PROJECT REPORT

Final project report submitted to the Organic Farming Research Foundation:

Project Title:

Effectiveness and economic impact of weed control systems in organic garlic production

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ORGANIC FARMING RESEARCH FOUNDATION

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Project Summary

Weeding hardneck organic garlic (*Allium sativum* L.) is a time consuming but necessary job. Garlic is unable to compete with weeds. Even moderate weed coverage can severely reduce garlic yield and bulb size. In addition, since garlic is a 9 month crop the organic farmer must combat multiple flushes of weeds. To help organic farmers choose suitable weed control, we evaluated the effectiveness of four different weed control methods on two varieties of organic hardneck garlic, German Red and Georgian Crystal. Pre-planting weed control included solarization or stale seedbed technique. Solarization used plastic placed over the crop bed to heat up the soil and kill weed seedlings and seeds. Stale seedbed technique used repeated shallow cultivation before planting to destroy emerging weeds. Post-planting weed control compared hand weeding with flame weeding. We evaluated weeding time, weed coverage, garlic bulb weight (total yield), garlic bulb size, and the economic feasibility for all weed control methods.

Solarization significantly reduced weed coverage by 1% compared to stale seedbed. Interestingly, solarization significantly decreased total garlic yield by 10% and bulb size by 5.5% compared to stale seedbed. This is an economically significant loss. Solarization cost more per plot than stale seedbed. Flame weeding was slightly faster than hand weeding in the first month of weeding. However, there was no difference in time between hand and flame weeding over the weeding season. Flame weeded plots remained weedier and had three times more weed coverage than hand weeded plots (3.7% compared to 1.3% weed coverage). This difference was enough to be noticed in the field plots. Most of the weeds present were flame resistant perennials and grasses. Flame weeding was approximately a third more costly than hand weeding. There was no difference in garlic bulb size between flame and hand weeding. However, German Red weeded by hand was 11% heavier than flame weeded German Red. There was no difference in garlic weight between hand or flame weeded Georgian Crystal. The most economically effective weed control method, as measured by cost of weed control per pound of garlic, was stale seedbed followed by hand weeding.

Intro to Topic

Organic gourmet hardneck garlic is an excellent niche market for small hard working farmers. This is a high value crop that can profitably be grown on a few acres. Demand for organic gourmet garlic is growing and the supply cannot keep up with the demand. As a result, interest in garlic production is increasing. Unfortunately, organic hardneck garlic is extremely labor intensive. Almost all work must be done by hand to preserve crop quality and extend storage life. The prospect of hand weeding an acre or two discourages many potential growers.

The most labor intensive aspect of organic garlic growing is weeding. Weed control is time consuming for several reasons. First, garlic's nine to ten month growing season forces growers to combat multiple flushes of emerging annual weeds. Garlic must compete with winter annuals as well as spring and summer annuals. In addition to annual weeds, perennials such as field bindweed (*Convolvulus arvensis),* Canada thistle (*Cirsium arvense*) and quackgrass (*Agropyron repens*) can also be a problem. Second, garlic plants emerge slowly in the spring and never form a canopy to discourage weed growth. Due to their short upright leaves, even vigorously growing healthy garlic cannot outcompete weeds. Weeds can quickly overwhelm a garlic field.

Controlling weeds in Allium crops such as garlic is very important. Weeds compete for available nutrients and water. Taller weeds block the crop's access to light. This can substantially reduce garlic growth and yield. According to a garlic weed study by Agamalian and Kurtz (1989), poorly controlled weeds may cut garlic yields in half. In addition, heavy stands of weeds can reduce air movement around the crop. This can promote diseases such as garlic neck rot. Since weed control is dependent on effective integrated farming systems, not single isolated components, our research focused on both pre-planting and post-planting weed control.

The weed control methods solarization, stale tillage, hand weeding and flame weeding were selected because they are common among organic producers. Studies report that solarization reduces weed coverage and increases yields in horticultural crops when compared to conventional tillage. When we conducted this experiment, I expected to see a decrease in weeds and no change or a slight increase in yield in the solarized plots when compared to stale tillage technique. I also expected flame weeding to be a faster method of weed control when compared to hand weeding. The actual results, in particular the 10% yield reduction caused by solarization, surprised me.

Objectives Statement

Project objectives were:

a) To determine which weed reduction system is the most economically effective by:
    1) Determining total labor and material cost for each weed control system.
    2) Determining effectiveness of each weed control system by recording percent weed species emergence and percent weed cover throughout the year.
    3) Determining total garlic yield for each weeding system.
    4) Determining garlic quality, as measured by bulb size, for each weeding system.
b) To disseminate the results obtained through this experiment to other organic producers through an article in HortScience or similar reputable journal, articles and handouts for Rural Roots and/or Master Gardeners, a farm field day, several informative power point research seminars for growers and researchers, information provided to county extension offices and inclusion of all results in Grey Duck Garlic's website.
c) To promote organic agriculture and our research, we placed a large sign in front of the garlic field next to the road. This sign contains our business name, "Organic Garlic Weed Trials" and "Sponsored by Organic Farming Research Foundation" in large print.

Materials and Methods

Garlic Field Site: The trial occurred at Grey Duck Garlic's certified organic farm (certification #1883) in the Palouse region of Washington. The farm is certified by the Washington State Department of Agriculture Organic Food Program and has been organic for three years. No synthetic fertilizers, pesticides, herbicides or fungicides had been used on the farm for the previous seven years before certification. The garlic field site is relatively flat, uniform and sunny. The topsoil is high quality silt loam that is over eight feet thick.

Field Preparations: Soil is amended with a green manure cover crop and through raw organic material (horse and cattle manure) added before planting. Amendments are plowed under with a 1950's John Deere tractor. A commercial tractor tiller is used to prepare the four foot garlic beds to a depth of 9-12 inches. Hardneck garlic is rotated with a green manure crop of buckwheat, fava beans and/or green peas. The garlic is not irrigated. Soil tests are taken in spring and fall. Previous soil tests have indicated that all nutrients are high except nitrogen levels. Garlic is top dressed with blood meal in late November and early May to provide the appropriate level of nitrogen.

Garlic Planter

Our garlic planting time was significantly speeded up after Chris built a garlic planter. The garlic planter was made out of two pieces of ½ inch plywood (2' by 4'). Sharpened/tapered 7" long and 1" diameter wood dowels were placed 6" apart across the 2' side and 8" apart across the

4' side of the plywood creating a 3 by 6 pattern (total = 18 spikes). Holes were drilled through one piece of plywood creating a centered pattern of holes according to the above specifications. The second piece of plywood was glued and screwed to the first drilled piece of plywood creating recessed holes. The flat end of the 1" diameter wood spikes was screwed and glued into the recessed hole. Rope handles were placed on both ends. After the bed was tilled, two people would place the garlic planter on top of the plots and step on the top of the planter creating 18 evenly spaced and straight holes for planting cloves.

Rainfall: The Palouse region of Washington is normally very dry with an average rainfall of less than 19 inches a year. After several years of drought, last year we had an unusually wet year with 20 inches of rain during the garlic growing season alone. This flooded the lower part of our garlic field in the spring. We were able to avert tragedy by quickly draining away the excess water.

Seed varieties: We used two popular commercially grown premium hardneck garlic varieties, Georgian Crystal (GC) and German Red (GR). Georgian Crystal is a vigorous variety that does well under almost all conditions. German Red is an heirloom variety obtained locally that is more sensitive to soil fertility and weed competition. Planting cloves were uniform in shape and weighed 9-12 grams.

Experimental design: Experimental design was a split plot randomized block design (see Diagram 1). The two main treatments were pre-planting solarization and stale seedbed technique. The subplots were garlic variety (GR or GC) and weeding method (flame or hand). Each of the larger main plots contained four randomized subplots: GR flame weeded, GR hand weeded, GC flame weeded or GC hand weeded. There were four repetitions per main plot treatment for a subtotal of 16 plots (total 32 plots). This was a large experiment covering approximately 1/10 of an acre and containing 8,000 garlic plants.

Figure 1: Experimental Design for Organic Garlic Weed Control. Two garlic varieties, German Red (GR) and Georgian Crystal (GC), were grown under four weed control methods: solarization, stale seedbed, flame weeded (flame) and hand weeded (hand).

Fence

	Stale Seedbed		Solarization	
1	Flame GR	Hand GC	Hand GR	Hand GC
2	Hand GC	Flame GC	Flame GR	Flame GR
3	Flame GC	Hand GR	Hand GC	Hand GR
4	Hand GR	Flame GC	Flame GR	Flame GC
5	Flame GR	Flame GR	Flame GC	Hand GR
6	Flame GC	Hand GR	Hand GC	Flame GR
7	Hand GR	Hand GC	Hand GR	Flame GC
8	Hand GC	Flame GR	Flame GC	Hand GC

Plot and spacing: Plots were approximately 48" by 252" (4 x 21 feet) with six garlic rows spaced eight inches apart. Each plot contained approximately 250 garlic plants. Garlic was planted the week of October 20th, four inches deep and six inches apart within each row. We used a homemade garlic planter to ensure even spacing.

Mulch and emergence: Plots were mulched with four to six inches of straw immediately after planting. The purpose of the straw was to protect the garlic cloves and newly emerged garlic from sudden soil temperature shifts during the winter. Heaving during the winter can expose cloves and damage the garlic. The straw mulch was somewhat detrimental to our flame weeding efforts due to its tendency to suddenly catch fire. To prevent field fires and reduce any interference with weed control methods, we removed about 85% of the mulch in the weed experiment the first week of May. The small amount remaining on the plots did not appear to interfere with weed removal or influence weed growth. Garlic emerged in late February.

Weed control: Pretreatment: The plot was divided into either stale seedbed technique or solarization. In stale seedbed technique the crop bed was cultivated on Sept 6th approximately 6 weeks before planting to encourage a flush of weed growth. Shallow tillage every 2 weeks (on Sept 20, Oct 4, and Oct 18) was used to destroy emerging weed seedlings. In solarization, clear UV resistant plastic was anchored over the soil using concrete blocks and pallets on Sept 6th for 6 weeks. The plastic heats up the soil, killing weed seedlings, reducing weed germination rate and destroying pathogenic soil organisms.

Garlic in the plots was weeded either by hand or by flame weeder (Weed Dragon®, propane torch) weekly from May 12th to July 7th (a total of nine weeks). The flame weeder, Weed Dragon, was a hand-held unit with a long nozzle attached to a propane tank. The operator is able to control the heat and size of the flame. After July 7th weeding was discontinued due to low weed coverage, dry weather and high risk of fire. Plots remained virtually weed free until harvest. All plots were weeded on the same day. Weed species composition was evaluated using a plant transect line placed down the middle of the plot. A 20 foot transect line was knotted every 6 inches. This line was rolled down the 3rd row of each plot. Every weed that touched a knot was recorded. This information was used to determine weed species composition. Weed coverage was evaluated visually using total percentage of plot covered with weeds before the plot was weeded each week. Time spent weeding the entire plot was recorded for each week. Aisles were also hand weeded weekly from May to July for weed control. The area around the research plot was rototilled to control weeds. Removal of the garlic 'seedhead' or scape occurred on July 6th and 7th.

Bulb yield and quality: Bulbs were harvested on August 12th and 13th. Bulbs were cured for 6 weeks in an airy barn before taking yield measurements. To reduce edge effect and any possible damage from cultivation, 140 garlic bulbs from the middle four rows of each plot were used to collect data on bulb yield and size (5,040 bulbs total for the experiment). Bulb weight was measured to the nearest tenth gram on a digital scale. Bulb size was measured to the nearest fourth inch using a homemade bulb measurer.

Statistical analysis: Data analyses were conducted using the PROC MIXED and GLM procedures in SAS® version 9.1 (SAS® Inst., Cary, NC). Weeding times and weed coverage were analyzed using PROC GLM for repeated measures. Tukey's HSD was used to perform post-hoc analysis. Tukey's HSD is basically a t-test that performs a pairwise comparison for each possible set of means. Statistical comparisons were considered significant at $P \leq 0.05$.

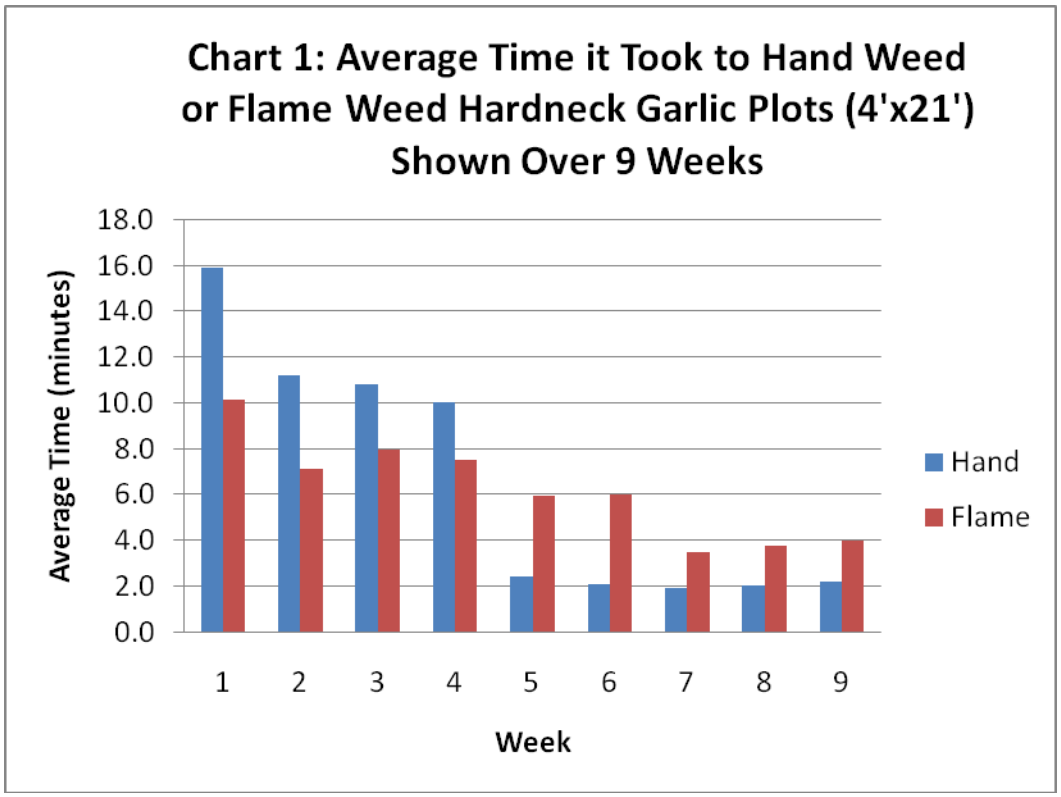
Project Results

Solarization reduces weed coverage compared to stale seedbed technique:
Solarization significantly reduced overall weed coverage by 1% ($p < 0.0001$) compared to stale seedbed. Weed coverage averaged 3% with stale seedbed and 2.1% with solarization. Solarization can kill weed seeds in the upper levels of the soil.

Solarization decreased garlic bulb size and weight compared to stale seedbed technique:
Solarization significantly decreased garlic bulb size by 5.5% and garlic bulb weight by 10% compared to stale seedbed ($p < 0.0001$ for both). Garlic bulbs in plots treated with solarization averaged 2.2 inches across and 76.9 grams. In contrast, garlic bulbs in plots treated with stale seedbed averaged 2.4 inches across and 84.8 grams. This is an economically significant

difference. Average yield with solarization was 13,550 lbs/acre compared to 14,943 lbs/acre with stale seedbed. Stale seedbed increased yield by 1,393 lbs/acre.

There was no difference in the time spent weeding between flame and hand weeding:
Flame and hand weeding took an average 6.2 and 6.5 minutes per plot, respectively, during the weeding season. These two weeding methods were not significantly different over the entire weeding season. Flame weeding took significantly less time than hand weeding (7.3 min/plot vs. 11.3 min/plot, $p < 0.001$) over the first month. At week 5 hand weeding became less time consuming (Chart 1) than flame weeding.

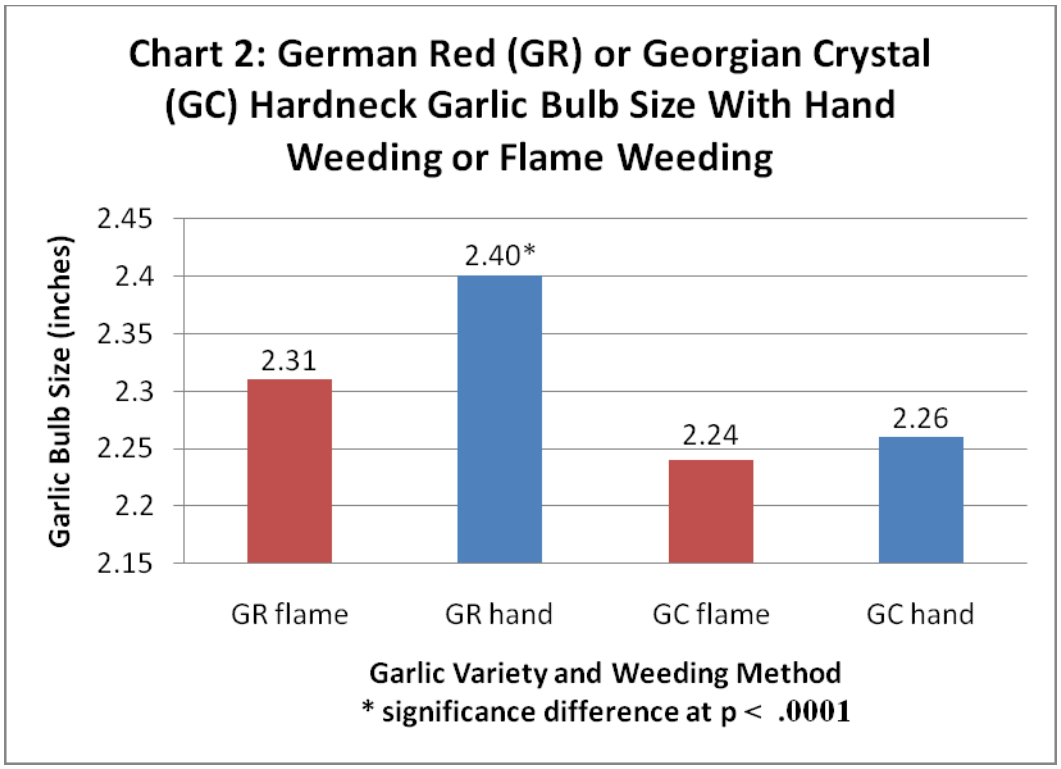


Bulb size was different between the two hardneck garlic varieties:
German Red was significantly larger than Georgian Crystal ($p < .0001$). Georgian Crystal bulbs averaged 2.24-2.26 inches across compared to German Red bulbs which averaged 2.31-2.40 inches across (Chart 2).

There was no difference in bulb size due to flame or hand weeding:
Weeding method did not significantly affect bulb size in either hardneck garlic variety.

Bulb weight was significantly heavier in hand weeded German Reds:

German Red was 11% heavier when hand weeded ($p < .0001$). Hand weeded German Red averaged 86.6 grams/bulb compared to flame weeded German Red at only 77.5 grams/bulb. This is an economically significant difference. There was no difference in bulb weight between flame and hand weeded Georgian Crystal (Chart 2).



Weed coverage was greater in flame weeded plots:
Weed coverage was recorded each week before weeding. Overall the weed coverage was three times greater in flame weeded plots than hand weeded plots (3.7% compared to 1.3% weed cover, $p < .0001$). This indicates that flame weeding was not killing as many weeds. Most of the weeds remaining in the flame weeded plots were noxious weeds that are flame resistant.

Economic Feasibility

Average cost for weed control:
Average cost for each weed control method was determined for each 4' x 21' plot using total material, labor and machine costs. Details of costs for each weed treatment are found in the Addenda**.** Average cost per plot for pre-planting weed treatment varied from a low of $1.90 for stale seedbed to a high of $10.69 for solarization ($5.31 for second year of solarization if plastic reused). Flame weeding costs per plot were $14.20 and hand weeding costs were $9.73 (Chart 3). Average cost for the combination weed control treatments are shown in Chart 4.

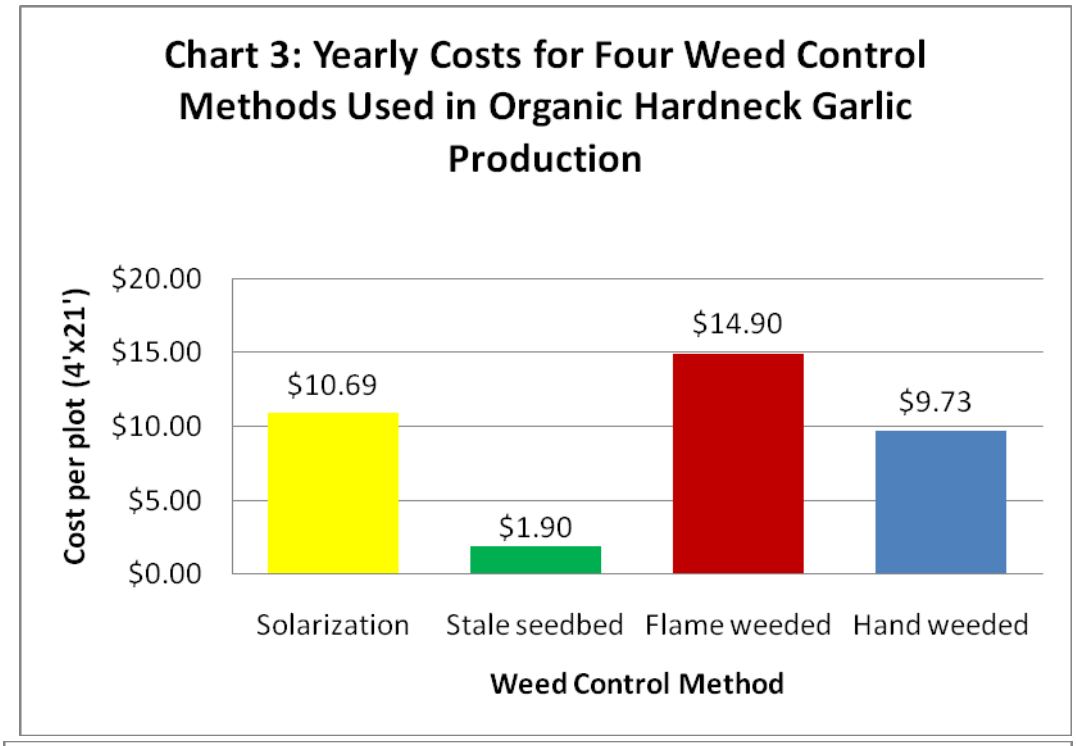


Chart 3: Yearly Costs for Four Weed Control Methods Used in Organic Hardneck Garlic Production
Cost per plot (4'x21')
$20.00
$15.00
$10.00
$5.00
$0.00
$10.69
$1.90
$14.90
$9.73
Solarization
Stale seedbed
Flame weeded
Hand weeded
Weed Control Method

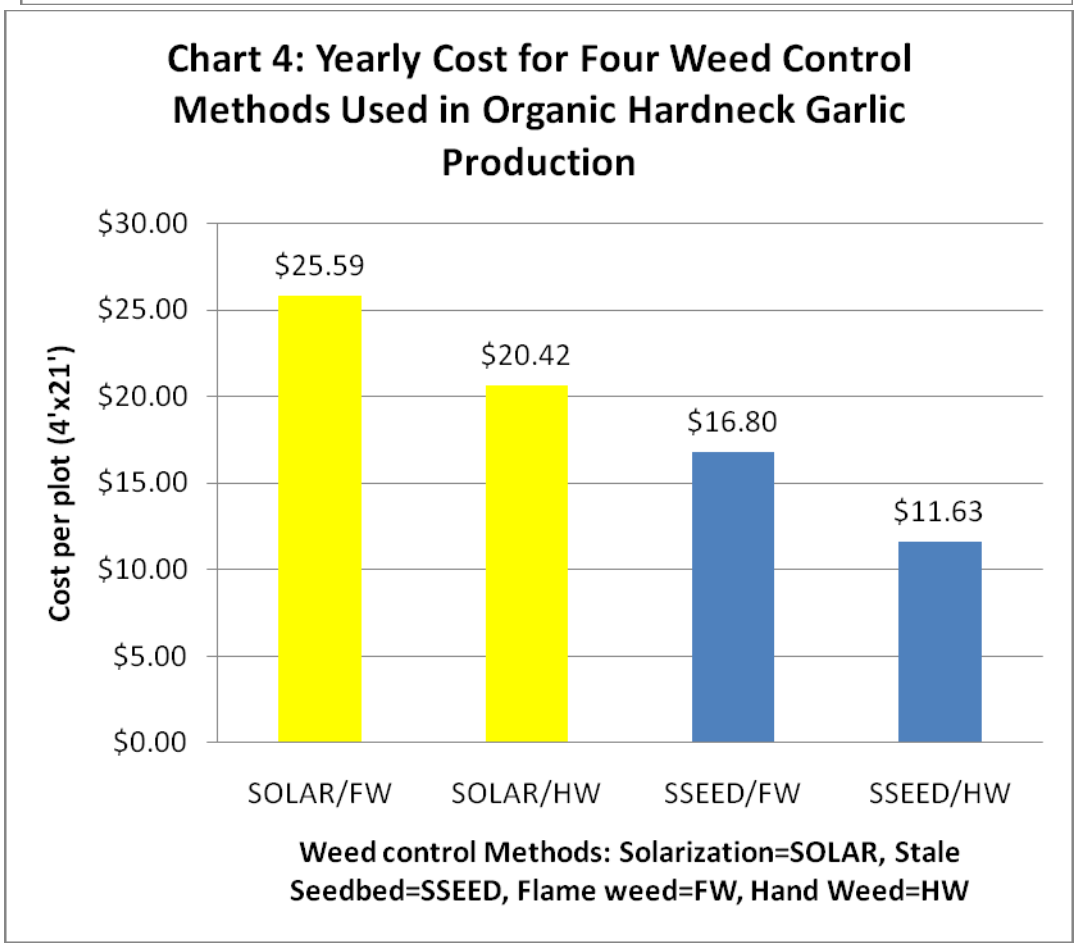
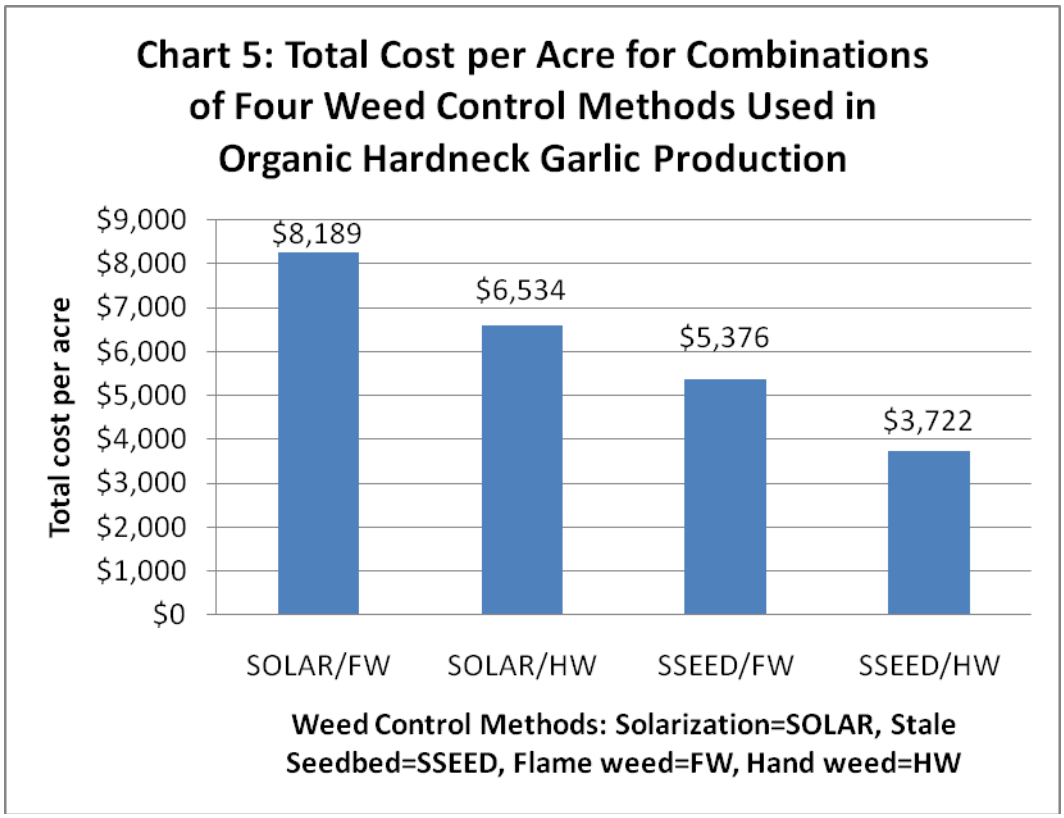


Chart 4: Yearly Cost for Four Weed Control Methods Used in Organic Hardneck Garlic Production
Cost per plot (4'x21')
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$0.00
$25.59
$20.42
$16.80
$11.63
SOLAR/FW
SOLAR/HW
SSEED/FW
SSEED/HW
Weed control Methods: Solarization=SOLAR, Stale Seedbed=SSEED, Flame weed=FW, Hand Weed=HW

Economic feasibility for weed control:

Garlic yield per acre was calculated assuming a garlic seeding rate of 80,000 plants per acre. This seeding rate is similar to our experimental plot (8,000 plants per 1/10 acre) and Grey Duck Garlic's normal planting rate. Garlic cost per pound was calculated using cost per acre (Chart 5) and total yield per acre (Chart 6) from each combination of weed control methods; solarization followed by flame weeding, solarization followed by hand weeding, stale seedbed followed by flame weeding, and stale seedbed followed by hand weeding. Economic feasibility for each of these weed control methods was determined using weed control costs per pound of garlic (Chart 7). Using these criteria, the most economical combination of weed control methods was stale seedbed followed by hand weeding. The least economically feasible was solarization followed by flame weeding. Stale seedbed followed by hand weeding cost only $0.25 per pound of garlic produced. Due to lower yield and higher weed control cost, solarization followed by flame weeding was the most costly at $0.61 per pound of garlic produced.



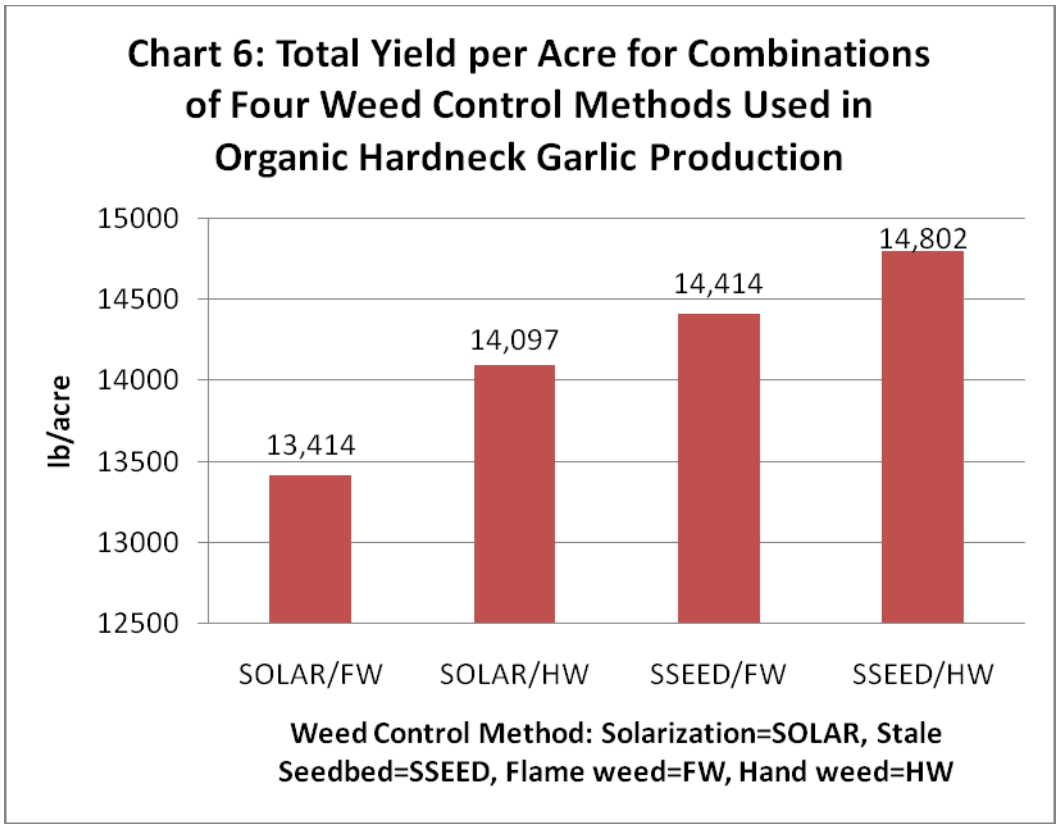


Chart 6: Total Yield per Acre for Combinations of Four Weed Control Methods Used in Organic Hardneck Garlic Production
lb/acre
15000
14500
14000
13500
13000
12500
13,414
14,097
14,414
14,802
SOLAR/FW
SOLAR/HW
SSEED/FW
SSEED/HW
Weed Control Method: Solarization=SOLAR, Stale Seedbed=SSEED, Flame weed=FW, Hand weed=HW

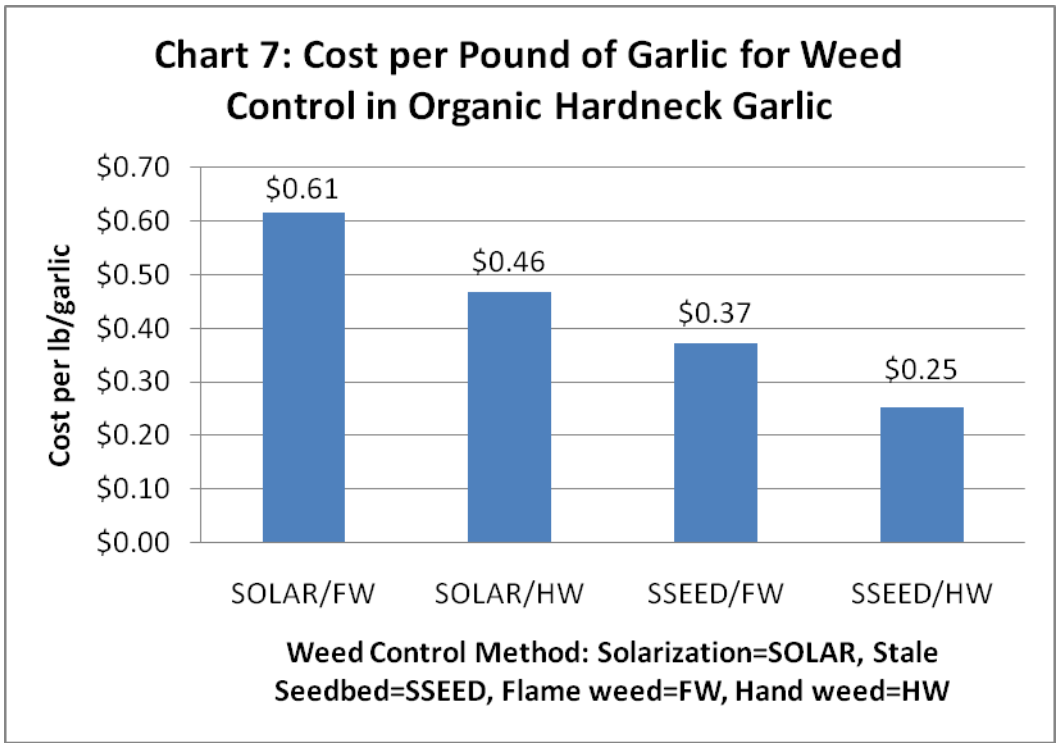


Chart 7: Cost per Pound of Garlic for Weed Control in Organic Hardneck Garlic
Cost per lb/garlic
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
$0.61
$0.46
$0.37
$0.25
SOLAR/FW
SOLAR/HW
SSEED/FW
SSEED/HW
Weed Control Method: Solarization=SOLAR, Stale Seedbed=SSEED, Flame weed=FW, Hand weed=HW

Conclusion and Discussion

Solarization reduced overall weed coverage by 1% compared to stale seedbed technique. There was no difference in weed species composition between the two weed control methods. Solarization heats up the top layers of the soil which can kill weed seeds and emerging plant seedlings. Solarization may also reduce or change the composition of soil microflora such as microorganisms and fungus. Although a 1% weed coverage reduction may not seem like a lot, even a small increase in weeds can add significantly to the weed seed bank in the soil.

Unfortunately, solarization resulted in a significant 10% decrease in total garlic yield as measured by bulb weight. This is an economically significant loss. Over an acre of intensively grown garlic, a 10% bulb weight loss could result in a 1,400 pound yield loss. Organic hardneck seed garlic is typically sold for $12-$24 a pound. Even assuming a low average of $14 a pound for garlic seed, this would be a $19,600 loss to the grower. In addition, the 5.5% decrease in bulb size would result in fewer premium sized bulbs. Garlic bulbs are priced by quality and size with the larger bulbs receiving premium pricing.

The decrease in yield with solarization is surprising since studies in different non-root crops have shown that solarization increases crop yield (Candido et al. 2008, Hasing et al. 2004, Stapleton 1997, Davis 1991). This loss in yield and size due to solarization may be caused by temperature shifts in the soil. Solarization has been reported to significantly increase soil temperature. Garlic prefers a cooler planting soil and develops smaller bulbs when planted in Southern areas compared to Northern areas. When planted in warm soil the garlic clove quickly develops a green shoot and has reduced root growth as a result. Garlic planted in a cooler soil develops a stronger root system which seems to lead to larger bulbs. Unfortunately, I could not find any studies looking at soil temperature and garlic yields. It is also possible that heating up the soil caused a decrease in available soil moisture, reducing yield.

Flame weeding was faster than hand weeding in the first month of weeding but slower than hand weeding the last month. Due to this, there was no difference in time spent flame weeding compared to hand weeding over the growing season. This contrasts with a previous study by Stonaker (2004) reporting that hand weeding garlic took approximately three times longer than flame weeding. Differences in flame weeding times between our two studies may be due to weed species composition in the field. In our study, flame weeding was extremely effective on tender annuals such as lambsquarter (*Chenopodium album)*. Lightly running the flame over the plants at a slow walking speed wilted and killed most young broadleaf annuals immediately. However, flame weeding was less effective on grasses and thistles. These resistant plants remained in the plot week after week even after repeated blasts with direct flame. It took more time to try to kill a large Canadian thistle with a concentrated application of heat than it would have to pull it up by hand. In addition, it was hard to deliver blasts of flame to resistant weeds without inadvertently scorching garlic stems.

Flame weeded plots remained weedier and had three times more weed coverage than hand weeded plots (3.7% compared to 1.3% weed cover). This difference was enough to be noticed in the field. Some weeds were very susceptible to flame weeding and were killed quickly and easily. These included hoary alyssum (*Berteroa incana*), field bindweed (*Convolvulus arvensis*), shepherd's purse (*Capsella bursa-pastoris),* lambsquarter (*Chenopodium album)*, henbit (*Lamium amplexicaule*) and houndstongue (*Cynoglossum officinale*). After the first month of weeding, over 90% **o**f the weeds present in the flame plots were perennials and/or grasses. The most common flame resistant weeds included perennial sow thistle (*Sonchus arvensis*)*,* Canada thistle (*Cirsium arvense*), Scotch thistle (*Onopordum acanthium*), quackgrass (*Agropyron repens*), some mustards such as hoary cress (*Cardaria draba*) and an annual grass, Downy brome *(Bromus tectorum).* These weeds were very resistant to flame weeding unless a concentrated blast of heat was aimed directly at the plant's stem until it begin to wilt. This procedure slowed down the pace of the flame weeding considerably. Similarly, grasses would simply sprout from their crown after being flamed. These resistant weeds would keep coming back so you would end up trying to destroy the same plants over and over again. Most of the charred plants even managed enough energy to send up a bloom stalk. In addition, the dead and dried leaves would build up and become a fire hazard.

Flame weeding had advantages and disadvantages. One positive aspect of flame weeding is how easy it is to use. It can be done from a standing position which may be easier on some grower's backs. It also effectively and quickly controls tender annual flushes in the spring and early summer. Overall, flame weeding can be fun to use. Unfortunately, flame weeding has some disadvantages. In our study, flame weeding was about a third more expensive than hand weeding due to the additional cost of propane. Flame weeding can also cause damage to plants or start fires. As the summer progressed, the older drier garlic stalks seemed to be more susceptible to flame damage. One of the reasons I decided to terminate weeding on July 7th was that flame weeding was becoming increasingly risky. A few small fires occurred and several garlic plants were sacrificed when dry grass patches started on fire and burned too hot next to the garlic stems. Garlic is somewhat heat resistant but it is not fireproof.

There was no difference in garlic bulb size between flame and hand weeding. However, hand weeded German Red was significantly heavier (9 grams) than flame weeded German Red. Hand weeding German Red resulted in an 11% yield increase. There was no difference in garlic weight between hand or flame weeded Georgian Crystal. German Red is an heirloom garlic variety and is more sensitive to environmental variations than Georgian Crystal. In normal field conditions, German Red is smaller and weighs less than Georgian Crystal. However, under ideal conditions, such as a controlled experiment, German Red can grow extremely well. The additional weed coverage in the flame weeded plots may have been enough to decrease German Red bulb weight. Alternately, the stress of heat damage may have decreased yield in the more sensitive German Red variety. Other studies have showed that flame weeding may cause damage in Allium crops. A meta-analysis of six European studies using flame weeding in onions showed yield reduction due to crop damage (Desvaux and Ott 1988).

We conducted an economic analysis comparing total cost of labor, materials and machine hours for each weeding method (details in the addenda) with garlic quality and yield. Stale tillage was the most economical and productive pre-planting weed control. It increased yield by 10% and bulb size by 5.5% compared to solarization. It did result in slightly more weed coverage than solarization. For post-planting weed control, hand weeding was cheaper and more productive than flame weeding. Weed coverage in hand weeded plots was a third of that recorded in flame weeded plots. In addition, bulb weight in German Reds was 11% heavier in hand weeding when compared to flame weeding. The most effective weeding combination as measured by cost, weed control and total yield was stale tillage followed by hand weeding. This weed control combination had the lowest cost at $11.63 per plot with the highest total yield and largest bulb size for both garlic varieties.

Outreach

- October 28th, 2008, we presented a poster detailing our research at the 2008 BIOAg Research Symposium in Pullman, WA. This event was coordinated by the Center for Sustaining Agriculture and Natural Resources (CSANR) at Washington State Univ. and focused on organic and sustainable agriculture. Several hundred people attended this event and listened to the poster presentations. I gave a three-minute speech and answered questions from interested participants. We also distributed handouts about the research. OFRF has a copy of the poster. Abstracts from the symposium are posted at http://csanr.wsu.edu/BIOAg/symposia/2008/2008.html.
- We put up a large sign on our farm in the winter of 2009 announcing the Organic Garlic Weed Trials and OFRF funding. Over the summer and fall numerous people, including our farming neighbors, have stopped to ask us about our sign, garlic research and garlic production.
- July 25th, 2009, we had a fun free farm field day for a group of enthusiastic garlic lovers. We discussed our experiment and organic hardneck garlic production. To supplement the talk, we passed out informative brochures on our research and organic garlic growing both at our field day and to interested members of the Master Gardener's Club. Chris gave a detailed description of garlic cultural practices and demonstrated his garlic growing and drying equipment.
- October 28th, 2009 I gave an hour seminar of our preliminary research results to a group of approximately 30 greenhouse users and gardeners at the University of Idaho. I answered numerous questions about our research and discussed how to grow the biggest garlic and passed out garlic samples and informative brochures about the weed control research.
- November 16th, 2009 I passed out informative garlic brochures and gave a 1.5 hour seminar with PowerPoint about our weed research results to a group of approximately 25 interested researchers and potential garlic growers at Washington State University.

- The results of this research will be summarized on our website, www.greyduckgarlic.com, over the next month.
- I am working on publishing this research in a peer reviewed journal. This will be completed this winter and I will send the results to OFRF.
- Future outreach plans include at least one garlic growing seminar where we discuss our weed research, inclusion of our research in Master Gardener's and/or Rural Root's monthly newsletter, providing informative brochures about our weed research to interested members of the public and extension agencies, and disseminating our research results using our brochures at the Moscow Farmer's Market and other venues this spring.

References

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Addenda

Economic Analysis Details

Solarization Cost:

Material

Polyethylene plastic 2 ml thick (60'x50') = $86.00

Thick plastic is reusable for several seasons

Labor Total = 8.5 hr@$10 hr = $85.00

4 hours labor laying down and covering edges of plastic with pallets and concrete blocks

1.5 hour replacing plastic after it blew out due to freak windstorm

3 hours removing plastic, concrete blocks, and pallets from field

Ugly factor of plastic, concrete blocks, and pallets on field = priceless

Total Cost

$171.00 for first year = $10.69 per plot

$85.00 for second year (plastic can be reused) = $5.31 per plot

Stale Seedbed Technique Cost:

Machine and Operator Cost:

Light surface tillage = 3 times@ 10 min each = 30 min total (0.5 hr)

Total Cost 0.5 hr@$61.36 hour for tractor/ tiller = $30.36 total ($1.90 per plot)

Hand Weeding Cost:

Labor Cost

Each plot weeded 9 times; total weeding time calculated for all 16 plots

Total of 935 min weeding time for all plots over the weeding season

935 min/16 plots = 58.4 min

Average weeding time of 58.4 min (0.973 hr) per plot

0.973 hr @$10/hr = $9.73 per plot

Flame Weeding Cost:

Fuel Cost

Propane cost = $4.90 per plot

Labor Cost

Total 893 min@$10/hr (16 plots = 55.8 min plot) = $9.30 per plot

Initial investment flame weeder (Weed Dragon®):

Flame weeder with cart $135.00

Propane tank $49.00

Fire Factor: low in spring, increasing to dangerous in summer

Final Cost (Without Initial Investment Included) = $14.20 per plot

Photos taken at our Garlic Field Day

Susan discussed our weed control research.

Enthusiastic future garlic growers brave the 95F heat to visit the research plots.

Chris demonstrates the equipment we use to grow garlic. Behind Chris is a garlic rack for drying bulbs and a garlic planter that he built.

Here are some other photos of our weed control research:

Annabel demonstrates the proper use of the garlic planter (helped by Katie and Jane).

Susan checks on the emerging garlic plants in the weed research trial.

Susan flames some weeds in our experiment.

Patty holds some beautiful Georgian Crystal harvested from our weed control research.