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2013 Fruit Rot Management Special Edition

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Editor's Note: So far this season has been more typical of those routinely observed and recorded in the NY State in seasons past, with cool, wet weather prevailing. These more "typical" conditions, as always, set the stage for potential development of fruit rots. This special fruit rot edition of NY Berry News is both by way of reminder and also of reporting new information about fruit rot monitoring and/or management techniques such as mummy berry observation stations.

Fruit Rots of Berries: A No Frills Approach to Management - *Kerik Cox, Cornell University*

The last few berry crop growing seasons have been characterized by wet (2011) or freezing (2012) weather in the spring followed by a drought period from June to August, and finally a wet period for weather from late July to October. In addition, the implementation of season extension practices can keep ripe fruit on plants much longer than the typical field season. In extended season plantings of berry crops, the potential for fruit loss resulting from fruit rots increases with the proportion of ripe remaining on the plant. Luckily, the presence and time that over ripe fruit remains on berry crops will likely be curtailed by the need to harvest fruit quickly to avoid damage by spotted wing drosophila. Given that fruit rot diseases will be of secondary importance in the face of recently emerging devastating invasive pests, a simple set of guidelines needs to be established for managing berry fruit rots so that small fruit producers can focus the majority their efforts on the pests of critical importance. In these proceedings, I will first present a concise set of guidelines for managing fruit rot and include information on key fungicides and important pathogens in later sections.

The "No Frills Approach"

Regardless of the fruit rot and berry crop, there are a few simple guidelines to follow each season that can minimize or prevent the loss due to fruit rot pathogens. These guidelines include the following:

- Adhere to all proper horticultural crop management practices such as managing weeds and maintaining proper nutrition and irrigation. The proper use of nitrogen and irrigation in the planting is paramount to avoiding fruit rot. Fruit rot fungi are constantly seeking a source of water and free nitrogen and will readily rot fruit if plants are wet and/or over fertilized. Keeping the irrigation restricted to the ground will greatly reduce the risk of fruit rot, especially at harvest. This is why fruit rots rarely occur in covered plantings.

- Practice delayed dormant application guidelines as relevant to the crop of interest.

Fruit Rot Management *(continued)*

Delayed dormant applications are especially important for reducing fungal pathogen inoculum in raspberries and blueberries. Although this practice is specifically pertinent for shoot/cane pathogens, the fruit rot pathogens are endemic in the planting will also be affected by any inoculum reduction practices. Lower levels of initial fungal inoculum will slow fruit rot disease epidemics.

Make a fungicide application at bloom. Select one of the fungicides suggested below that best manages the fruit rot of prime importance for your planting (e.g. *Botrytis* on raspberry). Many of the fruit rot pathogens can infect flowers or even green fruit in the case of anthracnose. Fruit rot pathogens may blight the flowers or, more tragically, cause latent infections (especially anthracnose). In this case, the fungal pathogen infects the flowers and initiates a rot later when the fruit ripens. Such latent infections will result in fruit rot regardless of the fungicide program used later at harvest as no fungicides will be able to reach the fungus protected in the developing fruit. Make sure that the bloom time application is made prior to any rain events as many fungicides work best when use protectively. Finally, bloom time applications further reduce the pathogen inoculum that will be present at harvest and as such will slow the rate at which harvest fruit rot epidemics occur.

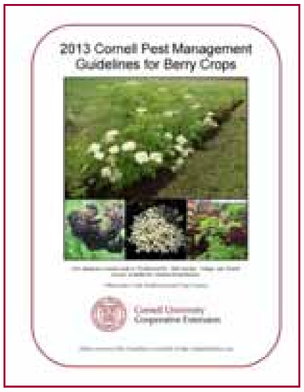
Make 1-2 fungicide applications of one of the fungicides suggested below when fruit100% fruit maturity. Mature fruit are highly susceptible to fruit rot especially if other fruit with sporulating latent infections are present in the planting. An application interval of 14-21 days should be sufficient unless there is more than 2" of accumulated rain and or rotting fruit present in the plantings. In these is instances, you may wish to protect the planting before the next rain. If the planting is in a tunnel or other covered production system, only one pre-harvest application might be warranted to promote shelf life. Many of the fungicides suggested below are safe enough to have DTH of 1 day or 0 days, which allows for considerable flexibility for managing a disease during harvest.

Harvest all mature fruit as quickly as possible and cool them quickly. This practice will help manage all pests and diseases by restricting the buildup of pest numbers or disease inoculum.

Key Fungicides

Numerous fungicides from all major chemistry groups are registered for use on berry crops in New York. However, the number and type of registered fungicides is highly dependent on the economic value of the crop and the prevalence of disease problems. There are several key fungicides that provide excellent control of fruit rots and can be used at or near harvest.

Fungicides are classified by the EPA into one of three categories: conventional, minimum-risk, and biopesticide. The Fungicide Resistance Action Committee (FRAC), an organization committed to prolonging the effectiveness of fungicides, classifies fungicides on the basis of chemistry and mode of action. The following section describes several key fungicide chemistries labeled for berries in New York. Since the goal of this work to simplify management practices, it will primarily focus on site-specific or single-site inhibitor fungicides most of which function in protective and curative modes and



PIMS

Product, Ingredient, and Manufacturer System:

http://pims.psur.cornell.edu/

http://www.omri.org/omri-lists

Berry Diagnostic Tool

http://www.fruit.cornell.edu/berrytool/

Fruit Rot Management (continued)

have low DTH requirements.

Single-site inhibitors

Single-site inhibitor fungicides are generally safer, more expensive, have both protectant and post-infection activity, and have propensity for resistance development due to highly specific modes of action (which makes them safer for the environment and non-targets).

Thiophanate-methyl (thiophanates); FRAC Code: 1; MOA: Cell division, Typical DTH: 1

These fungicides include generics of Topsin-M, which are only labeled for control of gray mold and a few foliar diseases of strawberries. They are effectively benzimidazoles in terms of chemistry, which are high risk for resistance development, especially in *Botrytis*.

Fludioxonil (phenylpyrroles) quinoxyfen (quinolines); FRAC Code: 12 &13; MOA: Cellular signal transduction PLUS
Cyprodinil, pyrimethanil (Anilinopyrimidines); FRAC Code: 9; MOA: Amino acid biosynthesis, DTH: 0

Switch is a formulation of fludioxonil and cyprodinil labeled primarily for *Botrytis* diseases and anthracnose and mummyberry disease of blueberry. A foliar allowed formulation of fludioxonil is a rare registration, which makes Switch a valuable fungicide option for berries. Scala is a formulation of pyrimethanil labeled for use on *Botrytis* fruit rot of strawberry.

Fenhexamid (Hydroxyanilides) & Myclobutanil, Fenbuconazole (Demethylation Inhibitors); FRAC Codes: 17 & 3; MOA: Sterol biosynthesis inhibition, Typical DTH: 0 to day of harvest

Sterol biosynthesis inhibiting (SI) fungicides are considered to be fairly potent fungicides with good post-infection activity. Elevate (Fenhexamid) and CaptEvate (Fenhexamid and Captan) are labeled for numerous blueberry, strawberry, and bramble diseases, particularly anthracnose. Indar 2F is the only demethylation inhibitor (DMI) currently labeled for berries fruit rots and only on blueberries.

Azoxystrobin & Pyraclostrobin (Quinone outside Inhibitors); FRAC Code: 11; MOA: Respiration inhibition, Typical DTH: 0

Quinone outside Inhibitors (QoI) (a.k.a. Strobulurins, Strobys) are newer fungicides and are considered slightly less potent than the SIs, but also have good post-infection activity. Abound (Azoxystrobin) was one of the first QoI fungicides available and is labeled for numerous berry diseases including mummy berry and anthracnose. Cabrio EG (Pyraclostrobin), and Pristine WG {Pyraclostrobin & boscalid (Dicarboximides; FRAC Code 2)} are some of the newest QoI fungicides and are widely labeled for berry diseases in New York. In particular, Cabrio EG is specifically marketed for use on small fruits.

Key Fruit Rot Pathogens

Botrytis blossom blight and fruit rot (Gray mold)

Botrytis blossom blight and fruit rot, caused by the fungus *Botrytis cinerea*, is primarily driven by excessive moisture and free sugars, which are readily abundant in open flowers and ripe fruit. As long as there is sufficient moisture, *Botrytis* can infect and colonize blossoms in fairly cold weather, which makes it potentially devastating for NY small fruit. In addition to favoring cool weather, *Botrytis* thrives in situations of overhead irrigation.

Fruit Rot Management (continued)

Once infection has occurred, the fungus will colonize flower and fruit tissue, which becomes covered in fluffy tan to grey colored masses of mycelium and spores. Underneath, the flower or developing fruit will be shriveled and killed.

At bloom, begin scouting for the signs of *Botrytis* blossom blight in your plantings. If discovered, consider protecting your crop with a fungicide that has activity against *Botrytis*. Applying a fungicide now will protect your crop from blossom infections during this period of cold wet weather, and help keep the level of *Botrytis* inoculum down when fruit comes into maturity. Applying fungicides such as Switch, Scala, Pristine WG, and Elevate will provide excellent protection against Botrytis blossom blight. In addition, all of these materials may have some post infection activity against *Botrytis*.

Anthracnose fruit rot

Strawberries: Anthracnose can manifest itself on strawberries in several forms including crown rots, fruit rots, and leaf spots. Of the species of *Colletotrichum* that attack strawberry, only *C. acutatum* is known to be prevalent in the region and it is not one of the species that causes crown rots. *C. acutatum* blights leaves, petioles, runners, flowers, and most importantly, rots the fruit. On fruit, green or red lesions will start as slightly depressed water-soaked spots that become sunken, larger (>3mm), brown, and finally black. Interestingly, *C. acutatum* needs copious amounts of free moisture and can drain water right out of the fruit, which causes them to become hard and shriveled. The primary sign of this pathogen is the salmon to orange colored ooze (spore masses that typically form in fruit lesions, but can potentially appear in any plant lesion.

Blueberries: Anthracnose on blueberries is also caused by *C. acutatum*. On blueberries, *C. acutatum* may infect flowers, fruit, bud scales, and even blight young shoot tissue if conditions are favorable. Although shoot and bud blights can be devastating to blueberry operations, anthracnose fruit rot is the most commonly encountered form of the disease in NY production operations. Infection occurs when spores produced on infected fruit spurs and buds are dispersed by rain to flowers and developing green fruit. Infection is highly dependent on the availability of free water and may occur at sub optimal temperatures (< 75 °F) if the period of surface wetting is long enough (> 8 hours). Infected flowers can be blighted when inoculum levels are high and the wetting period is long enough. However, blossom and green fruit infections often remain latent until fruit ripening when sugar content is highest. Flowers and fruit with latent infections will appear symptomless, but will begin to rot and become shriveled as the pathogen resumes colonization during ripening. If there is enough free moisture or high relative humidity, orange to salmon-colored spore masses will be produced over the surface of the fruit. The spore masses are composed of countless numbers of spores, which are capable of infecting neighboring berries during rains at harvest and during the sorting and packing process post-harvest. *(Reprinted from: Proceedings 2013 Empire State Producers EXPO berry session, January 22, 2013, Syracuse, NY.)*

Failing Fungicides For Gray Mold Control And What to Do About It - *Guido Schnabel, Clemson University and Frank Louws, North Carolina State University*

Gray mold (Figure 1) is the most important disease of many small fruits, including strawberry and grapes. It is caused by the fungus Botrytis cinerea, which during wet weather and relatively cool temperatures, attacks the flowers and the fruit. To protect the crop from rotting, fungicides must be used during bloom and during preharvest fruit development. In recent years, the efficacy of fungicides has declined dramatically in experimental fields in North Carolina and

Fruit Rot Management *(continued)*

Florida, which signaled for the first time the emergence of a problem. Follow up studies showed that years of exposure to modern fungicides selected for resistance to many fungicides in North Carolina and South Carolina fields rendering many applications ineffective

Figure 1. Gray mold of strawberry

During the 2011/2012 growing season Clemson initiated an evaluation program and received and analyzed gray mold samples from about 80 commercial strawberry farms in 8 states (including Arizona, Florida, Georgia, South Carolina, North Carolina, Kansas, Maryland, and Virginia) and investigated the sensitivity of the causal agent to all 7 chemical classes (FRAC codes 1, 7, 11, 12, 17, 3, and 9) registered for the suppression or control of gray mold (Figure 2).

Sensitivity assays were performed on fungicide - amended media containing specific discriminatory doses of fungicides that allowed the distinction of sensitive from resistant isolates. Discriminatory doses were largely described previously (3), but we made some adjustments due to assay - specific differences. Briefly, spores from 10 fruit per location were collected with cotton swabs (one swab per fruit), shipped to the Clemson lab, transferred with a toothpick to the center of amended medium in 24 - well plates and incubated for 4 days. Growth was assessed visually and growth data were entered in a web application specifically developed for this purpose (2). The web application calculates a resistance factor that determines whether a sample is sensitive, or has low resistance, medium resistance, or high resistance to a certain fungicide. 0 20 40 60 80 100 9 3 17 12 7 11 1 Fields with highly resistant strains (%) FRAC Code 2012 Fungicide Resistance Snapshot from 80 Strawberry Fields in 8 States Scholar Rovral Elevate Scala Endura, Fontelis Abound, Cabrio Topsin M

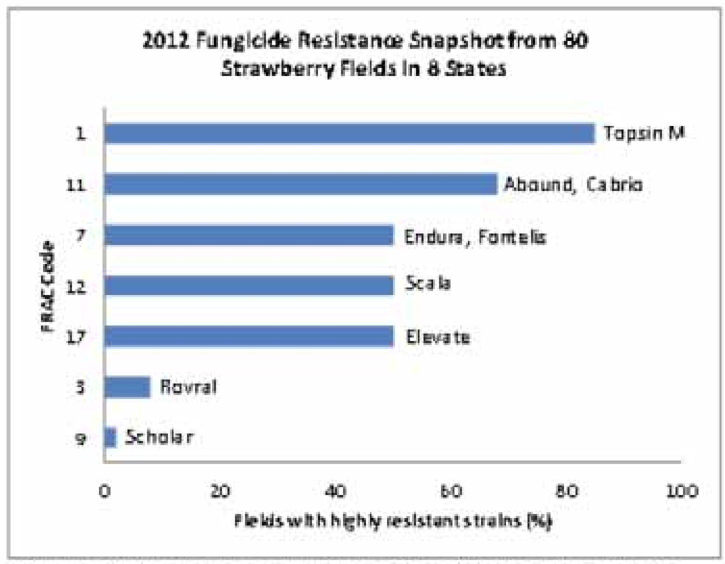


Figure 2. *Average occurrence of resistance in samples from fields of 8 states. A sample was considered 'highly resistant' if at least 20% of the strains were resistant to a fungicide.*

Figure 2. Average occurrence of resistance in samples from fields of 8 states. A sample was considered 'highly resistant' if at least 20% of the strains were resistant to a fungicide.

The monitoring indicated that the gray mold fungus from strawberry in many states had developed resistance to different classes of fungicides. The majority of all samples indicated resistance to Topsin M, Abound, and Cabrio fungicides. The latter two products are not exactly gray mold products, but according to the labels they have 'suppressive action'. To our surprise, about half of all samples revealed resistance to Elevate, Scala, and Endura. All of those products are commonly used for gray mold control. The newly registered Fontelis is listed in the figure together with Endura because these two products are more or less cross resistant. On the flipside, resistance to Rovral and fludioxonil (Scholar formulated product) was either rare or non - existent. Fludioxonil is a component of Switch. The monitoring results indicated that resistance to various fungicides is present in the gray mold fungus, which might be surprising to many growers because pre - and postharvest gray mold has not been a tremendous issue in recent years. T

Fruit Rot Management *(continued)*

There may be several reasons for this apparent discrepancy:

- **inoculum (=infectious forms of the pathogen) levels in plasticulture systems are generally low.** The crop starts with new, mostly disease - free plants on fumigated soil with very little plant debris from the previous season. It likely takes a couple of infection periods for the fungus to gain in numbers for an epidemic.

- **we have had relatively dry springs in recent years making it hard for the fungus to establish**

- **we have far fewer infection periods than previously thought.** Two years of monitoring infection periods in SC has demonstrated that there were only 3 (during dry springs) to 6 (during wetter springs) infection periods per season. That is it. That means a lot of our sprays are applied in the 'off season'. But it only takes a wet spring and the application of ineffective fungicides for gray mold to thrive. Therefore we must implement resistance management practices. Below are some suggestions on how producers can extend the productive life of a chemical class in their operation and save money by spraying smart**.**

- **reduce inoculum levels.** If there is little fungus, there is little problem. Conservative application of nitrogen fertilizer makes plants less susceptible to pathogens in general and allows water to evaporate quicker due to less luscious canopies. Also, increasing plant spacing could be considered for improved air circulation. However, growers should optimize plant spacing for yield and optimum plant spacing depends on soil type among other factors.

- **moderate used of fungicides.** The fewer sprays applied the less selection pressure there is for fungicide resistance. In other words, it is much better to spray only when needed than calendar - based. Applications should be done PRIOR (if possible) or soon after (using fungicides with kick - back action) to anticipated rain events of more than one inch or so of rainfall. Research has shown that the focus of fungicide applications should focus on protecting the strawberry flowers**.**

- **reduce the use of materials that are prone to resistance development.** If growers want to spray prior to bloom, products like thiram and captan should be used exclusively. These products also provide effective control during bloom unless unusually high rainfall is experienced. Rovral is an effective botryticide and can be used once per season before bloom. In our experience, Rovral is the product of choice if growers encounter Botrytis crown rot du e to early wet and warm spring conditions when plants are large. Products like Elevate, Pristine, Switch, should be used only during bloom and only when weather conditions such as extended rain favor disease development.

- **perform sanitation measures.** The majority of the Botrytis inoculum that goes to the flowers is believed to come from dead and dying leaves present in the beds after winter. Removing these leaves before bloom can help reduce the amount of Botrytis in the system. In our experience, sanitation increases yield slightly or has no effect. Many growers perform sanitation as part of their practice to remove weeds from holes, to lift plants from under the plastic and remove dead and dying leaves. If multiple tasks are 10 accomplished in one pass, then the practice may prove economical. However, sanitation does not pay for itself if gray mold management is the only purpose and if effective fungicide programs (if resistance is not a major problem) are implemented. *(Reprinted with permission from: SRSFC Small Fruit News, Vol 13(1), January 2013)*

Mummy Berry for 2013 – *Kerik Cox, Cornell University*

In 2009, there were severe outbreaks of mummy berry disease outbreaks in NY. During the late spring and summer months of 2009, there was considerable rainfall and some fairly long wetting periods. Given the number of blueberry farms devastated by mummy berry in 2009, we were concerned about the high levels of mummy berry inoculum the growers would face in 2010. It turned out that 2010 had a fairly dry spring, and few growers had problems with the disease. The spring of 2011 was characterized by cool temperatures, heavy extended rains, and even flooding. Although the disease went unnoticed in the spring, there many growers who still suffered losses to mummy berry at harvest. The 2012 season was met with early season freezes, a mid-season drought, and a wet early harvest season. Although we (CCE) were only made aware of a single farm with mummy berry, there is still a possibility that mummy berry will cause problems for other farms in the region.

Mummy berry disease is caused by a fungus belonging to a genus responsible for many fruit diseases. Unlike the species

Fruit Rot Management (continued)

causing other fruit diseases, the species of *Monilinia* causing mummy berry disease in blueberries is unique in that it has evolved the ability to mimic flowering, a process that is important to both the plant and the blueberry producer. Fortunately, it is possible to stop the mummy berry fungus from 'mimicking' flowers and tricking bumblebees into perpetuating its devastating life cycle.

The first step in breaking the cycle of infection is to develop an understanding of how it occurs. The process begins with mummy berries present on the orchard floor or in a nearby planting. As early as April in NY, these germinate to form little trumpet shaped mushrooms called apothecia (Fig 1). The apothecia emerge at time when the predominately-affected cultivar at the operation is at green tip.

Fig 1. Apothecia produced on mature mummy berries hidden and protected by ground covering.

These apothecia release ascospores, which are capable of traveling great distances to infect young leaf buds. The blighted leaf buds, referred to as strikes, become transformed by the fungus to appear like a flower to pollinating bumblebees (Fig 2). The fungus causes the tissue to reflect in the UV spectrum in a pattern similar to that of flowers. Moreover, the sporulating tissues on these strikes (Fig 2) produce sweet odorous chemicals that "smell" and "taste" like the floral nectar that bumblebees are seeking during pollination. Bumblebees visit both mummy berry strikes and flowers as they forage, and during this process spores from strikes are transferred like pollen grains to the stigmatic surface of open flowers. These spores germinate like pollen grains and infect the ovaries through the stylar canal. Unlike flowers fertilized by pollen grains, flowers infected by spores from strikes develop into a mummy berry (Fig 3) instead of a blueberry.

Fig 2. Blight leaf tissue "strikes" with powdery grey infective spores that are attractive to bumblebees.

The mummy berry disease cycle can be stopped at two places: the mummy, and the leaf strikes. Because elimination of flowers is not an option for blueberry producers, fungicides are the most logical means of killing mummy berry spores and leaving pollen grains unaffected. Unfortunately, the spring rains can wash off fungicide residues and cause strikes to sporulate with increase abundance. In order to give fungicides a chance, one must try to reduce the numbers of spores available to infect flowers by targeting the mummies and protecting young leaf tissue. In operations that were greatly impacted by mummy berry in 2012 there will simply be too many mummies for fungicides to prevent leaf and subsequent flower infection.

In order reduce the number of mummy berries with apothecia at leaf bud break there are a few options. One option is the use of urea fertilization. This typically involves the application of a high rate of urea (200 lbs/A) to the planting floor to burn apothecia after emergence. This option is high risk because apothecia emerge over a fairly long period and the application would have to be timed just right to affect the majority of the apothecia. An alternative is to try a lower rate (40 lbs/A) application of feed grade urea to the row middles and area under the bush. This should be done before leaf bud break and as soon as you can get the spray equipment into the field. This practice is meant to enhance microbial degrada-

Fruit Rot Management *(continued)*

tion of the mummies instead of burning the apothecia, which is why the application needs to be made as soon as possible in the spring. This practice is quite successful for reducing apple scab inoculum in apple orchards and could promote reduction of mummy berry inoculum as the mummies are quite susceptible to microbial degradation, which is enhanced by available nitrogen.

Fig 3. Developing mummy berries (A, above) cut at 50 to 75% coloring to reveal infection of ovaries, and mature mummy berries (B, below) that have fallen to orchard floor in autumn and overwintered to spring.

Another option is the use of fresh mulch to cover mummy berries and smother emerging apothecia. Applying 2-3 inches of mulch as soon as the snow melts should be sufficient to cover mummies and prevent apothecia from emerging. The mulch helps to increase the distance that emerging apothecia would need to extend to eject spores and limits light exposure, which is needed to stimulate germination of apothecia on mummy berries. If your operation had a serious mummy berry problem in 2012 and you have mulched beds, you may need to remove the existing mulch (despite labor intensity),

Fruit Rot Management (continued)

and re-mulch beds. Once mummy berry becomes established in existing mulch, it is actually a favorable organic matter rich environment for the pathogen. Similar to established mummy berry in mulch beds, moss can be an extremely favorable ecosystem for mummy berries, providing moisture and organic matter. Moreover, moss protects mummy berries from exposure to detrimental environmental conditions and management practices. Although moss can be a nice feature in pick your own blueberry operations it can be a serious problem if mummy berry becomes established. In these instances, the moss should be removed manually by removing the sod on which it is established. There are chemical means of the killing moss, but these means must be repeated on a yearly basis, and often provide limited success. If you decide to remove the sod, it is important mulch over bare soil to ensure than unearthed mummies are covered.

Once the best efforts are made to reduce inoculum, a regular program of fungicides aimed at protecting emerging leaf and flower tissue needs to be implemented. The chemical management program should be started when the first variety is showing ¼" of green tissue on leaf buds, and end when the latest flowering variety is at 50% petal fall. Fungicide applications should be made prior to rain events and re-applied on 10-14 day interval unless the planting receives more than 2" prior to the end of the interval. There are several excellent mummy berry fungicides, but one of the best fungicide programs consists of applying Indar 2F (6 fl oz/A) alternating with Pristine (20 oz/A) or Switch 62.5 WG (14 oz/A). These materials will not only help control mummy berry, but also control the majority of other fungal diseases of blueberry such as anthracnose and *Botrytis*. Previously, Pristine WG had blueberries removed from the label. Fortunately, this registration on blueberries was restored in 2012.

If you previously had mummy berry, you should consider practicing all of the recommended cultural and chemical management practices. If you do not implement the inoculum reduction practices, you can easily overwhelm the ability of your fungicides to control the disease. Even if you do both cultural and chemical management, do not be surprised if the problem is not immediately solved in 2013. Although mummy berry disease appears to become established "out of the blue", it actually becomes slowly established over time. Mummy berry can take several years of proactive management to eliminate. If you did not have mummy berry in previously, it is not necessary to implement the cultural and chemical management practices. However, it will be important to begin scouting for mummy berry strikes around bloom to ensure that mummy berry doesn't surprise you in later seasons.

Preparing and Using Mummy Berry Observation Stations in Blueberries - *Annemiek Schilder, Michigan State University Extension*

Visual monitoring of mummy berry germination and apothecial development in the spring is critical for optimal control of mummy berry in blueberries. Mummy berry observation stations facilitate monitoring.

April 23, 2013. Mummy berry, caused by the fungus *Monilinia vaccinii-corymbosi*, is a common and widespread disease of blueberries in Michigan, particularly in wetter sites and in susceptible cultivars such as Blueray, Bluehaven, Rancocas, Rubel and Jersey. The fungus survives the winter on the ground as small, black, pumpkin-shaped fungal structures (sclerotia) in mummified fruit. These germinate in the spring to form small, trumpet-shaped mushrooms (apothecia) that release ascospores into the air. Ascospores cause primary infections called "shoot strikes" on young blueberry leaves and shoots in the spring.

The disease is notoriously variable from year-to-year. Most of the unpredictability is due to variability in the rate and timing of germination of the mummies, which are greatly influenced by soil moisture and soil temperature over the winter and early spring. The number of mummies overwintering on the ground from the previous season will also determine disease pressure in the current year. A snow cover usually helps protect mummies from desiccation and muffles temperature extremes. While mummies can withstand very cold temperatures, they do need a certain number of chilling hours below 7 degrees Celsius (45 degrees Fahrenheit) before they can germinate. This ensures synchronization of the mummy berry pathogen and its blueberry host. However, with sufficient soil moisture and warm spring temperatures, the fungus may be early in relation to the blueberry plant, whereas a dry, cold start of the spring may delay mummy berry germination. In that case, rains in April and May can result in later flushes of apothecia.

Fruit Rot Management (continued)

Infection of young blueberry shoots in the spring is directly correlated with the number of apothecia on the ground below blueberry bushes. Since 2012 was a dry year with relatively low mummy berry pressure, there are not as many overwintering mummies to be found this year, making observation even more difficult at this time. In order to facilitate spring monitoring of mummies that are well-camouflaged due to their brown color, small size and growth underneath leaf litter, it is helpful to set up mummy berry observation stations or “nurseries” in fields with a history of the disease. These stations will help you determine the percentage germination, the size of the apothecia as they develop (the larger they are, the more ascospores are released and the higher the infection risk), and when the apothecia collapse or dry up, ending the primary infection period. A hard frost at ground level may also injure apothecia, reducing their capacity to produce spores.

For optimal management of mummy berry, Michigan State University Extension advises each grower to monitor mummy berry germination on his or her own farm as germination and disease pressure tend to be site-specific. A mummy berry observation station consists of a small concentrated area of mummified berries in one or more locations on a farm. Multiple locations will help cover variability in soil type and moisture. Having the mummies concentrated in known locations will make it easier to find them and monitor them in the spring. If you are concerned about having a concentrated area of mummies in your field, don’t worry; you can spray the bushes in this area a little extra or use the site to also monitor shoot strike development.

The observation sites are selected based on conditions that are expected to be conducive to mummy berry germination, such as moist, low-lying areas, and areas along a woods edge such as areas that are normally prone to mummy berry infection on your farm. Also, you want to place them where you can have easy access to them and where they are not likely to be disturbed by farm machinery, like between two bushes at the end of a row. Sometimes mummy germination is highest in the rut next to the row, which may be a good place to set up a nursery as well. Mark the site with a colorful stake or flag so you can easily find it again in the spring. Because it is fairly easy to see the pale pink to light-purple mummies as they fall from the bushes around harvest time, late summer or early fall is the best time of the year to set up the observation stations.

Clear an area of about 1 square foot of weeds and leaves or other debris. To contain the mummies, use a barrier, such as the rim of a 5-gallon, light-colored plastic bucket. Cut the rim off about one-third down the bucket, leaving enough of the bucket to push into the ground to keep the rim in place. Leave about 2 inches of the bucket rim above the soil line. Don’t use a pan or anything with a bottom as that would change the moisture content of the soil where the mummies are located; the soil should drain naturally. Metal rings are not a good choice either due to reflection of sunlight and heating of the rim, leading to faster development or possible desiccation of apothecia near the rim.

Collect 50 to 100 mummies from areas within the field. Mummies can also be collected from the culls from blueberry sorting lines. Sprinkle 50 to 100 mummies evenly on the ground within the rim. You may press them lightly to ensure good soil contact, but don’t bury them. Then, treat the area like any other area on your farm, allowing rain and leaves to fall on the site. Weeds may make it difficult to see them in the spring, so an occasional weeding may be helpful. However, don’t disturb the mummies after October-November.

If an observation station was not established in the fall, one can still be improvised in the spring to facilitate observation. At this time, the mummies are very sensitive to being moved and apothecial initials can break or desiccate easily, especially if they are dislodged from the surrounding soil. Also, apothecia grow towards the light, so if the mummy is placed upside down, the apothecia will stop developing and will die. Carefully scoop up germinated mummies with surrounding soil and place them in indentations within the rim without changing their orientation if possible. Make sure the site is as moist as where the mummies came from and set them carefully, causing as little disturbance as possible. This may help in observing apothecium size and development.

For the first infections to occur, three conditions must be met:

- Apothecia must be present and have an opening of at least 2 mm.

Fruit Rot Management (continued)

- ◊ Green leaf tissue should be visible.
- ◊ There must at least four to six hours of moisture on the leaves.

Infection can occur at temperatures as low as 36 F, but the leaves must be wet for about eight to 10 hours in that case. Do keep in mind that under warm conditions, apothecia can go from a pin-prick opening to 2 mm in a day.

Above: A mummy berry nursery in 2011. This nursery was set up with a metal rim which heated up during sunny weather later in spring, plastic rims are now advised instead. Photo courtesy Annemiek Schilder, MSU..

(Dr. Schilder's work is funded in part by MSU's AgBioResearch. This article was published by Michigan State University Extension. For more information, visit http://www.msue.msu.edu.)

Fruit Rot Management *(continued)*

Strawberry Fruit Rots- Organic Management - *Mike Ellis and Mizuho Nita, Ohio State University*

Botrytis Fruit Rot (Gray Mold) One of the most serious and common fruit rot diseases of strawberry is gray mold. Gray mold is caused by the fungus *Botrytis cinerea*. Under favorable environmental conditions for disease development, serious losses can occur. The gray mold fungus can infect petals, flower stalks (pedicels), fruit caps, and fruit. During wet springs no other disease causes a greater threat to flowers and fruit. The disease is most severe during prolonged rainy and cloudy periods during bloom and harvest. Abundant gray-brown, fluffy, fungal growth on infected tissue is responsible for the disease's name "gray mold".

During wet, cool springs, gray mold will be a major threat to organic strawberry production. In conventional production systems, application of fungicide during bloom generally results in good disease control. Fungicides used in organic systems (sulfur and copper) are not very effective for control of Botrytis. Several biological control products are currently available for Botrytis control; however, their effectiveness under moderate to heavy disease pressure is questionable. Resistance is not available in most varieties; therefore, the use of several cultural practices are the key control methods in organic plantings.

Symptoms - Young blossoms are very susceptible to infection. One to several blossoms in a cluster may show blasting (browning and drying) that may spread down the pedicel. Fruit infections usually appear as soft, light brown, rapidly enlarging areas on the fruit (Figure 1). If it remains on the plant, the berry usually dries up, "mummifies", and becomes covered with a gray, dusty powder (Figure 2). Fruit infection is most severe in well-protected, shaded areas of the plant where the humidity is higher and air movement is reduced. Berries resting on soil or touching another decayed berry or a dead leaf in dense foliage are most commonly affected. The disease may develop on young (green) fruits, but symptoms are more common as they mature. Often, the disease is not detected until berry picking time. During harvest, the handling of infected fruit will spread the fungus to healthy ones. After picking, mature fruits are extremely susceptible to gray mold, especially if bruised or wounded. Under favorable conditions for disease development, healthy berries may become a rotted mass within 48 hours after picking.

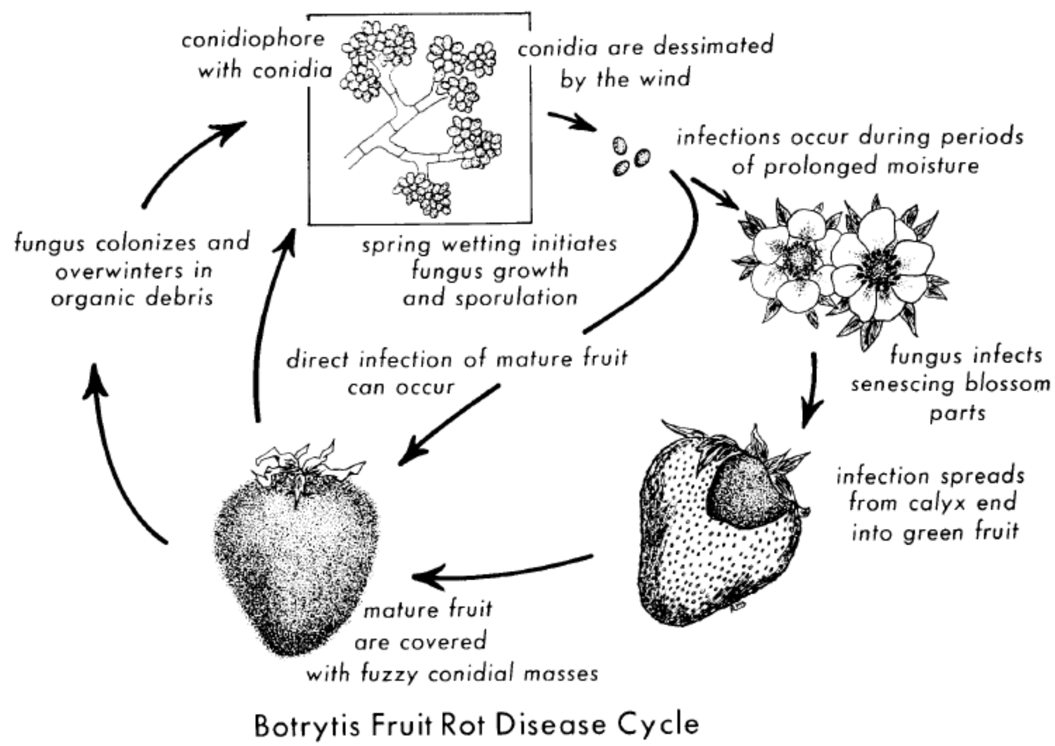
Figure 1 Immature strawberry fruit with symptoms of Botrytis fruit rot (gray mold). Note the symptoms usually develop first on the calyx end of the fruit.

Figure 2 Botrytis fruit rot (gray mold) on a mature strawberry fruit.

Disease Development - The fungus is capable of infecting a great number of different plants. It overwinters as minute, black, fungal bodies (sclerotia) and/or mycelium in plant debris, such as dead strawberry leaves in the row. In early spring, these fungal bodies produce large numbers of microscopic spores (conidia), which are spread by wind throughout the planting. They are deposited on blossoms and other plant parts where they germinate in a film of moisture. Infection occurs within a few hours (Figure 3).

Fruit Rot Management (continued)

Figure 3. Disease cycle of gray mold on strawberry. We wish to thank the New York State Agriculture Experiment Station for the use of this figure. Figure taken from the Small Fruit IPM Disease Identification Sheet No. 1



Disease development is favored by wet conditions accompanied by temperatures between 41 F and 86 F. Conditions that keep flowers and fruit wet, such as rain, dew, or sprinkler irrigation encourage Botrytis rot.

Strawberries are susceptible to Botrytis during bloom and again as fruits ripen. During the blossom blight phase of the disease, the fungus colonizes senescing flower parts, turning the blossoms brown. The fungus usually enters the fruit through flower parts, where it remains inactive (latent) within the tissues of infected green fruits. As the fruit matures, the fungus becomes active and rots the fruit. Thus, while infection actually occurs during bloom, symptoms are usually not observed until harvest. This is important to remember when one considers control. Temperatures between 70 and 80 F and moisture on the foliage from rain, dew, fog, or irrigation are ideal conditions for disease development.

Leather Rot

Leather rot is caused by the soil-borne fungus *Phytophthora cactorum*. Leather rot has been reported in many regions throughout the United States. In many areas, it is considered a minor disease of little economic importance. However, excessive rainfall during May, June, and July can lead to severe fruit losses and quality reduction. In 1981, many commercial growers in the Midwest lost up to 50 percent of their crop to leather rot. The leather rot fungus primarily attacks the fruit but may also infect blossoms. Organic fungicides (sulfur and copper) are not effective for control. The key control methods in organic as well as conventional systems are maintaining a good layer of straw mulch between fruit and the soil, and site selection or improvement for good water drainage (avoid saturated soil).

Symptoms - The leather rot pathogen can infect berries at any stage of development. When the disease is serious, infection of green fruit is common. On green berries, diseased areas may be dark brown or natural green outlined by a brown

Fruit Rot Management (continued)

margin (Figure 4). As the rot spreads, the entire berry becomes brown, maintains a rough texture, and is leathery in appearance. The disease is more difficult to detect on ripe fruit. On fully mature berries, symptoms may range from little color change to discoloration that is brown to dark purple (Figure 5). Generally, infected mature fruit is dull in color and is not shiny or glossy. Infected ripe fruit are usually softer to the touch than healthy fruit. When diseased berries are cut across, a marked darkening of the water-conducting system to each seed can be observed. In later stages of decay, mature fruits also become tough and leathery. Occasionally, a white moldy growth can be observed on the surface of infected fruit. In time, infected fruit dry up to form stiff, shriveled mummies.

Figure 4 Leather rot symptoms on an immature strawberry fruit.

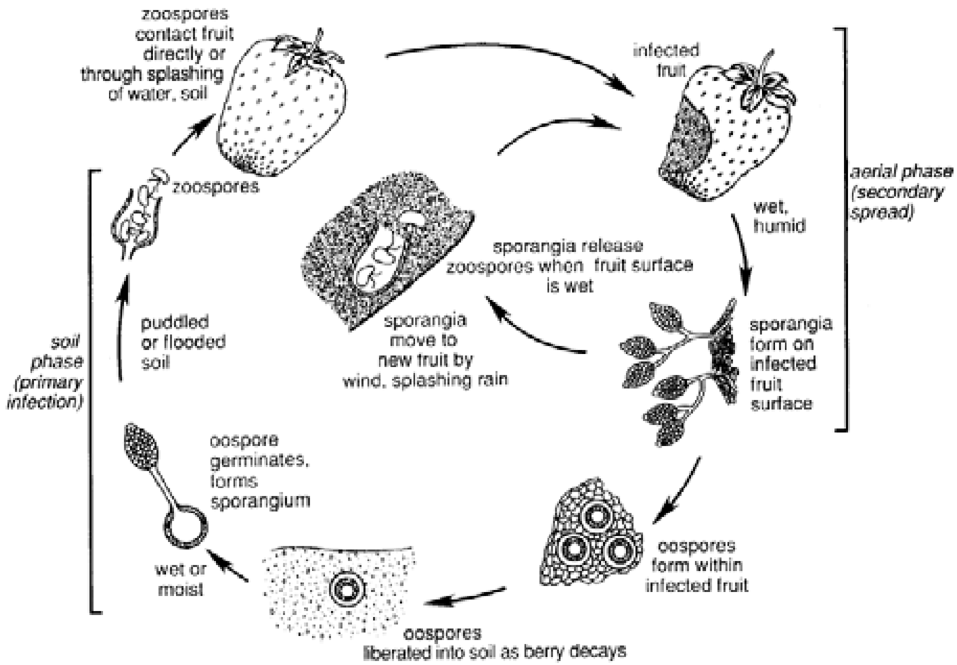
Figure 5 Leather rot symptoms on a mature strawberry fruit. Note the purplish discoloration.

Berries that are affected by leather rot have a distinctive and very unpleasant odor and taste. Even healthy tissue on a slightly rotted berry is bitter. This presents a special problem to growers in pick-your-own operations. An infected mature berry with little color change may appear normal and be picked and processed with healthy berries. Consumers have complained of bitter tasting jam or jelly made with berries from fields where leather rot was a problem. Leather rot is most commonly observed in poorly-drained areas where there is or has been free-standing water or on berries in direct contact with the soil.

Disease Development - The fungus survives the winter as thick-walled resting spores, called oospores that form within infected fruit as they mummify (Figure 25). These oospores can remain viable in soil for long periods of time. In the spring, oospores germinate in the presence of free water and produce a second type of spore called a sporangium. A third type of spore called a zoospore is produced inside the sporangium. Up to 50 zoospores may be produced inside one sporangium. The zoospores have "tails" and can swim in a film of water. In the presence of free water on the fruit surface, the zoospores germinate and infect the fruit. In later stages of disease development, sporangia are produced on the surface of infected fruit under moist conditions.

Figure 6. Disease cycle of leather rot on strawberry. We wish to thank the New York State Agriculture Experiment Station for use of this figure. Figure taken from the Small Fruit Crop IPM Disease Identification Sheet No. 4

Fruit Rot Management (continued)



The disease is spread by splashing or wind-blown water from rain or overhead irrigation. Sporangia and/or zoospores are carried in water from the surface of the infected fruit to healthy fruit where new infections occur. Under the proper environmental conditions, the disease can spread very quickly. A wet period (free water on fruit surface) of two hours is sufficient for infection. The optimum temperatures for infection are between 62 and 77 F. As the length of the wet period increases, the temperature range at which infection can occur becomes much broader. As infected fruit dry up and mummify, they fall to the ground and lie at or slightly below the soil surface. Oospores formed within the mummified fruit enables the fungus to survive the winter and cause new infections the following year, thus, completing the disease cycle.
Strawberry Anthracnose - Anthracnose is a disease that can affect foliage, runners, crowns and fruit. Various forms of anthracnose can be caused by several fungi. In the Midwest, the most common form of the disease is fruit rot, caused by the fungus *Colletotrichum acutatum*. Although the disease is not very common, if it becomes established in the planting, serious losses can occur. Organic fungicides (sulfur and copper) are not effective for control. Midwest varieties with resistance are not available. Once the disease develops on fruit in the planting there is little that can be done to control it. Managing the movement of pickers into and out of infested areas and adjusting irrigation practices can be beneficial in preventing disease spread.

Symptoms - Affected stems are sometimes girdled by lesions, causing individual leaves or entire daughter plants to wilt. Under warm, humid conditions, salmon-colored masses of spores may form on anthracnose lesions.

When crown tissue is infected and becomes decayed, the entire plant may wilt and die. When infected crowns are sliced open, internal tissue is firm and reddish brown. Crown tissue may be uniformly discolored or streaked with brown.

On fruit, symptoms first appear as whitish, water soaked lesions up to 1/8 inch in diameter which turn brown and enlarge within 2 to 3 days to involve most of the fruit (Figure 7). Lesions are covered with salmon-colored spore masses. Infected fruit eventually dry down to form hard, black, shriveled mummies. Fruit can be infected at any stage of development.

Fruit Rot Management *(continued)*

Figure 7. Anthracnose lesion on strawberry fruit.

Disease Development - The disease is probably introduced into new plantings on infected plants. Spore production, spore germination, and infection of strawberry fruits are favored by warm, humid weather and by rain. Spores require free water on the plant surface in order to germinate and infect. Anthracnose fruit rot is considered to be a warm-weather disease with an optimum temperature for disease development near 80 F. Thus, the disease is generally a problem in the Midwest when abnormally high temperatures and rainfall occur during fruit set and harvest. Spores are dispersed primarily by water splash. Once the disease is established in the field, the fungus can overwinter on infected plant debris, primarily old-infected, mummified fruit.

Cultural Practices for Fruit Rot Management in Strawberries – *Mike Ellis and Mizuho Nita, Ohio State University*

Cultural practices are the major means of control for strawberry fruit rot diseases. The use of any practice that reduces or eliminates pathogen populations or creates an environment within the planting that is less conducive to disease development must be used. The following practices should be carefully considered and implemented whenever possible in a fruit rot management program.

Fertility

Fertility should be based on soil and foliar analysis. Soil should be analyzed and nutrient levels adjusted before planting. The use of excess fertilizer, especially nitrogen, should be avoided. Sufficient fertility is essential to produce a crop, but excess nitrogen results in dense foliage that increases drying time in the planting (stays wet longer) and also results in softer berries that are more susceptible to fruit rots. Avoid the application of nitrogen in the spring prior to harvest on medium to heavy soils. Excessive use of nitrogen has been shown to increase the level of Botrytis fruit rot (gray mold).

Weed Control

Good weed control is essential to successful strawberry production. From the disease control standpoint, weeds in the planting prevent air circulation and result in fruit and foliage staying wet for longer periods. Gray mold, in particular, is a much more serious problem in plantings with poor weed control versus plantings with good weed control. In addition, weeds will reduce production through direct competition for light, nutrients, and moisture with strawberry plants and will make the planting less attractive to pick-your-own customers, especially if you have thistles!

Mulch

Research and grower experience has shown that a good layer of straw mulch is very beneficial for controlling fruit rots, especially leather rot. Bare soil between the rows should be avoided and a good layer of straw mulch is highly recommended. The mulch keeps berries from contacting the soil where the leather rot fungus overwinters. In addition, it also aids in preventing infested soil from splashing onto the berries. Recent research has shown that plastic mulch (a layer of plastic) under the plants and/or between the rows increases splash dispersal of the pathogens that cause anthracnose and leather rot. Especially where fruit rots have been a problem, the use of plastic mulch is not recommended.

Sanitation

Any practice that removes old leaves and other plant debris from the planting is beneficial in reducing the amount of Botrytis inoculum. Leaf removal at renovation is highly recommended.

Irrigation Practices

The application of supplemental water should be timed so that the foliage and fruit will dry as rapidly as possible. For example, irrigating early in the day is better than in the evening. If diseases, such as gray mold, leather rot, anthracnose or bacterial blight, become established in the planting, overhead irrigation should be minimized or avoided.

Fruit Rot Management (continued)

Control Movement of People and Machinery
Movement of people (pickers) and machinery from a field or area that is infested to a clean or uninfested field should be avoided. Diseases of primary concern are anthracnose and leather rot. Diseases such as these are usually spread over relatively short distances by splash dispersal (rain or irrigation). Movement from one field to another field through the air (wind blown spores) is generally not a problem with these diseases. However, pickers moving from a field where the disease is present to a non-infested field can transport fungal spores very efficiently on shoes, hands, and clothing. If people or machinery are used in fields where these diseases are a problem, they should complete work in non-infested fields before moving to infested fields. In addition, any machinery that moves soil from one field to another can introduce soil-borne diseases, such as leather rot, from infested into non-infested fields.

Harvesting Procedures
a) Pick fruit frequently and early in the day before the heat of the afternoon (preferably as soon as plants are dry). Picking berries as soon as they are ripe is critical. Overripe berries will cause nothing but problems during and after harvest.
b) Handle berries with care during harvest to avoid bruising. Bruised and damaged berries are extremely susceptible to rot.
c) Train pickers to recognize and avoid berries that have disease symptoms of gray mold and leather rot. If at all possible, have pickers put these berries in a separate container and remove them from the field.

Post Harvest Handling
a) Always handle fruit with care during movement from the field to market to avoid any form of damage.
b) Get the berries out of the sun as soon as possible.
c) Refrigerate berries immediately to 35 to 40°F in order to slow the development of gray mold (Botrytis) and other fruit rots.
d) Market the berries as fast as possible. Encourage your customers to handle, refrigerate, and consume or process the fruit immediately. Remember that even under the best conditions, strawberries are very perishable.

Strawberry fruit rot disease control strategies

All possible control strategies must be employed if strawberry diseases are to be controlled.
Key: ++=most important controls; +=helpful controls; -=no controls

Disease Control Considerations`	Fruit rot
Good air/water drainage	++
No shade	++
Adequate plant and row and plant spacing	++
Resistant varieties	-
Disease-free plants	-
Mulch for winter injury and/or fruit rot	Leather rot (++)
Fruit storage conditions	++
Renovation	-
Weed control	++

(Excerpted and reprinted with permission from: OSU Organic Small Fruit Disease Management Guidelines .)

Fruit Rot Management *(continued)*

Cultural Practices for Gray Mold Control in Brambles – *Mike Ellis and Mizuho Nita, Ohio State University*

Cultural practices are the major means of control for several important bramble diseases, including gray mold. The use of any practice that reduces or eliminates pathogen populations or creates an environment within the planting that is less conducive to disease development must be used. The following practices should be carefully considered and implemented whenever possible in the disease management program.

Site Selection Proper site selection is critical to developing a successful disease management program. Establishing a planting on a site that is conducive to disease development is a critical error. Such plantings may be doomed to failure, regardless of the amount of pesticide a grower uses. The following considerations should play a major role in the disease management program.

Soil drainage - Soil drainage (both surface and internal drainage) is an *extremely important* consideration when selecting a planting site. Planting brambles on poorly or even marginally drained sites is a poor management decision. For example, poorly drained soils that are frequently saturated with water are highly conducive to the development of Phytophthora root rot, *especially in red raspberries*. Even in the absence of plant disease, wet soils are not conducive to good plant growth and productivity. Any practice such as tiling, ditching, or planting on ridges that aids in removing excessive water from the root zone will increase the efficacy of the disease management program. Once the planting is established, it is difficult, if not impossible to improve soil drainage.

Site Exposure (Air Circulation and Sunlight Exposure) - Avoid sites that do not have full exposure to sunlight, such as shaded areas near woods or buildings. In addition, sites with poor air circulation that tend to accumulate still, damp air should be avoided. Planting rows in the direction of the prevailing winds will help promote good air circulation and rapid plant drying. The primary reason for the above considerations is to ***promote faster drying of canes, foliage, and fruit.*** Most plant pathogenic fungi and bacteria require water on plant surfaces in order to penetrate and infect the plant. Any practice that reduces wetness duration (speeds drying time) of susceptible plant parts is beneficial to the disease management program.

Avoid Excessive Fertilization
Fertility should be based on soil and foliar analysis. The use of excessive fertilizer, especially nitrogen, should be avoided. Sufficient fertility is essential for producing a crop, but excessive nitrogen can result in dense foliage that increases drying time in the plant canopy, i.e., it stays wet longer. Research has shown that excessive use of nitrogen can result in increased levels of Botrytis fruit rot (gray mold).

Control Weeds In and Around the Planting
Good weed control within and between the rows is essential. From a disease-control standpoint, weeds in the planting prevent air circulation and result in fruit and foliage staying wet for longer periods. For this reason, most diseases caused by fungi are generally more serious in plantings with poor weed control than in those with good weed control. Any practice that opens up the canopy in order to increase air circulation and reduce drying time of fruit, foliage and young canes is generally beneficial to disease control. Controlling wild brambles (which are weeds) near the planting is also important because they can serve as a reservoir for several important diseases and insect pests.

Sanitation (Removal of Overwintering Inoculum)
The fungus causing Botrytis fruit rot (and other disease causing fungi as well) overwinters within the planting on canes infected during the previous year. Pruning out all old fruited canes and any diseased new canes (primocanes) immediately after harvest and removing them from the planting breaks the disease cycle and greatly reduces the inoculum. All infected pruning waste should be removed from the field and destroyed. If you are attempting to minimize fungicide use, good sanitation (removing old fruited canes) is critical. If old fruited canes cannot be removed before winter, they

Fruit Rot Management (continued)

should *definitely* be removed before new growth starts in the spring. For fall bearing raspberries, such as Heritage, all canes are cut off each year. Removing all cut canes from the planting will aid the disease management program. If it is impossible to remove pruned canes from the field, they should be chopped in place as quickly as possible with a flail mower to speed decomposition before new canes emerge.

Plant population and canopy management

Any practice that alters the density of the plant canopy and increases air circulation and exposure to sunlight is generally beneficial to disease control. Optimizing between-row and within-row spacings and maintaining interplant spacings through judicious cane thinning throughout the life of the planting is desirable. Ideally, rows for red raspberries should not be over 2 feet wide and should contain about 3 or 4 canes per square foot. Control of plant vigor, particularly through avoidance of high levels of nitrogen and careful use of cane vigor control techniques, can greatly aid in improving the canopy density. Specialized trellis designs for various Rubus spp. can further improve air circulation and increase exposure to sunlight, as well as increase harvest efficiency. Trickle irrigation, as opposed to overhead sprinkler irrigation, greatly reduces the wetting of foliage and fruit and the risk of splash dispersal of several important fungal pathogens.

Removing young fruiting shoots (before they exceed 4 inches in length) from the lower portions of canes (approximately the lower 20 inches) will remove fruit that might become soiled. This practice also removes shoots that disproportionately contribute to shading and poor air circulation in the canopy.

For information on methods for cane vigor control, trellis designs and optimum spacing requirements, the following book is very useful: Raspberry and Blackberry Production Guide, edited by Lori Bushway, Marvin Pritts and David Handley. It can be purchased from: Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853. Phone: 607-255-7654.

Adjust Production Practices to Prevent Plant Injury and Infection

Many plant pathogens take advantage of wounds in order to penetrate and infect the plant. Therefore, any practice that minimizes unnecessary physical damage to the plant is beneficial to the disease management program. The use of sharp pruning tools will help minimize damage to canes during pruning operations. Prune only when necessary (avoid cosmetic pruning of primocanes) and avoid pruning during periods when plants are wet or immediately before wet weather is forecast. Most plant pathogens require water on the surface of plant tissues before they can penetrate the plant. Providing proper cane support through trellising or otherwise tying the canes will aid greatly in avoiding abrasions from sharp spines and wind whipping of plants during windy conditions. Proper spacing between rows and the use of the proper size equipment will also prevent plant damage.

Proper Harvest, Handling and Storage of Fruit

Proper harvesting and storage methods are critical components of the disease management program. It is of little value to produce high-quality fruit in the field if it is bruised or crushed during harvest or permitted to rot during storage. Raspberry and blackberry fruit are ***very perishable***. Even under the "Best conditions" these tender fruits are extremely susceptible to physical damage and postharvest rots. The following practices need to be considered well in advance of initiating the harvest. The proper implementation of these practices will aid greatly in providing your customers with the best quality fruit possible.

a) Handle all fruit carefully throughout all phases of harvest, transport and sale. Bruised or crushed (leaky) fruit are much more susceptible to fungal infection and rot than firm, intact fruit.

b) Harvest all fruits as soon as they are ripe. During periods of warm weather, harvest may require picking intervals as short as 36 to 48 hours. Pick early in the day before the heat of the afternoon. Overripe fruit in the planting will attract a number of insect pests and provide a source for inoculum buildup of fruit rotting fungi.

c) It is highly desirable to combine harvesting and packing into one operation. This prevents unnecessary handling

Fruit Rot Management (continued)

and additional physical injuries.

d) If possible, train pickers to remove damaged or diseased berries from the field. Some growers have programs where they pay the picker as much, or more, for damaged berries picked into separate containers, than for healthy berries. This is a good sanitation practice that reduces inoculum levels of fruit rotting-fungi in the field. Providing hand-washing facilities in the field so pickers can periodically clean their hands, should be helpful in reducing the movement of fungus spores that are encountered by touching rotten (diseased) berries.

e) Pick into shallow containers. Ideally, fruit should be no more than 3 to 4 berries deep; this greatly reduces bruising and crushing the fruit, which results in juice leakage that encourages the development of fungal fruit rots.

f) Refrigerate fruit immediately after harvest. Fruit should be cooled as close to 32°F as possible within a few hours after harvest. This temperature should be maintained throughout storage and, if possible, throughout shipment and sale. If you do not have refrigeration, fruit should be placed in the coolest place possible. Never allow the fruit to sit in the sun.

g) Avoid condensation of water on fruit after it is removed from cold storage. This is best accomplished by enclosing it in a waterproof over-wrap before it leaves the refrigerated area. The over-wrap should be kept in place until the fruit temperature has risen past the dew point.

h) Sell the fruit immediately ("Move it or lose it". Many berries produced in the Midwest are sold to pick-your-own customers or directly at farm markets, and are not refrigerated prior to sale. Customers should be encouraged ("educated" to handle, refrigerate, and consume or process the fruit immediately in order to assure the highest quality possible. We must remember that even under the best conditions, raspberry and blackberry fruits are very perishable.

BRAMBLE DISEASE CONTROL STRATEGIES

Key: ++ = most important controls; + = helpful controls; - = no effect.

Disease Control Considerations`	**Fruit rot**
Good air/water drainage	++
500+ ft from wild brambles	
Rotation	-
Cultivar tolerance or resistance	-
Avoid adjacent plantings	-
Eliminate wild brambles	-
Disease-free stock	-
Aphid control (vectors)	-
Rogue infected plants	-
Speed drying (weeds, pruning)	++
Prune 3 days before rain	
Dispose of diseased pruned canes	-
Maintain plant vigor	-
Fungicide sprays	+/-
Harvest before overripe	++
Fruit storage conditions	++

(Excerpted and reprinted with permission from: OSU Organic Small Fruit Disease Management Guidelines .)

Fruit Rot Management (continued)

Blueberry Fruit Rots – Organic Management - *Mike Ellis and Mizuho Nita, Ohio State University*

Mummy Berry (*Monilinia vaccinii-corymbosi*) Mummy berry is becoming increasingly important in some parts of the Midwest (and New York); its severity varies from year to year. It is caused by a fungus which attacks new growth, foliage, and fruit and can cause extensive loss. The fungus overwinters in mummified fruit on the ground (Figure 1a). The mummies form cup or globe-shaped structures called apothecia (Figure 1b). Apothecia produce spores that infect young tissue and cause rapid wilting (Figure 1c). This is called leaf and twig blight, or bud and twig blight. These symptoms are difficult to distinguish from frost injury. These first infections form more spores, which are spread by rain, wind and bees to blossoms and other young tissue. The fungus infects and invades the developing fruit (Figure 1d). The fruit becomes malformed looking like a pumpkin, and turns salmon or grey by midsummer (Figure 1e). By fall, these fruit drop to the ground where they turn into mummies ready to produce apothecia the next spring (Figure 1f). *(From left to right, Figures 1a through 1f, photos courtesy C. Heidenreich).*


Mummies on soil under bushes


Fungal fruiting structures – Ascocarps


Shoot blight with gray spore mass

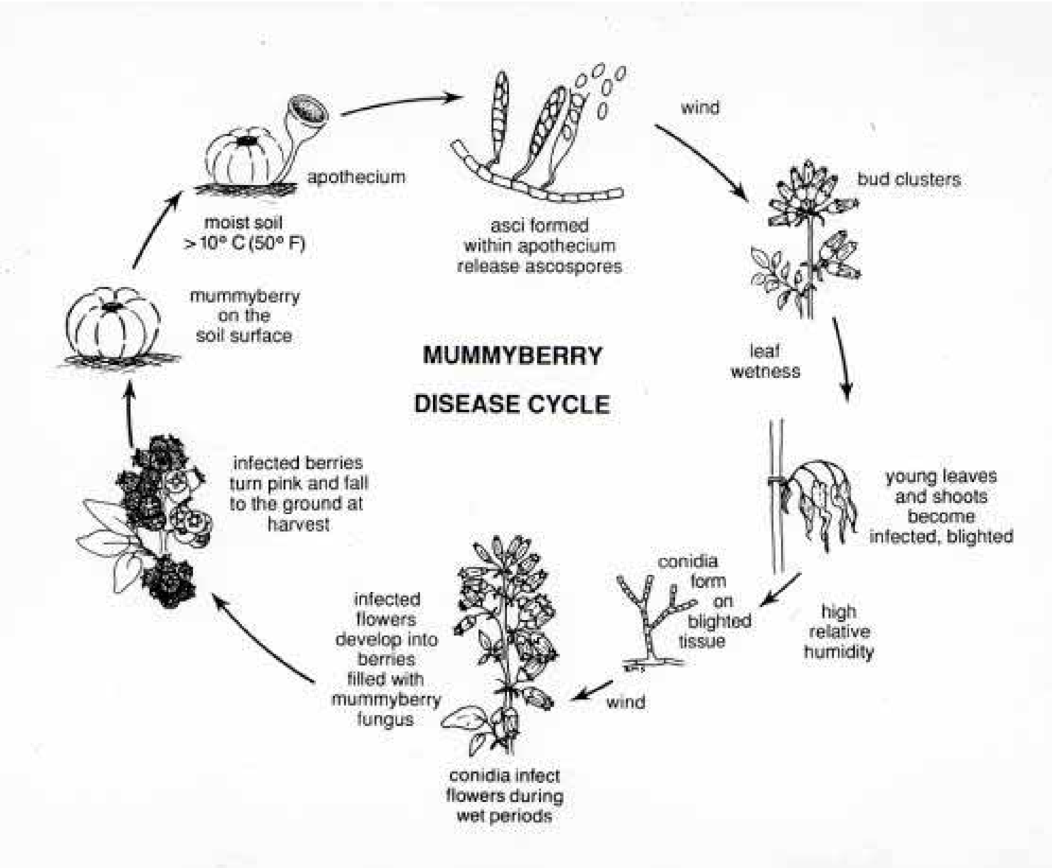

Infected fruit in mid-summer


Infected fruit late summer


Infected berries becoming "mummies"

Figure 2**: Mummy berry disease cycle.** Taken from Small Crop IPM Diseases Fact Sheet No. 3. We wish to thank the New York State Agriculture Experiment Station for use of this figure.

Fruit Rot Management (continued)



Management - Cultural controls are extremely important in organic production and can be used to reduce inoculum levels in the spring. In very small plantings, mummies can be raked up and burned. In larger plantings, mummies can be buried by cultivating or disking between rows or by covering them with a new layer of mulch at least 2 inches in thickness. Combining cultivation with an application of nitrogen in the spring speeds destruction of the mummies. The cultivation should be done just as apothecia start to emerge in the spring, which usually coincides with budbreak on the blueberry bushes.

Botrytis Blight/Gray Mold (*Botrytis cinerea*) As with other small fruits, Botrytis primarily affects ripening fruit, although under certain circumstances the fungus can cause stem blight as well. Infection occurs primarily during bloom on flowers (Figure 2a, left). The fungus survives the winter on dead twigs and in soil organic matter. It is present every year, but only causes severe damage during cool, wet periods of several days duration. The most critical period for infection is during bloom. The disease is more severe when excessive nitrogen has been used, where air circulation is poor, or when frost has injured blossoms. Rotted berries typically have a gray cast due to mycelium and spore-bearing structures present, which gives the disease its name (Figure 2b, right). Stem symptoms are difficult to distinguish from those caused by Phomopsis. For positive diagnosis, the fungus usually must be isolated from infected tissue in a diagnostic laboratory. Cultivars possessing tight fruit clusters (‘Weymouth’, ‘Blueray’ and ‘Rancocas’) are particularly susceptible to this disease. *(Photos courtesy C. Heidenreich, W. Turechek)*

Fruit Rot Management *(continued)*

Management - Any cultural practice that promotes faster drying of foliage and fruit in the planting should be beneficial for gray mold control. The use of excessive nitrogen should be avoided. Fertilization should be based on results for soil and foliar analysis. Organic fungicides sulfur and copper are of little value for gray mold control. Several biocontrol products are available for control of gray mold on small fruit crops. In general, their efficacy under moderate to severe disease pressure needs to be determined.

Anthracnose (*Colletotrichum gloeosporioides*) This fungus damages primarily fruit, but also infects twigs and spurs. It causes a salmon-or rust-colored berry rot. Infected fruit often exhibit a soft, sunken area near the calyx-end of the fruit. Spores spread to "good" fruit during and after harvest, causing significant postharvest losses. Spores are spread mainly by rainwater. The disease is especially prevalent during hot, muggy weather and frequently occurs postharvest.

The anthracnose fungus overwinters in dead or diseased twigs, fruit spurs, and cankers. Spores are released in the spring and are spread by rain and wind. Blossoms, mature fruit and succulent tissue are infected; spores spread from these infections Blossom clusters turn brown or black. Infected fruit shows bright pink spore masses at the blossom end. Stem cankers are rare, but when present are about 1/8" in diameter, with raised purple margins. Young girdled stems die back, resulting in a brown withering of the leaves (Figures 3a, b, c, d). Cultivars in which the ripe fruit hangs for a long time on the bush prior to picking are especially susceptible. These include: 'Berkeley', 'Coville', 'Bluecrop', 'Blueray', and 'Jersey'. No cultivars are entirely resistant when the weather conditions are favorable for the disease development (warm and wet). *Below left to right: Figures 3a, b, c, d; photos courtesy W. Turechek, C. Heidenreich.*

Spore masses at fruit blossom ends

Post-harvest fruit rot caused by Anthracnose

Fruit Rot Management (continued)

Girdled young cane with dead blossom cluster

Sporulation on infected stem tissue

Management - Organic fungicides are of little value for controlling anthracnose. Pruning out small twigs and frequent harvesting are beneficial to control. Removing and destroying infected fruit should be beneficial. Old canes and small twigs should be removed in order to increase air circulation around the fruit clusters.

For more information on post-harvest blueberry fruit rots see: "*Blueberry Fruit Rot Identification Guide" by Phillip Wharton and Annemiek Schilder*, MSU at: http://migarden.msu.edu/uploads/files/e2847.pdf

Cultural Practices for Fruit Rot Control in Blueberry - *Mike Ellis and Mizuho Nita, Ohio State University*

The use of any practice that provides an environment within the planting that is less conducive to disease development and spread should be used. The following practices should be carefully considered and implemented in the disease management program.

Site Selection - Select a planting site with good water drainage. *Soil Drainage (Extremely Important)* Avoid low, poorly-drained wet areas. Good water drainage (both surface and internal drainage) is especially important for control of Phytophthora root rot. This disease requires free water (saturated soil) in order to develop. If there are low areas in the field that have a tendency to remain wet, this is the first place that Phytophthora root rot will develop. Any time there is standing water in the field, plants are subject to infection. *Any site in which water tends to remain standing is, at best, only marginally suited for blueberry production and should be avoided.*

Any practice, such as tiling, ditching, or planting on ridges or raised beds, that aids in removing excessive water from the root zone will be beneficial to the disease management program.

Site Exposure - A site with good air circulation that is fully exposed to direct sunlight should be selected. Avoid shaded areas. Good air movement and sunlight exposure are important to aid in drying fruit and foliage after rain or irrigation. Any practice that promotes faster drying of fruit or foliage will aid in the control of many different diseases.

Weed Control - Good weed control is essential to successful blueberry production. From the disease control standpoint, weeds in the planting prevent air circulation and result in fruit and foliage staying wet for longer periods. Several diseases can be more serious in plantings with poor weed control versus plantings with good weed control.

In addition, weeds will reduce production through direct competition with blueberry plants for light, nutrients, and moisture and will make the planting less attractive to pick-your-own customers, especially if you have thistles!

Sanitation - Any practice that removes twigs or branches infected and other plant debris from the planting is beneficial

Fruit Rot Management *(continued)*

in reducing the amount of fungal inoculum. Removal of fruit mummies is critical for mummy berry control. Removal of infected twigs and branches is also critical for control of Phomopsis twig blight and Fusicoccum canker. Infected plant material should be removed from the planting and destroyed.

Maintaining proper soil conditions - One of the most common problems in mid-western blueberry plantings is iron chlorosis. Affected plants are chlorotic (yellow) and stunted. The major cause of chlorosis is planting on a site with improper ph. The best soils for blueberries are well-drained sandy silt loam or silt loam, with pH 4.5 to 5.2, organic matter of 4 to 7% and adequate phosphorus and potassium. At pH levels above 5.2, chlorosis will probably be a problem.

Most soils will need to be adjusted in pH. Too low a pH can result in manganese or aluminum toxicity, while a high pH results in the unavailability of certain nutrients such as iron. Do not plant blueberries without amending the pH at least 1 -2 years before planting. pH test kits are available from your local county Extension office. Where top and subsurface soils have a naturally high pH (6.0 to 8.0) and there is a high buffering capacity, soil amendments will not adjust the pH and blueberries should not be planted. Sulfur can be used to decrease the pH to the proper level if the pH is not too high. Incorporate sulfur and organic matter into the raised bed (upper 6 to 12 inches) 3 to 6 months prior to planting. This allows time for the chemical reaction to occur and reduces potential root damage. Retest the soil 3 to 6 months after application to determine whether further adjustments are needed. Apply all nutrients according to soil test. Phosphorus will not move through the soil and is ineffective after plant establishment.

In major commercial blueberry areas, blueberries are produced on sandy soils with high water tables. Most mid-western soils (except some Michigan and Wisconsin soils) require soil amendments and irrigation for maximum growth and yield. Tile drainage may be required, but in most mid-western soils containing 10% or more clay, raised beds are preferred for optimal growth. A raised bed 8 to 10 inches high (original height) and 4 feet wide is required. Over time, the bed will compact to 6 inches, but the addition of hardwood or other suitable mulches maintains a height of 6 to 8 inches.

Avoid Excessive Fertilization - Fertility should be based on soil and foliar analysis. The use of excessive fertilizer, especially nitrogen, should be avoided. Sufficient fertility is essential for producing a crop, but excessive nitrogen can result in dense foliage that increases drying time in the plant canopy, i.e., it stays wet longer.

Harvesting Procedures
a) Pick fruit ***frequently*** and early in the day before the heat of the afternoon (preferably as soon as plants are dry). Picking berries as soon as they are ripe is critical. Overripe berries will cause nothing but problems during and after harvest.
b) Handle berries with care during harvest to avoid bruising. Bruised and damaged berries are extremely susceptible to rot.
c) Train pickers to recognize and avoid berries that have disease symptoms of mummy berry or anthracnose. If at all possible, have pickers put these berries in a separate container and remove them from the field.

Post-Harvest Handling
a) Always handle fruit with care during movement from the field to market to avoid any form of damage.
b) Get the berries out of the sun as soon as possible.
c) Refrigerate berries immediately to 32 to 35°F in order to slow the development of fruit rots.
d) Market the berries as fast as possible. Encourage your customers to handle, refrigerate, and consume or process the fruit immediately. Remember that even under the best conditions, blueberries are quite perishable.

Products Labeled for Use in Organic Strawberry Fruit Rot Management in NY

(Last updated 05/10/2013, compiled by C. Heidenreich, Cornell University)

ALWAYS CHECK WITH YOUR CERTIFIER before using a new product. At the time this table was compiled, the following materials were labeled in New York State for managing these strawberry fruit rots and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System **(PIMS) website** **http://pims.psur.cornell.edu**. *(Source: 2013 Production Guide for Organic Strawberries, in press)*

Trade Name (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[1]**	**Comments**	**Botrytis***	**Anthracnose***	**Leather Rot***
BIOLOGICAL								
Actinovate-AG (*Streptomyces lydicus WYEC 108s*)	3-12 oz/A	0	1 (or until spray has dried)	2	Streptomyces lydicus products effective in 1/3 trials. Foliar applications: for best results apply with a spreader/sticker prior to onset of disease.	X	X	X
Actino-Iron (*Streptomyces lydicus WYEC 108)*	10-15 lb/A	-	4	?	Water in after application	--	--	X
Bio-Tam (*Trichoderma asperellum, Trichoderm garnsi)*	0.25 - 2 lb BIOTAM/gal water;	-	1	?	bare root dip	--	--	X
	1.5 - 3 oz/1000 row feet;				in furrow			
	2.5 - 3 lb/A				banded			
Double Nickel 55 (*Bacillus amyloliquefaciens str. D747)*	0.25-3 lb/A	0	4	?	Foliar application	X	X	0.125 - 1 lb/A
Double Nickel LC (*Bacillus amyloliquefaciens str. D747)*	0.5-6 qt/A	0	4	?	Foliar application	X	X	0.5 - 4.5 pt/A
Optiva (*Bacillus subtilis)*	14-24 oz/acre	0	4	3	Bacillus subtilis products effective in 0/5 trials. Repeat on 7-10 day intervals.	X	--	--
Prestop (*Gliocladium catenulatum str. J1446*)	3.5 oz/5 gal	-	0	?	Foliar spray. Apply at 0.5 gallon of mixed spray per 100 sq. ft. Apply only when no above-ground harvestable food commodities are present	X	--	1.4 - 3.5 oz/2.5 gal water (soil drench)

1 Efficacy: 1-effective in some research studies, 2- inconsistent efficacy results, 3-not effective, ?-not reviewed or no research available. PHI-Pre-harvest interval. REI-Restricted Entry Interval. - = pre-harvest interval isn't specified on label.
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Products Labeled for Use in Organic Strawberry Fruit Rot Management in NY

(Last updated 05/10/2013, compiled by C. Heidenreich, Cornell University)

Trade Name (***active ingredient***)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[1]**	**Comments**	**Botrytis***	**Anthracnose***	**Leather Rot***
BIOLOGICAL								
Regalia Biofungicide *(Reynoutria sachalinensis)*	1-3 qt/A	0	4	?	Initiate at first sign of disease then every 7-14 days	**X**	**X**	1 - 4 qt/100 gal (plant dip) Treat only the growth substrate when above-ground harvestable food commodities are present.
Serenade ASO *(Bacillus subtilis str. QST 713)*	2-6 qt/A	0	4	3	Bacillus subtilis products effective in 0/5 trials. Begin application at or before flowering repeat every 7-10 days.	**X**	**X**	**--**
Serenade MAX *(Bacillus subtilis str. QST 713)*	1-3 lb/A	0	4	3	Bacillus subtilis products effective in 0/5 trials. Begin application at or before flowering repeat every 7-10 days.	**X**	**X**	**--**
COPPER								
Cueva Fungicide Concentrate (*copper octanoate*)	0.5-2.0 gal/100gal[1]	Up to day of harvest	4	?	[1]Product is applied as a diluted spray at 50-100 gallons per acre.	**X**	**X**	**--**
OIL								
Organic JMS Stylet Oil *(paraffinic oil)*	3qt/100gal water/A	0	4	2	When using oil a high volume of water is needed for through coverage. Many common pesticides are phytotoxic when applied with or close to oil sprays. Check the label for restrictions.	**X**	**--**	**--**
PureSpray Green *(petroleum oil)*	0.75-1.5 gals oil/100 gals water	Up to day of harvest	4	?	Apply 100-200 gals water per acre. Spray at no less than 400 PSI using ceramic nozzles.	**X**	**--**	**--**
Trilogy *(neem oil)*	0.5-1% in 25-100 gal water/A	-	4	?	Maximun labeled use of 2 gal/acre/application	**--**	**X**	**--**
Sporatec (*rosemary, clove, and thyme oils*)	1-3 pt in 100 gal/A	0	0	?	25(b) pesticide. Conduct phytotoxicity test prior application.	**X**	**--**	**--**

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Trade Name (*active ingredient*)	Product Rate	PHI (days)	REI (hours)	Efficacy[1]	Comments	Botrytis*	Anthracnose*	Leather Rot*
OTHER								
EcoMate ARMICARB 0 (*potassium bicarbonate)*	2.5-5.0 lb/100 gal water	0	4	3	Potassium bicarbonate products not effective in 1/1 trial.	**X**	**X**	**--**
Milstop (*potassium bicarbonate*)	2-5 lb/A	0	1	3	Potassium bicarbonate products not effective in 1/1 trial.	**X**	**X**	**--**
OxiDate Broad Spectrum (*hydrogen dioxide)*	40-128 fl oz/100 gal water/A	0	Until spray has dried	3	Hydrogen dioxide products not effective in 3/3 trials.	**X**	**--**	**--**
OxiDate 2.0 (*hydrogen dioxide, peroxyacetic acid)*	64 fl oz/100 gal water	0	Until spray has dried	?	Pre-plant dip	**X**	**--**	**--**
	32 fl oz – 1 gal/100 gal water				Foliar application, at-planting and for existing plantings -See label for additional instructions.			
PERpose Plus (*hydrogen peroxide/dioxide)*	1 fl oz/gal (initial/ curative)	-	Until spray has dried	3	Hydrogen dioxide products not effective in 3/3 trials. For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment.	**X**	**X**	**X**
	0.25-0.33 fl oz/gal (weekly /preventative)				For weekly or preventative treatments, apply lower rate every five to seven days. At first signs of disease, use curative rate then resume weekly preventative treatment.			

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ALWAYS CHECK WITH YOUR CERTIFIER before using a new product. At the time this table was compiled, the following materials were labeled in New York State for managing these blueberry fruit rots and were allowable for organic production. Listing a pest on a pesticide label does not assure the pesticide's effectiveness. The registration status of pesticides can and does change. Pesticides must be currently registered with the New York State Department of Environmental Conservation (DEC) to be used legally in NY. Those pesticides meeting requirements in EPA Ruling 40 CFR Part 152.25(b) (also known as 25(b) pesticides) do not require registration. Current NY pesticide registrations can be checked on the Pesticide Product, Ingredient, and Manufacturer System **(PIMS) website** **http://pims.psur.cornell.edu**. *(Source: 2013 Production Guide for Organic Blueberries, in press)*

Trade Name (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[1]**	**Comments**	**Botrytis***	**Anthracnose***	**Mummy berry***
BIOLOGICAL								
Actinovate-AG (*Streptomyces lydicus WYEC 108s*)	3-12 oz/A	0	1 or until spray has dried	?,?, 2	For best results apply with a spreader/sticker prior to onset of disease. Re-apply at 7-14 day intervals depending on disease pressure and environmental conditions.	**X**	**X**	**X**
Double Nickel 55 (*Bacillus amyloliquefaciens str. D747*)	0.25-3 lb/A	0	4	?		**X**	**X**	**X**
Double Nickel LC (*Bacillus amyloliquefaciens str. D747*)	0.5-6 qt/A	0	4	?		**X**	**X**	**X**
Optiva (*Bacillus subtilis*)	14-24 oz/acre	0	4	?	Begin application prior to disease development and repeat on a 2-10 day interval or as needed.	**X**	**X**	**X**
Regalia Biofungicide (*Reynoutria sachalinensis*)	1-4 qt/A	0	4	?		Apply every 7-14 days at the first signs of disease.	Apply at green tip then every 7-10 days.	Apply at bud break then every 7-10 days.
Serenade ASO (*Bacillus subtilis str. QST 713*)	2-6 qt/A	0	4	2	For improved performance, add an organic-approved surfactant to improve coverage.	Begin application prior to disease development and repeat at 7-10 day intervals or as needed.	Begin prior to disease development, then every 2-10 days.	For suppression begin application at bud break and repeat on a 7- 10 day interval or as needed. For improved performance, use in a tank mix or rotational

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Trade Name (*active ingredient*)	**Product Rate**	**PHI (days)**	**REI (hours)**	**Efficacy[1]**	**Comments**	**Botrytis***	**Anthracnose***	**Mummy berry***
								program with other registered fungicides
Serenade MAX *(Bacillus subtilis str. QST 713)*	1-3 lb/A	0	4	2	For improved performance add an organic-approved surfactant to improve coverage.	**X**	Begin prior to disease development. Repeat on a 2-10 day interval or as needed	Begin application at bud break and repeat on 7-10 day interval for suppression
COPPER								
Badge X2 (*copper octanoate, copper hydroxide*)	1.0-2.25 lb/A	-	48	?		**--**	**X**	**--**
CS 2005 *(copper sulfate pentahydrate)*	25.6-51.2 oz/A	-	48	?		**--**	**X**	**--**
OIL								
Sporatec (*rosemary, clove, and thyme oils*)	1-3 pt in 100 gal/A	0	0	?		**--**	**X**	**--**
Trilogy *(neem oil)*	0.5-1% in 25-100 gal water/A	-	4	?	Maximum labeled use of 2 gal/acre/application	**X**	**X**	**--**
OTHER								
EcoMate ARMICARB 0 *(potassium bicarbonate)*	2.5-5.0 lb/100 gal water	0	4	?		**X**	**--**	**X**
Milstop (*potassium bicarbonate*)	2-5 lb/A	0	1	?		**X**	**X**	**X**
OxiDate 2.0 *(hydrogen dioxide, peroxyacetic acid)*	128 fl oz/100 gal water (curative)	0	Until spray has dried	?, --, 3	Apply 30 – 100 gallons spray solution per treated acre. Apply first 3 treatments using curative rate at 5-day intervals. Reduce rate to 32 fl oz/100 gal water and maintain 5-day interval for preventative treatment.	**X**	**--**	Hydrogen peroxide products effective in 0/1 trial.

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Trade Name (*active ingredient*)	Product Rate	PHI (days)	REI (hours)	Efficacy[1]	Comments	Botrytis*	Anthracnose*	Mummy berry*
OTHER								
OxiDate Broad Spectrum (*hydrogen dioxide*)	128 fl oz/100 gal water (curative)	0	Until spray has dried	?	For curative treatments, use 128 fl oz /100 gallons of water and apply 30-100 gallons spray solution/A for one to three consecutive days and continue treatments on five to seven day intervals.	X	--	--
	32 fl oz/100 gal water (preventative)				For preventative treatments, apply first three treatments using curative rate at five day intervals. After the third treatment, reduce the rate to 40 fl oz/100 gallons of water, applying 30-100 gallons of spray solution per acre and maintain five day interval spray cycle until harvest.			
PERpose Plus (*hydrogen peroxide/dioxide*)	1 fl oz/gal (initial/curative)	-	Until spray has dried	?, 3, --	Hydrogen peroxide products effective in 0/1 trial. For initial or curative use, apply higher rate for 1 to 3 consecutive days. Then follow with weekly/preventative treatment	X	X	--
	0.25-0.33 fl oz/gal (weekly/ preventative)				For weekly or preventative treatments, apply lower rate every five to seven days. At first signs of disease, use curative rate then resume weekly preventative treatment.			
Sil-MATRIX (*potassium silicate*)	0.5-1% vol/vol	0	4	?	Apply 50-250 gals spray per acre. Repeat applications no sooner than every 7 days.	X	--	--

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