Blasting the competition away: Air-propelled abrasive grits for weed management in organic grain and vegetable crops

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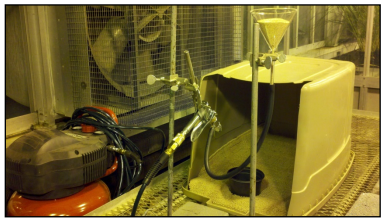
Webinar overview

- **Brief history of the project**
- Applicator and nozzle designs
- Applications in grain crops
- Applications in vegetable crops
- Future directions



Weeds are a top management concern for organic farmers

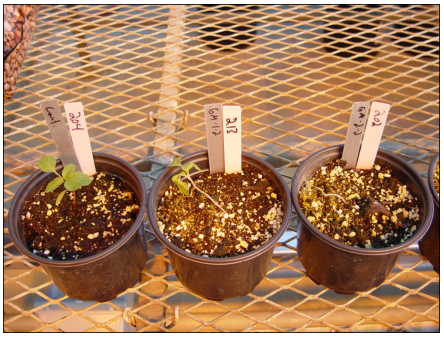
- Yield, quality, disease, and seedbank concerns
- OMRI-listed herbicides are not cost-effective
- Hand-weeding is expensive and difficult to source
- Heavy dependence on tillage

There are no silver bullets in organic weed management

- Need to employ "many little hammers"
- How can we control weeds that escape the crosshairs of cover crops, rotation, or tillage?

"Weed blasting" may serve as another *little hammer*

- Grits abrade weedy stem and leaf tissue
- Destroy apical meristem in dicots
- Height differential between crop and weed essential



Frank Forcella demonstrated proof of concept

INSIGHTS

DOI: 10.1111/j.1365-3180.2009.00711.x

Potential use of abrasive air-propelled agricultural residues for weed control

F FORCELLA
USDA-ARS Soils Lab, Morris, MN, USA

Weed Technology 2012 26:161–164

Received 9 January 2009
Revised version accepted 3 March 2009

Air-Propelled Abrasive Grit for Postemergence In-Row Weed Control in Field Corn

Frank Forcella*

Renewable Agriculture and Food Systems: 26(1); 31–37

doi:10.1017/S1742170510000438

Post-emergence weed control through abrasion with an approved organic fertilizer

Frank Forcella[1,*], Trevor James[2], and Anis Rahman[2]

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*Corresponding author: frank.forcella@ars.usda.gov

Accepted 30 August 2010; First published online 30 September 2010 **Research Paper**

GRIT APPLICATION CONTROLS WEEDS IN ORGANIC CROP PRODUCTION. 2014. M. Erazo-Barradas*[1], S. A. Clay[1], F. Forcella[2]; [1]South Dakota State University, Brookings, SD, [2]USDA, Morris, MN. WSSA Abstract #268, Vancouver, BC.

Next stage was to scale-up the technology

- Awarded NCR-SARE grant to do just that
- Dan Humburg and students designed a fabricated first multi-row grit applicator

Weed blasting and applicator effective, but challenges remained

- Economics
- Logistics of grit sourcing and application on a large scale
- Applying organic fertilizers in vegetable crops helps to address these issues

Weed Technology 2014 28:243–252

WSSA
WEED SCIENCE SOCIETY OF AMERICA

Integrating Weed and Vegetable Crop Management with Multifunctional Air-Propelled Abrasive Grits

Sam E. Wortman*

Combined what we've learned thus far and identified new directions

- USDA-NIFA OREI award
- Partnering with eOrganic
  - Webinars
  - YouTube videos
  - Articles

United States Department of Agriculture
National Institute of Food and Agriculture

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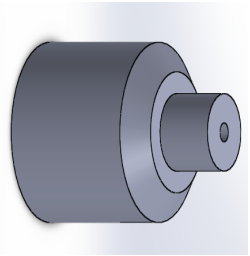
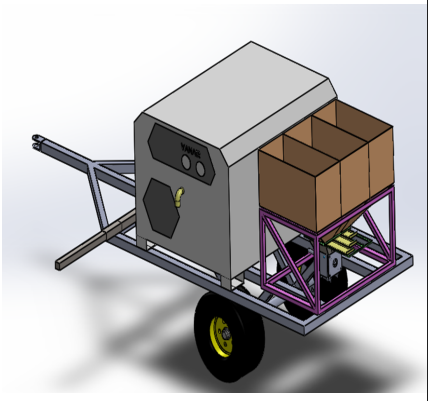


PAGMan: Air-Propelled Abrasive Grit Management

- 4-Row, 8 Nozzles, Fully Mounted, PTO driven, ~100 PSI screw compressor

New design for research in vegetable crops - Objectives

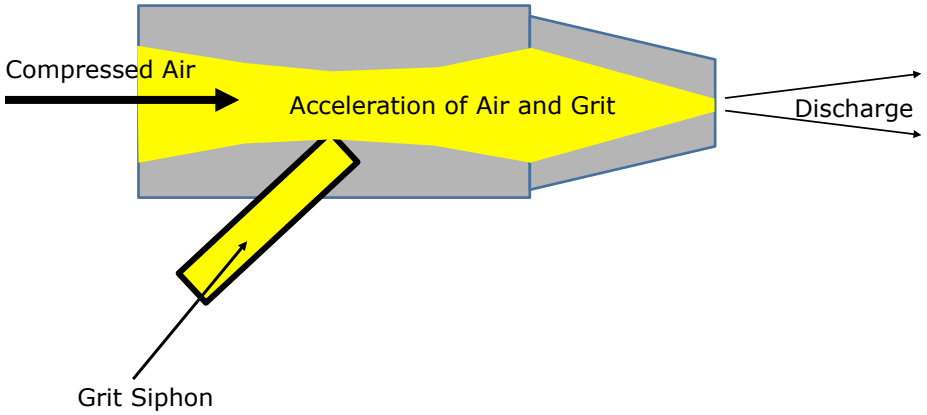
- Trailered design – less lateral sway
- Adaptable to varying row practices
- Self contained power (ATV pulled?)
- Multiple product bins for research
- Early season – two nozzles
- Single side nozzle for trellised crop
- Hand nozzle for research and spots
- Experiment with alternate grit



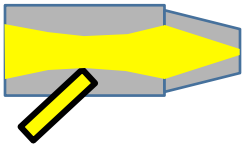
Grit Applicator Nozzles – System Objectives

- Achieve a high exit velocity of the grit
- Achieve the highest air velocities possible for the available supply
- Manage the grit application pattern geometry
- Achieve reliable, trouble free, mechanism for grit entrainment
- Allow for inexpensive experimentation with component design

Sandblast nozzles with Siphon Feed



Sandblast nozzles with Siphon Feed



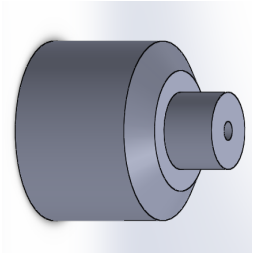
- Advantages of Siphon systems
  - Grit is accelerated with air to very high velocities
  - Feeding is simple in concept
- Disadvantages of Siphon systems
  - Feeding is poorly controlled
  - Grit tends to plug the discharge orifice if not uniform in size and feed rate
  - Nozzle wears rapidly and air and grit velocities will change with wear
  - Tip replacement required at ? intervals depending upon abrasive qualities

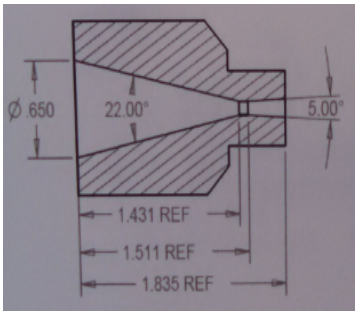
Pen Cage Nozzle Design Concept

- Design the throat of the system for air only
- Design orifice and expansion cone to maximize the efficient use the available air volume and pressure
- Achieve full expansion of the compressed air for maximum air velocity without shock waves
- Entrain grit into the high speed air stream at atmospheric pressure

Nozzle Design- Lanoue PEN

- PEN: Perfectly Expanded Nozzle
  - Optimized for 100 PSI
  - Accelerates air to supersonic velocities
  - Utilizes high pressure low velocity air to disperse into low pressure high velocity air
  - OREI system will be optimized for higher air pressure

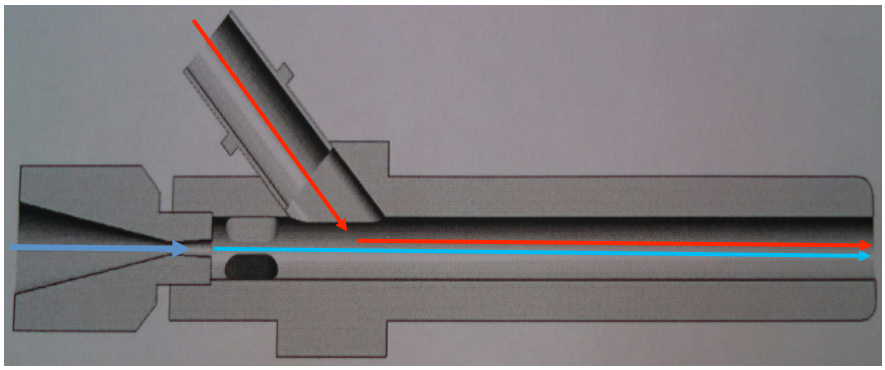




Nozzle Design - Lanoue CAGE

CAGE: Constant Area Grit Entrainment

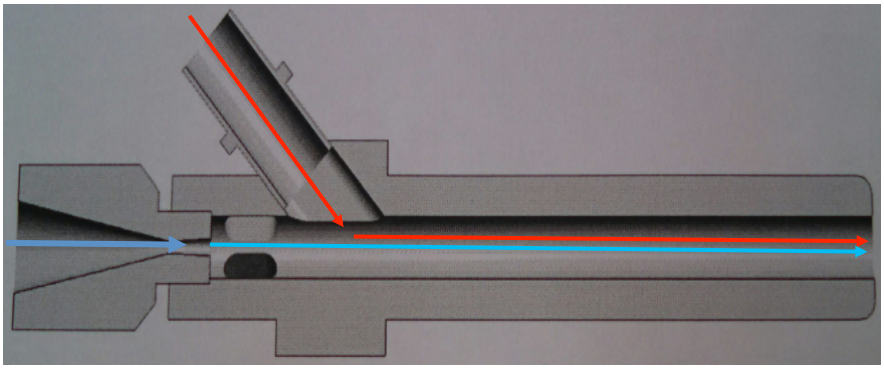
- Openings near air nozzle prevent back pressure
- Current design draws grit and some air in through side entry
- CAGE clamps to the nose of the PEN



Optimized by: Corey Lanoue

CAGE: Areas for study

- Constant area prevents back pressure and velocity fall as grit accelerates
- Bore diameter has not been optimized
- Vents have not been optimized
- Bore could change section shape while maintaining constant area



CAGE: Fabrication and Test of Alternates

- Existing CAGE is machined from steel and brass. Slow and expensive
- Experimental CAGEs could be 3-D printed from plastic
  - Fast. SDSU has MakerBots that are appropriate for these parts
  - Much easier to achieve complex internal and external geometry
  - Easier to design to accommodate fittings for grit entry

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Recent field studies in field crops focused on IWM strategies

- Objectives were to examine weed control and corn silage yield in response to weed blasting in combination with:
  - Flame-weeding
  - Cultivation
- Various timings and frequencies

Single grit applications	Double grit applications	Triple grit application
V1	V1+V3	V1+V3+V5
V3	V1+V5	
V5	V3+V5	

Grits were applied at a rate of 385 lbs/ acre (100 psi and speed of 1.5 mph)

Season Long Weedy Check at V3

Hand-Weeded Check at V3

Treated at V3

Treated at V1 + V3

Season Long Weedy Check

Hand Weeded Check

Corncob Grit + Flaming Treatment

Corncob Grit +
Cultivation Treatment

Morris, MN: Early grit application (V1) reduced weed biomass by 71% and increased yield by 40% relative to a weedy check

	Stage	Within-Row	Yield (lb/ac)	% increase over Season Long Weedy Check	Weed Biomass Row (lb/ac)	% reduction from Season Long Weedy Check
Single applications	V1	Grit	16,960	+40	755	-71
	V3	Grit	15,649	+29.5	1,201	-54
	V5	Grit	12,937		448	-83
Double applications	V1+V3	Grit	17,130	+41.8	528	-80
	V1+V5	Grit	13,204		506	-80
	V3+V5	Grit	12,089		332	-87
Triple application	V1+V3+V5	Grit	13,293		598	-77
	Season Long Weedy Check	Control	12,080		2,630	
	Hand Weeded Check	Control	14,043		599	
LSD (0.05)			1,963		328	

Morris, MN: Flaming and cultivation reduced weed biomass in the inter-row area, but had less effect on yield

Stage	Flaming	Cultivated	Flaming	Cultivated
	Yield (lb/ac)		Weed Biomass (lb/ac)	
V1	-4%	+4%	105 (-93%)	315 (-80%)
V3	-3%	+9%	610 (-60%)	526 (-66%)
V5	0	+2%	1,051 (-32%)	263 (-83%)
V1+V3	-4%	+4%	657 (-57%)	369 (-76%)
V1+V5	-7%	0	762 (-51%)	552 (-64%)
V3+V5	0	0	263 (-83%)	421 (-73%)
V1+V3+V5	-6%	0	868 (-44%)	474 (-70%)
Season Long Weedy Check			1,559 inter row weed biomass	
Hand Weeded Check			364	
LSD (0.05)			236	

Results demonstrate the importance of in-row weed management

- Compared to the season long weedy treatment:
  - Blasting reduced in-row weed biomass from 54 to 80%
  - Blasting at V1 or V1+V3 increased corn yield by 40%
- Grit application at V5:
  - Resulted in 80% in-row weed biomass reduction
  - Weed interference permanently stunted corn growth and yield
- Inter-row flaming and cultivation reduced weeds by avg. of 63%, but little effect on yield

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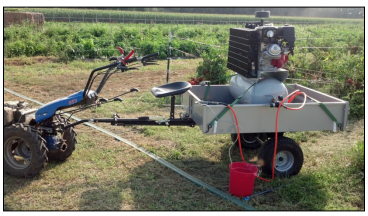
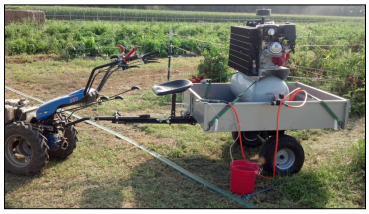


Vegetable trials conducted in 2013 and 2014 at Urbana, IL

- 2013 fresh market tomato
  - Diversified organic vegetables previous 4 years
- 2014 green bell pepper
  - Conventional corn – soy rotation previous 3 years

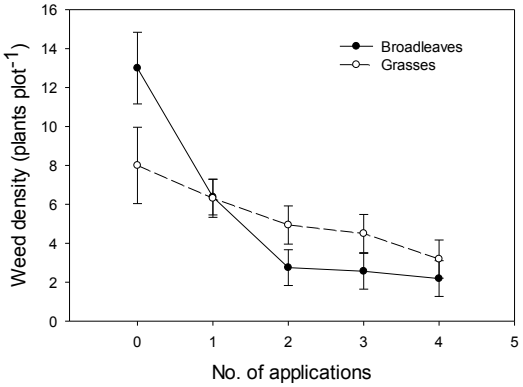


Abrasive grits applied between 1 and 4x

- Weeds between VC and V3 stage
- **Grits:** corn cob, walnut shells, soybean meal, greensand (2013)

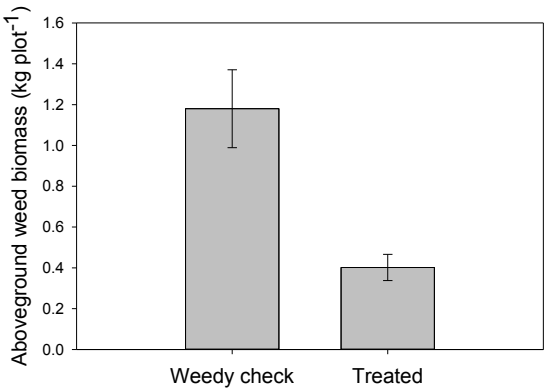
Air-propelled abrasive grits applied within crop hole

Weed density 37 days after 1st application in tomato



✓ Blasting reduced the density of both broadleaf and grass weeds by as much as 83.2 and 60.1%, respectively

End-of-season weed biomass in tomato

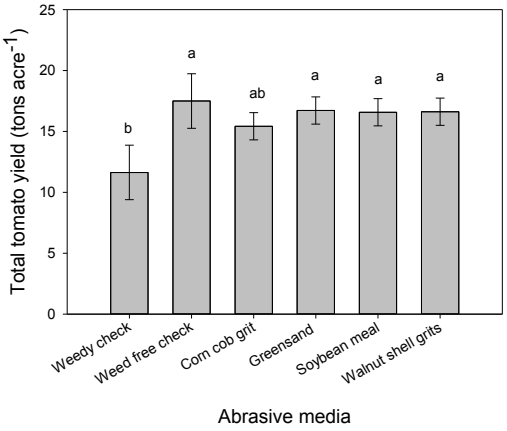


✓ Blasting, regardless of media or rate, reduced weed biomass by 66% relative to the weedy check

Treatment differences were obvious in the field

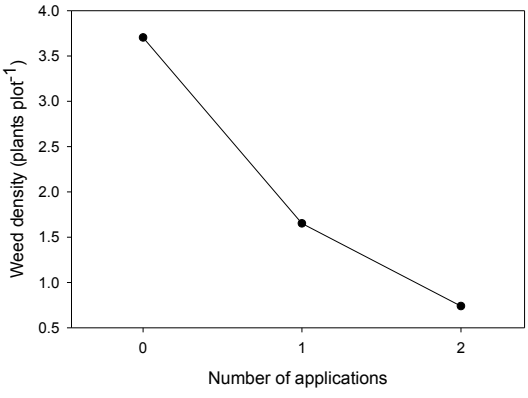
Untreated control

Total tomato yield (marketable and non-marketable)



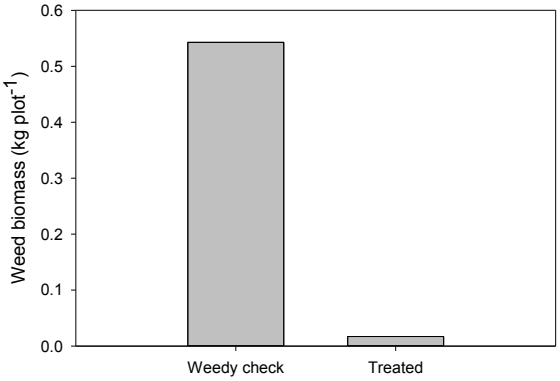
- ✓ Blasting increased total tomato yield by up to 44%
- ✓ Ratio of M:NM not influenced by blasting

Weed density 25 days after 1st application in pepper



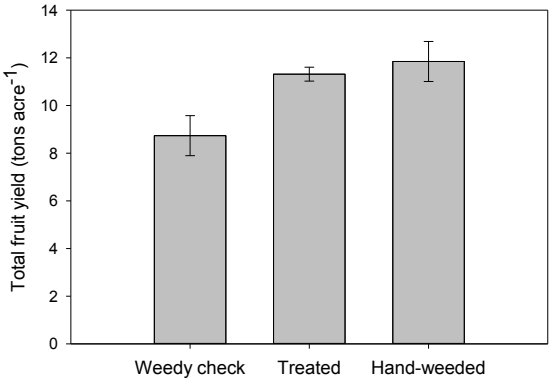
- ✓ Regardless of media, blasting 1x reduced weed density by 55% and blasting 2x reduced weed density by 80%

End-of-season weed biomass in pepper



✓ Blasting, regardless of media or number of blasts, reduced end of season weed biomass by 97%

Total pepper yield (marketable and non-marketable)



✓ Blasting increased yields by 29.5%

✓ Ratio of M:NM not influenced by blasting

Crop damage is a concern, but no disease or yield loss observed

Early weed growth stage is critical for effective control

Future research directions

- 1- or 2-row applicator for vegetable crops
- New nozzles and spray patterns
- On-farm trials in tomato, pepper, sweet corn, and cole crops, and corn and soybean
- Nitrogen mineralization and uptake from organic fertilizer grits (lab and field)
- Monitor diseases
- Integrating weed blasting with biodegradable and organic mulches, tillage, and flaming

Questions?

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