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VERMONT HORSES VS. TWISTED TOMATOES: A COMPOST CASE STUDY

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ABSTRACT

Herbicide residues were identified in compost from a commercial compost facility (CCF) in Chittenden County, Vermont in June, 2012 when clients utilizing compost on their home gardens experienced damaged vegetable crops. As general assumptions and accusations were aired on local news programs, public concern, a need to mitigate misinformation and to validate herbicide residue testing methods mounted. The Vermont Agency of Agriculture (VT-AG) worked on sorting through fact and assumptions, and University of Vermont Extension (UVM-EXT) made efforts to support affected gardeners, to train garden evaluators, to provide science-based information about herbicides and horses, as well as deflecting misdirected accusations against the Vermont horse industry for being the source of the tainted compost. Because a complex testing situation emerged based on abilities (or lack thereof) of local and national testing facilities to accurately and consistently identify herbicide presence in compost and raw products, VT-AG is now working with the American Association of Pesticide Officials and Dow AgroSciences to establish and validate testing techniques. The open communication and collaboration between VT-AG and UVM-EXT helped to mitigate a volatile situation and minimize negative impacts. Efforts to identify and address these issues with long term herbicide persistence and compost are being discussed and undertaken at a state and national level, especially as more municipalities develop compost streams in an effort to keep organic materials out of landfills.

INTRODUCTION

In the summer of 2012, Chittenden County, Vermont was flooded with news of herbicide-contaminated compost, damaged garden crops, and television stories implicating Vermont horse feed stocks and manure as a potential key source of contamination. A large commercial compost facility (CCF) that processes yard waste, food scraps, equine and other livestock manure and other organic by-products such as coffee bags and chaff into a marketable compost commodity was identified as the site of the contaminated compost. In late June 2012, CCF was receiving complaints that tomato plants which had been exposed to the compost were expressing epinasty (i.e. twisting), yellowing, and death. In all, 626 complaints were filed, of which, 510 were confirmed to have verifiable damage directly related to the compost amendments. Eighty-four samples of feedstocks, animal feeds, and composts were sent to a laboratory (Testing Facility A) for analysis in June and July 2012. It became evident that there was an issue with the bulk products causing damage to a variety of broadleaf garden plants. The Vermont Agency of Agriculture (VT-AG), and the University of Vermont Extension (UVM-EXT) stepped in to verify facts and to confirm trace amounts of the herbicides. While there is little or no harm caused to the animal, some consumed herbicides can pass through the digestive tract, remain chemically active in manure and urine, and even survive the heating and compost process. When present in finished composts, in the low part per billion concentration range, these herbicides can damage sensitive garden plants (Table 1) such as tomatoes, beans, peas and many common flowers (Davis, 2010). Symptoms include twisted and stunted stems, curled leaves, reduced and misshapen fruit, and poor seed germination. The four primary herbicides (Table 2) that can elicit this type of plant injury after composting include picloram, clopyralid, and aminopyralid from Dow AgroSciences and aminocyclopyrochlor from DuPont.

Table 1. Crops known to be sensitive to picloram, clopyralid, or aminopyralid (Davis, 2010).

Beans	Carrots	Compositae family
Cotton	Dahlias	Eggplant
Flowers in general	Grapes	Legumes
Lettuce	Marigolds	Mushrooms

Peas	Peppers	Potatoes
Roses, some types	Spinach	Sugar Beets
Strawberries*	Sunflowers	Tobacco
Tomatoes	Umbelliferae family	Vegetables, in general

*Applies to aminopyralid and picloram only.

Table 2. Active ingredients, manufacturers and trade names of herbicides.

Active Ingredient	Manufacturer	Trade Names
Picloram	Dow AgroSciences	Tordon, Grazon, Access, Pathway
Clopyralid	Dow AgroSciences	Curtail, Redeem, R&P, Transline, Confront, Lontrel
Aminopyralid	Dow AgroSciences	Milestone, Forefront, Chaparrel
Aminocyclopyrachlor	Dupont	Imprelis, Perspective, Viewpoint, Streamline

All herbicides must be registered by the United States Environmental Protection Agency and regulated by State Lead Agencies. Picloram, clopyralid, aminopyralid and aminocyclopyrochlor, in particular, are used to control broadleaf weeds. Livestock grazing in treated areas ingest these herbicides via residues on treated plants. All four of these herbicides have very low toxicity to mammals, fish, amphibians and fowl. Further, these herbicides are effective in controlling target plants and therefore heavily relied upon in the agriculture community to control broadleaf weeds, especially in pastures. Some of these are the only herbicides that can be used in pastures where the animals can remain grazing in the pastures after use. Aminopyralid has been singled out as the best option for controlling bedstraw.

THE CONVOLUTED AND CONTRADICTORY PATH TO HERBICIDE IDENTIFICATION IN CONTAMINATED COMPOST

As calls about tomato plants exhibiting herbicide injury symptoms were received, the Vermont Secretary of Agriculture and the agrichemical management section from his office were called upon to investigate. They worked with the UVM Extension Plant Diagnostic Clinic plant pathologist as a resource to field complaint calls, examine samples, and consult with gardeners. UVM Extension also trained garden evaluators before they went out to assess affected gardens to confirm that the damage was caused by herbicide exposure. Furthermore, it was confirmed that CCF compost had been used as a soil amendment at the affected gardens. This established the need to test CCF compost for herbicide residue, and CCF sent samples to a local laboratory (Testing Facility A) to test for Picloram and Clopyralid. Compost samples tested positive for Clopyralid and Picloram.

Since VT-AG's testing laboratories were unavailable as a result of long term damage from Tropical Storm Irene, they were unable to conduct tests to support or refute the initial results. However, when the VT-AG sent 68 different samples of feedstocks (hay samples from multiple horse and dairy farms), animal feeds (e.g. beet pulp, oats, rice bran, mixed feeds), beddings (e.g. straw, wood shavings, wood chips) and composts to a second independent laboratory (Testing Facility B), all samples were negative for picloram, some samples tested positive for clopyralid, and 78% of samples tested positive for aminocyclopyrachlor. Since Aminocyclopyrachlor was only registered for use on turf and only for a few months, there was a consensus that the results may be in question or there was a significant amount of pesticide misuse occurring nationally. There was a clear need for further testing to confirm herbicide residue levels and to determine the source of contamination.

Dow Agrochemical offered to cover the costs associated with having additional samples analyzed at a third commercial laboratory (Testing Facility C) to determine potential sources of contamination from raw product brought into CCF. The results from Testing Facility C did not support the initial CCF results from Testing Facility A, or a second set of test results from Testing Facility B, in terms of consistent values or presence of active ingredients. However, Testing Facility C results were indicative of clopyralid, picloram, and aminopyralid contaminated compost. This initiated a more thorough backtracking investigation into the raw materials brought into the CCF facility. As part of the trace-back investigation, the VT-AG personnel also collected raw samples from 15 horse farms in the area who frequently contribute manure and bedding to the compost facility.

In order to analyze and compare results between the samples sent to independent laboratories by VT-AG, data from Testing Facility B and C was converted from actual concentrations to simply "detected" or "not detected". Since each sample was tested by two laboratories, the proportions of samples detected by each lab are not independent, so the McNemar Test (Fleiss et al., 2003) was utilized. Based on the proportions of samples between Testing Facility B and C where clopyralid ($P < 0.001$) (5/49 vs. 40/49 samples, respectively) and picloram ($P = 0.002$) were detected (0/49 vs. 10/49 samples, respectively), there appears to be little agreement whether the two compounds were even present, regardless of concentrations.

In addition, the scale of tracked and approved chemical use through the VT-AG Pesticide Program did not reconcile with the results from raw product samples tested from farms. While clopyralid is still approved for non-residential lawns, the application of aminocyclopyrachlor is no longer registered for use on turf or ever registered for use on pasture and hay fields, yet one laboratory reported its presence in horse manure. According to pesticide application records, only one horse farm in the past three years had used a herbicide containing one of the active ingredients identified in the compost. A Vermont horse farm had applied Aminopyralid on one of its pastures; however, samples of grass clippings from various other residential and commercial properties tested positive for the herbicide indicating a misuse of the product on yards. Another confounding factor is that hay and feed are frequently purchased from out-state and brought into Vermont; and all persistent herbicides in question are labeled for use in other states.

With such different results reported from two separate and independent laboratories (Testing Facilities B and C), the VT-AG collected 9 compost samples in early September 2012. Samples were homogenized in the laboratory and representative split samples were sent out to seven laboratories (Testing Facilities A, B, and C, as well as D, E, F and G) one of which was an Environmental Protection Agency (EPA) laboratory, in a round-robin attempt to arrive at the best methodology to determine presence of the four persistent herbicides in compost. Many of the labs could not get their detection levels low enough to measure aminopyralid presence, and EPA's lab had yet to report four months after receiving the samples. This exercise yielded highly variable data, as well as differences in detection sensitivities between laboratories. Taken together, these data are indicative of the difficulty to accurately detect herbicides at the concentrations capable of impacting sensitive garden plants.

Clopyralid and picloram, the active ingredients that are used at higher concentrations and have been on the market for a longer period of time, were most consistently detected among the laboratories compared to aminocyclopyrachlor a aminopyralid. DuPont has recently published a method to detect aminocyclopyrachlor for use in commercial and regulatory laboratories. This method is a direct result of the initial findings of this investigation. Aminopyralid has proven to be the hardest compound to detect as it is used in very low quantities and can harm plants at levels below 1 ppb. In cooperation with the VT-AG and the American Association of Pesticide Control Officials (AAPCO), Dow AgroSciences chemists have surveyed the equipment capabilities of regulatory and commercial laboratories across the U.S. and are in the process of developing methods these laboratories can use on difficult matrices like horse manure and compost.

Since July 2012, CCF has been producing compost from raw materials excluding horse manure, which has negatively impacted horse owners who have limited manure disposal options. However, grass clippings are still being accepted. Regardless, it appears that the concentration of aminopyralid in the CCF compost has dropped compared to compost made with horse manure. It is possible that horse manure is more likely to be contaminated with persistent herbicide residue. Many commercial horse feeds contain beet pulp and clopyralid is one of only a few herbicides labeled for use in sugar beets. Plus, horses could easily consume both hay and pasture treated with persistent herbicides. These issues combined with the fact that the composting process can actually concentrate pesticide residue in the short term as other organic compounds break down more quickly can lead to detectable herbicide levels even when labeled directions are followed.

The current concentrations are down to just above the threshold (ranging from 1-10 ppb) that can cause negative impacts in broadleaf plants (including tomatoes and other garden plants) (Table 2). CCF continues to closely examine all inputs and processes to ensure they are not reintroducing contaminated materials. Based upon laboratory results, it is fairly clear that tests to detect aminocyclopyrachlor were not accurate or repeatable, and most likely incorrect. However, Dow AgroSciences confirmed the presence of clopyralid and aminopyralid compounds in 4 of the 5 CCF samples since they stopped incorporating horse manure. While the test results were inconsistent regarding concentration and type of chemicals present in samples, the fact remains that herbicide-contaminated compost was sold to the public, and that this compost resulted in a great deal of damaged vegetable crops in home gardens.

THE MEDIA AND PUBLIC PERCEPTION ISSUES

University of Vermont Equine Extension first became involved when several calls and emails were received following the airing of a news story on July 26, 2012 which attributed the twisted tomato and dead garden plants to horse manure and bedding, and herbicide-laced grass clippings. Horse business owners expressed concern about the damage this negative information could have on reputations and/or businesses, when in fact, they had not necessarily done anything wrong. They felt that they had been slandered with a broad brush of misguided blame, and potential misinformation in a very public forum. Following phone and email conversations with VT-AG personnel, the UVM Equine Specialist participated in a follow-up interview with the local news station (aired August 13, 2012), responding to the broad brush blame, and requesting quick jumps to judgment and/or accusations be withheld until actual and repeatable data had been collected and verified. In that same news story, the CCF manager backed off from accusations of intentional wrongdoing by horse businesses, yet named a national equine feed company as a contributor of herbicide contaminated feed based on laboratory tests that had yet to be repeated to determine accuracy of the data.

The public wanted immediate answers regarding the exact source of contamination, the potential impacts, and probable repercussions of this persistent herbicide situation, often not understanding the complexity of the questions that were being asked. Six months and multiple laboratories and samples later, there are still questions regarding the source(s) of the contaminated compost ingredients and solutions to managing persistent herbicide issues. One potential concern of the public could be the potential to negatively affect their health. However, after thorough risk analysis, the health department never became actively involved, since the levels of clopyralid and aminopyralid present were enough to damage fragile broadleaf plants such as tomatoes, yet were much lower than concentrations that would warrant concern for health of humans or animals (Table 3). Current health based tolerances for the active ingredients of concern are orders of magnitude higher than the levels being found in the contaminated compost.

Table 3. Range of herbicide residue detected in submitted samples, amount necessary in compost to cause plant injury and label and use information of four persistent herbicides[a].

Criteria	Picloram	Clopyralid	Aminopyralid	Aminocyclopyrachlor
Range detected[b] at Testing Facility C	Trace ppb	Trace - 623 ppb	Trace - 6.4 ppb	0 ppb
Levels Known to Cause Harm in Compost[b]	5 ppb	10 ppb	1 ppb	Unknown
Tolerance on Hay[c]	400,000 ppb	500,000 ppb	50,000 ppb	No food uses
Registered for use in VT	yes	yes	yes	no
Pounds used in Vermont in 2012	0.0	19.71	16.43	0.0

[a]Products are labeled as restricted use in Vermont.

[b]Data gathered from VT-AG records.

[c]Tolerance numbers published in General Register Code of Federal Regulations referring to allowable residue on a crop.

ACTIONS

Strategies for Mitigating Misinformation in the Media:

UVM-EXT responded by maintaining communication with VT-AG personnel and correcting public misinformation through newscasts and social media outlets in an attempt to mitigate the unjustified negative perception on an agricultural industry. Since UVM-EXT was hosting the national annual meeting of the United States Department of Agriculture project NE-1041: Environmental Impacts of Equine Operations, many state extension specialists with expertise in equine, agronomy, weed science and manure management were able to meet with the VT Secretary of Agriculture and the State Pesticide Group Leader to discuss the situation, possible solutions, and similar experiences in other states. The team also discussed the potential causes of contamination and, effects and outcomes related to the immediate problem and media attention.

In an effort to attempt to replace assumptions and information not based on fact which had aired in media reports, UVM-EXT worked with producers of the daily agricultural show *Across the Fence* to interview several national experts at the NE-1041 meeting to address facts and research surrounding composting and herbicide use. *Across the Fence* producers were able to move quickly to air an episode on which the UVM Equine Specialist and VT-AG Pesticide Section Chief discussed the facts and misconceptions regarding the contaminated compost (University of Vermont Extension, 2012a). The compost and plant expert interviews were incorporated into an additional *Across the Fence* episode, (University of Vermont Extension, 2012b).

IMPLICATIONS

Many Vermont equine operations do not have an adequate land base or the equipment to stockpile, compost, or spread manure and stall waste produced by their horses. With the exclusion from CCF facilities, Vermont horse farm owners have potentially lost a primary outlet for disposing of manure. Many local equine farm owners will rent roll off dumpsters to store manure for disposal, and pay for compost facilities to haul off the filled dumpsters on a weekly or monthly basis. Local compost facilities are a convenient solution for horse farms for disposal of waste (e.g. manure, shavings, bedding); raw waste materials are then turned into compost and sold as a value-added product for local farmers and gardeners. The 2012 compost contamination and resulting in damage to tomato plants, has potential severe implications for equine operations in Vermont. The issues arise primarily by limiting means for disposing of manure and bedding waste, managerial challenges, environmental concerns from long-term stockpiling of manure, and the increased financial burden of alternative waste disposal methods.

Financial implications of these events also burdened CCF. Settling complaints with customers and retrieving unsold product from retailers has cost an estimated $270,000. Additionally, CCF internal cost for items such as testing, legal services, and contractors in regard to solving this issue is estimated at an additional $372,000. Finally, the loss in value added sales of products that could not be made or sold due to the presence of persistent herbicides adds another estimated $150,000. All things considered, this one persistent herbicide event will cost CCF an estimated $792,000. Potential damages cause by the events were not only financial, but included misinformation aired in local media, accusations regarding the source(s) of the contaminated herbicide, and a likely everlasting negative public perception of the equine industry in Vermont.

ONGOING EFFORTS

Although CCF is not currently accepting horse manure, other composters are taking horse manure and soiled stall bedding since these products contribute great value to the compost mix. However, compost facilities are very cautious and wary of potential persistent herbicide affecting finished compost and customer's gardens. Many composters are using long and slow composting methods, working the compost for up to two years prior to turning out a finished product to customers. The extended composting length seems to allow adequate time for clopyralid, and perhaps other persistent products, to break down naturally. The concentration of aminopyralid does not seem to be affected by the length of time the compost is allowed to break down. Ultimately, horse owners will always need a method for disposing of manure and stall waste. While horse manure and bedding (straw and shavings) are excellent sources of raw material for compost, these materials have been extensively scrutinized due to the negative publicity and misinformation aired by the media.

VT-AG is currently working with the American Association of Pesticide Control Officials (AAPCO) and Dow Agrosciences to survey state lead agency laboratories on their capability and equipment for detecting persistent herbicides in raw materials and compost. One of the key issues is the fact that a pesticide applicator may have followed the letter of the law, but the downstream users may not know or follow labeling restrictions or guidelines. In addition, even if state regulations are followed, many farmers may potentially and unknowingly contaminate compost inputs. Dow Agrosciences chemists are committed to collaborating with state agencies and designing a method to detect these compounds at extremely low levels. Officials convened in March 2013 in Washington D.C. to further this agenda and to develop and implement a plan for more advanced and consistent methods of detecting herbicide residues.

In response to herbicide residuals in manure and compost causing injury to bedding plants, the Vermont Agency of Agriculture has declared all Aminopyralid and Clopyralid products with pasture or hay use sites on their labels as Class "A" State Restricted Use products in Vermont. Classifying these products as restricted use institutes the requirement that any applicator be licensed and certified to purchase and use these products. The usage and sales are also tracked and recorded, and must be made available to the Agency upon request. New label language on Aminopyralid products (Table 4) will make it possible to take enforcement against applicators or farmers that allow waste containing herbicide residue to be moved off the farm where initial application occurred.

Residues of both Aminopyralid and Clopyralid were found in compost in Vermont. Aminopyralid is the herbicide that caused the issues with the CCF compost in 2012. Aminopyralid residues only come from pasture use or hay and subsequently horse manure; these uses have been eliminated in New England and New York. Based on the Agencies trace back investigation sampling results, potential sources of Clopyralid residues are mostly from out of state uses and include animal feed (grains), lawn clippings, and food waste primarily pasta and bread.

Raw inputs that contain Clopyralid and Aminopyralid can be managed. However, compost facilities must develop and implement best management practices to deal with inputs. The threat of Aminopyralid residues in the Northeast and nationally have been greatly reduced, if not eliminated entirely by a collaborative effort between the State Regulatory Agency and the chemical manufactures involved in this process.

Table 4: Proposed New Label Restrictions for Aminopyralid Prodcuts

Complete prohibition on use on pastures in Connecticut, Maine, Massachusetts,

New Hampshire, Rhode Island, and Vermont. All other labeled uses are permitted in these states including grazed areas in and around these sites.
On a treated field grasses grown for Hay must not be harvested and sold as hay for 18 months following treatment, Hay CAN NOT be distributed or made available for sale off the farm or ranch where harvested hay should only be used on the farm.
On a treated field grasses grown for Hay must not be harvested and sold as hay for 18 months following treatment, Hay CAN NOT be distributed or made available for sale off the farm or ranch where harvested hay should only be used on the farm.
Livestock owners must ensure manure and urine or bedding from animals consuming treated hay or grasses not be used for composting or distributed for use in home or commercial gardens.
Do not transfer grazing animals from areas treated with the product to areas where sensitive broadleaf crops occur without first allowing 3 days of grazing on an untreated pasture. Otherwise, urine and manure may contain enough herbicide residual to cause injury to sensitive broadleaf plants.

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ADDITIONAL RESOURCES

Dow Agrosciences United Kingdom website with information on aminopyralid: http://www.manurematters.co.uk/

Washington State University Web site on clopyralid carryover includes pictures of affected vegetables, research results, and the bioassay protocol http://www.puyallup.wsu.edu/soilmgmt/Clopyralid.htm

Article from Minnesota Extension explaining the problem in hay and how to avoid it. The article is devoted to “ditch hay”, but the information is relevant to all hay. http://www.extension.umn.edu/distribution/livestocksystems/M1197.html

CDMS Agro-chemical database with access to all the herbicide labels: http://www.cdms.net/LabelsMsds/LMDefault.aspx?t

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