Current Substances for Organic Weed Control in Vegetables or What Do We Have In Our Organic Weed Control Tool Box?

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Introduction

Weed control is the top research priority among organic producers (OFRF, 1999). The genetic diversity among, and within species, make weeds formidable competitors that can cause substantial yield reductions, reduce crop quality, and serve as disease sinks and insect hosts. The eradication of weeds from a production area is extremely difficult due to prolific seed production, longevity of seed viability in the soil, and continued introduction through animals, equipment, and environmental factors. Herbicide development for conventional agriculture has 60 years of experience and a history of hundreds of synthetic herbicides for use in a broad spectrum of crops to control an even broader spectrum of weeds. The mode of action for the synthetic herbicides is very diverse; including non-selective contact and systemic herbicides, and preemergence and postemergence herbicides that can control a majority of either monocots, dicots or a combination of both. Synthetic herbicide development is now linked with genetically engineered plants that are resistant to over-the-top broadcast application of broad spectrum systemic herbicides. In the case of organic production, growers have a short, but growing list of organic approved herbicides to integrate into their existing weed control strategies that may include crop rotations, cover crops, planting systems, mulches, mechanical methods, and flaming.

Objective

The purpose of this presentation is to provide general information on alternative weed control options for organic crop production.

Organic Herbicides

\textit{Corn Gluten Meal and Mustard Meal}

Corn gluten meal (CGM), a by-product of the wet-milling process of corn, and mustard meal (MM) are phytotoxic. The non-selective preemergence, or preplant-incorporated, herbicides CGM and MM
inhibit root development, decrease shoot length, and reduce plant survival of weed and crop seedlings. Research has demonstrated that CGM can be effectively used for weed control with established turf, transplanted vegetables, and, if precisely applied to provide a CGM-free planting strip, for direct-seeded vegetables. It is essential to understand that as non-selective herbicides, CGM and MM can injure or kill germinating and emerging crop seedlings. Crop safety is greater when these substances are applied to established annual or perennial plants. Initial research with mustard meal has shown similar application and weed control potential as CGM. Although CGM and MM can provide effective early preemergence weed control of germinating weed seeds, supplemental weed control measures will be required to control escaped weeds, established perennial weeds, or weeds emerging in the mid- to late-growing season. CGM and MM must not be derived from genetically modified organisms (GMO) to be cleared as potential organic materials. Mustard meal can cause extreme dermal reaction in humans and should be used with suitable protective equipment.

**Vinegar/Acetic Acid**

There are a number of organically approved products that contain vinegar (i.e., 5%, 10%, and 20% acetic acid). Vinegar (acetic acid) is a non-selective contact herbicide. In general, weed control increases as acetic acid content and application volume increase (i.e., 20, 40, 80, and 100 gpa). Typically, vinegar is less effective in controlling grasses than broadleaf weeds and more effective on annual species than perennials. In addition to application volumes and concentration, weed control is also dependent on the weed size and the species. Carpetweed (*Mollugo verticillata* L.) is very sensitive to acetic acid at very low concentrations and application volumes, while yellow nutsedge (*Cyperus esculentus* L.) is able to tolerate high acetic acid concentrations and application volumes. Repeated applications of acetic acid may be necessary for satisfactory weed control depending on weed size, weed species, and whether it is an annual or perennial plant. There is also a difference between non-synthetic and synthetic acetic acid and approval for use in organic production. If the material is intended for use on certified organic land, check for approval of your specific product with your organic certifying agency. Also keep in mind that clearance for organic use does not mean a product can not cause personal injury, if handled in an unsafe manner. Vinegar with greater than 10% acetic acid can cause severe eye damage or even blindness.

**Clove Oil**

Clove oil is the active ingredient in a number of organically approved postemergent non-selective herbicides. Clove oil weed control efficacy can be as good, or better than acetic acid herbicides, and can be applied at lower application volumes and remain effective. As with acetic acid and other contact herbicides, broadleaf weed control, in general, is greater than grass weed control. There is evidence that adding certain organically approved adjuvants (i.e., garlic and yucca extracts) will increase weed control with clove oil.
Ammonium Nonanoate

Ammonium nonanoate/ammonium pelargonate is another non-selective contact postemergent herbicide that has shown excellent weed control activity and has just recently received clearance as an organic herbicide. Ammonium nonanoate occurs in nature and is formed from the biodegradation of higher fatty acids. Ammonium nonanoate is more effective on broadleaf weeds than grasses, and smaller/younger weeds than larger/more mature weeds. Ammonium nonanoate can be effective at more application volumes than acetic acid products.

Fatty Acids

A recent National Organic Program (NOP) ruling decided that pelargonic acid is a prohibited substance for organic crop production. Until the recent ruling, pelargonic acid, a fatty acid, had tremendous potential as an organic herbicide. It had proven effective as a non-selective postemergent contact herbicide. It provided excellent weed control at low application rates and volumes, but has not been cleared due to its manufacture by synthetic methods. In addition to pelargonic acid, other fatty acids are under consideration and development as potential organic herbicides.

Precautions

Always read and follow the herbicide labels, take appropriate safety precautions, and don’t hesitate to contact your certifying agency prior to applying any substance.

Organic Herbicide Conclusions

Additional active ingredients and formulations are also being developed. Approval of these involves conducting greenhouse screenings, and progressing to extensive field evaluations. Even if all these active ingredients and their commercial formulations are registered by EPA and approved for organic use, the application technology and timing will play an essential element in their successful integration into existing certified organic systems. Research with post-directed applications of non-selective contact herbicides is showing promise. The height and plant maturity differences between the crop and target weeds are important factors in controlling weeds and protecting the crop from herbicide damage. The post-directed technique is especially effective when used in combination with either preemergence corn gluten meal applications or transplanted crops.
Alternatives to Organic Herbicides

Organic producers typically understand better than others the importance of a holistic approach to crop production and weed control. The initial site selection for a certified organic production area can have tremendous long term benefits, or adverse consequences, for crop yields and weed control. Although any site that is selected may have some indigenous weed species either present or stored in the soil profile, it is critical to select lands that minimizes these weed sources, and then pursue a diligent weed control program to control existing weeds and prevention of the introduction of new weeds. Many of the certification requirements favor site selections and processes that help reduce weed growth and the introduction of new weeds (i.e., avoiding drainage into the certified area, good soil health and conservation, cover crops and mulches, and cleaning equipment entering from not certified areas).

Crop Rotations, Cover Crops, and Mulches

Research and grower experience has shown the importance of crop rotations, cover crops, and mulches for crop and soil health, and reduced weed competition. Weeds are opportunistic plant species that will occupy voids between crop sequences, crop rows, and crop plants within rows. The judicial selection of beneficial plant species that will fill these voids between growing seasons, and cover the soil surface as mulches, can promote crop productivity by increasing nutrients, organic matter, preserving soil moisture, and reducing weed competition. Great care must be taken when using plant mulches from locations other than your own certified land to prevent the introduction of additional weeds to your production area. In the same manner, the use of animal manures from outside sources may introduce new weeds. If a new weed species does appear, take immediate action to eliminate the plants, minimize seed dispersal, and determine the source of infestation.

Stale Seedbeds and Reduced Tillage

Stale seedbeds and reduced tillage practices can be used in conjunction with many of the other organic weed control practices. In a stale seedbed, the planting area is prepared earlier than normal to allow for the germination, growth and control of weeds, or the killing of an established cover crop to serve as a mulch. The weeds or the cover crop might be killed with a mower, a choper, organic herbicides, or by some other means. The crop is then direct-seeded, or transplanted into the seedbed using a minimal amount of soil disturbance in order to not promote weed seed germination and growth.

Solarization and Tillage
Solarization and fallow tillage are two other approaches that use the weeds' aggressive growth tendencies as a method to help control future weed competition. Solarization is the use of solar radiation to kill weeds, normally using clear polyethylene mulch on moist soil surfaces. Solar radiation passes through the clear plastic, heating the soil. The moist hot environment initiates weed seed germination and stimulates weed growth, but then the hot humid confined environment becomes detrimental to continued weed growth and survival (Johnson et al., 2007). Solarization can also benefit the future crop by adversely impacting other plant pests such as nematodes, fungi, and insects (Johnson et al., 2007). Fallow tillage is the repeated use of soil tillage on fallow land to reduce future weed populations (Johnson et al., 2007). The weeds are repeatedly allowed to germinate and grow, but tilled prior to seed production. Fallow tillage can be used independently or in conjunction with solarization or other organic weed control methods (Johnson et al., 2007). During the cropping season, paper, fiber, and colored plastic mulches serve as weed barriers while promoting crop growth by warming the soil and conserving soil moisture. Soil cultivation during the growing season is also an effective method for controlling weeds between crop rows until canopy closure between rows. Hoeing and hand-weeding is also an option, depending on the production area, labor impacts on return on investment, and the removal of newly induced weed species.

Flaming

Flaming uses propane gas (LP, LPG, LP-gas) to control weeds with a directed flame (Johnson, et al., 2008). Flaming equipment can either be LP hand-held devices or full size field flamers with multiple flamers across the width of the boom flame (OFRF, 2006; Johnson, et al., 2008). Flaming research has produced mixed results depending on the equipment used, the weed species and size, and the exposure time to the flaming treatment. Research investigating organic weed control methods on stale seedbeds determined that a hand-held LP flamor produced better and more convenient weed control than a number of organic herbicides containing either clove oil and/or acetic acid (OFRF, 2006). The researchers did state that flaming was their least favorite method “due to it being a non-renewable resource.” Other researchers have reported unsatisfactory results with full size flaming equipment due to safety and operational issues, and ineffective weed control, especially with consistent long term control of grasses (W.C. Johnson, personal communication).

Conclusions

In addition to using existing and future organic herbicides, producers should also integrate as many non-chemical methods of weed control as possible into their production systems.
References


