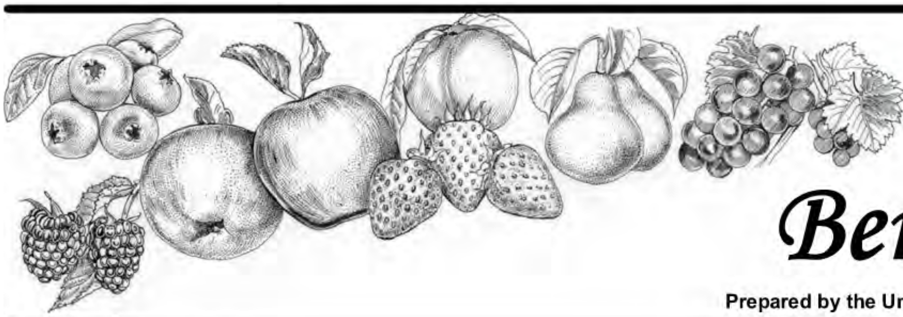

UMassAmherst EXTENSION

Berry Notes

Prepared by the University of Massachusetts Fruit Team

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IN THIS ISSUE:

Current Conditions:

Strawberry flower trusses are emerging from the crown. Row-covered fields are in early bloom. Once bloom begins, row-covers must be removed in order for pollination to occur. All fields should have irrigation in place for frost protection during bloom. See more in this issue on frost protection. Bloom is the most important period for controlling gray mold. Begin scouting for clipper and tarnished plant bug as we approach bloom. New fields are being planted. **Raspberry** leaves are expanded and flower buds are visible. Fall raspberry new cane growth is about 6". Watch for raspberry fruitworm feeding on new leaves. **Blueberries** are in full bloom. No reports of frost damage so far but we're not out of the woods yet. Sublethal damage may predispose tissue to fungal infections, especially mummyberry. In this case pay particular attention to your fungicide programs and make sure to use correct rates and get excellent coverage. **Mummyberry** is active at this time. See information on this in the last issue. Botrytis gray mold can also infect blossoms at this time. See more below. Be ready for pollination with adequate numbers of bee hives. The first fertilizer application should be made now and the second in about a month. Pre-emergent herbicides may still be applied, though it is getting late for this. **Grapes** buds have burst and leaves are unfolding in some varieties. Some varieties have flower clusters visible. Fungicide applications now for controlling early infections of Phomopsis are critical. Scout fields for Flea beetles damage. Fertilizer may be applied now as well as pre-emergent herbicides. **Currants and Gooseberries** are at or past bloom and showing excellent fruit set.

ENVIRONMENTAL DATA

The following growing-degree-day (GDD) and precipitation data was collected for a one-week period, April 29, 2009 through May 5 2009. Soil temperature and phenological indicators were observed on May 6, 2008. Accumulated GDDs represent the heating units above a 50° F baseline temperature collected via our instruments from the beginning of the current calendar year. This information is intended for use as a guide for monitoring the developmental stages of pests in your location and planning management strategies accordingly.

Region/Location	2009 GROWING DEGREE DAYS		Soil Temp (°F at 4" depth)	Precipitation (1-Week Gain)
	1-Week Gain	*Total accumulation for 2009*		
Cape Cod	37	132	58˚F	0.75"
Southeast	54	157	55˚F	0.30"
East	69	156	60˚F	0.06"
Metro West (Waltham)	--	--	--	--
Metro West (Hopkinton)	60	172	58˚F	0.25"
Central	58	134	45˚F	0.03"
Pioneer Valley	50	188	52˚F	0.18"
Berkshires	56	181	58˚F	0.29”
AVERAGE	59	160	55˚F	0.26"

(***Source****: UMass Extension 2009 Landscape Message #10, May 8, 2009*) *-- = information not available*

STRAWBERRY

Irrigation For Frost Protection Of Strawberries

Pam Fisher and Rebecca Shortt – Ontario Ministry of Agriculture Food and Rural Affairs

Summary

- Frost injury can cause significant damage to strawberry plants, especially open bloom, but also to unopened buds if it is cold enough.
- Strawberry fields are often colder at ground level than the weather forecast suggests.
- Irrigation for frost protection works because heat is released as water freezes.
- Irrigation rates must be adjusted to account for evaporative cooling due to winds and relative humidity. More water is required on windy nights.
- Failure to apply enough water can result in greater damage than no irrigation at all.
- When to start up the irrigation is critical. Two tools can determine the optimum time for starting frost protection: dew point, and wet bulb temperatures. Use the dew point and table 5 to determine the temperature at which to start irrigation. Alternatively measure the wet bulb temperature; irrigation should start before the wet bulb temperature reaches the critical temperature (table 1).
- Dew point is also useful in predicting the lowest expected temperature, and how quickly the temperature will drop.
- In general, the start temperature for frost protection is higher when the humidity is low; the start temperature for frost protection is lower when the humidity is high.
- Where row covers are used, irrigation can take place over the cover. Information on temperatures under the cover can be determined by using digital thermometers and thermocouples.

Introduction

There's nothing colder than a strawberry field on a frosty spring night. Strawberry plants bravely bloom in early spring, often before the last frost. The blooms are close to the ground, and the ground, covered with straw, doesn't provide much heat. That's why many strawberry growers pull a few all-nighters each spring to run the irrigation system and use a thermodynamic principle to protect their crop from frost injury.

This paper will describe types of frost, frost injury, and how irrigation can be used to protect strawberry plants from frost injury.

Symptoms of Frost Injury

Frost occurs when the temperature around the plant drops below 0°C (32°F). At this temperature, pure water forms ice crystals on surfaces which have fallen below the freezing point of water.

Plant sap is not pure water; therefore strawberries have a lower freezing point than 0°C (32°F). When the critical temperature (Table 1) is reached, crystals form and damage cell membranes allowing cell fluids to leak out.

Frost can kill flowers outright, or injure them enough to cause misshapen berries. When a flower is injured by cold, the pistils are killed first. If killed after pollination, then embryos do not develop. A seedy spot on the berry forms, with hollow seeds. Sometimes fruit cracks at the bottom. Leaves can also be injured by the frost, especially when they are growing vigorously and very tender. The edges or tips of leaves blacken, and then dry out.

Figure 1: Frost-injured strawberry bloom

Figure 2: Misshapen berries resulting from blooms which are partially damaged by frost

Figure 3: Frost injury on strawberry leaves

Frost usually damages the biggest and earliest bloom. This represents the best and most lucrative part of the berry crop, because prices are highest at the beginning of the season. Further, the first flowers to open produce the largest fruit. If 5 percent to 7 percent of the flowers are lost, and these flowers are mostly king bloom, the total crop will be reduced by 10 to 15 percent.

Critical Temperatures for Frost Injury

Bloom and flower parts are most susceptible to freezing temperatures.

Table 1. Critical temperatures of strawberries based on stage of development (Perry and Poling, 1985)

Stage of Development	Approximate Critical Temp. °C (˚F)
Tight bud	-5.5 (22˚F)
"Popcorn"	-2.2 (26˚F)
Open blossom	-1.1 (30˚F)
Fruit	-2.2 (28˚F)

These temperatures are tissue temperatures, and a degree or two lower than the critical air temperature in the plant canopy. There are many variables that affect the actual critical temperature for a given plant and the amount of injury.

- Duration of cold
- Growing conditions prior to the cold event
- Cultivars: (because of plant habit, or avoidance, rather than genetic differences)
- Stage of development
- Super cooling (in the absence of ice nucleation points, plant sap can cool below the freezing point without forming ice crystals)
- Soil type and condition (moist dark soil holds more heat than dry light soil)

Understanding Heat Transfer

Cold conditions occur when heat is lost. Cold can not be added, only heat can be removed.

Heat can be transferred by:

- **Conduction**: transfer of energy within an object or system. Metal is a good conductor, water is a good conductor, but air is a poor conductor of heat. Ice is a good conductor.
- **Convection**: Transfer of heat by movement and mixing of liquid or gas. Most air is warmed by convection.
- **Radiation**: Is the transfer of energy through free space without a transporting medium. We receive energy from the sun by radiation. Objects on earth also radiate energy back to space.

- **Changes in state**: When water molecules change state, from gas to liquid to ice, heat is released. This potential energy is called latent heat. It is not measured by a thermometer, until it is released by a change in state of the water.

When water condenses, cools or freezes, the temperature around the water rises as latent heat is released. Water changing to ice on the surface of a plant will add heat to that plant. Conversely, when ice melts, or water evaporates, the temperature around the water is cooled, as heat moves to the water. Water evaporating from the surface of a plant will draw heat from that plant.

Table 2. Heat exchange due to changes in state: Positive signs indicate the water is cooling or freezing and air is warming. Negative signs indicate water is warming or evaporating and air is cooling

Change in state	Heat exchange (calories/gram)
Water freezes at 0°C (32°F)	+79.7
Water evaporates at 0°C (32°F)	-597.3
Water condenses at 0°C (32°F)	+597.3

Energy Budgets

During the day, the sun warms the soil and solid objects, i.e. crops. When these objects become warmer than the air, they pass heat to the air by conduction. This warm air is less dense, and rises, and is replaced by cooler air from above. This mixing of air is how the lower atmosphere is warmed. Normally, air near the surface of the earth is warmer than the air above it. Crops also radiate heat to outer space. Some of this energy is reflected back to the earth by clouds and $C0_2$ in the atmosphere.

At night, there is no incoming radiation from the sun. If the atmosphere is clear, there is little heat reflected back to earth. The soil and crops continue to radiate energy out to space. Temperatures drop near the earth's surface, forming a layer of air that is colder at the bottom and warmer at the top. If a wind or breeze is present, the warm air and cooler air are mixed. But on a still night, especially when the air is dry, the air temperature at ground level is coolest, and the temperature increases with height up to a certain level. Because this situation is the opposite of normal daytime conditions, the term inversion is used to describe these conditions.

Objects can radiate heat faster than the air around them. Frost can form on the roof of a building or the hood of a car when air temperatures are still a degree or two above zero. Strawberry blooms can also radiate heat quite quickly on a clear night.

Important Facts about Weather

Although the terms "frost" and "freeze" are used interchangeably, they describe two distinct types of cold events.

An advective, or windborne freeze, occurs when a cold air mass moves into the area, and brings freezing temperatures. Significant wind occurs as the cold front moves in. the thickness of the cold air layer is 500-5000 feet deep. It is difficult to protect crops from frost injury when these conditions occur.

A radiation frost, occurs when a clear sky and calm winds allow an inversion to develop and temperature near the surface of the earth drop below freezing. The thickness of the cold air inversion is 30-200 feet (with warm air above).

Table 3. Characteristics of a radiation frost and an advective freeze

Radiation frost	Advective freeze
Calm winds (less than 5 mph)	Winds above 5 mph
Clear skies	Clouds may exist
Cold air 30-200 feet deep	Cold air mass 500-5000 feet deep
Inversion develops: air next to the ground is cooler than air above it.	Protection success limited
Cold air drainage occurs	-
Successful frost protection likely	-

Microclimate monitoring

Air temperatures referred to in weather reports and forecasts are measured 5 feet above the ground. Temperatures can be much colder at ground level and even colder in the low parts of the field. Cloud cover and wind speeds are also important factors to consider when determining the risk of frost.

Use max/min thermometers to monitor the low temperatures in your fields. Compare these to the forecast lows. In cloudy breezy weather, forecast lows are likely to be similar to the observed low in a region. On clear calm nights, especially in a strawberry field, the observed low can be much lower than the forecasted low.

You can also use max/min thermometers to compare the temperatures at several locations on your farm on a given night. After several observations you will know just how much colder each field is compared to your back yard. A frost alarm can be installed in a convenient location if you know how much colder it gets in the field.

Factors affecting the risk of frost

Cold air is heavier than warm air, and it sinks and flows across a field like water. It also piles up where obstructions block its flow to a lower area. Road banks, hedge rows, berms are examples of obstructions to cold air flow. Cold air will drain from elevated areas, to lower storage areas, such as a large body of water. Strawberry fields on sloping fields, or in generally elevated areas, are less prone to frost damage. Be aware of frost pockets within the field.

Remove obstructions at the lower end of the field to improve air drainage. Windbreaks should be designed to slow the wind, not block all air movement. To allow air drainage through a windbreak about 50% air space at the bottom of the windbreak is recommended.

Soil moisture and compaction can have a significant effect on temperature. A moist compact soil will store more heat than a loose dry soil and therefore has more heat to transfer to the crop at night. Cultivation just before a frost can increase the risk of injury, because the soil is looser and drier after cultivation. Soil under a grassy cover crop will hold more heat if the grass is mowed short.

Irrigation for Frost Protection

Most growers rely on sprinkler irrigation for frost protection. When water from sprinklers turns to ice, the heat released protects the plant from injury. As long as a thin layer of water is present, on the bloom or on the ice, the blossom is protected. (This is important. It's not the layer of ice that provides the protection. It's the water constantly freezing that keeps the temperature above the critical point.)

System specifications

- Make sure the sprinkler irrigation system has the capacity to irrigate the whole field at one time.
- Use sprinkler heads designed for frost protection. These have low output nozzles, made of metal rather than plastic, and the spring is covered to prevent freeze-up. Sprinkler rotation should be rapid, at least 1 revolution per minute. The back nozzle should be plugged (Figure 4).
- Spacing of risers should not exceed 30-60% (depending on wind conditions) of the area wetted by each sprinkler. Generally an off-set pattern provides more uniform coverage than a square or rectangle, but this really depends on the nozzle and sprinkler you are using. The Center for Irrigation Technology has developed a program called SPACE, which predicts the distribution of water from the sprinklers, and calculates the efficiency of different designs. Tools like this are used by irrigation supply specialists who can help design your system.
- Traditional spacing is 60' by 60', not as many sprinklers required, but it takes longer for sprinklers to cover area. In areas where many advective freezes occur, with winds, a spacing of 30' x 30' is recommended.
- Need enough water on hand to irrigate for several nights in a row.

For example: For 1 acre, you need about 60 gallons per minute, to irrigate 0.125 inch/acre/hr. This is 3600 gallons per hour. If irrigation is required for 10 hours, you need 36000 gallons per night. Plan to irrigate for several nights in a row.

Figure 4: Sprinkler used for frost protection with back nozzle plugged

How much water to apply

The amount of water applied per hour is based on the amount of wind and the temperature (Table 4). Higher water application rates are required on windy nights, or when humidity is low because considerably more energy is removed when a gram of water evaporates than is added when a gram of water freezes (Table 2). A rate of 0.1 inch/hour is considered adequate to protect to -4.4°C (24°F) with no wind. When the water is frozen on the plant the ice should be clear, which indicates that there was enough water applied. If the ice is cloudy or milky white, the water application rate is not fast enough to protect the flower (Figure 5). In this case you can increase the water application rate by reducing the sprinkler spacing or changing to higher flow rate nozzles. At wind speeds above 16 km/hr or at temperatures below -6.7°C (20°F) sprinkler irrigation can do more harm than good because of rapid freezing.

Figure 5: Strawberry bloom coated in clear ice

When to start irrigation
To successfully use irrigation for frost protection, growers need information about the dew point. Dew point is especially important in determining the irrigation start-up point.

The dew point
The dew point is the temperature at which moisture condenses from the air to form dew. The dew point is related to relative humidity: when the air is humid the dew point occurs at a higher temperature than when the air is dry. Once dew begins to form, the air temperature begins to drop more slowly. When temperatures reach freezing, the dew turns to frost.

Dew points are available from agricultural weather forecasts, e.g.

- Environment Canada - provides current dew points and other current weather conditions, for certain locations
- Farmzone.com - provides forecasted dew points

Table 4. Inches of Water/Acre/Hour to Apply for Protection at Specific Air Temperatures and Wind Speeds (Martsoff and Gerber, Penn State University)

Wind speed at crop height (km/hr)	-2.8°C (27°F) air temperature at canopy	-4.4°C (24°F) air temperature at canopy	-6.7°C (20°F) air temperature at canopy	-7.8°C (18°F) air temperature at canopy
0 - 2	0.10	0.10	0.16	0.20
3 - 6	0.10	0.16	0.30	0.40
7 - 14	0.10	0.30	0.60	0.70
15 - 19	0.10	0.40	0.80	1.00
20 - 35	0.20	0.80	-	-

What is the significance of dew point?
Growers can use dew points to estimate how quickly the temperature might drop in any given night. Once dew begins to form, the air temperature drops more slowly because heat is released. Frequently, the nighttime temperature drops to the dew point, but not much below it. Sometimes the dew point is referred to as the basement temperature.

If the air is dry, then the dew point will be low. If the dew point is below 0°C (32°F), frost forms instead of dew. Black frosts occur when temperatures are below freezing but above the dew point. Don't wait for frost to form before starting the irrigation system (especially when the humidity is low).

Table 5: Suggested starting temperatures for irrigation, based on dew point. The lower the dew point, the sooner you should start to irrigate.

Dew Point	Suggested starting air temperature
-1.1°C (30.2˚F)	0°C (32.0˚F)
-1.7°C (28.9˚F)	0.5°C (32.9˚F)
-2.8°C (26.9˚F)	1.1°C (34.0˚F)
-3.8°C (25.2˚F)	1.6°C (34.9˚F)
-4.4°C (24.1˚F)	2.7°C (36.9˚F)
-5.5°C (22.1˚F)	3.3°C (37.9˚F)
-6.7°C (19.9˚F)	3.8° C (38.8˚F)
-8.3°C (17.1˚F)	4.4°C (39.9˚F)

Wet bulb temperature
Sometimes the term wet bulb temperature is used to determine when to start up irrigation systems. The wet bulb temperature represents the temperatures a wet

surface will cool to as the water evaporates. A wet bulb thermometer is covered with clean muslin soaked in distilled water. Air is passed over the bulb; the water evaporates, reducing the temperature around the thermometer.

If wet bulb temperatures are available, these can be used directly to determine when irrigation should begin, and when the system can be shut off. Start irrigation just before the wet bulb temperature reaches the critical temperature (Table 1).

When to stop irrigation
Irrigation can be stopped when ice on the plants begins to melt, usually after sunrise. Monitor carefully to make sure that the ice continues to melt and the temperature remains above freezing. Changes in wind speed could change temperatures near the plant surface. Irrigation should be started up again if water begins to freeze.

Ice does not have to be completely melted. The plant temperature will warm up as the sun rays hit the field. When the ice can be sloughed off the plant, you know that plant temperatures are above freezing and the water next to the pant has started to melt. At this point, you can turn off the irrigation water, usually around 7:30 or 8 am.

The best way to know when to turn off the irrigation is to monitor plant tissue temperatures beneath the ice. Digital thermometers, attached to thermocouples inserted into the plant tissue can indicate when plant temperatures begin to warm up above the critical temperature.

Negative side effects
One negative side effect of irrigation for frost protection is increased potential for disease outbreaks. Angular leaf spot is a bacterial disease that is spread by splashing rain or irrigation, and seems to get established in frosty conditions. Anthracnose, which can cause fruit rot, generally likes warm humid weather. However, even during cool periods, it will spread by water splashing on the plants and, after establishing itself, it will thrive when warm weather arrives (Figure 6).

Root rots, such as red stele, thrive in saturated soil conditions. Outbreaks of red stele and other root rots have occurred after long periods if irrigation for frost protection. The sites most suited for frost protection by irrigation are well drained sites with sand or sandy loam soils.

Figure 6a: Angular leaf spot

Figure 6b: Anthracnose fruit rot

Figures 6a, 6b: Splashing water can spread diseases like angular leaf spot and anthracnose fruit rot

Figure 7a: Standing water and water-saturated soil in a strawberry field

Figure 7b: Water-saturated soils favour root diseases such as red stele.

Disease and fungus can be limited by reducing the water applied. Water volumes can be reduced by:

- Low application rates / nozzles
- Stopping when ice begins to melt, not when all the ice is melted.
- Monitor the weather to irrigate only when needed.
- Using row covers. This can delay the start up time for irrigation by several hours.

Row Covers

Row covers reduce evaporative cooling and the rate of cooling under the cover. According to vendor's information, the heavier weight covers (1.5-2 oz/yd^2) can protect 4-6 degrees, but this varies both with the weight and between manufacturers. They do buy time on a frosty night.

When frost protecting with irrigation and row covers, you need to know plant temperature under the cover. Start when temperatures under the cover drop to 0.6 - 1.1°C. Irrigate right over the cover. Stop when plant temperatures start to climb. Digital thermometers attached to thermocouples, inserted in the flower buds before the frost event, are necessary for successful protection with covers.

Research suggests that 2 layers of 1 oz cover provide more protection than 1 layer of 2 oz material. Research on the use of low impact sprinklers, i.e. mini-wobblers, is in progress. These sprinklers, widely used in the ornamental industry, wet a smaller diameter, use lower pressures, and are less prone to freezing. By using irrigation and row covers it may be possible to frost protect in adverse conditions.

Related Links

- Environment Canada
- Farmzone.com
- Frost/Freeze Protection for Horticultural Crops,North Carolina State University Horticulture Information, Leaflet 705
- Rainbird Agricultural Irrigation - Technical resources, specifications
- Center for Irrigation Technology Technical resources, SPACE program
- Biometeorology Program, Atmospheric Science, University of California - web site with tables, theory, course on biometeorology
- Berry agent, North Carolina State University

(***Source**: OMAFRA Factsheets at: www.omafra.gov.on.ca/english/crops/facts/frosprot_straw.htm*)

RASPBERRY

Bramble Disease Control

Janna Beckerman, Purdue University

Raspberries are beginning to show new growth. Delayed dormant applications of lime sulfur should only be made before buds are 1/2” long for control of many bramble diseases, including cane blight, spur blight and anthracnose. Unless cane blight, anthracnose or spur blight have been problems, fungicide applications prior to bloom are usually not required. This is especially true if the delayed dormant application of limesulfur has been made. Unfortunately, if you didn’t make an application of lime sulfur, pruning out disease tissue is one of the only options available until 6-12” of growth, or bloom. At bloom, the captan/fenhexamid mixture (Captevate 68WDG) is labeled for control of anthracnose and spur blight on raspberries. Only 2 sequential applications of this product may be used before switching to a different group of fungicide chemistry. The strobilurins, which include azoxystrobin (Abound), pyraclostrobin (Cabrio EG and a pyraclostrobin/boscalid mixture (Pristine WG) should be used at disease onset. Pay careful attention to label restrictions for these products. Like Captevate, no more than 2 sequential applications of these products may be made before switching to an alternate chemistry.

A word to the wise on fungicide resistance development; Elevate, Rovral, Switch, and Pristine should not be used alone for seasonlong control of Botrytis fruit rot due to the high risk of fungicide resistance developing to each fungicide. The addition (tank mix) of Captan to Elevate (or the pre-mix CaptEvate), Rovral, Switch, or Pristine should provide a higher level of disease control and aid in preventing fungicide resistance development. Rotating the use of these fungicides in one-two-spray blocks is a good resistance management strategy. Keep in mind that because brambles are a relatively small market share for fungicide companies, fewer fungicides are available for use. For this reason, it is imperative to maximize the efficacy and to carefully rotate and/or tank mix fungicides to minimize the risk fungicide resistance development. (***Source***: *Facts for Fancy Fruit, Vol. 8, No. 3, April 2008*)

BLUEBERRY

Blueberry Fruit Diseases

Cathy Heidenreich, Cornell Cooperative Extension

Botrytis Blossom and Twig Blight and Fruit Rot of Blueberry: Botrytis (gray mold) infects young shoots (twigs) and blossoms, leaves, and fruit. Infected twigs turn brown to black and later bleach to tan or gray. Twig infections by this fungus are frequently mistaken as winter injury. Gray mold overwinters in debris or as black sclerotia on twigs. This disease occurs most often after several days of rainy or foggy weather.

Management: Cultural practices that improve air movement in the canopy such as annual pruning and removal of old canes and twiggy wood to increase air circulation. Avoid excessive application of spring nitrogen. Effective fungicides applied during bloom.

Blueberry anthracnose: This fungus overwinters in remnants of old fruiting twigs and infected canes. In spring and summer, fruiting bodies release spores which are dispersed by rain and infect flowers, fruit and other tissues. On twigs, dark brown lesions may originate from infected buds and kill part of the twig. On the leaves, lesions look reddish brown with distinct borders. Flower and green fruit infections may occur at any time, but are often are not apparent until after berries ripen. Anthracnose occurs primarily during warm, wet seasons most often after several days of rainy or foggy weather.

Management: Plant resistant cultivars. Create an open canopy to reduce humidity and increase spray penetration. Prune out old or infected wood. Limit overhead irrigation. Harvest in a timely manner. Cool fruit rapidly after harvest. Apply effective fungicides from pink bud to harvest.

Blueberry cane diseases

Phomopsis canker: New shoots wilt and die back from tip to crown. Wood and pith become discolored. Mature canes suddenly wilt and collapse during summer. Suspect this disease if single canes die while the rest of the plant remains healthy.

Fusicoccum canker: Small, water-soaked lesions develop on green stems in the fall. These expand into sharply delineated, reddish brown cankers during the following spring and summer. Cankers usually center on a leaf scar, are 1 to 10 cm in length, and have a bull's-eye pattern. Most cankers are near ground level, but some occur as high as 3 feet above the ground. Cankers enlarge each year until they girdle and kill the stem. Wilted leaves remain attached. Small, black fruiting bodies of the fungus may be found in cankers.

Botryosphaeria canker: A vascular disease starting from a wound site. Early symptoms are small red lesions on succulent stems. Lesions become swollen and broadly conical in about 6 months. On susceptible cultivars, large, swollen cankers develop, with deep cracks and numerous fruiting bodies, after 2 to 3 years. Stems may be girdled and killed. Flagging of infected stems (do not drop leaves) occurs during warm summer months. Look for light-brown discoloration of stems when cut.

Canker management: Cultural practices are more effective than chemical management for these diseases. These practices include: minimizing winter and early spring frost injury, avoiding mechanical damage, using drip irrigation to minimize drought stress, pruning out and burning cankered twigs and canes as they appear, removing all brown tissue below the canker, managing fertilizer to avoid formation of succulent shoots late in the season. Dormant applications of elemental sulfur or copper may help reduce inoculum.

Crown gall: A soil-borne bacterial disease infecting the plant vascular system. Galls are most commonly found at the base of canes or near the soil line. Infected plants may appear stunted or weak. Foliage may discolor prematurely in summer.

Management: Because this is a systemic disease, pruning out galls will not prevent further spread. Remove and burn infected plants where possible. Minimize wounding. If infected plants are allowed to remain, sterilize pruners (10-20% bleach solution) between pruning cuts to prevent spread between plants.

To prevent disease introduction plant disease-free nursery stock in non-infested soils. Grow grasses or vegetables in infested fields for at least 2 to 3 years before replanting. Dip new plants in a suspension of the biological control product *A. radiobacter* strain K84 before planting in soils with known infestations of this bacterium.

Witches' Broom: Diseased plants have broom-like masses of swollen, spongy shoots with short inter-nodes and small leaves. Young stems on the brooms are initially yellow or reddish, but later become brown and shiny, and, eventually, dry and cracked. Heavily infected plants produce no fruit. The brooms can persist for many years, producing infected new growth every year.

Management: Because the pathogen is systemic in the blueberry crown, pruning will not eliminate this disease. Remove fir trees within 500 yards (460 m) of planting. Eradicate infected plants with an herbicide. 'Rancocas' is a resistant cultivar. (***Source****: New York Berry News, Vol. 8, No. 3, April 2009*)

GRAPE

Early Season Sprays for Phomopsis Can Save Your Crop

Tim Weigle, Cornell Cooperative Extension of Suffolk County

Recent research at the Fredonia Vineyard Lab by Wayne Wilcox, Department of Plant Pathology, NYSAES, Geneva shows that an application of a material for Phomopsis will significantly reduce rachis infections. Wayne found that without the early (3- to 5-inches of shoot growth) spray aimed at Phomopsis the shoulders of clusters were missing resulting in significant crop loss. This early timing also is key for protection against shoot infections which are a source of inoculum for years to come as they are found mainly on the first three internodes and are difficult to remove during pruning.

With the limited amount of green tissue that you are shooting for at 3- to 6-inches of shoot growth you can adjust your sprayer to put the application just in the zone where green tissue is present. With top wire cordon training systems this can dramatically reduce the amount of water per acre that is needed to get good coverage. Remember not to be fooled when you see the spray appear to go four rows over. It is quite common for growers to go every other row this early in the season, as there is not much leaf tissue to intercept the spray but do you really know if you are getting the coverage that you need? Take the time to calibrate your sprayer whenever you change the amount of water per acre, the amount of air used or the area that is being sprayed (reducing nozzles for example).

Every sprayer is different so take the time to determine how effective your sprayer is by using water sensitive spray cards in the canopy of rows directly adjacent to the sprayer and one two and three rows over. You may be surprised at how quickly the coverage becomes commercially unacceptable. With the costs of spray material going up it is even more important to ensure that it is getting where you want it to be. Figure 1. To the left is a Concord cluster with a missing shoulder due to early season Phomopsis infection / Figure 2. To the right is a Concord cluster with the shoulder intact. (***Source****: Lake Erie Grape Update, 5/7/2009*)

GENERAL INFORMATION

Biological Fungicides and Batericides; Using Fungi and Bacteria for Disease Management

Steve Bogash, Penn State University

Direct application of beneficial fungi and/or bacteria to soil, potting media, and plant foliage is a relatively recent practice which is rapidly catching on with producers. The methods and philosophy of using biofungicides such as Actinovate AG and Plant Shield are distinct from our past practices of starting with "sterile" media and fighting to keep it clean. We've typically fought the plant disease wars through the application of various chemical fungicides in rotation as we attempt to slow the development of resistance.

Standard chemical fungicides fall into two main categories: protectant and systemic. Protectant materials such as chlorthalonil (Bravo, Daconil, and many other trade names) provide fungal disease protection by creating a chemical barrier to disease penetration. Systemic materials such as Azoxystrobin (Quadris, Heritage, and other trade names) move into plant tissue to provide disease management from within. Protectants cannot manage a disease once it has infected a plant; however, systemic materials will provide a measure of "clean-up" disease control activity. The mindset of relying completely on non-biological materials assumes that growers take a long series of "fall back" positions as there are always new strains of disease causing organisms as well as diseases that get missed until our crops have received serious damage.

The application of beneficial organisms (biofungicides) is another tool to add to our arsenal in managing diseases in the greenhouse and field. These materials have unique modes of action (MOA) that can provide levels of disease management not possible with our traditional fungicides. Since these are living organisms, their application requires strict adherence to the labeled application instructions. Often pH, tank mixing, and surfactant instructions are very precise in order to reach reasonable levels of efficacy. Even with these challenges, field experience over the past few years has proven that these biological materials can provide disease management in situations where traditional chemistries have failed to do so. Also, since they are living materials, many of these biological materials have short storage lives and specific storage instructions.

How biological fungicides work

Direct Competition: Before infection can occur, the pathogen must gain access to the root zone then penetrate plant tissue. An effective biofungicide will grow faster than the pathogen and out compete it for nutrients and space.

Antibiosis: Some biological materials produce chemical compounds such as antibiotics and toxins that kill or inhibit pathogen growth. These compounds can prevent germination of fungal spores or restrict growth.

Predation and or Parasitism: Some materials such as Actinovate AG, Plant Shield, and SoilGard 12G claim that their materials actively seek out pathogens and destroy them.

Induced Resistance: While plants do not have immune systems like animals, they do have defense mechanisms. Certain biological controls will induce plants to produce defensive compounds such as salicylic acid (similar to aspirin). Salicylic acid can travel throughout the plant and stimulate the plants own defense mechanisms prior to infection.

All of these biological fungicides require application before the plant becomes infected with a pathogen. Most commonly, a producer will drench transplants or cuttings either just before or during the planting process. Products like SoilGard 12G are incorporated directly into potting media. Those with foliar activity are applied (as a foliar spray) in much the same manner as protectant fungicides such as Chlorthalonil. These living materials colonize the root zone (rhizosphere) and surface of leaves (phylosphere), fruit and flowers. For those growers using fumigants, it is very important to inoculate soil with a beneficial organism immediately after fumigation in order to have the desired organism (biological fungicide) dominates. Most fumigants require a waiting period before planting so that the fumigant can do its' job and move out of the soil or breakdown. Talk to your fumigant supplier's technical support for advice on when to apply a biofungicide after treatment.

This is a different way of thinking about disease management. As we rapidly move from the age of miracle chemicals to solve all of our production challenges further into the era of IPM, these biological materials are a great fit. Many of these materials are OMRI approved. Used properly, they can provide cost effective, proactive disease management when used with other IPM practices. Crop rotation, variety selection, cover cropping, organic matter management, and nutrient management are other parts of our current toolbox.

Current Biological Fungicides and Bactericides

Material	Active Ingredient / Organism	Greenhouse or Field	Labeled diseases controlled	Foliar or Soil Application	Mode of action
Actinovate AG	*Streptomyces lydicus*	Greenhouse & Field	Fusarium, Rhizoctonia, Pythium, Phytophthora, Verticillium….	Foliar and Soil drench	Defensive barrier & parasitism
Companion	*Bacillus subtillus* GB03	Greenhouse only	Rhizoctonia, Pythium, Fusarium, Phytophthora	Soil drench	Defensive barrier and antibiosis
Mycostop	*Streptomyces griseoviridis* K61	Greenhouse and Field	Fusarium, Alternaria, Botrytis, Pythium, Phytophthora & Rhizoctonia	Foliar, soil drench and seed treatment	Defensive barrier and growth enhancer
PlantShield & RootShield	*Trichoderma harzanium* T-22	Greenhouse and Field	Botrytis, Powdery mildew, Pythium, Rhizoctonia, Fusarium, & *Thielaviopsis*	Foliar and soil drench	Defensive barrier, parasitism, & nutrient enhancer
Rhapsody	*Bacillus subtillus* QST 713	Greenhouse, Field, Turf, Interiorscapes, Landscapes, and Forests	Rhizoctonia, Pythium, Fusarium, & Phytophthora…	Foliar, soil drench & post harvest cut flower dip	Defensive barrier (multiple MOA's)

Serenade	*Bacillus subtillus* QST 713	Field: fruits and vegetables	Botrytis, Mildews, Alternaria, Bacterial spot & speck, Rusts…	Foliar	Defensive barrier (multiple MOA's)
SoilGard 12G	*Gladicladium virens* GL-21	Greenhouse, Field, Interiorscapes, & nurseries	Pythium, Rhizoctonia	Soil drench	Defensive barrier, parasitism & Antibiosis

Read and follow label instructions carefully since these materials have specific mixing instructions, varying compatibility with other materials, pH requirements, shelf life and storage conditions. (***Source***: *The Vegetable & Small Fruit Gazette, April 2008, Volume 12, No. 4*)

UPCOMING MEETINGS:

May 13, 2009 *Twilight Meeting for Commercial Fruit Growers*, UNH Woodman Horticultural Research Farm, 70 Spinney Lane, Durham, NH, 5:30 - 8 PM, 603-868-2345

May 19, 2009, *UMass Fruit Team Twilight Meeting*, UMass Cold Spring Orchard, 391 Sabin St., Belchertown MA (www.coldspringorchard.com/)
5:30 PM Farm tour including update on phenology and current pest status in tree fruit and grapes.
6:30 PM Speaking program will include updates of current cultural and integrated pest management practices. This meeting will cover current work high tunnel blackberries as well as an update on apple thinning and other tree fruit topics.
Pesticide-license recertification credit (2 hours) will be offered. You must be there on time to receive pesticide credits. ***$20/person registration fee. Light refreshments will be served.***

May 20,2009, *UMass Fruit Team Twilight Meeting***,** Carlson's Orchard, 115 Oak Hill Rd, Harvard, MA 01451 (http://www.carlsonorchards.com/)
5:30 PM Farm tour including update on phenology and current pest status.
6:30 PM Speaking program will include updates of current cultural and integrated pest management practices.
Pesticide-license recertification credit (2 hours) will be offered at all meetings. You must be there on time to receive pesticide credits.

May 21, 2009, *UMassURI Fruit Team Twilight Meeting***,** Barden Family Orchard, 56 Elmdale Road, North Scituate, RI (http://bardenfamilyorchard.com/)
5:30 PM Farm tour including update on phenology and current pest status.
6:30 PM Speaking program will include updates of current cultural and integrated pest management practices.
Pesticide-license recertification credit (2 hours) will be offered at all meetings. You must be there on time to receive pesticide credits. ***$20/person registration fee. (Except NH meeting.) Light refreshments will be served.***

For more info on the Fruit Team Meetings, go to http://www.umass.edu/fruitadvisor/meetinginfo/april08twilight.pdf .

June 2, 2009, *Massachusetts Farm Wineries & Growers Association Spring/Summer Marketing Conference***,** 9 am – 2 pm, Hopkinton Country Club, 204 Saddle Hill Rd. Hopkinton, MA, $45 MFWGA Members (includes lunch). $60 Non-Members (includes lunch). For more information contact John Comando at 781-559-8061, johnc@needhamgroup.com

July 15, 2009: *Massachusetts Fruit Growers' Association Summer Meeting*, **Tougas Family Farm**, 234 Ball St., Northboro, MA. All are invited but you must pre-register. The registration fee includes the program, lunch, and 2 pesticide recertification credits. Check the UMass Fruit Advisor website (www.umass.edu/fruitadvisor) for details at the date gets closer.