Plant Injury From Herbicide Residue

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Introduction

In recent years, an increased number of cases of injury from herbicide residue in straw/hay, manure, and compost have been diagnosed in the Virginia Tech Plant Disease Clinic. Growers are surprised and dismayed to learn that manure, straw, mulch, or other amendments intended to improve their garden or landscape might have such unforeseen consequences. Of particular concern to organic growers are herbicide residues.

Herbicides that are usually associated with contamination of straw/hay, turf clippings, manure, and composts are growth regulator herbicides or synthetic auxins, a group of herbicides that mimics plant hormones and regulates growth. These herbicides are labeled for control of broadleaf weeds in grass crops, such as pastures and corn; in turfgrass, including lawns, golf courses, parks, and highway turf; and in noncrop areas. Vegetable and fruit crops, as well as broadleaf ornamentals, can inadvertently be injured by these chemicals through drift of spray droplets, volatilization, and spray tank contamination or by residues in straw, manure, turf clippings, or compost. Diagnosing the specific herbicide responsible for the plant damage can be difficult. This publication focuses on damage caused by herbicide residues.

Growth Regulator Herbicides

Growth regulator herbicides (table 1) are classified into four groups: phenoxies (2,4-D, 2,4-DB, dichlorprop, MCPA, and MCPP); benzoic acids (dicamba); pyrimidines (aminocyclopyrachlor); and pyridines (aminopyralid, clopyralid, fluroxypyr, picloram, and triclopyr). Growth regulator herbicides vary in their effectiveness for controlling individual broadleaf weeds. Therefore, these herbicides are typically sold in combinations of multiple active ingredients (e.g., 2,4-D + aminopyralid) designed to control a wider range of broadleaf weeds with a single product (tables 2 and 3). (Keep in mind that tables 2 and 3 contain examples and are not a complete list of all available products. Look at the active ingredients when evaluating combination products not on these lists.) Commercially available products are essentially different combinations and concentrations of growth regulator herbicides within the phenoxy, benzoic, pyrimidine, and pyridine groups. Additionally, these growth regulator herbicides can be mixed with herbicides that have a different mode of action.

Table 1. Characteristics of selected growth regulator herbicides.

Herbicide group	Herbicide	Trade names	Approximate half-life range (days)	Approximate use rate range (lb ae[1]/A)	Water solubility (acid; g/L)
Arylpicolinate	florpyrauxifen-benzyl	Loyant	41-55	0.006-0.010	0.015
Benzoic acid	dicamba	Banvel, Clarity, DiFlexx, Engenia, XtendiMax	30-60	0.25-2.0	4.50
Phenoxy	2,4-D	(many)	1-14	1.0-2.0	0.57
Picolinic acid	halauxifen-methyl	Elevore	1-8	0.0045	1.8
Pyridine	aminopyralid	Milestone	6-74	0.047-0.128	205
	clopyralid	Lontrel, Stinger, Transline	12-70	0.124-0.5	1.00
	fluroxypyr	Starane Ultra, StareDown	11-38	1.0-2.0	4.00
	picloram	Tordon 22K	20-300	0.0675-0.54	0.43
	triclopyr	Element 3A, Garlon 3A, Garlon 4, LandVisor Ultra, Remedy Ultra, Renovate 3,Turflon Ester, Vastlan	10-46	0.5-1.0	0.43
Pyrimidine	aminocyclopyrachlor	Method 50SG, Method 240SL	114-433	0.074-0.27	4.20

[1]Acid equivalent.

Table 2. Examples of combination herbicide products labeled for broadleaf weed control in pasture and/or noncrop areas.

Trade name	Active ingredients
Chaparral	aminopyralid + metsulfuron
Crossbow	triclopyr + 2,4-D
Curtail	clopyralid + 2,4-D
DuraCor	aminopyralid + florpyrauxifen-benzyl
GrazonNext HL	aminopyralid + 2,4-D
Grazon P + D	2,4-D + picloram
Gunslinger AMP	aminopyralid + 2,4-D
PastureGard HL	triclopyr + fluroxypyr
Latigo	2,4-D + dicamba
Surmount	picloram + fluroxypyr
Weedmaster	2,4-D + dicamba

Table 3. Examples of broadleaf herbicide combination products used for weed control in turfgrass.

Trade name	Active ingredients
Celsius WG	dicamba + iodosulfuron + thiencarbazone-methyl
Chaser Turf Herbicide	2,4-D + triclopyr
Confront	clopyralid + triclopyr
Cool Power	MCPA + triclopyr + dicamba
Escalade 2	2,4-D + fluroxypyr + dicamba
Millennium Ultra 2	2,4-D + clopyralid + dicamba
Powerzone	MCPA + MCPP + dicamba + carfentrazone
Speedzone	2,4-D + MCPP + dicamba + carfentrazone
Surge	2,4-D + MCPP + dicamba + sulfentrazone
Trimec Classic	2,4-D + MCPP + dicamba
TZone	2,4-D + triclopyr + dicamba + sulfentrazone

Herbicide Persistence

Growth regulator herbicides vary in their persistence in soil. Table 1 lists approximate soil half-life values for selected growth regulator herbicides. Soil half-life is the length of time it takes for half the active ingredient to degrade in soil. Half-life calculations vary depending on the soil type, rainfall amounts, soil temperature, and other factors. Use these numbers only as a guide, and keep in mind the amount of chemical remaining after each half-life (table 4). For example, after three half-lives, there is still 12.5 percent of a given herbicide remaining in soil. Depending on unit activity (level of weed control per quantity of herbicide) of the chemical, there could be a sufficient amount of herbicide remaining in the soil to injure sensitive plants.

Generally, phenoxy herbicides do not persist more than a month in soil. For example, 2,4-D has a relatively short persistence in soil, with a half-life of 14 days or less (table 1). Dicamba, a benzoic acid, and triclopyr, a pyridine herbicide, can last somewhat longer — a month or so in soil — depending on application rate and weather conditions. The most persistent growth regulator herbicides are in the pyridine and pyrimidine groups (aminocyclopyrachlor, aminopyralid, clopyralid, and picloram). These chemicals can potentially cause injury to susceptible crops six months or more after application. As an example, the waiting period before planting certain sensitive broadleaf crops in a field treated with clopyralid (Stinger) can be as long as 18 months. These herbicides retain their activity even after composting. This is why growth regulator herbicides in the pyridine and pyrimidine groups are of greatest concern to growers worried about herbicide residues as garden amendments and straw or grass mulch.

Herbicides in all four growth regulator groups can cause injury to nontarget broadleaf plants. The risk of injury depends on the dose to which the broadleaf crops are exposed. Chemicals with higher unit activity, longer persistence, and/or greater water solubility will have greater potential to injure crops. Concern about the pyridine and pyrimidine herbicides, which are generally applied at much lower rates than the phenoxy group, relates to their high unit activity coupled with longer soil persistence. The use rates listed in table 1 are estimates, as the application dose will vary by site, targeted weeds, and other factors.

Table 4. Half-life values.

Time	Percentage of active ingredient remaining in soil
After 1 half-life	50%
After 2 half-lives	25%
After 3 half-lives	12.5%
After 4 half-lives	6.3%
After 5 half-lives	3.2%

Herbicide Residue

Hay harvested from pastures treated with growth regulator herbicides can contain plant-damaging levels of these chemicals. Moreover, these herbicides are capable of retaining activity after passage through the digestive systems of grazing animals. Therefore, manure obtained from animals that fed on treated pasture (or treated hay) can also contain residues at a high enough level to injure broadleaf plants. Degradation of aminocyclopyrachlor, picloram, clopyralid, and aminopyralid in compost containing hay, grass clippings, and/or manure is slow and residues of these herbicides pose a risk if applied in proximity to sensitive plants.

Because some of these herbicides are labeled for use on turfgrass, there is potential for herbicide residues to be present in grass clippings following growth regulator applications to turfgrass. Do not use clippings from lawns recently treated (within six weeks of application) with the growth regulator herbicides 2,4-D, dichlorprop, dicamba, MCPP, or triclopyr in fields, vegetable gardens, or ornamental beds. These herbicides are capable of carryover in compost and can cause injury to broadleaf crops. Clopyralid and combination products containing clopyralid (e.g., Confront) were previously registered for use on home lawns. Registration for home lawns has since been discontinued due to concerns about herbicide residues in compost or mulch derived from grass clippings injuring sensitive broadleaf plants, such as snap bean and tomato. Clopyralid and combinations containing this herbicide are still used in areas such as sod farms and golf courses where grass clippings are not collected for composting or mulching.

Damage from growth regulator herbicides can also occur by spray particle drift, drift of vapor to nontarget plants, contaminated irrigation water, or residues remaining in spray equipment. The extent of injury depends on the specific herbicide, concentration, and growth stage of the sensitive plants.

Symptoms of Growth Regulator Herbicide Injury

Growth regulator herbicides are plant hormones and cause plants to grow abnormally. They move systemically through the plant and are rapidly translocated to actively growing tissues. This explains why symptoms of growth regulator herbicide injury appear on new growth and not on tissue that was fully mature when exposed to the herbicide. Growth regulator herbicide exposure can also cause abnormal development of the vascular system. Because an abnormal vascular system does not transport water or nutrients efficiently, wilting is often an early symptom of growth regulator herbicide injury. Symptoms of new growth include epinasty (downward bending), twisting of stems and petioles, and distorted new leaves. Leaf edges can cup downward or upward, and veins can be prominent. Dicamba tends to cause upward cupping of leaves, whereas picloram tends to cause downward cupping. New leaves could also pucker and/or become strap-shaped and thicker than normal. Stem tissue could crack and adventitious roots can occur on the stem. Growth regulator herbicide exposure can also cause flowers to abort and/or reduce seed germination.

Plant species vary in their sensitivity to growth regulator herbicides. Grape, rose, tomato, potato, pepper, lettuce, peas, beans, and spinach are examples of some plants that are especially sensitive to injury from growth regulator herbicides. Symptoms of growth regulator injury to various plant species can be seen in figures 1-6.

Figure 1. Symptoms of wilting, epinasty, and twisting in a squash field, caused by herbicide residue in straw used to mulch crops. The herbicide Grazon P+D (active ingredients picloram and 2,4-D) had been applied to the hayfield from which the straw was harvested. The straw was sold to the vegetable farmer, who was unaware of the herbicide residue. (Photo courtesy of Rachel Bynum and Eric Plaksin.)

Figure 2. Symptoms of downward leaf cupping or “epinasty” on a tomato are characteristic of certain growth regulator herbicides. This injury was a result of herbicide residue in straw used to mulch the tomato field. (Photo courtesy of Rachel Bynum and Eric Plaksin.)

Figure 3. A potato plant showing “fiddlehead” symptoms of growth regulator herbicide injury on the new growth. (Photo by Elizabeth Bush, Virginia Tech)

Figure 4. Stunting, epinasty, and swollen stems of snap bean caused by growth regulator herbicide injury. (Photo by Elizabeth Bush, Virginia Tech.)

Figure 5. Vein proliferation, leaf puckering, and general distortion due to drift of 2,4-D herbicide. (Photo by Mary Ann Hansen, Virginia Tech)

Figure 6. Abnormal development of a grape leaf caused by growth regulator herbicide injury. (Photo courtesy of Paul Bachi, University of Kentucky Research and Education Center, Bugwood.org.)

Avoiding Plant Injury From Herbicide Residues

Labels for growth regulator herbicides registered for broadleaf weed control in pasture and turf often include precautionary statements to prevent damage to nontarget plants from residues. For example, the product label for GrazonNext HL (active ingredients aminopyralid + 2,4-D) includes the following. Examples of such statements are:

- Manure and urine from animals consuming grass or hay treated with this product may contain enough aminopyralid to cause injury to sensitive broadleaf plants.

- Hay can only be used on the farm or ranch where product is applied unless allowed by supplemental labeling.

When the product label is not followed, hay, manure, grass clippings, or composts containing these materials can make their way into fields, gardens, or landscapes and cause soil contamination and/or herbicide injury to nontarget plants. If you purchase manure, compost, hay, and/or grass clippings, make sure to use trustworthy suppliers who know the management history of the crop or, in the case of manure, the crop on which the animals were fed.

Diagnosing Growth Regulator Herbicide Injury

Some laboratories offer testing services for certain herbicide residues in plants and soil; however, the cost of lab tests is often prohibitive, and the client must specify each herbicide active ingredient to be tested. There is no general screen to test for unspecified active ingredients.

Herbicide injury is typically diagnosed by plant symptoms and by ruling out other possible causal agents. Symptoms, in conjunction with the timing of symptom development, information on herbicides used in the vicinity, and pattern of injury in the field, landscape, or garden are typically adequate for diagnosing herbicide injury.

If injury from a herbicide is suspected, carefully examine nearby plants and vegetation. If a growth regulator herbicide is the culprit, more than one broadleaf plant is likely to be affected. Look for injury symptoms in broadleaf weeds growing in the area. Bioassays using easily germinated, fast-growing plants sensitive to growth regulator herbicide — such as snap bean — are also useful to confirm growth regulator herbicide residue in soil, manure, mulch, and/or compost.

The Virginia Tech Plant Disease Clinic can diagnose herbicide injury based on the symptoms and the pattern of the problem, along with relevant background information (the clinic does not test for herbicide residue, a proper digital sample might be sufficient for visual assessment and consultation) in consultation with weed scientists. Refer to the Plant Disease Clinic website (https://bit.ly/VTplantclinic) for the current diagnostic form, fees, and instructions on collecting an appropriate diagnostic sample and submitting samples to the Plant Disease Clinic.

Recommendations for Herbicide-Contaminated Field and Garden Plots

The pesticide product label is the law, so when nontarget edible crops have been injured by growth regulator herbicides, the fruit or food produced by those plants is not recommended for eating.

Resources

Bezdicek, D., M. Fauci, D. Caldwell, R. Finch, and J. Lang. 2001. "Persistent Herbicides in Compost." *BioCycle*. 42:25-30.

CDMS herbicide labels. www.cdms.net/Label-Database.

National Pesticide Information Center. Oregon State University and the U.S. Environmental Protection Agency. http://npic.orst.edu/.

Virginia Cooperative Extension. 2023. *Pest Management Guide for Field Crops, 2023*. VCE Publication 456-016. https://www.pubs.ext.vt.edu/456/456-016/456-016.html.

Weed Science Society of America. 2014. *Herbicide Handbook*. 10th ed. Lawrence, KS: WSSA.

Scan to visit the Plant Disease Clinic website

https://bit.ly/VTplantclinic

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