Combining mulch films with abrasive weeding increases yield and profitability of organic pepper production

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Background

- Weeds continue to be a top management concern among organic vegetable farmers. Abrasive weeding, or weed blasting, is a newly developed non-chemical tactic that uses air-propelled abrasive grits to destroy weed seedlings within crop rows.
- 700 kPa compressed air accelerates any gritty material, which shred and destroy stem, leaf, and meristematic tissue.
- Many different grit types are effective, but if organic fertilizers are used as abrasive grits it could allow farmers to integrate weed and nutrient management in one field pass and increase profitability.
- Abrasive weeding should be limited to in-row and spot applications, but information is needed about compatibility with between-row weed management tactics.
- Our objective was to determine if abrasive weeding with organic fertilizer grits can be used in combination with agricultural mulches to increase weed suppression, soil fertility, crop yield, and profitability.

Methods

- A two-year factorial experiment was conducted in organic red pepper (*Capsicum annuum* 'Carmen') at Urbana, IL
- Five abrasive grit treatments: 1) walnut shell grits, 2) soybean meal fertilizer, 3) Sustâne composted turkey litter fertilizer, 4) a weedy control, and 5) a weed-free control
- Four mulch treatments: 1) straw mulch, 2) BIO 360 bioplastic film, 3) polyethylene plastic film, and 4) a bare soil control
- Sampled in- and between-row weed density one and two months after transplanting peppers, and sampled weed biomass at the end of each season
- Plant Root Simulator (PRS) probes (Western Ag Innovations) installed 1 week after 1st grit application, and every 2 weeks thereafter for 8 weeks to measure mineral soil nitrogen
- Peppers harvested when red until first killing frost, sorted as marketable or cull, and weighed
- Yield data and a range of retail or wholesale market prices were used to estimate crop revenues, and cost estimates were generated for hourly wages, cost of ownership for grit applicator, abrasive grits, and fuel

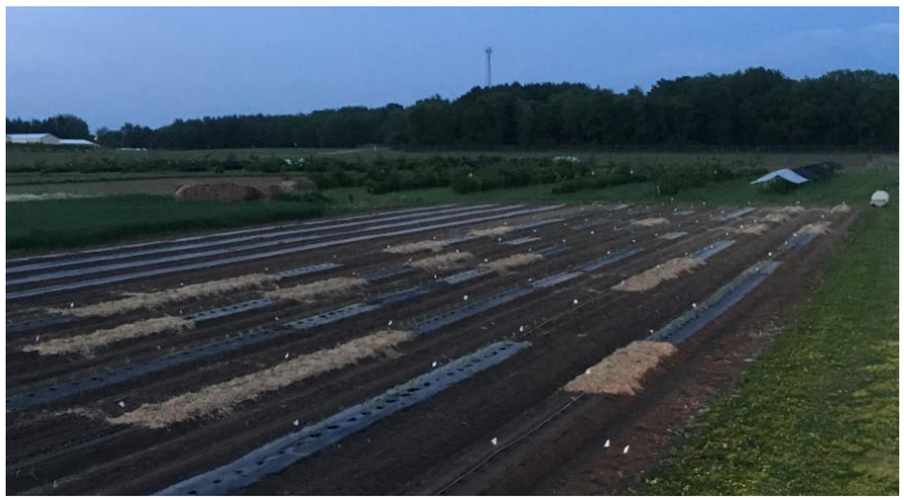

Figure 1. Randomization scheme for mulches used in combination with abrasive weeding.

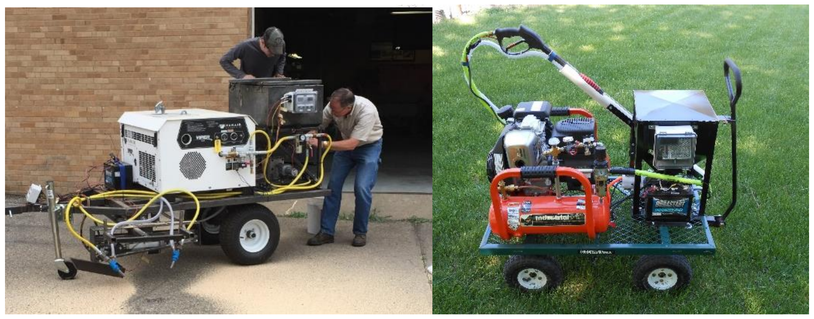

Figure 2. Grit applicators developed for medium- (left) and small-scale (right) specialty crop production. The two-nozzle applicator would retail for approximately $12,500, compared to $3,500 for the hand-held, single-nozzle applicator.

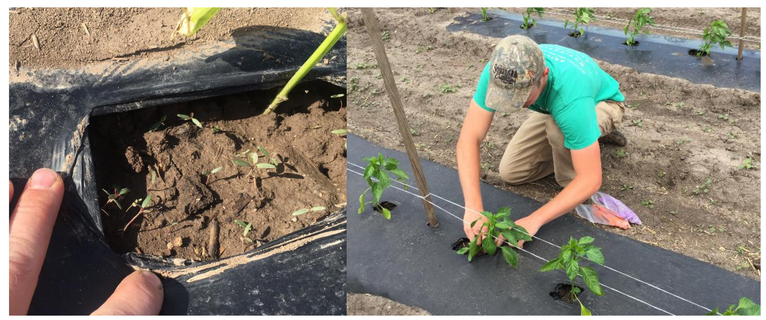

Figure 3. Ideal growth stage for abrasive grit application (left), and installation of Plant Root Simulator Probes (Western Ag Innovations) for continuous measurement of mineral soil nitrogen.

Results

- Abrasive weeding alone reduced in-row weed density by 35%
- Plastic and bioplastic films alone reduced in-row weed density by 86%
- Abrasive weeding combined with plastic or bioplastic films reduced weed density by 94-98%
- In-row weed biomass was greater in planting holes of films compared to bare soil, but abrasive weeding reduced that biomass by 77-87%
- Plastic and bioplastic films increased soil N two-fold by reducing weed competition
- Organic fertilizer grits combined with plastic and bioplastic films increased soil N by 23%-30% and 12%-31%, respectively
- Films alone increased yield 6-fold, whereas films plus abrasive weeding increased yield 8-fold (Table 1)
- Abrasive weeding combined with plastic or bioplastic films for weed control increased net income potential by an average of $33,265/ha (Table 2)
- Frequent hand-weeding paired with films to achieve weed-free conditions was most profitable, but required six to nine times more labor

Table 1. Marketable yield of organic red peppers (cv. Carmen) averaged across the 2015 and 2016 growing seasons in Urbana, IL.

	Marketable yield (kg m row^{-1})			
Abrasive grits	**Bare soil**	**Bioplastic**	**Polyethylene**	**Straw mulch**
Weed-free control	3.45 abc	3.47 ab	3.61 a	2.50 bcde
Weedy control	0.34 g	1.67 ef	2.43 cde	0.50 g
Soybean meal	0.49 g	2.18 de	2.81 abcd	0.79 fg
Turkey litter	0.40 g	2.50 bcde	2.79 abcd	0.72 fg
Walnut shell	0.54 g	2.77 abcd	3.11 abcd	0.58 g

Table 2. Profit-loss scenarios for two different levels of weed control and yield benefits resulting from hand weeding or abrasive grit application (via single-nozzle, hand-held applicator) within plastic mulch film planting holes of organic sweet red peppers. Based on yield data from Braun (2017) M.S. thesis. "Hand-weeded" and "Hand-held applicator, weed-free" represent hypothetical scenarios where hand-weeding is reduced to efficacy of abrasive weeding and where abrasive weeding efficacy is increased to that of hand-weeding, respectively.

	Weed-free	**Hand-weeded***	**Hand-held applicator**	**Hand-held applicator, weed-free***
Revenue				
Yield increase (kg/ha)	9,206 - 12,454	4,322 – 5,846	4,322 – 5,846	9,206 - 12,454
Sale price ($/kg)	$2.20 - $9.92	$2.20 - $9.92	$2.20 - $9.92	$2.20 - $9.92
Gross revenue increase($/ha)	$20,253 - $123,543	$9,509 - $57,997	$9,509 - $57,997	$20,253 - $123,543
Expenses				
Wages($/ha)	$430 - $820	$213 - $410	$69 - $94	$138 - $193
Cost of ownership for applicator			$84 - $398	$84 - $398
Tractor use ($/ha)				
Abrasive grits ($/ha)			$15 - $232	$30 - $465
Fuel for applicator ($/ha)			$20 - $64	$40 - $133
Net income range ($/ha)	$19,433 - $123,113	$9,099 - $57,784	$8,721 - $57,809	$19,064 - $123,251
Net income mean ($/ha)	$71,273	$33,442	$33,265	$71,158

Conclusions

- Abrasive weeding is compatible with plastic and bioplastic agricultural mulch films, but not straw mulch (blown by compressed air).
- Abrasive weeding has greatest value when: 1) high density of annual broadleaf weeds in the crop row; 2) can apply grits when weeds are less than 2-4 cm tall (cotyledon or 1-2 leaf stage); 3) can source or prepare inexpensive grits (e.g., on-farm residues); 4) in-season fertilizer application is necessary; 5) labor is difficult to source, afford, or retain; and 6) growing high-value specialty crops susceptible to weed interference.
- Further research is needed to improve efficacy of abrasive weeding, which may include changes to nozzle design or grit spray pattern.

Acknowledgements

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