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MONTANA STATE UNIVERSITY EXTENSION

MontGuide

Minimizing Pesticide Contaminated Soil Around the Home and Garden

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This publication was developed as a tool to reduce the prevalence of contaminated manure, grass clippings and compost while teaching homeowners to recognize toxicity symptoms and purchase only non-contaminated soil amendments.

MT201008AG Revised 11/16

ADDING SOIL AMENDMENTS TO ORNAMENTALS, lawns and gardens is a common practice in order to improve soil properties and increase nutrients within the soil. These amendments may injure sensitive plants if contaminated with pesticides. Some pesticides are not broken down through animal digestion, composting or under anaerobic conditions which often persist in manure.

The Montana State University (MSU) Schutter Plant Diagnostic Laboratory diagnosed 112 incidents of non-target plant toxicity from May 2009 to June 2010 partly due to pesticide contaminated grass clippings, manure or compost. A few general use pesticides popular in managing noxious weeds were thought to be the reason for the incidents. Since 2011, multiple government agencies and private organizations have implemented pesticide stewardship programs to address non-target plant injury from pesticides. This publication is a guide that compliments the pesticide stewardship program to assist applicators, homeowners and retailers in minimizing these incidents into the future.

The Movement and Degradation of Pesticides in the Soil

Many homeowners and applicators assume pesticides will break down to safe levels within a year of application. This is not always the case as pesticide movement and degradation rates vary depending on the characteristics of the soil and the pesticide itself. Characteristics such as sorption potential, solubility, pesticide persistence, volatilization and degradation determine how long the pesticide will be present in the environment.

Movement of Pesticides

Pesticide movement through soil is determined by its sorption potential and solubility, as well as the volatility of the pesticide. The sorption potential of a pesticide is the ability of the pesticide to bind to soil particles. A pesticide with a high sorption potential will readily bind to soil particles and will not move easily through the soil. These pesticides may remain in the soil for long periods of time and are less bio-available to microorganisms. A pesticide with a moderate sorption potential may remain in the root zone while being available for plant and microbe use. A pesticide with low sorption potential moves readily through the soil profile. Soil texture is also a factor in sorption. Soils with higher percentages of organic matter and clay will readily bind pesticide molecules while sandy soils will not.

The ***solubility*** of a pesticide determines the ease of pesticide movement through soil with water. A highly soluble pesticide flows with water through the soil profile. However, even if a pesticide is water soluble, it will not move through the soil profile if it has a high sorption potential (Table 1, page 2). Pesticides with low sorption potentials and high solubility easily move through the soil profile with water; this process is termed leaching. Leaching is a concern with pesticides as the product may leave the target area and impact other areas or enter surface or groundwater potentially causing health and environmental issues.

Volatilization occurs when a pesticide changes from a solid or aqueous state to a gas. Pesticides can still be effective in their gaseous state but are more prone to drift. The vapor pressure of a pesticide, temperature, and moisture influence volatilization rates, as well as the size, structure and function of the pesticide. A pesticide with a high vapor pressure tends to volatilize quicker and easier than pesticides with low vapor pressures. Volatilization of pesticides increase as temperature increases, and as material is mixed. Mixing soil or compost often leads to a subsequent 30 percent loss of pesticide due to volatilization (Singer & Crohn, 2002).

Volatilization and leaching are both examples of pathways which allow pesticides to move out of contaminated soils. However, degradation is needed to breakdown the pesticide into an inactive state.

Degradation of Pesticides

Pesticide persistence is the rate of time it takes a pesticide to naturally break down under ideal soil conditions. This is often expressed as a pesticide half-life. Pesticide persistence can be divided into three categories:

TABLE 1. Coefficient of sorption, solubility, degradation rate (persistence), and overall leaching potential of some commonly used agricultural and residential pesticides.

Active Ingredient	Product Names*	Sorption Coefficient (K_{oc})	Solubility (mg/L)	half life in soil (days)	half life in compost (days)	Leaching Potential
2,4-D	Weed-B-Gon	20	796,000	10	7 – 14[a]	Moderate
Aminopyralid	Milestone®	0.81-28[b]	2,480[b]	5-533[b]	No data	Conflicting data[d]
Aminocyclop-yrachlor	Method®	2-26[c]	4,200[c]	114-433[c]	No data	Conflicting data[e]
Atrazine	Atrazine	100	33	60	21 – 50[a]	High
Clopyralid	Stinger®, Curtail®	6	300,000	40	1 – 2 yr[a]	Very High
Glyphosate	Roundup®	24,000	900,000	47	No data[a]	Extremely Low
Picloram	Tordon®	16	200,000	90	No data[a]	Very High

Information gathered from the National Pesticide Information Center (Oregon State University, http://npic.orst.edu/ppdmove.htm) unless stated otherwise.

* This represents only a few common herbicide products which may be available on the market. Discrimination or endorsement is not intended with the listing of commercial products by Montana State University Extension.

a. (US Composting Council, 2015); b. (US BLM, 2014); c. (USFS, 2012); d. Field dissipation studies determined there is minimal leaching of aminopyralid through soil (<15-30 cm), however Koc values indicate very high leaching potential. (US EPA, 2005).; e. Results indicate aminocyclopyrachlor is highly mobile based on sorption coefficients. However, models using Kd sorption coefficients may overestimate leaching potential due to hysteretic desorption. (Oliveira et al., 2011).

- Non-persistent: half-life less than 30 days.
- Moderate: half-life of 30 to 100 days.
- Persistent: half-life of more than 100 days.

These broad categories only represent a pesticide half-life under ideal conditions as persistence varies due to degradation factors which vary by soil type and environmental conditions. Persistence, solubility, soil type and sorption potential form the overall leaching potential of a pesticide (Table 1).

Pesticides in soil primarily break down through microbial and chemical degradation. These reactions increase when temperatures are warm, soil pH is favorable, soil is moist but not saturated, and where aerobic soil conditions exist. Anaerobic conditions, or conditions where there is a lack of oxygen, exist in manure piles, un-worked compost, dried and baled forage, and in compacted soils. If compost or manure is thoroughly mixed, microbial and chemical degradation will increase due to the increase in oxygen.

A pesticide may also be broken down from sunlight through photo-degradation. The rate of breakdown is influenced by the intensity of sunlight, length of exposure, and pesticide properties. Pesticide residues on the surface of compost or manure will be reduced quickly through photo-degradation, but a majority of the pesticide will be within compost or manure where photo-degradation has little effect. Mixing compost will increase the rate of photo-degradation significantly.

Pesticide persistence combines with microbial and chemical factors to produce the final degradation rate (Table 1). Most pesticides (diquat, paraquat and 2,4-D) breakdown readily in compost piles, while others including pyridine pesticides (Table 2) and some chlorinated hydrocarbon insecticides may take years to breakdown in compost and soils. Fungicides may temporarily slow down the degradation process by suppressing decomposing fungi in compost.

The percentages of some active ingredients may actually increase under composting conditions (Granatstein, 2001). This is due to total compost mass decreasing during decomposition resulting in higher concentrations of persistent pesticides.

Applicators Should be Aware

Applicators should be wary if using certain growth regulator herbicides, especially if the applicator is spraying grasses which may be used for compost or converted to manure which will be distributed as a soil amendment. Active ingredients of highest concern are picloram, clopyralid, aminopyralid, and aminocyclopyrachlor due to the high use and persistence these active ingredients display when present in grass clippings, manure and compost (Table 2). Some other common growth regulator herbicide active ingredients which may contaminate gardens, but break down faster are dicamba (Banvel®, Clarity®, Fallow Star®, Vision™, etc.) and 2,4-D (Hardball®, Latigo™, Unison®, etc.). These pesticide products target invasive and troublesome broadleaf weeds while allowing desirable grasses to survive.

TABLE 2. Active ingredients and a subset of agricultural and residential pesticide products* which may persist for years under anaerobic conditions present in manure and/or compost.

Picloram	Clopyralid	Aminopyralid	Aminocyclopyrachlor
Tordon® K	Curtail® M	Cleanwave®	Method® 240SL
Tordon® 22K	Spur®	Chaparral™	Viewpoint®
Outpost 22K	Redeem™ R & P	Opensight®	Streamline®
Trooper® 22K	Accent Gold®	Milestone®	Perspective®
Grazon® P & D	Clopyralid 3	Milestone® VM	Method® 50SG
Picloram 22K	Transline®	Milestone® VM Plus	
Surmount®	Confront®	Forefront® R&P	
Graslan™ L	Stinger®	Pasturall®	
Triumph®22K	Thistledown™	Capstone®	

*This represents only a few high risk growth regulator herbicide products which may be available on the market. Discrimination or endorsement is not intended with the listing of commercial products by MSU Extension.

Always read and follow all 'Environmental Hazard' and 'Use Precaution' statements on the pesticide product label for compost, grass clipping and manure restrictions. Many pesticides also have re-cropping or planting restrictions which inhibit the planting of many broadleaf crops in subsequent seasons. A re-cropping or planting restriction may last as long as one to three years. These restrictions are under the 'Use Precautions' statement on the pesticide product label. Applicators should be aware of other factors which increase risk toward non-target sites:

1. Precipitation immediately after application will increase leaching into surface and groundwater and runoff onto other non-target sites.
2. Wind (more than 10 mph) will increase drift onto non-target sites.
3. Applying pesticide products at rates above those on the product label may increase risk of injury to non-target plants in future seasons.
4. Applying pesticide products illegally on sites not on the product label (ex. Spraying Milestone® or Tordon® products on lawns).

There may be other pesticide products which can offer broadleaf weed control while being safe for use on grasses. Contact your local MSU Extension office or the MSU Pesticide Education Program for alternative chemistries which may be available.

Homeowners & suppliers should be aware

Homeowners and suppliers purchasing or distributing grass, hay, straw, manure or compost for use as soil amendments should be aware of potential pesticide contamination. When purchasing grass clippings, manure or compost, ask the supplier if their plant stands or pastures were treated with high risk growth regulator herbicides (see Table 2). Do not purchase grass clippings, manure or compost if the distributor verifies the application of high risk growth regulator herbicides while not following one of the use restrictions often on an herbicide's pesticide product label.

- Do not use manure from animals that have grazed forage or eaten hay harvested from treated areas within the previous three days if manure will be applied to areas where susceptible broadleaf plants may be grown.
- Grass clippings from treated areas should not be used where broadleaf plants grow, or used as compost or mulch which will later be applied to areas where susceptible broadleaf plants grow.
- Do not plant broadleaf plants in soils treated with persistent herbicides or amended with manure from animals that have ingested treated forage until a bioassay is conducted to determine that concentrations in the soil are at safe levels.

Homeowners should be aware of symptoms of growth regulator herbicide injury when using compost, grass clippings or manure on their vegetable gardens or ornamentals. The symptoms include leaf cupping, curling, stunted growth, and curling of the growing points on any broadleaf plants (Photo 1). Broadleaf plant species especially sensitive to this type of herbicide damage include beans, peas, tomatoes, potatoes, lettuce, spinach, sugar beets, carrots, dahlias, and some roses. A simple bioassay may be used to verify the presence of herbicides (see box above). Don't use grass clippings, manure or compost if pesticide toxicity symptoms are visible using the bioassay. A bioassay is preferable over lab testing due to the expense and, at times, unknown pesticides which are causing plant damage.

Bioassay for testing manure or compost.

1. Compare plants grown in pots with suspect mixture, to plants grown in non-contaminated potting mix or soil. Peas, beans and tomatoes are good candidates for testing as they are extremely sensitive to growth regulator herbicide contamination.
2. Observe plants for symptoms of herbicide injury, such as poor seed germination, yellowing, dead leaves or shoots, or cupped or curled leaves.
3. If there is apparent herbicidal activity, do not use the tested manure or compost. If already in use, don't plant the intended crop or plant only non-susceptible plants.

For specific instructions visit: http://whatcom.wsu.edu/ag/aminopyralid/bioassay.html

Homeowners have a few options if contaminated soil is evident in their gardens or ornamentals. Homeowners may: Plant other non-susceptible garden plants including wheat and corn (if soil is contaminated from a growth regulator herbicide).

- Create another vegetable garden in a different location until the contaminated garden passes toxicity tests in subsequent seasons.
- Incorporate one pound activated charcoal per one gallon water for each 150 square feet into the top six inches of contaminated soil (Fishel, 2014). The activated charcoal should adsorb some of the pesticide and decrease toxicity towards non-target plants.
- Remove soil and replace with clean soil. This may be less costly if homeowners have smaller gardens.

If you see pesticide toxicity symptoms in your garden you should retest for toxicity the following season prior to planting. Growth regulator herbicides such as picloram, clopyralid and aminopyralid may take as long as two to five years or in some cases longer to breakdown to safe levels for many susceptible broadleaf vegetable plants.

For further confirmation of pesticide toxicity symptoms, contact the local MSU Extension office or the MSU Pesticide Education Program. If you wish to seek legal action or reimbursement contact the Montana Department of Agriculture (406-444-5400) or, http://agr.mt.gov/agr/About/Staff/FieldOffices/AgriculturalServicesBureau/index.html.

Can I Eat the Vegetables or Fruit of Plants Displaying Non-Target Injury?

It is unlikely, although uncertain, whether pesticide contamination is a health concern if vegetables or fruit grown from a contaminated area are ingested. Follow the directions on the pesticide product label regarding the pesticide which is contaminating your garden. If your vegetables or berries are not listed as a site on the pesticide product label then do not ingest the produce. If the produce is listed as a site on the product label, it may be safe to ingest. Read any further harvest restrictions if present. Never ingest produce if the exact pesticide contaminating your produce is unknown. Homeowners should wait until fruits and vegetables no longer show signs of pesticide damage prior to consumption.

For More Information

For confirmation of herbicide toxicity symptoms visit the 'Home & Garden' page at www.pesticides.montana.edu. You may also contact your local MSU Extension Office or the MSU Pesticide Education Program Office at:

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Herbicide damage to a vegetable plant from the MSU Schutter Diagnostic Laboratory. Photo by Noelle Orloff (2015).

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File under: Agriculture and Natural Resources (Pesticides)
Revised November 2016 1116SA