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In This Issue:

IPM and fungicide resistance management

Like any other pests, plant diseases can be best managed through an integrated approach that includes host resistance and cultural, mechanical, biological and chemical tools. A combination of tactics not only improves the efficacy but also makes it more sustainable by preventing resistance development of a pathogen population to a specific management tool.

Although each component of an integrated pest management program is important, fungicides play an important role in managing diseases in many crops. While poor disease control with fungicides can occur for multiple reasons, resistance to fungicides in fungal pathogens is most common when fungal population are no longer sensitive to a certain group of fungicides.

In 2001, the DuPont chemical company voluntarily withdrew the fungicide Benlate (benomyl) from the market because of lawsuits related to resistance development in target organisms, resulting in devastating crop losses. However, historically, plant pathogens also could overcome host resistance, causing similar losses. One recent example is cucurbit downy mildew (caused by *Pseudoperonospora cubensis*) that caused an epidemic in 2004 when the pathogen overcame the resistance of previously known resistant varieties of cucurbits.

Fungicide resistance development

Multiple factors may affect fungicide resistance development in a fungal population, including the fungicide's properties, biology of the pathogen and crop production system where the fungicide is used. Based on the breadth of metabolic activity, there are two major types of fungicides popularly known as single-site and multi-site active fungicides.

Single-site fungicides affect only one point of a metabolic pathway or against a single critical enzyme/protein. As a result, fungi are more likely to become resistant, because a single mutation in the pathogen allows it to nullify the action of the fungicide.

Multi-site fungicides, on the other hand, affect several different metabolic sites within the fungus. These products usually work as contacts and against a broad spectrum of unrelated pathogens. As they affect multiple metabolic sites, these fungicides are considered a low-resistance risk group. Therefore, they offer the possibility for use as mixing partners or alternating with single-site, high-resistance risk fungicides. Over the past decades, no cases of field resistance against multi-sites have been reported, making them a valuable tool to manage resistance.

Managing fungicide resistance

Once a disease control failure is reported from a specific fungicide, fungal isolate should be collected in pure culture and tested for resistance. Upon request, plant pathology labs can conduct such tests. If fungicide resistance is confirmed, take the following steps:

- Use of the fungicide in question should be stopped, as well as other fungicides under the same mode of action under the same fungicide resistance action committee group.
- Since cross-resistance of a fungal pathogen to the products belonging to same fungicide resistance action committee group is possible, start using a fungicide with a different mode of action that is also labeled for the disease.

– continued on page 4 –

Management of anthracnose of cucumbers

Anthracnose, caused by the fungal pathogen *Colletotrichum orbiculare* (syn. *Colletotrichum lagenarium*), is a destructive disease of cucumbers grown in the open field. The disease is common in West Virginia and causes serious losses to cultivars lacking resistance. It also can affect squash, muskmelon and watermelon.

Disease identification

On leaves, lesions start as small, water-soaked areas that turn chlorotic (yellow) or necrotic (light brown to bleached) and enlarge to about ¼ to ½ inch in diameter over time with circular to irregular borders. As the lesions grow older and bigger, the centers may fall out giving the leaf a shot-hole appearance (Figure 1).

Figure 1. Anthracnose symptoms on cucumber leaves of plants grown in the field without any mulch. (Photo credit: MM Rahman)

Because all parts of a cucumber plant are susceptible to anthracnose, lesions also can appear on stems and fruits. Stem lesions are usually light brown in color and may appear spindle-shaped. Stem lesions on smaller plants can seriously stunt the growth and may eventually kill plants. Fruit lesions usually appear sunken and round. Under high humidity, lesions turn orange or salmon-colored due to excessive sporulation (Figure 2).

Symptom appearance on the fruit usually coincides with heavy leaf infection and can develop while still in the field. In some cases, infection may not express any symptoms in the field but continue to progress after harvest, which results in infected cucumber fruit with sunken lesions in storage and/or transit.

Infection requirements

Like many other fungal diseases, warm wet weather favors anthracnose infection, disease development and spread. Free moisture on the plant surface is needed for infection to take place, and splashing rain helps in dispersal of the fungal spores from diseased to healthy plants. With the enlargement of plant canopy, microclimate at the canopy level becomes more favorable due to increased humidity, which aggravates the disease situation.

Figure 2. Sunken anthracnose lesions on cucumber fruit. (Photo credit: Charles Averre, North Carolina State University, Bugwood.org)

Disease management

The fungus *C. orbiculare* can survive on infected crop residues between cucumber crops. It also can survive on volunteer cucurbits and weeds, such as cockleburs. Crop rotation of at least two years without a cucurbit crop is the best option. In the absence of a rotation option, deep fall tillage will help reduce crop residue, thus help reduce anthracnose inoculum.

Anthracnose-causing fungus can be seed borne; therefore, disease-free or treated seeds should be used. Transplants should be carefully inspected for anthracnose symptoms before planting. Choose disease-tolerant cucumber varieties to easily manage the disease with chemicals. If the variety is highly susceptible to disease, it is often difficult to control, especially in a favorable disease environment. Look for "AN" or "Co" on the seed packet, which indicates anthracnose resistance. Slicer varieties with resistance include Bristol, Marketmore 76, Speedway F1, Stonewall, SV3462CS, SV4719CS and Thunder.

Along with the management methods mentioned above, growers can take preventative measures by applying contact fungicides, such as chlorothalonil (Bravo®, Echo®, Equus®) and mancozeb (Dithane®, Manzate®, Penncozeb®) when early symptoms appear. However, once disease has set in, systemic strobilurin fungicides (Cabrio®, Pristine®, Quadris®, Topsin®, Inspire Super®), can be applied at 7- to 14-day intervals. Organic growers can use copper (Kocide, Champ) or Bacillus subtilis strain QST 713 (Serenade) on a preventative basis.

Applying insecticides correctly

There are a number of things to keep in mind when you are applying insecticides to control insect pests.

Follow all label directions

Information on the insecticide label provides you with instructions on how to use the product safely and correctly. Furthermore, pesticide users are required by law to comply with all the instructions and directions for use on the label (Figure 3).

Use the correct protective clothing and equipment

The label tells you if you need to wear special personal protective equipment (PPE) when applying the product. For example, some labels state that during application you must wear a long-sleeved shirt and long pants, closed-toe shoes plus socks and chemical-resistant gloves. Additional PPE (e.g., chemical-resistant apron, protective eyewear) also may be needed during mixing, loading or other tasks. Wearing anything less than what is listed on the label can be dangerous. Also, never eat, drink, use tobacco products or handle cell phones when using insecticides.

It also is equally as important to use the correct type of application equipment. Many insecticide products are sold ready-to-use (RTU) or as concentrates. Many RTU products are packaged so that application equipment is not required; however, some may be easier to apply with the appropriate tools. For example, insecticide dusts are easier to apply using a bulb duster rather than sprinkling it by hand. Insecticides sold as concentrates must be diluted (mixed), often in water, before use. When mixing insecticides, use measuring cups and tools that have been designated exclusively for this use. Make sure the sprayer you are using is in good working condition, and the hoses and connections do not leak.

Use in the manner intended

Some insecticides are designed to be sprayed, others to be dusted and still others to be placed as a bait that the insect eats. Again, the label will tell you where and how to use the selected product.

When mixing insecticides, measure the proper amount of product as specified on the label. More is not better when it comes to insecticides. Applying too much can damage plants or other treatment surfaces, and it can pose health and environmental risks.

Figure 3. Pesticide users are required by law to follow all instructions for use on the label.

If applying insecticides in enclosed spaces, only use products specifically labeled for indoor use. Many insecticides intended for outdoor use are designed to break down into less toxic substances with ventilation and exposure to sun and rain. Without these conditions, the insecticides may linger and cause health risks for humans and/or pets. If applying insecticides outdoors, it is best to spray on a calm day, preferably in the morning or evening when there is less wind and less potential for airborne movement to an unintended site.

Use careful cleanup procedures

Always clean application equipment inside and out immediately, because insecticides are harder to remove once dried. Clean at a location where any spilled rinse water will not contaminate water supplies or other non-labeled areas, and at a location that is inaccessible to children and/or pets. Remove nozzles and screens, and flush the sprayer system at least twice with clean water. Capture the rinse water and apply to areas listed on the label.

Wash your hands thoroughly with soap and water immediately after handling insecticides, and shower every day that you use them. Change to clean clothes and wash the ones you wore as soon as possible, separately from the other laundry. Wash clothing in warm or hot water using detergent, and line-dry or dry on high heat immediately after washing. Clean the washer afterwards by running a complete cycle without clothes but with a full amount of hot water and detergent. If clothes have been saturated with the insecticide, they should be thrown away.

Preparation work for a beautiful and healthy lawn

An attractive, healthy lawn is an integral part of a home's landscape – a welcoming mat that influences the first impression and can significantly affect the property value. Building the foundation for a healthy lawn requires planning and preparation, in order to fit the owner's uses and the land's conditions.

Planning

Before buying the grass seed or sod, sketch out the property considering the areas that will be utilized for kids play and areas that will have heavy foot traffic. Map out the approximate sizes of the different areas of the lawn, and identify the shaded areas and the areas that are exposed to direct sunlight.

There is an appropriate seed mix or sod for the following conditions: high traffic areas, shaded areas or direct sun areas. The next step is to determine the hardiness zone for a given area. Hardiness zone is defined by certain climatic conditions necessary for plant growth and survival. Based on the hardiness zone, choose grasses suited for those conditions. If you do not select the appropriate grass for the conditions, it can result in future issues with weeds, insects and diseases. For instance, it is difficult to maintain a quality lawn in the dense shade under an oak or basswood tree. The thinning lawn in that area will create an opportunity for weed invasion and, with that, possible issues with nematodes. Additionally, if you put grasses that require full sun exposure in shady areas, it will result in disease development and grass dieback.

Preparation

Soil testing should be conducted to reveal potential problems with drainage, compaction, fertility due to inadequate pH values, and disease and insect susceptibility. Based on the soil test results, soil amendments, such as liming and adding fertilizer, should be done before lawn establishment (Figure 4).

Figure 4. Grading and smoothing of surface should be carried out prior to hydroseeding to prevent tire marks. (Photo credit: M. Danilovich)

Another part of soil preparation for a new lawn is getting rid of perennial vegetation by applying a systemic total herbicide. Allow at least four weeks between herbicide application and seeding or sodding. Next, level the terrain to ensure a 2 to 3% pitch for better drainage. It also is good practice to spread starter fertilizer over the top and do the final grading before seeding or sodding.

Growing green manure plants will help add biomass and improve air and water retention capacity. Those plants are grown with the sole purpose of tilling them under to incorporate them into the soil. Seeding mustards and oil-seed radishes provide the bonus of acting as a biofumigant, which reduces the populations of soil-dwelling pathogens. Two or three years of this preparatory planting prior to lawn establishment will particularly benefit large lawn areas.

Providing a sufficient lawn foundation will ensure good seed germination and grass establishment, resulting in a thick, healthy, attractive lawn.

IPM and fungicide resistance management *– continued from page 1 –*

- Do not use single-site active products for more than two consecutive applications prior to rotating with multi-site active products or products from a different fungicide resistance action committee group with different modes of action. Fungicide labels indicate how many times or the total amount a site-specific product can be used in a growing season without risking resistance development.
- In the early stage of resistance development, use fungicides in a tank mix or pre-mix of multiple active ingredients that may control the resistant pathogen.
- If any fields have a history of fungicide-resistant fungi, avoid moving soil or plant parts to other fields and farms. Follow sanitation methods to clean equipment used in these fields. Use farm equipment in these fields last.

Preventing tobacco mosaic virus in protected culture

West Virginia growers should be aware of tobacco mosaic virus (TMV), which can be found on tomatoes, peppers, potatoes, eggplants, cucumbers, petunias and a number of ornamentals. Fortunately, through proper sanitation practices and the use of virus-free plants and seeds, you can reduce the chances of this virus appearing in your farm.

What is tobacco mosaic virus?

Tobacco mosaic virus was the first virus to be discovered and was named for one of the first plants in which it was found – tobacco. However, it can infect more than 350 different species of plants, including the rest of the solanaceous crops, cucumbers and several ornamental plants. The virus can survive in a dormant state waiting for a host to infect.

The virus is a member of the tobamovirus group and has a close relative, tomato mosaic virus (ToMV). In fact, it is nearly impossible to tell these two viruses apart without laboratory testing. As a result, some information sources may use the names or abbreviations interchangeably. Also, the plants they infect, as well as symptoms and treatments, are similar.

Symptoms

Some plants can carry these viruses for a considerable period of time without showing any symptoms – particularly tobacco plants. In addition, the same general symptoms associated with infection are similar to those seen when plants are exposed to high temperatures, insect damage, herbicide or growth regulator damage, or mineral excesses or deficiencies, which makes the diagnosis complicated.

Classic tobacco mosaic virus symptoms on plants are young leaves with a light green coloring between the veins, followed by a mosaic or mottled pattern of light and dark green areas on the leaves (Figure 5). Leaves may also begin to curl and form a shoe string-like appearance, with newer growth being distorted or deformed.

Management

Unfortunately, there is no cure for a plant infected with these viruses other than removing it from production. Using a resistant variety is a good step to reduce the chances of having plants infected. In the case of tomatoes, most newer varieties are bred for resistance, which can be confirmed by looking at the codes on the seed packets. Starting with virus-free plants and seeds also should be considered when choosing what to include in your operation. If you save your own seeds, be sure that you select fruit from plants that you believe are not virus-infected before extracting seeds.

Figure 5. Leaves of a plant infected with tomato mosaic virus. (Photo credit: The American Phytopathological Society)

Spread

Transmission of these viruses most often occurs thru mechanical means by touching an infected plant or plant materials with hands, tools or clothing, and then transferring the virus to other uninfected plants.

Tobacco products are a potential source of these viruses; therefore, most researchers do not allow staff to use these products. While that can be difficult for growers, consider limiting staff who use tobacco products or offering an incentive to be tobacco-free to work in these spaces. Because these viruses can survive in a dormant state and be easily spread, care must be taken to minimize exposure to tobacco products, sanitize tools and surfaces, as well as remove infected plant debris.

Plant sap from infected plants also can be transmitted via hands and clothing. Changing gloves, washing hands and cleaning protective clothing can help reduce the chances for viral transmission. Removal of weeds also is an important component of removing the potential for virus transmission, because they may harbor the virus as well.

If you use sound sanitation practices, virus-free plants and seeds, as well as resistant varieties, your chances of having the viruses in your operation will be significantly reduced.

Growing degree day model to help manage Japanese stiltgrass

Weed seeds germinate when dormancy is completed and when the environmental conditions are favorable. Summer annuals, such as Japanese stiltgrass *(Microstegium vimineum)*, germinate in spring as the ambient air temperature and soil temperature start to rise.

Japanese stiltgrass is a non-native invasive weed seen in woodlots, pastures, lawns or other types of turf (Figure 6). This shade-loving grass possesses the potential to displace desirable forages if not managed early on.

Figure 6. Japanese stiltgrass is often seen in woodlots, pastures and lawns. (Photo credit: R. Chandran)

What is growing degree day?

Growing degree day (GDD) is a tool that can be used to predict weed seed germination due to its direct relationship with soil temperature. The GDD is calculated based on the difference between the average temperature for a given day and a base temperature, usually 50 F (GDD_{50F}). It accrues from the beginning of the Julian calendar, which is January 1.

When other factors are suitable, summer annual weeds begin to germinate when a threshold soil temperature is attained. Then, they continue to germinate over a certain period of time depending on the species.

Online tools can be used to determine the GDD for a particular location. Cornell University's Climate Smart Farming website *(http://climatesmartfarming.org/tools/csf-growing-degree-day-calculator/)* contains a tool to determine the GDD for specific locations in West Virginia.

How is GDD used to manage Japanese stiltgrass?

Pendimethalin is an effective pre-emergent herbicide used to control annual grasses and certain small-seeded broadleaf weeds. To achieve ideal weed control, pre-emergent herbicides must be applied prior to weed germination.

Different formulations of pendimethalin are available. For example, Prowl H2O is labeled for use in pasture, and Pendulum 3.3 EC is labeled for turfgrasses and other non-crop areas.

Research determined that pendimethalin applied at 4 pounds per acre with GDD_{50F} reaches 75 to 100 consistently provided excellent control of Japanese stiltgrass (>95%) up to four months after treatment. This usually corresponds to the early bloom stage of forsythias in West Virginia, which could be used as a phenological indicator even though it is less accurate.

To ensure herbicide activation, adequate soil moisture levels should be maintained following treatments. This can be accomplished by ¼ inch of rainfall or irrigation within a week after herbicide application.

About IPM Chronicle

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