EXTENSION

Volume 11 • Issue 1
Winter/Spring 2023

IPM Chronicle

extension.wvu.edu

In This Issue:

Effects of winter deep freeze on trees and shrubs

The degree of cold injury depends on how well prepared the trees and shrubs were before the onset of the very cold temperatures. To help us determine that, it is helpful to have access to reliable weather data. Sites like the Network for Environment and Weather Applications (newa.cornell.edu) are very helpful in providing us with weather overviews or detailed weather information.

Based on the records, autumn temperatures for our state were 0.9 degrees cooler than normal, making West Virginia the only state with below normal temperatures for the given period. This allows for proper plant preparation for the winter.

Figure 1. Apple tree shoots collected in February to be checked for cold injury.

In West Virginia, we are in USDA Hardiness zones 5a, 5b, 6a, 6b and 7a, meaning that we are dealing with temperate-zone plants. Temperate-zone plants are programmed to go into a state of suspended animation or dormancy during the winter. Entering dormancy starts with the onset of shorter days and cooler temperatures.

Based on the NEWA data for West Virginia, having cooler temperatures during pre-dormancy helps plants go through necessary metabolic processes that lead to changes in the carbohydrate ratio between starches and sugar (sucrose and sorbitol) in preparation for the extreme cold temperatures that are common during full dormancy from the end of November through December. The winter blast we experienced just before Christmas 2022 hit during that full dormancy period while our trees and shrubs had maximum amounts of sugar in their tissue that prevented significant freeze-injury.

Checking degree of cold injury

Normally, one would wait for spring to check for the viability of the buds and shoots. However, for the less patient among us, there is a method of “forcing” the shoots to bloom, thus providing us with a peek into the things to come.

The prerequisite is to have accumulated enough chill hours, or exposure to low temperatures between 32 F and 45 F, in order to get out of dormancy and “wake up.” That chill requirement varies from about 100 chill hours in sub-tropical and tropical climates up to 1,500 hours in the northern areas or high-elevation areas.

Given the topography of the state, our chill requirements range from 700 to 1,300 hours to ensure spring frost injury is minimal.

To do so, all we need is to cut the branches, put them in water and place them at room temperature (Figure 1). At this point, ambient temperature is the driving force behind getting out of dormancy. From that point on, favorable outside conditions will cause plants to grow again. The bud development and growth become apparent once the buds become swollen and start to show green. Once budded, plants lose the ability to readjust to colder temperatures and extreme cold temperatures will cause injury to the buds.

Reducing herbicide injury in gardens

Herbicides can be an effective way to control unwanted plants when used properly. Typically, differences between plant species and the method of herbicide application offer the ability to control weeds selectively without causing injury to desirable plants.

However, crop injury can occur occasionally as a result of herbicide application. Such injuries often result from improper selection of an herbicide, misapplication, unfavorable environmental conditions, or through contaminated mulch, compost or manure.

Pre-emergence vs. post-emergence herbicides

In order to be effective, herbicides have to be applied at a specific stage for both the crop and weeds. Certain herbicides may have to be applied before weed germination (pre-emergence herbicides), whereas others have to be applied during the active growth period of the weeds (post-emergence herbicides).

Several lawn and garden weeds that grow and come to bloom in spring, such as hairy bittercress *(Cardamine hirsuta)* and purple deadnettle *(Lamium purpureum)*, actually germinate during the fall of the previous year. Hence, application of a pre-emergence herbicide in late summer or a post-emergence herbicide in late fall are effective to control such weeds.

On the other hand, to control perennial weeds, late-season systemic herbicide applications are usually more effective, but sometimes multiple applications may be required. Pre-emergence herbicides labeled for use in a particular crop or situation are safe on established plantings given the crop's ability to tolerate that herbicide.

However, post-emergence herbicides are less forgiving, especially if a non-selective herbicide, such as glyphosate or diquat, or a broadleaf herbicide, such as 2,4-D or dicamba, are applied near desirable plants. Injury usually occurs while they are sprayed too close to plantings or when applied under windy conditions that can cause drift of spray particles.

Less frequently, herbicide in the solution form may move to the rooting zone of desirable plants either by runoff from rainfall or by leaching into the soil profile.

Contaminated mulch, compost and fertilizer

Certain herbicides applied to control weeds in pastures and hayfields may persist in the manure from the animal that consumed this forage. Similarly, grass clippings from lawns treated by certain herbicides may persist even if the clippings are composted.

Treated clippings when used as mulch in gardens during the following growing season can injure garden plants. Plants, such as bell peppers, potato, eggplant and tomato, that belong to the nightshade family *(Solanaceae)* are especially sensitive to such herbicides.

Herbicides exhibiting such carryover characteristics belong to the pyridine class of herbicides, which are generally considered as growth regulators. Growth regulator herbicides mimic the naturally occurring auxins that regulate plant growth.

As a result of exposure to such herbicides, the plants undergo unregulated growth and the symptoms manifest as twisting and curling of stems and leaves. The leaves may appear to be strapped or cup-shaped, and the symptoms are referred to as epinasty (Figures 2A and 2B). In vegetables, such an injury is irreversible, and the affected plants either die or remain stunted as a result of a single exposure event.

The active ingredients (and their trade names) of herbicides used to control weeds in forages or turfgrasses that have the potential to cause such carryover effects include clopyralid (Lontrel, Confront, Curtail, Millennium Ultra, Stinger), aminopyralid (Milestone, GrazonNext, Chaparral, Duracor) and picloram (Grazon P+D, Surmount, Tordon RTU).

The labels of these herbicides include precautionary statements warning the user to properly recycle the contaminated manure, hay or clippings back to the treated area and that these materials are not to be sold as hay where it would be used as mulch or manure for crops. Failure to follow the label, inadvertent transfer or gaps in communication between the applicator and the end user may result in such mishaps.

Composting for extensive time-periods (over 18 months) may break down the active ingredients; however, it would be better to not to use any contaminated hay or clippings as mulch or compost. Suspicious manure, compost or mulch can be tested for the presence of noticeable amounts of such herbicides by performing bioassays. To do so, extracts from these materials may be planted with a sensitive species, such as tomatoes, and compared to that from untreated material to serve as a control. Signs of epinasty may reveal herbicide presence.

– continued

Reducing herbicide injury in gardens

– continued from page 2

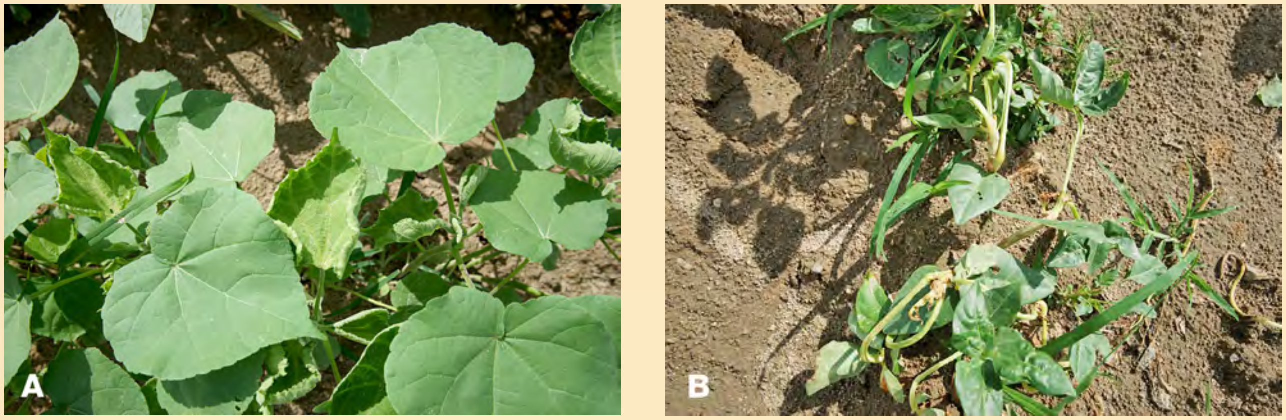

Figure 2. Symptoms of distorted plant growth (epinasty) caused by growth regulator herbicides, such as cupping (2A) and strapping (2B). (Photo credit: R. Chandran)

Proper application and protection

To ensure that the herbicide is applied properly, properly calibrated application equipment should be used. Improper calibration or application techniques may lead to crop injury or off-target movement. Use of proper nozzles, tank pressure, walking speed and adherence to optimum environmental conditions, such as temperature and wind, are other factors that can affect results. (Certain formulations may volatilize and cause injury to non-target vegetation when applied at higher temperatures or due to temperature inversions.)

Proper cleanup of the equipment as stated on the label will minimize the risk of crop injury during subsequent pesticide applications (Figures 3 and 4). Storing herbicides in properly marked containers, proper handling and maintaining a sprayer dedicated for herbicide applications are other precautions to be considered to avoid costly mistakes.

Finally, one must take all measure to protect oneself from chemicals. To minimize exposure, personal protective equipment (PPE), such as gloves, glasses, mask, coveralls or other equipment specified on the label, should be worn while handling and applying the herbicide.

Figure 3. Herbicide injury to tomato plants when a contaminated sprayer was used to apply a fungicide. (Photo credit: R. Chandran)

Figure 4. Injury to beans from a pigment synthesis inhibitor herbicide used in sweet corn due to improper tank cleanup. (Photo credit: R. Chandran)

Biologicals and anaerobic soil disinfestation to manage soilborne diseases

There are two major types of plant diseases that can affect the yield and quality of plant products.

Foliar diseases

One group infects foliage – leaves, stems, and fruit – and causes necrosis of tissues to compromise plants' ability to thrive, eventually killing the plant. These disease-causing organisms (pathogens) are primarily spread by wind or rain splash from diseased to healthy plants. It is relatively easy to manage foliar diseases if diagnosed early, and measures are taken on time by adding highly effective fungicides or bactericides to the disease management program.

Soilborne diseases

Another group of pathogens survives in the soil and infects plants through the root system, colonizing the vascular or water-conducting tissues to plug the tissues. As a result, water and nutrients can't move upward to the foliage.

Plants dry up gradually, which is known as wilt. The fungal pathogen Verticillium is one of them. But, there also are other soil pathogens, such as *Fusarium*, *Pythium*, *Rhizoctonia*, *Phytopthora*, *Sclerotinia*, and tomato wilt-causing bacteria, like *Ralstonia solanacearum*.

As these pathogens survive in the soil organic matter or plant debris, applications of fungicides or bactericides are usually not effective.

Control measures

The most effective measure growers can take is rotating crops from different families. In the absence of a rotational option, growers would use fumigation for high-value crops, such as strawberries and tomatoes. However, after phasing out of the most effective synthetic fumigant methyl bromide, alternative products such as Basamid (dazomet), Telone C-35/C-17, Pic-clor-60, Vapam (metam sodium), have been used with lower and variable efficacy.

In addition, these restricted category products can't be used without large specialized equipment. Small growers and landowners near schools, churches, or dwellings are not allowed to use these products due to health and environmental regulations. Consequently, small, and organic growers want alternate options that are environment- and user-friendly.

Biological control

Experiments on biologicals and bio-fumigation for the last few years at the WVU Research, Teaching and Outreach Center to manage soilborne diseases, including Verticillium wilt, provided results that can be used by organic as well as conventional growers. This approach was tested in strawberry, tomato, eggplant and okra with positive results.

The major principle of biological control is indirect antagonism or competition. If you have beneficial microbes on the root system of plants, harmful ones do not get space to infect.

These beneficial microbes also take up nutrients that are mostly available on the roots' surface from fluids emitted through the roots to deprive harmful ones. These microbes are also called probiotics, as they can take nutrients, such as phosphorus and potassium, from the earth's crust and make them more soluble so they're available to plants, and can produce phytohormones, which reduce environmental stress to plants.

So, we used a commercially available biological control product called TerraGrow, which has five different beneficial bacterial species by adding the recommended amount of product to Johnny's organic planting mix, followed by thoroughly mixing. Seeds also were soaked in the product slurry for five minutes before planting.

The planting mix was dispensed in a plastic plug tray, where seedlings were grown in the greenhouse for six weeks. Some seedlings were grown in medium without any beneficial microbes. While seedlings were growing in the greenhouse, we inoculated field plots with Verticillium pathogen grown on oat grains. We had three different treatments, including no treatment of field plots where non-treated seedlings were planted.

Anaerobic soil disinfestation

In another treatment, seedlings grown on non-pasteurized media inoculated with beneficial microbes were planted in anaerobically disinfested soil (ASD). In the third treatment, pasteurized media were inoculated with probiotic bacteria to grow seedlings that were planted in ASD soil.

ASD was done in three different steps. Plots were plowed and mustard meal was added at the rate of 5 tons per hectare, mixed with a walk-behind rototiller, followed by covering with plastic mulch.

Plots were then irrigated through a dripline up to saturation. So, all the air was out of the soil to make an anaerobic condition. Beds were kept undisturbed for three weeks for anaerobic microbes to multiply and

– continued

Biologicals and anaerobic soil disinfestation – continued from page 4

Figure 5. Management of Verticillium wilt on okra: a) Non-treated; b) Seedlings grown on pasteurized planting mix inoculated with TerraGrow + ASD; c) Seedlings grown on regular planting mix inoculated with TerraGrow + ASD.

produce volatile organic compounds (VOCs) that may have suppressed Verticillium. Plastic was cut perpendicularly 24 hours before seedlings were planted in field plots by digging holes to ensure toxic gas has dissipated.

Results

Plants were grown to maturity; fruits were harvested three days a week and cumulative yield was recorded by number and weight.

A significantly higher yield was obtained from treated plots compared with non-treated (Table 1). More than 50% of plants wilted and died in non-treated plots, whereas only one died in the biological treatment. No plants died in the combination treatment by the end of the growing season (Figure 5).

The combination treatment of seedling production in beneficial microbe inoculated planting mix and planting them in ASD field plots seems a promising option for growers for managing soilborne diseases those who can't use synthetic fumigants.

Although the work mentioned in this article relates to Verticillium wilt control on okra, a similar methodology may work against other soilborne diseases in other crops, such as eggplant, tomato, strawberry, etc.

Table 1. Fruit yield, plant height and mortality as affected by treatments of biologicals and anaerobic soil disinfestation at seedling stage, field, and combination of both.

Treatment	Fruit/plant	Fruit weight/ plant (ounces)	Average plant height (feet)	Mortality (%)
Non-treated	52 c	45 c	5.6 b	55 a
Pasteurized mix TerraGrow treated plus ASD	67 b	60 b	5.8 b	5 b
Regular mix TerraGrow treated plus ASD	72 a	62 a	6.2 a	0 c

Numbers followed by different letters in a column are significantly different from each other according to Fisher's protected LSD test (P=0.05).

Biology and control of flea beetles

Flea beetles are small coleopterans that belong to the subfamily Alticinae. They are named flea beetles because they can jump long distances like true fleas. This mechanism helps flea beetles escape from some predatory interactions. Typically, flea beetles cause problems in the spring when crops are in the early development stage with less than five leaves. In West Virginia, there are several species of flea beetles that commonly attack ornamentals, blueberries, grapes, melons and several vegetables.

Life cycle

Flea beetles live through the winter as adults in leaf litter, hedgerows, wooded areas and other protected areas. Adults typically become active during warm days in early to mid-spring and then seek the plant species they feed on. Adults can be identified by having large hind legs, stripes or spots, and most species range in color from green, metallic-blue, black and brown. The size of adults can vary from 1/15- to 1/4-inch long. Depending on the species, females lay eggs in roots, soil, leaves or flowers. Flea beetle larvae feed for about a month on the roots or leaves of plants, but their damage is minimal and usually cannot be detected unless it is a tuberous plant. After flea beetles pupate in soil, they emerge as adults around mid-summer.

Damage and scouting

Flea beetles can cause significant damage to host plants if left unchecked. They create shallow pits and small rounded, irregular holes (usually less than 1/8 inch) in the leaves; this damage is distinctive to flea beetles (Figure 6). Because of their high mobility, many physical methods of sampling or trapping, such as hand picking or vacuuming, are ineffective. Sticky cards are one of the most effective methods of scouting.

Control

Control of flea beetles should be focused during spring. In summer, control is often unnecessary, especially at the end of the season when plants are strong enough to survive damage. The number of adult flea beetles also decreases late in summer.There are several cultural practices to reduce flea beetles. For example, removing old crop debris so that beetles cannot get protection in the winter. Also, effective weed control near crops limits food sources for insects.

Figure 6. Flea beetle damage on plant leaf.

In addition, watering plants during mid-day can help repress populations because of their dislike of water. Trap cropping also can be effective; flea beetles are highly attracted to radishes and mustard plants.

Row cover is an effective mechanical control that keeps beetles out when the seedlings are growing. However, row covers should be removed during the blooming stage of the crop to allow pollinators to reach them. There are several natural enemies of flea beetles, but no species are commercially available currently.

Several insecticides with different active ingredients are labeled to manage flea beetles. For example, Spinosad and several pyrethrins are organic products that kill flea beetles. Other active ingredients, such as carbaryl, malathion, lambda-cyhalothrin and cyfluthrin, also kill flea beetles; however, these products are harmful to beneficial organisms and can occasionally cause spider mite outbreaks. Many products are commercially available with the mentioned active ingredients, but federal laws indicate that the site of application (crop) must be listed on the pesticide label.

About IPM Chronicle

Rakesh S. Chandran, *IPM Chronicle Manager*
304-293-2603

WVU Extension Contributing Authors:

Rakesh S. Chandran, *Weed Scientist and IPM Program Coordinator*

Mira Danilovich, *Consumer Horticulturist*

Carlos Quesada, *Entomologist*

MM (Mahfuz) Rahman, *Plant Pathologist*

WVU Extension Creative Team:

Greg Jacobs, *Graphic Designer*

Hannah Booth, *Editor*