Effectiveness of Vinegar and Clove Oil for Control of Annual Weeds. W. S. Curran* D.D. Lingenfelter, and C.B. Muse, Penn State University, University Park. (58)

Natural product herbicides are being considered for use in organic cropping systems. Nonselective foliar applied contact type products that include acetic acid or vinegar, citric acid, and clove oil are being marketed to and considered by the organic community. Acetic acid is one of the more common ingredients found in a number of natural product herbicides including Burnout Weed Killer (St. Gabriel Laboratories), Alldown (Summerset Products), Groundforce (Abby Science), Blackberry and Brush Block (Greenenergy Products), and Horticultural Vinegar (Bradfield Industries). Clove oil, also known as eugenol, is the active ingredient in several products one of which is Matran II (Ecosmart Technologies). Although much discussed, few studies have been published with regard to performance and questions continue about their potential use.

Study objectives: Evaluate several factors that may impact vinegar and clove oil performance for annual weed control in the field and in a controlled environment.

MATERIALS AND METHODS

Field.

Vinegar (two experiments)

- 20% vinegar (Fleishmann's) applied postemergence at 281 (30 gal/A), 562 (60), and 843 (90) l/ha to emerged soybean (*Glycine max)* and annual weeds.
- 10, 15, 20, and 30% vinegar solution applied at 562 and/or 843 l/ha.
- Weeds ranged from 5 to 20 cm in height and soybean had 3 to 5 trifoliate leaves.
- Boom equipped with 11003 nozzles applied at 207 kPa. Nu-Film-P surfactant (pinolene based) included at a constant rate of 1.2 l/ha.

Clove oil

- Clove oil (Matran II) applied at 66 (7 gal/A) 94 (10), and 131 (14) l/ha in a water mixture with a total volume of 281 or 562 l/ha.
- Applied to weeds 3 to 8 and 9 to 13 cm tall.
- Natural Wet surfactant (yucca extracts) included at a constant rate of 1.2 l/ha.
- All experiments conducted during summers 2003 and 2004.
- Air temperature at application ranged from 22 to 25 C and relative humidity from 45 to 78% with clear skies.

Controlled environment.

Application timing

- 20% vinegar (Fleischman's or Bradfield) and clove oil (Matran II) applied at 66 l/ha.
- Treatments applied with greenhouse sprayer delivering 281 and 562 l/ha spray volume to 3 to 8 and 9 to 13 cm tall giant foxtail (*Setaria faberii*) and velvetleaf (*Abutilon theophrasti*).
- Air temperature and relative humidity 24 C and 55% respectively.
- Supplemental light with metal halide lamps (750 µE $m^{-2}s^{-1}$) for 16 hour photo period.

Light and temperature experiments

- 3 to 4-leaf stage velvetleaf subjected to one of three light treatments (full, half, and darkness) three hours prior to application or prepared for one of three growth chambers set at 15, 24, or 32 C following treatment.
- 20% vinegar or 26 l/ha clove oil applied at 562 l/ha with adjuvants previously described.
- Plants sprayed and immediately returned to the light treatments for 6 hours following application or placed in temperature chambers for 24 hours and then returned to the greenhouse.

50% reduction

All experiments.

- Replicated 3 or 4 times and repeated.
- Fertilized and watered as necessary.
- Visual estimates of control on a 0 to 100 scale.
- Shoot fresh wt. collected in light and temperature experiments.
- ANOVA and mean separation (LSD at p = 0.05) performed. Linear regression analysis conduced on vinegar rate and application volume experiment.

Table 1. Effect of vinegar application volume on annual weed control and soybean injury (20% acetic acid).

Vol.	GLYMX[a]		SETFA		CHEAL		AMACH		AMBEL	
	% Control days after application									
l/ha	3	10	3	10	3	10	3	10	3	10
281	58a[b]	26a	72a	58a	89a	62a	89a	69a	83a	61a
562	76b	41ab	75a	61a	92a	77a	95a	88b	91a	77a
843	80b	58b	81a	65a	95a	84a	97a	91b	93a	83a

[a]GLYMX = soybean; SETFA = giant foxtail; CHEAL = common lambsquarters; AMACH = smooth pigweed; AMBEL = common ragweed.
[b]Same letters within a column are not significantly different at the 5% level.

RESULTS

Field.

- Wilting and necrosis visible within hours after application.
- 20% vinegar provided 58 to 97% control of soybean and annual weeds 3 days after application (DAA) (Table 1). Ten DAA, control ranged from 26% with soybean up to 91% with smooth pigweed (*Amaranthus hybridus*).
- Soybean was the the least susceptible species with 58% control or injury at the high rate 10 DAA.
- Weed response to clove oil was similar to vinegar (Table 2). Soybean injury ranged from 58 to 76% 3 DAA decreasing to 35 to 56% by 10 DAA.
- Order of susceptibility to both vinegar and clove oil from most to least was smooth pigweed, common lambsquarters, common ragweed (*Ambrosia artemisiifolia*) giant foxtail, and soybean.
- Increasing concentration and spray volume generally increased control (Figure 1). Increasing rate and volume had the greatest effect on soybean, followed by giant foxtail, and the least impact on common lambsquarters and smooth pigweed. The response followed species susceptibility with the least susceptible species showing the greatest response with increase in rate and volume.

Vinegar on larger AMBEL and AMACH

20% vinegar at 562 l/ha 3 DAA

Table 2. Effect of clove oil application rate on annual weed control and soybean injury.

Rate	GLYMX		SETFA		CHEAL		AMACH		AMBEL	
	% Control days after application									
l/ha	3	10	3	10	3	10	3	10	3	10
66	58a[b]	35a	71a	66a	87a	76a	92a	83a	88a	76a
94	71b	49b	77b	69a	91b	81b	94a	86a	91a	79a
131	76b	56b	76b	68a	93b	82b	94a	83a	90a	77a

[b]Same letters within a column are not significantly different at the 5% level.

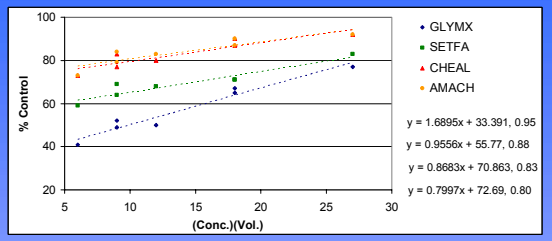

Figure 1. Effect of vinegar concentration and application volume on % control 3 days after application for three annual weeds and soybean in the field.

Controlled environment.

- Both vinegar products and the clove oil performance were similar (data not shown).
- Giant foxtail control was less than velvetleaf and control decreased with both species from 3 to 10 DAA. Smaller weeds were sometimes controlled better with vinegar than the larger weeds early, but control was similar by 10 DAA.
- Clove oil provided better giant foxtail control early (43 vs. 32%) with the bigger grass compared to the smaller, perhaps due to greater coverage of the weed.
- In the light experiment, light intensity did not significantly affect velvetleaf control with either vinegar or clove oil (data not shown). However visual estimates of control suggested better control with the dark treatment (trend), but this was not reflected in plant fresh wt. (data not shown). Clove oil provided more consistent control of velvetleaf than vinegar regardless of treatment. Relative humidity (RH) was not kept constant in this experiment and may help explain the observed trend.
- In the temperature experiment, increased temperature did not result in better velvetleaf control with either vinegar or clove oil (Table 3). Again, RH was not regulated and may have impacted results.
- Clove oil performance was better than vinegar at both 12 and 168 hours after application.

20% vinegar @ 562 l/ha

66 l/ha clove oil @ 562 l/ha

Table 3. Effect of temperature on velvetleaf control and % fresh wt. reduction with vinegar and clove oil.

Herbicide	Temp.	% Control		% Reduction	
	(C)	12 h	168 h		
Vinegar	15	26	47	23	
	24	27	41	28	
	32	24	36	27	
		26a	41a	ns	
Clove oil	15	51	66	25	
	24	47	60	32	
	32	45	61	43	
		47b	62b	ns	

Same letters within a column are not significantly different at the 5% level.

Summary

- Vinegar and clove oil provided fair to good control of small seeded broadleaves, less control of velvetleaf and common ragweed, and poor control of giant foxtail.
- Clove oil performance was equal or better than vinegar and neither product controlled soybean,but both severely injured the crop.
- In general, a spray volume of at least 562 l/ha was necessary for adequate herbicide performance.
- Increasing clove oil rate above 94 l/ha generally did not improve performance.
- According to the rate-volume experiment, a spray volume of 562 l/ha (60 gpa) required a 20% vinegar concentration to achieve at least 80% control of susceptible broadleaves. This suggests a spray volume of 1124 l/ha (120 gal/A) with 10% vinegar or 281 l/ha (30 gal/A) with 40% should produce similar results.
- Neither light nor temperature consistently affected herbicide activity– RH may be an important environmental variable.