Four-Corners WSARE Organic Weed Management Conference

Alternative Weed Management

Phil Shuler, FLC Agriculture Dept.
New students at Cambridge University Gonville & Caius College traditionally begin their studies by walking through the humility gate (circa 1565)
Alternative Weed Management, aka the Farmer’s “New” Tools
## Contents

<table>
<thead>
<tr>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tool 1: Vinegar</td>
</tr>
<tr>
<td>Tool 2: Corn Gluten Meal</td>
</tr>
<tr>
<td>Tool 3: Soap Based Herbicides</td>
</tr>
<tr>
<td>Tool 4: Bio-fumigation</td>
</tr>
<tr>
<td>Miscellaneous Products</td>
</tr>
<tr>
<td>Closing Comments</td>
</tr>
</tbody>
</table>
Purpose

The purpose of our discussion today is to examine a few of these alternative techniques with the hope that some of us may find ways to successfully integrate some of these into our own production practices.
Background
• What is your greatest challenge in organic weed management?
  • Selectivity?
  • Labor cost?
  • Time?
  • Product cost?
  • Effectiveness?
  • Aggressive, perennial weeds?
  • Others?
• A bit of context with regard to alternative weed mgt.

• Techniques that are “alternative” to synthetic herbicides include biological weed management

Aphthona nigriscutis – Insect used to manage leafy spurge populations
• Mechanical Cultivation
• Cover Crops
• Mulching
There are also a number of novel and experimental techniques being tested for effective organic weed management which include a variety of products and a range of active ingredients such as:

- Vinegar
- Corn Gluten Meal
- Herbicidal Soaps
- Clove Oil
- Citrus Oils
- Cinnamon Bark / Oil (eugenol)
- Baking Soda
- Bio-fumigant crops (Allelopathy in cover crops)
Vinegar Based Herbicides

Canada Thistle
(Cirsium arvense)
<table>
<thead>
<tr>
<th>General</th>
<th>Natural product created by fermentation of fruit or grains, widely used as a food source, and so considered a safe product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode of Action</td>
<td>Disruption of membrane Integrity &amp; leakage of Cell Contents, leading to cell death</td>
</tr>
<tr>
<td>Active Ingredient</td>
<td>Acetic Acid (10-20% acid versus 4-8% for household vinegar; newer products may contain vinegar combined other active ingredients such as clove oil, citric acid, or citrus oils)</td>
</tr>
<tr>
<td>Selectivity</td>
<td>Non-selective on broadleaf, grassy weeds, most effective on young, actively growing weeds – e.g. “Vinegar containing 9% acid killed 80-100% of 30-day old or younger sunflower, and 10-day old pigweed, “ – USDA study</td>
</tr>
<tr>
<td>Examples of Weeds Managed</td>
<td>Chickweed, plantain, lambsquarter, dandelion, pigweed, oxalis, mustards, foxtail, morning glory, Canada thistle</td>
</tr>
</tbody>
</table>

Giant Foxtail
Miscellaneous comments / Concerns

- Short term soil acidification and repression of soil organisms (1-2 days?)
- Strong acid (e.g. 20% acetic acid), therefore a skin and eye hazard!
- pH <3, thus a potential poison if swallowed
- Some certifiers consider only vinegar made from fruits or grains appropriate for organic farming standards (vs. distilled white vinegar from ethanol)
- Cost per acre – Depending on product and frequency of application may be >$200/acre (relative to est. Roundup cost $90/acre)
Effectiveness / Research Validation

• In general, research results suggest that effectiveness is dependent on wetting leaves thoroughly (some products contain surfactants such as soap type compounds), on concentration of product, and on growth stage of weed.
• “Vinegar provided 95-100% kill on all growth stages of the weeds studied [lambsquarter, giant foxtail, smooth pigweed, and canada thistle] at 15 and 20% concentrations.” – (Radhakrishnan et al.)
<table>
<thead>
<tr>
<th>Effectiveness / Research Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Burnout II (contains vinegar, citric acid, clove oil) controlled about 90% of broadleaf and grassy weeds in southern California park and college campus – (Wilén and Boise)</td>
</tr>
</tbody>
</table>
Effectiveness / Research Validation

• Conclusion – although research on vinegar is not "extensive" relative to synthetic herbicides it does appear to be an effective non-selective herbicide at relatively high concentrations (>15% acetic acid), although lower concentrations may be effective when combined with other active ingredients such as clove oil and citrus oils.
Corn Gluten Meal

Dr. Nick Christians, Iowa State University (ISU) – discoverer of CGM
| General | • Corn gluten meal is a by-product of processing corn grain to make corn starch  
• It contains about 10% Nitrogen, so it is also considered to be a useful, slow release fertilizer, and is also used in dog food  
• It has traditionally been marketed especially for use in established lawns where some N is desirable and where the concern is for weeds that might encroach into the lawn |
<table>
<thead>
<tr>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The EPA has granted a FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) exemption for CGM – meaning it is considered safe to the environment and does not need to be regulated as more toxic herbicides are regulated</td>
</tr>
<tr>
<td>• Recommended rate is in the range of 12-20 pounds per 1,000 square feet, needs some moisture to activate</td>
</tr>
<tr>
<td>• Residual activity may be several weeks</td>
</tr>
</tbody>
</table>
| Mode of Action | • CGM contains natural substances which inhibit the growth of a germinating weed seed’s initial root
• This reduces the ability of the weed seedling to take up water and results in weed seedling mortality |

Germinating Purple Coral Pea (*Hardenbergia violacea*) seed.
| Active Ingredients | Laboratory studies on root growth in germinating seeds suggest that five dipeptides (glutaminyl-glutamine, alaninyl-asparagine, alaninyl-glutamine, glycinyl-alanine, and alaninyl-alanine) are the active ingredients in this product |
| Selectivity | • CGM is a pre-emergence herbicide, only considered effective against germinating weed seeds in the soil, i.e. before they emerge through the soil surface  
• It is generally non-selective for germinating seeds – meaning it would inhibit growth of desirable germinating seeds  
• Thus selectivity will be achieved by timing (established crop vs. new crop) |
<table>
<thead>
<tr>
<th>Examples of Weeds Managed</th>
<th>Crabgrass, dandelion, henbit, chickweed</th>
</tr>
</thead>
</table>

Henbit (*Lamium amplexicaule*)
Miscellaneous comments / concerns

• Addition of N to a new seedbed may encourage weed growth
• Important to remember it is only considered effective against germinating weeds in soil – not existing weeds
• Effectiveness experience is mixed
• Cost – Depending on product and frequency of application may be as high as $300/acre
Effectiveness / Research Validation

• In general, research on the effectiveness of CGM has been mixed
• Some researchers have noted improved weed control where the product was incorporated by shallow cultivation, rather than being left on the soil surface
• Other research suggests that split applications of the product are more effective than a single application
Effectiveness / Research Validation

- In Iowa research on Kentucky bluegrass, split applications of 20 lb/1000 ft² over a 5 year study reduced crabgrass from 33-95%, varying by year.
- A Kentucky study on an organic field with incorporated CGM resulted in a 14% reduction in weed count after tillage.
- “We conclude that CGM’s low herbicidal effect at recommended rates does not justify its high cost.” – (Bomford et al, Kentucky study)
Herbicidal Soap

Redroot Pigweed
| General | • These products include various mixes of natural fatty acids in a form that chemically resembles common dish soap  
• They are considered safe with regard to human or ecosystem health and thus desired by organically minded growers – although they are considered a moderate irritant for eyes and skin |
| General | • Generally sold as liquid concentrate that is diluted to a 5-10% solution and sprayed on a cost that can range as high as 34-$63/gallon |
Active Ingredients

Fatty acids (e.g. Pelargonic Acid, Nonanoic acid) mixed with additives (e.g. emulsifiers) to enhance performance
| Selectivity | • HS is a contact, non-selective herbicide that will help manage annual weeds, esp. younger weeds during warm, dry weather  
• HS is considered ineffective against perennial weeds because it will only kill top-growth, thus allowing re-growth |
| Examples of Weeds Managed | Chickweed, Plantain, Corn spurry, Redroot pigweed, Groundsel Lamb’s-quarters, mouse-eared chickweed, moss, algae |

Corn Spurry (*Spergula arvensis*)
<table>
<thead>
<tr>
<th>Miscellaneous comments / concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Because it is non-selective care must be taken around desirable plants</td>
</tr>
<tr>
<td>• Depending on weed and product, results visible within hours to a few days</td>
</tr>
<tr>
<td>• Relatively low residue concern – treated areas may be planted within a few days or less</td>
</tr>
<tr>
<td>• May require multiple treatments during the growing season</td>
</tr>
</tbody>
</table>
Effectiveness / Research Validation

- Anecdotal reports suggest HS can be an effective spot treatment for smaller weeds
- There is a dearth of independent, peer-reviewed long term cost and effectiveness research on HS
Bio-fumigation

White Mustard *Brassica alba*
<p>| General | Biofumigation (BF) refers to the process of treating soil with natural substances released by decomposing cover crops. Some of the natural substances released appear to be toxic to some phytopathogenic nematodes and weed seeds. BF is being touted as an alternative to chemical fumigation with toxic synthetic products such as methyl bromide. |</p>
<table>
<thead>
<tr>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Current research suggests that the phytotoxic aka fumigation effect of the cover crops results from at least 2 factors:</td>
</tr>
<tr>
<td>1) Releasing allelochemicals (natural chemicals that inhibit the growth or germination of other plants such as weeds)</td>
</tr>
<tr>
<td>2) Sequestering soil nutrients (thus depriving weeds of nutrients)</td>
</tr>
</tbody>
</table>
General

• Traditional practice and research literature on BF often focuses on crops in the mustard family (Brassicaceae)
• Brassica crops implicated in biofumigation include brown mustard (*Brassica juncea*), black mustard (*Brassica nigra*), and white mustard (*Brassica birta*)
• Other studies have tested legumes and even animal droppings as BF treatments
<table>
<thead>
<tr>
<th>Mode of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A number of Brassica crops, in the process of decomposing, release compounds known as glucosinolates, which in turn are metabolized in the soil to form compounds known as isothiocyanates (e.g. <a href="#">sulforaphane</a>, found in fresh broccoli)</td>
</tr>
<tr>
<td>• Isothiocyanates are toxic to some phytopathogenic nematodes, weed seeds, and other soil organisms (possibly including mycorrhiza)</td>
</tr>
</tbody>
</table>
Active Ingredients

Isothiocyanates in general, other allelopathic compounds as yet not characterized may be involved

Conversion of Glucosinolates to Isothiocyanates by Plant Myrosinase.
| Selectivity | • Traditional weed management in Mexico using BF crops in the legume family (velvetbean, jackbean, and jumbiebean) as well as U.S. based research into biofumigation with Brassicas suggests that the effect of BF crops is both complex and specific  
• It appears that local / traditional knowledge of how each BF crop fits in with other crops is critical in successful use of BF crops |
| Selectivity | • Case in point – in a 5 year field experiment with field corn in Mexico, velvetleaf and jackbean cover crops provided biofumigation control of barnyardgrass; however they also inhibited growth of tomato • A small scale study in Maryland suggests that brassica cover crops may at least temporarily inhibit the infection of soybeans by beneficial soil fungi (mycorrhiza) |
| Examples of Weeds Managed | Barnyardgrass, Pigweed, Lambsquarters |

Barnyardgrass (*Echinochloa crus-galli*)
Effectiveness / Research Validation

- Research results show variability in effectiveness across years, cover crop species, and combining BF with other weed management techniques, e.g. solarization
- Nevertheless, there are enough positive results that there is reason to hope that BF can be a viable, affordable organic weed management option
Effectiveness / Research Validation

• Field studies in Germany with incorporating turnip (*Brassica rapa*) mulch into soil resulted in releases of high levels of isothiocynates and reduced germination of scentless mayweed and spiny sowthistle

• In a greenhouse study in Washington State, white mustard and brown mustard residues mixed into soil reduced germination of redroot pigweed and barnyard grass by 20-95%
Effectiveness / Research Validation

• Research in strawberry fields in Spain demonstrated moderate control of annual bluegrass, Purslane, and pigweed with various combinations of chopped strawberry residue and hen droppings.
• Various studies with rye, sudangrass, and buckwheat have documented the release of allelochemicals that appear to inhibit the growth of a variety of weeds including lambsquarter, pigweed, and Canada thistle.
Miscellaneous comments / Concerns

• BF is becoming prized as much or more for **nematode and disease management** as for weed management in potatoes, grapes
• Case in point - Napa Valley grape growers face challenging nematode issues in establishing new stands
• Using in a new planting – chop, turn in, and water Brassica cover crop at least 3-4 weeks before planting
• Depending on seed cost and management costs may be as low as $90/acre
Miscellaneous Products
As the development of organic weed management products continues, herbicides containing various mixtures of natural substances are being marketed.
• Reputed weed inhibiting materials in these products include:
  • Clove Oil, Wintergreen Oil, Garlic Extract, Citrus oil (limonene), mustard meal, cinnamon extract, yucca extract, thyme oil
• Independent research on the variety of products and mixtures available is limiting – it’s probably too early to offer strong recommendations for these products, except by personal experience – caution and careful experimentation is suggested
Closing Comments
• Organically based and approved weed management products show promise in managing weeds as part of a comprehensive weed management plan that may include mulching, hand weeding, steam, tillage, or flaming.

• Alternative organic herbicides may be suited for spot spraying relatively small infestations keeping a close eye on costs.
• Vinegar-based herbicides & Biofumigation show promise as effective and environmentally sound weed management options.

• Because of the specific knowledge needed to use BF effectively, local growers may want to develop a formal (web-based) or informal (lean against the fence or diner-based) database of experiences with specific BF cover crops and their effectiveness with different crop combinations (e.g., white mustard and potatoes) – in this way we can continue to build and preserve local traditional knowledge.
• One of the best things a person can do on their farm is to have test strips to try new things each year – Dr. Merle Teel – Agricultural Professor and Nebraska farm boy – a key mentor for this speaker
Eric Bristow has reached 100 but is still growing, thanks to flower power.

The retired joiner has shown an amazing ability to shrug off his age - which he puts down to fresh air and tending his modest garden for the past 62 years. 'I love being able to spend every day working in the garden. It keeps me going,' said Mr Bristow.
End