United States Department of Agriculture

FINAL STUDY REPORT
(Cape May Plant Materials Center, Cape May Court House, NJ)

EFFICACY OF ORGANIC WEED CONTROL METHODS

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ABSTRACT

Organic weed control methods have varying degrees of effectiveness and cover a broad range of costs financially and in time. Studies were conducted at the USDA Natural Resources Conservation Service Cape May Plant Materials Center, Cape May Court House, New Jersey to examine the efficacy and costs of a variety of organic weed control methods: tillage, organic herbicide (acetic acid), flame treatment, solarization, and use of a smother cover crop. The smother cover and organic herbicide treatment plots displayed the least efficacy to control weeds with the average percent weed coverage of each method being over 97%. The organic herbicide plots also had the greatest financial costs and required the second most treatment time following the flame treatment plots. Although the flame treatment method was time consuming, it was effective resulting in an average of 12.14% weed coverage. Solarization required below average treatment time and resulted in an average of 49.22% weed coverage. The tillage method was found to be the most effective means of control and also had well below average financial costs and required slightly above average treatment time.

INTRODUCTION

The final results of the third biennial national Organic Farming Research Foundation's (OFRF) survey found that organic producers rank weed control as one of the top problems negatively affecting their farms' profitability (1999). Weed control options available for organic producers are far more limited than those of conventional production due to organic certification standards. Flaming, solarization, tillage, organic herbicide (acetic acid), and living mulch (smother cover crop) are all acceptable weed control methods within organic certification standards when implemented following the certification standard guidelines (Webber et al., 2012). Flaming is a weed control method that kills weeds by rupturing plant cells by applying an intense heat wave. Flame weeding may be more cost efficient than physical hand weeding, but requires greater initial equipment costs (Ascard, 1990). Solarization uses clear plastic laid on the soil surface to trap heat and raise the soil temperature. The hot humid conditions under the plastic allow for weed seed germination and fast initial growth, but then become detrimental to plant survival (Johnson et al., 2007). Mechanical tillage resulting in the uprooting and burial of weed seedlings is one of the most effective non chemical weed control methods (Jones et al., 1995; 1996). However, extensive cultivation can be detrimental to overall soil health and contribute to loss of organic matter, increased soil erosion, nutrient loss, and encourage new weed growth (Pekrun, 2003; Six, 1999). Organic post emergence herbicides (such as acetic acid) kill weeds by damaging the cell walls of the plant leading to desiccation. Horticultural vinegar has been shown to be more effective on broad leaf plants than grasses, annuals than perennials, and immature seedlings than mature weeds (Webber et al., 2012). Smother cover crops function as a means of weed suppression by preventing the germination and establishment of weeds through competition for necessary resources: preventing sun light from reaching the soil surface and the uptake of available soil moisture and nutrients (Hatfield, 1997; Law, 2006).

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The purpose of this study is to examine the efficacy, cost, and time requirements of the listed organic weed control methods in the Mid-Atlantic coastal plains region. Considering that weed control is one of the top challenges facing organic producers, this study is relevant and timely. The objective is to provide guidance to certified organic producers and producers transitioning to organic production when considering weed control methods that are acceptable within the scope of certified organic standards. By considering monetary costs, time requirements, and efficacy of the methods examined, organic producers will be better able to make informed decisions and successfully implement weed control strategies in their management plan.

MATERIALS AND METHODS

The study area occurred in fallow production field which had been minimally managed for at least five years. Field mustard (*Brassica rapa L.*) had been the most dominant species volunteering in the study area in previous years. The soil type of the study area is a Downer sandy loam, 0 to 2 percent slope. Six organic treatment methods were examined: cultivation, solarization, burn kill, organic herbicide, smother cover (high rate), and smother cover (low rate). The test area was divided into 12' by 20' plots. The six treatment methods were replicated three times for a total of 18 trial plots which were randomly assigned locations within the test area among control plots.

The entire test area was initially cultivated on April 17, 2012 to kill any existing weeds and to provide a uniform weed free seedbed prior to test treatments. The test area was cultivated using a John Deere PTO driven rototiller.

After initial tillage, cultivated plots were treated with shallow tillage once every three weeks using a walk behind rototiller throughout the entire growing season. The plots were tilled with a model M8 (8 hp) Troy-Bilt rototiller powered by a Kohler gas engine. This model rototiller has a tilling width of 20". The depth regulator was set at 1" below the tines providing a tillage depth of about 2" depending on field conditions. The rototiller was operated in the slow gear during cultivation treatments.

Solarization plots were covered using UV stabilized polyethylene greenhouse film on April 17, 2012 following the initial cultivation of the test area. The green house film used for the solarization test plots is manufactured by Celanese Ethylene Vinyl Acetate (EVA) Performance Polymers, Inc. (formerly At Plastics Inc., Edmonton, Canada) and is referred to by the product name Dura-Film Super 1 UV. The gauge of the film is 3 mil. The green house film was secured using lawn staples every 2 feet and burying the edges with soil to prevent wind from lifting the film. The film will remain in place for the entire growing season.

Controlled burn plots were spot treated with a 400,000 btu Red Dragon propane backpack torch (model: BP 2512 C) manufactured by Flame Engineering Inc., LaCrosse, Kansas. Treatments were performed once every three weeks throughout the growing season beginning on May 10, 2012. All weeds within these plots were treated with the flame torch until completely defoliated. Flame treatments were carried out in the afternoons after all morning dew had evaporated to increase the efficiency and effectiveness of the flame treatment to desiccate the weeds.

Organic herbicide plots were spot treated with Natures Wisdom horticultural organic vinegar (20% acetic acid) once every two weeks throughout the growing season beginning on May 10, 2012. No adjuvant or surfactants were added to the spray mixture. The spray was applied using a Green Thumb 3 gallon hand pump tank sprayer manufactured by Truserve. All weeds within these plots were sprayed to achieve complete foliar coverage.

Smother crop plots were seeded with buckwheat (*Fagopyrum esculentum*) on April 17, 2012 following the initial seed bed cultivation. Using the Cover Crop Conservation Practice Standard (code 340) as a guide, two seeding rates within the suggested range (35-134 lb/acre) were implemented. A midrange rate (70 lb/acre or 5.42 oz/plot) and a high end rate (130 lb/acre or 11.46 oz/plot) were tested. The buckwheat was broadcast seeded by hand and rolled in using a cultipacker roller to improve seed to soil contact. The cultipacker roller was pulled across all plots in perpendicular directions to maximize seed to soil contact in the smother crop plots and maintain consistency with the other test plots.

Control plots had no further treatment following the initial cultivation.

For all treatment methods, time spent applying treatments and amounts of materials (vinegar and propane) used was recorded.

Data were collected after one growing season of treatments on November 8, 2012. The data collected at this time were the percent of weed coverage in each plot. For the weed coverage sampling, 3 randomly placed 1 meter square quadrats were sampled for each plot. The total (forbs and grasses) weed coverage was recorded in addition to the grass coverage and forb coverage individually. This sampling was done 38 days after the last vinegar treatment and 30 days after the most recent burn and tillage treatments.

RESULTS AND DISCUSSION

Results of the random sampling of weed coverage suggest that the vinegar and both the high rate and low rate smother cover treatment plots provided minimal weed control (Table 1). The most overall effective methods were tillage and flame treatment. Although forb weed coverage was low in all plots, including the control plots, it was highest for the flame treatment plots. This finding is likely due to the fact that field mustard was the most dominant plant prior to treatments. Furthermore, it has been found that managing field mustard by burning may result in increased populations (Young, 2012).

Grasses were consistently more problematic to control than forbs for all treatment methods with the exceptions of the tillage and burn plots (Figure 1). Smooth crabgrass (*Digitaria ischaemum*) was by far the most common grass species found throughout all test plots. Additionally, several scattered clumps of stinkgrass (*Eragrostis cilianensis*) were found growing exclusively under the plastic of the solarization plots.

The cost benefit analysis of all control methods examined indicates that the smother cover plots had the least required treatment time and the lowest financial costs, however provided almost no control of grass weeds (Figure 2). A mix of smother cover species may have produced better results as the monoculture of buckwheat became defoliated shortly after producing mature seed in early July. This left the smother cover plots without any weed control mechanism for the remainder of the growing season. Solarization provided average weed control with minimal time requirements and low costs. Tillage plots showed the most effective weed control at a well below average cost and slightly above average time requirement. However, this does not take into consideration the effects of over tillage on soil health. Organic herbicide treatments controlled forbs well, but had little effect on grasses. This resulted in the organic herbicide plots reaching nearly 100% coverage of grasses at the time of sampling. It was also the most costly treatment method. Flame treatment proved to be an effective treatment method, however it also had the highest time requirements. Flame treatments were found to be most efficient in the afternoon after all morning dew had evaporated. It is important to note that the costs and time requirements of all treatment methods examined will vary with the methods of implementation and equipment used.

Table 1

Weed Coverage Samples, Cape May PMC										
Cape May Plant Materials Center										
8-Nov-12										
Total Percent Weed Coverage										
Treatment	Plot 1			Plot 2			Plot 3			Average
Burn	21	16	33	3	11	8	8	7	2.25	12.14
Vinegar	100	99	99	96	97	94	99	96	95	97.22
Tillage	0.5	0.1	0.5	0.5	0.5	0.75	0.25	0.25	0.1	0.38
Solarization	52	27	86	24	67	60	6	39	82	49.22
Smother (high)	100	100	100	100	100	100	100	100	100	100.00
Smother (Low)	100	100	99	100	100	100	100	100	99	99.78
Control	100	100	100	100	100	100	100	100	100	100.00
Percent Grasses Coverage										
Treatment	Plot 1			Plot 2			Plot 3			Average
Burn	0	0	0	0	0	0	0	0	0	0.00
Vinegar	100	99	99	96	96	94	99	96	95	97.11
Tillage	0	0	0	0	0	0	0	0	0	0.00
Solarization	46	25	80	22	66	60	4	38	76	46.33
Smother (high)	100	100	96	100	99	100	100	100	100	99.44
Smother (Low)	99	99	99	99	99	99	100	99	99	99.11
Control	100	100	99	97	99	100	100	100	100	99.44
Percent Forbs Coverage										
Treatment	Plot 1			Plot 2			Plot 3			Average
Burn	21	16	33	3	11	8	8	7	2.25	12.14
Vinegar	0	0	0	0	1	0.5	0	0	0	0.17
Tillage	0.5	0.1	0.5	0.5	0.5	0.75	0.25	0.25	0.1	0.38
Solarization	7	3	10	1	1	1	2	1	7	3.67
Smother (high)	1	1.5	5	2	1	0.5	1	0.5	1	1.50
Smother (Low)	6	2	10	4	1	1	1	2	1	3.11
Control	1	2	2	3	1	1	2	1	2	1.67

Table 1 shows the results of the randomized percent weed coverage samplings for total weed coverage, grass coverage, and forb coverage.

Figure 1

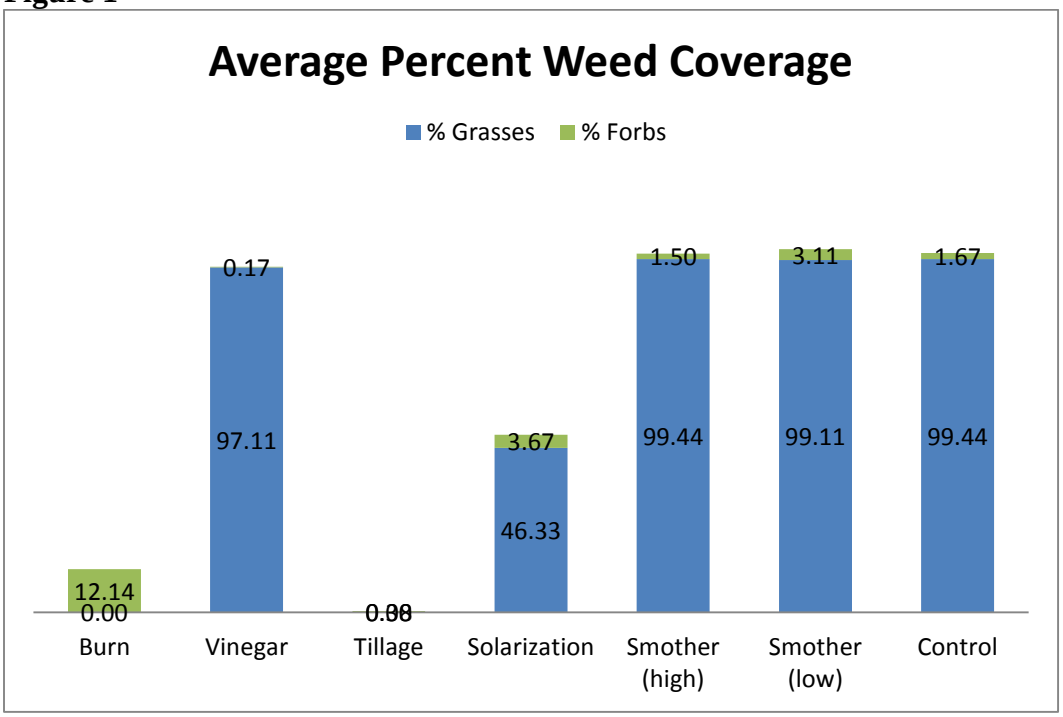

Figure 1 shows the average percent weed coverage of grasses and forbs for each treatment method.

Figure 2

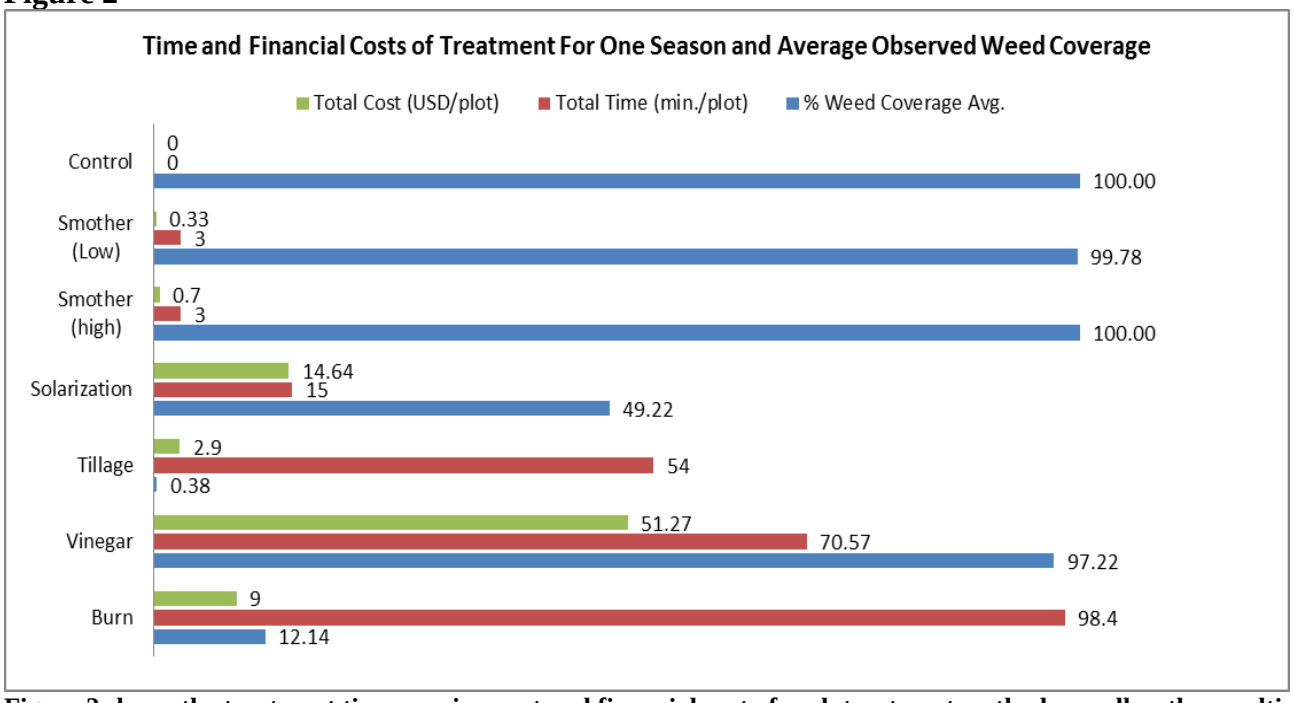

Figure 2 shows the treatment time requirement and financial cost of each treatment method as well as the resulting average percent weed coverage.

Figure 3

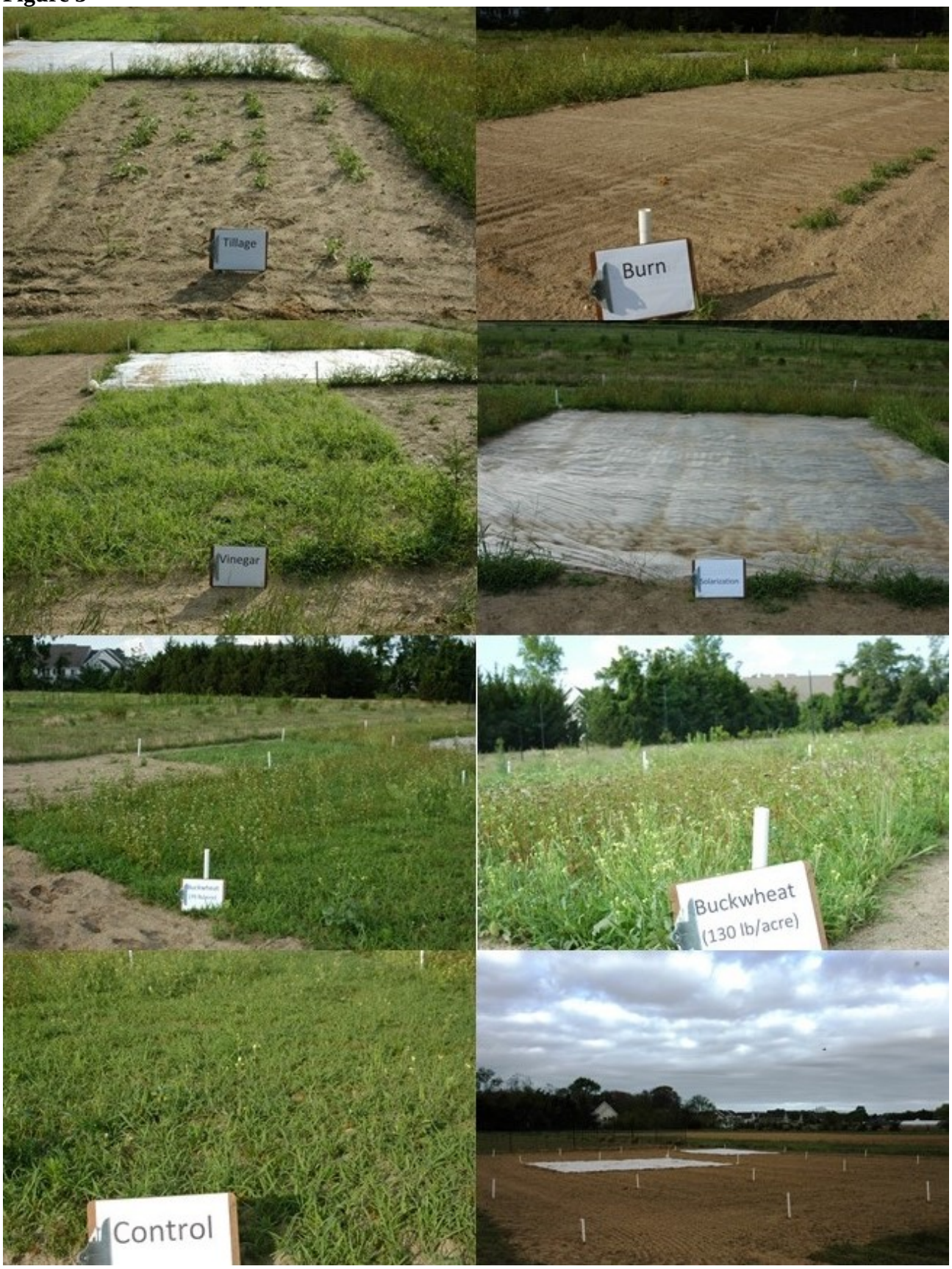

Figure 3 shows an example plot of each treatment method and no treatment (control) approximately 6 weeks after initial treatment. The photo in the lower right corner shows all the plots immediately following the initial treatment.

CONCLUSION

This study found that using buckwheat as a single species smother cover crop was ineffective as a standalone method of weed control. It also found 20% acetic acid vinegar (organic herbicide) as a sole weed control method to be ineffective and costly. Solarization showed potential as an effective organic weed control option. Flame treatments and tillage were found to be the most effective organic methods of weed control tested. While tillage proved to be the most effective weed control method examined, this study did not take into consideration the negative impacts of extensive tillage on overall soil health. An organic weed management strategy that incorporates several means of weed control may be the best option to reduce time requirements and costs, achieve the most effective weed control, and reduce negative impacts to soil health associated with excessive tillage.

LITERATURE CITED

Ascard, J. 1990. Thermal weed control with flaming in onions. In: Proceedings 3rd International Conference IFOAM, Non-Chemical Weed Control, Linz, Austria, 175–188.

Hatfield, J.L., Stewart, B.A. 1997. Integrated Weed and Soil Management. Long term soil management workshop. CRC Press. https://books.google.com/books?id=jYeCIt8yoJ0C. (accessed 02 June 2015)

Johnson, W.C., Davis, R.F., and Mullinix, B.G., Jr. (2007). An integrated system of summer solarization and fallow tillage for Cyperus esculentus and nematode management in the southeastern coastal plain. Crop Protection 26:1660-1666.

Jones, P.A., Blair A.M., and Orson, J. 1995. The effects of different types of physical damage to four weed species. In: Proceedings 1995 Brighton Crop Protection Conference – Weeds, Brighton, UK, 653–658.

Jones, P.A., Blair A.M., and Orson J. 1996. Mechanical damage to kill weeds. In: Proceedings Second International Weed Control Congress, Copenhagen, Denmark, 949–954.

Law, D.M., Rowell, A.B., Snyder, J.C., Williams, M.A. 2006. Weed control efficacy of organic mulches in two organically managed Bell Pepper production systems. HortTechnology 16:225-231.

Organic Farming Research Foundation (OFRF). 1999. Final results of the third biennial national organic farmers' survey. Santa Cruz, CA, USA.

Pekrun, C., El Titi, A., and Claupein, W. 2003. Implications of soil tillage for crop and weed seeds. Soil Tillage in Agroecosystems, A. El Titi, Editor, pp. 115–146. CRC Press, Boca Raton, FL.

Six, J., Elliot, E.T., 1999. Aggregate and Soil Organic Matter Dynamics under Conventional and No-Tillage Systems. Soil Science Society of America Journal 63; 5: 1350-1358.

Webber, C.L., J.W. Shrefler, and L.P. Brandenberger. 2012. Organic Weed Control, Herbicides – Environmental Impact Studies and Management Approaches. InTech. http://www.intechopen.com/books/herbicidesenvironmental-impact-studies-and-management-approaches/organic-weed-control. (accessed 02 June 2015)

Young-Mathews, A. 2012. Plant guide for field mustard (*Brassica rapa* ssp. *rapa)*. USDA-Natural Resources Conservation Service, Plant Materials Center, Corvallis, OR.