HS1003

UF UNIVERSITY of FLORIDA
IFAS Extension

Status and Preliminary Research on Non-Synthetic Herbicides for Organic Production[1]

James J. Ferguson and Carlene A. Chase[2]

Organic growers have consistently ranked weed management as one of their most important production problems and have used a variety of methods including flaming, hot water treatments, solarization, cultivation, mowing, mulching, and cover crops to control weeds. Non-synthetic herbicides may also be used in organic production. However, these non-synthetic herbicides are restricted (must be approved by the grower's organic certifying agency), suggesting that other cultural practices like cover crops and mowing be used first.

Procedures for identifying and registering non-synthetic herbicides for possible use in organic production are complex, involving federal and state laws and regulations as well as national and local organic certifying agencies. Our purpose is to explain this process and to review preliminary research on several non-synthetic herbicides.

The Organic Materials Review Institute

The National Organic Program establishes general standards for certification procedures and inputs that are used in organic farming and processing but does not maintain a list of trade name products. The Organic Materials Review Institute (OMRI), a non-profit organization, fulfills this function, charging “certifiers, growers, manufacturers, and suppliers for an independent review of products intended for use in certified organic production, handling, and processing under the USDA National Organic Program standards.” OMRI approval is an ongoing process. That is, products may be added or deleted, depending on continual product evaluation.

Note also that OMRI reviews products in terms of their ingredients but not in terms of their effectiveness or federal and state registration. Furthermore, products listed by OMRI, like herbicides, must also be approved by the local organic certifying agency if such products are restricted. Another option for pesticide

1. This document is HS1003, one of a series of the Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Publication date: January 2005. Please visit the EDIS Web site at http://edis.ifas.ufl.edu.

2. James J. Ferguson, professor, and Carlene A. Chase, assistant professor, Horticultural Sciences Department, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

manufacturers to market their products to organic growers is to ensure that the ingredients of their products conform to national organic standards, without going through the OMRI, fee-based approval process.

Minimum Risk Pesticides

All pesticides (including herbicides), be they conventional pesticides or those listed by the Organic Materials Review Institute for use in organic farming, must either be registered by the Environmental Protection Agency (EPA) *or* be exempted from registration. The federal law governing pesticide registration is The Federal Insecticide and Rodenticide Act (FIFRA). Under section 25 (b) of FIFRA, *"minimum risk"* pesticides are exempted from EPA registration because such pesticides contain compounds that are classified as Generally Regarded as Safe (GRAS) and can be used on food crops without the pesticide label listing all possible crop uses.

Another important distinction for pesticide registration or exemption is made between "active" and "inert" pesticide ingredients. An active ingredient is intended to kill, poison, or repel a pest whereas an inert ingredient, listed separately, is not intended to affect a target pest. Active ingredients must be listed by name and percentage (by weight). All other (inert) ingredients must be listed by name but not necessarily listed separately by percentage weight. Tables 1 and 2, respectively, contain the current list of allowed active and inert ingredients of minimum risk pesticides under Section 25 (b) of FIFRA.

For example, the product label for Matran 2, an herbicide listed by OMRI, contains the statement: "This product has not been registered by the US Environmental Protection Agency. Biorganic® represents that this product qualifies for exemption from registration under the Federal Insecticide, Fungicide, and Rodenticide Act." The active ingredient for Matran 2 is Clove Oil (45.8%), found in Table 1 with "Other Ingredients" or inerts listed as "Water, Lecithin: 54.4%," found in Table 2.

Another more controversial example is acetic acid or vinegar. Acetic acid has been used by researchers at relatively high concentrations (about 20%) to control weeds and could presumably be used to manage weeds in organic farming systems. But the classification of acetic acid as an inert or secondary ingredient (Table 2), rather than as an active or primary ingredient, in herbicides (Table 1) has prevented its registration as an herbicide in some states like Florida. If a company developed an herbicide with acetic acid as an active ingredient, tolerances **for food crops** for this compound would have to be established - a costly process. Two acetic acid herbicide formulations are registered in Florida: Nature's Glory Weed and Grass Killer® in a 6.25% ready-to-use concentration, and the same product in a 25% concentration requiring dilution. Both formulations are registered in Florida for use on ornamental plants and turf, farm yards, rights of way, etc. for a range of grass and broadleaf weeds **but not for food crops**, because as mentioned above, tolerances have not been established. However, inert ingredients can be included in minimum risk herbicides at high enough concentrations to have an herbicidal effect. This is exactly what has happened, with some manufacturers directly or indirectly claiming herbicidal properties for materials containing an undefined concentration of acetic acid.

State Regulation of Minimum Risk Herbicides

A product fulfilling FIFRA requirements as a minimum risk herbicide and listed by OMRI may not be exempt from state registration or other regulatory requirements. The Florida Department of Agriculture and Consumer Services (FDACS), Division of Agricultural Environmental Services, and the Bureau of Pesticides (http://www.flpesticide.us/) maintain an on-line Florida Registration Tracking System that lists pesticides registered in Florida as a minimum risk pesticide according to section 25 (b) of FIFRA. For example, non-synthetic herbicides like Matran 2 and Xpress are listed by OMRI (http://www.omri.org/crops_generic.pdf) and are found in the FDACS Registration Tracking System but other non-synthetic herbicides may not be so listed.

Preliminary Research

OMRI had listed Alldown®, Matran 2®, and Xpress® as all contact or burn down herbicides. However, as of 10/25/04, only Matran 2 and Xpress were listed on the OMRI product web site (http://www.omri.org/crops_alpha.pdf) (Table 3). Alldown is mentioned here because it was OMRI-approved when the research described below was conducted. The active ingredients of Matran 2 and Xpress are essential oils (the oil obtained after extracting highly aromatic cells from a plant by distillation), with Matran 2 containing clove oil and Xpress containing both clove and thyme oil plus acetic acid and other ingredients. Both clove oil and thyme oil contain phytotoxic compounds and have been reported to kill johnsongrass, common lambsquarters, and other grasses and broad leaf weeds. Xpress contains acetic acid but as an inert ingredient at an undefined concentration (Table 3). Alldown, another non-synthetic herbicide, also contains acetic acid. However, acetic acid is not listed as an active ingredient allowed in minimum risk herbicides (Table 1). Therefore acetic acid cannot be registered as an herbicide and cannot be recommended for weed control for food crops by Extension faculty. Such recommendations are based on several years of field research, usually funded by the pesticide manufacturer. Unfortunately, many small companies producing pesticides and other materials for possible use in organic production do not have the financial resources to fund such research.

Alldown, Matran 2, and Xpress have been applied to grasses and broadleaf weeds in Kentucky and Florida (Table 4). Alldown applied at high rates (40 to 70 gallons per acre) killed from 82 to 100% of Kentucky bluegrass turf in that state within 24 hours but within five weeks all the turf recovered, compared with 7% recovery of turf treated with Roundup®. More variable results were reported from Florida, with Alldown, at 40 gallons per acre providing inconsistent control of grasses and broadleaf weeds in one trial but in another experiment (rate per acre not specified) providing 70% control within one week, declining to 60% in three weeks. Both tests were conducted on former pasture land as a weed control trial with no host crop. Note also that Alldown was applied at full product concentration. Further testing is being conducted this year.

In Florida, Matran 2 provided 70% control in one case, declining to less than 60% within three weeks. However, when weeds were tilled before herbicide application, Matran 2 provided up to 75% control within five weeks. In both Florida trials Xpress did not provide uniform weed control.

USDA researchers have also used acetic acid to control weeds but at higher concentrations (up to 20%) than are found in food-use acetic acid or vinegar (3-5%). When acetic acid was applied at about 6 to 13% concentrations as a directed spray or broadcast at different times, broadleaf weeds were suppressed during the potato growing season in West Virginia but nutsedge and other grasses were only temporarily controlled. In sweet pepper fields, higher concentrations of acetic acid (18%) provided better control but only for about a month. Using 5 to 20% acetic acid concentrations as basal and foliar sprays on corn and soybeans, early-season sprays afforded greater control of younger weeds than later, seasonal sprays but at the cost of some crop damage (Table 4).

USDA researchers also advise that due to the corrosive nature of acetic acid, spray equipment should be taken apart and individual components such as O rings should be rinsed well after using herbicides containing acetic acid. Note also that acetic acid concentrations over 11% can cause burns upon skin contact.

Summary

Active and inert ingredients allowed in minimum-risk herbicides are clearly defined under federal laws but the percent composition of inert ingredients is not clearly defined, allowing for inclusion of compounds with some herbicidal effect. Two non-synthetic herbicides listed by OMRI are also registered for use in Florida but preliminary research has indicated varying efficacy. Acetic acid has been used as an herbicide in experimental trials but is not now registered as the active ingredient in an herbicide because of lack of data on tolerances in food crops.

Table 1. Active ingredients that may be in minimum risk pesticide products exempted under section 25(b) of FIFRA. Appendix A PR Notice 2000-6.

1. Castor Oil (U.S.P. or equivalent)	17. Linseed Oil
2. Cedar Oil	18. Malic Acid*
3. Cinnamon* and Cinnamon Oil*	19. Mint* and Mint Oil*
4. Citric Acid*	20. Peppermint* and Peppermint Oil*
5. Citronella and Citronella Oil	21. 2-Phenethyl Propionate (2-phenylethyl propionate)
6. Cloves* and Clove Oil*	22. Potassium Sorbate
7. Corn Gluten Meal*	23. Putrescent Whole Egg Solids (See 180.1071)
8. Corn Oil*	24. Rosemary* and Rosemary Oil*
9. Cottonseed Oil*	25. Sesame* (includes ground Sesame plant stalks) See 180.1087) and Sesame Oil*
10. Dried Blood	26. Sodium Chloride (common salt)*
11. Eugenol	27. Sodium Lauryl Sulfate
12. Garlic* and Garlic Oil*	28. Soybean Oil
13. Geraniol	29. Thyme* and Thyme Oil*
14. Geranium Oil	30. White Pepper*
15. Lauryl Sulfate	31. Zinc Metal Strips (consisting solely of zinc metal and impurities)
16. Lemon Grass Oil*	
* These active ingredients are exempt for use on all food commodities from the requirement of a tolerance on all raw agricultural commodities at 40 CFR 180.1164(d).	

Table 2. Appendix B PR Notice 2000-6. LIST 4A Minimal Risk Inerts. Parentheses indicate exemption from tolerance as inerts if all the conditions set forth in the text and tables shown for the particular substance at 40 CFR 180.1001(c), (d) and/or (e) are met.

Acetic acid (c, d, e)	Lanolin (d)
Agar	Lard (c)
Alfalfa	Latex
Alfalfa meal	Lecithin (c)
Almond hulls	Lime
Almond shells (c)	Limestone

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Alpha cellulose (c)	Linseed oil
Apple pomace (c)	Malt flavor
Attapulgite-type clay (c, e)	Meat meal
Beef fat	Meal scraps
Beeswax (c)	Medicated feed
Beet powder	Mica (c)
Bentonite (c)	Milk
Bicarbonate (c)	Millet seed
Bone meal	Mineral oil, U.S.P. (c,e)
Bran	Molasses (c)
Bread crumbs	Montmorillonite-type clay (c,e)
Calcareous shale (c)	Nitrogen
Calcite (c)	Nylon
Calcium carbonate (c, e)	Oatmeal (c)
Canary seed	Oats (c)
Cane syrup	Olive oil
Carbon dioxide	Onions
Cardboard	Orange pulp (as pomace c)
Carrageenan (c, d, e)	Oyster shells
Carrots	Paper (fiber; d)
Casein (c)	Paprika
Cheese	Paraffin wax
Chlorophyll	Peanut butter
Cinnamon (d)	Peanut oil
Citric acid (c, e)	Peanuts
Citrus meal (c)	Peanut shells (c)
Citrus pectin	Peat moss
Citrus pulp	Pecan shell flour
Clam shells	Pectin
Cloves (d)	Polyethylene film (c)
Cocoa	Polyethylene pellets, edible
Cocoa shells (c)	Potatoes
Cocoa shell flour	Pumice
Cod liver oil (c)	Raisins
Coffee grounds (c)	Red cedar chips
Cookies	Red dog flour

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Cork	Rice
Corn (d)	Rice hulls
Corn cobs (c)	Rubber
Corn flour	Rye flour
Corn meal (c)	Safflower oil
Corn oil (c)	Sawdust
Cornstarch (c)	Seaweed
Corn syrup (c, e)	Shale
Cotton	Soapstone (c, e)
Cottonseed meal	Sodium (c)
Cottonseed oil (c)	Sodium chloride (c)
Cracked oats	Sorbitol (c, e)
Cracked wheat	Soy flour (c)
Dextrin (c, e)	Soy protein (c, e)
Dextrose (c, e)	Soybean hulls
Dolomite (c)	Soybean meal
Douglas-fir bark, ground (d)	Soybean oil (c, e)
Egg shells	Sucrose
Eggs	Sugarbeet meal
Edible fish meal (c)	Sunflower seeds
Edible fish oil (c)	Tallow
Flour (wheat, d)	Vanillin (d)
Fuller's earth	Vermiculite
Gelatin	Vitamin C
Glue, as depolymerized animal collagen	Vitamin E
Glycerin (glycerol; c, d, e)	Walnut flour
Granite (c)	Walnut shells (c)
Graphite (c, d, e)	Water
Ground oats	Wheat (d)
Guar gum (c)	Wheat germ oil
Gum tragacanth	Whey
Gypsum (c)	Wintergreen oil (c)
Hearts of corn flour	Wool
Hydrogenated vegetable oils	Xanthan gum (c, e)
Honey	Yeast
Invert sugar (c)	

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Invert syrup (c)	
Kaolinite-type clay (c, e)	
Lactose (c)	
180.1001 (c) = exempt for both growing crops & crops after harvest (d) = exempt for growing crops only (e) = exempt for animal applications only Please Note: List 4A, "Minimal Risk Inerts" (Appendix B of this notice) is updated on a continuing basis. Current versions are available on the Pesticides Web site at http://www.epa.gov/opprd001/inerts/inerts_list4.pdf	

Table 3. Herbicides approved by the Organic Materials Review Institute (OMRI).

Herbicide	Active ingredients (%)	Estimated cost/gallon ($)	Manufacturer
Matran - 2	Clove oil: 45.6 Other: (lecithin, water) 54.4	79.60	Encore Technologies, Minnesota
Xpress	Thyme oil: 10.4 Clove oil: 10.1 Inert ingredeitns: 79.5 (acetic acid, molasses, water)	84.00	BiohumaNetics, Arizona

Table 4. Weed control with OMRI-approved herbicides (Matran 2 and Xpress) Alldown and acetic acid.

Location (Date)	Crops	Treatments	Results	Authors
Florida (2004)	Pasture	Three nonsynthetic, postemergence, contact herbicides (Alldown, Matran 2 and Xpress) and corn gluten meal applied preemergence, and flaming, applied after a mowing or tillage pretreatment or with no pretreatment.	With no pretreatment or with mowing as a pretreatment, flaming provided 97% weed control after 1 week, declining to 79% after 3 weeks. Alldown (undiluted) and Matran 2 (20%) provided 70% control within 1 week, but control declined to less than 60% by 3 weeks. With tillage as a pretreatment, corn gluten meal, Matran 2 (20%), and flaming provided 68-75% control within 5 weeks. Xpress gave inconsistent results.	Chase, C.A., J.M. Scholberg, and G.E. MacDonald. 2004. Preliminary evaluation of nonsynthetic herbicides for weed management in organic orange production. Proc. Fla. State Hort Soc. In press.
Florida (2004	Pasture	Three nonsynthetic, postemergence, contact herbicides plus an adjuvant (Alldown, Matran 2 and Xpress) compared with glyphosate (Roundup Pro).	Alldown (100% concentration at 40 gallons per acre), Matran 2 (10% at 5 gallons per acre), Xpress (7.5-15%) at 7.5-15 gallons per acre provided inconsistent weed control compared with glyphosate (5% Roundup Pro).	Ferguson, J.J. 2004. Evaluation of organic herbicides. HortScience. 39:876. Abstract.
Iowa (1999)	Kentucky bluegrass	Alldown at 10, 20, 30, 40, 50, 60, and 70 gallons per acre compared with Roundup (label rate) and an untreated control.	10 to 40 gallons per acre killed from 13 to 73% of turf within 24 hours but within one week, from 93 to 57% turf had recovered, respectively. 40 to 70 gallons per acre killed from 82 to 100 % of turf within 24 hours but within 5 weeks 100% of turf recovered compared with 7% treated with Roundup.	Bingaman, B.R., M.J. Howieson, and N.E. Christians. 1999. Alldown natural herbicide study. http://turfgrass.hort.iastate.edu/pubs/turfrpt/2000/alldown.html
West Virginia (2002)	Potatoes	Vinegar (Acetic Acid: 6.25 or 12.5%) as directed spray or broadcast early, late, or early + late.	Broadleaf plaintain and yellow wood sorrel counts lower in vinegar-treated plots than in nontreated plots during the growing season. Yellow nutsedge and orchardgrass were suppressed for two to three weeks but regrew later.	USDA: Chandran, R.S., M. Stenger, and M. Mandal. Abstract. Effect of vinegar on potato weed control. Northeastern Weed Science Society.

Table 4. Weed control with OMRI-approved herbicides (Matran 2 and Xpress) Alldown and acetic acid.

Location (Date)	Crops	Treatments	Results	Authors
West Virginia (2002)	Sweet peppers	Vinegar (acetic acid: 4.5, 9.0, and 18%); corn gluten (20, 40, and 80 lbs/1000ft^2)	Directed application of vinegar (4.5, 9.0, and 18%) provided >90% control of carpetweed, Canada thistle, yellow wood sorrel, common purslane, common lambsquarters, smooth pigweed, and velvet leaf and 50% control of yellow nutsedge when applied at 18% concentration. However, 1 month after treatment, only 20 to 30% weed control was obtained compared with untreated plots. Corn gluten applied at 80 lbs/1000 ft^2 reduced weed counts 78% three weeks after treatment and 32% 2 months after treatment.	Chandran, R.S. Evaluation of vinegar and corn gluten for weed control in field-grown sweet pepper. Northeastern Weed Science Society.
	Corn, soybeans	Vinegar (acetic acid at 10 and 20%) sprayed (early treatment) to base of corn planted in rows (40 days old) and soybeans (55, 61, and 80 days old). Vinegar (acetic acid at 10 and 20%) sprayed (late treatment) to base of corn (55 days old) and soybeans (68, 74, and 93 days old). Vinegar (acetic acid at 10 and 20%) foliar and basal spray in replicated plots. Vinegar (acetic acid at 10 and 20%) sprayed at 30, 60, and 90 gallons/acre.	5-35% Corn injury. Giant foxtail control ranged from 100 (early spray) to 55% with late spray. Pigweed control ranged from ranged from 99% (early spray) to 55% (late spray). 5 to 45% soybean damage, especially on younger plants. More corn damage with foliar spray at 20% concentration. 20% acetic acid at 90 gallons per acre did not control weeds > 50 days old.	Radhakrishnan, J., J.R. Teasdale, and C.B. Coffman. Agricultural applications of vinegar. Northeastern Weed Science Society.
2001		0.0, 5.0, 10.0, 15.0, and 20.0 % vinegar sprayed on common lambsquarters, giant foxtail, velvetleaf, and smooth pigweed (22, 29, and 35 day-old plants) and Canada thistle (30, 40, and 50 days old) weed foliage in greenhouse experiments.	5 and 10.0 % concentrations more effective on younger weeds but 15 and 20% more effective on older weeds. 15 and 20% concentrations killed 90-100 % of all weeds. 5% concentration provided 100% top kill of Canada thistle with some root regrowth.	Radhakrishna, K.J., J.R. Teasdale, and C.B. Coffman. Vinegar as a potential herbicide for organic agriculture. Northeastern Weed Science Society.
Matran 2 and Xpress are listed by the Organic Materials Review Institute (OMRI). Alldown was listed as of 10/25/04 http://www.omri.org/crops_alpha.pdf.				