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, a high level of 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 at least should be avoided.

Notes on Disease Resistance

Phytophthora Root Rot

Phytophthora root rot is most serious on red raspberries and some of the hybrids. The black raspberry cultivars 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 cultivars 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 Latham, 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. It is important to remember that many diseases, such as viruses, cannot be controlled with fungicides. Thus, cultural practices are the major means for their control. When fungicides are used, certain cultural practices, such as maintaining narrow row width or cane thinning to open the plant canopy, will greatly increase the efficacy of the fungicide program by allowing better spray penetration and promoting faster drying of susceptible plant parts. The practices described in the next section 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 a neighbor may be contaminated with a number of pathogens that experienced nurserymen work hard to control.

Select the Site Carefully

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 considerations discussed here 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 air circulation and rapid plant drying.

The primary reason for these previously mentioned 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 horse nettle 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 five 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 if 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 1,000 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."

Consider 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 soil-borne 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 soil-borne diseases.

All soil-borne 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 five 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 soil-borne 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.

Manage the Plant Population and Canopy

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 more than 2-feet wide and should contain about three or four 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, this book is very useful: ***Bramble Production Guide,*** edited by Marvin Pritts and David Handley. It can be purchased from the 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 by means of 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), and 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 aecio-

spores 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 practices described in this section 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.

- 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.
- 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.
- It is highly desirable to combine harvesting and packing into one operation. This prevents unnecessary handling and additional physical injuries.
- 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.
- Pick into shallow containers. Ideally, fruit should be no more than three to four berries deep; this greatly reduces bruising and crushing the fruit, which results in juice leakage that encourages the development of fungal fruit rots.
- 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.
- 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.

- 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.

Fungicides for Bramble Disease Control

Fungicides can play an important role in the bramble disease-management program. However, in order to obtain maximum benefits with minimal use, fungicides must be integrated with the use of the previously described cultural practices and resistant or less susceptible cultivars. Several important bramble diseases cannot be controlled with fungicides. These include Verticillium wilt and all of the virus diseases. On the other hand, fungicides can be a very effective component in control programs for Botrytis fruit rot (gray mold), powdery mildew, Septoria leaf spot, raspberry leaf spot, anthracnose, cane blight, Phytophthora root rot, and rust diseases.

Although fungicides are an important disease management tool, **relatively few** fungicides are currently labeled for use on brambles in the United States. The lack of currently registered fungicides combined with the fact that several important diseases cannot be controlled with fungicides makes the diligent use of cultural practices within the disease-management program **extremely important.** The content presented here is intended to provide some general information about the currently registered fungicides. It is always the growers' responsibility to read and follow all label instructions. Regulations and recommendations can **change rapidly**; therefore, the information contained here could change before you read it.

Cabrio 20EG

Cabrio is registered for control of anthracnose, spur blight, leaf spot, powdery mildew, and rust on brambles. Cabrio provides good to excellent control of all these diseases and provides some suppression of Botrytis fruit rot (gray mold). It is used at the rate of 14 oz per acre and can be applied up to and including the day of harvest; however, the re-entry interval for Cabrio on brambles is 24 hrs. No more than four applications can be made per season, and no more than two sequential sprays can be made without alternating to a fungicide with a different chemistry in order to prevent the development of fungicide resistance.

Pristine 38WG

Pristine 38WG fungicide is registered for use on all brambles (blackberry and raspberry) for control of anthracnose, Botrytis gray mold, leaf spots, powdery mildew, rust diseases, and spur blight. Pristine is a combination of two active ingredients (pyraclostrobin and boscalid). It cannot be applied more than four times per season and has a 0-day preharvest interval. Pyraclostrobin is the same material as in Cabrio (strobilurin fungicide); thus, Cabrio and Pristine cannot be alternated with each other in a fungicide resistance management program. For control of rust diseases, Cabrio and Pristine should be alternated with Nova to prevent fungicide resistance development.

Captan 50WP, 80WP, and Captec 4L

In 1995, Ohio received a special local need (24-C) label for the use of Captan 50WP and 80WP on brambles. This registration is good for Ohio only. For information about the use of Captan on brambles in Ohio, contact Mike Ellis at 330-263-3849. Contact your local Extension office for up-to-date information on the status of Captan.

Captan 80WDG

Several changes and additions have occurred on the Captan 80WDG label. These changes have not been made on any other formulations of Captan to date (Captan 80W, Captan 50W, and Captec 4L). However, these changes are in the registration process and should be made soon on other formulations.

Blackberries, raspberries, and dewberries have been added to the label. Ohio has a 24-C registration for the use of Captan 50W and Captan 80W. The 24-C registration is not needed for use of the Captan