



Organic Small Fruit Disease Management Guidelines

Integrated Management of Bramble Diseases

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Introduction

Disease management strategies are very similar for both organic and conventional small fruit production systems in the Midwest. In both systems it is important to develop and use an integrated disease management program that integrates as many disease control methods as possible, the more the better. Major components of the disease management program include: **use of specific cultural practices; developing knowledge of the pathogen and disease biology, use of disease resistant cultivars, and timely application of organically approved fungicides or biological control agents or products when needed.** These guidelines have been written for caneberries (raspberry and blackberry), strawberry, blueberry and grape. Specific information is provided for each crop in its respective chapter. Most disease control methods or strategies are identical for both conventional and organic production systems. Perhaps the greatest difference between organic and conventional production systems is that organic growers are not permitted to use synthetic "conventional" fungicides. If disease control materials are required in the organic system, growers are limited to the use of "inorganic" fungicides such as sulfur (elemental sulfur and lime-sulfur) or copper fungicides (Bordeaux mixture and fixed copper products). In addition, there are several new "alternative" disease control materials and biological control products that are currently available and are cleared for use in organic production.

There are several problems associated with the use of these inorganic fungicides and "alternative" products in small fruit disease control programs. Among the most important are 1) **Phytoxicity**, which is the potential to cause damage to foliage, fruit set and fruit finish (this is a concern primarily with copper and sulfur fungicides); and 2) **their limited spectrum of fungicide activity**, which means they may not be capable of providing simultaneous control of the wide range of fungal pathogens that can cause economic damage to the crop. For example, sulfur is highly effective for controlling powdery mildew on most fruit crops, but provides little or no control of most other diseases.

In a climate like the Midwest, environmental conditions during the growing season are generally very conducive (warm and wet) to the development of several important diseases, insect pests and weeds. Limitations in relation to which pesticides may or may not be used, present the organic grower with some unique and very demanding challenges. Whereas the use of various cultural practices and disease resistance will be the "back bone" of the organic disease management program, the limited use of organically approved pesticides or biocontrol agents will probably be required at times.

Integrated Management of Bramble Diseases

An integrated disease management program for controlling raspberry and blackberry diseases integrates the use of all available control methods into one program. The use of organically approved fungicides or biological control agents for control of several important diseases can be a major part of the overall disease management program, but the use of various cultural practices is perhaps even more important in obtaining effective disease control. An effective disease management program for brambles must emphasize the integrated use of specific cultural practices, knowledge of the pathogen and disease biology, disease resistant cultivars, and timely applications of organically approved fungicides or biological control agents or products when needed.

The objective of the disease management program is to provide a commercially acceptable level of disease control on a consistent (year-to-year) basis, with minimal fungicide use.

Identifying and Understanding the Major Bramble Diseases

It is important for growers to be able to recognize the major bramble diseases. Proper disease identification is critical to making the correct disease management decisions. In addition, growers should develop a basic understanding of pathogen biology and disease cycles for the major bramble diseases. The more you know about the disease, the better equipped you will be to make sound and effective management decisions.

The following literature contains color photographs of disease symptoms on brambles as well as in-depth information on pathogen biology and disease development. These publications also contain excellent color photographs and information about insect pests as well.

Compendium of Raspberry and Blackberry Diseases and Insects

Published by the American Phytopathological Society, 3340 Pilot Knob Rd., St. Paul, MN 55121. Phone: 612-454-7250. (1-800-328-7560). This is the most comprehensive book on bramble diseases and insects available. All commercial growers should have a copy.

Bramble Production Guide

This is a comprehensive book covering most phases of bramble production. It can be purchased from: Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853. Phone: 607-255-7654.

Brambles: Production, Management and Marketing

Bulletin 783 of Ohio State University Extension, can be obtained from Ohio State University Extension Publications Office, 385 Kottman Hall, 2021 Coffey Rd., Columbus, OH 43210-1044. Phone 614-292-1607

If the virus is transmitted by nematodes, the nematodes must be controlled in order to control the disease. Have the soil tested for plant parasitic nematodes before planting. Samples should be taken in July of the year preceding planting. Spring samples, taken when soils are cold, are not accurate and do not give the grower sufficient time to apply a preplant nematicide. Information on collecting soil samples and submitting them for analysis is available from your Extension service.

Use of Disease-Resistant Cultivars

In an organic disease management program where emphasis is placed on reducing overall fungicide use, it is essential to identify any available disease resistance and use it. Unfortunately, resistance to most of the major diseases is not available in most commercially grown raspberry and blackberry cultivars in the Midwest. Thus, the disease management program must rely mainly on the use of cultural practices and efficient fungicide use. Whereas resistant cultivars are not generally available for most diseases, cultivars do vary greatly in their level of susceptibility to certain diseases. If resistance is not available, those cultivars that are highly susceptible to important diseases should at least be avoided.

Disease resistance varieties

Phytophthora Root Rot

Phytophthora root rot is most serious on red raspberries and some of the hybrids. The black raspberry varieties 'Cumberland' and 'Munger' are reported to be susceptible. The cultivars 'Bristol', 'Dundee' and 'Jewel' appear to be moderately to highly resistant. Among red raspberry cultivars, none are immune to the disease, but cultivars do differ greatly in their level of susceptibility. Among varieties grown in the Midwest and Northeast, 'Titan' and 'Hilton' are extremely susceptible, with 'Festival', 'Heritage', 'Reveille', and 'Taylor' moderately to highly susceptible. 'Newburgh' is somewhat resistant, and 'Ratham', 'Boyne', 'Killarney', and 'Nordic' are considered to be fairly resistant.

Verticillium Wilt

Red raspberries are more tolerant than black raspberries. 'Cuthbert' and 'Syracuse' appear to be resistant under field conditions. Black raspberries are highly susceptible. Blackberries are susceptible, but the disease is seldom a serious problem.

Orange Rust

Red raspberries are immune. Other brambles are susceptible. Of blackberries, 'Eldorado', 'Raven', 'Snyder', and 'Ebony King' are reported to be resistant. The Arkansas erect types (Arkansas Indian series) are reported to be resistant to orange rust.

Virus Diseases

Mosaic Virus

Blackberries are resistant. Black and purple raspberries are more severely affected than red raspberries. Of the purple or black raspberries, 'New Logan', 'Bristol', and 'Black Hawk' are tolerant and 'Cumberland' is susceptible. The red raspberries 'Milton', 'September', 'Canby', and 'Indian Summer' are resistant because the aphid vectors of the virus avoid them.

Leaf Curl Virus

Blackberries are symptomless. All raspberries are susceptible.

Tomato Ringspot Virus

Red raspberries and blackberries are susceptible.

Raspberry Streak

Black and purple raspberries are susceptible.

Cultural Practices for Disease Control in Brambles

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. Cultural practices are the major means of control for several important bramble diseases. The following practices should be carefully considered and implemented whenever possible in the disease management program.

Use Virus-Indexed Planting Stock

Always start the planting with "Healthy" virus-indexed nursery stock from a reputable nursery. The importance of establishing plantings with virus-indexed nursery stock

cannot be overemphasized, since the selection of planting stock and planting site are the only actions a grower can take to prevent or delay the introduction of most virus diseases. Plants obtained from an unknown source or neighbor may be contaminated with a number of pathogens that experienced nurserymen work hard to control.

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.

Previous Cropping History - Avoid establishing plantings on sites that have a previous history of problems with Verticillium wilt, either in previous plantings of brambles or other susceptible crops. In general, it is not a good practice to plant brambles immediately after solanaceous or other Verticillium-susceptible crops, such as tomatoes, potatoes, peppers, eggplant, melons, strawberries and other related crops. Certain common weeds, such as black nightshade, redroot pigweed, lamb's-quarters, and horsenettle will also support growth of the Verticillium fungus, and fields with a high population of these weeds should also be avoided. This is particularly important if Verticillium wilt is known to have been a problem on the site in the past. The fungus that causes Verticillium wilt

can survive in soil for very long periods of time (at least 14 years in California). If a site is known to have had a problem with Verticillium wilt within the last 5 to 10 years it should probably not be used for establishing plantings of Verticillium-susceptible bramble cultivars unless the soil is fumigated before planting.

Most brambles are susceptible to Verticillium wilt and when the disease becomes established within the planting, it can be devastating. Resistance to Verticillium wilt in the cultivars currently grown in the Midwest is not available. In general, black raspberries are significantly more susceptible than red raspberries, and (in general) blackberries are the least susceptible.

If the site has a previous history of Phytophthora root rot, either in previous bramble plantings or other perennial fruit crops, it should probably be avoided. Phytophthora spp. (like Verticillium) can also survive in soil for extended periods of time. It is important to remember that Phytophthora root rot is usually associated with poorly drained (wet) sites and improving soil drainage is one of the principal means of control.

If nematodes have been a problem in previous crops or they are suspected to be a problem on the site, a soil analysis to determine the presence of harmful nematodes should be conducted. Nematodes are most likely to be a problem on the lighter (sandy) soils. Nematode sampling kits and instructions on taking samples can be obtained through your Extension office. Infested sites may be treated with an approved nematicide before planting if sampling indicates a need to do so.

Proximity (closeness) to established bramble plantings and wild bramble plants -

Ideally, a new planting should be isolated as far as possible from old established plantings or wild bramble plants that serve as reservoirs for diseases and other pests. The benefits of using virus-indexed plants to establish a new field are greatly reduced if the fence row around the planting or a woods directly adjacent to the planting contains wild, virus-infected or orange rust-infected plants. The same is true if a new planting is established next to an old planting that has disease problems.

Currently no information is available on exactly how far away from an established planting or weeded area is "Far enough". The distance of 600 to 1000 feet is used commonly in Extension literature; similarly, the New York State virus certification program requires that nurseries in the program use a minimum distance of 1,000 ft. It is probably safe to say "The farther the better".

Crop Rotation (Replanting Brambles)

When replanting brambles on the same site, the practice of crop rotation must be considered. Due to the build up and persistence of soilborne plant pathogens, replanting brambles on the same site is not recommended without the use of crop rotation. Soil fumigation is not an option in organic production systems.

At present, data describing how long a rotation is required before replanting brambles on the same site is not available. In fact, this requirement is probably different for every different planting site. Once again, the safest recommendation is probably "the longer, the better", particularly if the site has a history of soilborne diseases.

All soilborne diseases, however, are not the same. For instance, Verticillium wilt generally becomes a problem only after populations of the Verticillium fungus slowly build up to high levels. Thus, if no brambles or other susceptible crops are grown for a suitable period (probably at least 5 years), the fungus population declines and brambles can be reintroduced and grown for a number of years before the population builds back up to damaging levels. This same principle is true for many harmful nematodes, but it is not true for Phytophthora root rot. The Phytophthora fungi reproduce very rapidly under proper environmental conditions, so even a low population can rebuild to damaging levels within one or two seasons.

Crop rotation will not eliminate all problems associated with soilborne diseases. It should always be integrated with other control measures, such as the choice of resistant or partially-resistant cultivars, improvements in drainage, etc. Where other control measures cannot be used (for instance, the site cannot be adequately drained), it is not advisable to replant brambles.

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. Furthermore, some disease-causing organisms (Verticillium wilt fungus, crumbly berry virus) can build up on certain broadleaf weeds in the planting. 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 fungi that cause anthracnose, cane blight, spur blight, Botrytis fruit rot, cane and leaf rust and several other important diseases overwinter 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 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: *Bramble Production Guide*, edited by 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.

Inspect the Planting Frequently and Rogue Out (Remove) Diseased Plants

Plants showing symptoms of virus diseases, rosette, or orange rust must be removed and destroyed immediately, including the roots, whenever they are found. These plants may bear fruit, but it will be of poor quality. The longer these plants remain, the greater the chances that other plants will become infected. Viruses and the orange rust fungus are systemic and can move to adjacent plants via root grafts. Because of this possibility, use a

flag to mark the locations where diseased plants are removed so the adjacent plants can be checked frequently for new symptoms.

For **orange rust**, it is particularly important to inspect the planting early in the growing season. The planting should also be inspected on a routine basis (at least once a week) from the time growth starts in the spring through harvest. New leaves of early spring growth on orange rust infected plants are chlorotic (yellowish), shoots are bunched and spindly. They are easy to identify in the spring. It is important that infected plants be identified and removed prior to the development of the "Orange rust" pustules on the leaves. If these pustules are allowed to develop, they will produce large numbers of aeciospores which will spread the disease. If infected plants are not removed early in the spring, they become more difficult to identify later in the growing season.

Early spring is also a good time to inspect for virus diseases. Symptom expression of many viruses is more obvious during cool growing conditions. The higher temperatures of mid-to late summer often reduce virus symptoms making infected plants difficult, if not impossible, to detect.

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. Cane blight and bacterial crown gall are two important pathogens of brambles that enter the plant almost exclusively through wounds. 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 post harvest 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 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

Disease control considerations	Viruses ^a	Verticillium wilt	Orange rust	Cane blights ^b	Powdery mildew	Fruit rot
Good air/water drainage	-	-	-	++	+	++
500+ ft from wild brambles	++	-	-	-	-	-
Rotation	+ ^c	++ ^d	-	-	-	-
Cultivar tolerance or resistance	++ ^e	++ ^f	++ ^g	-	+	-
Avoid adjacent plantings	++ ^j	-	++	-	+	-
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	-	-	++	++ ^h	++ ⁱ	-
Harvest before overripe	-	-	-	-	-	++
Fruit storage conditions	-	-	-	-	-	++

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

^a Viruses: Mosaic (rasp.), Leaf Curl (raspberry, with blackberry symptomless), Ringspot (red raspberry), and Streak (purple and black raspberry).

^b Cane blights: anthracnose, cane blight, spur blight, and Botrytis blight.

^c Rotation effective for ringspot virus only; 2 years of grass crop (e.g. corn) with excellent weed control before planting red raspberry should eliminate need to fumigate for *Xiphinema*, a nematode vector.

^d Rotation for *Verticillium* wilt: Avoid fields planted to susceptible crops (tomatoes, potatoes, eggplant, peppers, strawberries, raspberries, stone fruit) within the past 5 years. Avoid fields with history of *Verticillium* wilt unless soil is fumigated.

^e Virus resistance, tolerance, and immunity: Mosaic-Blackberries are not affected; black and purple raspberries are more severely affected than red raspberries. Of purple and black raspberries, "New Logan", "Bristol", and "Black Hawk" are tolerant; "Cumberland" is susceptible. Of red raspberries, "Milton",

"September", "Canby", and "Indian Summer" are Resistant because aphid vectors avoid them. Leaf Curl-Blackberries are symptomless; all raspberries are affected. Tomato Ringspot-Red raspberries are affected. Streak - Black and purple raspberries are affected.

^f Verticillium tolerance: Most blackberries are resistant; red raspberries are more tolerant than black raspberries. "Cuthbert" and "Syracuse" red raspberries appear to be resistant under field conditions.

^g Orange Rust resistance: Red raspberries are immune. Other brambles are affected. Of blackberries, "Eldorado", "Raven", "Snyder", "Ebony King", "Choctaw", "Commanche", "Cherokee", and "Cheyenne" are reported resistant.

^h Fungicide program for cane blights: The lime-sulfur spray (delayed dormant) is most important for anthracnose and cane blight.

ⁱ Fungicide program for powdery mildew: Sulfur will provide good control of powdery mildew.

^j Keep blacks and purples away from reds because mosaic virus can spread from reds and is more severe on blacks and purples; Keep all reds away from blackberries because blackberries can be a symptomless carrier of leaf curl

Fungicide use strategies for organic production

Unfortunately, there are not many options to choose from when one considers current fungicide use strategies. The current options are:

1. Do Not Use Fungicides

This is always an option, but may not be a wise decision for commercial grape plantings in the Midwest. This option should not be confused with "organic" production. Grape growers in "organic" production systems will most probably use Sulfur or Copper to some extent for disease control. Sulfur and Copper are fungicides. Growers that choose not to use fungicides must rely completely on cultural practices, disease resistance, or biological control agents or products for disease control. For strawberries, caneberries and blueberries organic fungicides are often of little value against the more common diseases such as Botrytis fruit rot (gray mold); therefore, little or no fungicide will probably be used in organic production of these crops.

2. Protectant Fungicide Program

In a protectant program, fungicides are used as a protective barrier on the plant surface. This chemical barrier prevents the fungus from entering the plant. It works much like paint on a piece of wood to keep out water. Protectant fungicides (such as sulfur and copper) are not systemic and cannot move into plant tissues. Once the fungus penetrates into the plant, protectant fungicides will not control it. As the protective barrier breaks down or new foliage is produced, additional applications are required to maintain the protective barrier.

Protectant fungicide programs have been, and still are very effective; however, they generally result in a fairly intensive use of fungicide. On grapes, protectant fungicides are usually applied on a 7-10 day schedule early in the growing season and on a 10-14 day schedule later in the season. Obviously, maintaining a protective barrier on the plant surface throughout the growing season requires several applications.

The following is a brief description of some disease control materials that are commonly or traditionally used in organic production systems. Copper fungicides, elemental sulfur and liquid lime sulfur are the old “standard” fungicides, and have been used for many years in organic production systems.

Note: Prior to using any material in the organic system, it is important that the grower consult his/her organic certification agency or program to be positive that use of the material is permitted.

Copper Fungicides

When different formulations of copper are dissolved in water, copper ions are released into solution. These copper ions are toxic to fungi and bacteria because of their ability to destroy proteins in plant tissues. However, because copper can kill all types of plant tissues, the use of copper fungicides carries the risk of injuring foliage and fruit of most crops. Factors promoting this injury include: 1) the amount of actual copper applied, and 2) cold, wet weather (slow drying conditions) that apparently increases the availability of copper ions and, thus, increases the risk of plant injury. Because of the potential to injure plants and to accumulate in soil, the use of copper fungicides in conventional production systems has largely been replaced with conventional fungicides that are generally safer to plant tissues and often more effective.

Several terms are used when discussing copper as a fungicide. The original material used was copper sulfate (also known as blue vitriol or bluestone). When this material was combined with lime in the French vineyards, the combination became known as Bordeaux mixture.

Bordeaux Mixture

Bordeaux mixture is a mixture of copper sulfate and hydrated lime in water. It has long residual action and has been used for years to control many diseases, including downy mildew and powdery mildew of grape. It can be made (mixed) on site by combining copper sulfate with spray grade lime. It is also commercially available as a dry wettable powder.

Fixed Copper Fungicides

Following the discovery and use of Bordeaux mixture, several relatively insoluble copper compounds or fixed coppers were developed. Fixed copper formulations release less copper ions and are generally less injurious to plant tissues (safer to use) than Bordeaux mixture, but their use is still limited because of their potential to injure plants and lack of compatibility with other pesticides. Some of the more common commercial formulations of fixed copper include C-O-C-S, Kocide 101, Tribasic Copper sulfate, Champ, and Tenn-Copp 5E. There are several fixed copper fungicides registered for use on small fruit.

Sulfur Fungicides

Sulfur is available as liquid lime sulfur and as dry wettable powders or liquid (flowable) formulations of elemental sulfur.

Liquid Lime Sulfur

Liquid lime sulfur can be used at high concentrations as a dormant spray on raspberries and blackberries for control of cane blight, spur blight and anthracnose and on grapes for control of anthracnose. At high concentrations, it should be used only when plants are dormant. It can cause severe damage if applied after green foliage appears. Lime sulfur has a foul odor that many people dislike. It is also registered for use on grapes and caneberries as a more dilute concentration for use during the growing season.

Dry Wettable Sulfurs or Flowable Sulfurs

Sulfur for use as a fungicide is available under many trade names. The microfine wettable sulfurs or flowable sulfurs are usually much less injurious to foliage and fruit than liquid lime sulfur, but their use during hot weather (above 85°F) may result in some leaf burning and fruit damage. Sulfur fungicides are very effective for control of powdery mildew on most fruit crops, but are not highly effective for control of most other fruit crop diseases. Sulfur is very toxic to foliage of certain grape varieties (mainly American grapes) including Concord, Chancellor, DeChaunac and Foch. Sulfur is relatively safe on most other varieties see Table 6, page 68. Applications after the fruit begins to ripen may pose problems during fermentation if the grapes are intended for wine making.

Growers should note that sulfur is lethal to some beneficial insects, spiders and mites. These beneficial insects are natural predators of harmful insects and mites that affect fruit crops. Killing these beneficial insects may increase certain pest problems, especially mites.

Specific comments on fungicide use will be made in the text for each crop where applicable.

“New Alternative” Disease Control Materials for Small Fruit

Many products are currently available or currently being introduced as “biological control agents” or “biopesticides”. These include living microorganisms, “natural chemicals such as plant extracts, and “plant activators” that induce resistance in plants to disease. For most of these products, independent evaluations are currently being conducted; however, their effectiveness under moderate to high disease pressure is uncertain. Although many of these new products have great potential for use within organic production systems, their effectiveness needs to be determined in field tests. It is important to remember that registration of these materials for control of a specific disease on a crop is no guarantee that they will provide effective control under moderate to heavy disease pressure. In addition, many products may be effective for only one or a few diseases and most have very limited residual activity (they have to be applied often). It is also important to remember that these are registered pesticides and growers need to be certain that their use is permitted within their organic certification program.

The biological control committee of the American Phytopathological Society has developed a web page for “**Commercial Biocontrol Products Available for Use Against Plant Diseases**”. The web page address is: www.oardc.ohio-state.edu/apsbcc/productlist.htm. This web page lists all the products currently available along with information such as registered crops and diseases controlled. It also lists the name of the company that manufactures or distributes the product along with phone numbers and web site addresses. This site is updated regularly and is a valuable resource for growers interested in these products.

The following are a few of the most common “alternative disease control products currently registered for use on small fruit.

- **AC10** (*Ampelomyces quisqualis*) is a biofungicide registered for control of powdery mildew in grapes, strawberries, blueberries, raspberries, currants, and gooseberries. *A. quisqualis* is a fungus, that parasitizes powdery mildew fungi. Preliminary results in grapes in Michigan show moderate disease control. Adding an adjuvant such as Nufilm (0.02% v/v) enhances its efficacy. Application should start as soon as susceptible tissue becomes available and continue on a 7 to 14 day schedule. A minimum of 2 sequential applications if needed to maintain the population of *A. quisqualis*. The following chemicals cannot be tank-mixed with AQ10: sulfur and potassium salts of fatty acids.
- **Armicarb 100** (potassium bicarbonate=baking powder) is a reduced-risk, protectant (contact) fungicide. Armicarb 100 is registered for control of powdery mildew and other diseases in grapes, blueberries, strawberries, and brambles. Preliminary results in grapes in Michigan indicate moderate control of powdery mildew. Start applications at the first sign of disease and continue on a 7-14 day schedule. The preharvest interval (PHI) on all crops is 0 days.
- **Galltrol** (*Agrobacterium radiobactor* strain 84) is a biological control product for control of crown gall, caused by *Agrobacterium tumifaciens* on several tree fruit and nut crops. The active ingredient is the bacterium, *Agrobacterium radiobactor*

- strain 84. On small fruits it is effective for control of crown gall on raspberry and blueberry. It is not effective for controlling crown gall on grapes. It is purchased as a pure culture grown on agar in petri plates. The bacterial mass from one plate is diluted into one gallon of non-chlorinated water and plants are treated with a pre-plant dip in the solution or as a soil drench.
- **Kaligreen** (potassium bicarbonate = baking powder) is a reduced-risk protectant (contact) fungicide. Kaligreen is registered for control of powdery mildew on grapes, strawberry, brambles (raspberry and blackberry) and blueberry. It provides good control of powdery mildew when applied on a frequent-protectant program of 7 to 10-day intervals. It has little or no efficacy against most other fungal diseases on small fruit. It is formulated as a micro-encapsulated powder that is mixed in water and sprayed directly on the crop. Kaligreen has a preharvest interval (PHI) of 1 day on all small fruit crops.
 - **Messenger** (harpin) is a reduced risk product registered for use on grapes, blueberries, cranberries, strawberries, brambles, and currants. The active ingredient is derived from a protein produced by certain bacteria. This protein stimulates natural plant defenses. Messenger has no direct effect on pathogens. The efficacy of this material for disease control or suppression has not been sufficiently confirmed. Messenger has a 0 day PHI.
 - **Mycostop** (*Streptomyces griseoviridis* strain K61) is a biocontrol product registered for use on all fruit crops for control of several important pathogenic fungi that cause seed, root, and stem rot and wilt diseases. The active ingredient is the bacterium, *Streptomyces griseoviridis* strain K61. It is sold as a powder formulation that is mixed with water and applied as a spray or a drench.
 - **Oxidate** (hydrogen dioxide) is a broad-spectrum bactericide/fungicide registered for use in grapes, blueberries, cranberries, strawberries, and brambles. It is a rather corrosive material and works by oxidizing fungal and bacterial cells. The efficacy of the material for disease control has not been sufficiently confirmed on several diseases. In one Ohio fungicide evaluation, it provided no control of grape black rot.
 - **Serenade** (*Bacillus subtilis*) is a biocontrol product registered for control of powdery mildew, Botrytis bunch rot and sour rot in grapes. Serenade is also reported to provide some suppression of downy mildew. This product needs further evaluation, but preliminary results show a moderate level of control of Botrytis bunch rot and powdery mildew. Serenade did not control grape black rot in Ohio. Good coverage is important for control. Applications are recommended on a 7-10 day schedule. Serenade has no maximum seasonal application rate and has a 0 day PHI.
 - **Trichodex** (*Trichoderma harzianum*) is a biofungicide registered for use on all small fruit crops for control of a wide range of diseases, but primarily for control of Botrytis fruit rot. It is sold as a wettable powder formulation that is mixed with water and sprayed directly onto the plants.
 - **Trilogy** (Clarified Hydrophobic Extract of Neem Oil). The label states that Trilogy is a broad spectrum fungicide of certain diseases and controls mites in citrus, deciduous fruits and nuts, vegetable crop, cereal grains and other miscellaneous crops. The label does not state what diseases are controlled on

specific crops. Trilogy is registered for use on grapes, strawberry, brambles (raspberry and blackberry), and blueberry. Trilogy is a liquid that is applied for diseases as a 1% solution in sufficient water to achieve complete coverage of the foliage.

As the efficacy of these new materials is tested and validated, they will be included in these guidelines where appropriate.

Efficacy of Disease Control Materials

for Powdery Mildew

Powdery mildew is different from most other plant diseases caused by fungi, because the fungus that causes it lives almost entirely on the surface of infected plant parts. The fungus may penetrate only one cell layer deep into the plant. Thus, it is exposed to eradication following topical treatment with a range of products that do not affect many other pathogenic fungi that colonize deeper into infected plant tissues. Research in New York and other locations has demonstrated that many new and “alternative materials can provide effective control of powdery mildew if applied often enough (7 day schedule) through the growing season. These

materials burn out the fungus growing on the surface, but do not provide protection against new infections; thus, repeated applications are important. These materials include: Nutrol (manopotassium phosphate); Kaligreen and Armicarb (potassium bicarbonate-baking soda); oils such as Stylet Oil and Trilogy; and dilute solutions of hydrogen peroxide (Oxidate).

Unfortunately, these materials have little or no effect on many other small fruit diseases. In addition, organic growers need to consult with their certification agency or program to be sure that any material they use is “certified” or acceptable as organic.

Organic Fungicides for Bramble Disease Control

Liquid Lime Sulfur

Lime sulfur is recommended for use on brambles as a delayed-dormant application in early spring (when buds show 1/4 inch green). It is used at the rate of 10-20 gal per acre. If applied at this rate later in the season (after 1/4 inch green) it can cause severe damage to leaves and young canes. Lime sulfur is recommended for control of the cane infecting fungi (anthracnose, cane blight and spur blight). The delayed dormant application in spring is intended to eliminate or reduce the overwintering inoculum for these diseases on canes. Where cane diseases are a problem, this spray is very important. Where good sanitation is used, (old fruited and

infected canes are removed from the field) and cane diseases are not a problem, the need for this spray may not be necessary, or at least it would probably be safe to use the lower rate, especially on red raspberries.

Lime sulfur has a bad smell (rotten eggs) so there can be a problem spraying it around your neighbors. Some growers have received complaints from neighbors after applying lime sulfur. In addition, lime sulfur is very caustic. It is harmful to machine parts, paint (especially on cars) and sprayers. Special care should be taken to avoid drift to nontarget objects and proper protective clothing should be worn by the applicator.

Copper Fungicides

If a dormant application of fungicide is required, and lime sulfur cannot be used, Bordeaux mixture or a fixed copper fungicide can be used in its place. Although lime sulfur is the proven material, dormant sprays of copper should provide some level of control. The use of copper in the growing season (after leaves are present), could result in significant plant damage.

Sulfur

Sulfur is available as a wettable powder or in flowable formulations. Sulfur is registered for control of powdery mildew. Sulfur has little or no activity against the other bramble diseases caused by fungi. Because powdery mildew is generally not a serious problem in the Midwest, sulfur is of little importance within the bramble disease management program.

There are several biocontrol products available for control of Botrytis fruit rot. Their efficacy under moderate to severe disease pressure needs to be determined.