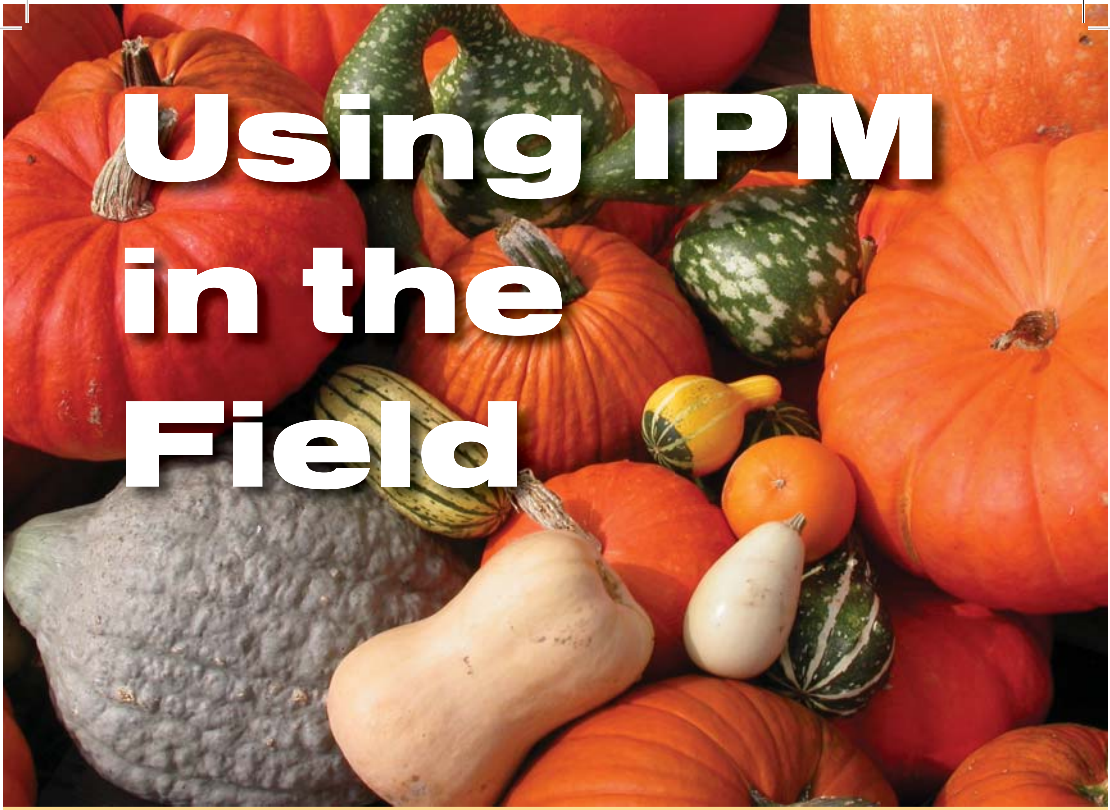
Using IPM in the Field



Diseases of Cucurbit Crops: Scouting & Management Guide

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Note

This guide is for educational purposes and is based on the best available information at the time of publication. Where trade names or commercial products are used, no company or product endorsement is implied or intended; nor does absence indicate lack of endorsement. Always read the label before using any pesticide. The label is the legal document for product use.

Contents

Introduction

Cucurbit crops comprise almost 30% of all vegetable crop acreage in New England, and are grown on over 4,000 acres in Massachusetts. The number, severity and complexity of diseases attacking these vital crops have increased in the past decade. In particular, Phytophthora capsici has increased dramatically in the past five years and is causing severe crop losses and infecting more and more vegetable acreage. Plectosporium, a fungal disease that affects summer squash, zucchini and pumpkin leaves, stems and fruit, is relatively new to the region and is spreading rapidly. Bacterial wilt affects increasing numbers of cucurbit crops, including pumpkin. Downy mildew has reached the area early in the growing season on several occasions, causing loss of foliage in August. The fungal, bacterial, and viral diseases and the abiotic disorders covered in this guide are the ones that are most commonly seen in the Northeastern U.S. Correctly identifying these diseases and understanding the biology of the pathogens is necessary in order to produce healthy cucurbit crops.

An effective management strategy for these diseases requires employing a variety of tactics. Selection of resistant cultivars, crop rotation, proper field preparation, and other cultural practices detailed in this manual can have a significant impact in slowing or preventing the development of these diseases. Proper soil health & crop nutrition can help to suppress disease development. Monitoring for diseases in the field and identifying them correctly are crucial to creating an effective and timely spray program.

When deciding when and what to spray to protect the crop from diseases, it is critical to consider the entire disease complex which exists on their farm and the efficacy of different materials against the full range of diseases. Because certain fungicide groups are more likely to lose efficacy against some diseases due to the development of fungicide resistance in pathogen populations, resistance management also needs to be considered.

The goal of this handbook is to help growers identify the diseases they see in their cucurbit crops, use preventative practices as effectively as possible, and develop a more complete understanding of how to design a spray program to address all these different diseases.

Using The Guide

Review the General Cultural Practices section to see how you might increase your use of preventative strategies. While cultural practices alone are not sufficient to guarantee a healthy crop for the full growing season, they are critical to your success. Look for additional cultural controls listed under each disease.

Take this guide with you into the field when you scout your cucurbit crops. Even a brief scouting trip into the field with this guide will provide you with important information about what's happening with diseases in your cucurbit crops. To be able to respond quickly and effectively to changing conditions, you need to be able to make correct identifications—on your own, when that is possible, and using the resources available to you through UMass Extension or Disease Diagnostic

Laboratory services when necessary. For each disease, this guide offers color photographs and information on the biology of the causal organism, typical symptoms, and cultural practices that can prevent or delay the onset of disease. Identification is challenging due to the number of diseases, the variation of symptoms on different crops, and similarity of symptoms between some diseases. Using this guide in combination with Disease Diagnostic Laboratory services will help you learn, with certainty, what diseases are present on your farm.

Putting together a spray program that will give the best control at a reasonable cost can be challenging and frustrating. Review the Scouting and Management section to learn about general principles that are key to designing a whole-season approach to managing cucurbit diseases. In addition to correct identification, some management choices depend on weather conditions, crop stage, or the risk of infection due to movement of pathogens from other locations. The spectrum of efficacy and the risk of resistance development must also be considered. All decisions should be based on understanding the whole complex of diseases in your particular crop. We have avoided recommending specific products in this guide in order to keep the information relevant, as new products are developed and old ones are frequently lost to resistance. For current recommendations on specific chemistries, please see the New England Vegetable Management Guide, available in print or on-line at www.nevegetable.org. Also watch for a periodic supplement to this cucurbit disease guide which will provide updated, current recommendations for an integrated spray program.

Using The UMass Disease Diagnostic Laboratory

The UMass Plant Disease Diagnostic and Nematode Assay Lab provides diagnostic services for vegetables, fruit, and turf. There is a $50.00 fee for a diagnosis which includes a report detailing lifecycle, symptoms, and management recommendations. It is recommended that you call the lab (413) 545-3209 when submitting samples. Specimens can be submitted by mail or in person. If sent by mail, they should be mailed for next-day delivery.

Where to Submit Samples

For current instructions on where to submit a sample in Massachusetts and a list of services available in other states, please visit www.nevegetable.org and click on the "pest management" link. The resulting page will have much useful information and a link to diagnostic services on the left.

How to Submit a Sample

Case-history: A complete case-history of your crop can be very important for an accurate diagnosis. Information should include: herbicides used for present and previous year, previous crops, soil type and drainage, prevailing environmental conditions, development and distribution of symptoms in the field (random, uniform, clumped) and variety of plant. Include any other information that you believe may be useful.

A case-history form for submitting samples is available online at:
http://www.umassvegetable.org/growers_services/pdf_files/disease_case_history_form.pdf

Collecting and mailing the specimen: Before collecting the specimen, call the lab at (413) 545-3209 to discuss the problem and to make sure someone will be available when the specimen arrives. Collect specimens that show a range of symptoms but avoid rotten specimens. Mail the specimen on the same day or store it in a refrigerator and mail the next day. Overnight mail is preferred since the specimen will arrive in better condition. Specimens can also be brought directly to the lab which is located near the UMass Amherst campus. If no one is in the lab when you arrive, leave the specimen with accompanying information in the lab, or if the door is locked, on the floor in front of the door. Specimens are processed by the lab Monday through Thursday. Specimens that arrive Friday may not be processed until Monday.

Collecting and Packaging Specimens

Leaf spots and blights: Select leaves which show a range of symptom development. Specimens that are dead or dry are of little diagnostic value. Place leaves between sheets of newspaper or inside a magazine. Place the package in a plastic bag, then into the envelope for mailing. Never wrap leaves in wet paper towels.

Fruit rots: Select early stages of disease rather than badly rotted tissue. With large fruit such as a pumpkin, cut the affected area out with a knife, but include some healthy tissue. Wrap fruit or sections in newspaper and place in a plastic bag for mailing.

Stem cankers: When a canker occurs on a large plant such as a pumpkin vine, cut a section of the stem with the symptoms (be sure to include healthy tissue adjacent to the canker), wrap in newspaper and place in a plastic bag.

Wilt, crown rot and root rot: If the plants are one foot in height or less, submit the entire plant. Dig the plant including a good handful of the root system. Leave the soil on the roots. Place the root/soil ball into a plastic bag and tie off at the crown to prevent soil from spilling out. Wrap in newspaper and place in plastic bag.

Scorch, defoliation and poor growth: These symptoms are usually caused by nutritional or environmental factors. They may also be the result of root rot or vascular disease. Collect a specimen as for wilt (above), and also submit a soil sample to the soil testing laboratory. Soil or tissue analysis combined with a disease diagnosis may help identify the cause of the problem.

Using the UMass Soil and Plant Tissue Testing Lab

Proper soil health and crop nutrition are essential components to any disease management program. Fertile plants growing in healthy soil are generally much more resistant to disease. Regular soil testing can take the guesswork out of your fertility program.

Where to Submit Samples

To obtain online instructions on submitting a sample to the UMass Soil and Plant Tissue Testing Lab, including a printable soil sample submission form, visit: http://www.umass.edu/plsoils/soiltest/brochlink1.htm

How to Sample

- Each sample submitted for testing should be a composite or mixture of 6-12 separate scattered samplings taken over a well-defined area.
- Soils that are distinctly different based on appearance, crop growth or past treatment should be sampled separately.
- Define a sample area based on uniformity of texture, slope, drainage, color, and past pest and fertility management.
- Avoid sampling very wet soils.
- Using a clean spade, auger, or sampling tube, obtain soil from the surface through the primary rooting zone. For most plants the top 6-8 inches is appropriate. For established grasses sample the top 3-4 inches.
- Place each of the 6-12 randomly spaced samplings in a clean container (pail or bag) and mix thoroughly. Spread the mixture out on a clean paper to air-dry (do not place soil in an oven).
- Mix the soil again. Obtain a one cup measure of the soil mixture and place it in a zip-lock type bag.
- Label the outside of the bag clearly with your name, address, and a sample identification.

Available Tests

Services offered by the UMass Soil and Plant Tissue Testing Lab include a wide variety of soil tests, plant tissue testing, water testing, fertilizer testing, compost testing, and soil-less greenhouse media testing.

To see a complete list of available tests from the UMass Soil and Plant Tissue Testing Lab, visit: http://www.umass.edu/plsoils/soiltest/services1.htm. For additional information, call the UMass Soil and Plant Tissue Testing Lab at (413) 545-2311, or visit their web site at http://www.umass.edu/plsoils/soiltest.

General Cultural Practices

Good cultural practices can go a long way toward mitigating the impact of diseases and reducing crop losses. They are an essential component of any management system and are particularly important for organic production, where the availability of effective chemical controls is limited. Certain practices that are specific to individual diseases are covered in the appropriate section for each disease. The following cultural practices represent good management practices common to all cucurbit diseases.

Site selection

- Do not plant cucurbits for at least two years in fields where cucurbit diseases have been a problem.
- Separate successive cucurbit plantings physically to prevent older plants from serving as an innoculum source for later, younger plantings.
- Use plant spacings which reduce the density of the plant canopy.
- Plant in sites with good air circulation to encourage rapid drying of the foliage.

Crop nutrition

- Use regular soil tests to determine the need for adjusting the pH and major and minor nutrients to meet the needs of the crop. See the *New England Vegetable Management Guide* for specific recommendations (available online at www.nevegetable.org).
- Apply some fertilizer at planting and some as a side or top dress to meet crop needs.
- Build soil health and organic matter through cover cropping, soil amendments, and/or reduced tillage.

Crop management

- Incorporate plant debris after harvest; if using reduced tillage, mow after harvest.
- Reduce weeds to allow for faster drying of plant surfaces.
- Avoid injuring fruit before or during harvest; use proper post harvest practices.
- Plant resistant varieties where available.
- Avoid planting low areas of the field where water may collect.
- Manage soil for good drainage, use subsoiler or vertical tillage to break up compacted layers.
- Manage compaction.

Irrigation

- Use trickle irrigation where possible.
- If using overhead irrigation, apply in the middle of the day to allow leaves to dry.
- Prevent leaks that lead to standing water and pooling.

Additional Resources

This guide does not cover every pest and disease affecting cucurbit crops. Additional information on less common diseases, nutrient, weed and insect management, and organic pest management can be found in the following resources:

New England Vegetable Management Guide. Comprehensive guide on crop and pest management updated every two years. Includes a photo management guide with color photos of insects, diseases, and weeds. Available in printed copy from UMass Extension, 413-577-3976 (http://umassextensionbookstore.com) and online at www.nevegetable.org.

UMass Extension Vegetable Notes Newsletter. Weekly crop and pest updates during the growing season, including region-wide reports on cucurbit crops. Available through e-mail or hard copy subscription (contact umassvegetable@umext.umass.edu or 413-545-3696) and on the UMass Vegetable Program website: www.umassvegetable.org.

University of Massachusetts IPM Guidelines. Provides a list of Integrated Pest Management methods (soil and nutrient, insect, disease, weed and water management) for many vegetable and fruit crops including cucumber, pumpkin, and squash. The most current crop-specific guidelines may be found online at www.umass.edu/umext/ipm/publications/gudielines/index.html.

Scouting & Management

The list of diseases affecting cucurbit crops is long and new diseases such as Plectosporium blight are increasing the risk in growing these crops. Downy mildew and Phytophthora blight have become more prevalent in recent years. Management of these diseases is complicated by the presence of different types of pathogens which require different classes of materials for effective control, and the danger of fungicide resistance developing in pathogen populations.

Systemic or Single Mode of Action Fungicides

Systemic fungicides and fungicides with a single mode of action targeting a particular disease often provide the best control of many cucurbit diseases. Systemic insecticides provide protection to both the upper and lower leaf surfaces. However, these materials have only one mode of action per fungicide group and tend to have more problems with resistance development than contact fungicides, which provide multi-site activity against diseases. Fungicide resistance can occur in a single season if systemic fungicides are overused. Once a disease organism develops resistance to one of these materials, the pathogen will also become resistant to other products in the same fungicide group (i.e. stobilurins). As a result, newer materials that have not been exposed to disease organisms as long usually tend to work better than older products, but not for long. In contrast, many contact fungicides have been used for decades without experiencing resistance problems. Although stobilurin fungicides have, in the past, been some of the most effective materials available for cucurbit diseases, powdery mildew and black rot pathogens have already developed resistance to strobilurins in some states. Downy mildew resistance has occurred outside the United States. The best resistance management strategy to help preserve the useful life of the systemics and single mode of action fungicides is to make a single application from each effective fungicide group in a given season. The incorporation of appropriate cultural practices will also help reduce resistance development. In addition, pathologists are now recommending that all systemic and single mode of action materials be applied with a contact fungicide to help slow resistance development. Never apply a systemic insecticide to a field where the disease has reached epidemic proportions, as this will result in the rapid development of fungicide insensitivity due to the high level of selection pressure.

Contact Fungicides

Contact fungicides such as copper hydroxide, sulfur, chlorothalonil, and maneb may aid in the control of Plectosporium blight and other diseases, but they do not have the efficacy to provide sufficient protection against all cucurbit diseases when used alone. Fungicides must be mixed or alternated to produce a combination that will provide a full range of disease protection. Contact fungicides are most useful when used prophylactically. Once downy or powdery mildew sprays are required, a systemic or single mode of action fungicide that targets those diseases should be added to the spray program.

Organic Fungicides

There are a number of materials that are OMRI listed for use by organic growers. Copper and sulfur based products are typically the most effective. Always check the label to be sure that the material is labeled for your crop, and check with your local certifier to make certain that the material is allowed for organic production.

Biological and Biorational Disease Control Products

Biofungicides, or biological fungicides, contain living organisms such as fungi, bacteria or actinomycetes that may have some efficacy against plant pathogens. They can be used as part of an integrated disease management program to reduce the risk of pathogens developing resistance to traditional fungicides. Currently, there are no pathogens known to be resistant to biological fungicides.

While some trials have shown some biological agents to have an impact on disease, these results have not been consistent across studies. In addition, storage conditions, soil and air temperatures and use of other chemicals may affect their efficacy. Biofungicides should be used as a preventative treatment in conjunction with a regular monitoring program where plant health and crop quality are evaluated. Biological fungicides need to be used in conjunction with standard cultural practices that help prevent disease. Many biologicals are allowed for use in organic production, check with your certifier for current information.

Biological fungicides are living organisms which require specialized storage and application procedures. These materials have a limited shelf life, must be protected from temperature extremes, and applied correctly (with plenty of water and under the correct environmental conditions) for effectiveness.

Biorational disease control products (fungicides, bactericides, and nematicides) fall into three categories—botanicals, minerals, and synthetics. Sulfur, potassium bicarbonate, phosphites and copper compounds are examples of minerals or synthetics that can control fungal and bacterial diseases. Not all of these products are OMRI listed; be sure to check with your state certifying authority for more information on these materials. A new category of non-toxic pesticide is based on naturally occurring proteins called harpins that are produced by bacteria and other microbes. Pathogenic bacteria need harpins to infect their host plants. When applied to plants, synthetic harpins stimulate the plant's defense systems. They do not have any direct pesticidal effect, but reduce disease progress by strengthening plant defenses. Botanicals such as rosemary oil, soybean oil, or garlic extracts are also available as disease control products and are generally approved for use in organic production by OMRI. These products require thorough coverage, application at the first signs of disease, and frequent repeated dosages to be effective.

Please see the pest management section of the *New England Vegetable Management Guide* for more details on biological and biorational disease control products. The guide is available for free online at www.nevegetable.org.

FRAC Groups

A simple way to keep your rotations straight is to refer to the FRAC group listed on the fungicide label. Fungicides that share a FRAC group number have the same mode of action, and therefore are likely to be cross-resistant. If a pathogen is resistant to one product in a FRAC group, it will also be resistant to others in the same group. Use of systemic products from the same FRAC group will reinforce the selection pressure for resistant strains. Contact fungicides generally have multi-site modes of action, and therefore are at less risk to resistance. These multi-site mode of action fungicides are designated with an an "M" before their FRAC group number—for example, clorothalonil is in FRAC group M5. The systemic fungicides generally have a single mode of action, which puts them at a higher risk for resistance. These fungicides DO NOT have an "M" before their FRAC group number—for example, Quadris is FRAC group 11. You should always rotate between FRAC groups with systemic fungicides, mix systemic materials with multi-site mode of action fungicides (these are designated with an "M") and, if possible, not use systemic materials from the same FRAC group more than once per season. Check the individual labels for allowed tank mixes.

Monitoring

We recommend a sampling procedure based on the guidelines developed at Cornell University. It is impossible to overestimate the value of getting out into the field and looking at individual plants. By the time a problem is visible from the back of the tractor or the cab of your truck, it's often too late for efficient control. We recommend that you get out and scout a field at least once a week. It does not have to be a time intensive procedure. Each time you scout a field, chose five representative sites from which to make counts. The sites should vary from week to week to increase the probability that localized problems will be detected. The plant parts examined will change as the plants grow, vine, and form fruit.

Begin scouting for striped cucumber beetles as soon as plants emerge or are transplanted. When the plants are still small, inspect five individual plants at each of the five scouting sites. Overwintered striped cucumber beetle adults can colonize a field very quickly and cause direct damage to emerging or newly transplanted plants, in addition to possibly transmitting bacterial wilt. The only way to effectively control bacterial wilt is to control striped cucumber beetles early in the season. Twice weekly scouting may be necessary while overwintered striped cucumber beetle adults are colonizing fields, especial for crops in or near fields where cucurbits were planted in the previous year. Pay particular attention to the edges of fields, where localized "hot spots" of heavy damage may be found.

Later in the season, when the canopy starts to fill in and disease problems become more likely, inspect two older leaves on each of five plants at each scouting site for the presence of each disease (during a wet spring particularly note presence of scab and angular and bacterial leaf spot, as subsequent fruit infection can occur) and record how many plants are infected. Ideally, a total of 50 leaves should be inspected for each field. After the rows close for the vining types and individual plants can no longer be easily distinguished (for bush types this time frame would correspond to plants with fruit set and enlarging), it is preferable to substitute five plant areas (10 sq.ft.), examining 10 leaves/area and five fruit at each scouting location. To aid in finding the initial occurrence of powdery mildew, if summer squash is planted in the vicinity, inspect these plantings first for the presence of powdery mildew. Examine both surfaces of each leaf. Look for small (1/4"), white powdery mildew colonies and the angular yellowish spots associated with downy mildew, examine fruit for black rot, Phytophthora blight, and scab, and check all plant parts for Plectosporium lesions. See the monitoring section under each individual disease for specific scouting guidelines.

Spray Programs

If powdery mildew is detected first, begin your spray schedule with a systemic that is effective against powdery mildew. Remember to mix this systemic material with a contact fungicide. Follow this with another systemic or single mode of action material from another FRAC group, also mixed with a contact fungicide. Fungicide applications should be applied on a 7-10 day schedule and systemic or single mode of action fungicides should be limited to a single application per season for each FRAC group. If Plectosporium, black rot, or scab, are detected before powdery mildew, apply a recommended contact fungicide on a weekly basis until powdery mildew is found. In unusually wet weather, in unrotated fields, you may want to start your disease program at fruit set even if disease symptoms are not yet present. Apply a recommended contact fungicide every 7-10 days until powdery mildew is found during weekly scouting trips. Then follow the powdery mildew program detailed above.

Downy mildew overwinters in the deep south and is carried north each year on storm fronts. It makes its way up the coast, moving from cucurbit field to cucurbit field. In recent years it has also overwintered in greenhouses in Ontario, which means it can also reach us from the north or west. The progress of downy mildew epidemics can be monitored on-line at http://www.cdm.ipmpipe.org/ or by the University of Massachusetts Vegetable Notes Newsletter to better time scouting. A contact fungicide can be used alone when the forecasted risk of downy mildew is moderate and before downy mildew has been found in the area. By the time downy mildew arrives this far north, you may already be applying a contact fungicide to control other diseases. Systemic and single mode of action fungicides specific for downy mildew should be reserved for when risk is high or when the disease has been reported in your area or found in your field.

For organic growers, the options are more limited. Copper and sulfer are traditionally the most effective materials available to organic growers for managing the diseases that occur on cucurbit crops. There are also numerous biological and biorational materials allowed for organic production, though their efficacy may be more variable. Check with your certifier or state extension service for information about which formulations are currently approved for organic production.

The roster of effective systemic and single mode of action fungicides is always changing as older materials are lost to fungicide resistance and new products are developed. For current recommendations subscribe to UMass Extension Vegetable Notes Newsletter (email: umassvegetable@umext.umass.edu to be added to the subscription list) or visit the diseases section of the UMass Extension Vegetable Crops website (www.umassvegetable.org). In addition to efficacy, another consideration when choosing a material is the range of other crops it may be useful for. Ideally we recommend that you only use a systemic or single mode of action material one time in a season before you retire that FRAC group. It is more cost effective to buy a material that you will use on more than one crop, especially if you are only going to spray it once per season in your cucurbits. The available materials are generally labeled for multiple diseases and crops, the best choices in this regard will vary from farm to farm. As always, accurate identification of the disease is critical to making good decisions about your spray program.

Phytophthora Blight

Identification

Figure 1. The progression of a *Phytophthora capsici* infection in winter squash fruit. The pathogen causes a firm rot, but as the disease progresses the center of the infected area will become soft as secondary organisms begin to invade the decaying fruit.

Figure 2. Symptoms of Phytophthora rot developing on summer squash fruit.

Figure 3. Summer squash vine collapsing from *Phytophthora capsici* infection. Fruit symptoms can begin around the stem when the infection is passed systemicly through the vine.

Figure 4. White growth of sporangia on zuchinni fruit in storage.

Life Cycle

Phytophthora capsici is a soil-borne pathogen with a wide host range including pepper, tomato, eggplant, snap beans, soybeans, and most vine crops (cucumber, squash, pumpkins, watermelon and muskmelons). It is likely that the pathogen can be introduced by moving soil from infected fields on tires and cultivation equipment, spreading rotten fruit on new fields, infected transplants, and in run-off from infected fields. It is also possible that the pathogen can be spread through irrigation water from farm ponds or rivers and streams (Figure 5). Human activity is likely a major factor in the spread of this disease from field to field.

Figure 5. A contaminated pumpkin field draining into an irrigation pond. The pond was contaminated and the pathogen was spread to new fields through the irrigation system. Sporangia are not easily spread but splashing water can move them from row to row.

Phytophthora capsici has two mating types (called "A1" and "A2"). Both mating types must be present to form the resting or survival spores, called oospores. The pathogen overwinters as oospores in the soil or in plant debris. These resting spores are resistant to drying and freezing, and can survive in the soil for many years even in the absence of host plants. Due to the persistence of this pathogen in the soil and the difficulties associated with management of infected fields, a key management goal is to prevent the movement of the pathogen into clean fields. Most infected fields have been found to contain both mating types.

In the summer when soil moisture is at field capacity, oospores germinate to produce two types of asexual spores (called sporangia and zoospores). Sporangia can directly infect host tissue, or if conditions are wet, they can also develop and release zoospores. Zoospores are motile and will swim to a host plant through soil water, infecting the roots or crown. Repeated flooding events alternated with drier periods stimulate the release of zoospores.

When crops are infected abundant sporangia are produced on infected tissues, particularly on fruit (Figure 6). Sporangia are primarily spread by the movement of water, including irrigation water. The movement of infected soil can also spread the pathogen. The disease can develop very rapidly under favorable environmental conditions. Phytophthora blight is favored by high soil moisture, frequent rains or irrigation, and warm temperatures (75-90°F). The disease is usually associated with heavy rainfall, excessive-irrigation, or poorly drained soil. Outbreaks often begin in low lying depressions in the field, where soil saturation is high.

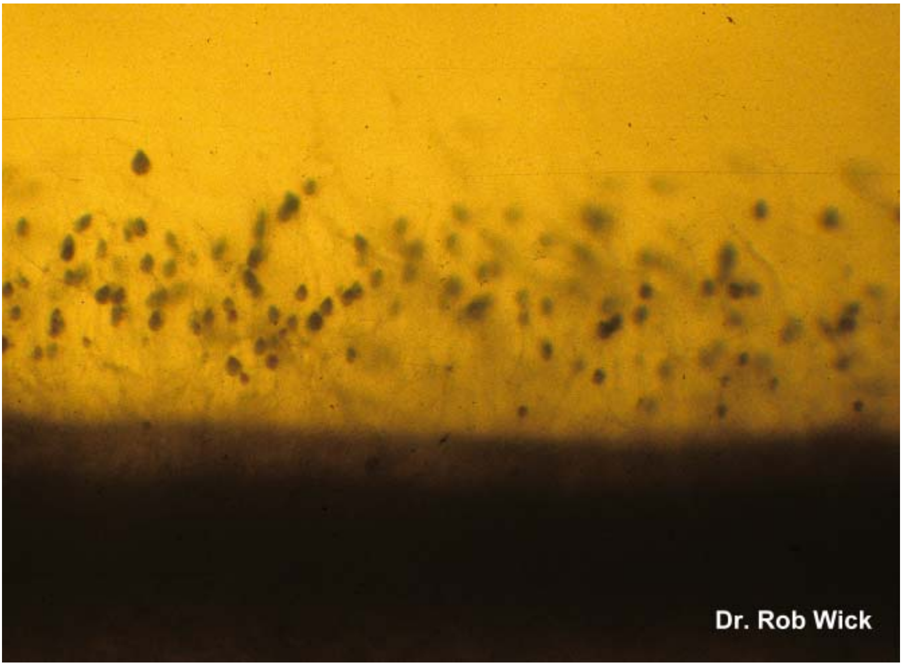

Figure 6. Thousands of sporangia forming on a tiny slice of infected fruit. Each sporangia can release 15-30 swimming zoospores that will move in soil water.

Symptoms & Signs

Leaf and crown rot: Symptoms include seedling damping-off, leaf spots, foliar blight, root and crown rot, and stem lesions. Foliar symptoms are uncommon in the Northeast, but when present appear as large, dark brown leaf spots up to 2" in diameter. Crown rot causes the plant to collapse, killing the entire plant in a short period of time. Summer squash often die back from the growing tip. Affected tissue is brown, appears water-soaked, and often collapses (Figure 3).

Fruit rots: Phytophthora fruit rot typically starts on the underside of the fruit where there is contact with the soil, but can also appear on the upper surface as a result of pathogen dispersal in splashing water. Initial symptoms consist of a water-soaked lesion that may have visible fungal growth or, less commonly, a depressed spot (Figures 1, 2). Lesions are initially firm. The leading edge of the infection will remain firm, while the center will eventually become soft and easily punctured. Symptoms can also begin around the stem due to systemic infection from the vine (Figure 3). Fruit can become completely infected and collapse. Fruit symptoms can develop rapidly after harvest. The fungus produces a white to grey mealy, growth that contains many sporangia, especially under moist conditions (Figure 4).

Two diseases that can be confused with Phytophthora fruit rot are Pythium fruit rot (Figure 8), which is characterized by white fluffy growth resembling fine cotton (when new) or shaving cream (when old), and Sclerotinia white mold, which is characterized by white dense cottony growth with black, hard, pea-like structures (Figures 7, 9). Both Pythium and Sclerotinia tend to cause a soft rot.

Figure 7. Sclerotinia infection on a butternut fruit.

Figure 8. The fuzzy white mycelial growth of Pythium can sometimes be mistaken for *Phytophthora capsici.*

Figure 9. Sclerotinia growing on zuchinni. Note the small black nodules, which occur with sclerotinia, but not with *Phytophthora capsici.*

Management

Monitoring

- Scout fields for symptoms on a regular basis, especially after heavy rainfall and in areas of poor drainage. Inspect crowns, stems, and fruit underneath the crop canopy. When symptoms are localized in a small area, disking the area may be worthwhile. Start with a border of healthy plants. This may help to reduce the inoculum and slow the spread of the disease. When the disease occurs on cucurbit fruit, a firm rot with a white to gray mealy growth develops on the surface. The lesions may turn soft in the center as the disease progresses.

Cultural practices

- Avoid planting susceptible crops in Phytophthora infested soil whenever possible. Keep records of infested fields.
- Rotate with corn or small grains. It is possible that other crops or weed plants can act as hosts for the pathogen. The full range of possible hosts for *Phytophthora capsici* is not known. Corn and small grains are likely to be the safest rotation crops.
- In some soils, installation of drainage systems may be warranted. Subsoiling or vertical tillage can increase drainage enough to reduce disease. Subsoil between rows before the crop vines over. Water management is probably the most important tool for minimizing crop losses from this disease.
- Ensure good drainage between raised beds, especially at the end of rows. Remove berms and dig ditches at field edges where necessary to improve drainage out of the field.
- After working in Phytophthora-infested soil, wash soil from equipment at a location that does not put other fields at risk from the run off. Always work in clean fields first. The extra work it takes to keep clean fields from being contaminated is well worth it—once a field is contaminated with *Phytophthora capsici* it may never again be suitable for planting cucurbits or peppers and other susceptible solanaceous crops.
- Plant non-vining cucurbit crops on raised beds at least 6-8” high.
- Never dump culls or diseased fruit from other fields or farms into production fields. Once *Phytophthora capsici* is introduced, it may remain indefinitely.
- Pumpkins with hard, gourd like rinds are reported to be less susceptible to Phytophthora blight than conventional cultivars. Examples are “Lil’ Ironsides”, “Apprentice”, “Iron man”, “Rockafellow”, and “Cannon Ball”.

Sprays

- No fungicide program has been shown to be sufficiently effective to be the sole management strategy for *Phytophthora capsici* diseases; however, when used in conjunction with cultural practices they can be a valuable tool. See the latest recommendations in the *New England Vegetable Management Guide* for some materials that may have some efficacy against *Phytophthora capsici*.

Powdery Mildew

Identification

Figure 1. Powdery mildew developing on leaves, stems, and petioles.

Figure 2. The right side of the leaf is displaying the round, powdery white colonies typical of powdery mildew. On the left are the angular, vein delimited lesions associated with downy mildew.

Figures 3 and 4. Powdery mildew spots coalescing into irregular white patches.

Life Cycle

Powdery mildew is one of the most common diseases in cucurbit crops in the Northeast. All cucurbits are susceptible, but the disease is less common on cucumber and melon due to the prevalence of resistant cultivars. Resistance is also available in pumpkin cultivars. The loss of foliage caused by the disease affects yield by reducing the number and/or size of fruit. Fruit quality can also be adversely affected by sun scald (due to defoliation), incomplete ripening, reduced storability (winter squash), and poor rind quality or discolored handles (pumpkins). In addition, infection by powdery mildew pre-disposes plants to other diseases such as gummy stem blight (black rot).

The primary initial source of this pathogen in the Northeast is believed to be airborne spores originating in southern states, where cucurbit crops are grown earlier in the year. The fungus generally overwinters in the deep South. Since it can not easily overwinter in the Northeast, it makes its way North field by field over the course of the summer, borne on wind currents and carried by storms. Spores remain viable for 7-8 days. The fungi responsible for this disease are obligate parasites and cannot easily survive in the absence of living host plants. There are many different types of powdery mildew, but they are generally very host specific. The powdery mildew you see on phlox, plantains, lilacs, or other landscape plants will not infect your cucurbit crops.

Powdery mildew develops quickly under favorable conditions because the length of time between infection and the appearance of symptoms is only 3-7 days and a large number of spores can be produced in a short time. Favorable conditions include dense plant growth and low light intensity. High relative humidity (RH) is favorable for infection and spore survival, but infection can take place at RH levels as low as 50%—making this one of the few fungal diseases that can develop quickly without free moisture. Dry conditions are actually favorable for colonization, sporulation, and dispersal. Infection can occur at 50-90°F; the ideal temperature range for the disease is 68-80°F. Powdery mildew development is arrested at day-time temperatures of 100°F or higher. Plants in the field are often not affected until after fruit initiation. Symptoms often begin on older leaves.

Symptoms & Signs

White, powdery fungal growth develops on both leaf surfaces, petioles, and stems (Figure 1). It usually develops first on inner leaves, on shaded lower leaves, and on leaf undersurfaces. It begins as circular colonies (Figure 2) that quickly coalesce into irregular white patches (Figures 3, 4). Yellow spots may form on upper leaf surfaces opposite powdery mildew colonies. Infected leaves shrivel and die; plants may senescence prematurely.

Management

Monitoring

- Follow the scouting program detailed in the Scouting & Management section of this book. Look for small (1/4”) white powdery mildew colonies. Older leaves are often affected first. Be sure to check both sides of the leaf. Early crops of zucchini and summer squash often show the first symptoms, and can be indicators of when to scout other vine crops.

Cultural practices

- Following good cultural practices common to all cucurbits will help mitigate the effects of this disease. Initiate fungicide sprays when symptoms are first found in the field.
- Plant resistant varieties where available.
- Separate successive cucurbit plantings physically to prevent older plants from serving as an inoculum source for the newer plantings.

Sprays

- Powdery mildew develops best on the lower leaf surfaces; thus a successful fungicide program requires controlling the pathogen on both leaf surfaces. An important component of fungicide programs are materials which can move to the lower surface (systemic or translaminar). Systemic fungicides, due to their single site mode of action, are prone to resistance development and the powdery mildew fungi have demonstrated the ability to develop resistance to these fungicides. Tank mixing with a protectant may help delay resistance. Please see the Scouting & Management section of this guide for details.
- Sulfur products are probably the most effective option for organic growers. Check with your certifier for current OMRI listed products. Care should be taken as sulfur products can injure plants, especially if applied when temperatures are >90°F.
- Powdery mildew cannot be effectively controlled by fungicides after the disease is established in the field, so early detection is the key to effective management.
- See the *New England Vegetable Management Guide* for specific chemical recommendations (online at www.nevegetable.org).

Downy Mildew

Identification

Figure 1. Downy mildew on the underside of a leaf. Note how the lesions are delimited by the leaf veins. On dewy mornings a light, purplish fuzz of spores may be visible.

Figure 2. Downy mildew on the upper surface of a leaf. Affected tissue in pumpkin can be more orange than yellow. These lesions will quickly become dry and necrotic.

Figure 3. Cucurbit planting decimated by downy mildew. Petioles often remain green and upright after the leaf has died.

Life Cycle

The source of this disease in Northeast is windblown sporangia from the southern United States where host plants survive the cold season. The spores are carried up the coast from field to field by storms and wind and fall with the rain. Generally, downy mildew of cucurbits does not arrive in southern New England until September. However, in some seasons it can move up the eastern seaboard early and arrive in July. In recent years it has also been overwintering in greenhouses in Ontario, Canada and making its way southeast toward our region, attacking us on two fronts. The progress of downy mildew is tracked by the North American Plant Disease Forecast Center and warnings are issued based on where the disease has been found and how expected weather patterns are likely to disperse the spores (www.cdm.ipmpipe.org). Spread of downy mildew within a field can be by air currents, rain splash, workers, and tools. The spread and development of downy mildew is favored by cool to warm (not hot) temperatures, wet conditions and high humidity. A period of six continuous hours of leaf wetness allows downy mildew to become established in a crop.

Host specialization occurs in this pathogen, and at least five pathotypes have been described. A pathotype is a particular strain that attacks only certain varieties of the host crop. Cucumber and netted melon are susceptible to all strains, while squash and watermelon vary in their reactions. This explains why cucumber and certain melons are sometimes heavily infested, while nearby watermelon, squash, or pumpkin are not affected.

Symptoms & Signs

Leaf spots and blights are the primary symptom of this disease. Lesions are generally angular, as pathogen growth is restricted by leaf veins (Figure1). Initially spots are pale green, then yellow before the tissue dies (Figure 2). Affected tissue in pumpkin can be more orange than yellow. On watermelons, yellow leaf spots may be angular or non-angular, and they will later turn brown to black in color. Also, on watermelons an exaggerated upward leaf curling may occur. Often several spots occur together in a coalesced group. On the leaf underside, spots typically appear water-soaked before a downy growth of gray to purplish sporangia is evident. In contrast with powdery mildew, sporangia of the downy mildew fungus are darker (purplish gray) and develop only on the underside of leaves. Extensive defoliation can occur quickly when conditions are favorable leaving the field looking as if it had been hit by frost. Leaf petioles often remain green and upright after the leaf blade has died and drooped (Figure 3). Sporangia are not always present and symptoms can vary greatly, making diagnosis difficult. The most effective fungicides for downy mildew may not be very effective against other cucurbit diseases—and vice-versa—so proper identification is essential.

Management

Monitoring

- The progress of downy mildew epidemics can be monitored online at www.cdm.ipmpipe.org and is reported in the University of Massachusetts Vegetable Notes Newsletter. These reports can be used to better time scouting and the inclusion of downy mildew specific fungicides into your spray program. The level of risk to cucurbits in our area is assessed based on the proximity of confirmed infections and the expected weather conditions. For an interpretation of the forecasted risk levels, see the downy mildew forecast website (http://cdm.ipmpipe.org/).

- Start scouting when the forecast indicates that our area is at risk. Follow the program outlined in the Scouting & Management section of this guide. Examine upper and lower leaf surface. Look for small angular lesions as described in the Sypmtoms & Signs section above. If you think you have downy mildew in your field, please contact the UMass Plant Disease Diagnostic Lab for confirmation. This diagnosis will help you and other growers know whether or not downy mildew has arrived in your region. Proper diagnosis of this disease is of particular importance because the most effective chemicals for downy mildew may not be effective against other cucurbit diseases.

Cultural practices

- Use resistant cucumber varieties. There are low levels of resistance in some varieties of melons and watermelons.

Sprays

- A contact fungicide can be used alone when the forecasted risk of downy mildew is moderate and before downy mildew has been found in the area. By the time downy mildew arrives in the Northeast, you may already be applying a contact fungicide to control other diseases. Systemic and single mode of action fungicides specific for downy mildew should be reserved for when risk is high or when the disease has been reported in your area or found in your field.
- Copper-based fungicides have traditionally been recommended for suppressing downy mildew in organic production systems. Caution is advised, however, as copper can be phytotoxic to cucurbits. Crop damage appears to be most common during periods of cool wet weather—precisely the conditions in which downy mildew thrives. As a result, it is suggested that the most dilute application recommended for each product be followed. Check with your certifier for allowable formulations.

Plectosporium Blight

Identification

Figure 1. Plectosporium lesions on cucurbit petioles. Note the distinctive elongated lens shape of the lesions. This is a distinctive symptom of Plectosporium.

Figures 2 and 3. *Plectosporium* lesions on zucchini vines and petioles.

Figure 4. Plectosporium lesions on a pumpkin handle. Note the rounder shape of the lesions compared to the angular, lens shaped lesions found on the vines and petioles.

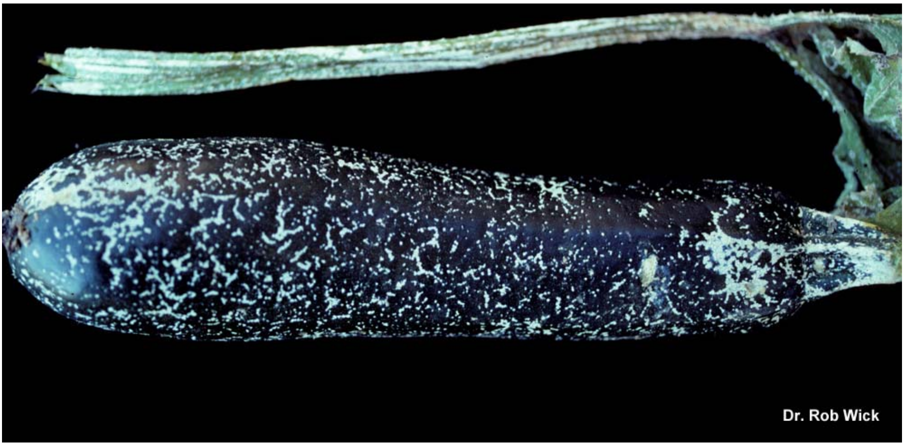

Figure 5. Zucchini fruit disfigured by Plectosporium. On zucchini fruit, Plectosporium blight can occasionally resemble scab.

Figure 6. Pumpkin fruit disfigured by Plectosporium. Note the roundness of the lesions on fruit in comparison to the angular, lens shaped lesions found on the vines and petioles.

Life Cycle

Plectosporium blight *(Plectosporium tabacinum)* is known to cause damage to a wide variety of cucurbit crops in Europe and Asia. In the United States, the disease seems to primarily damage pumpkins, summer squash, zucchini and a few varieties of gourds. The optimum temperature for spore germination is about 77°F. In wet years, which favor disease development and spread, crop losses in no-spray and low-spray fields can range from 50 to100%. Fortunately, this disease is easily recognized and can be effectively managed with chemical controls.

Plectosporium blight is favored by cool, rainy weather. Plectosporium has not been reported to be seed-borne. Tiny spores are formed in lesions on vines, stems, fruit, leaves and leaf petioles. Spores are dispersed by wind over long distances and by rain splash within fields.

Symptoms & Signs

Lesions are small (<1/4 inch) and white. On vines, petioles and leaf veins, the lesions tend to be diamond to lens-shaped (Figures 1, 2, 3). Fruit lesions are usually round (Figures 4, 5, 6). On fruit, *P. tabacinum* causes white, tan, or silver russeting which can merge to form a continuous dry, scabby surface that renders the fruit unmarketable (Figures 5, 6). Fruit lesions also allow for entry of soft rot pathogens that hasten the destruction of the crop. The lesions increase in number and coalesce until most of the vines and leaf petioles turn white and the foliage dies (Figures 2, 3). Severely infected pumpkin vines become brittle and will shatter if stepped on. Early in the infection cycle, foliage tends to collapse in a circular pattern before damage becomes more universal throughout the field. These circular patterns can be easily detected when viewing an infected field from a distance.

Management

Monitoring

- The disease will most likely begin in areas of the field where plants remain wet for longer periods of time, such as low or shaded areas. Scout these areas first.
- Make sure to examine the vines, petioles, and stems as well as leaves and fruit when scouting the field. Look for the distinctive lens shaped lesions that are typical of Plectosporium. Note that on fruit the lesions can be more round or irregular. Scab can occasionally look similar to Plectosporium on zucchini and summer squash.

Cultural practices

- When Plectosporium blight occurs, rotate away from summer squash, zucchini, and pumpkins for two years.
- Choose sunny, well drained sites for cucurbit production.
- Promptly incorporate diseased plant residue after harvest to hasten decomposition and reduce inoculum.
- No pumpkin or summer squash varieties are known to be resistant to the disease, although differences in susceptibility do occur. The pumpkin varieties Sorcerer, Gold Standard and sugar pumpkins seem to be less susceptible than other varieties grown in the same fields.

Sprays

- Plectosporium is generally controlled by the same materials used for powdery mildew. If Plectosporium blight is found in the field before powdery mildew, use a contact fungicide that is effective against Plectosporium. See the *New England Vegetable Management Guide* www.nevegetable.org for current recommendations.

Black Rot

Identification

Figure 1. Symptoms of black rot on various cucurbit fruit. While the lesions vary considerably from fruit to fruit, they are often characterized by a pattern of irregular concentric rings.

Figure 3. Leaf symptoms can begin as a marginal necrosis followed by larger wedge shaped necrotic areas, often with a yellow halo.

Figure 4. Stem Cankers may produce a brown, gummy exudate. Stems may be girdled on seedlings, killing the plant. On older plants stem cankers lead to wilt and decline.

Life Cycle

Black Rot is the fruit rot phase of the fungal disease gummy stem blight. In the Northeastern United States, the disease occurs mainly on winter squash, pumpkin, and greenhouse cucumber. The pathogen, *Didymella bryoniae*, is both seed and soil-borne. It may be carried in or on seed. In the field, the fungus can survive in infected plant residue for more than one year. Disease development is favored by relative humidity over 85% and leaf wetness periods greater than one hour. The optimum temperature for disease development is 75-77°F. Leaves are penetrated directly by the fungus, stems are infected through wounds or the expansion of leaf lesions, and fruit are infected through flower scars or wounds or possibly through direct contact with the soil when conditions are favorable. On fruit held for fall sales or winter storage, a water-soaked lesion develops, usually associated with an injury to the rind, and soon black rot develops. Large Halloween pumpkins are more susceptible to black rot than smaller pie types.

Wounding, striped cucumber beetle injury, aphid feeding, and powdery mildew all predispose plants to black rot infection. Control of powdery mildew by chemicals or by planting resistant varieties can significantly reduce black rot in pumpkins and winter squash.

Symptoms & Signs

Symptoms vary on different cucurbits. On pumpkin and winter squash, symptoms on the leaves begin as a marginal necrosis followed by larger, wedge shaped necrotic areas, often with a yellow halo (Figure 3). Stem cankers develop in the cortical tissue and a brown, gummy exudate is produced (Figure 4). Small fruiting bodies may appear as black specks in diseased tissue. Stems may be girdled on seedlings, killing the plant. On older plants stem cankers lead to wilt and decline. Small, water-soaked spots develop on fruit, enlarge, exude gummy material and contain many black speck-like fruiting bodies (Figure 1).

Monitoring

- Check fruit weekly for signs of black rot.

Cultural practices

- Powdery mildew tolerant cultivars should be selected and powdery mildew should be controlled, as this disease predisposes the crop to black rot.
- Control cucumber beetles and aphids as these insects can increase the severity of black rot in your crop.
- Use certified disease-free seed for all cucurbit plantings.
- Rotate out of cucurbits for two years. Fields in the second or third year of winter squash or pumpkin often develop black rot.
- Crop debris should be plowed under promptly after harvest.
- Reduced tillage systems with cover crop residue on the soil surface may improve fruit quality.
- Cure pumpkin and squash at 85°F for two weeks before storage. An empty greenhouse may work well for this.
- Avoid chilling injury to winter squash and pumpkins, which is a cumulative effect from temperatures below 50°F. Store fruit at 50° to 55°F and ~60% relative humidity. For winter squash in long-term storage, pay special attention to storage temperatures when outdoor temperatures drop in December and January. Chilling injury activate dormant black rot lesions and increase losses in storage.

Sprays

- Satisfactory control of black rot can usually be obtained by regular applications of protectant fungicides, which are generally applied as part of a powdery mildew spray program. In early crops or non-rotated fields you may want to apply a protectant alone before the onset of powdery mildew.

Scab

Identification

Figure 1. On leaves, symptoms consist of gray to brown lesions with a yellow halo that may become shot-holed in appearance. Numerous lesions may cause leaf twisting and deformation.

Figures 2 and 3. Fruit lesions at first resemble insect stings and appear as small, sunken, gray areas. Dark green sporulation may occur in the lesions. A sticky substance may ooze from infected tissue and secondary decay organisms may invade.

Life Cycle

Scab, caused by *Cladosporium cucumerinum* can be a significant problem for summer and winter squash, pumpkin, melon, and watermelon. Resistant cultivars of cucumber are widely available. The fungus can infect all above ground portions of the plant, but is most serious when it occurs on fruit. Scab is favored by fog, heavy dew, light rains, and cool temperatures. The disease begins when spores land on plant parts and invade by direct penetration of the plant tissue or through natural openings and wounds. Lesions develop quickly after infection and new spores are produced about 24 hours later. Cool (at or below 70°F), wet weather is highly favorable for disease development. Spores can be moved locally by contaminated equipment, workers, and insects; and can travel long distances in moist air. The pathogen can survive between susceptible crops in and on infested crop debris, and in the soil as a weak saprophyte. It may also be seed-borne.

Symptoms & Signs

On leaves, symptoms consist of gray to brown lesions with a yellow halo that may become shot-holed in appearance (Figure 1). Numerous lesions may cause leaf twisting and deformation. Fruit lesions at first resemble insect stings and appear as small, sunken, gray areas (Figures 2, 3). Dark green sporulation may occur in the lesions. A sticky substance may ooze from infected tissue and secondary decay organisms may invade.

Management

Monitoring

- Follow the scouting program outlined in the Scouting & Management section of this guide. Look for both fruit and leaf symptoms.

Cultural practices

- Rotate with non-cucurbit crops for 2-3 years.
- Plant in sunny locations where cool air does not tend to accumulate.
- Orienting rows parallel to the prevailing wind direction can also help to reduce periods of leaf wetness.
- Avoid overhead irrigation and dense plant canopies.

Sprays

- Protectant fungicides are recommended for control. Fungicide sprays may not be effective during extended cool, wet weather due to the short disease cycle of this pathogen.

Anthracnose

Identification

Figure 1. Anthracnose leaf lesions start as small pale yellow, water-soaked areas that emerge near veins and enlarge rapidly, turning tan to dark brown. The spots may coalesce, resulting in blighting, distortion, and death of entire leaves.

Figure 2. The dry, dead centers of old lesions often crack and tear, giving a ragged appearance to the foliage.

Figure 3. Older fruit develop circular, noticeably sunken, dark-green to black lesions which may exhibit a salmon colored exudate in moist weather. Infected fruit may have a bitter or off taste and deteriorate quickly when invaded by secondary, soft-rotting organisms.

Life Cycle

Anthracnose of cucumbers, caused by *Colletotrichum orbiculare*, is a serious disease of cucurbit crops during warm, rainy summers. Lesions can form on seedlings, leaves, petioles, stems, and fruits. The pathogen affects cucumbers, melon, squash, watermelon, and pumpkins. *C. orbiculare* is both seed and soil-borne and can cause losses when control measures are not practiced. *C. orbiculare* survives between crops in infected crop debris, in volunteer plants, or in weeds of the cucurbit family. It can be carried on seed harvested from infected fruit and spread by the feeding of cucumber beetles. Frequent rains, warm temperatures (74-78°F), and high humidity favor the development of anthracnose. The fungus does not require a wound for infection to occur and is spread by splashing water, workers, and tools. There are different strains or races of the fungus that differ in their ability to infect cucurbit genera, species, and cultivars. Races 1 and 3 primarily infect cucumber and melons, while race 2 occurs mainly on watermelon.

Symptoms & Signs

Symptoms on seedlings when the fungus is seed-borne occur as wilt of cotyledons and stem lesions near the soil line. On leaves, small pale yellow, water-soaked areas emerge near veins and enlarge rapidly, becoming tan to dark brown (Figure 1). The spots may coalesce, resulting in blighting, distortion, and death of entire leaves. The dry, dead centers of old lesions often crack and tear, giving a ragged appearance to the foliage (Figure 2). Lesions on petioles and stems are elongate and slightly sunken. Young fruit may turn black and die if their pedicels are infected, while older fruit develop circular, noticeably sunken, dark-green to black lesions which may exhibit a salmon colored exudate in moist weather (Figure 3). Infected fruit may have a bitter or off taste and deteriorate quickly when invaded by secondary, soft-rotting organisms.

Management

Monitoring

- Follow the scouting program outlines in the Scouting & Management section of this guide. Look for both fruit and leaf symptoms. Leaf symptoms have been confused with downy mildew, so proper identification is critical.

Cultural practices

- Plant only certified disease-free seed.
- Rotate out of cucurbits for at least one year.
- Control weeds, especially volunteer cucurbits.
- Collect and burn or plow down deeply all infected crop debris after harvest.
- Grow cultivars with resistance to the common races of anthracnose.
- Avoid wounding fruit during harvest. Immerse fruit in clean and fresh water containing a labeled chlorine-based disinfectant.

Sprays

- Chemical control can be obtained through a regular spray program of systemic and/or contact fungicides. Coverage of leaf undersides and fruit is crucial to success.

Bacterial Wilt

Identification

Figure 1. Leaf showing symptoms of bacterial wilt.

Figure 2. Early stages of bacterial wilt, affecting only a few isolated leaves.

Figure 3. An entire plant suffering from wilt caused by *Erwinia trachephilia*, the causal organism of bacterial wilt. This plant will soon die.

Figure 4. Bacterial wilt is almost invariably fatal.

Figure 5. Cross section of a stem infected with *Erwinia tracheliphila*. Note the viscous white bacterial exudate oozing from the vascular tissues (red circles).

Life Cycle

Bacterial wilt *(Erwinia tracheiphila)* is a serious disease of cucumbers and muskmelons and is becoming more of a concern on other cucurbit crops. In recent years, we have seen increasing incidence of bacterial wilt in squash and pumpkins. Once a plant is infected, the pathogen lives within the vascular system of the plant, clogging the trachea and leading to wilt and death of the plant (Figures 1 to 4). Because this bacterium is transmitted by the cucumber beetle, copper sprays are of no value. The pathogen does not survive on seed or in the soil, but may overwinter within the insect vector. Plants are infected when the beetles feed, and are most susceptible up to the four or five leaf stage. The only way to protect your crop from this disease is to manage the striped cucumber beetles early in the season.

Using a perimeter trap cropping system (PTC) can drastically reduce the amount of insecticide used to control striped cucumber beetles. The system involves planting a perimeter of Blue Hubbard, buttercup, or other *Cucurbita maxima* squash around butternut, pumpkin, summer squash, zucchini, or cucumber, encircling it like castle walls. When the striped cucumber beetles colonize vine crops from overwintering sites outside the field, they hit the *C. maximas* first. They like *C. maxima* squash much more than they like the other types of squash, so they pile up in the border for a while instead of spreading out through the main crop as they normally would. This creates a window of opportunity to kill the beetles in the border before they get into the main crop. Treating just the borders reduces feeding damage and bacterial wilt transmission, and drastically reduces the amount of spray needed for control. Treating the *C. maxima* squash in the border with a systemic insecticide at planting makes this system very simple to implement. Note that some giant and specialty pumpkins are actually *C. maxima spp*.; ask your seed sales representative if you are not certain. For more information on using a PTC system, see www.umassvegetable.org and go to the pumpkins or squash section in the crops area.

Figure 6. Butternut field surrounded by a perimeter of Blue Hubbard squash.

Symptoms & Signs

Initial symptoms of bacterial wilt consist of wilting of a few to several leaves (Figures 1, 2), individual runners or stems (Figure 2), or throughout a plant's foliage (Figure 3). Wilting foliage becomes dark green, then yellows and dies (Figure 3). In advanced stages of the disease, entire plants collapse and die (Figure 4). Fruit infections can occur and appear as small, irregular water-soaked lesions. Wilt is most severe in young, succulent plants.

Management

Monitoring

- Follow the scouting program outlines in the Scouting & Management section of this guide. If the average number of beetles per plant exceeds one beetle per plant before the plants reach the five true leaf stage, treatment is warranted. If using a PTC system that relies on a foliar treatment in the border, begin a spray program in the perimeter at the first sign of beetles and follow the above recommendations for the main crop.

Cultural practices

- Rotate cucurbits to reduce beetle numbers.
- Use a PTC system, rogue infected plants (in small plantings).
- Use spun-bonded row covers to exclude beetles.

Sprays

- Manage cucumber beetles to prevent losses from bacterial wilt as well as from direct feeding damage. The most susceptible period is from crop emergence to the four true leaf stage. There are no effective sprays once the bacteria is within the plant. The only way to manage this disease is by managing the beetle vector early in the growing season.

Angular & Bacterial Leaf Spot

Identification

Figure 1. Angular leaf spot damage. Note how the lesions are limited by secondary veins.

Figure 2. Leaves tattered by angular leaf spot damage. Note the yellow margins around lesions in the leaf on the left.

Figure 3. Angular leaf spot lesions on pumpkin fruit. While ALS fruit infections are uncommon in the Northeast, these lesions can penetrate deeply, causing an internal rot.

Figure 4. Fruit damage caused by bacterial leaf spot. Fruit damage from this disease can be severe.

Life Cycle

Cucurbits are subject to both angular leaf spot (*Pseudomonas syringae pv. lachrymans*) and bacterial leaf spot (*Xanthomonas campestris pv. cucurbitae*). Angular leaf spot and bacterial leaf spot are diseases of the foliage and fruit; their symptoms are similar and easily confused with each other and with those of downy mildew. Bacterial leaf spot of cucurbits does not infect other crop families.

Angular leaf spot (ALS) is generally only a problem under warm and wet conditions. Symptoms of bacterial leaf spot (BLS) appear similar to those of ALS and the disease occurs sporadically on squash, cucumbers, gourds and pumpkins. Bacterial leaf spot can potentially affect the fruit more seriously than ALS, but is rarely a problem in the Northeast.

Both ALS (*P. syringae pv. lachrymans*) and BLS (*X. campestris pv. cucurbitae*) are seed-borne and can cause cotyledon spot. The bacterium that causes ALS survives in infected crop residue and in dry leaves for up to three years. Very little is known about the biology of BLS of cucurbits. Attempts to isolate it from the soil have been unsuccessful. It can be seed-borne and spread between plants once it is established in the field. Both bacterium are spread within the field by splashing rain, windblown sand containing infested debris, insects, humans, and equipment. Spread is enhanced when the foliage is wet from rain, dew, or irrigation. Neither foliage disease is normally a serious threat to cucurbit production in the Northeast.

Symptoms & Signs

Angular leaf spot symptoms first appear as small, water-soaked lesions which expand until they are limited by secondary veins, often accompanied by a clear to milky exudate (Figure 1). Lesions dry, turn brown, and may fall out giving leaves a tattered appearance. Lesions may also be surrounded by yellow margins (Figure 2). The bacteria can also infect petioles, stems, and fruit and the exudate may be present here. Fruit lesions can penetrate deeply causing an internal rot allowing the invasion of secondary soft rot organisms (Figure 3).

Symptoms of bacterial leaf spot appear similar to those of ALS. Fruit lesions vary in size and appearance depending on rind maturity and the presence of moisture. Initial small, slightly sunken, beige lesions with a dark, brown halo can expand, become sunken, and cause the cuticle and epidermis to crack (Figure 4). Fruit rot in the field or in storage may be significant. Both of these diseases can only be confirmed in the laboratory.

Management

Monitoring

- Follow the scouting program outlined in the beginning of this book.
- If you suspect you have either of these diseases, pay careful attention to the fruit. If they display symptoms of BLS, you should get a diagnosis and current control recommendation from the Plant Disease Diagnostic lab, as this disease can be severe on fruit under favorable conditions.

Cultural practices

- The most effective method for control is planting certified, disease-free seed.
- Crop rotation is also helpful.

Sprays

- Application of copper compounds in the early stages of fruit development may reduce symptoms.
- Copper applications after these diseases are well established are largely ineffective.
- Some varieties of pumpkin may be sensitive to copper applications—test on a few plants before spraying the field.

Viruses

Identification

Figure 1. Deformity and mottling of summer squash fruit due to viral infection.

Figure 2. Color Breaking caused by zucchini yellow mosaic virus.

Figure 3. Leaf mottling caused by zucchini yellow mosaic virus.

Figure 4. Leaf mosaic caused by zucchini yellow mosaic virus.

Figure 5. Leaf blistering and deformity.

Life Cycle

Cucurbits are susceptible to five major virus diseases: Cucumber mosaic virus (CMV); watermelon mosaic Virus (WMV); papaya ringspot virus (PRSV); zucchini yellow mosaic virus (ZYMV); and squash mosaic virus (SqMV). ZYMV and SqMV seldom occur in the Northeast. The most susceptible cucurbits are summer squash (yellow, zucchini, and scallop types), pumpkin, and winter squash (acorn, delicata, and spaghetti types). Winter squashes such as butternut, Blue Hubbard, buttercup, and kabocha are not severely affected by viruses, though their foliage may show symptoms. Cucumber is resistant to CMV and not seriously affected by the other viruses. Severity of infection is determined by the timing of infection; the earlier infection occurs, the greater the impact on plant growth, fruit symptoms, and fruit set. Delaying the onset of infection by several weeks can have a dramatic effect on the amount of damage. Virus diseases are not usually seed-borne and migrant aphids (winged forms) are therefore responsible for the introduction of all but SqMV which is vectored by cucumber beetles. All of these viruses are transmitted in a non-persistent manner; there is just enough virus on the stylet to infect one or two plants. Aphids can infect a plant quickly; insecticides DO NOT act quickly enough to prevent infection or control the spread of non-persistent viruses.

Aphids pick up viruses by merely probing (tasting) an infected leaf. This happens rapidly—within seconds or minutes. A dormant period is not required and the aphid can immediately transmit the virus by probing another plant. Aphids remain infective for a short time, usually just a few hours.

Winged aphids stop on many types of plants and probe to determine if the plant is the "right one" for them—if it is their host plant. If it does not "taste right", they will fly away. During the few seconds in which it tastes the plant, any viruses that it is carrying can be acquired. No insecticide works fast enough to prevent subsequent transmission.

Systemic materials are generally the most effective insecticides available for aphid control, but they still do not help to deter the spread of viruses in our region. Systemic insecticides are taken into the plant and become present in the plant juices. Aphids feed by sucking juices from the plant, and when they do so they also ingest some of the insecticide. However, when probing a leaf an aphid is not feeding and does not ingest plant juices or insecticide. In fact, the presence of an insecticide may actually stimulate probing and cause aphids to move from plant to plant in an effort to find a suitable feeding site. This can increase the spread of viruses in cucurbit crops.

Symptoms & Signs

Curcurbit viruses can cause a wide variety of symptoms, including color breaking or mottling of fruit (Figures 1 and 2), mosaic or mottled patterns on leaves (Figures 2 and 3), and darkening, distortion, and/or blistering of leaf tissue (Figures 4 and 5).

Management

Monitoring

- Once a virus becomes visible in your crop there is very little that can be done.

Cultural practices

- Where possible, do not grow ornamental plants and vegetable transplants in the same greenhouse.
- Plant resistant cultivars. Currently, virus resistance exists only in summer squash and zucchini varieties, but resistance can slow the spread of virus diseases in squash and to nearby pumpkin fields.
- Cover the crop with floating row covers in the spring to prevent the early influx of virus carrying aphids. Be careful with this tactic, as aphid populations can develop quickly under row cover if there are aphids present when the crop is covered. Make sure plants are not already infested before you apply row cover.
- Reflective mulches can repel aphids; though expensive, they may be useful if virus is a chronic problem.
- Eliminate weed host reservoirs such as shepherds purse, field bindweed, dandelion, purple dead nettle, and Canadian goldenrod.
- Prunus species (peaches, cherries, etc.) are attractive to green peach aphids. Removal of wild prunus such as wild cherry trees from around fields can make the area less attractive to green peach aphids. The green peach aphid is not the only aphid that transmits viruses, but it is important because it is a universal vector.

Abiotic Disorders

Identification

Figure 1. Blossom end rot on summer squash fruit.

Figure 2. 2, 4-D injury on watermellon leaves.

Figure 3. 2, 4-D injury on watermellon vine.

Figure 4. Sevin injury on leaf.

Figure 5. Ozone damage on leaf.

Figure 6. Sunburn on pumpkin.

Disorders

Abiotic disorders include any physiological disorder not caused by a living or infectious agent (i.e., fungi, bacteria, insects, or viruses). It is important to be able to tell the difference between abiotic disorders and true diseases because while the symptoms may sometimes appear similar, the management tactics are completely different.

Poor pollination: Cucurbit crops are dependent on insects for pollination. There are a number of native pollinators that can do the job, but often these native bees need to be supplemented by managed honey bee hives. Honey bees have been on the decline in recent years due to mites, disease, and Colony Collapse Disorder. Recent research has indicated that cucurbit crops in the Northeast are generally well pollinated, receiving services from both native pollinators and honey bees, but there are conditions under which crops may suffer from a lack of pollination. Poor pollination can occur due to the attractiveness of other flowering plants, cloudy overcast conditions that deter bees from flying, an imbalance of male and female flowers, and winter injury to hives. Even if insects are doing a good job of pollinating the flowers, excessively cold or hot temperatures can disrupt pollination in the flower. Always remove row covers at flowering to provide access for pollinators.

Blossom end rot: Blossom end rot is associated with a calcium deficiency, though it does not necessarily indicate that your soil is low in calcium. The plant takes up calcium with the water it gets from the soil. Anything that disrupts the plants ability to take up water—and therefore calcium—can cause blossom end rot. This includes fluctuations in moisture, excessive salts in the soil, cultivation too close to the plant, even excessive rain that smothers the fine root hairs. Blossom end rot will differ from most other diseases in that the rot will consistently start at the blossom end of the fruit.

Herbicide and chemical injury: Herbicide and chemical injury can result from a number of different situations such as soil residues of herbicides from applications in previous crops, spray drift, mistakes in application rates, improper herbicide choice, excessive rain or irrigation moving the material too close to the emerging seed, or improper timing of application. Some cucurbit herbicides (including halosulfuron, clomazone, and sethoxydim) can cause crop injury even when applied at labeled rates, though often plants recover with no effect on yield. Copper has also been know to cause phytotoxicity in some varieties of pumpkin. Some insecticides or fungicides may also cause phytotoxicity when used at excessive rates or improperly tank mixed. See the *New England Vegetable Management Guide* (www.nevegetable.org)for more details. Herbicide and chemical injury can be hard to diagnose—nutrient deficiencies, salinity, drought, insect damage, disease, and nematode injury can all produce symptoms that can be mistaken for herbicide damage. When in doubt, send a sample to the disease diagnostic lab.

Air pollution injury: When environmental conditions are right, air pollution injury may occur on cucurbits. The most common air pollution injury results from excess ozone. Ozone is produced by the action of sunlight on exhaust fumes, most commonly exhaust from vehicles. Ozone concentrations high enough to cause injury are generally only produced in high-traffic environments, but weather patterns can disperse the ozone many miles away from where it was originally generated. If the plants are not too badly damaged they will recover from the injury.

Sunscald: Sunscald occurs when there is insufficient leaf cover to protect tender fruit from the sun, and typically occurs on winter squash and pumpkin later in the season. Sunscald can mar the skin of the fruit, making it unmarketable, and can cause rot in the affected area.

Symptoms & Signs

Poor pollination: Misshapen or deformed fruit, aborted fruit or, poor fruit set.

Blossom end rot: Usually first apparent when the fruit is one-third to one-half full size. Symptoms appear only at the blossom end of the fruit. Initially a small, water-soaked spot appears, which enlarges and darkens rapidly as the fruits develop. The spot may enlarge until it covers as much as one-third to one-half of the entire fruit surface, or the spot may remain small and superficial. Large lesions soon dry out and become flattened, black, and leathery in appearance and texture (Figure 1).

Herbicide and chemical injury: Symptoms vary with the type of herbicide or chemical, can include yellowing, mottling, or bleaching of foliage, deformation and distortion of plant tissue, and stunted growth (Figures 2, 3, 4).

Air pollution injury: Leaves affected by ozone initially have a yellow netted appearance due to loss of chlorophyll between the veins. These yellow areas later turn brown or bronzed (Figure 5).

Sunscald: Papery white areas on the side of the fruit that is exposed to direct sunlight appear (Figure 6).

Management

Poor pollination: To improve pollination, do not apply foliar insecticides when bees are active, and choose pesticides that are less toxic to bees (see Table 1). Use of Perimeter Trap Crop Systems may help to reduce the threat to pollinators. Place beehives near cucurbit fields if poor pollination is a consistent problem. Contact local or state beekeepers associations to find beekeepers who provide hives.

Blossom end rot: Preventing blossom end rot can be done by first making sure that your soil has adequate calcium levels, and that the calcium/magnesium levels are not out of balance. Magnesium and calcium can compete for uptake in a plant, so an excess of magnesium could prevent the plant from taking up calcium. Excessive salts in the soil—possibly from fertilizer residue—can also prevent the plant from taking up adequate water. After making sure adequate levels of calcium exist and are available for uptake, irrigation may be necessary if conditions are dry.

Herbicide and chemical injury: Always read and follow label directions. Use correct rates and apply only as recommended. Calibrate your sprayer before applying any herbicide or chemical. Do not mix two chemicals together unless they are compatible. If chemicals are combined, be sure they are mixed thoroughly in the sprayer before spraying. Never spray when it is windy. Keep spray boom or nozzles close to the ground and spray only the targeted area. When applying herbicides containing 2,4-D, use only the amine or the low volatile formulations and spray when air temperatures are below 80°F. Do not apply soil-active herbicides where water run-off could carry the chemical to non-target plants.

Sunscald: Good vine growth and leaf coverage should be maintained throughout the season to prevent sunscald. Proper fertilization, protecting leaves from fungal diseases that cause defoliation, and proper irrigation are ways to promote good vine health.

Bee Toxicity Value	Insecticide
Low	**kaolin (Surround WP):** Group 25. Suppression/repellence only. OMRI listed.
Medium	**pyrethrin (PyGanic EC5.0)** Group 3A. OMRI listed.
Medium	**Acetamiprid (Assail 30 SG)** Group 4. Toxic to bees when exposed to direct treatment, apply when bees are not active.
Medium	**pyrethrins + piperonyl butoxide (Pyrenone):** Group 3A.
Medium	**endosulfan (Thionex* 50W)** Group 2A.
High	**bifenthrin (Capture* 2EC)** Group 3A.
High	**deltamethrin (Decis* 1.5EC)** Group 3A.
High	**cyfluthrin (Baythroid*2)** Group 3A.
High	**esfenvalerate (Asana* XL)** Group 3A.
High	**imidacloprid (Admire 2F)** Group 4.
High	**imidacloprid (Admire Pro)** Group 4.
High	**thiamethoxam (Platinum)** Group 4. CT and MA only.
High	**Methomyl (Lannate SP)** Group 1A.
High	**Lambda-cyhalothrin (Warrior)** Group 3A.
High	**oxydemeton-methyl (MSR*)** Group 1B. DO NOT apply more than once per season.
High	**carbaryl (Sevin XLR Plus)** Group 1A. Very toxic to bees; do not apply during blossom time, apply in the evening.
High	**permethrin (Pounce*)** Group 3A.
High	**Zeta-cypermethrin (Mustang)** Group 3A.

Table 1: Bee toxicity values for insecticides commonly used in cucurbit crops. Based on information from the New England Vegetable Management Guide.