Evaluation of Organic Weed Control Methods in Northwestern Washington

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Abstract

In order to evaluate the effects of organic herbicides and flaming on weed control, a field trial was conducted on two different three-year rotations of potato, spinach seed, cucumber and broccoli at the Washington State University Mount Vernon Northwest Washington Research and Extension Center. Mid-summer weed growth was greater during 2005 and 2006 than 2004, with common chickweed, shepherd's-purse, and henbit constituting the majority of the weeds. An infrared flamer provided the most effective postemergence weed control in this trial in all tested crops, although spinach and broccoli foliage were damaged. In certain instances, preemergence flaming resulted in a similar level of weed biomass as in hand-weeded check plots. Vinegar (20% acetic acid) and clove oil (15% rate of Matran 2) in shielded applications beside the crop row were less effective than flaming. Broccoli provided the poorest weed suppression in two of three years, followed by spinach/cucumber and potato in 2004 and by potato, spinach, and cucumber in 2005. In 2006, spinach seed was the poorest competitor with weeds, followed by potato and cucumber/broccoli.

Introduction

Weed management is a major concern for organic farmers, especially during transition; however, research in the development and evaluation of weed control techniques in organic cropping systems is limited. Flame has been used for selective weed control in crop production since the early 1940's. In these systems, open flame is directed toward the soil surface near the base of crop plants that are large enough to withstand the brief exposure to heat while weeds are young and tender and susceptible to cellular rupture and cuticle loss. Flaming is normally employed with a stale seedbed system, in which a crop is seeded some days after final seedbed preparation after initial weed emergence has occurred. These weed seedlings are then removed using flame prior to crop emergence. Several non-synthetic herbicides have recently been approved for use in organic systems. Two of these herbicides, vinegar and clove oil, are non-selective contact herbicides that are applied in a narrow band beside the crop row and show promise in controlling many annual weeds. The objective of this study was to determine the effectiveness of several weed control techniques in organic transition rotational crops.

Figure 3. Potato tubers

Figure 2. Damage to spinach foliage (photo taken 4 days after third treatment)

Table 1. Effect of early flaming on weed dry weight (all crops)

Treatment	2004	2005	2006
	----------g/m^2----------		
Early flame	6.7 c	18.4 b	33.5 cd
No early flame	10.1 b	43.5 a	73.9 ab
Early flame w/hand weed	0.4 d	8.9 b	5.7 e
No early flame w/hand weed	1.1 d	13.1 b	7.7 e
Untreated	21.3 a	56.6 a	82.8 a

Materials and Methods

Two three-year organic transition rotations, Rotation A: spinach seed, cucumber, and potato, and Rotation B: spinach seed, broccoli, and potato, were tested from fall 2003 through summer 2006 with each crop being grown each year. Plots measured approximately 18.28 by 30.48 m (6,000 ft^2 or 0.14 acre) and were arranged in a randomized complete block design with four replicates (approx. 3.5 acres total experiment size). Rotational crops were seeded/transplanted during April through June of 2004. For each crop, sub-plots were marked for different weed control programs. Preemergence flaming was done using a standard propane flamer (wand with open flame) while postemergence flaming was done using a high-efficiency infrared flamer (**Figure 1**) that ignites propane on a wire mesh. Postemergence herbicides were applied using a shielded sprayer to apply herbicides in a narrow band immediately beside the crop row. Combinations of two levels of preemergence (PRE) treatments (flaming or not) and three levels of early postemergence (EPOST) and late postemergence (LPOST) treatments with flame, vinegar (20% acetic acid) and clove oil (10% of Matran 2) were compared to untreated and hand-weeded check plots. The interval from the initial preemergence treatment to the second postemergence treatment averaged 30 days among the four crops. After the third treatment, weed cover and biomass was recorded for each weed control program to determine the efficacy of the different treatment programs. At harvest, the sub-plots were harvested separately and crop productivity was determined for each weed control program. Weed control treatments in 2005 and 2006 were the same as in 2004, except clove oil was applied at 15% and the duration from initial preemergence application to second postemergence application averaged 36 days among the four crops.

Table 2. Effect of early flaming on harvest yield for potato

Treatment	Potato tuber yield		
	--------- kg/plot ---------		
	2004	2005	2006
Early flame	2.03 a	1.08	1.38
No early flame	2.10 a	0.94	0.80
Early flame w/hand weed	1.87 a	1.05	1.24
No early flame w/hand weed	2.19 a	0.87	1.23
Untreated	2.24 a	0.80 a	0.68 a

Table 3. Percentage of weed control resulting from each treatment program (all crops)

Treatment	2004	2005	2006
	-------% control--------		
flame / flame / flame	93 fg	63 cd	65 d
flame / flame / vinegar	87 fg	64 cd	48 c
flame / vinegar /vinegar	44 c	70 d	67 d
flame / clove oil / vinegar	46 c	72 d	60 cd
flame / vinegar / flame	69 d	71 d	65 d
flame / clove oil / flame	73 de	65 cd	52 cd
flame / hand / hand	98 g	84 d	93 e
no flame / flame / flame	85 efg	34 bc	9 ab
no flame / flame / vinegar	82 def	22 ab	2 a
no flame / vinegar / vinegar	26 b	29 ab	3 a
no flame / clove oil / vinegar	22 b	4 ab	13 ab
no flame / vinegar / flame	54 c	22 ab	13 ab
no flame / clove oil / flame	48 c	27 ab	25 b
no flame / hand / hand	95 fg	77 d	91 e
Untreated (weedy check)	0 a	0 a	0 a

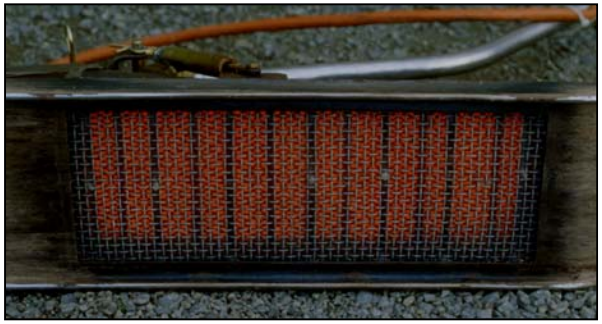

Figure 1. Infrared flamer

Results

Spring and summer weed growth was much greater during 2005 and 2006 than during 2004. Mid-season weed heights ranged from 1.02 to 15.50 cm among herbicide treatments in 2004 compared to heights from 8.38 to 46.48 cm in 2005 and 2006 (data not shown). Weed cover and dry weight were similarly affected, with weed dry weight within non-treated check plots measuring 1422 kg/ha (71% cover) in 2004 compared to 3778 kg/ha (83% cover) in 2005 and 5536 kg/ha (79% cover) in 2006 (data not shown). Primary spring and summer weed species were common chickweed, henbit, shepherd's-purse and common lambsquarters.

Flaming prior to crop emergence was helpful for weed control in all crops (Table 1). Preemergence flaming gave particularly good results with potato tuber yield (Table 2), as weed germination was extensive in 2005 and 2006 prior to emergence of potato foliage. The infrared flamer provided effective postemergence weed control, although damage to spinach and broccoli was apparent after early postemergence use (Figure 2). Vinegar and clove oil in shielded applications beside the crop row were less effective than flaming. Vinegar caused slight injury to weed foliage, yellowing, but not killing, soft-leaved plants such as pale smartweed and common chickweed. Clove oil activity was substantially improved when applied at 15% in 2005 and 2006 than when used at 10% in 2004, but still was not as effective as flaming.

Weed control percentage was significantly improved in all of the treatments that were flamed prior to crop emergence compared to treatments that were not flamed prior to crop emergence (Table 3). In 2005, for example, the F/C/V treatment resulted in total weed biomass of 15.9 g/m^2, while the weedy check had 56.6 g/m^2, a reduction in weed biomass of 72%. This contrasts with the N/C/V treatment, which resulted in a weed biomass of 54.1 g/m2, a reduction in weed biomass of only 4%.

Of all rotational crops, broccoli provided the poorest suppression of weed growth, with weed height, cover, and biomass being greatest in broccoli the first two years. In 2006, weed height and biomass was greatest in potatoes, while weed cover was greatest in broccoli. Potato did the best job at suppressing weed biomass in 2004 and 2005, while broccoli and cucumber suppressed weed biomass the best in 2006 (data not shown).

Conclusions

- Weed control was significantly better in all the treatments that were flamed prior to crop emergence compared to the treatments that were not flamed prior to crop emergence. In some instances, preemergence flaming resulted in a similar level of weed biomass as in hand-weeded check plots, as weed germination was extensive in 2005 and 2006 prior to emergence of potato foliage.
- The infrared flamer provided the most effective postemergence weed control in this trial in all tested crops, although spinach foliage was damaged primarily due to variable emergence between replicates and the quickness of emergence of cotyledons (some as soon as one week after seeding).
- Vinegar (20% acetic acid) and clove oil (15% rate of Matran 2) in shielded applications beside the crop row were less effective than flaming.