vinegar was the second easiest to use and seemed less hard on the gaskets. Also on our backpack sprayers we started off using a diaphragm sprayer only to experience multiple diaphragm failure. After switching to a piston sprayer we did not experience sprayer failure.

At Rhoads Farm we will use all these materials and methods in our *stale seedbed arsenal* depending on the season and weed pressure. Basically our current strategy looks something like this:
1. Areas with grasses or purslane we use the LP flaming.
2. Moderate weed pressures we use Matran 5.
3. Moderate to slight weed pressures we use 10% or 13% vinegar.

The timing of application of these products can be played with and adjusted for different crops to increase their effectiveness. Variables that can be played with include:
1. Length of time of letting seedbed set before application.
2. Doing planting before application of herbicides and timing treatment to 1-2 days before crop germination.

Many of the plantings at Rhoads Farm have a sheet of clear plastic laid over the prepared seed bed to speed up germination of weeds, in some seasons to get some weed kill due to solarization, in the spring to bring soil temperatures above the germination threshold of chickweed and to preserve the soil texture of the prepared seed bed. (Note: These herbicides and flaming do not kill established chickweed clumps that have over-wintered.)

Costs Analysis

Getting cost figures from small test plots like this can be a little difficult. Typically we manage our farm on 3' x 100' growing beds. In using these herbicides in our daily production we generally consider that we are investing under $20 in materials and labor to use an organic herbicide and even less with the LP flaming. Hand weeding the same size area for us typically is a 10-15 hour expense, which is very much more expensive than setting up a stale seedbed with an herbicide.

In figuring costs from these trials several factors need to be considered. The first of those factors is **weed density**. The first trials were in an area that is far weedier than we typically encounter. This is due to the test area being in a place where raw manure was placed the year prior giving a much higher concentration of weeds. In this trial ½ gallon of mixed spray material was used on each 3' x 5' test plot. In the third trial, where there were far fewer weeds, ½ gallon of mixed spray material was used for all three- 3' x 5' test plots in the trial.

The other factor that needs to be addressed in estimating the amount of spray to be used is the type of weeds. In the second trial there were weeds that are harder for the herbicides to kill such as purslane and grasses. In an effort to give the treatments a better chance to possibly kill those weeds, 1 gallon of spray material was used on each 3' x 5' test plot. So the second factor to consider for how much spray and at what concentration to use it at is **type of weeds to be killed**.

The third factor in determining how much spray material to use is **weed size**. In the second trials we had allowed the weeds to grow to 4"-8" tall, much larger than what we typically do in the field. Obviously taller weeds need more spray material to kill the weeds.

The three factors to consider are:
1. Weed density
2. Weed types
3. Weed size

Some experience is necessary to be able to gauge these three factors. Hopefully this report can be a beginning place in determining what to use when in what concentration.

With all those factors in mind here is the following cost table.

Product name	Price per gallon	Price for in-field use with low being 3 gallons per 300 sq feet and 6 gallons for the high amount or greater concentration
LP Gas	$1.00 pound	Low 3 pounds- $3.00 High 7 pounds- $7.00
Vinegar 10%	$2.03	$6.09- $12.18
Matran EC @ 5 ozs/ga	$2.05	$6.15- $12.30
Vinegar 13%	$3.03	$9.03- $18.18
Matran EC @ 10 ozs/ga	$4.10	$12.30- $24.60
Burnout II	$18.40	$55.50- $111
Hand weeding	$8.00/hr	5-15 hours or $40-$120

Note- Labor of herbicide application for 300 sq feet is about 0.5 hour.

These costs are in line with what we experience in the field with daily use of these herbicides. They are very effective for us because most of our weed pressure is weeds that kill readily with these products. We do not use these herbicides to try and kill larger weeds (4" and up), where their effectiveness and therefore their costs go up.

It cannot be stated enough times that these herbicides in our opinion work best in setting up a stale seedbed for closely grown crops that will not outcompete weeds by themselves. This is for crops like salad greens, carrots, beets, cilantro, etc. The weeds should be under 4" in height to get good kill. And the herbicide used and the concentration it is used in must be matched up to the type, density and size of weed to be killed.

How useful was this project to your farm and can other farms use this?

We have spent several years experimenting with these methods, with each year seeing improved control of weeds, reduction of labor and increase of overall profit. Doing these trials in many ways wraps up our learning in their use with some fine tuning yet to do. We make use of these methods with almost every crop we grow, whether it is a short lived crop like salad greens or something in the ground all season like tomatoes or squash.

Doing these trials has led us to the next area of weed control management that we are beginning to explore, a greater use of cover crops and mixing cover crops with field crops. We think making use of these techniques could be of value to many farms with many different crops and in many different applications.

What would you do differently and what happens next?

We have arranged in 2006 to increase the scope of these trials with two other farmers in two other states and three research universities' extension services. In these extended

trials we want to detail more specific information about protocol for using these techniques with specific crops, explore a larger range and stronger dilution rates with vinegar and test all the available products that are on the market. I also have designed a weed counting box to give a more accurate method of determining weed coverage percentages both before and after treatment to help quantify data more accurately. The results of those trials should be available at SARE in early 2007.

Weed Counting Box Details
In performing these trials it was thought that an accurate and fast method of determining weed percentages in the trial plots for future research was needed. For the 2006 trials I designed a weed counting box and OFRF has asked me to report on the design of that weed counting box.

I constructed a wood rectangle the size of the test plots, 3' wide x 5' long. This rectangle was constructed of 1"x 4" wood. The bottom and top of this "box" was left open. Across the 3' wide top was nailed a series of lathe strips 1"x 1.5" x 3'. On the bottom side of the lathe strips was a series of 16d nails that projected approximately 2" from the lathe strips. As the counting box was placed on a 3' x 5' test plot the nails would be resting approximately 1" off the ground. Each nail touching a weed was considered a hit and nails not touching weeds were misses. All the nails or counters were kept at least 6" from any edge of the counting box to ensure no effect from adjacent plot treatments.

I made several different versions of the counting box wanting to have as few nails to count to determine weed coverage percentage as possible to speed up conducting the weed trials. I then tested the various boxes for accuracy, testing boxes of 20, 25 and 40 and 50 nails. (The 40 and 50 box trials were made by moving the 20 and 25 count boxes to two locations within one plot.) It was discovered that the boxes with 50 points would give the same results over and over within 2-4% of accuracy, which is sufficient for these trials. Therefore the last version of the counting box had 50 nails or counters. The number of hits or weeds touching a nail would be multiplied by 2 giving the percent of weed coverage of that plot. For example if 30 of the 50 nails were touching or directly above a weed in the case of very short weeds, then the plot had 60% weed coverage. If after herbicide weed kill there were 3 weeds touching nails the weed coverage after application was 6%.

Further Notes on Organic Herbicides
All of these herbicides (except flaming) are restricted products. My certifier is interpreting that as they cannot be used as the "sole" means of weed control. That we use cover crops, tilling and hand weeding along with the organic herbicides allows us to make use of them.

Burnout II is not certifiable having a mineral carrier. In the trials we performed in 2006 this was also the case with Dow Chemicals herbicide Scythe. (It took me weeks to get this information from them.) Using a product with a mineral carrier is a violation of one's certification. My certifier did not write me up as a violation in the several trials I did on small test plots with Burnout II but agreed with me I should not to use it again. The

manufacturers of Burnout II reported to me that they were not considering changing the formulation to be certifiable. Dow Chemical was thinking of changing Scythe to be certifiable. Burnout II is comparably expensive and not really applicable to larger areas.

To date the organic herbicides we have tried here on our farm are:
Matran EC- a clove oil-based herbicide
Weedzap- clove and cinnamon oil
Alldown- Vinegar and acetic acid
Vinegar- apple cider vinegar
LP Flaming
(Do a web search and see the manufacturer labels for exact contents of products. And see the 2006 group SARE project doing more advanced trials of these products in various strengths of dilution.)

There is one other organic herbicide on the marker that we are aware of. This is Eco-exempt which like Matran is made by Ecosmart. This organic herbicide contains 21.4% 2-phenyl propionate in addition to the formulation used in Matran. It is more expensive than Matran and designed for the home garden market and not farms.

The apple cider vinegar comes in 200 grain or a 20% dilution. It is further mixed with water for more dilution. An earlier study by a garlic farmer measured acidity before and after applications and found there to be an increase in soil acidity.

Outreach

Rhoads farm did a farm tour in which these trials were presented on September 1, 2005.

Rhoads presented this information on the New Ag Network website. The NAN is a Midwestern collaborative effort of organic farmers and researchers primarily in Indiana, Illinois and Michigan to share organic farming techniques. http://www.new-ag.msu.edu/

It is planned that at the 2006/07 Indiana Horticultural Congress that a presentation about the results of these trials will be given. Writing of articles for magazines has been delayed until after the 2006 trials of all the available organic herbicides on the market.

Elizabeth Maynard, Purdue University, presented at the 46th Annual Meeting of the Weed Science Society of America, February 13-16, 2006 an oral abstract presentation, *Evaluation of essential-oil based herbicides for weed control,* based on this study and preliminary joint trials with Rhoads Farm.

Rhoads Farm and two other farmers in two other states and University Extension personnel in those states are planning on doing a larger version of these trials at three locations in 2006 for information to be included in a comprehensive organic weed control manual.

Rhoads have highlighted presenting information about these trials at a presentation at the Southern Indiana Vegetable Growers meeting in March 2006.

Photos [Some photos provided here. Visit ofrf.org for additional selected photos.]

Photos for Trial #1 did not turn out for unknown reasons

Trial #2 Photos

 Photo 1.

1. Shows test area on June 15th before any treatment is made. Many of the weeds are purslane and all weeds were allowed to get a little larger than we usually let them get before killing.

2. Gives an idea of the size and kinds of weeds in this area.

3. Shows treatment area day after treatment. Notice the dead but still standing weeds. The green weedy areas are untreated plots.

4. This pic and the next were taken on June 21st. Notice untreated areas with lots of weeds. Dead weeds have deteriorated from picture 3 taken one day after treatment. Purslane is partially re-generating from burn down.

5. Shows Vinegar 13% and an untreated area in background. Vinegar 13% killed most of the purslane but some is re-growing. Notice the dead purslane stalks on the ground.


Photo 6.

6. This pic shows a Matran 5 area in the foreground and Vinegar 13% in the middle ground with a Burnout area behind them. It is evident the Matran killed more purslane than the Vinegar 13% and the Burnout killed most of its weeds.


Photo 7.

7. This picture shows the Vinegar 13% seen in the last picture and then starting with the stake, two Burnout areas, a flaming area and an untreated area. The Burnout is expensive and not allowed in certified production but works. It can be seen that the

flaming area not only has few, if any weeds, the weed stalks have dried up and disappeared.

8. This is a closer view of the last of the Burnout areas described in picture number 7, with the flaming area next and the untreated area in the top of the picture.

9. This picture shows from the first stake back Vinegar 10%, Vinegar 13%, Flaming (notice the bare ground) and then two more Vinegar 10% areas, a flaming area, a Matran area and the last untreated area. There was a lower concentration of weeds on this end of the test plot.

10. Shows four rows of corn on the right. The row that is clear of weeds was burned with LP when corn was 10 days from germination. Notice this row is relatively weed free when compared with other rows. Also see some burned leaf tips on the burned row that does not affect corn growth.

Trial #3 Photos


Photo 11.

11. Not the best pics, we have high humidity but it is not that bad! Pic was taken August 28th. In the middle of the picture in the rows running away starting from the left of the photo is a row of parsley, an area germinating weeds, a pathway that shows up green, the test area stakes, the test area to the right of the stakes and then another area germinating weeds then three rows of some other plant and on off into the edge of the photo. This test was a little different: we planted before applying the treatments. The planted area is just to the right of the stakes and compares with the area just to the right of it (3'-4') that has not been planted into. Planting into the standing weeds kills some weeds and increases effectiveness of treatments.

12. This is a closer view of #11. The planted area had just as many weeds as the area to the right that is germinating weeds awaiting planting. Most of the weeds are hairy

galinsoga. This field has no purslane in it. This picture was taken prior to treatments and three days after planting, timed to kill weeds right before crop seed germination.


Photo 13.

13. Shows the area five days and 3" of rain later. Treatment was made five days ago and areas are relatively weed free. You can see in the untreated area in center of photo how the weeds have really grown. Treated areas are almost 100% clear of weeds.

14, 15 & 16. These three pictures show various treatment areas, almost all weed free. Even the 10% Vinegar kills hairy galinsoga.


Photo 17.

17. Shows the same planting of the last several photos at time of harvest. Treatment area is the second 3' wide salad baby lettuces bed from the left. Treatment area can also be recognized in the photo by the large quantity of red lettuces. Notice weeds on untreated paths that someone was hoeing as pictures were taken. Greens bed to the far left had weeds killed and was planted one week after treatment area. Notice it also is

fairly weed free. The next planting or 3’ wide bed to the right of the treatment area shows poor timing of use of these techniques. This was done on purpose to show timing importance. This area had weeds killed with treatments one week prior to crop planting. See next picture.

18. In this picture the treatment area is on the left, mostly red lettuces and relatively weed free at harvest time. The 3’ wide lettuce bed to the right was planted one week after weed kill and many emerging hairy galinsoga weeds can be seen emerging. These weeds would have been suppressed with proper timing of planting to weed kill.

Other Photos

19. Shows herbicide spotty kill on heavy chickweed in greenhouse in late winter.

20. Shows spotty kill of herbicides on chickweed in early spring.

21. Shows clear plastic seed bed conditioning we often use after beds are prepared and used to germinate weeds.


Photo 22.

22. Shows an area that had the 10’ wide plastic on it in June. Notice some weed kill from solarization in center of the weedy area in center of picture. Notice no weed kill within 1’-2’ of where edges of plastic were. We are planning on more work with solarization using 20’ wide by 100’ long plastic sheets.


Photo 23.

23. Another picture of corn trials. Corn row on left had weeds killed with 5 minutes labor with Matran EC. Center row of corn took 30 minutes to hoe.

24. Another corn picture showing hand weed row and the next row that can be either burnt with LP or herbicides to leave a corn row relatively weed free until harvest.


Photo 25.

25. The next two pictures are of a field that hairy galinsoga was allowed to seed in the year prior to these pictures. On the right is a baby lettuces area that is filled with hairy galinsoga weeds. On the right no stale seedbed was created and no weed management treatment was used as an illustration of how effective these techniques can be, even in areas with heavy weed pressures. On the left is a planting that was allowed to germinate weeds the same time as the planting on the right was made. Ten days later Matran EC was used to kill weeds and baby lettuces were planted. This picture was taken 10 days after application. Area is still relatively weed free and rows of germinating baby lettuces can be seen.


Photo 26.

26. The same field as in picture 25 two weeks later. On the right the galinsoga was weeded, with much effort, one half the way down the field. In the remainder of the field in the background the hairy galinsoga was not weeded, is now 6-8” tall and overgrown the lettuces crop, killing it. No applications or treatments were made on the right hand side. On the left can be seen the area that was treated. While some weeds germinated, this field under heavy weed pressure will still produce a crop.

27. After chickweed had been tilled and cleaned from planting bed, greenhouse is too warm to germinate chickweed and hairy galinsoga has been allowed to germinate on beds and paths. This picture shows the beds after Matran EC application and kill. Notice a few weeds still in beds probably from inconsistent spraying. Note weeds on paths.

Photo 28.

28. Same area in greenhouse 10 days later. See germinating lettuces in beds relatively weed free and weed choked paths.

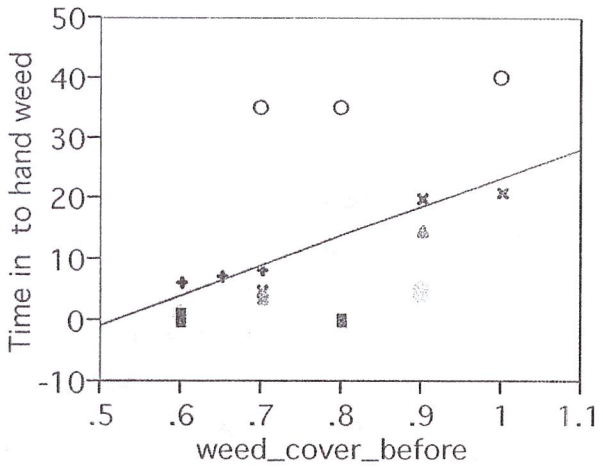
Analysis of the Relationship between Weed Cover before Weed Control Treatment and the Time Required to Handweed

In June the percent of ground covered by weeds was estimated before treatment. It ranged from about 60% to 100%. The analysis of variance, which included percent weed cover as a covariate, showed that the percent weed cover prior to treatment influenced the amount of time it took to weed plots after the treatment. This relationship, between percent weed cover before treatment (wcbt), and the time to hand weed (time) was further explored using regression analysis.

Figure 1 shows the relationship between wcbt and time. A little over ¼ of the variation in the time it took to handweed plots could be accounted for by the weed cover prior to treatment. For the range of weed cover in the trial, each additional 10% of ground covered by weeds, required on average an additional 4.8 minutes of weeding.

Legend for Figs. 1,2, 3, 4
X (blue) = Vinegar 13%
+ (blue) = Vinegar 10%
Triangle (green) = Matran
Rectangle (red) = Flame
Solid Circle (yellow) = Burnout
Clear Circle = no treatment

Fig. 1 Time to hand weed versus proportion of ground covered by weeds prior to weed control treatment.



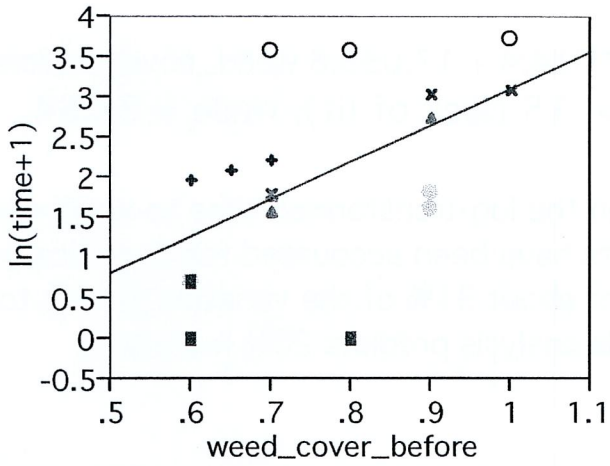
Linear Fit

Time to hand weed (min) = -25.1±15.5 + 48.3±20.0 weed_cover_before

$r^2 = 0.267$, $P < .05$ (linear fit), $P > .50$ (lack of fit), rmse = 11.48

Figure 2 shows a similar relationship, this time using the log-transformed values for the time to handweed, in order to better meet the assumptions of the statistical analysis. This is the same transformation that was used in the analysis of variance. With this analysis, about 30% of the variation in the time it took to handweed plots could be accounted for by the weed cover prior to treatment. For the range of weed cover in the trial, this analysis would predict that weed cover of 60% would require double the handweeding time of weed cover of 50%; and weed cover of 90% would require about 2/3 again as much time as weed cover of 80%.

Fig. 2 Relationship between log-transformed time to handweed versus proportion of ground covered by weeds prior to weed control treatment,



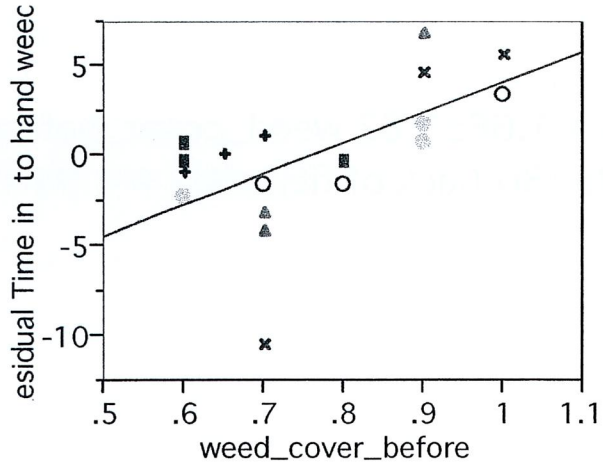
Linear Fit

ln(time+1) = -1.50±1.35 + 4.58±1.73 weed_cover_before

r^2 = 0.304, P < .025 (linear fit), P > .50 (lack of fit), rmse = 0.9946

Figure 3 shows the relationship between time and wcbt after the effects of the treatments have been accounted for statistically. In this analysis, weed cover accounts for a little over 1/3 of the variation in time to weed. For each 10% of weed cover, this analysis predicts an additional 1.7 minutes of weeding required beyond the average for that treatment.

Fig. 3 Residual time to hand weed (after fitting treatment effects) versus proportion of ground covered by weeds prior to weed control treatment.



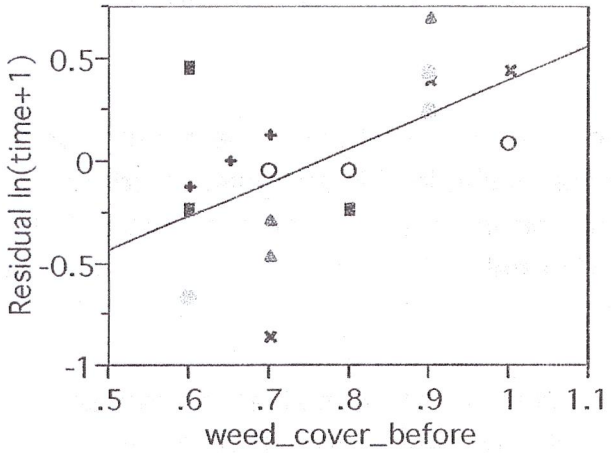
Linear Fit

Residual Time to hand weed (min)= -13.0±4.4 + 17.0±5.6 weed_cover_before

$r^2 = 0.362$, $P < .01$ (linear fit), $P > .15$ (lack of fit), rmse = 3.234

Figure 4 shows the relationship between the log-transformed time to weed and wcbt after the effects of the treatments have been accounted for statistically. In this analysis, weed cover accounts for about 31% of the variation in time to weed. For each 10% of weed cover, this analysis predicts 20% more time required for weeding.

Fig. 4 Relationship between the residual of log-transformed time to handweed (after fitting treatment effects) versus proportion of ground covered by weeds prior to weed control treatment,



—Linear Fit

Linear Fit

Residual ln(time+1) = -1.27±0.48 + 1.66±0.62 weed_cover_before

$r^2 = 0.311$, $P < .025$ (linear fit), $P > .30$ (lack of fit), rmse = 0.3549

E. Maynard, January 11, 2006