New England

Small Fruit Pest Management

Guide

Managing Diseases, Insects and Weeds in Small Fruit Crops

2010-2011

New England Vegetable & Berry Growers Association
University of Connecticut
University of Maine
University of Massachusetts
University of New Hampshire
University of Rhode Island
University of Vermont
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NEW ENGLAND
SMALL FRUIT PEST MANAGEMENT GUIDE
2010-2011

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General Information

This guide is intended for commercial farmers to provide information on pest management practices for small fruit crops in New England. Both chemical and non-chemical pest control measures are suggested. Whenever possible, the use of integrated pest management (IPM) practices is encouraged. General concepts of IPM are described in the "About Pest Management" section of this guide. Contact your state small fruit or pest management specialists for details regarding specific crops.

All pesticides listed in this publication are registered and cleared for suggested uses according to federal and state regulations in effect on the date of this publication. Pesticide labels are constantly changing, however. It is still required that applicators read the labels carefully before application to be sure of restrictions and rates.

Trade names are used for identification only; no product endorsement is implied, nor is discrimination intended against similar materials.

The user of this information assumes all risks for personal injury or property damage. If the information in this guide does not agree with the current labeling, follow the label instructions. The label is the law.

WARNING! Pesticides are poisonous. Read and follow all direction and safety precautions on labels before using. Handle pesticides carefully and store out of reach of children, pets, and livestock. Dispose of empty containers immediately in a safe manner and place. Contact your state Department of Agriculture for current regulations.

Berry Crops at a Glance

Below are some vital statistics relevant to several small fruit crops. Many factors including site suitability, time commitment and market strategies will have to be thoroughly researched before entering into a small fruit enterprise. Consult with local growers, Extension Specialists, and others to help determine the suitability of a small fruit enterprise. Books and guides can also be very helpful in answering questions about small fruit production. See the resource list at the end of this guide for some useful books and guides.

Soil Fertility Management

Soil and Tissue Testing

Soil tests provide the best way to determine lime and fertilizer requirements for phosphorus and potassium. Leaf tissue or petiole analysis is the best way to determine nutrient status for nitrogen and minor nutrients. With the information from these tests, the grower can make informed decisions about fertilizing and liming small fruit crops. This is important for cost effectiveness and to achieve optimum yield and quality and to safeguard water quality. Following is a list of soil test laboratories in New England. It is best to use local labs because they are calibrated for local soils and recommendations are tailored to New England conditions.

Soil Testing Labs of New England
soil testing (1), leaf tissue analysis (2), compost testing (3), manure testing (4)

CONNECTICUT
Soil Nutrient Analysis Lab (1)
6 Sherman Place, Unit 5102
Storrs, CT 06269
Telephone: 860-486-4274
http://soiltest.uconn.edu/

MAINE
The Analytical Laboratory (1,2,3,4)
5722 Deering Hall, Room 407
Orono ME 04460-5722
Telephone: 207-581-2945
http://anlab.umesci.maine.edu

MASSACHUSETTS
Soil & Plant Tissue Testing Laboratory (1,2,3,4)
West Experiment Station/UMass
Amherst MA 01003
Telephone: 413-545-2311
www.umass.edu/soiltest

Table 1. General information for some small fruit crops.

	Strawberry	Summer Raspberry	Blackberry	Blueberry	Grape
Expected yield	10-20,000 lb/A	2-7,000 lb/A	3-7,000 lb/A	6-12,000 lb/A	6-12,000 lb/A
Age to maturity	2 years	3 years	3 years	6-8 years	3-4 years
Life of planting	5 years	8+ years	8+ years	30+ years	20+ years
Hardiness -35°F	-20°F	0°F	- 20°F	-15°F	
Optimal pH	5.5-6.5 (6.2)	5.8-7.0 (6.5)	5.5-7.0 (6.5)	4.2-5.2 (4.5)	5.5-7.0 (6.5)
Typical Spacing	1.5′ x 4′	3′ x 10′	4′ x 12′	5′ x 12′	8′ x 10′
Plants/Acre	7,260	1,452	908	726	550

NEW HAMPSHIRE
University of NH Analytical Services Lab (1,2,3,4)
Spaulding Hall, Room G28A, 38 Academic Way
Durham NH 03824
(603)862-3200
http://extension.unh.edu/agric/agpdts/soiltest.htm

VERMONT
UVM Agricultural & Environmental Testing Lab (1,3,4)
219 Hills Building, UVM
Burlington VT 05405
Telephone: 802-656-3030, 800-244-6402
http://pss.uvm.edu/ag_testing/

PRIVATE
Woods End Research Lab, Inc. (1,3,4)
290 Belgrade Rd., P.O. Box 297
Mt. Vernon, ME 04352
Telephone: 207-293-2457
http://woodsend.org/

Crop Production Services (1)
25 Elm St.
South Deerfield, MA 01373
Telephone: 413-665-2115
www.cropproductionservices.com/Farmcenter

Brookside Laboratories (1,2,3,4)
308 South Main St.
New Knoxville, OH 45871
Telephone: 419-753-2448
http://blinc.com

Spectrum Analytic (1,2,3,4)
1087 Jamison Rd.
Washingon Court House, OH 43160
Telephone: 800-321-1562
http://www.spectrumanalytic.com/

Taking a Soil Sample

Although soil samples can be taken any time, many prefer to take samples in summer or fall because this allows time to apply any needed lime and to plan a fertility program and order materials well in advance of the growing season. Avoid sampling when the soil is very wet or soon after a lime or fertilizer application. If a field is uniform, a single composite sample is sufficient. A composite sample consists of 10 to 20 sub-samples taken from around the field and mixed together. To obtain sub-samples, use a spade to take thin slices of soil representing the top six to eight inches of soil. (A soil probe is faster and more convenient to use than a spade.) Put the slices into a clean container and thoroughly mix. Take about one cup of the mixture, dry it at room temperature, put it in a sandwich type bag and tightly close it. Label each sample on the outside of the bag. For each sample, indicate the crop to be grown, recent field history and any concerns.

In many cases fields are not uniform. There are many reasons for this including: uneven topography, wet and dry areas, different soil types and areas with varying previous crop and fertilizing practices. In such cases, the field should be subdivided and composite samples tested for each section.

Soil testing laboratories vary somewhat in their services and prices. Soils should be tested for organic matter content every two or three years. Be sure to request this if it is not part of the standard test. For more information, check with your state's laboratory or Extension Specialist.

Cation Exchange Capacity

Cation exchange capacity (CEC) is an important measure of the soil's ability to retain and supply nutrients, specifically the positively charged nutrients called "cations." CEC is reported as milli-equivalents per 100 grams of soil (Meq/100g). Cations are attracted to negatively charged surfaces of small clay and organic matter particles called colloids. CEC can range from below 5 in sandy soils low in organic matter to over 20 in clay soils and those high in organic matter. A low CEC indicates and soil with little ability to store nutrients and one that is susceptible to nutrient loss through leaching.

Base Saturation

The cations calcium (Ca++), magnesium (Mg++), potassium (K+), hydrogen (H+) and aluminum (Al+++) normally account for nearly all cations adsorbed on soil particles. Ca++, Mg++ and K+ are bases which tend to raise soil pH while H+ and Al+++ are acidic and tend to lower the soil pH. If all the cations are basic and none are acidic there would be a 100% base saturation and the soil pH would be about 7 or neutral. In acidic soils there are acidic cations present and the percent base saturation is less than 100. Besides having sufficient quantities of Ca, Mg and K, it is important that they be in balance with each other because an excess of one of these can suppress the uptake of another. As a general rule a Ca:Mg:K ratio of about 20:4:1 is desirable. When expressed as percent base saturation, desired levels are Ca 65-80%; Mg 5-15%; and K 2-5%.

Soil pH and Liming

One of the most important aspects of nutrient management is maintaining proper soil pH. A pH is a measure of soil acidity. A pH above 7.0 indicates alkalinity and a pH below 7.0 indicates acidity. Most of our soils are naturally acid and need to be limed periodically for optimal growth of most small fruit crops with the exception of blueberries which require a pH of between 4.5 and 5.2. (See the table at the beginning of each crop section for the desired pH

range for each small fruit crop.) When the soil is acid, the availability of nitrogen (N), phosphorus (P), and potassium (K) is reduced; there are usually low amounts of calcium (Ca) and magnesium (Mg) in the soil; and there may be toxic levels of iron, aluminum and manganese present. Acid soil also reduces the effectiveness of some herbicides.

Besides raising soil pH, lime is the main source of Ca and Mg for crop nutrition. It is important to select liming materials based on Ca and Mg content with the aim of achieving desired base saturation ratios. If the Mg level is low, a lime high in Mg (dolomite) should be used. Lime high in calcium (calcite) is preferable if Mg is high and Ca is low.

The neutralizing power of lime is determined by its calcium carbonate equivalence. Recommendations are based on an assumed calcium carbonate equivalence of 100. If your lime is lower than this, you will need to apply more than the recommended amount, and if it is higher, you will need less. To determine the amount of lime to apply, divide the recommended amount by the calcium carbonate equivalence of your lime and multiply by 100. Your supplier can tell you the calcium carbonate equivalence of the lime you purchase.

The speed with which lime reacts in the soil is dependent on particle size and distribution in the soil. To determine fineness, lime particles are passed through sieves of various mesh sizes. A 10-mesh sieve has 100 openings per square inch while a 100-mesh sieve has 10,000 openings per square inch. Lime particles that pass through a 100-mesh sieve are very fine and will dissolve and react rapidly - within a few weeks. Coarser material in the 20- to 30-mesh range will react over a longer period, such as one to two years or more. Agricultural ground limestone contains both coarse and fine particles. About half of a typical ground limestone consists of particles fine enough to react within a few months, but to be certain you should obtain a physical analysis from your supplier. Super fine or pulverized lime is sometimes used for a "quick fix" because all of the particles are fine enough to react rapidly.

Lime will react most rapidly if it is thoroughly incorporated to achieve close contact with soil particles. This is best accomplished when lime is applied to a fairly dry soil and disced in (preferably twice). When spread on a damp soil, lime tends to cake up and doesn't mix well. A moldboard plow has little mixing action.

Buffer pH

In addition to soil pH, many soil tests provide a reading called buffer pH (sometimes called lime index). Soil pH is a measure of hydrogen ion (H+) concentration in the soil solution. This is called active acidity. It is an indicator of current soil conditions. When lime is added to a soil, active acidity is neutralized by chemical reactions that remove hydrogen ions from the soil solution. However, there are also hydrogen ions attached to soil particles which can be released into the soil solution to replace those neutralized by the lime. This is called reserve acidity. Soils such as silts, clays or those high in organic matter have a high cation exchange capacity (CEC) and a potential for high reserve acidity. To effectively raise the soil pH, we must neutralize both active and reserve acidity. Buffer pH is a measure of reserve acidity and is used by the soil testing laboratory to estimate lime requirements. Low buffer pH readings indicate high amounts of reserve acidity, and therefore, high amounts of lime will be recommended. The soil pH should always be lower than the buffer pH except on some alkaline soils. Instead of using buffer pH, some laboratories calculate lime requirement form CEC and base saturation while others make this determination based on aluminum level.

Plant Nutrients—major and minor

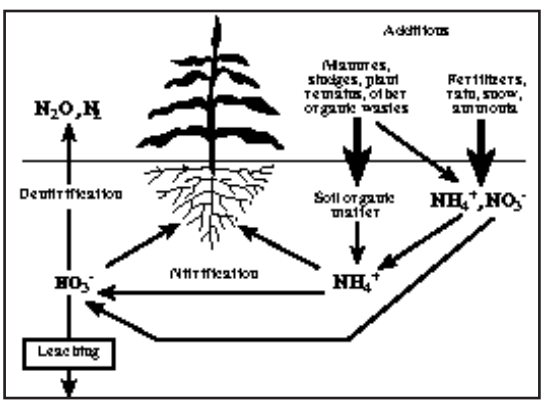
Nitrogen

Nitrogen (N) has a pronounced and often dramatic influence on the growth and yield of crops. Management of soil and fertilizer N is difficult because N undergoes numerous transformations and is easily lost from the soil. These losses concern growers for two principal reasons: 1) the losses can and often do adversely affect plant growth and crop yield, and 2) when N is lost in the nitrate form, there is a chance for contamination of groundwater and drinking water supplies.

The Nitrogen Cycle

The N cycle (Fig. 1) illustrates N inputs, losses and transformations. When inputs exceed plant needs, nitrates can accumulate in the soil and pose a threat to groundwater. Conversely, when plant-available forms of N from the soil and any inputs are too low, crop growth suffers. The key to successful management of N is to find the relatively "thin line" region between too much and too little N. It is not an easy task. N transformations and losses are affected by soil conditions and the vagaries of the weather.

Figure 1. The nitrogen cycle.



Nitrogen Inputs

As can be seen from the N cycle, there are several different sources of the N used by plants:

Soil organic matter: The total amount of N in the plow layer of agricultural soils is surprisingly large. One can estimate the total N in pounds per acre in the six to seven inches of surface soil by multiplying the soil's organic matter content by 1,000. Thus, a soil with 4% organic matter contains about 4,000 lbs N per acre.

The amount of this total N available to plants in any one year, however, is relatively small. Research has shown that for most soils 1% to 4% of the total N is converted annually to forms plants can use. For soil with a total of 4,000 lbs N per acre, a 1% to 4% conversion would produce 40 to 160 lbs N per acre annually for plant use. If the crop needs 200 lbs N per acre for adequate growth and development, additional N must come from nonsoil sources. Manure and/or commercial fertilizer are the most likely candidates to furnish this supplemental N. On well managed soils used for small fruit production, 20 to 30 lbs of N per acre will result from each percentage of organic matter during the growing season.

Previous cow manure applications: Up to 50% of the total N in cow manure is available to crops in the year of application. Between 5% and 10% of the total applied is released the year after the manure is added. Smaller amounts are furnished in subsequent years. The quantity of N released the year after a single application of 20 tons per acre of cow manure is small (about 15 lbs N per acre). However, in cases where manure has been applied at high rates (30 to 40 tons per acre) for several years, the N furnished from previous manure increases substantially.

The buildup of a soil's N-supplying capacity resulting from previous applications of cow manure has important consequences for efficient N management, two of which are:

1. The amount of fertilizer N needed for the crop decreases annually;
2. If all the crop's N needs are being supplied by cow manure, the rate of cow manure needed decreases yearly.

In cage layer poultry manure, a higher percentage of the total N in the manure is converted to plant-available forms in the year of application. Consequently, there is relatively little carry-over of N to crops in succeeding years. This is due to the nature of the organic N compounds in poultry manure. This does not mean, however, that there is never any carry-over of N from poultry manure applications. If excessive rates of poultry manure (or commercial N fertilizers) are used, high levels of residual inorganic N, including nitrate, may be in the soil the following spring. High levels of soil nitrate in the fall, winter and spring have the potential to pollute groundwater.

Previous crops: Previous crops can supply appreciable amounts of N to succeeding crops. Legumes, such as alfalfa and red clover, furnish 100 pounds or more of N to crops that follow. Other legumes, mixed grass-legume stands and grass sods supply less N to succeeding crops (Table 2).

Manures and other waste products: The N content of manures and their N fertilizer equivalents are highly variable. Differences in N content are due to the species of animal, the animal's age and diet, the moisture content of the manure, handling and storage and the amount of bedding in the manure. The N fertilizer equivalent of a given manure varies not only with the animal species and the total N content of the manure, but also with the time of application and time elapsed between spreading and incorporation (Table 3).

The values in this table are based on numerous analyses of Connecticut manures as well as published data from other states. If specific manure analysis data for the farm are not available, growers should estimate N credits by using Table 3.

Table 2. Nitrogen credits for previous crops.

Previous Crop	Nitrogen Credit Lbs N per acre
Grass sod	20
"Fair" clover (20-60% stand)	40
"Good" clover (60-100% stand)	60
"Fair" alfalfa (20-60% stand)	60
"Good" alfalfa (60-100% stand)	100
Sweet corn stalks	30
"Good" hairy vetch winter cover crop	106
Corn for grain	40

Compost as a nutrient source: Finished compost is a dilute fertilizer, having an analysis of about 1-1-1 (N-P_2O_5-K_2O). The nitrogen content of composts varies according to the source material and how it is composted. In general, nitrogen becomes less available as the compost matures. Nitrogen in the form of ammonium (NH_4+) or nitrate (NO_3-) is readily available, however in a finished compost there should be little ammonium, and any nitrate that is produced could have leached away, especially if the compost is cured or left out in the open. The majority of the nitrogen in finished compost (usually over 90%) has been incorporated into organic compounds that are resistant to decomposition. Rough estimates are that only 5% to 15% of the nitrogen in these organic compounds will become available in one growing season. The rest of the nitrogen will become available in subsequent years.

Synthetic chemical fertilizers: Fertilizers used to supply N include urea (46-0-0), diammonium phosphate (DAP: 18-46-0), monoammonium phosphate (MAP: 11-48-0), ammonium nitrate (34-0-0), urea-ammonium nitrate solution (UAN: 32-0-0) and various manufactured and mixed fertilizers such as 15-8-12, 15-15-15 and 10-10-10. In bulk blended or custom blended mixes, N-containing fertilizers with almost any grade can be provided.

Table 3. Nitrogen credits from manure incorporated before planting.

	APPLICATION TIMING (lbs N/ton)		
Kind of Manure	April/ May	Fall Only	Other times
DAIRY (COW)			
Solid	5	2	3
Liquid	16	8	12
POULTRY, CAGE LAYER			
fresh (20-40% D.M.)[4]	16	5	8
sticky-crumbly (41-60% D.M.)	22	7	11
crumbly-dry (61-85% D.M.)	32	10	16
LIQUID POULTRY	26	7	13

1. "April and/or May" credits are for manure applied and incorporated in April and/or May for spring-planted crops and for manure applied and incorporated within four weeks of planting at times other than spring.
2. Use "fall only" values for manure applied in no-till or maintenance situations where the manure is not incorporated.
3. Other times" means times other than April and/or May or fall only for manure applied for spring-planted crops. "Other times" also means any combination of times from fall through May other than April and May for spring-planted crops. Examples: March, February, March and April; November, April and May.
4. Dry matter.

Nitrogen Losses

Nitrogen losses occur in several ways. Some, such as volatilization, denitrification or immobilization, result primarily in N being unavailable to crop plants. Leaching loss results in potential groundwater contamination in addition to reduced crop growth.

Volatilization Losses: These losses occur mainly from surface-applied manures and urea. The losses can be substantial - more than 30% of the N in topdressed urea can be volatilized if no rain falls within two or three days of application. Losses are greatest on warm, moist sandy soils with pH values above 7.0. Delaying the incorporation of manures after they are spread also leads to volatilization losses of N. The Pennsylvania State University estimates, for example, that only 15% of the total N in poultry manure and 20% of the total N in cow manure is available to the crop in the year of application if the manure is incorporated more than seven days after spreading.

Leaching Losses: Nitrogen can be lost by leaching in either the ammonium or nitrate form. Usually, much more N is leached as nitrate than as ammonium. Leaching losses are greatest on permeable, well-drained to excessively-drained soils underlain by sands or sands and gravel when water percolates through the soil. Percolation rates are generally highest when the soil surface is not frozen and evapotranspiration rates are low. Thus, October, November, early December, late March and April are times in Connecticut that percolation rates are highest and leaching potential is greatest. This is why nitrate remaining in the soil after the harvest of annual crops, such as corn in September, is particularly susceptible to leaching. Of course, leaching can occur any time there is sufficient rainfall or irrigation to saturate the soil. The use of cover crops following row crops can take up this residual N and prevent it from leaching. The N will then be released for crop use after the cover crop is plowed down in the spring.

Denitrification Losses: These losses occur when nitrate is converted to gases such as nitrous oxide (N_2O) and nitrogen (N_2). The conversions occur when the soil becomes saturated with water. Poorly drained soils are particularly susceptible to such losses. In especially wet years on some soils, more than half the fertilizer N applied can be lost through denitrification.

Immobilization: Immobilization occurs when soil microorganisms absorb plant-available forms of N. The N is not really lost from the soil because it is held in the bodies of the microorganisms. Eventually, this N will be converted back to plant-available forms. In the meantime, however, plants are deprived of this N, and N shortages in the plants may develop. Immobilization takes place when highly carbonaceous materials such as straw, sawdust or woodchips are incorporated into the soil. Manure with large amounts of bedding may cause some immobilization.

Phosphorus

Phosphorus (P) is referred to as P_2O_5, for the purposes of soil testing, fertilizer grades and recommendations. We don't apply P in this form, but it has become the standard over many years. Phosphorus plays an important role in plant metabolism. This nutrient is nearly motionless in the soil, so it must be incorporated before planting. Little phosphorus enters the plant from soil water, so most uptake is by direct contact with the root surface. Plant uptake of P is very slow in cold soils. For this reason, when planting early, it is advisable to apply a liquid starter fertilizer high in P at planting.

Potassium

Plants use potassium to open and close stomates and to move nitrates from the roots to the leaves. Potassium (K) is expressed as K_2O similar to the way to P is referred to as P_2O_5. Crop need for K varies. See the table at the beginning of each crop section for the potassium needs for each crop. It is important that the soil K plus the applied K is enough to meet crop needs. However, excessive levels should be avoided because K can interfere with the uptake of Ca and Mg (see "Base Saturation"). K is subject to leaching on sandy soils low in organic matter. If high amounts of K are needed, split applications should be used. Potassium sulfate or potassium mag-

nesium sulfate are the best sources of potassium for brambles and strawberries. Although muriate of potash is less expensive, brambles are sensitive to the chloride in this fertilizer.

Calcium

Calcium is usually supplied in sufficient quantities by liming if appropriate liming materials are chosen (see "Soil pH and Liming"). If soil pH is high and Ca is needed, small amounts can be applied as calcium nitrate fertilizer (15%N, 19%CA). Ca can also be applied without affecting pH by applying calcium sulfate (gypsum) which contains 22% Ca or superphosphate (14 to 20% Ca).

Magnesium

Magnesium is necessary for chlorophyll production and nitrogen metabolism. High soil potassium levels can lead to reduced uptake of magnesium. Magnesium deficiency is characterized by interveinal reddening on older leaves, beginning at the leaf margin. It is important to maintain a proper balance between magnesium, potassium, and calcium. These three nutrients and phosphorus can be applied in late fall after plants are dormant. Nutrients can then move into the root zone and be available when growth begins again in the spring. Magnesium (Mg) is most economically applied as dolomitic or high-mag limestone (see "Soil pH and Liming"). If liming is not needed, Sul-Po-Mag (11% Mg, 22% K) can be used. You can order blended fertilizer containing Mg.

Minor Elements

Minor elements are difficult to analyze accurately with soil tests. Plant tissue analyses are more reliable for determining whether or not plants are getting sufficient quantities of minor elements. Of the minor elements, boron (B) and Zinc (Zn) are the most likely to be needed to supplement soil levels.

Soil Organic Matter

Soil organic matter (SOM) is a small but critical component of soils. SOM is continuously being produced by plants and animals and broken down by soil microbes that use it is a source of energy. As such it provides food for a diverse population of microbes in the soil and this helps prevent any one type of organism, such as a plant pathogen, from dominating. As microbes break down SOM, nutrients are released which are available for plant growth. This process is called mineralization and can provide some or all of the nutrients needed for successful crop production. Soil microbes are most active in warm soils (over 70° F) that are moist, but well aerated, with a pH between 6 and 7. Mineralization of nutrients will proceed rapidly under these conditions.

SOM also improves soil structure. It binds individual soil particles together into aggregates. This makes soil friable, allowing for good drainage, aeration, and root growth. SOM also improves the moisture holding capacity of soils. SOM is also the chief contributor to cation exchange capacity in New England soils.

Adding to Soil Organic Matter

Using compost is an effective way to add organic matter to the soil. Small fruit growers can make compost on the farm although most don't have enough raw materials to satisfy their needs. Some are bringing in additional materials such as municipal yard wastes to compost on site. Others are purchasing compost from the increasing number of commercial composters. Regardless of the source, compost should be finished before use. Finished compost has no recognizable bits of matter and will not heat up after turning. Compost should also be tested for nutrient content. Finished compost should have a low ammonium content, high nitrate level and a pH near neutral. Repeated use of a compost high in a particular element could cause a nutrient imbalance. For more information, obtain a copy of On-Farm Composting Handbook (see references on page 105).

Animal manure is an excellent source of nutrients and organic matter. About half of the nitrogen in fresh dairy manure and 75% of the nitrogen in poultry manure is in the form of ammonia. Ammonia is subject to loss through volatilization if not incorporated immediately after spreading. In the soil, ammonia is converted to nitrate and is available for plant use. However, nitrate is subject to leaching and large applications should generally be avoided. There are times when readily available nitrogen is needed, but fresh manure should be applied only with caution. Many people prefer to compost manure before field application. This stabilizes the nitrogen. Manure can be mixed with other materials for composting. Manure samples can be analyzed by several of the laboratories listed on page 2.

Cover crops are used by most growers to protect soil from erosion and to take up unused N. Cover crops also contribute to SOM when they are plowed down, although SOM varies considerably among crops (see cover crop section, page 8).

Carbon-To-Nitrogen Ratio

Organic matter is broken down by microbes which use carbon for energy. They also have a need for nitrogen. Microbes have a requirement of about one nitrogen atom for each 25 carbon atoms. This is a carbon-to-nitrogen ratio (C:N) of 25:1 or 25. If the organic matter has a higher C:N (more C and less N), microbes will need more nitrogen and will take it from the soil. Microbes are more efficient than crops in obtaining nitrogen from the soil. If there is not enough nitrogen for both the microbes and the crop, the crop will not obtain what it needs. Eventually there will be a net gain in nitrogen, but crops can suffer in the short term. If organic matter with a high C:N is applied to soil shortly before planting a crop,

additional nitrogen may be needed to assure the needs of both the microbe and the crop are met. Organic matter with a C:N of less than 25:1 (25) should not be a problem and in some cases can contribute nitrogen for crop use. See Table 4 for examples of C:Ns of some sources of organic matter.

Cover Crops and Green Manures

Cover crops are grown to protect and/or enrich the soil rather than for short term economic gain. When turned into the soil, a cover crop is called a green manure, so the terms are reasonably interchangeable.

When a cash crop is not growing, it is wise to sow something to protect the soil from wind and water erosion, thus the term cover crop. It is also wise to "rest" your fields by occasionally rotating out of cash crop production, while at the same time growing something to improve soil fertility, thus the term green manure. Some green manure crops can also suppress weeds, by "smothering" them and starving them for light. Use high seeding rates if cover crops are grown for weed suppression.

Depending on their growing requirements, cover crops can be sown after vegetable harvest, between a spring and fall crop or by overseeding into a standing small fruit crop after a final cultivation.

In selecting a green manure crop, consider the following: seed cost, winter hardiness (if applicable), ability to fix nitrogen, suppress weeds, and suitability to soil conditions, tillage equipment and the crop to follow. Here is a list of some common cover crops in New England and a description of their uses.

Table 4. Typical carbon-to-nitrogen ratios.

Material	Carbon:Nitrogen Ratio
Legume hay	15-19:1
Non-legume hay	24-41:1
Corn stalks	42:1
Oat straw	70:1
Rye straw	82:1
Cow manure	18:1
Finished compost	17-20:1
Agricultural soils	8-14:1
Hardwood sawdust	500:1

NONLEGUMES

These are selected when nitrogen contribution to the soil is not a priority. They tend to grow more rapidly and thus are better at short-term weed suppression than legumes. Late-season grasses are useful for recovering leftover nitrogen after crops have been harvested.

Winter Rye is a common winter cover crop, sown after cash crops are harvested in the fall. It is very hardy, adapted to a wide range of conditions, and seed is inexpensive. The latest-sown cover crop, it produces a lot of biomass in the spring. This adds organic matter to the soil but may be difficult to incorporate prior to crop planting.

Oats are used as a winter cover crop to protect the soil without requiring intensive management in the spring, because they are frost-killed. Shallow incorporation of residues may still be necessary before crop planting. Enough growth is needed before first frost to adequately protect the soil, so plant by late August, at a rate of about 100 lb/acre. Oat residues left on the soil surface may chemically suppress weed growth, and act as a physical barrier. Oats are also a good cover crop to plant any time during the spring or summer when land is out of production. Unlike winter rye, oats grow vigorously and upright when seeded in the spring or summer and compete effectively with weeds. Can grow in soils with low pH (5.5).

Ryegrass is a low-growing cover crop that produces an extensive root system good at capturing leftover nitrogen. It is well suited to undersowing, after last cultivation of a cash crop, in order to establish a winter cover prior to harvest. Annual ryegrass is less expensive than perennial ryegrass, and is more likely to winterkill; however, it may overwinter in milder areas, and perennial ryegrass may winterkill in harsher zones. These crops form a dense sod that reduces erosion.

Sudangrass and Sorghum-sudangrass (Sudex) are fast-growing, warm season crops that require good fertility and moisture to perform well. Under such conditions, their tall, rank growth provides excellent weed suppression. Such heavy growth can be difficult to cut and incorporate. Due to its growth habit, sudan grass should be cut back when growth exceeds 20-25 inches or plowed down if a second growth is not desired.

Buckwheat is a fast-growing summer annual that can be used to protect the soil and suppress weeds for a month or two between spring and fall cash crops. It grows fairly well on acid and low phosphorus soils. It decomposes rapidly, so is easy to incorporate, but does not contribute a lot of organic matter to the soil. Mow or incorporate at flowering, prior to setting seed so it does not become a weed in subsequent crops. Grows well in low soil pH. To smother weedy fields, some growers plant two successive crops of buckwheat followed by winter rye. Do not allow buckwheat to go to seed prior to plow-down.

Annual Field Brome: Winter annual grass. Establishes rapidly and has extensive fibrous root system contributing organic matter to soil. Plow down in spring. Seed not readily available so plan ahead.

Japanese Millet: Summer annual grass. Fast growing and competes well with weeds. Establishes faster than sudan grass on cool soils. Can be cut back and allowed to regrow after reaches 20 inches. Can reach 4 ft. in 7-8 weeks. Do not allow to mature and drop seed.

LEGUMES

Sown when "free" nitrogen is desired for a subsequent cash crop with a high nitrogen demand. Legumes generally require good drainage and fertility. Most grow slowly at first so they do not compete much with weeds until well established. Drill seed for best stands. Mix seed with proper inoculant to insure nodulation. Often sown with a nurse crop such as oats, or in mixes with perennial grasses. When legumes are mowed, tarnished plant bugs may be driven into adjacent crops, such as strawberries or raspberries increasing the likelihood of damage.

Red Clover is a short-lived perennial that is somewhat tolerant of acid or poorly drained soils. Mammoth red clover produces more biomass for plow-down than medium red clover, but does not regrow as well after mowing. Mammoth will often establish better than medium in dry or acid soils. Sow in early spring or late summer.

White Clover is a low-growing perennial, tolerant of shade and slightly acid soil. Ladino types are taller than the Dutch or wild types. White clover is a poor competitor with weeds unless mowed. Suitable for use in walkways or alleys. Expensive seed.

Sweetclover is a biennial (except for annual types like Hubam) that is deep-rooted and adapted to a wide range of soils. It is a good soil-improving crop with a strong taproot that opens up subsoil. Yellow sweetclover is earlier maturing and somewhat less productive than white sweetclover. Sow in early spring or late summer at 15 to 20 lb/acre. Heavy growth is produced in spring after overwintering. Incorporate in late spring or mid-summer at flowering. May deplete soil of moisture, which can be a problem for subsequent crops in dry years.

Hairy Vetch has become increasingly popular as a cover crop. It can fix tremendous amounts of nitrogen. Generally this cover crop is seeded in the fall after August 15 or before mid September in most areas. It should be allowed to grow at least until mid May before plowdown. It is advisable to seed winter rye (30-40 lbs/acre) or oats (40-50 lbs/acre) with the vetch when seeded in the fall to take up unused nitrogen and to ensure a good ground cover for erosion control. Most growers prefer oats to winter rye because the oat will not overwinter and the vetch alone is easier to manage the following spring. Hairy vetch can also be seeded in early spring or summer. When seeded in early April it will produce significant nitrogen in time for a late seeding of sweet corn or brassica. When seeded in the summer it will usually winter kill and the following spring the nitrogen will become available for an early crop. Treat seed with a pea-type inoculant.

Alfalfa requires deep, well-drained soil with a pH near neutral for good growth. It is a long-lived perennial that is probably not worth the expense in a short-term rotation. Fixes large amounts of nitrogen if maintained for several years. Seed early spring or late summer at 15 to 25 lb/acre.

Mixtures

Legumes and grasses are often mixed as cover crops to hedge against failure of one and to get some of the benefits of both. The grass will usually establish quickly, holding soil in place and "nursing" the legume along. By taking available soil N, the grass promotes N-fixation by the legume. Fertilization with N or the absence of mowing favors growth of grass over legume. Some common

Table 5. Pre-plant cover-crop seeding dates and rates.

Cover Crop	Recommended Seeding Dates	Seeding Rate
Alfalfa	Early April to late May or Late July to mid August	14 - 20 lbs/A
Buckwheat	Late May to early June or Late July to early August	60 - 75 lbs/A
Clovers (Alsike, Ladino, White)	Early April to late May or Late July to mid August	4 lbs/A (alsike and white) 2 lbs/A (ladino)
Red Clover	Early April to late May or Late July to mid August	8 - 10 lbs/A
Sweet Clover	Early April to mid May or Early August	12 - 20 lbs/A
Hairy Vetch	August to early Sept.	30 - 40 lbs/A
Annual Field Brome	July and August	20 lbs/A
Japanese Millet	Late May to mid July	20 lbs/A
Spring Oats	Early to mid April or Mid August	100 lbs/A
Annual Ryegrass	Early April to early June or Early August to early Sept.	30 lbs/A
Perennial Ryegrass	August to mid Sept.	25 lbs/A
Winter Rye	August to mid Sept.	80-100 lbs/A
Sudan Grass	Late May to Early June	80 lbs/A
Sorghum-Sudan Grass Hybrids	Late May to Early June	35-50 lbs/A

mixtures, in addition to vetch and rye described above, are red clover and oats (combine or mow oat heads, leaving established clover); ryegrass and white clover for mowed alleys. Timothy is often used as a nurse crop for alfalfa. It is advisable to trial unfamiliar cover crops or mixtures on a small scale to determine if they are suited to your climate and management resources before growing them widely.

Note: N fixed in root nodules moves to the leaves and stems of legumes. If hay is harvested from the field prior to plowing, very little N will be contributed to the subsequent crop.

Guidelines for Organic Fertilization

Soil fertility is a function of the biological, physical and chemical characteristics of soil. An organic fertility program should consider all of these interrelated factors in order to optimize and sustain crop production.

Soil tests are useful for monitoring soil organic matter content, which influences the physical and biological quality of soil. Soil tests also estimate the level of chemical nutrients in the soil that are available to plants. This helps determine the quantity and type of soil amendments needed for good crop yields.

Organic Matter management is an essential part of organic agriculture. Generous additions of compost, animal or green manures are needed to fuel soil microbes, the by-products of which bind soil particles together to improve the physical condition, or structure of soil. Good structure promotes root growth and thus enhances plant retrieval of soil nutrients.

Decaying organic matter releases a slow, steady supply of nutrients to a crop so long as soil temperature, moisture, and aeration support microbial activity (as when soil is properly drained and well warmed). When this release of nutrients, or mineralization, is low, as when soils are cool, fertilizing with soluble forms of nutrients may benefit crops. This is why some soluble phosphorus (P) and nitrogen (N) should be banded, or placed near the roots of crops early in the growing season. For example, use bone meal and dried blood to provide soluble P and N, respectively, or use a commercial organic fertilizer blend. Check with your local Organic Certification organization or Extension specialist for information on the nutrient content of various organic fertilizer sources.

Nitrogen Up to half the N contained in manures and immature compost can become available to plants during the season following incorporation. Each ton of compost containing 1% N can provide a crop with 5 to 10 lb of N per acre. Similarly, there is a release of about 20 lb/acre or more of N for each 1% soil organic matter. These releases of N vary with drainage and other soil conditions, and may not be well timed to crop needs, especially early, short season crops. Annual crops need N most intensely about three to four weeks after emergence or transplanting. Therefore, sidedressing, or spreading soluble N along the crop row, at this time is most efficient. Because soluble organic N fertilizers are expensive, it is advisable to use lower rates than recommended for synthetic fertilizers. A sidedressing of 25 lb/acre of actual N is reasonable for many crops growing in a fairly fertile soil. That requires 200 lb dried blood, 400 lb soy or cottonseed meal, or the equivalent from other sources of N.

Rock powders can be used, along with organic matter, to build up and balance soil reserves of plant nutrients. However, these are not very soluble nutrient sources, and are not effective for treating short-term nutrient deficiencies. Using some soluble fertilizers may be advisable while building soil reserves of plant nutrients with rock powders and organic matter.

Limestone is a widely used rock powder. It raises the soil pH and provides calcium (Ca) and varying amounts of magnesium (Mg). When Mg tests below about 100 lb/acre, high-Mg limestone, or dolomite, should be used for liming. If Mg is above about 150 lb/acre, use calcite, or low-Mg lime. Choose your fertilizer materials considering the desired 20:4:1 base saturation ratio of Ca:Mg:K in the soil, but remember, this goal is only a ballpark figure and is definitely secondary to establishing the proper pH of 6 to 7 for most crops and supplying nutrients shown to be deficient by a soil test (see page 1).

Magnesium is best applied as dolomitic lime, but when liming is not required, other Mg sources are Sul-Po-Mag or Epsom salts. Sul-Po-Mag is the better choice if potassium is also required, as it is less expensive than Epsom salts. However, Epsom salts can be applied as a foliar spray to alleviate Mg deficiency. Dissolve 1.5 lb per 10 gal water and spray at weekly intervals.

Phosphorus is low in many New England soils, and can limit crop growth, especially early in the season. Soils testing less than 10 lb/acre available phosphate (P_2O_5) usually require substantial applications of phosphate. Hard rock phosphate contains about 2% available P_2O_5, soft, or colloidal, rock phosphate contains 3% available P_2O_5. Thus, a ton of these materials provides only 40 to 60 lb available P_2O_5/acre. Bone meal contains about 20 times more available P_2O_5 by weight, but is more expensive. With soils low in P, it can help crops to place proportionally more P fertilizer in the crop row than to broadcast it evenly. Maintain a pH of 6 to 7 with limestone to maximize P_2O_5 availability. Compost and manures tend to contain P_2O_5 than N or K_2O, but repeated applications will raise P levels substantially.

Potash is very slowly available from granite dust or greensand, which are applied at 3 to 5 tons to the acre to build up K reserves. Wood ashes contain soluble K, but must be used with caution because they will raise the pH rather rapidly and can be caustic. The liming effect of 1 pound of ashes is roughly equal to 2/3 of a pound of limestone. No more than 1/2 ton of ashes per acre should probably be applied at once, and only then if called for by low pH, low K and sufficient Mg. Sul-Po-Mag is the K fertilizer of choice

Table 6. Nutrient recommendations for small fruit crops.

Crop	Age	Amount/Timings (actual N)	N Source	Comments
Strawberries	0	30 lb/A early June 30 lb/A early Sept.	calcium nitrate ammonium or calcium nitrate	Be sure plants are growing well prior to application
	1+	70 lb/A at renovation 30 lb/A early Sept.	ammonium or calcium nitrate or urea	Adjust fall amount based on leaf tissue analysis
Raspberries (summer bearing)	0	25 lb/A 4 weeks after planting	calcium nitrate	Avoid touching plants with fertilizer
	1	50-80 lb/A split between May and June	ammonium nitrate or urea	Use higher amount on sandier soils or if irrigation is used
	2+	70-100 lb/A split between May and June		
Raspberries (fall bearing)	0	25 lb/A 4 weeks after planting and again in August	calcium nitrate	Avoid touching plants with fertilizer
	1	50-80 lb/A split between May and June	ammonium nitrate or urea	Use higher amount on sandier soils or if irrigation is used
	2+	70-100 lb/A split between May and June		
Blueberries	0	Do not fertilize newly planted blueberries		Soil pH should be adjusted to 4.5-5.0 prior to planting
	1	15 lb/A	ammonium sulfate or urea **do not use aluminum sulfate**	
	2	20 lb/A		
	3	25 lb/A		
	4	35 lb/A		
	5	45 lb/A		
	6	55 lb/A		
	7+	65 lb/A		

Source: Cornell University

when Mg is also needed.

Minor elements are generally sufficiently supplied to plants by regular additions of organic matter to the soil. Some seaweed extracts may also supply trace minerals. In soils low in boron (B), remedial applications are widely recommended for crops that readily suffer from B deficiency, such as crucifers. In this case, 1 to 2 lb/acre of B is applied to the soil with other fertilizers. Several forms of B are organically permitted, including Solubor (20% B) and Borax (11% B). It is advisable to monitor B levels with soil tests and tissue tests (for perennial fruits). Excess levels of B are toxic to plants, and some crops are quite sensitive to boron.

Organic Certification

Some small fruit growers choose organic production methods. Consumers of organic produce represent a growing market niche. Organic agriculture is based on the use of practices and inputs that enhance the physical, biological and chemical aspects of the soil and its ability to sustain crop and animal production in an environmentally safe manner. In general, the use of synthetic substances for pest management or to supply nutrients is prohibited. Organic agriculture relies on cultural practices and natural based materials for pest management and on-farm or locally available sources of nutrients as much as possible. This guide includes information on many materials and inputs approved by the National Organic Program. Organically accepted practices are also included in the recommendations for specific crops and so designated with the symbol ⊗. The Organic Materials Review Institute (OMRI) lists products it finds suitable for certified organic production. These products are generally allowed, but some are regulated and subject to restrictions. In some cases, certain formulations of a product are permitted and others are not. The list of substances approved by the OMRI is subject to change. Be sure to check with your certifier in advance to be certain that the materials and practices you plan to use are approved. Some materials labeled as organic may not be allowed by the program. For a current list, visit the OMRI web site at: www.omri.org. Some growers choose organic production methods for personal and/or marketing reasons. Consumers of organic produce represent a growing market. This market is increasingly looking for certification to substantiate product claims. Federal legislation now requires certification of food products that are labeled as organic except for producers who gross under $5,000. These small producers must follow the same practices as certified growers.

The following is a list of certifying organizations currently accredited by USDA.

CT Baystate Organic Certifiers
Don Franczyk
683 River St.
Winchendon, MA 01475
http://www.baystateorganic.org/ (978) 297-4171

MA Baystate Organic Certifiers
Don Franczyk
683 River St.
Winchendon, MA 01475
http://www.baystateorganic.org/ (978) 297-4171

ME MOFGA, P.O. Box 170, 257 Crosby Brook Road, Unity ME 04988, (207) 568-4142
http://www.mofga.org
certification@mofga.org

NH NH Department of Agriculture, Markets & Food
Division of Regulatory Services
PO Box 2042, Concord, NH, 03302-2042
(603) 271-3685
agriculture.nh.gov/OrganicCertificationProgram.htm

RI Matt Green
Div. of Ag.
235 Promenade St.
Providence, RI 02908
(401) 222-2781 x4509

VT Vermont Organic Farmers, LLC
P.O. Box 697
Richmond, VT 05477
(802) 434-4122 http://www.nofavt.org
info@nofavt.org

Organic Materials Listing:

OMRI Organic Materials Review Institute, PO Bx 11558, Eugene, OR 97440,
(541) 343-7600
http://www.omri.org
info@omri.org

About Pest Management

Effective fruit crop production depends on the grower developing a system of crop management that is appropriate for each farm. Decisions need to be made for how to manage all of the normal cultural practices such as planting, fertility, harvesting, and pruning as well as managing the insect, disease, and weed problems that occur either regularly or sporadically. The information in this guide will address management issues related to both common, expected pest problems as well as the occasional appearance of minor pest problems.

Effective pest management depends on:

- correct diagnosis of the problem and correct identification of the pest causing it.
- use of techniques to prevent or delay infestations or infections as well as techniques to control them.
- early detection of pests by frequent inspection of plants.
- tolerance of pests at population densities that do not cause economic damage.

Diagnostics

Correct diagnosis of a problem and correct identification of the pest (insect, disease, biotic factor, nutrition, etc.) causing it are key to successful crop management and profitability. Below is a list of laboratories that offer disease diagnostics on a fee-for-service basis. See page 108 for a sample submission form that can be used for any of the labs listed below. In general, virus screening is a procedure that is done outside of this region and is referred out by one of the clinics listed below. Contact your local clinic or lab for more information on virus screening.

In order to submit a sample for diagnosis, some basic preparation instructions should be followed. These include:

1. Collect specimens that show a range of symptoms (i.e., from healthy to seriously affected), usually collected from the margin of the affected area. Avoid specimens that are completely dead or decayed as they are not diagnostically useful.
2. Fill out case-history or sample submission form like the one at the end of this guide. This is very important. Without the information included in the form, a correct diagnosis is very difficult.
3. Pack specimen in dry paper and place in a plastic bag (never pack with wet paper towels).
4. Mail specimen and case-history form same-day or overnight delivery, or deliver specimen personally the same day. If this is not possible, place in a refrigerator and mail or deliver the following day. Specimens should come to the diagnostic labs early in the week to avoid problems with weekend hold-overs.
5. Soil samples for nematode analysis.

Plant Diagnostic Clinics of New England

(D=disease ID, I=insect ID, N=nematode analysis, W=weed ID)

CONNECTICUT

The Plant Disease Information Office (D,I,N)
The Connecticut Agricultural Experiment Station
123 Huntington Street, P.O. Box 1106
New Haven, CT 06504
http://www.ct.gov/caes
(203)974-8601
Cost: call to inquire

UConn's Home & Garden Education Center (D,I,W)
Radcliffe HIcks Bldg, Rm 4
1380 Storrs Rd., Unit 4115
Storrs, CT 06269
http://www.ladybug.uconn.edu/index.html
(203)974-8601
Cost: $10 - $25

MAINE
Insect Pest and Disease Diagnostic Lab (D,I)
Pest Management Office
491 College Avenue
Orono, ME 04473-1295
pmo.umext.maine.edu/ipddl/ipddl.htm
1-800-287-0279 (within Maine)
(207)581-3883
Cost: call to inquire

MASSACHUSETTS
UMass Extension Plant Diagnostic Laboratory (D,I,N)
Holdsworth Hall
160 Holdsworth Way/UMass
Amherst, MA 01003
www.umass.edu/agland/diagnostics
(413)545-3208
Cost $50

NEW HAMPSHIRE
The Plant Diagnostic Lab (D,I,W)
Plant Biology Dept.
38 Academic Way, G37 Spaulding
Durham, NH 03824
(603) 862-3841
http://extension.unh.edu/agric/AGPDTS/PlantH.htm
Cost: $15

RHODE ISLAND
URI Plant Protection Clinic (D,I)
3 East Alumni Avenue
Kingston, RI 02881
http://www.uri.edu/ce/ceec/plantclinic
(401)874-2900
Cost: $10

VERMONT
University of Vermont Plant Diagnostic Clinic (D,I,W)
Attn: Ann Hazelrigg
235 Hills Building
University of Vermont
Burlington, VT 05405
(802)656-0493
http://pss.uvm.edu/pd/pdc/
Cost: $15

VIRUST TESTING
Agdia Inc.
30380 County Rd. 6
Elkhart, IN 46514
800-622-4342
www.agdia.com
Cost: varies

Integrated Pest Management (IPM)

Integrated pest management is a unified program of multiple strategies used to avoid economic damage to crops and to minimize environmental disturbance. IPM includes cultural and mechanical practices to prevent pest outbreaks from developing; biological control to encourage the pest's natural enemies to survive and attack the pests; and chemical control, which is usually used when cultural and biological controls are inadequate and a crop needs to be rescued from a damaging pest population. During the years from the mid-1940s to the mid-1970s, chemical control of pests was widely used on most commercial crops in the United States, often to the exclusion of other methods. Due to increasing incidence of some pests developing resistance to pesticides and to concerns about pesticides contributing to environmental contamination, there has been a trend since the mid-1970s towards using pesticides more judiciously and taking a more multi-tactic or integrated approach to pest management. Although the term 'pest' means 'insects' to many people, in IPM the term 'pest' is usually used in a broader sense that includes disease-causing microorganisms and weeds as well as certain insects, mites, birds, and mammals.

For some commercial crops in some regions of the world, a comprehensive IPM program has been worked out and simple instructions are available to growers who want to follow an IPM program. In these cases, the only knowledge required of the grower is how to identify the important pests and natural enemies in the system, and how to follow the recommended procedures for preventive cultural practices, monitoring, and control decisions.

For other commercial crops or in other regions of the world, no guidelines are yet available for a comprehensive IPM program. This does not mean that a grower cannot attempt to manage a crop with an IPM approach, but it means that the grower may have to learn more about the habits and life cycle of all pests and natural enemies found in a crop, and be willing to experiment with various thresholds and control measures in order to develop an appropriate management strategy.

In the case of small fruit, some very good information has been generated in the Northeast on certain components of the IPM system. An excellent source of comprehensive IPM guidelines for strawberries, blueberries, summer raspberries, and grapes is the publication Massachusetts Integrated Pest Management Guidelines: Commodity Specific Definitions. C.S. Hollingsworth and W.M. Coli (eds). Univ. Mass. Ext. Bull. IP-IPMA. 66 pp. This publication can be obtained from the UMass Extension Bookstore by calling (413)545-2717.

Monitoring Pests and Making Control Decisions

Action thresholds: Many crops can tolerate a certain amount of pest damage. Some pests cause economic damage only when they occur in large numbers (for example, spider mites and aphids), while others are considered serious even at very low levels (for example, strawberry clipper and plum curculio). A rescue treatment is not needed until the pest population reaches a critical density usually referred to as a threshold or an action threshold. A threshold is the density of pests that signals the need for control if economic damage is to be avoided. Thresholds for different pests may vary greatly and may be expressed as a number of pests per leaf or per plant, or as a percentage of leaves infested.

One goal in the development of IPM programs is to have an appropriate action threshold for each pest. For example, spider mite control on strawberries is suggested if the percentage of mite-infested leaflets is 25% or greater in a random sample of 60 leaflets. Grape berry moth control is suggested on grapes if the average percentage of infested clusters is 5% or greater in a sample of 100 clusters from the interior of a vineyard and a sample of 100 clusters from the edge of a vineyard. Tarnished plant bug control in brambles is suggested if there is at least 0.5 plant bug per cluster in a sample of 50 clusters.

Monitoring overview: One basic principle of pest management is that you do not take action against a pest unless you are certain the pest is present and is a threat to your crop. Growers who practice IPM as part of their fruit production operation need to know how to monitor pests, because pest control decisions are based on knowledge of which pests are present in their plantings, how many of each are present, and when they are present, as well as how many are economically tolerable.

Two common types of pest monitoring methods are **scouting** and **trapping**. Scouting and trapping each have their merits. Scouting may be somewhat time consuming but can provide accurate information on the presence of the pest in its damaging life stage. Trapping is more easily done, but because it is often done to monitor the adult stage of pests that cause damage in the larval stage, the results may not be directly applicable to making a control decision for the larval form. Both methods should be used, where appropriate, to provide information on which pest control decisions can be based. Another monitoring method that is more predictive of when pests are likely to appear is based on weather monitoring. Development of several fungal diseases can be predicted by monitoring temperature, leaf wetness, and rainfall. Activity of some insects can be predicted by monitoring temperatures and calculating degree-days.

Scouting: Scouting means walking through the planting and looking for pests or symptoms of their presence. The purpose of scouting is to evaluate the effectiveness of preventive measures and the possible need for a rescue treatment. Scouting is done by examining a representative sample of each crop to determine the average infestation or infection level. Infestation may be expressed as presence or absence of pests on each sample, or as the number of pests on each sample, or as the percentage of plant parts damaged. The number of plants or plant parts to examine can vary according to the crop, size of the planting, and time of the year.

For some crops and pests, very specific scouting procedures have been developed so that a minimum number of leaves or fruit need to be examined in order to confidently make a decision about the need for applying a control measure. For other crops or pests, specific scouting procedures have not yet been worked out, and a general scouting plan can be followed, such as examining 25 whole plants per field. Under a general scouting plan, fruit plantings should be scouted on a regular basis, generally once per week. When examining plants, it is important to look at them closely in order to see small egg masses or small larvae that may be present before damage is evident. In a general scouting plan, all parts of the plant should be examined, even if they are not parts that will be harvested. Pests may be found on the underside of leaves, on top of leaves, on stems, in stems, in buds, on or in developing fruit, or in the crown. A prerequisite to scouting is knowing how to recognize the pests that can attack the crop.

Insect trapping: Traps that have the ability to catch insects are useful in some cases as a mechanical control method and in other cases as monitoring tools. Insect traps are a good method of determining if an insect species is present, and they can also give an estimate of the insect's concentration and distribution. Insects can be attracted to traps by visual appearance or by odor. **Visual** traps use light, color and/or shape to attract certain insects. **Odor** traps attract certain insects by using scents associated with food or mates. Another form of trap more often used in gardens than on commercial farms are shelter traps, such as shingles or boards placed on the ground to attract pests such as slugs that can then be collected and killed mechanically.

Food attractant traps: Traps based on the scent of a food source are now commercially available for rose chafer and Japanese beetle. Although these are most often used as mechanical control devices, they can also be used for monitoring purposes. A well-known bag trap for Japanese beetles uses a food attractant scent to lure both male and female beetles into the trap. This trap is so effective at attracting beetles that it can actually increase the number of beetles in the vicinity of the trap. Despite the sometimes bad reputation the Japanese beetle trap has earned because of its super-attractiveness, the trap still can be effectively used if it is placed at some distance away from the fruit planting to be protected.

Colored sticky traps: The adult form of blueberry maggot is a true fruit fly that is attracted to yellow and to the scent of ammonium. Traps commercially available for

monitoring blueberry maggot flies are yellow cardboard or plastic cards coated with a sticky material, which come with an ammonium bait included in the sticky material. The bait is effective for about one week. Small capsules of ammonium bait can also be purchased separately to prolong the attractive life of a trap. Another example is white sticky traps that are sold for monitoring the tarnished plant bug. An alternative to sticky traps is colored bowls filled with soapy water.

Pheromone traps: The most common type of trap used for monitoring certain pests in recent years is the pheromone trap. Pheromones are natural scents produced by insects for purposes such as attracting mates. The main advantage of pheromones is that they are specific to individual pest species; for example, the pheromone for grape berry moth attracts only grape berry moth and not the redbanded leafroller or other related moths. Man-made imitations of pheromones are commercially available as lures that can be placed in traps. Most commercial pheromones are imitations of secretions from unfertilized adult female insects, which are used to attract male insects of the same species. Most commercial pheromones are used to monitor various species of moths. Some of the fruit pests that can be monitored with pheromone traps are the grape berry moth, red-banded leafroller, grape root borer, Sparganothis fruitworm, variegated cutworm, and black cutworm.

Traps used with pheromone lures come in a variety of styles and materials; one of the most common types is called a wing trap. A wing trap is made of plastic or cardboard top and a sticky cardboard bottom held together by a wire hanger; the pheromone lure can be placed in the middle of the sticky bottom or glued to the trap top. Another style is a bucket trap such as a Unitrap or Multi-Pher trap. Bucket traps have a funnel entry system for keeping the pest from escaping, and do not require a sticky coating; the lure is placed near the top of the funnel. The traps can be hung from a vine or be mounted on fence posts. In either sticky wing traps or bucket traps, the pheromone lures need to be replaced periodically, usually every four weeks or as recommended by the manufacturer. Although it is convenient to buy traps ready-made, homemade traps can also be used, with materials such as cardboard milk cartons as a base and Tanglefoot as an adhesive; Tanglefoot is a sticky material available at many garden supply shops.

While it is the larval stage that often causes the damage, traps catch many pests when they are in the moth (adult) stage of their life cycle because only adult males are attracted by the odor of the pheromone. The moths lay eggs that develop into larvae that feed on crops. To complete their life cycle, the larvae pupate, then change to moths that in turn lay more eggs thus producing more larvae. By knowing when the moth stage of a pest is present, using traps, the grower can be on the lookout for damaging larvae that are likely to follow. The appearance of the first moth can also be used as a starting point for calculating the number of degree days before the emergence of the larvae, if such information is available for a specific pest. This information can help the grower determine the best time to spray for insect control. Some of the insects that follow this pattern of development in apples are the codling moth and San Jose scale; initial catches of either of these in their respective traps determine the timing and/or need of insecticide treatments against these pests. Similar management guidelines may be developed in the future for pests of small fruit crops.

Insect pheromone trapping guidelines:

- Use a minimum of two traps for each pest species in representative locations.
- Examine traps at least twice per week.
- Count and record the number of captured insects in each trap. Remove the captured insects during each visit with a wire or twig, wipe them on a rag or paper towel, and dispose of them away from the field.
- Record trap catches on each date in an IPM scouting log. It can help to keep a running graph of the information.
- Sticky panels (the bottom half of wing traps), should be changed regularly to maintain trap effectiveness; replace the panel each month or when covered with debris. Replace the complete trap if drooping or broken.
- Change pheromone lures (baits) every 4 weeks or according to the manufacturer's directions. DO NOT dispose of used pheromone lures in the fruit planting; these would compete with traps and cause lower trap catch numbers. It is useful to establish a pattern when changing lures, such as the first week of every month.
- Store replacement lures in a freezer or refrigerator. It is best to purchase only a one-year supply at a time, but lures can be stored from one season to the next in the freezer. On each package, write the date the lures were purchased and placed in the freezer so that you can use the oldest ones first.
- If you are trapping for more than one species, change gloves or wash your hands when handling pheromones for different species of insects to prevent cross contamination. Minute traces of one pheromone on another can render the second repellent completely ineffective to its target pest.
- If you are trapping for more than one species, be sure to label each trap with the target pest name and be sure to place the correct pheromone lure into the correct trap.

Weather monitoring. The optimum weather conditions for development of some diseases can be monitored to determine the optimal time to control the disease with pesticides. Temperature, leaf wetness, rainfall, and other weather factors can be measured either manually or by a computer. Weather data obtained then can be plugged into equations or computer programs for disease development to determine management actions. An example is management of powdery mildew on grapes, for which a computer forecasting program is available.

Insect development & degree days. While scouting

and trapping can give information about which pests are present at a given time, another monitoring tool of a more predictive nature is temperature-based development models. Temperature plays a major role in determining the rate at which insects develop. Each insect has a temperature range at which it is the most comfortable. Below that temperature range they will not develop, and above that temperature range development will slow drastically or stop. Each insect also has an optimum temperature at which it will develop at its fastest rate. By using this relationship, you can make predictions on the rate of development of insects. By being able to predict when an insect will appear, you can estimate when your crop is most likely to be damaged and when to intervene to prevent damage from occurring.

A method of estimating development time is called the degree day method. The degree day method can be used to predict when insects will reach a particular stage of their life cycle, if you know three things: the threshold temperature, the average daily temperature, and a thermal constant. Each insect species has a threshold temperature. Below this temperature no development of the insect occurs. The threshold temperature is 50˚F for many insect species or 43˚F for other species. A degree day is the number of degrees above the threshold temperature over a one day (24-hour) period. For example, if the threshold temperature of an insect is 50˚F and the average temperature for the day is 70˚F, then 20 degree days would have accumulated on this day (70 - 50 = 20).

The accumulation of degree days can be used to predict when insects will hatch, pupate and emerge as adults. By using accumulated degree days, a farmer can estimate when a pest should appear in his crop, then scout for the pest and determine if treatment is needed. However, for degree days to be used to make these predictions, researchers must have determined the number of degree days necessary for the event to occur. That is called the thermal constant. The thermal constant, just like the threshold temperature, will be different for different insects and for different events in the life cycle.

The easiest way to calculate degree days for a date is to subtract the threshold temperature from the average daily temperature. The average daily temperature can be determined by simply averaging the high temperature and low temperature for the date [(maximum temp + minimum temp)/2]. For example, if the high temperature for the day was 90˚F and the low was 60˚F, then the average temperature for the day would be [(90 + 60)/2 = 150/2 = 75]. If the threshold temperature for an insect were 50˚F, the degree days accumulated on this day would be 25 because 75 - 50 = 25.

Temperature extremes add variables to this simple method of calculating degree days. To overcome these and to more accurately predict when insects will be present, follow the following rules.

1. If the maximum temperature for a 24-hour period is not greater than the threshold temperature, no degree days are accumulated.

   For example:
   maximum daytime temperature = 45˚F
   threshold temperature = 50˚F

2. If the high temperature for the day is greater than the threshold temperature but the low temperature for the day is less than the threshold temperature, then when calculating the average temperature for the day the threshold temperature is used as the low temperature for that day.

   For example:
   maximum daytime temperature = 65˚F
   low daytime temperature = 45˚F
   threshold temperature = 50˚F
   The threshold temperature of 50˚F would be used as the low day-time temperature when calculating the average daily temperature.

3. If the high temperature for the day is greater than the optimum temperature, the temperature at which the insect will develop at the fastest rate, then you use the optimum temperature as the high temperature for the day when calculating the average temperature for the day.

   For example:
   maximum daytime temperature = 98˚F
   optimum temperature = 95˚F

   The optimum temperature of 95˚F would be used as the high temperature for the day when calculating the average temperature for that day.

Biorational Pesticides

(adapted from 2010 New England Vegetable Mgt Guide)

Pesticides vary in their toxicity and in their potential ecological impact. Pest control materials that are relatively non-toxic to people with few environmental side-effects are sometimes called "biorational" pesticides. These fit well into an integrated pest management strategy, which relies on monitoring for early detection of pests and emphasizes the use of selective products that provide control while preserving the ecological health of the farm and minimizing negative effects on beneficial insects that suppress pests. The term 'biorational' is a qualitative term intended to help provide information and guidance for decision making. All pesticides have some toxicity; always read and follow the label regarding agricultural use requirements and personal protective equipment. All of the insecticide products listed as biorationals in the tables below carry the signal word "Caution", the least toxic clas-

sification, on the label (see Toxicity of Insecticides section in this chapter). None are federally restricted-use products. Most have dermal and oral LD50 values over 2,000 mg/kg.

Some, but not all, biorationals are approved for use on certified organic crops. For a given active ingredient, some products or formulations may be approved for use in certified organic crops, while others are not. Products that are generally approved for organic production are designated "OMRI" or "OMRI listed", which indicates they are listed on the website of the Organic Materials Review Institute at the time of publication (July 2007). Growers should consult with their certifying agency to be sure about what products are approved for use.

The tables below list biorational insecticides, biological controls for insect management. The major categories of biorationals include botanicals, microbials, minerals, and synthetics.

Botanicals are plant-derived materials and include pyrethrin, azadiractin and neem oil, garlic, capsaicin, and vegetable oil. Botanicals are generally short-lived in the environment, as they are broken down rapidly in the presence of light and air. Products derived from the seeds of the Neem tree, including azadiractin and neem oil, are selective and have low mammalian toxicity. Garlic and capsaicin act primarily as repellents and thus need to be reapplied as long as pests are present. They are registered for use on a wide range of crops and pests. However, none are listed in this Guide for commercial use unless they carry the proper agricultural use requirements on the label. Vegetable oil may be derived from soybean, corn or other plants; the only labeled product for commercial use is produced from soybean oil.

Microbial pesticides are formulated microorganisms or their by-products. They tend to be selective, so specific pests may be controlled with little or no effect on non-target organisms. Microbial insecticides include bacteria (Bacillus thuringiensis and spinosad) and fungi (Beauvaria bassiana). While these active ingredients are generally approved for organic crops because of their natural origin, certain formulated products are prohibited because the inert ingredients or procedures used in producing the product may be prohibited.

Minerals and synthetics. Some biorational pesticides are minerals, mined from the earth and minimally processed. Kaolin clay, insecticidal soap, and iron phosphate are examples. Minerals that are heated, chemically reacted, or mixed with surfactants may be considered synthetics. Synthetics include growth inhibitors or insect growth regulators (any of which is commonly known as an IGR), materials that interrupt or inhibit the life cycle of a pest.

Biological Control

Biological control is taking place in fruit crops all the time, because native and naturalized populations of natural enemies overwinter on the farm and move into crops to feed on or lay their eggs into pest insects. Predators consume several insects over the course of their development. Parasites (also called parasitoids) tend to lay eggs in their host insect, which then feed internally, develop and kill the host. Pathogens invade the body of the host insect. The impact of beneficial insects is often underestimated because it is easy to overlook and difficult to measure. It may become obvious if they are killed by broad-spectrum insecticides and pest outbreaks occur as a result. Conservation of beneficials by use of selective insecticides when pests exceed threshold levels is recommended wherever practical.

The release of lab-reared beneficials can also aid in suppressing pests. These tend to be more successful in greenhouses than in the field, but there are several instances where releases in the field have been proven to suppress or completely control key pests. Neoseiulus fallacis and Phytoseiulus persimilis are tiny mite predators that feeds on pest mites such as two-spotted spider mites and European red mites. N. fallacis is indigenous to the Northeast as well as available for release from reared populations in commercial insectaries. Both have been very useful tools for New England Fruit Growers.

Biorational Disease Control

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

Sources of traps and lures, weather and other monitoring supplies are listed at the end of this guide.

Microbial products are all living organisms that require specialized storage and application procedures. These include beneficial fungi and bacteria (Streptomyces, Gliocladium, Trichoderma harizanum) that compete with plant pathogenic fungi, produce toxic metabolites, or actively parasitize pathogens. Their effectiveness in University research trials has been inconsistent because of variations in environmental

conditions and disease pressure. Microbial fungicides perform best in a greenhouse environment where they can establish and flourish. Control of plant pathogenic organisms on the phylloplane (leaf surface) is especially problematic, as the competing organisms must establish themselves and can fail due to dessication and exposure to sunlight. These materials have a limited shelf life, must be protected from temperature extremes, and correctly applied (plenty of water and under the correct environmental conditions) to be effective.

Beneficial Insects

Biological control is taking place in fruit crops whenever the existing populations of natural enemies are conserved. The impact of natural enemies is often underestimated but may become obvious if they are killed by broad-spectrum insecticides. However, they are not always sufficient to bring pests under economic control. The release of mass-reared beneficials can also aid in suppressing pests. This tends to be more successful in greenhouses than in the field, but

Table 7. Biorational Insect and Mite Control Materials.

Active Ingredient	Trade Name(s)	Target Pests	Comments
azadiractin	Aza-Direct Azatin XL Neemix Trilogy	Aphids, leafminers, thrips, whitefly, leafhopper, flies, true bugs, some beetles and caterpillars	Insect growth regulator, repellent, antifeedant. Disrupts growth of immature stages. Use preventatively before outbreaks. Repeat applications may be neded. Efficacy varies.
Beauvaria bassiana strain GHA	Mycotrol O Botanigard 22WP	Aphids, whiteflies, thrips	This fungus penetrates the insect cuticle, proliferates and eventually releases new spores. Best applied in evening. Use prevenatively based on monitoring before pest populations are high.
Bacillus thuringiensis subsp. kurstaki	Dipel Biobit Javelin	Caterpillars, including cranberry/cherry fruitworm, blueberry sawfly, winter moth, grape berry moth, leafrollers, etc.	Acts as stomach poison, must be ingested to be effective. Not all products are OMRI listed; check the label.
bifenzate	Acramite 50WS Floramite SC	Mites	A long residual selective nerve poison for mite control.
extract of neem oil	Triology	Primarily labeled for (but not limited to) mite control	Can be used to control mites. For best results use when population levels are low to prevent build-up. Repeat applications are needed.
potassium salts of fatty acids (insecticidal soaps)	M-Pede	aphids, leafminers, mites, thrips, whiteflies	Works on contact. Can be phytotoxic to some crops, test on small plot first. Avoid treatment when plants are stressed or air temperatures are above 85°F. Ma also harm some beneficials. Also active against powdery mildew.
iron phosphate	Sluggo	snails slugs	Bait which causes feeding to cease. Death occurs over 3-5 days. Exempt from tolerance and has a zero hour reentry interval due to low mamalian toxicity.
methoxyfenozide	Intrepid	Many species of caterpillar	Mimics moulting hormone; causes premature molt and death. Labeled for Grape Berry Moth.
pyrethrin	Pyganic EC Pyrenone Crop Spray	Many pests of fruit crops; see label.	Botanical insecticide with broad-spectrum activity. Contact toxin with rapid knockdown bur short residual. Highly toxic to fish. Derived from chrysanthemum. Some formulations OMRI listed.
spinosad	Entrust 2SC	caterpillars, leafminers, thrips	Acts both as a contact and stomach poison. Somewhat toxic to some beneficials. Rotate with other selective biorationals to prevent the development of resistance.
spiromesifen	Oberone	whiteflies and some mites	Contact insecticide and miticide.
Steinernema and Heterohabditis parasitic nematode species	Beneficial Nematodes	White grubs, weevil larvae, wireworms	Predatory nematodes seek out and penetrate host insects, multiply within the host and kill it. They are most likely to be effective against soil-dwelling immature stsges of susceptible host insects. They require moist soil conditions to survive.

Table 8. Biorational Disease Control Materials

Active Ingredient	Trade Name(s)	Target Pests	Comments
Acibenzolar-S-methyl	Actigard 50 WG	Downy Mildew, Xanthomonas	Plant defense activator
Calcium polysulfide	Lime-Sulfur (various manufacturers)	Cane and spur blights, Phomopsis, Fusicocum, Overwintering inoculum of Monolinia	This is a caustic compound that must be thoroughly cleaned from spray equipment to avoid damage. Some formulations are OMRI listed.
Cupric hydroxide	Champion WP, Champ, Nu-Cop, Kocide	Botrytis, downy mildew, powdery mildew, Anthracnose, Phomopsis	Be careful of potential phytotoxicity in some crops or cultivars; do not apply in close succession w/ Captan; read label carfefully for cautions and restrictions.
Harpin protein	Messenger	Bacterial diseases, adverse environmental conditions	Plant defense activator; variable efficacy
Hydrogen dioxide	Oxidate	Alternaria, Phytophthora, Pythiom, Rhizoctonia, Antracnose, Botrytis, Powdery Mildew	Kills on contact by oxidation. Will also kill beneficial organisms. Requires repeated applications.
Kaolin clay	Surround WP	Powdery Mildew, heat stress, sunscald	Creates a thin film of clay particles on the surface of treated plants. Must be rinsed off of harvested fruit if residue persists.
Neem oil	Trilogy Agroneem Azatrol Aza-Direct Neemix	Anthracnose, Botrytis, Downy and Powdery Mildew	Also effective for insect and mite control. Repeat applications needed for good control.
Potassim bicarbonate	Kaligreen Armicarb MilStop	Alternaria, Bortyris, Downy and Powdery Mildew	
Potassim phosphite	ProPhyt	Downy mildew, Phytophthora	Systemic material
Mono- and dibasic sodium, potassium, and ammonium phosphites	Phostrol	Downy mildew, Pythium, Phytophthora	Systemic material, see label for tank mix cautions
Sulfur	Kumulus	Powdery Mildew	Be careful of potential phytotoxicity in some crops or cultivars; do not apply in close succession w/ Captan; read label carfefully for cautions and restrictions.

there are now several instances where releases in the field have been proven to suppress, if not completely control, key pests. For example, beneficial nematodes are very small roundworms attack soil-dwelling insects. Two in particular (Steinernema and Heterorhabditis) have been mass-reared for commercial use. These seek out and penetrate their host insects, multiply within the host and kill it. They are most likely to be effective against the soil-dwelling immature stages of susceptible hosts, such as root weevils, cutworms, white grubs (use Heterorhabditis), wireworms, and maggots. Nematodes require moist soil conditions to survive. Consult the Resources section in the appendices of this guide for sources of further information and suppliers of beneficial organisms.

Pesticide Safety & Use

(adapated from the 2010 New England Vegetable Mgt Guide)

All pesticides are poisonous. However, some are more toxic than others. The toxicity of the pesticide is usually stated in the precaution label. For example, a skull and crossbones figure and the signal word "Danger" are always found on the label of highly toxic (Toxicity Class I) materials. Those of medium toxicity (Toxicity Class II) carry the signal word "Warning." The least toxic materials (Toxicity Class III) have the signal word "Caution." The toxicity of a pesticide is expressed in terms of oral and dermal LD50. LD50 is the dosage of poison that kills 50% of test animals (usually rats or rabbits) with a single application of the pure pesticide for a given weight of the animal (mg/kg of body weight). The lower the LD50 value, the more toxic the material. Oral LD50 is the measure of the toxicity of pure pesticide when administered internally to test animals. Dermal LD50 is the measure of the toxicity of pure pesticide applied to the skin of test animals. Generally, an oral application is more toxic than a dermal one.

All pesticides listed in this publication are registered and cleared for suggested uses according to federal and state regulations in effect on the date of this publication. Follow

current label.

Trade names are used for identification only; no product endorsement is implied, nor is discrimination intended against similar materials.

Warning! Pesticides are poisonous. Read and follow all directions and safety precautions on labels. Handle carefully and store in original labeled containers out of reach of children, pets and livestock. Dispose of empty containers carefully and properly. Contact your State Lead Agency (SLA) for pesticide regulation located in either the state Department of Agriculture or state Department of Environmental Protection for current disposal regulations and guidelines.

Before Using Pesticides

Read and post safety rules and the list of poison control centers. See instructions on safe storage of pesticides on page 31. You should become familiar with the information on storage and toxicity of pesticides listed in the appendix of this guide. Similar pesticide products may not have the same crop uses. Always be certain the crop is listed on the product label before ordering or using the product.

Do not use concentrations greater than stated on the label. Do not apply more pesticide per acre or more frequently than the fewest number of days between applications recommended by the label.

Instruct your family, co-workers and farm laborers on the safe use of pesticides, protective clothing and reentry regulations concerning pesticides. See farm worker protection standards on the next page.

Do not spray or dust when bees are active in the field. Morning or late evening is usually the best time to spray.

Precautions

- Read and follow all directions and safety precautions on labels.
- Store pesticides in original containers, out of reach of children, pets and livestock.
- Dispose of empty containers immediately in a safe manner and place. Triple rinse.
- Do not contaminate forage, watersheds or water sources.
- Become familiar with life cycles of pests to properly time applications.
- Keep a complete diary of applications: crop, date of planting, pests, weather conditions, materials, date of application and amounts applied.
- Adhere to farm worker protection standards.

Emergency Information

Human Exposure

If someone has swallowed or inhaled a pesticide or gotten it in the eye or on the skin:

- Call 911 if the person in unconscious, having trouble breathing, or having convulsions.
- Check the label for directions on how to give first aid.
- Call the Poison Control Center at 1-800-222-1222 for help with first aid information.

The National Pesticide Information Center (NPIC) (1-800-858-7378) can also provide information about pesticide products and their toxicity.

Spills

The National Response Center can help you decide how to respond to a spill. They can be reached at: 1-800-424-8802. In addition, CHEMTREC maintains a large database of Material Safety Data Sheets, chemical information references, resources, and networks of chemical and hazardous material experts. CHEMTREC provides access to technical information regarding chemical products as well as telephone access to product specialists, chemists, or other experts. (1-800-424-9300 in the U.S. or 703-527-3887 outside the U.S.)

The Comprehensive Environmental Response, Compensations, and Liability Act (CERCLA) requires that all releases of hazardous substances (including radionuclides) exceeding reportable quantities be reported by the responsible party to the National Response Center (NRC). Title 40 of the Code of Federal Regulations Part 302 promulgates reportable quantities and reporting criteria. All the Extremely Hazardous Chemicals (EHS) that overlap with the CERCLA listed chemicals table (40 CFR Part 302.4) should be reported to NRC as well as to the LEPC and SERC.

For small pesticide spills or for more information, call the pesticide manufacturer or the National Pesticide Information Center (NPIC) at 1-800-858-7378.

Reporting a Spill:

The National Response Center (NRC) is the sole federal point of contact for reporting oil and chemical spills. If you have a spill to report, contact NRC at 1-800-424-8802 (toll-free) or check out their Web site for additional information on reporting requirements and procedures. For those without 800 access, please contact the NRC at 202-267-2675.

Producers should be aware that they may be required to report spills to their state Lead Agency (SLA) for pesticide regulation or their state department of environmental protection.

More Information:

For more information, contact the National Pesticide Information Center (NPIC) at 1-800-858-7378.

Agricultural Worker Protection Standard (WPS) for Pesticides

The WPS applies to all pesticides whether restricted or general use. You will know the pesticide product is covered by the WPS if you see the following statement in the "Directions for Use" section of the pesticide labeling:

Agricultural Use Requirements

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment, notification of workers, and restricted-entry intervals.

The primary WPS resource is the How to Comply manual, developed by EPA.?he manual is available from your State Lead Agency (SLA) for pesticide regulation, pesticide education office of the Cooperative Extension Service, the EPA Region 1 office and EPA's National Agricultural Compliance Assistance Center. Every agricultural producer should have a copy of the EPA How to Comply manual.

The WPS is a US EPA regulation, 40 CFR Part 170. ?t covers pesticides that are used in the production of agricultural plants on farms, forests, nurseries, and greenhouses. The WPS requires the owner or employer to take steps to reduce the risk of pesticide-related illness and injury: 1) if pesticides are used on the farm or 2) workers or pesticide handlers are employed who may be exposed to such pesticides.

Here's a brief summary of the major elements of the WPS. Each one of these categories is described in greater detail in the EPA How to Comply manual. Producers should refer to the How to Comply manual for complete explanations of the requirements of the Worker Protection Standard.

INFORMATION

To ensure employees will be informed about exposure to pesticides, the WPS requires:

- Pesticide safety training — for workers and handlers,
- Pesticide safety poster — to be displayed for workers and handlers,
- Access to labeling information — for pesticide handlers and early-entry workers, and
- Access to specific information — a centrally located Application List of pesticide treatments on the establishment.

PROTECTION

To ensure employees will be protected from exposures to pesticides, the WPS requires employers to:

- Prohibit handlers from applying a pesticide in a way that will expose workers or other persons,
- Exclude workers from areas being treated with pesticides,
- Exclude workers from areas that remain under a restricted entry interval (REI) with narrow exceptions,
- Protect early-entry workers who are doing permitted tasks in treated areas during an REI — requirements include special instructions and duties related to correct use of Personal Protective Equipment (PPE),
- Notify workers about treated areas so they can avoid inadvertent exposures, and
- Protect handlers during handling tasks — requirements include monitoring while handling highly toxic pesticides and duties related to correct use of PPE.

MITIGATION

To mitigate exposures that employees receive, the WPS requires:

- Decontamination sites — providing handlers and workers an ample supply of water, soap and towels for routine washing and emergency decontamination,
- Emergency assistance — making transportation available to a medical care facility if an agricultural worker or handler may have been poisoned or injured by a pesticide and providing information about the pesticide(s) to which the person may have been exposed.

Owners/Crop Advisors/ Commercial Handlers

Agricultural Owner Exemptions

Even if you are the owner of the farm, forest, nursery, or greenhouse and you or members of your family do all the work there, you are a "WPS employer." You must comply with SOME of the WPS requirements, such as adhering to restricted entry intervals, personal protective equipment (PPE) and ALL the specific requirements listed in the pesticide labeling.

If you hire commercial handlers, certain information must be given from you (the operator) to the commercial handler employer.

- Specific location and description of any areas that may be treated with a pesticide or be under an REI while handler is there, or that the commercial handlers may be in (or walk within 1/4 mile of),
- Restrictions on entering those areas.

Crop Advisors

The WPS requires employers to provide certain protections to their employees who are working as crop advisors. Examples of crop advisors are crop consultants, scouts, and integrated pest management monitors. An independent or commercial crop advisor is any person working as a crop advisor who is employed (including self employed) by anyone other than the agricultural establishment on which the work is being done. Certain provisions of the WPS apply to crop advisors depending on when the advisor is on the farm and when the pesticide has been applied.

Commercial Handlers

Employers of commercial handlers must make sure that their customer — the operator of the farm, forest, nursery or greenhouse, knows certain information such as: specific location and description of the area treated with the pesticide, time and date pesticide is to be applied, product name, EPA registration number, active ingredient(s), REI for the pesticide, whether the labeling requires treated area posting and oral notification and any other specific requirements on the pesticide labeling concerning protection of workers and other persons during or after application.

Please refer to the EPA How to Comply manual for details, specific requirements and explanations. The manual is available from your state lead agency for pesticide regulation, pesticide education office of the Cooperative Extension Service, EPA Region 1 office or the EPA National Agricultural Compliance Assistance Center. Every agricultural producer should have a copy of the EPA How to Comply manual.

For more information on the WPS, contact your State Pesticide Coordinator, EPA Region 1 office or your Cooperative Extension Specialist.

Web Site for WPS: http://www.epa.gov/agriculture/twor.html.

Information About Pesticides

A pesticide is referred to: (1) by a common name or (2) by a trade or brand name (trade names are capitalized in this guide).

Labeled Formulations: The recommendations within this publication list only one formulation. Growers should be aware of other formulations. The rates to be applied are on the label. **Note**: There may be several products registered with the same active ingredient. Each label is different, and some crops may be listed on some labels but not on others. It is the responsibility of the user to read the label and be sure that the material selected is labeled for the proposed use.

Labels are for your protection and information: Look for the percentage (by weight) or amount of material in the formulation. Compare costs of two similar products on the basis of effectiveness, the amount of actual pesticide contained and the quantity of the formulations needed/acre.

Follow all safety precautions. Some pesticides are extremely dangerous to handle. Protect yourself and your employees.

Control of target pest not on the label: Always be certain the crop is on the label before using a pesticide on that crop. Target pests which are not listed on the label may not be effectively controlled by that product.

To avoid illegal residues: Adhere strictly to days to harvest (dh). Accurately calibrate your equipment; never exceed label recommendations. Prevent drift to adjacent properties or crops, or contamination of bodies of water. The applicator is held responsible for problems caused by drift or contamination. High-volume, low-pressure, ground applications cause less drift than low-volume, high-pressure, air-blast, ground applications, aerial applications or dust.

Emulsifiable concentrates (EC) are less troublesome to spray equipment than wettable powders (WP). The water-based flowable concentrates and wettable powders are less likely to cause plant injury than oil-based concentrates of similar materials.

Wettable powders/suspendable powders (WP) are less likely than ECs to cause injury to sensitive plants or to cause trouble when mixed with fungicides or other pesticides.

Dry flowables (DF) are similar to wettable powders in their formulation but are pelletized to minimize dust.

Flowables (F) are liquid formulations with similar properties to latex paint. Clean equipment immediately after use.

Tank mixture and aerial application: Check the label and consult your state pesticide regulatory agency.

Disposal of pesticides: Read label. Contact your state pesticide regulatory agency for instructions on disposal of chemicals.

Restricted-Use Pesticides

In accordance with federal and state pesticide regulations, those pesticides that are highly toxic and those that persist and accumulate in the environment are placed on a restricted-use list and shall be sold and used only by certified applicators.

For information about training for certified applicators contact your Extension Specialist.

In some instances, states may require additional permits for certain pesticide users.

Poisoning Information

(Adapted from Ohio Vegetable Production Guide)

Make sure your doctor has a copy of the Note to Physicians that is placed on the labels of dangerous pesticides.

Treatment for pesticide poisoning is very precise. The antidotes can vary for the different pesticides. In an emergency, call your doctor and provide specific information on the trade name and common name of the pesticide exposed to. Your doctor will then consult the center if necessary.

Pesticide Storage

Pesticides should always be stored in their original containers and kept tightly closed. For the protection of others, especially firefighters, the storage area should be posted as Pesticide Storage and kept securely locked.

Herbicides, especially hormone-like weed killers such as 2,4-D, should not be stored with other pesticides (primarily insecticides and fungicides) as they can volatize and be absorbed by other pesticides.

Store pesticides in a cool (between 40° and 80°F), dry, well--ventilated area that is not accessible to children and others who do not know or understand the safe and proper use of pesticides.

Any restricted pesticide or container contaminated by restricted pesticides must be stored in a secure, locked

enclosure while unattended. That enclosure must bear a "pesticide storage" warning sign readable at a distance of 20'. If any pesticide has to be stored in other than its original container, that container must be labeled with the name and concentration of the active ingredient and the signal word and warning statements for the pesticide along with a copy of the label. Keep an inventory of all pesticides stored in an area away from the storage site, so that it may be referred to in case of an emergency at the storage site.

Make available to personnel at all times: a respirator with chemical cartridge, gas mask with canister, goggles, rubber gloves and aprons, fire extinguisher and a detoxicant for spilled materials suggested by your local fire department. Instruct all personnel on proper use of the above equipment and on what to do in case of emergency. A shower stall with plenty of soap should be made available on the premises. Prompt washing in case of accidental spillage may be a matter of life and death.

Keep your local fire department informed of the location of all pesticide storage areas. Fighting a fire that includes smoke from burning pesticides can be extremely hazardous. Firefighters should be cautioned to avoid breathing any smoke from such a fire. A fire with smoke from burning pesticides may endanger people in the immediate area or community. They may have to be evacuated if the smoke from a pesticide fire drifts in their direction.

Winter Storage of Pesticides

Plan pesticide purchases so that supplies are used by the end of the growing season. When pesticides are stored for the winter, keep them at temperatures above freezing, under dry conditions and out of direct sunlight. The following points should be observed:

- Read the label. Special storage recommendations or restrictions will be printed on the label.
- Write the purchase or delivery date of the product on the label with waterproof ink. Products may lose their effectiveness over several years.
- Ventilation is important for storage of most pesticides.
- Store herbicides separately from other pesticides to avoid cross contamination. Below are signs of quality deterioration:

Formulation	General Signs of Deterioration
EC	Evidence of separation of components such as sludge or sediment. Milky appearance does not occur when water is added.
Oils	Milky appearance does not occur when water is added.
WP, SP	Excessive lumping; powder does not suspend in water.
D, G	Excessive lumping or caking

After freezing, place pesticides in warm storage (50° to 80°F, or 10° to 26.7°C). Shake or roll container every few hours to mix product or eliminate layering. If layering persists or if all crystals do not completely dissolve, do not use product. If in doubt, call the manufacturer.

Water

Protect Groundwater

There is considerable public concern about water quality, and agriculture is coming under increasing scrutiny regarding practices that can affect water quality. Many pesticides and fertilizers are soluble in water and can leach through the soil to contaminate underlying groundwater. Several factors affect the movement of chemicals in the soil and their likelihood of reaching groundwater. Consideration of these factors can minimize the threat to groundwater.

Pesticide Characteristics: Solubility is very important in the leaching of a pesticide. Chemicals that are highly soluble in water are easily leached as water moves downward. If practical, use the least soluble material at the lowest effective rate.

Adsorption is the binding of a chemical to the surfaces of soil particles and organic matter. Some chemicals are tightly adsorbed and do not easily leach from soils.

Persistence refers to the amount of time a chemical will stay in the environment before being broken down into nontoxic substances. The rate of breakdown is affected by sunlight, temperature, soil pH, moisture and microbial activity. Pesticide persistence is measured in terms of half-life which is the length of time needed for one-half of the amount applied to break down. Persistent chemicals break down slowly, increasing the chance for them to leach from the soil. Conversely, short-lived materials may be degraded before significant leaching occurs. Many pesticides are broken down by sunlight (photodegradation) and/or microbial action. Incorporation of pesticides into the soil reduces or eliminates photodegradation. As depth in the soil increases, there is less microbial degradation. Any practice that slows degradation increases persistence and the likelihood of leaching. Generally, foliar applied materials are more likely to break down before significant leaching occurs than those that are applied to the soil.

Soil Characteristics: Soil texture and organic matter greatly influence the movement of pesticides and fertilizers. Fine textured soils and those with high amounts of organic matter are highly adsorptive, whereas sandy soils low in organic matter are not. Highly permeable soils with permeable underlying layers allow for rapid downward movement of water and dissolved chemicals. Know your soils and apply chemicals accordingly.

Water Table: High water tables are especially vulnerable

to contamination because little time is required for chemicals to reach groundwater.

Fertilizers: Nitrogen (N) in the nitrate form is highly soluble, persistent and not adsorbed to soil particles. Nitrate N is not only leachable but is recognized as a health threat at concentrations above 10 ppm in drinking water. Infants are most susceptible to nitrate in drinking water. The ammonium form of N is adsorbed by soil particles and is less subject to leaching. However, ammonium N is converted to nitrate N in the soil, and this can occur quite rapidly. Note that urea, a common form of fertilizer N, is converted in the soil to ammonium and then to nitrate.

Appropriate management practices can reduce the likelihood of nitrate leaching. Any time large amounts of N are applied, significant leaching can occur if there is heavy rain. By applying some of the needed N at planting and the rest during one or more topdressings, you can avoid having large amounts of nitrate present at any one time. Not only can this reduce leaching, it can improve production by providing N during periods of greatest crop uptake.

Nitrogen left over in the soil at the end of the season is highly subject to leaching. A cover crop should be planted to take up unused N. The N will again become available for future crops as the cover crop breaks down.

Contact Cooperative Extension and the Natural Resource Conservation Service about questions you may have regarding the use of certain pesticides on your soils.

Know Your Water

The pH of the water in your tank mix can sometimes affect the efficacy of pesticides. Insecticides, in particular, have a tendency to break down (hydrolyze) rapidly in alkaline water. Water pH can vary, depending on the source, from 5.0 to 9.5. Neutral water has a pH of 7.0, while alkaline water is higher than 7.0. If your water pH is much higher than 8.0, you may want to consider using an acidifying agent such as vinegar to lower the pH in the tank. Many of the pH-sensitive pesticides have acidifying agents in the formulation that moderate the effect of alkaline water. However, growers who suspect a pH problem should have their water tested. This can be done on the farm with pH test kits. Also, organic matter can tie up certain pesticides or clog nozzles.

Fumigation: Materials and Risks

The practice of soil fumigation, while providing significant benefits as outlined above, also carries with it significant risks. One such risks is reintroducing pathogens on transplant material or farm equipment. This can cause a phenomenon called "the boomerang effect" in which a pathogen is (re) introduced in a partially sterilized soil and proliferates rapidly because checks and balances no longer exist in that soil. In such a case, the resulting epidemic is worse than if the soil had never been fumigated. So, it is very important to take care to plant very clean transplant material and to use only clean equipment when working in a newly fumigated field.

Fumigation is also a costly practice, one which a grower must carefully consider before using. The cost must be justified by the anticipated benefits. And the benefits must be reliable and predictable. Moreover, availability of fumigants may decline in the future due to EPA restrictions and voluntary withdrawal by manufacturers. With this in mind, it is advisable to implement effective crop rotation plans and other soil management practices in anticipation of reduced availability of fumigants.

Table 9. Approximate dilutions for small volumes of spray mixes

Formulation	100 gallons	5 gallons	3 gallons	1 gallon
WETTABLE POWDER	5 pounds	15 tablespoons	9 tablespoons	3 tablespoons
	4 pounds	13 tablespoons	8 tablespoons	3 teaspoons
	3 pounds	10 tablespoons	6 tablespoons	2 tablespoons
	2 pounds	8 tablespoons	4 tablespoons	4 teaspoons
	1 pound	3 tablespoons	2 tablespoons	2 teaspoons
	1/2 pound	5 teaspoons	1 tablespoons	1 teaspoon
EMULSIFIABLE CONCENTRATE	5 gallons	1 quart	1 1/4 pints	13 tablespoons
	4 gallons	1 1/2 pints	1 pint	10 tablespoons
	3 gallons	1 1/4 pint	3/4 pint	1/4 pint
	2 gallons	3/4 pint	1/2 pint	5 tablespoons
	1 gallon	1/2 pint	8 tablespoons	3 tablespoons
	1 quart	3 tablespoons	2 tablespoons	2 teaspoons
	1 pint	5 teaspoons	1 tablespoon	1 teaspoon

Table 10. Toxicity information for some pesticides commonly used in small fruits[†].

Trade Name[(tm)]	Common Name	Resistance Group[&]	Signal Word[††]	Re-Entry Interval	Labeled Crops (Pre-Harvest Interval)
		INSECTICIDES/MITICIDES			
Acramite	bifenzate	25	Caution	12 hrs	S(1), G(14)
Actara	thiamethoxam	4A	Caution	12 hrs	S(3), B(3), R(3), G(5)
Admire	imidacloprid	4A	Caution	12 hrs	S(14), B(7), R(7), G(30)
*Agri-mek	abamectin	6	Warning	12 hrs	S(3), G(28)
Altacor	chlorantraniliprole	28	Caution	4 hrs	R(3), G(14)
*Asana	esfenvalerate	3	Warning	12 hrs	B(14, R(7)
Assail	acetamiprid	4A	Caution	12 hrs	S(1), B(1), R(1), G(7)
Avaunt	indoxacarb	22A	Caution	12 hrs	B(3), G(7)
⊗ Aza-Direct	azadirachtin	18B	Caution	4 hrs	S(0), B(0), R(0), G(0)
Belt	flubendiamide	28	Caution	12 hrs	G(7)
⊗Biobit, ⊗Deliver	Bacillus thuringiensis	11B2	Caution	4 hrs	S(0), R(0), G(0)
*Brigade	bifenthrin	3	Warning	12 hrs	S(0), B(1), R(3), G(30)
Confirm	tebufenozide	18A	Caution	4 hrs	B(14), R(14)
Clutch	clothianidin	4A	Caution	12 hrs	G(0)
*Danitol	fenpropathrin	3	Warning	24 hrs	S(2), B(3), G (21)
Deadline	metaldehyde	--	Caution	12 hrs	S, B, R
Delegate	spinetoram	5	Caution	4 hrs	B(3), R(1), G(7)
*Diazinon	diazinon	1B	Caution[z]	3-5 days	S(5), B(7)
*Dibrom	naled	1B	Danger	48-72hrs	S(1), G(3)
⊗ Entrust	spinosad	5	Caution	4 hrs	S(1), B(3), R(1), G(2)
Esteem	pyriproxyfen	7D	Caution	12 hrs	S(2)[s], B(7), G(21)[s]
Imidan	phosmet	1B	Warning	14-24 hrs	B(3), G(7-14)
Intrepid	methoxyfenozide	18	Caution	4 hrs	G(30)
Kanemite	acequinocyl	20B	Caution	12 hrs	S(1)
*Lannate	methomyl	1A	Danger[z]	2 - 7 days	S(3), B(3), G(1-14)
*Leverage	imidacloprid/cyfluthrin	4A/3	Warning	12 hrs	G(3)
*Lorsban	chlorpyrifos	1B	Danger	24 hrs	S(21), G(35)
⊗ M-Pede	insecticidal soap	--	Warning	12 hrs	S(0), B(0), R(0), G(0)
Malathion	malathion	1B	Warning	12 hrs	S(3), B(1), R(1), G(3)
*Mustang	zeta-cypermethrin	3	Warning	12 hrs	S(1), B(1), R(1), G(1)
Nexter	pyridaben	21	Warning	12 hrs	G(7)
Oberon	spiromesifen	23	Caution	12 hrs	S(3)
Platinum	thiamethoxam	4A	Caution	12 hrs	S(50), B(75), G(60)
Provado	imidacloprid	4A	Caution	12 hrs	S(7), B(3), R(3), G(0)
PyGanic	pyrethrins	3	Caution	12 hrs	S(0), B(0), R(0), G(0)
Pyrellin	pyrethrins/rotenone	3/21	Caution	12 hrs	S(0), B(0), R(0), G(0)
Pyrenone	pyrethrins	3	Caution	12 hrs	S(0), B(0), R(0), G(0)
*Renounce	cyfluthrin	3	Caution	12 hrs	G(3)
Savey	hexythiazox	10B	Caution	12 hrs	S(3), R(3)
Sevin	carbaryl	1A	Caution	12 hrs	S(7),B(7), R(7), G(7)
Sluggo	iron phosphate	--	Caution	0	S(0), B(0), R(0)
Spintor	spinosad	5	Caution	4 hrs	S(1), B(3),R(1), G(7)
⊗ Stylet Oil	Paraffinic oil	--	Caution	4 hrs	S(0), B(0), R(0),G(0)
Success	spinosad	5	Caution	4 hrs	S(1), B(3), R(1), G(7)
⊗ Surround	kaolin	--	Caution	4 hrs	B(0)[b], R(0)[b] G(0)[b]
*Thionex	endosulfan	2A	Danger/Poison	varies by crop	S(4), B(PH)

Table 10. Toxicity information for some pesticides commonly used in small fruits[†].

Trade Name[(tm)]	Common Name	Resistance Group[ꝏ]	Signal Word[††]	Re-Entry Interval	Labeled Crops (Pre-Harvest Interval)
Voliam Flexi	thiamethoxam/chlorantraniliprole	4A/28	Caution	12 hrs	G(14)
Zeal	etoxazole	10C	Caution	12 hrs	S(1)
		FUNGICIDES			
Abound	azoxystrobin	11	Caution	4 hrs	S(0), B(0), R(0), G(14)
Armicarb	potassium bicarbonate	NC	Caution	4 hrs	S(0), B(0), R(0), G(0)
Adament	tebuconazole/trifloxystrobin	3/11	Caution	12 hrs	G(14)
Aliette	fosetyl-aluminum	33	Caution	12 hrs	S(0), B(0), R(60), G(15)
Bravo Ultrex	chlorothalonil	M5	Danger	12hrs	B(42)
Cabrio	pyraclostrobin	11	Caution	24 hrs	S(0), B(0), R(0)
Captan	captan	M4	Danger	1-4 days***	S(0), B (0), R(3), G(0)
Captevate	captan/fenhexamid	M4/17	Danger	24-72 hrs	S(0), B(0), R(3)
Cuprofix	copper sulfate	M1	Caution	24 hrs	S(**), B (**), R(**), G(**)
Dithane	mancozeb	M	Caution	24 hrs	G(66)
Elevate	fenhexamid	17	Caution	12 hrs	S(0), B(0), R(0)
Elite	tebuconazole	3	Warning	12 hrs	G(14)
Endura	boscalid	7	Warning	12 hrs	G(14)
Flint	trifloxystrobin	11	Caution	12 hrs	G(14)
Indar	fenbuconazole	3	Caution	12 hrs	B(30)
⊗ Kaligreen/⊗ Nutrol	potassium bicarbonate	NC	Caution	4 hrs	S(1), B(1), R(1), G(1)
Kocide	copper hydroxide	M1	Danger	24 hrs	S(**), B (**), R(**), G(**)
Kumulus	sulfur	M2	Caution	24 hrs	S(0), B(0), R(0), G(0)
Lime Sulfur	calcium polysulfide	M2	Danger	48 hrs	B(0), R(0), G(0)
Mettle	tetraconazole	G1	Caution	12 hrs	G(14)
Omega	fluazinam	29	Warning	72 hrs	B(30)
Orbit	propiconazole	3	Warning	24 hrs	S(0), B(30), R(30)
⊗ Oxidate	hydrogen dioxide	--	Danger	0	S(0), B(0), R(0), G(0)
Phostrol	potassium/ammonium phosphites	NC	Caution	4 hrs	S (0), B(0), R(0), G(0)
Presidio	fluopicolide	43	Caution	12 hrs	G(21)
Pristine	pyraclostrobin/boscalid	11/7	Caution	12-120 hrs	S(0), B(0), R(0), G(14)
Procure	triflumizole	3	Caution	12 hrs	S(1), G(7)
Prophyt	phosphorus acid	33	Caution	4 hrs	S(0), B(0), R(0), G(0)
Quadris	azoxystrobin	11	Caution	4 hrs	S(0), B(0), R(0), G(14)
Quintec	quinoxyfen	13	Caution	12 hrs	S(1), G(14)
Rally	myclobutanil	3	Warning[z]	24 hrs	S(0), R(0), G(14)
Revus	mandipropamid	40	Caution	4 hrs	G(14)
Ridomil Gold SL	mefenoxam	4	Caution	48 hrs	S(0), B(0), R(45)
Rovral	iprodione	2	Caution	24 hrs	S(PreBloom), R(0), G(7)
Rubigan	fenarimol	3	Warning	12 hrs	G(21)
Scala	pyrimethanil	9	Caution	12 hrs	S(1), G(7)
Serenade	Bacillus subtillis	--	Caution	4 hrs	S (0), B(0), R(0), G(0)
Sovran	kresoxim-methyl	11	Caution	12 hrs	G(14)
⊗ Stylet Oil	paraffinic oil	--	Caution	4 hrs	S(0), B(0), R(0), G(0)
Sulfur	sulfur	M2	Caution	24 hrs	S(0), B(0), R(0), G(0)
Switch	cyprodinil/fludioxonil	9/12	Caution	12 hrs	S(0), B(0), R(0)
Syllit	dodine	M2	Danger	48 hrs	S(14)
Tilt	propiconazole	3	Warning	24 hrs	S(0), B(30), R(30)
⊗ Thiolux	sulfur	M2	Caution	24 hrs	S(0), B(0), R(0), G(0)

Table 10. Toxicity information for some pesticides commonly used in small fruits[†].

Trade Name[(tm)]	Common Name	Resistance Group[∞]	Signal Word[††]	Re-Entry Interval	Labeled Crops (Pre-Harvest Interval)
Thiram	thiram	M3	Caution	24 hrs	S(3)
Topsin-M	thiophanate-methyl	1	Caution	12 hrs	S(1)
⊗ Trilogy	neem oil	--	Caution	4 hrs	S(0), B(0), R(0), G(0)
Vangard	cyprodinil	9	Caution	12 hrs	G(7)
Vintage	fenarimol	3	Caution	12 hrs	G(21)
Ziram	ziram	M3	Danger	48 hrs	B(14), G(21)
		HERBICIDES			
Aim	carfentrazone-ethyl	14	Caution	12 hrs	S(0), B(0), R(14), G(3)
Callisto	mesotrione	27	Caution	12 hrs	B(pf)
Casoron	dichlobenil	20	Caution	12 hrs	B(ns), R(ns)
Chateau	flumioxazin	14	Caution	12 hrs	S(nb), G(60)
Dacthal	DCPA	3	Caution	12 hrs	S(ns)
Devrinol	napropamide	15	Caution	12 hrs	S(ns), B(ns), R(ns)
Formula 40	2,4-D	4	Danger	48 hrs	S(ns)
Fusilade	fluazifop	1	Caution	12 hrs	S(nb), B(nb), R(nb)
Gallery	isoxaben	21	Caution	12 hrs	B(nb), R(nb)
Goal	oxyfluorfen	14	Danger	24 hrs	S(pp)
*Gramoxone Inteon	paraquat	22	Danger	24 hrs	S(21), B(21), R(21)
Karmex	diuron	7	Caution	12 hrs	B(ns), R(ns)
*Kerb	pronamide	3	Caution	24 hrs	B(ns), R(ns)
Matrix	rimsulfuron	2	Caution	4 hrs	G(14)
Poast	sethoxydim	1	Warning	12 hrs	S(7), B(30), R(45)
Princep Caliber	simazine	5	Caution	12 hrs	B(pf), R(pf)
Prowl H20	pendimethalin	3	Caution	24 hrs	G(60)
Rely	glufosinate-ammonium	10	Warning	12 hrs	B(14), G(14)
Roundup Weather Max	glyphosate	9	Warning	12 hrs	B(14), R(14)
Scythe	pelargonic acid	27	Warning	12 hrs	S(0), B(0), R(0)
Select	clethodim	1	Warning	24 hrs	S(4), B(nb)
Sinbar	terbacil	5	Caution	12 hrs	S(70), B(70), R(70)
Snapshot	trifluralin	3	Caution	12 hrs	B(nb), R(nb), G(nb)
Solicam	norflurazon	12	Caution	12 hrs	B(60), R(60)
Surflan	oryzalin	3	Caution	24 hrs	B(ns), R(ns)
Touchdown	sulfosate	9	Caution	12 hrs	B(30), R(30)
Velpar	hexazinone	5	Danger	24 hrs	B(90)

S=strawberries, B=bushberries, R=brambles, G=grapes

[(tm)]Where trade names are used, no discrimination is intended and no endorsement is implied. Not a complete list.

∞ Insecticide, Fungicide or Herbicide Resistance Action Committee (IRAC, FRAC, HRAC) code lists

[†]Based on 2010 Label Registrations.

[††]See next page for description of toxicity class and signal word.

[b]no preharvest interval is required but application close to harvest is not recommended because of persistent residues.

[z]Some formulations carry a different toxicity class and signal word. Check the label. The most conservative designation is represented in the table.

[s]Supplemental Label.

⊗ OMRI certified for organic production

* Restricted Use Pesticide.

** Dormant or Post Harvest Applications recommended due to phytotoxicity concerns.

***Check captan label carefully for REI and PHI restrictions.

[Δ]REI varies up to 21 days for different crops and different activities. Check the label.

ns= phi not specified, may be dictated by use pattern; nb=for use on non-bearing fields; pp=labeled for pre-plant applications; pf=labeled for pre-fruit formation application

TOXICITY CATEGORY	SIGNAL WORDS* REQUIRED ON LABEL	ORAL LD_{50} (MG/KG)	PROBABLE LETHAL ADULT HUMAN DOSE
I Highly Toxic	DANGER and POISON, plus skull and crossbones symbol	0 to 50	A few drops to 1 tsp
II Moderately Toxic	Warning	50 to 500	1 tsp to 2 tsp
III Slightly Toxic	Caution	500 to 5,000	1 oz to 1 pint (1 lb)
IV Almost non-toxic	Caution	more than 5,000	1 pint (1 lb)

*Please Note: certain products may use signal words which do not correlate with LD_{50} ratings due to some special property of the chemical. For example, chlorothalonil has a very low toxicity (LD50 10,000 mg/kg) yet had DANGER and WARNING signal words on many of its formulations, due to a possibility of an extreme allergic reaction in some people.

Weed Management General Notice

The primary goal of weed management is to optimize yield by minimizing weed competition. Weeds can reduce yields by competing with the crop for water, light, and nutrients. Weeds also promote pest injury by acting as alternate hosts for plant pathogens and insects, inhibiting spray penetration, and maintaining a high humidity in the crop canopy. Timely cultivations, wise use of herbicides and mulches, and not allowing weeds to go to seed are integral parts of a good weed management system. Many of the weeds found in small fruit plantings are difficult-to-control perennials that are not common in other crops. Do not expect chemicals to completely control weeds. Every herbicide does not control every weed species and the selection of a given herbicide should be made on the basis of specific weed species present in the field.

Herbicide rates listed on the product label are for broadcast applications. Reduce rates proportionally for banded or strip applications. For best results with herbicides follow the manufacturer's application directions regarding rates, additives, soil type, soil moisture conditions, time of year, crop age, stage of weed growth, environmental conditions, and product limitations.

It is unlawful to use any pesticide for other than the registered use. ALWAYS READ AND FOLLOW ALL LABEL DIRECTIONS. The user assumes all responsibilities for use inconsistent with the label on the product container.

Trade names are used for identification. No product endorsement is implied, nor is discrimination intended against similar materials not mentioned. Cooperative Extension and the participating universities make no warranty or guarantee of any kind, expressed or implied, concerning the use of these products.

Certain herbicides listed in this publication may be discontinued by the manufacturer and thus no longer available. Use of remaining stocks on dealers shelves or farm storage is encouraged and legal provided the label directions are followed.

Herbicides - General

Herbicides are chemicals designed to control weeHerbicides are chemicals designed to control weeds. The use of these chemicals must be exact for satisfactory results. Proper rate selection, timing of application, activation, and observance of all precautions on the label must be followed to obtain optimum performance. Each herbicide controls

Table 11. Fumigant rates and spectrums of activity.

Common Name	Trade Name	Rates/A	nematodes	fungi	weeds	Comments
sodium methyl dithiocarbamate	Vapam HL	37.5-75 gal	yes	yes	yes	Water-soluble liquid that decomposes to a gaseous fumigant. Efficacy affected by soil moisture, temperature, texture, and organic matter content.
dazomet	Basamid	220-350 lb	yes	yes	yes	Not for bearing crops. Granular product. Incorporate thoroughly in soil. Toxic gases released following absorption of soil moisture by product. Affected by same factors as metam-sodium. 365 days-toharvest limitation. Higher rates than those listed above may be required for fumigation to depths greater than 6".
1,3 dichloropropene	Telone II	27-35 gal	yes	no	no	Liquid that diffuses as a gas through soil. Effective against nematodes and insects. Rates vary with soil texture; efficacy strongly affected by soil moisture and temperature.
1,3-dichloropropene + Chloropicrin	Telone C17 Telone C35	32.4–42.0 gal 39–50 gal	yes yes	yes yes	no[a] no[a]	Liquid that diffuses as a gas through soil. Added chloropicrin increases efficacy against soilborne fungi. Affected by same factors as Telone II.
Iodomethane + Chloropicrin	Midas 25 Midas EC Gold	24-46.4 gal 19.8-35.1 gal	yes yes	yes yes	yes yes	Liquid that diffuses as a gas through soil. Added chloropicrin increases efficacy against soilborne fungi. Allowable methods of application vary with the formulation.

Adapted from The Mid-Atlantic Berry Guide for Commercial Growers

certain weeds or families of weeds. Therefore, knowledge of the type of weed species present in the field is essential for good weed control (see the "Weeds of the Northeast" reference in the Resource Materials section). Once the weed problem is known, select the proper herbicide.

Certain considerations should be made in this process.

- Restrictions on rates, timing and crops for which the herbicide is approved.
- Degree of susceptibility of each weed to a specific herbicide.
- Limitations and special requirements of the herbicide.

General Principles for Safe Use

- Know the herbicide. Read the label.
- Check the output of sprayer frequently.
- Replace worn nozzles. It may be necessary to replace them several times a season if the sprayer is used constantly.
- Avoid skips and overlapping.
- Rinse spray equipment immediately after use. If possible, use one sprayer for herbicides and another for insecticides and fungicides.

Follow the Worker Protection Standards information printed on the label.

Herbicide Rate Selection

Always check the label to determine the proper rate to apply. For most soil-applied herbicides, knowledge of the type of soil and the percentage organic matter usually determines the rate. Generally, the more clay and/or organic matter present in the soil, the higher the herbicide rate necessary for good weed control. When applying herbicides to fresh mulch, use the lowest labeled rate. For postemergence herbicides, the type of weed as well as its size will usually determine the rate.

Incorporation of Herbicides

Some herbicides must be incorporated into the soil to be effective. Herbicides are incorporated because they are volatile and evaporate into the air if left on the soil surface or they will decompose when exposed to sunlight. Herbicides differ in their incorporation requirements; check the product label for the manufacturer' s requirements.

Weed Sprayer Systems

- Select a sprayer and pump that can deliver a volume of 20 to 50 gallons per acre. Most herbicides are applied at rates of 20 to 40 gallons of water per acre. Pressures of 20 to 40 p.s.i. at the nozzle are recommended for most herbicides. Higher pressures result in finer droplets and increase the chance for more drift. Lower pressures sometimes cause uneven spray patterns.
- Use 50-mesh screened filters for nozzles and suction lines.
- Select 80° or 110° flat fan nozzles. Because of wear, brass tips used exclusively for applying wettable powders should not be used on more than 30 acres before being replaced. Use stainless steel or hardened stainless steel tips for longer wear. Stainless steel nozzle tips are more than twice the cost of brass tips but last about 20 times longer. Hardened stainless steel tips are only slightly more expensive than stainless steel tips but last three times longer. Ceramic nozzles are the most durable.
- Calibrate sprayers frequently and check for wear, especially when wettable powders have been used.

Mechanical Weed Control

Cultivation is an important component of weed control in small fruits, particularly when the use of herbicides and/or mulches is to be minimized or eliminated. The timing of cultivation should be based on the stage of weed growth that your equipment is best suited to control, as well as to the stage of crop development that is most sensitive to weed pressure. In general, weeds are most effectively cultivated shortly after they germinate, and crops are most sensitive to weed pressure during their early stages of growth. Thus, cultivation is most critical early in the growing season. To get good weed control with cultivation requires use of the proper machinery, driven by a competent operator, in a timely fashion.

A variety of cultivation equipment is used by small fruit growers. These include **rotovators, multivators, rolling cultivators, rotary hoes, sweep cultivators and discs, S-tine or Danish S-tine cultivators, basket weeders, finger weeders, spring-hoe and spyder weeders, and spring-tine weeders**. For a full description of these cultivators, see references in resource materials section.

Stale Bed Technique

In many cases, choice of herbicides for use in newly planted small fruit crops is limited. Even when a herbicide is registered for use in the crop, certain weed species may be present which the herbicide cannot control. In many cases, it may be possible to use a method which utilizes Gramoxone, Roundup, Touchdown, Scythe or flaming. Except for cool early spring conditions, when weeds may be slow to germinate, this method, termed the stale bed technique, can mean the difference between good weed control and poor or no weed control. Here are the steps:

- Prepare the soil for transplanting. If a soil-incorporated herbicide is used, it must be applied and incorporated at this time. The soil should have good moisture (irrigate with 1/4" of water if necessary).
- Wait as long as possible so that weeds will germinate and emerge. Allow weed seedlings to grow to the third leaf

stage, or at least to the first true leaf.

- Flame the soil or make an application of Gramoxone, Scythe, Touchdown or Roundup (if registered for the crop) to the soil surface before transplanting. Transplant the crop and then apply any preemergence herbicide, which you would normally use, to the soil surface.

The main idea with this technique is that most of the weeds that have the potential to germinate, because of their placement in the upper 1" to 2" of the soil, will usually do so within two weeks after the soil is prepared. Adequate soil moisture and temperature (at least 50 ☐ F at a depth of 2") must be present. Gramoxone, Roundup, Touchdown, Scythe or flaming will kill these weeds. By not redisturbing the soil any more than is absolutely necessary during the transplanting process, no new weed seeds will be brought close to the soil surface. This technique, because it reduces the number of viable weed seeds near the soil surface will also help the residual herbicide, if any, to perform better than it normally would. Finally, any cultivation which is performed should be kept extremely shallow (3/4" to 1" maximum) so as not to reposition any additional weed seeds. Note: Check the current herbicide recommendations by crop to determine if Gramoxone, Scythe, Touchdown or Roundup is registered for use in that crop.

Finally, Roundup or Touchdown can be used for control of perennial weeds, such as quackgrass and dock, during the summer or fall prior to planting. For best results, the soil should be tilled about 2 weeks after application. Rates vary considerably so check the label for directions. Control of perennial weeds in the spring will be poor. Contact herbicides, including Gramoxone, Scythe and flaming will have minimal long-term effect on perennial weeds.

Flame Weeding

Flame weeding is the killing of weeds with intense, directed heat produced by a propane burning device, either hand-held or tractor-mounted. Flaming can be used as an alternative to non-selective herbicides for stale seedbeds. This involves preparing the soil as if for planting, without actually planting the crop. Instead, weeds are allowed, even encouraged (with irrigation or row covers), to grow. Weeds are then killed. Because, like with contact herbicides, flaming kills weeds without soil disturbance, it is ideal for stale seedbeds. Some growers use hand-held units to flame just in the row, relying on cultivation for between-row weed control.

Prepared fields or beds may be flamed one or more times, depending on when weeds appear and when the crop is to be planted. Once broadleaf weeds reach the 1-3-leaf stage, they should be flamed to prevent them from growing too large. For the longest weed control effect, it is important that the final flaming be applied as late as possible or just prior to transplanting. Digging in the soil to check crop seeds for sprouting, or using a small piece of glass or row cover as an early warning system is one way to optimize the timing of flaming after direct seeding.

Flaming does not burn the weeds but "blanches" them. They will not collapse and die for several hours. There are exceptions. The growing points of grasses are usually below ground for some time and will not be affected by flaming. Purslane can take high temperatures without dying. These weeds require subsequent cultivation or hotter temperatures. When weeds are moist from rain or dew, more heat (a slower tractor or walking speed) will be necessary. Safety is a big issue with flaming. Consult with a gas professional if constructing your own flaming unit. Do not mount propane tanks intended for stationary use onto tractors. Flame against the breeze and avoid areas with dry residues or dry hedgerows. Liability concerns may hinder the use of flaming.

Strawberries

General Information

Strawberries are attacked by a variety of pests, including insects, mites, pathogens and weeds. While much of this publication deals with chemical controls, the best overall approach to pest management integrates chemicals with other methods. Where possible, cultural practices that may help in managing these pests are presented.

The single most important factor in controlling pathogens is the maintenance of vigorously growing plants. Weeds compete with strawberries for essential water and nutrients. Weeds also promote pest injury by acting as alternate 'homes' for diseases and insects, inhibiting spray penetration, and maintaining high humidity in the strawberry leaf canopy.

Good soil and air drainage are essential for plant health. Roots rot quickly in waterlogged soil, and fruit rots are more common when the soil surface does not dry quickly. Well-drained loams are the most suitable soil types for good root penetration and plant growth. Sites where cold air can drain away to lower levels will decrease the possibility of frost damage to the flowers and fruit. A southern, sloping site is the most ideal location providing quick-drying soil and earlier ripening berries.

For good root penetration, aeration and drainage, organic materials should be added to the soil. Disc animal manures, compost, and/or green manure crops (cover crops) thoroughly into the soil before planting. The use of leguminous cover crops may increase soil nematode populations, which may be injurious to strawberries. Sudan grass (which will suppress nematode populations) and Japanese millet are annual cover crops well suited for most situations, providing heavy organic matter production. See section on "Cover Crops and Green Manures" on page 8 for more on this subject. If poultry manure is used, it must be applied cautiously. It is a rich source of nitrogen which, if used to excess, can promote excessive vegetative growth and soft berries (both conditions encourage disease).

In new beds, a soil test should be done to determine the pH, and the rate and types of fertilizer to apply. Have the soil tested at your state university or private soil-testing lab and apply the necessary lime to adjust the pH to within the range of 5.8 to 6.2. Some soils low in magnesium may benefit from the use of dolomitic (Hi-Mag) lime. Pre-plant fertilizer recommendations will generally call for the application of blended fertilizer containing nitrogen, phosphorous and potash in a 1-2-2 ratio (250 to 400 pounds of 10-20-20 is a typical recommendation). Nitrogen at up to 30 pounds per acre banded over the plant row is generally recommended during the period of heavy runner development (late June or early July). An additional, smaller application (up to 20 lbs N) may be suggested for early August.

Heavy fertilizer applications should be avoided in the spring on established beds; too much nitrogen will promote abundant vegetative growth that encourages disease by inhibiting good air circulation needed to dry plant surfaces. The longer moisture films remain on fruit and leaves from irrigation, rain, dew or high humidity, the greater the chance of fungal spores germinating and disease outbreaks occurring. Berries may also become soft as a result of too much nitrogen. Light applications of fertilizer may be made in spring (8-15 lbs of actual N per acre) to promote early plant growth and fruit development.

Leaf tissue analysis is a good way to determine nutrient levels actually in the plant rather than what is in the soil. Sometimes the nutrients in the soil are not available to the plant due to pH, organic matter content, or some other reason. Leaf tissue analysis tells you what the plant is getting and what the plant is lacking. The samples are taken after bed renovation in the summer from the first fully expanded new leaves. At least 50 complete leaves per planting should be taken, rinsed, and allowed to dry completely before processing. Contact your regional fruit specialists for the exact protocol, processing instructions, and fees. Standards are available for comparison to determine if your results indicate the need for corrective measures. See Table 12.

Good root development is essential to the continued productivity and health of the strawberry planting. Primary roots generally live only a year or slightly longer, requiring the development of new roots at successively higher nodes on the growing crowns. To encourage increased root development, strawberry crowns are mulched with about 1 inch of loose soil during the renovation process, enough soil to cover the crown extension that has occurred during the past year without covering the top of the crowns.

Strawberries are a cool weather crop, producing most of their growth in the spring and fall. Growth is greatly slowed during the hot, dry summer months, resulting in a shallow root system. During the growing season (April, May, August, September and October) applying 1-1/2" of water every 12 to 14 days will aid in maximum growth and fruit bud development. During fruiting, adequate moisture (1/2 to 3/4" of water per week) will maintain fruit size and production.

Table 12. Recommended optimal soil characteristics for growing strawberries.

Soil Characteristic	Desirable Range*
pH	5.8-6.2
Organic matter	4 to 6 %
Phosphorus	20-30 ppm
Potassium	120- 180 ppm
	Base Saturation >3.0
Magnesium	100-150 ppm
	Base Saturation >5.0
Calcium	1000 - 1500 ppm
	Base Saturation >50.0

** Desirable range will vary with soil type (sand, silt, or clay), soil organic matter, and pH.*

Irrigation can also eliminate frost damage to flowers during early bloom periods. If sprinklers are turned on before the temperature at ground level drops to 32˚F and continued until air temperature is above freezing and all ice has melted off the plants, the blossoms will be protected. (Remember, the first blossoms to open will bear the largest berries.) The sensitive, actively growing tissue in the crown will also be protected from freezing injury that would make it more susceptible to pathogen attack.

Diseases

Fruit Rots

Gray Mold (Botrytis cinerea): Symptoms of gray mold include light brown areas on fruit; a powdery gray growth produced on rotted fruit and leaf tissue; and whole rotted berries that retain their general shape but become tough and dry.

Gray mold is a serious problem because it often attacks other living plant parts in addition to developing and harvested fruit. The fungus overwinters in living plant tissue and proliferates in the spring as leaves die. Favored by cool, wet weather, the fungus establishes itself on dead or aging leaves, moving to healthy tissue as more and more spores are produced. Petals and other parts of older flowers are likely to be attacked first. These infections may destroy developing fruit immediately or become dormant until the fruit begins to ripen. Secondary infections may occur when spores that cling to ripening fruit germinate in moist packaging conditions after the fruit is harvested, causing uncontrollable storage rots.

Management: It is important to maintain proper spacing between plants and also narrow plant rows to allow good air circulation. This will promote rapid drying of foliage, blossoms, and fruit during periods of high humidity, rain, irrigation, or dew and lessen the chance of Botrytis spores germinating on plant surfaces. Beds that become too crowded are likely to promote Botrytis fruit rot. Heavy nitrogen applications, particularly early spring applications, also promote Botrytis development.

If Botrytis is a chronic serious problem or in years with a lot of rainfall during bloom, fungicides should be applied during the bloom period. See pest management schedule below for recommended materials and timing.

Leather Rot (Phytophthora cactorum): Symptoms include: fruit with dull and lifeless appearance; infected areas of immature fruit are brown to dark brown, while infected areas on ripe fruit appear bleached to lilac to normal in color; infected fruit is tough and has a bitter taste. After harvest white fuzzy growth may appear under moist packaging conditions.

Table 13. Number of strawberry plants per acre at different spacings.

In Row Spacing	Spacing Between Rows 36 inch	40 inch	42 inch
6 inches	29,040	26,241	24,891
12 inches	14,520	13,120	12,446
18 inches	9,680	8,712	8,297
24 inches	7,260	6,540	6,223

Table 14. Critical freeze temperatures for strawberries based on stage of growth.

Stage of Development	Approx. Critical Temperature
Tight bud	25˚F
“Popcorn”	26˚F
Open Blossom	30˚F
Fruit	28˚F

Table 15. Critical nutrient values for strawberry tissue analysis.

	Deficient	Below Normal	Normal	Above Normal	Excessive
N (%)	1.50	1.80	2.00	2.80	>2.80
P (%)	0.20	0.25	0.35	0.40	>0.50
K (%)	1.20	1.50	2.00	2.50	>3.00
Ca (%)	0.60	0.70	1.50	1.70	>2.00
Mg (%)	0.25	0.30	0.45	0.50	>0.65
Mn (ppm)	40	50	150	200	>250
Fe (ppm)	50	60	150	250	>300
Cu (ppm)	5	7	10	20	>25
B (ppm)	20	30	60	70	>85
Zn (ppm)	15	20	35	50	>60

This fungus is a common soil inhabitant that attacks many species of trees, shrubs, and perennial or annual herbs. The leather rot organism also causes a serious crown rot. Rainy weather promotes infection by splashing the fungus spores along with soil particles onto flowers or fruit. Maturing fruit in contact with wet soil may also become infected. Frequent fog or morning dew may supply adequate moisture for the "swimming" spores to cause infection. Fruits may be affected at all stages from blossom to maturity.

Management: Proper plant spacing and weed control for good aeration to promote rapid drying of plant surfaces. Clean straw mulch placed under plants and between rows keeps maturing fruit from getting rain-splashed soil on the surface. (Note: plastic mulch may "puddle" and actually make leather rot worse.) When conditions are very wet, and leather rot has occurred in a field, fungicides may be needed. See pest management schedule below for recommended fungicides and spray timing.

Anthracnose (Colletotrichum spp.): Symptoms of this disease include circular, sunken, water-soaked tan to brown lesions on both green and ripe fruit. In wet or humid weather, creamy pink to salmon colored spore masses occur in the centers of these lesions, and the fungus can produce fluffy white growth at the border of the lesion and healthy tissue. Under dry conditions, or if secondary organisms do not cause soft rots, the fruit may become mummified and black.

This fungus is an extremely important pathogen of strawberries in the Southeast. In addition to fruit, this fungus may also attack stolons, petioles, and strawberry crown tissues. The same fungus has been reported to cause fruit rots of crops such as apples, blueberries, raspberries, grapes, peppers and tomatoes.

The incidence of anthracnose fruit rot may be directly related to unusually warm weather in spring. Spore production, germination, and host infection are all favored by warm, humid environmental conditions. Spread of the fungus from infected tissues to uninfected fruit and crowns occurs primarily by splash dispersal and is aided by wind-driven rain. However, spread may also occur on runners and by the movement of people or equipment through the field, especially in wet weather.

Management: Control of strawberry anthracnose is difficult, especially under warm, wet conditions. Initial planting of uninfected crowns is important, and rotation out of strawberries for a period of time before replanting may be helpful, as the fungus overwinters on infected plant tissues or infested debris in the soil. Fungicides may be helpful in reducing infection, but may be less effective in hot, humid weather. Overhead irrigation of fields with infected plants or fruit and the movement of people or equipment through wet fields can increase spread of the pathogen. However, the retention of a straw mulch between rows will help reduce splash dispersal of the fungus. See pest management schedule below for recommended materials and timing.

Foliar Diseases

Bacterial Angular Leaf Spot (Xanthomonas fragariae): Angular leaf spot is a bacterial disease. Relatively little is known about the disease. It is not thought to be a consistent annual problem. Early symptoms on the leaves are tiny, water-soaked areas. When viewed against a bright light, lesions are translucent, but when viewed against a normal or dark background, the lesion areas are dark green. As the disease progresses, it may develop symptoms which are similar to common leaf spot, leaf scorch and Phomopsis leaf blight. Chlorotic halos will form, areas of tissue will appear red, and the lesions on leaves and petioles will join together into large, irregularly shaped areas. The most severe problem, from a marketing perspective, is that the calyx of the berries may become infected, darkening it and making the berries less attractive. To date in Massachusetts, the disease has damaged plants, limiting growth, but has not caused plant mortality. Reports from California indicate that infections can become systemic and will occasionally kill plants.

Inoculum for the first lesions in the spring comes from infected dead leaves. The bacteria are very resistant to drying and other harsh conditions, and may survive for a long time in the old leaves or in buried plant tissue in the soil. The pathogen does not move in the soil, or survive free in the soil. The bacteria may move from new lesions to other plants. It can be spread by rain or irrigation, or carried from plant to plant when fields are being worked. Wet, cool weather in the spring encourages the bacteria to build up to damaging levels. Long periods of rain, or frequent irrigation at times when the day temperatures are around 65° F, and night temperatures near 35° F, will encourage growth and spread of this disease.

Management: In general, antibiotics (streptomycin or oxytetracycline) or copper-containing pesticides are used to treat bacterial plant diseases. While some sources say these treatments will protect against angular leaf spot, field tests have shown only moderate success at best. Copper applications can damage strawberry plants.

In the absence of any better information, it is best to take a two-pronged approach where angular leaf spot has been a problem. First, in fields with a history of this disease, inoculum should be reduced by removing as much leaf debris as possible from the field at renovation. Rotate out of severely infested fields for at least a year. Second, begin scouting fields with a history of this disease as soon as buds extend from the crown. Continue scouting until bloom. If symptoms are observed, discontinue irrigation unless needed for frost protection or when excellent drying conditions prevail. Minimize the time leaf and blossom tissue is wet. Also, avoid worsening the problem by working in the field when the leaves are wet.

Leaf Spots

Fungal diseases of the leaf may occur as soon as the first

leaves unfold in early spring until dormancy in the late fall. Generally, these diseases do not exceed an economic threshold that calls for chemical control. The primary damage of leaf diseases is a loss of vigor through reduced leaf area that is needed to support the plant. If outbreaks of these leaf diseases become significant, the plants will become weakened during winter dormancy and become more susceptible to root diseases and winter injury.

The three major leaf fungal pathogens have a similar life cycle. Leaf spot, leaf scorch, and leaf blight all overwinter in infected dead or living leaves, producing spores and new infections during moist, warm conditions.

Leaf Spot (Mycosphaerella fragariae): Symptoms of leaf spot first appear as circular, deep purple spots. The spots enlarge and the centers turn grayish to white on older leaves and light brown on young leaves. A definite reddish purple to rusty brown border surrounds the spot.

Spores overwinter in lesions on living leaves. More spores are produced in early summer in spots on the upper and lower leaf surface, and are spread by splashing rain. Middle-aged leaves are most susceptible. Lesions also develop on fruit, stems, petioles and runners.

Leaf Scorch (Diplocarpon earliana): Symptoms of this disease consist of numerous small, irregular, purplish spots on leaves. The center of the blotches becomes brownish. Blotches may coalesce, covering the leaflet which then appears purplish to reddish to brown.

Fruiting structures are produced in the spring on lower leaf surfaces of dead leaves. Spores are produced most abundantly in midsummer. Oldest and middle-aged leaves are infected more readily than young ones.

Leaf Blight (Phomopsis obscurans): Symptoms of leaf blight infections begin as one to six circular reddish-purple spots on a leaflet. Spots enlarge to V-shaped lesions with a light brown inner zone and dark brown outer zone. Lesions follow major veins progressing inward. The whole leaflet may turn brown. In severe cases, stolons, fruit trusses and petioles may become infected which may girdle and kill the stem.

The fungus overwinters as mycelium or fruiting structures on the old leaves that remain attached to the plant. Spores are spread by rain splash early in the spring. Leaf blight is most destructive to older leaves in the late summer. Calyxes and fruit may also be infected.

Management: Leaf scorch and leaf spot are mainly controlled by use of resistant varieties. (See chart of disease resistant varieties.) No resistant varieties to leaf blight are known. Cultural practices and fungicides recommended for controlling fruit rots are also beneficial for managing leaf spot diseases, e.g. proper plant and row spacing for good air drainage and plant vigor. Mowing or removing the tops and old leaves at renovation has benefits for managing leaf diseases. But, this practice is only effective for this purpose if the mowings are removed from the field or thoroughly incorporated into the soil by tilling. Leaves less than 3 weeks old are susceptible to infection by leaf spot; older leaves are resistant. See pest management schedule below for recommended materials and timing.

Powdery Mildew (Sphaerotheca macularis): Symptoms include white powdery growth on the lower leaf surface, causing the leaf edges to roll upward. (Note: Some herbicides will cause leaf rolling on certain varieties.) Infected flowers and ripe fruit may also become covered with white growth; and infected green fruit may fail to ripen and will remain hard.

This fungus overwinters on living infected leaves. Infection periods are favored by dry weather and temperatures between 58° and 68°F. Thus, if a severe foliar infection occurs, it does so late in the season. Controlling these foliar infections with fungicides does not apparently increase yields. However, by controlling foliar infections, the amount of inoculum available to infect the spring growth is reduced. Crop losses occur as a result of flower and fruit infections.

Management: See pest management schedule for recommended materials and timing, and variety selection chart for resistant varieties.

Root Rots

The strawberry root system is composed of three types of roots: the perennial and structural roots that originate from the crown, and the transient feeder rootlets that originate from the perennial or structural roots. The structural roots are light in color with a well developed cortex. The perennial roots are dark due to the sloughed cortex surrounding woody secondary growth and are more or less permanent. They store food reserves to maintain the plant through winter dormancy.

Structural roots are produced from the crown during the current year. Transient feeder roots consisting of primary tissues are produced from both structural and perennial roots. They may only live a few weeks and are replaced during the growing season; they are constantly dying back and being replaced. The transient roots function to absorb water and nutrients; the perennial roots cannot. Thus, all types of roots are important in maintaining healthy plants and good yields. Death to transient rootlets by pathogens or unfavorable soil conditions is not as damaging to plant vigor if the plant is able to replace them. However, often the structural and perennial roots also become infected. When this happens, the plant is greatly weakened, producing little or no fruit. Plants may suddenly wilt, or plants which were healthy the previous season may develop slowly in the spring. Proper diagnosis of soil-borne problems requires careful examination of the roots and crown.

Red Stele (Phytophthora fragaria): Symptoms of red stele infection are numerous: wilting; young leaves with a bluish-green tint; and older red, orange or yellow leaves. Severely diseased plants may die or remain stunted, producing few runners and small berries. When roots are cut open lengthwise, the core will show a reddish-brown discoloration; however, a reddish core does not guarantee that red stele is present. Plants showing symptoms usually occur in patches where the soil is wettest.

This fungus causes a root rot and wilt, and is a major disease of strawberries where cool, wet soil conditions occur. The fungal spores actually swim and need water in the soil in order to find and infect roots. The fungus enters the main perennial roots and grows along the stele, the plant's food and water transport system. Roots begin to rot from the tip within a few days after infection. Depending on the extent of the infection and the plant's resistance, stunting or wilting and collapse of the plant will result.

Management: Good soil drainage, texture, and planting in raised beds in wet areas will discourage growth of the fungus. Purchase planting stock only from nurseries that have been inspected and certified disease-free. Disease resistant varieties are available. Consult your nursery supplier for more information. Pre-plant soil fumigation may reduce P. fragaria infestation in soil but avoiding wet sites is more reliable. Post-plant treatment with a systemic fungicide is also an option. See pest management schedule for materials and timing.

Verticillium Wilt (Verticillium albo-atrum): Symptoms of Verticillium wilt are marginal and interveinal browning and eventually collapse of outer leaves; inner leaves are stunted and may wilt but tend to remain green until the plant dies.

This fungus has a wide host range among annual and perennial crops and weeds. Verticillium is spread from field to field by water, wind or on infected planting stock, and crop and weed debris. Plants that are fruiting are affected more severely, and the first symptoms are noticeable as temperatures increase in late spring.

Management: Do not use solanaceous crops (such as tomato or potato), or squash or raspberries for rotation crops. In addition, control pigweed and lamb's-quarters which are also hosts for Verticillium. Preplant soil fumigation may help in managing this disease. See disease resistant variety chart for selection of resistant varieties.

Black Root Rot: Above-ground symptoms of this disease are similar in appearance to red stele. That is, a general lack of vigor and eventual collapse of plants especially during dry weather. Underground symptoms consist of blackened feeder roots and, eventually, structural and perennial roots. Structural roots will rot from the outside to the center, leaving the core white for a period of time, unlike red stele where the core is usually red.

Black root rot has no simple causes or remedies. It is a disease complex, involving several pathogens combined with plant stress. The key pathogens include Rhizoctonia, Pythium, and lesion nematode. The pathogens involved in this disease are commonly found in soils but usually don't cause disease symptoms on healthy plants. Stressed plants are a different story. Strawberry plants may be stressed in a number of ways, such as drought, winter injury, root feeding insects or nematodes, poor nutrition, soil compaction, or improper herbicide use. Stresses reduce the plant's resistance to disease. Long after the initial stress, root rotting pathogens may infect and continue to damage the plant's roots and crown.

Management: Control of black root rot in an existing field is difficult since there is no systemic material that can be applied for control. Stress management is the key to black root rot management. Therefore, replacing winter mulch that has blown off, irrigating during dry weather and after renovation, maintaining good nutritional status in the plants, and not allowing the soil to be compacted are important practices to reduce plant stress and thereby reduce possibility of black root rot developing in the field.

The long-term strategy for managing black root rot relies on site selection and crop rotation. Choose a site which has well drained soil with good soil organic matter content and has not grown strawberries recently. Where black root rot has been a problem, a rotation with a 3-6 year period without strawberries is recommended. This long rotation is needed because causal organisms can persist in the soil for a long time. Using a variety of crops and cover-crops in this period is recommended to help break up the disease cycle and avoid alternate hosts of this disease.

Soil fumigation for controlling black root rot can work well, but can also fail under certain conditions. Fumigation sterilizes the soil of pathogens and beneficial organisms. Organisms reintroduced in this "clean" soil grow rapidly in the absence of competition or predators. Pathogens, even in very small quantities, in soil from non-fumigated areas carried into fumigated areas on shoes, equipment or roots of strawberry transplants, may allow pathogens to build up to high levels. Thus, soil fumigation runs the risk of favoring Black Root Rot rather than controlling it. Moving to a planting site which has not grown strawberries recently, and is well-drained is the best method of managing this disease.

Virus Diseases

Viruses are disease-causing organisms so small they cannot be seen with an ordinary microscope. Several viruses infect strawberries in the Northeast, and it is not uncommon for two or more viruses to be found within the same plant. Viruses in a plant may not show obvious symptoms. However, their presence does weaken the plant.

Loss of vigor and yield caused by viruses are more likely to show up when growing conditions are unfavorable and plants are stressed. Virus symptoms on strawberries, include chlorotic (yellow) spots or irregular patches on leaves. Leaves may crinkle, or otherwise be malformed. Herbicide injury and virus symptoms may be similar.

Management: Once strawberry plants are infected with a virus, they cannot be cured. The infection is passed on to all daughter plants via runners. Most viruses are spread from plant to plant via aphids. Chemical insecticides will not kill aphids before they are able to transmit viruses and may even stimulate aphids to feed. Planting virus-free material will decrease overall damage from virus diseases.

Table 16. Strawberry cultivar descriptions.

			— DISEASE RESISTANCE[b] —				
CULTIVAR	SEASON	HARDINESS[a] ZONE	VERTICILLIUM WILT	RED STELE	LEAF DISEASES[c]	POWDERY MILDEW	SULFUR SENSITIVITY
AC Wendy	Early	3	U	U	U	U	U
Annapolis	Early	3	I	R	S	S	VS
Avalon	Early	4	R	R	T	R	U
Earliglow	Early	4	R	R	R	PR	NS
Evangeline	Early	4	U	S	R	R	U
Mohawk	Early	3	R	R	R	R	U
Northeaster	Early	4	R	R	I	S	U
Sable	Early	3	U	R	R	S	U
Brunswick	Early-mid	4	U	U	U	U	U
Honeoye	Early-mid	3	S	S	PR	S	MS
Itasca	Early-mid	3	U	R	U	U	U
L'Amour	Early-mid	4	S	S	U	U	U
Cavendish	Mid	3	R	R	PR	S	S
Darselect	Mid	4	U	S	S	U	U
Delmarvel	Mid	4	R	R	R	U	U
Eros	Mid	4	S	R	U	U	U
Guardian	Mid	4	R	R	R	S	VS
Jewel	Mid	4	S	S	PR	R	U
Kent	Mid	4	S	S	S	T	VS
Lester	Mid	4	S	R	R	R	U
Mira	Mid	4	S	R	R	R	U
Primetime	Mid	4	R	R	R	U	U
Redchief	Mid	4	PR	R	R	R	U
Allstar	Mid-late	4	R-T	R	T	T	NS
Cabot	Mid-late	4	R	R	T	T	U
Mesabi	Mid-late	3	R	R	PR	R	U
Raritan	Mid-late	4	S	S	S	U	U
Sparkle	Mid-late	3	PR	R	R	U	U
Seneca	Mid-late	4	S	S	U	U	U
Winona	Mid-late	3	T	R	R	R	U
Idea	Late	4	R	R	S	U	U
Lateglow	Late	4	R	R	PR	S	U
Ovation	Late	4	R	R	U	U	U
Diamante	Day Neutral	4	U	U	U	U	U
Everest	Day Neutral	4	S	R	U	R	U
Seascape	Day Neutral	4	U	U	U	U	U
Tribute	Day Neutral	3	PR	R	T	R	VS
Tristar	Day Neutral	3	R	R	T	R	VS

[a] Refers to USDA Hardiness Zones, [b]I=intermediate, PR= partially resistant, R= resistant, S= susceptible, T= tolerant, U= unknown. [c]Includes leafscorch and leafspot.

For information on sources and further descriptions of cultivars listed above, go to the Cornell Nursery Guide for Berry & Small Fruit Crops at: www.hort.cornell.edu/extension/commercial/fruit/Berries/nurseries/strawberries.html

Table 17. Efficacy of fungicides for strawberry disease management.

Fungicide	FRAC Group[a]	Phomopsis Leaf Blight	Leaf Spot	Leaf Scorch	Angular Leaf Spot	Powdery Mildew	Gray Mold	Anthracnose Fruit Rot	Leather Rot
Abound	11	+[b]	+	--	0	++	+	++	++
Aliette	33	0	0	0	0	0	0	0	+++
Cabrio	11	++	++	++	0	+++	++	+++	+++
Captan	M	++	++	++	0	0	++	++	+
Captevate	17,M	+	+	++	0	0	+++	++	+
Copper	M	0	0	0	+	0	0	0	0
Elevate	17	0	0	--	0	0	+++	0	0
⊗ JMS Stylet Oil									
Kumulus									
⊗ Microthiol									
Orbit, Tilt	3	--	++	--	0	+++	0	0	0
Phoostrol	33	0	0	--	0	0	0	0	+++
Pristine	7,11	++	+++	+++	0	+++	+++	+++	+++
Procure	3	--	0	--	0	+++	0	0	0
Quintec	13	0	0	--	0	+++	0	0	0
Rally	3	+++	++	+++	0	+++	0	0	0
Ridomil Gold	4	0	0	0	0	0	0	0	+++
Rovral	2	+	+	+	0	0	+++	0	0
Scala	9	0	0	--	0	0	+++	0	0
Syllit	M	++	++	++	0	--	--	--	--
Switch	9,12	0	+	++	0	0	++	++	0
Thiram	M	++	++	++	0	0	++	+	+
Topsin-M	1	++	++	+++	0	+++	+++	0	0

a. Chemistry of fungicides by activity groups: 1=benzimidazoles and thiophanates; 2=dicarboximides; 3=demethylation inhibitors (includes triazoles; 4=acylalanines; 7=carboxamides; 9=anilinopyrimidines; 11=strobilurins; 12=phenylpyrroles; 13=quinolines; 17=hydroxyanilides; 33=unknown (phosphonates); M=chemical groups with multisite activity. Fungicides with 2 activity groups contain active ingredients with different modes of action.

b. 0=not effective; +=slight effectiveness; ++=moderate effectiveness; +++=very effective; --=insufficient data

Insects

Fruit Damaging Insects

Tarnished Plant Bug (Lygus lineolaris): The tarnished plant bug (TPB) is a small (1/4") bronze-colored insect with a triangular marking on its back. The immature stage, or nymph, is smaller and bright green, resembling an aphid, but much more active. Both adults and nymphs feed on the developing flowers and fruit, sucking out plant juices with straw-like mouth-parts. This results in deformed fruit: typically "cat-faced" berries, also called nubbins or button berries. Such fruit are generally unmarketable.

Management: Controlling weeds in and around the planting may reduce populations of this insect, but insecticide sprays may be necessary. If mowing around fields, do so after insecticides have been applied (to control migrating insects). Avoid planting strawberries near alfalfa which attracts high populations of TPB. White sticky traps are available for monitoring tarnished plant bug adults. These traps are used as a indication of when plant bugs begin their activity in the spring and a relative indication of their abundance, not as an indication of when to control this insect. Immature TPB (nymphs) are sampled by shaking flower trusses over a flat white surface. Thirty flower clusters should be sampled evenly from across the field (typically 6 clusters at 5 locations or 5 clusters at 6 locations). If 4 or more flower clusters are infested with nymphs (regardless of how many) a spray is recommended. A follow-up spray application may be made after bloom if TPB are still present in high numbers (check harvest interval before selecting material). See pest management schedule for recommended materials and timing. Do not apply insecticides during bloom.

Table 18. Monitoring for tarnished plant bug in strawberry.

NUMBER OF CLUSTERS EXAMINED	NUMBER OF FLOWER CLUSTERS INFESTED			
	CONTROL NOT REQUIRED	KEEP SAMPLING	CONTROL REQUIRED	
			Low threshold 0.15 nymphs/cluster =4% damage	High threshold* 0.25 nymphs/cluster =2% damage
15	0	0 to 3; check 5 more	3 or more	5 or more
20	0	0 to 4; check 5 more	4 or more	5 or more
25	1 or less	1 to 4; check 5 more	4 or more	6 or more
30	2 or less	2 to 4; check 5 more	4 or more	7 or more
35	3 or less	3 to 5; check 5 more	5 or more	7 or more
40	3 or less	3 to 5; check 5 more	5 or more	8 or more
45	4 or less	4 to 6; check 5 more	6 or more	9 or more
50	5 or less	5 to 6; check 5 more	6 or more	9 or more

**Primarily for processing fruit.*

Sequential Sampling: a time-saver. To save time, a sequential sampling plan may used to determine how many clusters should be sampled. By using Table 16 below, you can make a spray/no spray/keep looking decision by first examining a minimum of 15 clusters. If you find 0 TPB nymphs, you can stop and make a "no spray" decision. If you find more than 0 but less than 3, (or, between 1 and 5 if you are using a high threshold) you must continue sampling. If you find 3 or more TPB nymphs, control is required in order to avoid economic damage to your crop. If the maximum of 50 flower clusters are sampled and no decision is indicated, the grower should sample again in 1 or 2 days. This method allows scouts to spend less time monitoring in fields where populations are very low, or very high. More time is spent sampling fields where TPB populations are close to the threshold.

Strawberry Bud Weevil, "Clipper" (Anthonomus signatus): The strawberry bud weevil or "clipper" occurs somewhat less frequently than tarnished plant bug. This insect is a very small beetle (1/8") with a copper-colored body and a black head with a long snout.

The female weevil chews a small hole in unopened flower buds and lays an egg in the hole. She then girdles the stem just below the bud. The flower bud dries up and dangles from the stem, eventually falling to the ground. The immature weevils, or grubs, develop in the girdled buds, emerging as adults in the early summer, and then migrating to wooded areas.

These insects are not always present and may only cause minimal damage some years. Examine the plants before bloom for clipped buds. If the field has had a history of clipper injury, the first appearance of clipper indicates the need to spray.

Management: Check for presence of clipper by examining new flower trusses as they first emerge from the crowns in April or May. The weevils will sometimes crawl in among the unopened buds for shelter. They are most likely to be in rows near woods or hedgerows. Later, look for shot-holes in opened flower petals and/or clipped buds of unopened flowers. In the past, the IPM action threshold for this insect is 1 clipped bud per 2 ft. of row or one live adult. Research done in recent years suggests that many more clipped buds can be tolerated without significant yield loss. A comparison of old

Table 19. Sampling procedure for strawberry bud weevil (clipper).

	Old Method	**New Method**	**New Method**
Unit examined	Flower buds	Flower Clusters	Flower buds
Assessment	Clipped buds or Not clipped	Cluster highly damaged* or Cluster with low amounts of damage	Clipped buds or Not clipped
Threshold	2 clipped buds/m	3 highly damaged clusters/m	3 clipped 1° buds/m or 30 clipped 2° or 3° buds/m

**highly damaged=1 clipped primary (1°) bud, or 2 clipped secondary (2°) bud, or 3 clipped tertiary (3°) buds*
Courtesy Pam Fisher, Ontario Ministry of Food and Agriculture

and new sampling methods done by researchers at Cornell University (Hortscience 34 (1): 109-111. 1999) can be seen in Table 17 below. Sample at least 5 locations in the field. If you determine that the infestation is limited to the edge of a field, you may only need to spray the border rows. If you see evidence of clipper and determine a spray application is necessary, follow recommendations for materials and timing in the strawberry pest management schedule.

Sap beetles (Stelidota geminata): Sap beetles cause hollowed out cavities on ripe fruit, an injury very similar to slug injury. Adults are small oval beetles about 2mm long and dark brown in color. They are often hard to see because they drop to the ground when disturbed, but they may be found in the cavities they have chewed out. They are found almost exclusively when there is ripe fruit in the field.

Management: The best management for this pest is sanitation; keeping the field as free as possible of ripe fruit. Sap beetles may be trapped with bait baskets of over-ripe fruit placed between the edges of the field and wooded areas. Spacing recommendations are not known. Place traps as soon as bait fruit is available. Brigade™ may be used for control if absolutely necessary; it can be sprayed within 12 hours of harvest, but might devastate mite predators. Read the label carefully. See pest management schedule for recommended materials and timing.

Thrips (Thysanoptera): Thrips are tiny insects that feed on flower parts. Several species occasionally infest the flowers of strawberries. The adults are slender, winged, about 1/25 inch long, and are orange or yellow. Young thrips are smaller, wingless, yellowish, and active. These insects breed on grasses and weeds in spring, and move to strawberries at bloom. They insert their eggs in plant tissue at the base of flowers, and in tender, new foliage.

Thrips begin feeding on the seeds and the inner surface of the hull soon after the buds open. As the fruit expands and the seeds separate the thrips feed extensively on the fruit between the seeds. Thrips feed by piercing the surface cells with their mouth-parts and sucking the contents, causing cells to die. With continued feeding, the entire fruit becomes bronzed.

Management: Thrips can build up to damaging levels. Scouting for this insect can be difficult because of their small size. Fruit should be examined when they are very small, 5-10 mm in diameter. Examine under the calyx for presence of thrips, or place in a zip-lock bag in the sun. This will drive the thrips out so that they can be counted. Canadian researchers indicate that more than 25 thrips per 50 sampled fruit will result in unacceptable levels of fruit damage. See Table 18 below. Several insecticides labeled for use on strawberries are effective on thrips. Consult the labels.

Table20. Guidelines for thrips in strawberries.

Characteristic	Definition
Sample Size	50 fruit/acre
Sample Time	Early fruit maturity stage (5-10 mm diameter)
Suggested Limits	25 thrips/50 fruit for PYO 5 thrips/50 fruit for shipping berries 2 thrips/berry = 20% damage

Leaf Damaging Insects and Mites

Strawberry Leafrollers (Ancylis comptana fragariae): These insects have an immature stage (larvae) which damages strawberry leaves. They are small green or bronze larvae (caterpillars) up to 1/2" long at maturity. They occur in the field prior to bloom and in mid- to late July. Larvae are first found on the undersides of leaves in silken covers, then on upper sides of leaves that have been folded or rolled and tied with silken threads.

Management: Remove and destroy rolled leaves. If infestation is severe, a pre- or post-bloom spray application may be needed. Timing will depend on when larvae are present. In Southern New England they occur in mid-May so a pre-bloom insecticide spray is recommended.

Twospotted Spider Mite (Tetranychus urticae): Twospotted spider mites (TSSM) are very small (1/50"), 6- or 8-legged creatures that feed on strawberry foliage. Under heavy infestations, mite feeding destroys leaf chlorophyll and causes leaves to have yellowish or whitish speckles, then an overall bronze color. Leaves will be covered in a fine webbing. Yield reductions may occur from repeated heavy infestations. The most serious reductions in yield may result from early season feeding, so scouting for overwintered mites in early May is especially important.

Twospotted spider mites are found on the underside of leaves, are barely visible to the naked eye, and are especially active during hot, dry months. Mites generally form colonies and may be most noticeable by the webbing that they produce around their aggregations, which may occur as localized "hotspots" in the field. Therefore, when looking for mites, the grower must look over the whole field, checking first for bronzing and then looking for mites with a hand lens. Overwintered female TSSM mites are easily seen because they are orange-colored.

Management. Mites should be monitored weekly by sampling the field in 5 to 10 locations. Five to ten leaves should be sampled at each location for a total of 60 leaves. Examine the underside of the leaves for the presence or absence of TSSM. Record the information on a field map so that "hot spots" can be identified and treated. A miticide application is recommended if 25% (i.e., 15 leaves) or more of a

60 leaf sample is infested with TSSM. See pest management schedule for recommended materials and timing.

Natural predators exist which feed on two-spotted spider mites. One such predator, also a mite (Neoseiulus fallacis), is native to the northeast and often maintains TSSM populations at non-damaging levels. It is equally small but lacks the two spots on its back, is teardrop shaped, shiny, and pale yellow in color. They are also easily distinguished from TSSM by their rapid movement across a leaf in search of prey; (they resemble bumper cars moving forward and backward as they search for food). When sampling a field, presence of predators as well as TSSM should be noted.

Several companies sell predatory mites, including N. fallacis, for release in various crops. However, the benefit of releasing commercially reared mites has not been demonstrated in the northeast, where natural populations of N. fallacis are pervasive. It is important to encourage natural enemies of spider mites by reducing the use of broad-spectrum pesticides (especially carbamate and pyrethroid insecticides) which harm natural enemies. One strategy that has worked exceptionally well has been the early-season use of 1% oil with a mist blower. This inexpensive treatment is highly selective: it kills TSSM, but not predatory mites. The resulting imbalance between predators and TSSM allows predators to "mop-up" the remaining TSSM. Please note that oil-incompatible pesticides should not be applied prior to the oil spray. See the table at the end of this guide for toxicity of pesticides to beneficial insects. Contact your local Extension Specialist or call (916) 324-4100 for a copy of Suppliers of Beneficial Organisms in North America, an excellent sourcebook for natural enemies such as predatory mites. This reference is also available via the Internet at http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm. Also, see Integrated Pest Management for Strawberries in the Northeastern United States (listed at the end of this guide) for more details on life cycles and biological control of twospotted spider mites.

Cyclamen Mite (Steneotarsonemus pallidus): This soft-bodied mite is orange-pink, white, or green and about 1/100" long. These mites feed on the unfolding leaves in the crown of the plant, leading to distorted, purplish leaves, and buds that fail to open. Cyclamen mite is not as common as two-spotted mite in strawberries and has been known to occasionally come in on nursery stock. It is, therefore, important to buy plants from a reputable source.

Management: See pest management schedule for recommended materials and timing.

Strawberry Aphids (Chaetosiphon spp.): There are several species of aphids that infest strawberries. Adults are small (1/16" long), soft-bodied insects. Aphids occur on new shoots, undersides of leaves, and on buds while they are still in crown. Root aphids have been found on rare occasions. Damage occurs primarily when aphids transmit viruses from infected to non-infected plants. When present in great numbers, feeding can result in stunted, malformed plants.

Management: See pest management schedule for recommended materials and timing.

Leafhoppers (Empoasca fabae): Leafhoppers are small (1/8"), green, bullet-shaped insects which take flight quickly if disturbed. The nymphs are lighter colored and do not fly. They are easily identified by their habit of moving sideways when disturbed. Leafhoppers feed primarily on the underside of strawberry leaves, causing them to yellow between the veins and become curled and distorted. These symptoms are often mistaken for herbicide injury. Feeding activity is most serious during the late spring and early summer. They reduce vigor and runner production. Insecticides should be applied only when large populations of nymphs are noted on the leaves or symptoms become apparent.

Management: See pest management schedule for recommended materials and timing.

Spittlebug (Philaenus spumaris): Hidden beneath masses of white frothy spittle are soft-bodied, tan and green, elongate bugs about 1/8-1/4" long. These insects feed on stems and blossom clusters before and during bloom. Heavy feeding activity results in reduced plant vigor and decreased yield. Early season feeding can result in stunted, off-color plants; damage appears much like that caused by cyclamen mites.

Management: Spittlebug seldom does damage to the plants. It is mainly a problem because customers are bothered by the froth in the field when picking. Often heavy rains and/or irrigation will wash froth from plants. This insect tends to be more of a problem in weedy fields. Insecticide applications early in the season (e.g., for tarnished plant bug) are usually adequate for keeping this insect in check. Recommended action threshold is one spittle mass per foot of row. See pest management schedule for recommended materials and timing.

Cutworms: The immature stage (larvae) of these insects causes feeding injury to plants. Larvae may reach 2" long at maturity. Color and arrangement of stripes and spots varies from one kind of cutworm to another, but are often mottled or dingy gray. Cutworms may be observed on plants at night during spring and summer. Larvae consume leaves, buds, flowers, and developing fruits.

Management: Consult with your Cooperative Extension Specialist for management options.

Root Damaging Insects

Root-feeding insects can cause above-ground symptoms that are similar to root diseases: general loss of vigor and collapse during dry weather. Where damage is suspected, plants can be dug with a spade to examine roots and to check soil for the presence of root-feeding insects.

Strawberry Rootworm (Paria canella): The

adult form of this insect are beetles that are small (1/8"), round, and copper-colored with a dark markings on their backs. The immature root-feeding grubs are also small (1/8"), creamy white in color with 3 pairs of legs, and are actively feeding on roots in the late spring to early summer. The new generation of adults appears after renovation (late July or early August).

This insect can be most easily observed in the field as adult beetles feeding on leaves. Feeding occurs at two times in the growing season in Massachusetts (May and July-August), and results in shot-holes in the leaves. The second feeding period usually is more evident because a greater number of beetles are feeding then. The earlier feeding is done by the overwintering population.

Management: As with all the root-feeding insects, control of the root-feeding stage is very difficult. Therefore, control measures for strawberry rootworm should be directed toward the adult stage of the insects. Presence of adults can be detected by feeding injury or direct sightings of the adult beetles in the field. Sticky traps used for monitoring tarnished plant bug may aid in sighting strawberry rootworm adults since they feed primarily at night. Some of these beetles find their way onto the traps.

If feeding injury is observed in May or June, an insecticide spray at this time will reduce the number of egg laying females and therefore, the number of grubs feeding during the summer. When the next generation of adults emerges in July or August, control measures may be needed again.

No threshold is established for this insect. Feeding injury, as with all the root-feeding insects, is most damaging if root diseases (i.e. black root rot) are also present. Therefore, it is advisable to keep the root-feeding population low. See pest management schedule for recommended materials and timing.

Root Weevils (Otiorhynchus spp., Polydrusus spp.): There are several rootfeeding weevils that are damaging to strawberries; black vine weevil (Otiorhynchus sulcatus) strawberry root weevil (O. ovatus), and the rough strawberry root weevil (O. rugosostriatus) are the best known. Additionally, green leaf weevils, (Polydrusus spp.) have also been found feeding on strawberries in Massachusetts and Connecticut.

These insects damage strawberries primarily through larval feeding inside the crown and on the root system, which weakens the plants. Root feeding is especially damaging where root diseases are also present. The grubs are whitish and crescent shaped, ranging in size from 1/4" to 1/2". They have no legs. Adult weevils feed on leaves from May through August, causing notching of the leaf margins. Adults in heavily infested fields can contaminate harvested berries. Adult feeding generally does not cause serious injury unless plants are already weakened. Under heavy infestation by root weevils, the plants decline, appear stunted and bear poorly. Infestations are generally in patches in the field.

Management: The easiest time to detect weevil activity is during harvest. Randomly pick 100 leaves from each field and count the number that have feeding notches along the margin. Greater than 50% leaf notching may indicate the need for control measures. Confirm the presence and species of weevils involved by observing them at night with a flashlight. The easiest time to detect root injury from larval feeding (and from other root disorders) is in the autumn. The foliage of plants with poor root systems turns orange-red earlier than healthy plants. Plants should also be examined in the spring if patches of poor vigor are noticed. Lift a section of row with a spade and examine the roots within a 6" layer of soil. If grubs are found, insect pathogenic nematodes should be applied in early May or late August. Be sure to keep the field irrigated during periods of active growth to avoid stress on the plants.

Predatory nematodes attack root weevil grubs in the soil. Although populations of these nematodes naturally occur, application of commercially produced nematodes can achieve faster biological control. Contact your local Extension Specialist or call (916) 324-4100 for a copy of Suppliers of Beneficial Organisms in North America, an excellent sourcebook for natural enemies such as predatory mites. (Also available via the Internet at http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm.) Available species useful against root weevils include Steinernema carpocapsae, S. feltiae, Heterorhabditis bacteriophora, and H. marelatus. The Heterorhabditis spp. have the ability to penetrate insect cuticle, which facilitates infection of white grubs. The cost and quality of nematodes can vary widely, so talk to your Small Fruit Specialist to find out more about different products. A banded spray may be very cost effective compared with application through overhead irrigation. Nematodes application should be preceded and followed with irrigation. Protect them from sunlight by applying them in the evening. Platinum™ may be applied as a soil drench in the spring or late summer to control grubs. Brigade™ is now registered to control the adults, before they lay eggs. Controlling root weevil adults requires the highest labeled rate, and is best applied at night when adults are active. This material can induce spider mite outbreaks, and may kill beneficial root weevils predators. See pest management schedule for recommended timing and rates.

White Grubs of Asiatic Garden Beetle, European Chafer, Japanese Beetle, and Oriental Beetle: (Maladera castanea, Rhizotrogus majalis, Popillia japonica, and Exomala orientalis): While not considered major pests of strawberry, it appears that many growers are experiencing leaf and root damage from these scarab beetles, collectively also called white grubs. Root feeding by larvae dramatically weakens the plants, especially where the root systems already suffer from diseases like black root rot. All of these species overwinter as a grub in the soil, emerging in late May through July in the Northeast. The adult Japanese beetle is copper-brown and -green in color and approximately 1/2" long.

They are often found feeding during the day on leaves in small groups. Asiatic garden beetles (AGB) are small (3/8") and a velvety cinnamon brown color, showing a faint green iridescence in the sunlight. AGB feed at night on the foliage and hide during the day under plants. Feeding by Japanese beetle or AGB is easily distinguished from root weevil feeding because these scarabs principally skeletonize leaves (making holes within the leaves), rather than notching the leaf edge. Leaf feeding typically occurs in June through mid-August. Oriental beetle and European chafer adults are rarely observed because they do not feed much. Oriental beetles are slightly smaller than Japanese beetles, and are usually tan and mottled with darker spots. European chafers are slightly more than 1/2" long and are a uniform tan.

The larvae (or grubs) of these insects look quite similar to one another and are called white grubs. They are c-shaped, have 3 pairs of legs, grow up to 1 inch long. They are easily distinguished from the larvae of root weevils, which have no legs. White grubs are very difficult to manage after a strawberry bed has been planted.

It is unknown how much leaf feeding can be tolerated, but if leaf area is greatly reduced it could affect the following year's flower bud formation, which is initiated in the fall. Large numbers of beetles are of concern, especially if it increases the amount of overwintering grubs. High populations of larvae can be expected the autumn and spring following a dry summer, especially where strawberry fields are surrounded by turf. These conditions favor movement of adults into strawberry fields to lay eggs.

Management: Management of grubs in the soil is possible with insecticides, and predatory nematodes may also have some value. (See source reference under root weevils above.) Chemical control of adult beetles can prevent extensive leaf damage, but is not guaranteed to prevent egg laying. Combination pheromone and floral scent lures are commercially available for Japanese beetle, but their placement near strawberries may actually attract more beetles to the area. Therefore, if traps are used, they should be placed at least 20 yards from the strawberry field.

Milky spore disease is a commercially available bacterium that is incorporated into the ground and attacks the grubs (especially Japanese beetles). However, soil temperatures in the northeast are too cool for this disease to easily become established, which makes it impractical for our area.

To avoid the risk of white grub problems, do not plant on newly turned sod land. Rather, plow the field, let it lie fallow or in a rotational cover crop such as Sudan, buckwheat, or a salable crop such as pumpkins or squash for at least one season prior to planting with strawberries. Also, avoid siting a strawberry field next to large grassy fields which would be a source of these beetles. Control grassy weeds within the planting, which are especially attractive to egg-laying Japanese beetles and European chafers.

Other Pests

Slugs: Slugs are dark grey, black, yellow-gray or brown worm-like mollusks. They may also be covered with spots and range in size from 1-1/2 to 4" long. Slugs feed mainly at night, eating ragged holes in leaves and/or fruit. They also leave a trail of slime in their paths. Damage occurs primarily on fruit.

Management: Slugs thrive in moist places. If mulch is very thick and rows close together, slugs will be favored. Try to open things up a bit by removing excessive mulch and planting at lower densities which also helps manage diseases. Some growers have used diatomaceous earth for slug control. Research results are not available to verify the effectiveness of this material. Baits are also available but are not considered highly effective according to some growers. Consult with your Extension Specialist if you need help with this pest.

Garden Symphylan, (Scutigerella immaculata):The garden symphylan, also known as the garden centipede, is an occasional but very destructive pest of strawberries. Symphylans are not insects but are more closely related to centipedes and millipedes. They have 12 pairs of legs and 14 body segments. Symphylans overwinter in the soil as adults. In spring they move into the top 6 inches when the soil temperature rises above 45°F.

Eggs are deposited in soil crevices and tunnels in late April, May, and June. The eggs hatch two to three weeks later into tiny, white nymphs that resemble the adults in appearance except they have only six pairs of legs. As the nymphs develop, they grow bigger and add a pair of legs at each molt until they have 12 pairs. About three months are required to complete development from egg to adult. The adults remain in the upper 6 inches of soil until extreme dryness or cold weather drives them deeper into the soil. Mature symphylans are white, slightly less than l/4 inch inlength, with a pair of long beaded antennae. Their entire life(one to two years) is spent in the soil.

Garden symphylans feed on the roots of strawberry plants, weakening or killing them. Infestations seldom encompass an entire field, but rather involve one or more small areas within a field. Usually, the first indication of a symphylan infestation is a small area of stunted, unhealthy plants. Crop losses continue in the same area of the field year after year, with the infected area increasing in size about 10–20 feet each year.

Management: It is best to control symphylans before the crop is planted or at the time of planting. To check for symphylans, turn over at least 10 shovelfuls of soil. Sift the soil while looking for active symphylans. An average of one symphylan per shovelful signals that a treatment is necessary before planting. If symphylans are abundant, an insecticide should be broadcast and incorporated into the soil of the infested area before planting takes place.

Table 21. Efficacy of common insecticides and miticides used in strawberries.

Insecticide/Miticide	IRAC Group[a]	Aphids	Clipper	Cyclamen Mite	Leafhoppers	Leafrollers	Root Weevils	Slugs	Sap Beetles	Spider Mites	Spittlebug	Tarnished Plant Bug	White Grubs
Acramite	25	--[b]	--	--	--	--	--	--	--	+++	--	--	--
Actara	4A	+++	--	--	+++	--	--	--	--	--	--	++[c]	--
Admire	4A	+++	--	++	+++	--	--	--	--	--	--	--	+++
*AgriMek	6	--	--	++	++	--	--	--	--	++	--	--	
Assail	4A	++	--	--	--	++	--	--	+	++	--	++	--
⊗ Aza-Direct	18B	--	--	--	--	--	--	--	--	--	--	--	--
*Brigade	3	+++	+++	--	++	++	++	--	+++	+	+++	+++	--
*Danitol	3	++	+++	--	++	+++	++	--	++	+	+++	+++	--
Deadline	--	--	--	--	--	--	--	+++	--	--	--	--	--
*Diazinon	1B	+++	--	+	+	++	+	--	++	+	++	+	++
*Dibrom	1B	++	--	--	--	--	--	--	++	--	--	--	--
⊗ Dipel	11	--	--	--	--	++	--	--	--	--	--	--	--
Esteem	7C	++	--	--	--	+++	--	--	--	--	--	--	--
Intrepid	18	--	--	--	--	++	--	--	--	--	--	--	--
⊗ JMS Stylet Oil	un	--	--	+	--	--	--	--	--	++	--	--	--
Kanemite	20	--	--	++	--	--	--	--	--	+++	--	--	--
Kelthane	un	--	--	++	--	--	--	--	--	++	--	--	--
*Lorsban	1B	++	+++	--	--	+	--	--	--	--	--	++	++
Malathion	1B	+++	--	--	++	--	--	--	+	--	++	++	--
⊗ M-Pede	--	++	--	--	--	--	--	--	--	+	--	--	--
Oberon	23	--	--	--	--	--	--	--	--	+++	--	--	--
Platinum	4A	+++	--	--	+++	--	++	--	--	--	--	--	+
Provado	4A	+++	--	++	+++	--	--	--	--	--	--	--	--
⊗ Pyganic	3	+	--	--	--	--	--	--	--	--	--	--	--
Radiant	5	--	--	--	--	+++	--	--	--	--	--	--	--
Savey	10	--	--	--	--	--	--	--	--	+++[d]	--	--	--
Sevin	1A	+++	+	--	++	+	--	--	++	--	++	++	--
Sluggo	--	--	--	--	--	--	--	+++	--	--	--	--	--
Spintor, ⊗ Entrust	5	--	--	--	--	++	--	--	--	--	--	--	--
*Thionex	2A	++	0	+++	++	+	--	--	+	--	+++	+++	--
⊗ Trilogy	18B	+	--	+	--	--	--	--	--	+	--	--	--
Vendex	12B	--	--	--	--	--	--	--	--	++	--	--	--
Zeal	10	--	--	--	--	--	--	--	--	+++[d]	--	--	--

a. Chemistry of insecticides by activity groups: 1A=organophosphates; 2A=chlorinated cyclodienes; 3=pyrethrins and synthetic pyrethroids; 4A=neonicotinoids; 5=spinosyns; 6=avermectins; 7=juvenile hormone mimics; 10=mitegrowth inhibitors with unknown or nonspecific sites of action; 11=Bt microbials; 12B=organotin miticides; 18=ecdysone agonists/molting disruptors; 20=Site II electron transport inhibitirs; 21=Site I electron transport inhibitors; 23=lipid synthesis inhibitors; un=unknown mode of action.

b. 0=not effective; +=slight effectiveness; ++=moderate effectiveness; +++=very effective, --=insufficient data to rank effectiveness.

c. Moderate effect on nymphs, but little or no effect on adult form.

d. Effective on eggs and immatures (crawlers), but little or no effect on adult form.

***Restricted use material; pesticide applicators license required. ⊗OMRI listed - organic production; see www.omri.org for details.**

Table 22. Strawberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Establishment Year - at planting			
Red Stele	Aliette WDG, 2.5 lb/100 (1) Phostrol, 2.5 pt/100 (-)		Use as preplant dip; soak roots and crowns for 15 - 30 minutes and plant within 24 hrs.
Aphids	Admire Pro, 10.5-14 oz (14) Platimum, 5-12 oz (50)		Just prior to or during transplating.
White Grubs, Leafhoppers, Strawberry root weevils	Platinum, 5-12 oz (50)		
Establishment Year - as needed throughout the growing season			
Two-spotted spider mites (TSSM)	Acramite 50WS, 0.75-1 lb (1) *Agri–Mek 0.15EC, 16 oz (3) Savey 50DF 6 oz (3) Zeal 2-3 oz (1) Vendex 50WP, 1.5-2 lb (1) Kanemite 15SC, 21-31oz (1) Oberon 2SC 12-16 oz (3) *Brigade WSB 16-32 oz (0) *Danitol 2.4EC 16-21 oz (2) ⊗ JMS Stylet Oil, 3 qts (0) ⊗ Trilogy (Neem) 1-2% solution (0) Predatory mite release, rate varies (0)	Do not overfertilize with Nitrogen as this stimulates higher mite populations. Scout for presence of TSSM by randomly sampling 60 leaves from whole field. Treat field with miticide or release mite predators if TSSM are found on more than 25% of leaves sampled. Consult your Extension Specialist for help identifying mite predators and/or finding a source of predators for release.	Good spray coverage, especially on the underside of leaves is important for successful control. Use adequate gallonage and sufficient pressure to achieve good spray coverage. Repeat applications may be needed for successful control. **If repeat applications are needed, rotate insecticides from different IRAC groups to reduce the chance of resistance development in the pest. See Table 21 for groups.** Savey and Zeal are effective on eggs and immatures and not adults so are best used when infestation levels are low.
Aphids	Admire 2F, 24-32 oz (14) Platinum, 5-12 oz (50) Actara, 1.5-3 oz (3) *Brigade WSB 16-32 oz (0) *Thionex 50WP, 2 lb (4) ⊗ Aza-Direct, 16-56 oz (0) ⊗ Pyganic EC, 1-4 pt (0)	Scout fields for presence and treat only if significant infestation is found. Spot treatments may be sufficient in many cases.	Admire and Platinim are systemic materials - make soil application or through drip irrigation.
Leafhoppers	Admire 2F, 24-32 oz (14) Malathion 8F, 1.5-2 pt (3) Platinum, 5-12 oz (50) Sevin 4F, 1-2 qt (7) ⊗ M-Pede, 2.0% solution (0)	Scout fields for leafhopper damage; distorted leaf shape; reflexed leaf growth.	Apply only if symptoms observed.
Leaf spot	Captan 50W, 6 lb (0) Captec 4L, 3 qt (0) Nova/Rally 40W, 2.5-5.0 oz (0) Syllit 3.4 2.4-3.0 (14) Cabrio EG, 12-14 oz (0) Pristine, 18.5-23 oz (0)		Apply only if symptoms observed.

Table 22. Strawberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Powdery Mildew	Topsin-M 70WP, 8 oz (1) **plus** Captan 50WP, 3-4 lb (0) **Or, use alone:** Quintec, 4-6 oz (1) Pristine 18.5-23 oz (0) Procure 50WS,4-8 oz (1) Rally 40W 2.5-5 oz (0) Cabrio EG 12-14 oz (0) Kumulus, 5-10 lbs (0) ⊗ Microthiol, 6-15 lb (0) ⊗ JMS Stylet Oil, 3 qts. (0) ⊗ Thiolux, 5-10 lb (0)	Plant beds in such a way as to maximize the air circulation and drying of foliage. Avoid excess nitrogen fertilization Some cultivars more susceptible to powdery mildew than others. See Table 16 for susceptibility rating.	Cultivars vary in their susceptibility to powdery mildew. **Captan** has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period. **For resistance management do not make more than 2 sequential applications of fungicides from the same FRAC group. See Table 17 for groups.**
Fruiting Years - Early Spring (new leaves are expanding and blossom buds visible)			
Cyclamen mite	*Thionex 3EC, 1.3 qt (4) Kelthane 50W, 3-4 lb (3)	Scout fields by looking for areas where the plants are slightly stunted and leaves are somewhat distorted or crinkled. Scout fields again in late summer for return populations.	Use high volume directed spray to ensure penetration of spray material into plant crowns for optimal control.
Strawberry bud weevil (clipper)	*Lorsban 4E, 1 qt (21) *Brigade WSB, 6.4-32oz (0) *Danitol EC, 10/6oz (2) Sevin 50WP, 2-4lb (7) ⊗ PyGanicEC, 1.4oz (0) Pyrenone WSB, 13-32oz (0)	Scout field perimiter especially near woods or hedgerows for incoming populations. Begin scouting prior to bud expansion and bloom and continue through petal fall. Spot treatments can be made if infestation is localized to field perimeter. See text on bud weevil for thresholds.	All of these insecticides are toxic to mite predators. **Lorsban** can only be used pre-bloom and is limited to two applications per season. Follow-up first spray with a second spray 10-14 days later.
Tarnished plant bug **only**	*Dibrom 8EC, 1 pt (1) *Danitol 2.4 EC, 10.6 oz (2) *Brigade WSB, 6.4-32oz (0)	Scout fields as fields approach bloom for adults and nymphs. Text contains details of scouting procedures. Weeds will attract and support tpb populations when strawberries are not in bloom. So, keeping weeds under control helps reduce threat from this pest. Avoid mowing nearby alfalfa as strawberries approach bloom as this will drive tpb into the strawberries. TPB nymphs resemble aphids. Be sure you can tell the difference. See resource section for hepful publications. See text for information on scouting for spittlebug. Suggested action threshold for spittlebug is 1 spittle mass per square foot of row.	**Brigade**, with 0 days to harvest (12 hr REI), and **Dibrom**, with only a 1 day harvest interval may be very useful for day neutral varieties.
Tarnished plant bug **and** Spittlebug	*Thionex 3EC, 1.3 qt (4) Malathion 57EC, 1.5-3 pt (3) Cythion 8E,1.5-2 pt (3) *Danitol EC, 10/6oz (2) *Brigade WSB, 6.4-32oz (0) ⊗ PyGanic EC 1.4, 16oz (0) Pyrenone WSB 13-32 oz (0)		**Thionex** may not be applied more than twice in a 35 day period when fruit is present; you must wait 15 days between applications.
Spittlebug **only**	Assail 70WP, 0.8-1.7oz (1) Sevin 50WP, 2-4lb (7) Provado 1.6F 3.8 oz (7)		Spittlebugs generally do not damage fruit but make them less appealing to pickers. **Provado** also labeled for use agains aphids and whitefly.

Table 22. Strawberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Thrips	*Dibrom 8E, 1 pt (1) Malathion 8F, 1.5-2 pt (3) Assail 70WP, 1.7-3 oz (1) SpinTor 2SC, 4-6 oz (0) Radiant SC, 6-10 oz (1) ⊗ Entrust, 1.25-1.5 oz (0)	See text on thrips for details of scouting and sampling methods.	Radiant effectiveness may be improved by addition of an adjuvant to the spray mix.
Two-spotted spider mite (TSSM)	Acramite 50W, 12-16 oz (1) *Agri–Mek 0.15EC, 16 oz (3) Savey 50DF 6 oz (3) Zeal 2-3 oz (1) Vendex 50WP, 1.5-2 lb (1) Kanemite 15SC, 21-31oz (1) Oberon 2SC 12-16 oz (3) *Brigade WSB 16-32 oz (0) *Danitol EC 16-21 oz (2) ⊗ JMS Stylet Oil, 3 qts (0) ⊗ Trilogy (Neem) 1-2% solution (0) Predatory mite release, rate varies (0)	Do not overfertilize with Nitrogen as this stimulates higher mite populations. Scout for presence of TSSM by randomly sampling 60 leaves from whole field. Treat field with miticide or release mite predators if TSSM are found on more than 25% of leaves sampled. Consult your Extension Specialist for help identifying mite predators and/or finding a source of predators for release.	Good spray coverage, especially on the underside of leaves is important for successful control. Use adequate gallonage and sufficient pressure to achieve good spray coverage. Repeat applications may be needed for successful control. **If repeat applications are needed, rotate insecticides from different IRAC groups to reduce the chance of resistance development in the pest. See Table 21 for groups.** Savey and Zeal are effective on eggs and immatures and not adults so are best used when infestation levels are low.
Leaf spot Leaf scorch Leaf blight	**Combine**: Topsin-M 70WP, 8 oz (1) **plus** Captan 50WP, 3 lb (0) **Or, use alone**: Syllit 65W, 1.5-2 lb (14) Cabrio EG, 12-14 oz (0) Pristine, 18.5-23 oz (0) Rally 40W, 2.5-5 oz (0) Captan 50WP, 3-6 lb (0)	Improve air circulation by narrowing row width, increasing distance between rows, and raising beds. This will allow faster drying after rain, irrigation, and dew. Remove or thoroughly incorporate leaf debris from field at renovation. This helps disrupt the disease cycle of these fungi. Avoid excess Nitrogen application that promotes dense foliage and poor air circulation.	Treatment not needed unless infection is severe. Fungicide applications for gray mold will usually manage leaf spots as well. Captan has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period. **For resistance management do not make more than 2 sequential applications of fungicides n the same FRAC group. See Table17 for groups.**
Red Stele	Ridomil Gold SL, 1 pt (0) Aliettte WDG, 2.5-5 lb (0) Phostrol 2.5-5 qt (0)	Early spring of fall applications are recommended for control of red stele. Use sufficient water to move **Ridomil** into the root zone. There is no preharvest interval for this application. **Phostrol** may be used as a preplant root dip or postplant foliar application. See label for specific instructions.	
Spring, Pre-bloom to Early-bloom (from bud expansion to 10% bloom)			
Tarnished plant bug (TPB) Spittlebug	Same as Early Spring, Pre-bloom treatments shown above.	See text on tarnished plant bug for details of scouting and sampling methods.	DO NOT SPRAY INSECTICIDES DURING BLOOM. In case of an emergency, use only those materials listed as having low toxicity to pollinators (see Table 54).
Strawberry Bud Weevil	Same as Early Spring, Pre-bloom treatments shown above.	See text on Strawberry bud weevil (clipper) for details of scouting and sampling methods.	
Two-spotted spider mite (TSSM)	Same as Early Spring, Pre-bloom treatments shown above.		
Thrips	Same as Early Spring, Pre-bloom treatments shown above. See text on thrips for details of scouting and sampling methods.		

Table 22. Strawberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Anthracnose	Abound F, 6.2-15.4 oz (0) Cabrio EG, 12-14 oz (0) Pristine, 12.5-23 oz (0) Captevate WDG, 5.25 lb (0) Captan 50WP, 6 lb (0)	This disease is becoming more prevalent in many southern New England locations. It can spread through a field by splashing rain or irrigation water. Staw mulch can reduce spread by reducing splashing as compared to bare ground or plastic mulch. **AboundF** will cause injury to McIntosh and other apple varieties if subject to drift or if the same sprayer is used. Use extreme caustion to avoid crop damage to apples. See label for additional cautions.	
Botrytis gray mold	**Combine either**: Topsin-M 70WP, 8 oz (1) **or** Elevate 50WDG, 1.5 lb (0) **plus** Captan 50WP, 3 lb (0) **or** Thiram 65WP, 5 lb (3) **Or, use alone**: Captevate 3.5-5.25 lb (0) Elevate 50WDG, 1.5 lb (0) Scala, 18 oz (0) Switch 62.5WG, 11-14 oz (0) Captan 50WP, 3-6 lb (0) Pristine, 18.5-23 oz (0) ⊗ JMS Stylet Oil, 3 qts/100 gal (0)	Improve air circulation by narrowing row width, increasing distance between rows, and raising beds. This will allow faster drying after rain, irrigation, and dew. Remove or thoroughly incorporate leaf debris from field at renovation. This helps disrupt the disease cycle of these fungi. Avoid excess Nitrogen application that promotes dense foliage and poor air circulation.	Blossom protection is the most important component of successful Botrytis control. An early bloom application should be made at 10% bloom and followed up at mid and late bloom if field conditions are wet. Captan has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period. **For resistance management do not make more than 2 sequential applications of fungicides n the same FRAC group. See Table17 for groups.** Be careful about phytotoxicity when using jms stylet oil in proximity to some other materials, especially Captan. Read label carefully before use.
Full-bloom (from 10% bloom until no blossoms remain)			
Tarnished plant bug (TPB)	DO NOT SPRAY INSECTICIDES DURING BLOOM TO PROTECT POLLINATORS	Do not mow hay or alfalfa in adjacent fields if possible since this will drive tarnished plant bug into nearby stawberry fields.	
Two-spotted spider mite (TSSM)	Same as Early Spring, Pre-bloom recommendations.		
Botrytis gray mold	Same as Spring, Pre-bloom to early-bloom recommendations		
Bacterial Angular leaf spot	Kocide 3000, 0.75-1.25 lb (0)	Avoid unneeded overhead irrigation; allow drying time between wetting periods when possible. Avoid excess Nitrogen application that promotes dense foliage and poor air circulation. Avoid work in fields when wet.	Apply in at least 20 gallons water. Use higher rates when conditions favor disease. Discontinue use if signs of crop injury appear.
Early Summer (Fruit-set to harvest)			
Tarnished plant bug (TPB)	Same as Early spring, Pre-bloom treatments shown above.	See text on tarnished plant bug above for details of scouting and sampling methods.	
Sap beetle	*Brigade WSB 16-32 oz (0) *Danitol EC 16-21 oz (2) *Dibrom 8E, 1 pt (1) Assail 70WP, 0.8-1.7oz (1) Malathion 57EC, 1.5-2 pt (3) Cythion 8E, 1.5-2 pt (3) ⊗ Pyganic, 16 oz (0)	Keep field free of over-ripe fruit to the extent possible. Prompt renovation can reduce migration into neighboring fields. Bait baskets with overripe fruit or balls of bread dough at intervals around edges of field to catch beetles as the migrate into the field.	

Table 22. Strawberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Spittlebug	Same as Spring, Pre-bloom to early-bloom recommendations		
Botrytis gray mold	Same as Spring, Pre-bloom to early-bloom treatments above	Do not allow fruit to become over-ripe. **Harvest regularly.** Spray only if weather is wet or very humid during this period to control secondary infections.	If good coverage was made during bloom, further fungicide applications may not be needed. Pay strict attention to re-entry periods and harvest intervals for materials used.
Anthracnose	Same as Spring, pre-bloom to early bloom recommendations		
Leather rot	Ridomil Gold SL, 1 pt (0) Aliettte WDG, 2.5-5 lb (0) Phostrol 2.5-5 qt (0) Prophyt, 2-4 pt (0)	Make sure to maintain a good mulch layer around plants to reduce puddling and splashing around plants from rain or irrigation.	For control of leather rot apply **Ridomil Gold** during the growing season at fruit-set.
Bacterial Angular leaf spot	Kocide 3000, 0.75-1.25 lb (0)	Avoid unneeded overhead irrigation; allow drying time between wetting periods when possible.	Apply in at least 20 gallons water. Use higher rates when conditions favor disease. Discontinue use if signs of crop injury appear.
Leaf spot Leaf scorch Leaf blight	No fungicides until after renovation	Fungicides are usually not applied at this time for leaf spot diseases. Materials used for Botrytis management should alleviate leaf spot symptoms until after renovation. Improve air circulation by narrowing row width, increasing distance between rows, and raising beds. This will allow faster drying after rain, irrigation, and dew. Remove or thoroughly incorporate leaf debris from field at renovation. This helps disrupt the disease cycle of these fungi.	
Harvest (within 4 days of harvest through harvest)			
Botrytis gray mold	Same as Spring, Pre-bloom to early-bloom treatments above.	Do not allow fruit to become over-ripe. **Harvest regularly.** If irrigating between harvests, be sure the plants have time to dry prior to nightfall or use drip irrigation to deliver water while keeping foliage dry.	Fungicide applications at this time are for emergency situations. Good coverage at infection periods during bloom should make late season sprays unnecessary. Be sure to follow label instructions for both REI and PHI restrictions.
Anthracnose	Same as Spring, pre-bloom to early bloom recommendations.		
Two-spotted spider mite (TSSM)	Same as Early Spring, Pre-bloom recommendations.		
Slugs	Deadline M-Ps 10-40 lbs Sluggo 24-44 lb (0)	Mulch can promote slug	Apply in mid-September to reduce egg-laying. Apply prior to fruit ripening to reduce new generation. Avoid contamination of edible plant parts.
Summer (post-harvest)			
Strawberry root worm; adult	Sevin 50WP, 2-4 lb (7)	Scout field for 'shot-hole' feeding injury on leaves. If found, look in duff around plants for small copper-colored beetle.	Apply post harvest only when foliar damage is noticed and beetles positively identified. Larvae feed on roots causing general loss of vigor and possible collapse of plant.

Table 22. Strawberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Root weevils (various)	*Brigade WSB, 8-32 oz (0) Actara, 4 oz, (3) Platinum, 5-12 oz (50) Exhibit 2.5 - 5 gals/1000 sq. ft. Steinernema spp., 3 billion/A (0) Heterorhabditis spp., 1/2 - 1 billion/A (0)	Scout fields early for areas of stunted growth. Where found, dig up the roots of a plant and look for grubs. In mid to late summer look every 1- 2 weeks for leaf notching caused by adult feeding. Adult beetles hide in the soil during the day and feed at night. Plow under old beds as soon as possible to avoid spread of the insect to new beds. Rotate to non-susceptible crop for 3 years.	The highest rate (16 oz.) of **Brigade** is needed to obtain control of black vine weevil (best if applied at night). Apply **Platinum** as soil drench in fall or early spring; may be applide to new plantings. Apply nematodes in early- to mid-May or mid- to late-August as a band treatment. Application rates are given for the treated area. Irrigate prior to and following the nematode spray.
Two-spotted spider mite (TSSM)	Same as Early Spring, Pre-bloom recommendations.		
Cyclamen Mite	Same as Early Spring, Pre-bloom recommendations.		
Leafhopper	Provado 1.6F 3.75 oz (7) Sevin 50W, 2-4 lbs (7) Malathion 57EC, 1.5 - 3 pt (3)	Plants may be able to tolerate some of this injury without long-lasting damage.	Leafhoppers can infest new or old planting and symptoms show up especially well during runner production.
White Grub	Admire, 16-24 oz (14) Platinum, 5-12 oz (50)		Apply within 2 hours of irrigation or rainfall as a broadcast or banded soil treatment, or in irrigation water.
Aphid	Same as Establishment Year recommendations.		
Powdery Mildew	Same as Establishment Year recommendations.		
Leaf spot Leaf scorch Leaf blight	Same as Early Bloom recommendations.		
Red Stele	Ridomil Gold SL, 1 pt (0) Aliette WDG, 2.5 - 5 lb (0) Phostrol, 2.5-5 pt (0) Prophyt, 2-4 pt (0)	Proper site selection and preparation to avoid prolonged periods of "we tfeet" should be the primary control stratagy for this disease.	Use sufficient water to move the **Ridomil Gold** into the root zone. There is no preharvest interval for this application. Routine or preventative application of these materials in not recommended. Apply Phostrol to foliage when weather is wet and cool in late summer or fall; repeat application in spring when growth begins.

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

***Restricted use pesticide; pesticide applicators license required. ⊗ OMRI listed for organic production**

Weed Management

Several weeds are usually cited by growers as problem species. As a general rule, always look for new or unusual weed species in fields. Attempt to cultivate or hand remove these weeds before seeds are produced. Following is some information on the most troublesome weeds with suggestions for control. Specific recommendations for any herbicides mentioned below can be found in the tables that follow.

Common Chickweed (Stellaria media): Common chickweed is a winter annual with an extended germination period. Germination can usually begin in late August or early September and continue into the next spring. Seeds are produced in late spring and early summer. 2,4-D is not effective on this weed and labeled rates of Sinbar™ applied at mulching over emerged chickweed are generally ineffective. Cultivation is impractical since the most competitive weeds are in the strawberry row where they also receive good winter protection. Effective control can be achieved with an application of Devrinol™ in late August. Since Devrinol™ does not control emerged weeds, it is important to make the application before emergence. While Dacthal™ can also control this weed from seed, residual activity is too short to make this application cost effective.

Field Pansy (Johnny jump-up) (Viola, spp.): This winter annual weed has become a serious problem for many growers. As with chickweed, germination is in the late summer, fall, and early spring. Cultivation is impractical in the strawberry row. Unfortunately, the weeds in the row are often better winter protected and produce more seed than those in the row middles. There is currently no postemergence herbicide control of this weed. The only herbicide that can provide effective control from seed (preemergence) is Dacthal™ which should be applied in late summer; however, Dacthal™ is rarely used in late summer because of its cost and short residual (4-6 weeks). Only the first flush can be controlled with this method. Until better control options become available, growers will continue to have serious problems with this weed.

Yellow Wood Sorrel (Oxalis, spp.): This weed is perhaps the most troublesome for many strawberry growers. Several species exist. Some are perennials and some are winter annuals. Seed production usually occurs during harvest with the plants "spitting" their seeds across the strawberry rows. This, of course, allows free spreading of this weed across the field. As with the above-mentioned weed species, germination can take place over several months making control difficult. 2,4-D provides good control of oxalis plants if they are small and not hidden under the strawberry foliage. Therefore a late fall application, prior to mulching over dormant strawberry plants, can be at least partially effective. A 2,4-D application prior to renovation is usually not effective since seed dispersal has already taken place. Sinbar™ also has some activity on this weed. Splitting the annual use rate of Sinbar™ into a renovation and late fall (dormant) application can also provide some control. This weed usually shortens the life of a planting due to its quick spreading habit.

Dandelion (Taraxacum officinale): While dandelion has been cited as a problem weed by many growers, acceptable control is possible. Dandelion is a "simple" perennial weed. Unlike other perennials, it does not spread by rhizomes, has a taproot, and uses seed dispersal as its primary method of reproduction. Seeds germinate in the fall and produce good size plants by November. None of the soil-applied herbicides currently registered in strawberry will control dandelion. The only effective control strategy is a late fall application of 2,4-D. This application must be made after the strawberry plants are dormant (no new growth, reddened leaves). If few plants are present, hand removal may be an option. Be sure, however, to remove the entire tap root or regrowth will occur.

The following Tables (21-23) provide information of on weed management and herbicide effectiveness in strawberries. Any questions about specific weed problems or weed management strategies should be directed to your local University or Extension Specialist. See Integrated Pest Management for Strawberries in the Northeastern United States for details on alternative weed management strategies.

Table 23. Weed management in strawberries during the transplant and establishment years.

Transplant Year			
Weed Problem	**Herbicide**	**Rate/Acre**	**Comments and Limitations**
PREPLANT WEED CONTROL			
Many annual broadleaf weeds	(oxyflourfen) Goal 2XL	1 - 2 pt	Must be applied at least 30 days prior to transplanting. The soil must be worked to a depth of at least 2.5 inches prior to transplanting the crop. The use of a preemergence herbicide after transplanting is also recommended.
Emerged annual and perennial weeds	(glyphosate) Roundup Weather Max	1 - 5 pt	Must be applied to emerged weeds at least 30 days prior to transplanting. For annual weeds, good soil preparation will also control these weed species. For perennial weeds, this application should take place in the late summer or fall prior to planting. Application to perennial weeds in the spring will provide top kill only and the same can be accomplished with tillage.
Annual grasses and many broadleaf weeds	(pendimethalin) Prowl H20	1.5 - 3 pt	Use before planting strawberries. Apply to the soil surface before planting to prevent the establishment of most annual grasses as well as suppressing several broadleaf weeds such as velvetleaf and purslane. Moisture is required to activate the herbicide, and it can be applied through an overhead irrigation system or shallowly incorporated. At least one day must elapse between application and planting, unless protective gear is worn. There are two formulations on the market, but only the H2O formulation is labeled for strawberries. The rate is 1.5 to 3 pints per acre (coarse to fine soils, respectively) and no more than 6 pints are to be used in any one season. Prowl H2O should not be used if plastic mulch will be applied.
PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds	(DCPA) Dacthal F	8 - 12 pt	Weak on ragweed, smartweed, and galinsoga. Apply at transplanting or after cultivating. Irrigation, rainfall, or shallow cultivation after application will improve control.
	(napropamide) Devrinol 50DF	2 - 4 lb (pre-bloom)	Apply to weed-free soil after strawberry plants become established. Heavy rate after planting may inhibit rooting of daughter plants. Application in late summer will control winter annuals. Application in late fall will control annual grasses and volunteer grains until harvest. This material must be activated with rainfall, irrigation, or shallow cultivation within 24 hrs. Consider using the 2 to 4 lb rate twice, once in late summer and again just prior to mulching in late fall.
	(pendimethalin) Prowl H20	1.5 - 3 pt	Apply a banded spray between rows of strawberries. Maintian a rate per treated area, not a rate per planted acre. Do not contact the strawberry plants including daughter plants. May also be applied as a banded spray between rows of plastic mulch. Do not exceed 6 pints per acre per year. No weed control is provided in the crop row.
Broadleaf weeds, some grasses, and some suppression of perennial weeds	(terbacil) Sinbar 80WP	2 - 8 oz	During the planting year, Sinbar may be applied at 2 to 3 ounces per acre after transplanting but before new runners start to root. If strawberry plants have developed any new foliage prior to application, irrigation or rainfall (0.5 to 1 inch) is required to wash the Sinbar off the strawberry plants. In late summer or early fall, a second application may be made at 2 to 6 ounces per acre to control winter annual weeds. This application must also be followed by 0.5 to 1 inch of irrigation or rainfall to was the Sinbar off the plants. A third application of 2 to 4 ounces per acrec can be made, as usual, after the strawberry plants are dormant and just prior to mulching. For soils with at least 2% organic matter, there is no maximum amount per application; however, no more than 8 ounces of Sinbar can be applied per year. For soils with between 1 and 2% organic matter, a maximum of 4 ounces of Sinbar can be applied at any one time with an annual maximum of 8 ounces per acre. For soils with between 0.5% and 1 % organic matter, a maximum of 3 ounces of Sinbar can be applied at any one time with an annual maxumum of 6 ounces per acre. Sinbar will also provide early postemergence control of some weeds. See the label.

Transplant Year			
Weed Problem	**Herbicide**	**Rate/Acre**	**Comments and Limitations**
	(flumioxazin) Chateau WDG	3 oz	Apply as a banded spray with a hooded or shielded sprayer to row middles or between plastic. Do not contact the strawberry plants including daughter plants. Apply prior to weed emergence. As an alternative, may be applied as a broadcast spray in the late fall after strawberries are dormant. Although the activity of Chateau is primarily preemergence, this product also provides some postemergence broadleaf activity when a crop oil concentrate, at 1% v/v or non-ionic surfactant at 0.25% v/v is added. Do not exceed 3 oz per acre per year.
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds between rows.	(paraquat) *Gramoxone Inteon	2 pt	Contact herbicide. Use with a non-ionic surfactant. Direct spray between rows using a shield to prevent contact with strawberry plants. Do not apply within 21 days before harvest or more than 3 times in a season.
Emerged annual and most perennial grasses	(sethoxydim) Poast	1 - 2 pt	Effective on small actively growing grasses. Do not apply to grasses under stress (e.g. drought). Add 1 qt of crop oil concentrate per acre. Application within 6 weeks of Sinbar may cause leaf injury. Applications on days that are unusually hot and humid will likely cause leaf burn. Avoid applications on these hot and humid days or delay application until late evening.
	(clethodim) Select 2EC Selectmax 0.97EC	6 - 8 oz 12-16 oz	Effective on small, actively growing grasses. Improved activity over Poast on cool-season and perennial grasses. Add 1qt/100 gal spray of crop oil concentrate. Repeat application at 14 days for perennial grasses. Can add ammonium sulfate at 2.5 lb/acre to improve activity on perennial grasses. Do not apply within 4 days of harvest.
Emerged annual weeds and supression of perennial weeds	(pelargonic acid) Scythe	3 - 10% solution	Contact herbicidefor burn down only. See Scythe comments below this table. See label for complete instructions.

Established Plantings			
Weed problem	**Herbicide**	**Rate/Acre**	**Comments and Limitations**
PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds	(DCPA) Dacthal F	8 - 12 pt	Weak on ragweed, smartweed, and galinsoga. Apply to weed-free soil in early spring after mulch removal or in late fall. Irrigation, rainfall, or shallow cultivation after application will improve control. Do not apply between first bloom and harvest. May be less effective on cool heavy soils.
	(napropamide) Devrinol 50DF	4 - 8 lb	Apply to weed-free soil. Heavy rate after renovation may inhibit rooting of daughter plants. Application in late summer will provide preemergence control of winter annuals. Application prior to mulching will control annual grasses and volunteer grains until harvest. This material must be activated with rainfall, irrigation, or shallow cultivations within 24 hrs. May be applied more than once per year but do not exceed a total of 8 lbs per acre per year. Do not apply from bloom through harvest. Consider the 4 lb rate twice. Once in late summer and again just prior to mulching in late fall.
	(pendimethalin) Prowl H20	1.5 - 3 pt	Apply a banded spray between rows of strawberries. Maintain a rate per treated area, not a rate per plantede acre. Do not contact the strawberry plants including daughter plants. May also be applied as a banded spray between rows of plastic mulch. Do not exceed 6 pints per acre per year. Do not apply within 35 days before harvest. Not weed control is provided in the crop row.

Established Plantings			
Weed problem	**Herbicide**	**Rate/Acre**	**Comments and Limitations**
Broadleaf weeds, some grasses, and some suppression of perennial weeds	(terbacil) Sinbar 80WP	2 - 8 oz	Will also provide early postemergence weed control. Apply at renovation, immediately after mowing and tilling but before new growth begins. A second application may be made in late fall, after strawberry plants become dormant, for additional control of winter annual weeds. DO NOT USE AT ANY OTHER TIMINGS AS PLANT DEATH MAY RESULT. Do not apply more than 6-8 oz of Sinbar per acre per growing season depending on soil type. Use only on plants established 6 months or longer. Do not use on soils with less than 0.5% organic matter. Following the establishment year, applications can only be made just after renovation and just prior to mulching. Applications are now allowed, however, on soils with between 0.5% and 2% organic matter using the same guidelines for rates as above. As always, be careful with Sinbar in strawberries, especially with potential overlap of sprayer passes which will double the rate and increase the potential for injury in some varieties. Please consult the supplemental label for additional information, rates, precautions, etc.
	(flumioxazin) Chateau WDG	3 oz	Apply as a banded spray with a hooded or shielded sprayer to row middles or between plastic. Do not contact the strawberry plants including daughter plants. Apply prior to weed emergence. Application after fruit set may result in spotting of fruit and should be avoided. As an alternative, may be applied as a broadcast spray in the late fall after strawberries are dormant. Although the activity of Chateau is primarily preemergence, this product also provides some postemergence broadleaf activity when a crop oil concentrate, at 1% v/v or non-ionic surfactant at 0.25% v/v is added. Do not exceed 3 oz per acre per year.
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Supression of emerged perennial weeds between rows.	(paraquat) *Gramoxone Inteon	2 pt	Contact herbicide. Use with a non-ionic surfactant. Direct spray between rows using a shield to prevent contact with strawberry plants. Do not apply within 21 days before harvest or more than 3 times in a season.
Emerged annual and most perennial grasses	(sethoxydim) Poast	1 - 2.5 pt	Effective on small actively growing grasses. Do not apply to grasses under stress (e.g., drought). Add 1 qt of crop oil concentrate per acre. Application within 6 weeks after Sinbar may cause leaf injury. Avoid applications on days that are unusually hot and humid. Do not apply within 7 days before harvest or use more than 2.5 pints per acre per season.
	(clethodim) Select 2EC Selectmax 0.97EC	6 - 8 oz 12-16 oz	Effective on small, actively growing grasses. Improved activity over Poast on cool-season and perennial grasses. Add 1qt/100 gal spray of crop oil concentrate. Repeat application at 14 days for perennial grasses. Can add ammonium sulfate at 2.5 lb/acre to improve activity on perennial grasses. Do not apply within 4 days of harvest.
Most emerged broadleaf weeds including dandelion	(2,4-D) Formula 40	2 - 3 pt	Apply at renovation, immediately after last harvest. Wait 3 to 5 days before mowing. Can also be used in late fall after strawberries are dormant for control of certain winter annual, biennial, and perennial weeds. Be sure that strawberry plants are dormant (i.e., no new growth and reddened leaves).
Emerged annual weeds and supression of perennial weeds	(pelargonic acid) Scythe	3 - 10% solution	Contact material for burn down only. See Scythe comments below this table. See label for complete instructions.

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

***Restricted use material; pesticide applicators license required. ⊗ OMRI certified for organic production**

Notes:

Scythe (pelargonic acid)

Note: General - Scythe herbicide is part of EPA's reduced-risk pesticide strategy. Scythe is a contact, non-selective, broad spectrum, foliar-applied herbicide. It controls only actively growing emerged green vegetation. It provides burndown of both annual and perennial grass and broadleaf weeds as well as most mosses. The degree of burndown and the longevity of control is less when the weeds are inactive, mature, or biennial/perennial types. The herbicide is not translocated; it will burn only those plant parts that are coated with the spray solution. Visible effects on most weeds occur within hours. This product does not damage non-green, woody parts of plants. Cool weather following treatment may slow the activity of this herbicide and delay or reduce visual effects. The burndown activity is similar to that of Gramoxone Extra (paraquat). DO NOT contact desirable crop plants or damage will occur.

Crop application timing and registration - For most small fruit crops, applications can be made in a number of ways: Vegetative Burn-down: General control of weeds for site preparation, non-crop, and around aquatic sites. Prior to Crop Emergence: Be sure that applications are made before crop emerges from soil or crop injury will occur. Directed and Shielded Sprays: Applications may be made in and around desirable plants as long as contact of foliage and green bark is avoided. Use of a shield is highly recommended. Sucker Control, Pruning, and Trimming: To burn back unwanted foliage growth on vines and excessive cane growth in brambles. Apply only to unwanted vegetative parts. Apply before suckers become woody. The current label for Scythe herbicide allows application in the following small fruit crops: blackberry, blueberry, boysenberry, cranberry, currant, dewberry, grape (all types), loganberry, raspberry, and strawberry.

Rates - Use a 3-5% solution for annual weeds (4-6 oz/gal water), a 5-7% solution for biennial and perennial weeds (6-9 oz/gal water), and 7-10% solution for maximum burndown (9-13 oz/gal water). Delivery rate for boom applications should be 75 to 200 gallons of spray solution per acre. For hand-held equipment, spray to completely wet all weed or plant foliage but not to the point of runoff. Repeat applications as necessary. Tank mixes are allowed with this product. These include tank mixes with glyphosate (Roundup), sulfosate (Touchdown), and residual herbicides. SEE THE LABEL FOR COMPLETE DETAILS!

Sinbar 80 WP (terbacil) - During the planting year, Sinbar may be applied at 2 to 3 ounces per acre after transplanting but before new runners start to root. If strawberry plants have developed any new foliage prior to application, irrigation or rainfall (0.5 to 1 inch) is required to wash the Sinbar off the strawberry plants. In late summer or early fall, a second application may be made at 2 to 6 ounces per acre to control winter annual weeds. This application must also be followed by 0.5 to 1 inch of irrigation or rainfall to wash the Sinbar off the plants. A third application of 2 to 4 ounces per acre can be made, as usual, after the strawberry plants are dormant and just prior to mulching.

For soils with at least 2% organic matter, there is no maximum amount per application; however, no more than 8 ounces of Sinbar can be applied per year. For soils with between 1 and 2% organic matter, a maximum of 4 ounces of Sinbar can be applied at any one time with an annual maximum of 8 ounces per acre. For soils with between 0.5 and 1% organic matter, a maximum of 3 ounces of Sinbar can be applied at any one time with an annual maximum of 6 ounces per acre.

Following the establishment year, applicaitons can only be made just after renovation and just prior to mulching. Applications are now allowed, however, on soils with between 0.5 and 2% organic matter using the same guidelines for rates as above. As always, be careful with Sinbar in strawberries, especially with potential overlap of sprayer passes which will double the rate and increase the potential for injury in some varieties. Please consult the new supplemental label for additional information, rates, precautions, etc.

Prowl H2O - Preemergence selective herbicide. Use pre-transplant for improved control of annual grasses and many broadleaf weeds during the transplant year. May also be used in row middles once strawberries are transplanted for control of weeds between the rows.

Chateau WDG - Preemergence and postemergence selective herbicide. Use either between the crop row for preemergence control of many broadleaf weed and some grasses or use in the late fall after the crop is dormant for both preemergence and postemergence control of many weeds.

Table 24. Weed management with and without herbicides in a strawberry planting.

Year	Timing	Herbicide Options	Non-herbicide Options
Planting year			
	Fall prior to planting	Roundup for emerged perennial weeds	Frequent tillage
	Prior to transplanting	Good soil preparation to control emerged weeds	Good soil preparation
	At planting	Sinbar to control broadleaf weeds Dacthal or Prowl to control annual grasses (Prowl must be applied prior to planting)	Cultivate/handweed
	Mid-Summer	Poast or Select to control emerged grasses	Cultivate/handweed
	4-6 weeks after planting	Devrinol at half rate	Cultivate/handweed
	Any time emerged weeds are present	Cultivate/hand weed	Cultivate/handweed
	After crop dormancy	2,4-D for emerged braodleaf weeds; Sinbar or Chateau preemergence for broadleafs; Devrinol at half rate for preemergence grass control	Mulch for winter protection
Fruiting years			
	Spring prior to bloom	Poast or Select for emerged grasses	Cultivate/handweed
	Renovation	2,4-D for emerged broadleaf weeds; Mow 5-7 days later; Sinbar half rate for broadleaf weed control.	Cultivate/handweed
	Mid- to late-summer	Poast or Select for emerged grasses	Cultivate/handweed
	Late summer	Devrinol at half rate for preemergence grass control	Cultivate/handweed
	After crop dormancy	2,4-D for emerged broadleaf weeds; Sinbar half rate or Chateau preemergence for braodleaf weeds; Devrinol at half rate for preemergence grass control.	Cultivate/handweed

Table 25. Herbicide efficacy against common weeds in strawberries.

HERBICIDE	POSTEMERGENCE					PREEMERGENCE				
Common Weeds	Scythe[1] (pelargonic acid)	Gramoxone Inteon[2] (paraquat)	Formula 40[3] (2,4-D)	Poast[4] (sethoxydim)	Select (clethodim)	Devrinol[5] (napropamide)	Dacthal[6] (DCPA)	Sinbar[7] (terbacil)	Goal[8] (oxyflourfen)	Roundup Weather Max[9] (glyphosate)
PERENNIALS										
Canada thistle	P	P	G	N	N	N	N	N	N	E
clovers	P	P	E	N	N	N	N	F	N	E
curly dock	P	P	G	N	N	N	N	N	N	E
dandelion	P	P	E	N	N	N	N	F	N	E
goldenrods	P	P	G	N	N	N	N	P	N	E
quackgrass	P	P	N	F	G	N	N	P	N	E
red sorrel	P	P	E	N	N	N	N	F	N	E
yellow nutsedge	P	P	F	N	N	P	N	F	N	G
ANNUAL GRASSES										
barnyardgrass	F	E	N	E	E	E	G	F	F	E
fall panicum	F	E	N	E	E	E	F	F	F	E
large crabgrass	F	E	N	E	E	E	E	G	F	E
oats or rye (from mulch)	F	E	N	G	E	E	E	G	F	E
ANNUAL BROADLEAVES										
bedstraw	G	E	E	N	N	P	P	F	F	E
carpetweed	G	E	G	N	N	G	G	G	F	E
common chickweed	G	E	F	N	N	E	G	E	F	E
common lambsquarters	G	E	E	N	N	G	E	E	G	E
common purslane	G	E	G	N	N	G	G	G	E	E
corn speedwell	G	E	G	N	N	F	F	G	F	E
galinsoga	G	E	G	N	N	G	P	G	G	E
horseweed	G	E	G	N	N	N	N	G	G	E
prickly lettuce	G	E	E	N	N	E	P	E	G	E
redroot pigweed	G	E	E	N	N	G	E	G	E	E
shepherd's purse	G	E	G	N	N	P	P	E	E	E
Virginia pepperweed	G	E	E	N	N	P	P	G	G	E
yellow wood sorrel	G	E	G	N	N	P	P	G	E	E

E=90% control or better; G=75-90% control; F=50-75% control; P=5-50% control; N=less than 5% control.

[1] **Scythe**; non-selective contact herbicide. See information on rates and timings earlier in this section.

[2] **Gramoxone Inteon**; non-selective contact herbicide. Excellent for use on emerged vegetation. Use between rows, with directed spray; use shields to prevent contact with non-target plants; extremely toxic to birds and wildlife.

[3] **Formula 40**; systemic broadleaf herbicide. Typically used just before renovation; allow 5 days before mowing; also can be used when strawberries are dormant on winter annuals and perennial broadleaf weeds. Never use an ester or low-volatile ester formulation.

[4] **Poast**; systemic grass herbicide; use on actively growing grasses; will not kill old established grasses. Use with crop oil, avoid applying on hot humid days.
Select; systemic grass herbicide; use on actively growing grasses; will not kill old established grasses; improved activity over Poast on sool season and pereennial grasses. Use with crop oil; avoid spraying on hot humic days.

[5] **Devrinol**; preemergent selective herbicide, must be activated with water or cultivation. Application after renovation for summer annual weed control or in late summer for winter annual weed control. Application before mulching will control volunteer grain from mulch. Heavy rates can inhibit daughter plant rooting.

[6] **Dacthal**; preemergent selective herbicide, use after mulch removal in spring or in late fall; water or cultivation after application improves control. May be ineffective on cool heavy soils. Do not apply between bloom and harvest. Safe on new plantings.

[7] **Sinbar**; selective preemergent herbicide. Moisture is required to activate the chemical; also provides early postemergence control.

[8] **Goal**: selective preplant herbicide. Must be applied at least 30 days prior to transplanting. The soil must be worked to a depth of at least 2.5 inches prior to transplanting the crop. The use of a preemergence herbicide after transplanting is also recommended.

[8] **Roundup Weather Max**; non-selective preplant herbicide. Must be applied at least 30 days prior to transplanting. Provides control of most annual and perennial weeds. Application to perennial weeds should take place the Fall prior to transplanting for best control.

Highbush Blueberries

General Information

There are two types of blueberries grown in New England. Highbush blueberries (Vaccinium corymbosum) are discussed here. For information on lowbush blueberries (V. angustifolium, V. myrtilloides), contact David Yarborough at the University of Maine Cooperative Extension in Orono, Maine, or Sonia Schloemann at the University of Massachusetts Extension in Amherst, Massachusetts.

New England is considered the northern edge of the climatic zone in which highbush blueberries can be grown. As a result, a number of disease problems associated with cold stress, particularly the canker diseases, are more common here than in other blueberry growing areas. High soil acidity (low pH) and a relatively high organic matter are essential for optimum production. Soils should be well-drained if wet. When these soil conditions are suboptimal, disease increases. Pruning out small twiggy wood and unproductive older canes is generally helpful in controlling fungus diseases on blueberries.

The blueberry has very specific soil requirements, dictated by its unique root structure. The blueberry root system is composed primarily of fine, fibrous roots near the soil surface. These fibrous roots lack root hairs, so the root system has a relatively low absorptive capacity. Blueberry roots are unable to penetrate compacted soils and have limited tolerance to excessively wet or dry soils. The shallow root system is sensitive to both high and low temperature extremes.

The ideal blueberry soil is a well-drained, yet moist sandy loam soil with a pH of 4.5 to 5.2. Soil organic matter levels should be augmented through the use of pre-plant green manuring and the addition of peat moss at planting. In addition, a permanent organic mulch (wood chips, bark, sawdust, pine needles) layer 3 to 4 inches thick is required to protect roots from high temperature injury in summer and cold temperature injury in winter as well as reduce moisture stress.

Fertilizer is generally applied in a split application, reducing the risk of root burn that can accompany a single large application. The first is applied at bloom and the second one month later. Since Nitrogen is generally the only nutrient needed, ammonium sulfate (21% N) or urea (45% N) are used as the principal fertilizers.

Table 26. Recommended optimal soil characteristics for growing blueberries.

Soil Characteristic	Desirable Range*
pH	4.5 - 5.2
Organic matter	4 to 7%
Phosphorus	20 - 30 ppm
Potassium	100-120 ppm
	Base Saturation 3.0-5.0
Magnesium	100-120 ppm
	Base Saturation 2.0-4.0
Calcium	800 - 1000 ppm
	Base Saturation 20-30

*Desirable range will vary with soil type (sand, silt, or clay), soil organic matter, and pH.

Diseases

Fruit

Mummy Berry (Monilinia vaccinii-corymbosi): Mummy berry is increasingly important in some parts of New England, and its severity varies from year to year. It is caused by a fungus which attacks new growth, foliage and fruit, and can cause extensive losses.

The fungus overwinters in mummified fruit on the ground. The mummies form cup or globe-shaped structures called apothecia. Apothecia produce spores that infect young tissue and cause rapid wilting. 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

Table 27. Amount of sulfur (in lb/100 sq ft)[a] required to lower soil pH for blueberries.

	DESIRED PH VALUE FOR BLUEBERRIES					
	4.5			5.0		
Present soil pH	Sand	Loam	Clay	Sand	Loam	Clay
4.5	0.0	0.0	0.0	--	--	--
5.0	0.4	1.2	1.4	0.0	0.0	0.0
5.5	0.8	2.4	2.6	0.4	1.2	1.4
6.0	1.2	3.5	3.7	0.8	2.4	2.6
6.5	1.5	4.6	4.8	1.2	3.5	3.7
7.0	1.9	5.8	6.0	1.5	4.6	4.8
7.5	2.3	6.9	7.1	1.9	5.8	6.0

[a] To convert to lb/A, multiply by 435

Table 28. Number of blueberry plants per acre at different spacings.

Feet Between	Spacing Between Rows		
PLANTS IN ROW	8 FEET	10 FEET	12 FEET
4	1,361	1,089	908
5	1,089	870	726
6	908	726	605

Table 29. Critical nutrient values for blueberry tissue analysis.

Element	Deficient	Below Normal	Normal	Above Normal	Excessive
N (%)	1.65	1.70	1.90	2.10	>2.50
P (%)	0.05	0.06	0.10	0.18	>0.22
K (%)	0.35	0.40	0.55	0.65	>0.80
Ca (%)	0.35	0.40	0.60	0.80	>1.00
Mg (%)	0.18	0.20	0.25	0.30	>0.40
Mn (ppm)	45	50	250	500	>650
Fe (ppm)	65	70	200	300	>400
Cu (ppm)	4	5	11	15	>20
B (ppm)	29	30	40	50	>65
Zn (ppm)	14	15	25	30	>35

spores, which are spread by rain, wind and bees to blossoms and other young tissue. The fungus infects and invades the developing fruit. The fruit becomes malformed looking like a pumpkin, and turns salmon or grey by midsummer. By fall, these fruit have dropped to the ground where they turn to mummies, ready to produce apothecia the next spring.

Management: Cultural controls can be used to reduce inoculum levels in the spring. In very small plantings, mummies can be raked up and burned. On a larger scale, mummies can be buried by cultivating between rows or by covering with a new layer of mulch at least 2" in thickness. Combining cultivation and an application of 50% urea prills in the spring speeds destruction of the mummies. Urea should not be applied to areas where there is standing water, as this may cause fertilizer burn. Apply urea to drier parts of the field and go back to the wet areas later. The cultivation should be done just as apothecia start to emerge in the spring, which usually coincides with bud-break in the blueberry bushes. Cultivars exhibiting resistance to the shoot blighting phase of the disease include Jersey, Elliott, Bluejay, Duke, Stanley and Darrow. Cultivars which appear to be more susceptible are Bluehaven, Bluegold, Northblue, Sierra, Harrison, and Coville.

Several fungicides are labeled for use against this disease. Labeled materials and state registrations change annually. Check with your Extension Specialist for current recommendations in your state.

Botrytis Blight/Gray Mold (Botrytis cinerea): As with other small fruits, Botrytis primarily affects blossoms and ripening fruit, although under certain circumstances the fungus can cause stem blight as well. Infection occurs largely during bloom on flowers. 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 several days in duration. The most critical period for infection is during bloom. Disease is most severe where excessive nitrogen has been used, where air circulation is poor, or where frost has injured blossoms. Rotted berries typically have a gray cast of the mycelium and spore-bearing structures present which gives the disease its name. Stem symptoms are hard to distinguish from those infected by Phomopsis, and the fungus usually must be isolated from the infected tissue in a diagnostic laboratory. Varieties possessing tight fruit clusters (for example, Weymouth, Blueray and Rancocas) are particularly susceptible to the disease.

Management: When weather or history indicates that Botrytis will be a problem, fungicides should be applied, starting at mid- bloom, with subsequent sprays at 7-10 day intervals through petal fall. See pest management schedule for recommended materials and timing.

Anthracnose (Colletotrichum gloeosporioides and C. acutatum): This fungus primarily damages fruit but may also infect twigs and spurs. It causes a salmon or rust-colored berry rot which can also ruin fruit quality. 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 post-harvest losses. The disease is especially prevalent during hot muggy weather and frequently occurs post-harvest.

The anthracnose fungi overwinter in dead or diseased twigs, fruit spurs, and cankers. Spores are released in spring, and are spread by rain and wind. Blossoms, mature fruit and succulent tissue are infected, and spores may be spread from these infections. Blossom clusters will turn brown or black. Infected fruit shows bright pink spore masses at the blossom end. Stem cankers are rare (but are about 1/8" in diameter, with raised purple margins when they are present). Young girdled stems die back, resulting in a brown withering of the leaves. Bluecrop, Bluetta, Chanticleer and Spartan are particularly susceptible to the disease. Varieties in which the fruit hangs ripe for a long time on the bush prior to

Table 30. Highbush blueberry variety descriptions for New England.

			Disease Resistance[b]					
Variety	**Hardiness Zone[a]**	**Season**	**MMBY[c]**	**PHOM[c]**	**FUS[c]**	**PM[c]**	**ANTH[c]**	**Growth Habit**
Auroroa	4	very late	U	U	U	U	U	spreading
Berkeley	5	mid	S	VS	U	R	U	upright bushy
Bluecrop	4	mid	MR	U	VS	S	MR	upright open
Bluegold	4	late	S	U	U	U	U	compact
Bluejay	4	early mid	R	U	U	U	U	upright open
Blueray	4	mid	S	U	U	S	S	upright open
Bluetta	3	very early	S	R	U	U	U	low bushy
Bonus	4	mid	U	U	U	U	U	upright open
Brigitta	4	late	U	U	U	U	U	upright open
Cara's Choice	6	mid	MR	U	U	U	MS	compact spreading
Chandler	4	mid late	U	U	U	U	U	spreading
Chanticleer	5	very early	MR	MR	U	U	VS	upright
Chippewa	3	mid	U	U	U	U	U	upright half high
Collins	4	early mid	MR	U	U	S	U	moderately upright
Coville	5	late mid	MR	U	MR	MR	U	upright open
Darrow	5	late	R	U	U	U	U	low bushy
Draper	5	early mid	U	U	U	U	U	upright tall
Duke	5	early	R	U	U	U	U	upright open
Earliblue	5	very early	S	VS	VS	R	U	upright bushy
Elizabeth	4	mid late	U	U	U	U	U	spreading
Elliott	4	very late	R	R	U	U	R	upright bushy
Hannah's Choice	6	very early	U	U	U	U	U	upright open
Jersey	4	late mid	MR	S	VS	MR	VS	upright bushy
Lateblue	4	very late	R	U	U	U	U	upright open
Legacy	5	mid late	U	U	U	U	U	upright spreading
Liberty	3	very late	U	U	U	U	U	upright
Meader	4	mid	U	U	U	U	U	upright open
Nelson	4	late	U	U	U	U	U	upright open
Northblue	3	early	R	U	U	U	U	half high
Northcountry	3	early mid	U	U	U	U	U	half high
Northland	3	mid	S	U	U	U	U	half high
Northsky	3	mid late	R	U	U	U	U	very low bushy
Patriot	3	early mid	U	U	U	U	U	compact open
Polaris	3	early	U	U	U	U	U	spreading half high
Reka	4	early	U	U	U	U	U	upright
Rubel	4	mid	MR	MR	MR	U	MS	upright open
Sierra	5	early mid	S	U	U	U	U	upright open
Spartan	5	early	MR	U	U	U	U	upright open
St.Cloud	3	late	U	U	U	U	U	upright half high
Sunrise	4	early mid	U	U	U	U	U	low bushy
Toro	4	mid	U	U	U	U	U	upright open
Weymouth	4	very early	S	VS	U	U	U	low bushy

[a] Refers to USDA Hardiness Zones, [b]MR= moderately resistant, R= resistant, MS=moderately susceptible, S= susceptible, VS= very susceptible, U= unknown.

[c]MMBY=Mummyberry, PHOM=Phomopsis canker, FUS=Fusarium canker, PM=Powdery Mildew, ANTH=Anthracnose

For information on sources and further descriptions of cultivars listed above, go to the Cornell Nursery Guide for Berry & Small Fruit Crops at: www.hort.cornell.edu/extension/commercial/fruit/Berries/nurseries/strawberries.html

disease, although Elliot appears to have good resistance.

Management: The disease is controlled primarily through the use of fungicide applications, though pruning for optimal air circulation and harvesting frequently are beneficial. Old canes and small twiggy wood should be cleared out in order to increase air circulation around the fruit clusters. See pest management schedule for recommended materials and timing.

Stems and Foliage

Fusicoccum Canker (Godronia Canker): Fusicoccum is a fungus which infects blueberry stems causing dieback and plant decline. Losses from this disease can be serious. The fungus overwinters as mycelium in cankers on living plants. In Massachusetts, spores are released from March to mid-July, and infection probably occurs during this period. Spores are disseminated by rainwater. New infections occur following rains during the time tender new tissue is present and temperatures are at 50-72° F. New infections can occur throughout the growing season. Cold stress may play a part in increasing disease damage. Leaves turn reddish-chocolate when dry and often hang-on late into the fall.

Symptoms of Fusicoccum canker are similar to Phomopsis canker on blueberry. The most unique symptom is a red-maroon-brown lesion centered around a leaf scar. A bulls-eye pattern often results. As the lesion enlarges, the margin remains red and the center turns gray and dies. On young (1-2 year old) stems, extensive stem infections quickly lead to flagging and dieback of the entire stem. On warm, dry days shoots will suddenly wilt and die due to the stem girdling.

Management: Sanitation is essential. A fungicide program should be used where incidence of the disease is high. Apply at 2-week intervals from late dormancy to petal-fall. Varieties differ in their resistance to this disease. See pest management schedule for recommended materials and timing.

Phomopsis Twig Blight (Phomopsis vaccinii): This disease may be the most prevalent of the canker diseases at the present time. The fungus Phomopsis causes stem damage similar to that caused by Fusicoccum.

Spores from old cankers are released in spring and, to a limited extent, in summer. Most spores are released from bud swell to petal fall, and none are released after September 1. Rain is necessary for spore release, and temperatures ranging from 70-80° F encourage infections. The disease is most severe after winters in which mild spells are interspersed with cold weather. Periods of hot, dry weather during the growing season probably also predispose the plants to a certain degree. The fungus overwinters in infected plant parts.

Symptoms first appear on smaller twigs, and the disease spreads into larger branches and may affect the crown. It is possible for Phomopsis to spread downward in injured canes to the crown and then progress upward on new canes. This rarely occurs, usually only where the crown itself has been injured after a particularly severe winter, or in highly susceptible varieties. Younger tissue may show no symptoms at first, then exhibit rapid wilting and dieback. Lesions, somewhat similar to those caused by Fusicoccum but generally lacking the bull's-eye pattern, may appear on the stems. Leafspots have also been observed where disease is particularly severe. The disease will cause premature ripening of the berries. Earliblue, Coville, Bluecrop, Blueray, Jersey and Berkeley are susceptible to the disease. Berkeley, Coville, Jersey and Weymouth are particularly susceptible varieties. The fungus may also cause fruit rot although this is rarely observed in New England.

Management: Since mechanical damage and cold stress seem to be necessary for Phomopsis infection, avoid careless pruning and cultivating, and do not fertilize late in the summer. Pruning the weakest canes to the ground is best for the long-term production of the bush. Keep the plants well-watered through prolonged periods of dry weather in the summer. Avoiding any stresses will help prevent this disease. Cultivars which appear to be more resistant include Bluejay, Duke, Pioneer, Darrow, Elliott, Stanley, Bluetta, Wareham, Rubel, Cabot, Rancocas and Pemberton. Fungicide applications may also be beneficial. See the pest management schedule in this chapter for recommended materials and timing.

Coryneum Canker (Coryneum microstictum): This canker disease appears to be uniquely situated in the southeast part of New England. No estimates of loss from the disease are available; it is not regular in occurrence and the fungus often occurs in conjunction with other canker fungi.

The symptoms are similar to other canker diseases. The cankers are commonly seen on sun-scalded or cold-stressed bushes where the fungus produces spores in specialized structures. Wounds are apparently necessary for infection.

Management: Cultural practices which maintain vigorous growth without stimulating too much succulent growth are recommended for this canker disease as well as the others. (See the Phomopsis section). No chemical controls are specifically recommended.

Powdery Mildew (Microsphaera vaccinii): This disease affecting primarily the leaves is uncommon in New England, although localized outbreaks of the disease may occur in certain fields when weather conditions are favorable for infection by the fungus. The symptoms include a white fungal growth on the upper leaf surface, puckering of the leaves, and reddish spots on the leaf. When severe infection occurs, defoliation may occur.

Management: Some cultivars are more resistant than other cultivars. Well-timed fungicides will also control the disease.

Roots

Phytophthora Root Rot (Phytophthora cinnamomi): This disease is usually associated with poorly drained areas of a

field. Symptoms are noted on the roots and on the above-ground portions of the plant. The very fine absorbing roots turn brown to black; larger diameter roots may also be discolored. In severely infected bushes, the entire root system is reduced in stature and is totally black. Above-ground symptoms include chlorosis and reddening of the leaves, smaller leaves, defoliation, branch dieback, death of entire canes, stunting, and death of the entire bush. The disease may be present in a few infected plants scattered throughout the planting or localized in group of plants in a low-lying area of the field. The disease is worst where plants are growing in heavy clay soils.

Phytophthora cinnamomi, in addition to attacking blueberry, attacks a number of additional susceptible Ericaceous hosts, including rhododendron, azalea, and cranberry. Lowbush blueberry appears to be immune. This species of Phytophthora is not an important pathogen on any other small fruit covered in this guide. The fungus thrives in wet soils and can survive for a long period of time.

Management: The disease is avoided through careful site selection before planting. Heavy soil which becomes waterlogged or suffers from a high water table should be avoided when selecting a site. Internal and surface water drainage should be improved. Plants can be grown on raised beds if desired. Most varieties are susceptible to the disease, although some varieties may better tolerate heavy infections. Bluecrop and Weymouth are two varieties which have shown promise. Mefenoxam (Ridomil Gold) can be used at planting if problems with Phytophthora root rot are anticipated. In both new and established plantings, it should be applied twice per growing season to remedy infection. However, the best strategy is to plant on well drained sites or improve soil drainage.

Armillaria Root Rot (Armillaria mellea and A. ostoyae): Although this disease is uncommon, it can cause serious injury to plants in fields where the fungus is present in the soil. To date, the disease has only been found in fields which were originally pine/oak forests.

Infected bushes usually decline over several growing seasons, and their symptoms can be confused with those caused by winter injury, Phomopsis twig blight, or a nutritional imbalance. Affected plants will be chlorotic, have smaller-than-usual leaves, and be more susceptible to other stresses than healthy-appearing plants. Branches may suddenly wilt, followed by plant mortality in some instances. The disease may be found throughout an entire field, or it may be confined to one or a few area(s). The most important diagnostic characteristics are the presence of the fungus: white mycelial fans underneath the outer bark or the crown of the plant, black rhizomorphs (resembling shoestrings) attached to the roots or the trunk, and yellowish-brown mushrooms produced at the base of the plant in late summer or early autumn.

Two species of the fungus, Armillaria mellea and A. ostoyae, are probably causal agents of the disease. The fungus survives in the soil on root pieces of susceptible hosts (pine, oak, etc.). The fungus can infect bushes through root grafts and it can survive on wood chip mulches.

Management: The disease is best avoided by thoroughly discing the soil where blueberries are to be planted, and removing as many of the root fragments as is possible. If possible, leave the field fallow three years after the trees have been removed. Soil sterilants or fumigants are effective at killing the fungal inoculum. The disease is very difficult to control once it is present in a field. Dead or dying plants should be removed, and adjacent plants should be inspected at the soil-line for mycelial fans or rhizomorphs. Remove any plants which have these signs of the pathogen. Wood chip mulch should be removed from infection "hot spots." Although spot fumigation might be effective, chemical controls are usually not feasible in fields where the disease is present. Most varieties are probably susceptible to the disease.

Viruses and MLOs

Blueberry Shoestring Disease: This viral disease was originally described in New Jersey. In Michigan, the disease has been found in 0.5% of the bushes; an assessment has not been done for potential losses due to the virus.

The most common symptom is an elongated reddish streak along the new stems. The leaves may also show red banding or a red-purple oak-leaf pattern. Diseased leaves are narrow, wavy and somewhat sickle-shaped. Flowers may be red-streaked, and berries turn purple prematurely. Within a few years, berry production drops dramatically.

Management: Other than buying disease-free plants, destroying wild plants near the planting, and removing diseased plants, controls do not exist. As with most virus diseases, the best controls are preventing disease introduction, and detecting the disease when it is localized in a small portion of the field. The virus has been observed most often in Burlington, Jersey, June, Cabot, and Rancocas. Other varieties may possess field resistance to the disease.

Blueberry Stunt: This disease was originally thought to be caused by a virus but it is now known to be caused by a mycoplasma-like organism or phytoplasma. The only known carrier is the sharp-nosed leafhopper, though other vectors probably exist.

Symptoms vary with the stage of growth, time of year, age of infection and the variety. Symptoms are most noticeable during mid-June and late September. Affected plants are dwarfed with shortened internodes, excessively branched, low in vigor with small downward cupped leaves which turn yellow along the margins and between the lateral veins giving a green and yellow mottled appearance. These mottled areas will turn brilliant red prematurely in the late summer, although the midrib remains a dark bluish-green. Fruits on infected bushes are small, hard, lack flavor, ripen late if at

Table 31. Fungicides registered for use on blueberries and their primary uses.

Fungicide	FRAC Group	Mummyberry primary	Mummyberry secondary	Phomopsis	Alternaria	Anthracnose	Botrytis	Phytophthora Root Rot
Abound[a]	11	++	+	++	++	+++	++	0
Aliette	33	0	0	++	--	+	0	+++
Bravo	M5	++	+	0	+	++	+	0
Cabrio	11	+	+	++	++	+++	++	0
Captan	M	+	+	++	+	++	++	0
Captevate	17,M	+	+	++	+	++	+++	0
Copper	M1	0	0				0	
Elevate	17	0	0	+	+	0	+++	0
Indar	3	+++	+++	+++	--	0	--	--
Lime sulfur[b]	M	0	0	++	0	0	0	0
Omega	29	--	--	--	--	+++	--	--
Orbit, Tilt	3	+++	+++	0	--	0	0	0
Oxidate	--							
Phosphorous Acid	33	0	0	0	0	0	0	+++
Pristine	7, 11	+++	+++	+++	+	+++	+++	0
Ridomil Gold	4	0	0	0	0	0	0	+++
Switch	9, 12	++	+	0	+++	++	+++	0
Ziram	M	+	0	++	0	+++	++	0

0=not effective, +=poor, ++=good, +++=excellent, --=insufficient data.

FRAC activity groups: 3=demethylation inhibitors(includes tirazoles); 4=acylalanines; 7=carbosamides; 9=anilinopyrimidines; 11=strobilurins; 12=phenylpyrroles; 17=hydroxyanilides; 29=2,6-dinitroanilines; 33=unknown (phosphonates); M=multisite.

[a]This material is very toxic to some varieties of apples; use extreme caution when spraying near apples; do not use same sprayer subsequently on apples.

[b]Use lime sulfur only on late dormant or dormant bushes. **Do not mix with oil.**

***Restricted use material; pesticide applicators license required. ⊗ OMRI certified for organic production**

all, and remain attached to the plant much longer than they would on healthy plants.

Management: Diseased bushes cannot be cured; these must be removed from the field as soon as a diagnosis has been made. The removal process may facilitate in the further spread of the disease in the field. Agitation of the bush will dislodge the leafhoppers, causing them to hop to a neighboring healthy bush. Infected bushes should be sprayed with malathion or another appropriate insecticide before the bush is removed. Using virus indexed plants is also helpful. Bluetta, Jersey, and Weymouth are particularly susceptible, whereas Rancocas is resistant.

Red Ringspot: This is the most widespread viral disease in New Jersey at the present time. The symptoms are very distinctive, including red spots, rings and oak-leaf patterns which usually appear on the older leaves in late June or July. Production of the bush is seriously reduced and the berries become pockmarked and unattractive. Bluetta, Coville and Darrow are susceptible, while Bluecrop, Collins, Jersey, Rancocas and Weymouth are resistant or tolerant to the disease. Infected bushes must be rogued out.

Mosaic: Like some of the previously described viruses, this virus is probably indigenous in wild blueberry plants. Infected plants become unproductive. Leaves are brilliantly mottled with yellow, yellow-green and pink areas. Not all leaves will show the symptoms and some branches on an affected bush may be symptomless as well. It may take several years for a bush to show symptoms. The disease appears most commonly in Herbert and Stanley; most varieties appear to have field resistance to the virus. Infected bushes cannot be cured and must be removed promptly.

Blueberry Scorch (formerly Sheep Pen Hill Disease): This disease has recently been found in fields in Massachusetts and Connecticut. It is a serious problem in fields in New Jersey (it was originally found in a field in the Sheep Pen Hill area). Symptoms fluctuate greatly from year to year, and disease has been worst during excessively wet years.

The disease is characterized by dieback of blossoms and young vegetative shoots in the spring followed by a flush of growth in the summer and the development of a necrotic line pattern in the fall foliage. The roots suffer injury, and production of the bushes can be greatly impacted. Weymouth and Bluecrop are known to be susceptible, and Blueray may also be affected.

Management: The causal agent appears to be a flexuous rod-shaped virus and it is probably vectored by aphids. The sole control strategy is to remove affected

bushes, though control of aphids is important in managing any spread of this disease.

Witches'-Broom: Witches'-broom is a relatively minor disease of highbush and lowbush blueberries and other Vaccinium spp. in North America. Although heavily infected plants produce no fruit, disease incidence is usually so low that crop losses are negligible. However, nearly 100% of blueberry plants may be infected in fields located near fir (Abies spp.) trees, the alternate host of the rust fungus that causes witches'-broom.

Diseased blueberry plants have broomlike masses of swollen, spongy shoots with shortened internodes and leaves reduced in size. The brooms usually begin to develop during the year following infection and then persist for many years, producing infected new growth each spring. Young stems on the broom are initially reddish or yellow, but as the season progresses they become brown and shiny, then dull, and eventually dry and cracked. Heavily infected plants produce no fruit.

Management: Because the pathogen is perennial and systemic in blueberry crowns and rhizomes, burning and other pruning methods do not eliminate witches'-broom. The best control strategy is to eradicate the alternate host (fir trees) within 1200 feet of the blueberry plants; this may not be practical, however, in areas where balsam fir is abundant in natural stands or in Christmas tree plantings. Eradication of diseased blueberry plants with a recommended herbicide effectively eliminates the disease from an affected field.

Bacteria

Crown Gall (Agrobacterium tumefaciens): There is only one bacterial disease which is a significant problem in the Northeast at present: crown gall. The disease is caused by the bacterium Agrobacterium tumefaciens. Since blueberries are grown on acid soils, and the crown gall bacterium does not grow well in an acid situation, the disease occurs infrequently.

Globose, pea-size to large galls occur on low branches, twigs, and at the base of canes near the ground. Injured tissue is more likely to produce galls.

Management: Sanitation, purchasing healthy nursery plants and maintaining proper soil conditions are the most reliable controls. An antibiotic called Agrocin is available for either soil treatment or for dipping the root systems of bushes prior to planting.

Post-Harvest Diseases

As with most soft fruit, blueberries have particular post-harvest disease problems. There are three fungi which can cause major post-harvest losses in the crop: Colletotrichum gloeosporioides or C. acutatum (anthracnose), Botrytis cinerea (gray mold), and Alternaria spp. The diseases can cause up to 30% rot within 7 days of harvest even when refrigeration is used. Without refrigeration, berries can show 15% rot in 3 days.

Management: In New England, where virtually all highbush blueberries are sold fresh, well-ventilated containers and refrigeration should be combined with careful picking and handling.

Insects

Scale Insects; Putnum Scale and Lecanium Scale (Aspidiotus ancylus and Lecanium nigrofasciatum): These insects appear mound-shaped, of varied colors, and usually measuring 1/8" or less in length. They are found on rough, loose bark of older stems and sometimes on fruit. Infestations can result in reduced vigor and yield of bushes by feeding on the plant's sap. Fruit lecanium scale eggs hatch in early July (late June in southernmost New England).

Management: Good pruning is the first step in control of scales on blueberries. Prune out weakened canes. During dormancy, apply superior-type oil of 60- or 70-second viscosity at 3 gallons per 100 gallons of water. To avoid injury, apply when there is no danger of freezing temperatures for at least 24 hours after treatment.

Gypsy Moth (Porthetria dispar): Gypsy moth larvae (caterpillars) are hairy, dark brown to black in color and marked with red and blue spots. They are large in size, from 1/4 to 2" in length, depending on their age. They are found on leaves, buds and stems of bushes. Feeding by the larvae can result in partial to full defoliation and partial to full bud (and fruit) loss.

Management: If possible, remove larvae by hand. Remove egg masses when found. If plantings are surrounded by wooded areas known to be infested, apply protectant sprays. Bt-type materials are effective only if eaten by the caterpillars and work best on young larvae. Forestry experts feel that gypsy moth outbreaks should be rare in New England now due to the presence of an introduced natural enemy Entomophaga maimaiga.

Blueberry Blossom Weevil; Cranberry Weevil (Anthonomus musculus): This is a dark reddish brown snout beetle, 1/8" long, with a curved snout. It emerges in spring and feeds and lays eggs in expanding flower and leaf buds. The weevils hide between the clustered buds, and in small infestations they may be difficult to find. Damage results when punctured flowers do not open. Damaged leaf buds produce an abnormal cluster of dwarfed leaves. Adults of the second generation sometimes feed on blueberry leaves.

Management: No insecticides are labeled for use against this pest. Disking between rows and raking/hoeing under plants is helpful. Eradication of wild blueberries or other ericaceous plants in the vicinity of the blueberry planting is advised.

Plum Curculio (Conotrachelus nenuphar): This dark brown snout beetle is about 1/4" long with 4 humps on its wing covers. It is found on developing flower buds and later on developing berries. The larva (caterpillar) bores into the fruit and eats

its contents. As a result, a prematurely ripened fruit drops off the bush. This feeding activity on buds and fruit reduces yield.

Management: Plum curculio are more abundant where blueberries are located near tree fruit. If possible, plant blueberries away from tree fruit. Spray applications made at petal fall to control cranberry or cherry fruitworm are also likely to control Plum Curculio.

Cranberry Fruitworm (Acrobasis vaccinii): The cranberry fruitworm larva (caterpillar) is mainly green with some brownish-red coloration on its top surface and measures about 1/2" long at maturity. It is found within developing and ripening berries. Feeding reduces the crop and spoils marketability of the berries. Eggs are laid in the calyx cup (blossom end) of unripe fruit. Hatching larvae move to the stem end of the fruit, enter, and consume inner flesh entirely. Larvae will consume from 3-6 berries, filling them with brown frass, and web together fruit with silk.

Management: When damage is severe, treat in the following year with insecticide. See pest management schedule for recommended materials. Cranberry fruitworm was effectively controlled formerly by picking off infested berries, which were easily detected because of the webbing and their early ripening. This method is still practical in small plantations with light infestations. Elimination of weeds and trash around plants cuts down on overwintering protection for cocoons.

Cherry Fruitworm (Grapholita packardi): The cherry fruitworm larva (caterpillar) at maturity is orange-red and about 1/4-1/2" long. It is found within developing and ripening berries. Feeding reduces the crop and spoils marketability of the berries. Hatching larvae bore into the calyx cup (blossom end) of the berry, feed until about half-grown, and then move to a second fruit. (This is distinct from the cranberry fruitworm described above.) The two infested berries are usually joined by silk.

Management: When damage is severe, treat in the following year with insecticide. See pest management schedule for recommended materials.

Blueberry Maggot (Rhagoletis mendax): The adult is a black fly about 1/5" long with a pattern of dark and clear bands on its wings. The maggots are white, legless, and about 1/4" long when full grown. Flies alight on fruit to lay eggs under the fruit skin just as the fruit begins to turn blue. Maggots are later found in ripening and harvested fruit. Maggots feeding within developing fruits renders fruit unmarketable. Berries become soft and mushy. Undetected infested berries contaminate pack-out.

Management: Red sticky spheres or yellow sticky rectangle traps (available from suppliers listed in appendix) can be used to monitor blueberry maggot populations in the planting. In large bushes, sticky traps should be hung in upper half of the canopy, suspended from wires and about 1-1/2 feet from the outer foliage. All fruit and foliage within 8 inches from the trap should be cleared away, and all traps positioned so that there is as much foliage and fruit surrounding them at this distance as possible. In small plantings, it may be possible to trap this insect out with sufficient trap density. Consult with your state's regional fruit specialist for further information. Spray recommendations are found in the blueberry pest management schedule.

Blueberry Tip Borer (Hendecaneura shawiana): In June, before new growth has begun to harden, some blueberry shoots may begin to wilt, arch over, and become discolored, the leaves turning yellowish with red veins and the stems purplish. This injury, which may be mistaken for primary mummyberry infection, is caused by the tip borer. The newly hatched worm, tiny and pink, enters the soft stem and bores channels that may extend for 8 or 10" by autumn and result in the destruction of the stem's fruit-production potential in the following year.

Management: Prune out damaged tips as observed and burn infected canes. The standard spray program used for other insect pests normally keeps this pest under control.

Blueberry Bud Mite (Acalitus vaccinii): Blueberry bud mites are whitish in color and tiny. Unlike other mites, they are elongate and conical, with 4 legs bunched near the head at the broad end of the mite. Heavily infested buds have a definite reddish coloration and characteristic rough bumps on the outer bud scales. Eggs and immature and adult mites are present throughout the year. They are generally confined to the buds and blossoms. During the fall and winter, many mites may be found between the scales of a single fruit bud.

Bud mites feed on the surface of the bud tissues and bud scales. Injured buds desiccate and usually produce distorted flowers. These flowers may fail to set fruit, or develop into fruit with rough skins. The potential for damage differs with variety.

Management: Plants should be inspected for bud mites in September, before the new buds are well formed. Look for them under bud scales and between bud parts. Economic threshold levels have not been determined for bud mites. Thorough pruning of infested canes provides good control of bud mites. Limited chemical control measures are available.

Blueberry Stem Gall Wasp (Hemadas nubilipennis): The adult blueberry stem gall wasp is a small (less than 1/8") shiny black insect with delicate wings. It lays its eggs in succulent shoots. Several grub-like larvae develop in closely associated chambers inside the shoot; the larvae release a chemical substance which induces the shoot to grow abnormally, resulting in a pithy, kidney-shaped gall 3/4 to 1-1/4" long. Pupation occurs within the larval chambers; the new adults bore an exit hole through the gall. Early in the season galls are greenish and spongy to the touch. By fall the galls turn brownish-red and become quite hard. Shoot growth is reduced and the shoot may be diverted at severe angles.

Unchecked, the blueberry stem gall wasp can cause

severe reduction in shoot growth and stem vigor. Hundreds of galls can develop on a single bush. Heavy infestations reduce fruit production and result in dense, stemmy growth. Susceptibility to galls may depend on variety. This insect is rarely encountered in fields managed with standard chemical pesticide programs, but it can be a major pest or organically managed fields.

Management: Chemical treatments directed toward other pests are generally sufficient to keep stem gall in check. Removal and destruction of gall during normal pruning operations will also control this pest.

White Grubs Japanese Beetle (Popillia japonica), **Rose Chafer** (Macrodactylus subspinosus), **Asiatic Garden Beetle** (Maladera castanea), **and others**: White Grubs are the larvae of a variety of beetle species some of which are listed above. The larvae are generally white or cream colored with brown heads and legs, and they hold their bodies in a distinct hooked or C-shape. Stretched out, larger species may be over one inch in length. Many of the species can be determined as larvae by distinctive patterns of stiff hairs on the undersurface of the tip of the abdomen. Some species feed on the roots of plants for more than one year before completing development. Most species overwinter as grubs deep in the soil. Pupae are white to cream colored and have many features of the adult insect. The time of pupation and the emergence of adults varies with species.

Adults of white grubs are known generically as May Beetles, June bugs, chafers, or scarab beetles. The adults of some species feed on the foliage, flowers and fruits of many plants. Japanese beetle and rose chafer adults can be significant pests of blueberry during harvest when they contaminate the berries.

For many years white grubs were a rare problem in blueberry fields, but recently they have become serious pests in some fields, with populations as high as 30 grubs per bush. The grubs consume feeder roots and may also girdle or clip off larger roots. Infested plants may not show any outward signs of injury until a period of drought stress, when the reduced root system cannot provide enough water to the plant. Damaged bushes show low vigor and reduced production. Adults, especially the Japanese beetle and rose chafer, sometimes become serious pests by consuming leaves and scarring the berries.

Management: Unfortunately, sampling for white grubs damages the roots of blueberry bushes. Growers should check new sites for white grubs before establishing a field, and take actions against grubs before planting. Admire is now registered for application to the soil to control white grubs. When applied correctly, it suppresses Asiatic garden beetle larvae and is effective against all other species of white grubs. There is great interest in the use of pathogenic nematodes as biological control agents for the grubs. Adults are generally easy to control with foliar sprays, but timing is difficult since these are highly mobile insects that may suddenly appear in the field. Surround is a kaolin clay-based product that can deter adults from feeding on foliage. It may be of interest to organic growers.

Yellownecked Caterpillar (Dantana ministra): These hairy yellow caterpillars are usually found in large groups in mid- or late summer. In un-noticed, they can entirely strip the foliage in a bush.

Management: Caterpillar strains of Bacillus thruingiensis products are effective in controlling the larvae, especially when they are small. Chemical insecticides are also effective. Spraying the entire planting is not required.

Winter Moth (Operophtera brumata): This is a new and important pest of blueberries and other deciduous plants, especially in Southeastern New England. They can severely defoliate bushes. Moths emerge from the soil usually in late November and may be active into January. The male moths are light brown to tan in color and all four wings are fringed with small elongate scales that give the hind margins a hairy or fringed appearance. The female is gray, almost wingless (brachypterous) and, therefore, cannot fly. Females are usually found at the base of trees or scurrying up tree trunks. After mating, the female deposits a loose egg cluster in bark crevices, under bark scales, under lichen, or elsewhere. The adult moths then die and the eggs over-winter. Eggs are dark-colored at first but turn orange within 3-4 weeks. In March, just prior to hatching, they turn red. Eggs hatch when temperatures average around 55˚F. It is believed that egg hatch in Massachusetts occurs when 20 Growing Degree Days (base 50) have accumulated, anywhere from late March into April, depending on the year. This means that egg hatch occurs just at or right before bud break of most of the host plants. After hatching, the larvae wriggle between bud scales of newly swelling buds of such hosts as: maples, oaks, ash, apples, crabapples, blueberry, cherries, etc. and begin feeding.

Caterpillars feed on both flower and foliar buds. Once a bud has been devoured from within, the caterpillar will migrate to other buds and repeat the process. Destruction of the flower buds leads to greatly diminished harvest on fruit crops. Older larvae feed in expanding leaf clusters and are capable of defoliating trees and other plants, when abundant.

Winter moth caterpillars are pale green caterpillars with a white longitudinal stripe running down both sides of the body. They are "loopers" or "inchworms" and have just 2 pairs of prolegs. At maturity, the caterpillars will beapproximately one inch long, whereupon they drop to the soil for pupation. Pupation occurs from late May into early June. Winter moth caterpillars are often found in association with both the fall and spring cankerworms, which look and have similar feeding patterns to the winter moth caterpillar.

Management: A dormant oil spray to the trunks and branches of bushes may be helpful to kill the overwintering

Table 32. Insecticides registered for use on blueberries and their primary uses.

Fungicide	IRAC[a] GROUP	Aphid	Blueberry Maggot	Bud Mite	Cranberry Weevil	Fruit Worms	Japanese Beetle Adults	Leafhopper	Leafroller	Plum Curculio	Scale	Thrips	White Grubs
Actara	4A	+++	+	0	+++	0	++	+++	--	+	--	0	--
Admire	4A	+++	+	0	--	0	++	++	--	--	--	0	+++
*Asana	3	++	++	0	+++	++	++	++	--	++	--	--	--
Assail	4A	++	+++	--	--	+	++	++	--	0	--	+	--
Avaunt	22	--	--	--	--	++	--	--	--	++	--	--	--
⊗ Aza-Direct	18B	--	+	--	--	--	+	--	--	--	--	--	--
*Brigade	3	+++	--	--	--	--	--	++	--	--	--	--	--
⊗ Bt products	11	--	--	--	--	--	0	--	++	--	--	--	--
Confirm	18	--	--	--	--	++	0	--	+++	--	--	--	--
*Danitol	3	++	--	--	--	--	+++	++	+++	--	--	--	--
Delegate	5	--	--	--	--	+++	--	0	--	--	--	++	--
*Diazinon	1B	++	++	0	++	++	0	+++	++	+++	+++	+	+
Esteem	7	--	--	--	--	--	0	+	--	--	+++	--	--
Imidan	1B	--	+++	--	+++	+++	++	+++	+++	+++	++	0	--
Intrepid	18	--	--	--	--	--	--	--	--	--	--	--	--
*Lannate	1A	++	++	--	++	+++	--	++	++	+	--	+	--
Malathion	1B	+	++[c]	--	+	+	+	+	--	++	--	++	--
⊗ M-Pede	--	++	--	--	--	--	--	+	--	--	--	--	--
*Mustang	3	--	+	--	--	++	++	++	++	++	--	--	--
Platinum	4A	+++	--	0	--	0	--	++	--	+	--	0	--
Provado	4A	+++	+++	--	--	--	+++	+++	--	--	--	+++	--
⊗ Pyganic	3	+	+	--	--	--	+	--	--	--	--	--	--
Sevin	1A	--	+	--	+	+	+++	++	+	+	---	--	--
Spintor, ⊗Entrust, Success	5	--	+++	0	--	+++	0	+++	+++	0	0	+++	--
Superior Oil[b]	--	++	0	+	--	--	0	--	--	--	+++	--	--
⊗ Surround	--	--	+	--	--	--	--	--	--	++	--	--	--
*Thionex	2A	++	0	+++	--	+	--	0	--	+	0	--	--

0=not effective, +=poor, ++=good, +++=excellent, --=insufficient data.

[a] IRAC = Insecticide Resistance Action Committee list; 1A=carbamates; 1B=organophosphates; 2A=chlorinated cyclodienes; 3=pyrethrins and synthetic pyrethroids; 4A=neonicotinoids; 5=spinosyns; 7=juvenile hormone mimics; 11=Bt mircrobials; 18=molting dirsuptors; 21=botanical electron transport inhibitors; 22=voltage dependent sodium channel blocker

bDormant or Delayed Dormant only. *c* For Blueberry Maggot Malathion must be combined with Staley's Sauce Base No. 7 aka NuLure

***Restricted use material; pesticide applicators license required. ⊗ OMRI certified for organic production**

eggs before they hatch. However, some egg clusters are under bark flaps and loose lichen and may be protected from oil sprays. Caterpillars may also invade host plants by ballooning onto them after treatment has been applied. Bacillus thuringiensis (B.t. (kurstaki), which is a bacterium and specific to caterpillars, works very well on the younger larvae of both winter moth and cankerworms while they are feeding on the foliage. B.t. is not effective when the caterpillars are feeding in the buds. Spinosad is another biorational compound that works well against winter moth and cankerworms. Finally, tebufenozide (e.g. Confirm) is an insect growth regulator (IGR) that works well on most lepidopteran caterpillars.

Vertebrate Pests

Deer: White-tailed deer can cause extensive damage to blueberries by browsing top-growth in winter. Deer can also cause damage to other small fruit crops. For more information on controlling deer, please see Deer Control in the Appendices.

Birds: Birds are a major pest problem in highbush blueberries. Left unchecked, they can destroy enough of the crop to ruin the profitability of a planting. The loss of chemical deterrents has made bird control a more difficult task in recent times, but effective means are still available.

Management: Netting is the most effective way to keep birds out of the planting. Although initial costs can be high, most netting will last for many years if cared for properly. Netting should be hung over some sort of support structure built around the planting. Usually posts are set nine feet above the ground around the perimeter of the planting, and wire is run from pole to pole to form a grid over the planting. The netting is hung over this grid when the fruit begins to turn color. Some temporary nine foot poles may be placed within the planting at intersections of the grid to keep the netting from drooping. Bury the edges of the netting or anchor it to the ground to keep birds from crawling underneath. Remove the netting when the harvest is complete, and store in a cool, dry place.

Visual scare devices have variable effectiveness on birds. Scarecrows, balloons, kites, or stuffed owls may work on certain bird species in certain areas, but none seem to have widespread dependability. When using scarecrows, "scare eye" balloons, stuffed owls, or snakes, put them in the planting only when the fruit begins to ripen, and move them regularly, at least once a day. Six scare-eye balloons per acre are recommended. Take them out of the field as soon as harvest is over. This will reduce the chance of birds becoming accustomed to the devices, and increase the longevity of their effectiveness. Kites and helium-filled balloons positioned high above the planting with a silhouette of a hawk hanging from them have provided good results in some areas.

Noise deterrents, such as propane cannons, alarms and recorded distress calls seem to have the least effect on birds in blueberries, but may greatly annoy neighbors. A combination of noise and visuals may be effective, however. Several operations have hired people to regularly drive motorcycles and/or ATVs through the plantings when the fruit is ripe, and this seems to keep birds away quite well. Be sure to make drivers aware of where pickers are however, to avoid possible accidents.

Bird Shield™, a repellent formulated from methyl anthranilate, is registered for use on blueberries, cherries, and grapes. Methyl anthranilate is commonly used as a grape flavoring in human food preparations. Bird avoidance is based on odor quality and irritation. To humans, this chemical has a grape-like or fruit odor and a slightly bitter, pungent taste. Unfortunately efficacy data does not support recommending the use of this material at this time.

Voles: Voles can be a serious problem in blueberry plantings. They feed on the bark of the stems or on the roots depending on which species of vole is present. In the Northeast, two species are found: the meadow vole (Microtus pennsylvanicus) and the pine vole (Microtus pinetorum). They may both be present in a blueberry planting. It is important to determine which species is present in order to make management decisions.

Size and appearance of the two species differ although it is somewhat rare to actually see them. The meadow vole has a long body (150-195 cm) and long tail, prominent eyes and ears, coarse fur, and is dull gray to chestnut in color with a gray belly. The pine vole has a short body (110-135 cm) and short tail, sunken eyes and ears, fine velvety fur, and is bright chestnut in color with a slate gray belly.

Evidence of their activity is more diagnostic. Meadow voles are active on the surface of the ground, feeding on the bark of the bushes and making shallow trails in the grass or mulch around the plants. Food caches and droppings can be found in these surface trails. Pine voles are active below ground, feeding on roots. Subsurface trails can be found by digging around the bushes. These trails come to the surface where mounds of dirt can be seen. Holes leading into these trails are about 1" in diameter.

Simply finding evidence of voles does not indicate a serious problem. To determine whether the voles are causing serious injury to the bushes, it is necessary to estimate the population of voles present. This requires some specialized sampling. It is best to contact your Extension Specialist for help with this sampling procedure.

Management: In some cases, the removal of mulch material around the bushes can help in reducing the meadow vole population. However, this is risky for bushes susceptible to drought stress. In those cases, choosing a mulch material that does not support tunnelling (caves in easily) is recommended. In some New England States, any application of toxicants or poisons for the purpose of killing any mammal or bird is prohibited. However, some toxicants may be allowed under certain situations with the proper permits. Call your Extension Specialist for recommendations.

Table 33. Highbush blueberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Dormant and Delayed Dormant			
Scale Insects Blueberry Spanworm	Superior oil, 2-2.5% (0) **plus** Esteem 35WP, 5 oz (7) or Confirm 2F, 16 oz (14) or Asana XL, 4.8-9.6 oz (14)	Prune out old, weakened canes. This application will also help reduce **Winter Moth**	Treat during dormancy using 250 - 300 gallons of spray (300-400 psi) per acre to ensure thorough coverage. Apply oil only when no danger of freezing temperatures within 24 hours.
Mummyberry		Bury overwintering mummies by cultivation or applying 3-4" mulch before mushroom cups (apothecia) appear. 'Burlington', 'Collins', 'Jersey', 'Darrow', 'Rubel' and 'Bluetta' appear somewhat resistant; 'Earliblue' and 'Blueray' appear more susceptible to mummyberry.	
Botrytis blossom and twig blight	Captan 50WP, 5 lb (0) Ziram 76DF, 3 lb (21) ⊗ Serenade Max, 1-3 lb (0) ⊗ Actinovate AG, 3-12 oz (0)	Avoid high rates of nitrogen fertilizer which tends to promote growth that is more susceptible to infection.	
Phomopsis canker Fusicoccum canker	Lime Sulfur, 5 gal (0) Ziram 76DF, 1.5 lb (21) Kocide 101, 3-5lbs/A (0) Cuprofix Ultra, 2-4 lb (0)	Prune out and destroy affected canes. 'Weymouth', 'Berkeley', and 'Earliblue' are very susceptible to Phomopsis. 'Jersey', 'Earliblue' and 'Bluecrop' are very susceptible to Fusicoccum.	Use **Lime Sulfur** only once in Spring. May be used again in autumn where Phomopsis is a problem. Do not use **Lime Sulfur** within 14 days of an oil spray or when temperatures are above 75°F.
		Avoid practices such as late season fertilization that make bushes more vulnerable to winter injury. Winter-injured bushes are more susceptible to Phomopsis and Fusicoccum infections.	
Phytophthora root rot	Ridomil Gold SL (45) New Plantings, 3.6 pt broadcast at or before time of planting (repeat once) Established Plantings, 1/4 pt/1000 ft of row, (repeat once) Aliette WDG, 5 lb (0.5) Phostrol, 2.5-5 pt (0) ProPhyt, 4 pt (0)	• Do not plant blueberries on wet soils. • If wet site is unavoidable, install drainage tile and plant blueberries on raised beds. • Phytophthora damage symptoms may mimic nutritional deficiency symptoms. **Ridomil Gold**: Apply only as an emergency use, not as a routine or preventative treatment. Apply in spring before growth begins in established plantings. In new plantings, apply at or just after planting. In new plantings, do not exceed 3.6 gallons/A within 12 months of harvest or illegal residues may result. Read the label. **Alliette**: Apply as a 5 ft. band. Do not tank mix Alliete with copper compounds or apply to foliage with copper residues or phytotoxicity may occur. See label for other restrictions **Phostrol**: Begin foliar sprays at approximately the pink bud stage, and continue on a 14-21 day interval.	

Table 33. Highbush blueberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Bud-break (aka Bud Swell, Green tip) through pre-bloom			
Blueberry Spaworm Gypsy Moth	Confirm 2F, 16 oz (14) Intrepid 2F, 16 oz (7) ⊗ Dipel DF 0.5-1 lb (0)	This application will also help reduce **Winter Moth**	Confirm and Intrepid belong to the same IRAC group and should not be used in succession. They are both most effective against young larval stages.
Blueberry Blossom Weevil Cranberry Weevil	*Asana XL, 4.8-9.6 oz (14)	Disking between rows and raking /hoeing under plants helpful.	Eradication of wild blueberries in the vicinity of the blueberry planting is advised.
Mummy Berry	Indar 75 WSP, 2 oz (30) Orbit, 6 oz (30) Pristine, 18.5-23 oz (0) Switch, 11-14 oz (0) Abound F, 6.2-15.4 oz (0) Bravo Ultrex, 2.7-3.6 lb (42) Captec 4L, 0.75-1 qt (0)	Before mummy cups appear (mid-March), disk between rows and rake, sweep, and hoe under plants or cover with 3-4" of mulch. As first mummy cups appear, apply 200 lbs of 50% Urea prills. Cultivation and Urea are most effective when both are used.	**Abound** should be used with **extreme caution** to avoid phytotoxicity to apples. See label for futher information. **For resistance management do not make more than 2 sequential applications of fungicides in the same FRAC group. See Table 31 for groups.**
Early to mid-bloom			
Mummy Berry	Same as bud-break through pre-bloom	Scout field for mummyberry strikes to determine risk level for secondary infections.	Fungicide applications are especially important following frost/freeze events during bloom.
Botrytis blossom and twig blight Anthracnose Phomopsis twig blight	Omega 500F, 1.25 pt (30) Elevate 50WDG, 1.5 lb (0) ⊗ Serenade Max, 1-3 lb (0) ⊗ Actinovate AG, 3-12 oz (0)		Many mummy berry materials also labeled for these diseases. Be aware of pre-harvest interval restrictions for this application.
Petal Fall (remove honey bees before spraying)			
Cranberry fruitworm Cherry fruitworm	*Asana XL, 4.8-9.6 0z (14) *Lannate 90, 0.5 - 1 lb (3) Avaunt 3.5-6 oz, (7) Imidan 70W, 1 1/3 lb (3) Intrepid 2F, 10-16 oz (?) Assail 70WP, 1.9-2.3 pt (1) Delegate WG, 3-6 oz (3) Sevin XLR, 1.5-2 qts (7) Malathion 5E, 1.5 pt (1) Pyrenone .5EC, 2-12 oz (0) Spintor 2SC 4-6 oz (3) Esteem 35WP, 5 oz (7) Confirm 2F, 16 oz (14) ⊗ Deliver, 0.25-1.5 lbs (0) ⊗ Entrust, 1.25-2 oz (3) ⊗ Biobit 1.6 FC 1-2 pt (0) ⊗ DiPel DF, 0.5-1 lb (0)	Disking between rows and raking and hoeing under plants is helpful for fruitworm management. In small plantings remove and destroy infested fruit (which can be identified because it turns prematurely blue)	Fruitworms are active for about five weeks and they cannot be controlled with only one post-pollination spray. **For resistance management do not make more than 2 sequential applications of insecticides in the same IRAC group. See Table 32 for groups.** **Biobit** and **DiPel** are bacterial biological insecticides containing Bacillus thurigiensis and **must** be ingested to be effective. Apply when newly hatched larvae (1st or 2nd instar) begin feeding. Larvae cease feeding in hours and die in 2-5 days.
White grubs	Admire 2F, 16-32 oz (7)	Apply through low pressure irrigation or as a band treatment followed by rainfall or irrigation. Do not exceed 0.5 lb active ingredient per acre per year for any combination of Admire and Provado. The most effective timing is between June 1 and July 15.	

Table 33. Highbush blueberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Thrips	Assail 70WP, 1.9-2.3 pt (1) Provado 1.6F, 3-4 oz (0) Spintor 2SC, 4-6 oz (3) ⊗ Entrust, 1.25-2 oz (3)		
Aphids	Provado 1.6F, 3-4 oz (0) Actara, 3-4 oz (3)		Aphids can vector the phytoplasma that causes Blueberry Scorch disease and so should be controlled in blueberry plantings.
Anthracnose	Same as early-mid bloom		
First cover (about 10 days after Petal Fall; some berries begin to color)			
Cranberry fruitworm Cherry fruitworm	Same as petal fall		Apply 7 to 12 days after petal fall
Blueberry maggot	*Asana XL, 9.6 oz (14) *Lannate SP, 0.25-0.5 lb (3) *Danitol 2.4EC, 10.6 oz (3) Assail SG, 4.5-5.3 oz (1) Imidan 70 W, 1 1/3 lb (3) Sevin 4F, 1.5-2 pt (7) Malathion 5EC, 1 pt/A (1) Pyrenone 0.5EC, 2-12 oz (0) ⊗ Surround WP, 12.5-50 lb (0) ⊗ Aza-Direct, 1-3.5 pts (0) ⊗ GR-120 Naturalyte Fruit Fly Bait, 10-20 oz (1)	Use sticky traps (red/green spheres or yellow rectangles; See source listing in appendix) to monitor population and activity. Apply insecticide 7-10 days after first trap catch. Check traps twice each week.	Apply sprays when berries begin to turn blue or when flies begin to lay eggs, usually late June. Repeat every 10 days through harvest. Be aware of pre-harvest intervals and other restrictions with repeated sprays. **Malathion** should be used with 1.5 qt Staley's Sauce Base No. 7 (NuLure). **For resistance management do not make more than 2 sequential applications of insecticides in the same IRAC group. See Table 32 for groups.**
Aphids	Same as petal fall		
Anthracnose	Same as petal fall		
Second and additional covers (10 days from previous cover, repeat as needed)			
Blueberry maggot	Same as first cover above	See comments above for Blueberry maggot	
Japanese Beetle and other scarab beetles	*Asana XL, 4.8-9.6 oz (14) *Danitol 2.4EC, 10.6 oz (3) Sevin XLR Plus, 1-2 qt (7) Provado 1.6F, 3-4 oz (0) Imidan 70W 1.3 lbs (3) Assail SG, 4.5-5.3 oz (1) ⊗ Surround WP, 12.5-50 lb (0) ⊗ Aza-Direct, 1-3.5 pts (0) Pyrenone 0.5EC, 2-12 oz (0)	Traps are not recommended as they tend to draw more beetles to the area than they remove. Bushes can withstand significant feeding injury without yield impact but fruit contamination with feces may be unacceptable, especially for packout.	The use of **Sevin** may result in the build up of aphids due to the elimination of natural predators. **Surround** labeled for supprssion only. Aza-Direct acts as a feeding repellent and requires frequent reappliation.
Blueberry Leafrollers	*Mustang 4.3 oz (1) Imidan 70W 1.3 lbs (3) Confirm 2F, 16 oz (14) Spintor 2SC, 4-6 oz (3)		
Anthracnose	Same as First Cover		See **Captan** comments in Petal Fall Section.

Table 33. Highbush blueberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Post-harvest			
Sharp-nosed leafhopper	*Lannate LV, 1.5 pt (3) *Asana XL, 4.8-9.6 oz (14) *Brigade WSB, 5.3-16 oz (1) Actara, 3-4 oz (3) Malathion 5E, 2.5-3 pt (1) Sevin XLR Plus, 1-2 qt (7) Provado 1.6F, 3-4 oz (3)	Rogue out plants affected with blueberry stunt. Monitor insects with yellow sticky traps and control when found.	Each of these sprays will control sharp-nosed leafhopper, the only known carrier of the blueberry stunt mycoplasma.
Blueberry bud Mite	*Thionex 3EC, 2 qt (**)	Apply immediately after harvest is complete and repeat 6-8 weeks later. ** Do not apply after buds are well formed; do not aply more than 2 times per year; do not exceed 3.0 lbs active ingredient per acre per year.	
Powdery Mildew	Indar 2F, 6 oz (30) Orbit, 6 oz (30) Tilt, 6 oz (30) ⊗ JMS Stylet Oil, 3 qts (0) ⊗ Milstop 2.5-5 lb (0) ⊗ Actinovate AG, 3-12 oz (0) ⊗ Thiolux, 5-10 lb (0)	Check for symptoms by examining underside of leaves for lesions with a water-soakes apearance beneath necrotic spots visible on upper leaf surface. Plant and prune for good air circulation and drying conditions.	
Phomopsis twig blight	Lime Sulfur, 5 gal (0)		Apply in late October or when 2/3 of leaves drop on Weymouth and Berkeley.

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

*** Restricted use material; pesticide applicator license required.** ⊗ **OMRI listed for organic production**

Weed Management

The primary goal of weed management is to optimize yields by minimizing competition between the weeds and the crop. Weeds reduce yields by competing with the crop for water, light, and nutrients. Weeds also harbor insects and diseases and encourage vertebrate pests. Timely cultivation, wise use of herbicides, and never permitting weeds to go to seed are integral parts of a good weed management system. Many of the weeds found in these fields are difficult-to-control perennial weeds that are not common in annual crop culture. New plantings usually have fewer perennial weed problems than older plantings. Annual and biennial weeds can also exist in these fields. Fields should be scouted at least twice a year (spring and fall) to determine specific weed problems. The selection of a weed management tool should be based on specific weeds present in each field.

The most important weed management strategy is employed prior to planting that is, eliminating all perennial weeds. Fields that have been dormant or have been in pasture may have perennial weeds that at well established. Fields that have been in cultivation are less likely to have established perennial weeds in them. Common perennial weeds include common dandelion, Canada thistle, stinging nettle, field bindweed, field horsetail, goldenrod, and quackgrass. Once these perennial weeds become established or remain established in a berry field, they are very difficult to remove. The most common way to remove perennial weeds is with Roundup (glyphosate) applied in the fall prior to planting. Perennial broadleaf weeds should be treated after flowering but prior to a killing frost. Perennial grasses can be treated well into November.

Cultural weed management in blueberry plantings includes mulching, cultivation, and soil pH management. Mulching is a major weed management tool in blueberry production. Mulches that are free of weed seeds and placed thickly enough can be very effective at reducing or eliminating most annual weeds from the crop row. They are seldom effective on perennial weeds, however. Use of cultivation is difficult and often is counter productive in blueberry plantings. It destroys surface feeding roots and does not work well where mulches are used. All cultivations should be timely and shallow to minimize crop root injury, to minimize loss of soil moisture, and to avoid repositioning new weed seeds to the soil surface. The low pH soil that blueberry plantings thrive in is not a good environment for most weed species. Keeping the soil pH at the right level will help to reduce weed pressure.

The areas between the crop row is usually maintained with a mowed cover of sod, clover, weeds, or a combination of these. This cover is used primarily for erosion control and to improve trafficability in the field.

Table 34. Weed management for highbush blueberries in the transplant year and in established plantings.

Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
PLANTING YEAR			
PREEMERGENCE WEED CONTROL			
Annual broadleaf weeds	(mesotrione) Callisto 4F	3-6 oz	Add nonionic surfactant to be 0.25%% of the spray volume, or 1 qt per acre crop oil concentrate. Apply in the late fall after leaf drop and/or in early spring before bud break as a spray directed toward the base of the bush. Broadleaf weeds controlled include horseweed and common lambsquarter. Tank-mix with an appropriate postemergence herbicide for broad-spectrum control of emerged weeds. Tank-mix with a residual grass herbicide to improved annual grass control. Do not apply more than 6 fl oz of Callisto per acre within one year.
Annual broadleaf weeds and suppression of annual grasses	(flumioxazin) Chateau WDG	6-12 oz	Only if plants established less than 2 years are protected from spray contact by nonporous wrap, grow tubes, or waxed containers. Add crop oil concentrate to be 1% of spray volume. Apply in late fall after leaf drop or in early spring before bud break. Tank-mix with an appropriate postemergence herbicide for broad-spectrum control of emerged weeds. Tank-mix with a residual grass herbicide to improve annual grass control. Do not allow spray to contact foliage or new green bark. Do not use more than 6 oz/a of product where the soil contains more than 80% sand until the plants have been in the field for more than 3 years. Follow instructions on label for tank clean-out if any part of the sprayer will be used to spray other crops; otherwise, crop injury may occur. See label for other cautions and restrictions, as even contact with treated residue can cause phytotoxicity.
Annual grasses and small seeded broadleaf weeds	(napropamide) Devrinol 50 DF	8 lb	Apply after transplanting to weed-free soil. Devrinol must be activated within 24 hrs by cultivation or enough water by irrigation or rainfall to wet the soil to a depth of 2 to 4 inches. The full rate may not be necessary at transplanting.
	(oryzalin) Surflan 4AS	2 to 4 qt	Do not apply until soil has settled around the plants and no cracks are present. Irrigation or 1 inch of rain is needed within 21 days of application. Shallow cultivation will improve control. May injure newly planted tissue culture plants.
Broadleaf weeds and some grasses	(simazine) Princep 4L Caliber 90	1 to 2 qt 1.1 to 2.2 lb	Use to improve the broadleaf weed activity of Devrinol or Surflan. Consider applying half the maximum rate after planting and half in the fall before winter annuals emerge. Do not use on newly transplanted tissue culture plants.
	(isoxaben) Gallery 75D	0.66 to 1.33 lb	NON-BEARING USE ONLY. Do not apply within 1 year of the first harvest. Do not apply over t he top of plants but as a directed spray to thebase of plants after the soil has settled. Does not control emerged weeds. Controls many broadleaf weeds from seed. See label for a complete list.
POSTEMERGENCE WEED CONTROL			
Emerged annual and most perennial grasses	(fluazifop) Fusilade DX	16 to 24 oz	NON-BEARING USE ONLY. See label for best times to treat specific weeds. Will not control broadleaf weeds or sedges. Do not apply to crops to be harvested within 1 year of application. Do not apply if rainfall is expected within 1 hour or if grasses are under drought stress. Must be used with a crop oil concentrate or non-ionic surfactant.
	(sethoxydim) Poast	1 to 2.5 pt	See label for best times to treat specific weeds. Will not control broadleaf weeds or sedges. Do not apply to grasses under stress (e.g. drought). Crop oil concentrate must be added to the spray tank. Do not cultivate 5 days before or 7 days after application. Do not apply more than 5 pints per acre per season.

Table 34. Weed management for highbush blueberries in the transplant year and in established plantings.

Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
Emerged annual and most perennial grasses	(clethodim) Select 2EC Select Max	 6-8 oz 12-16 oz	Use the lower rate to control annual grasses and the perennial grasses listed to the left. Repeat the application if regrowth occurs. Always add oil concentrate to be 1% of the spray solution, or a minimum of 1 pint per acre, to Select 2EC. Always add oil concentrate to be 1% of the spray solution, or a minimum of 1 pint per acre, or nonionic surfactant to be 0.25% of the spray solution to Select Max. Do not tank-mix with any other pesticide unless labeled. Do not apply within 1 hour of rainfall. Do not apply to grasses suffering from drought, heat, cold, or any other stress condition. Select is currently labeled for nonbearing fields only. Do not apply within 12 months of harvest.
Emerged annual weeds and suppression of perennial weeds.	(pelargonic acid) Scythe	3-10% solution	Contact material for burn down only. See Scythe comments in Strawberry section. See label for complete instructions.
Emerged annual and perennial weeds	(sulfosate) Touchdown	1 to 5 pt	NON-BEARING USE ONLY. Apply to actively growing weeds during site preparation prior to planting and no later than 1 year before harvest. Apply with a wiper or a shielded/directed spray. Do not allow the spray, spray drift, or mist to contact green foliage or green bark on the trunk, suckers, open wound, or other green parts of the bush. Consult the label for rates for specific weeds and other precautions. Use with a surfactant or wetting agent.
ESTABLISHED PLANTINGS			
PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds	(napropamide) Devrinol 50DF	8 lb	Apply in the early spring before seedling weeds emerge. Devrinol must be activated within 24 hours by shallow cultivation or with enough rainfall or irrigation to wet the soil to a depth of 2 to 4 inches.
	(oryzalin) Surflan 4AS	2 to 4 qt	Apply to weed-free soil in the spring. Irrigation or 1 inch or rainfall is needed within 21 days of application.
	(norflurazon) Solicam 80DF	2.5 to 5 lb	Apply in early spring when crop is dormant to clean and weed-free soil. May result in temporary bleaching or chlorosis of leaves from which the plant will recover. Do not use on nursery stock.
NOTE: For broad spectrum preemrgence weed control, consider applying one of the above three "grass" herbicides (napropamide, oryzalin, or norflurazon) in addition to one of the following "broadleaf" herbicides (simazine, terbacil, hexasinone or dichlobenil).			
Perennial grasses	(pronamide) Kerb 50WP	2-4 lb	Apply in late fall when soil temperatures are between 35 and 55°F. Spring transplants should be at least six months in the field, and fall transplants should be in the field for twelve months prior to treatment. When applied in the fall, also provides early control of annual grasses the following spring. Apply Surflan, Solicam, or Sinbar the following spring for full season annual grass control. Tank-mix Kerb with Princep for residual broadleaf weed control.
Annual broadleaf weeds	(mesotrione) Callisto 4F	3-6 oz	Add nonionic surfactant to be 0.25% of the spray volume, or 1 qt per acre crop oil concentrate. Apply in the late fall after leaf drop and/or in early spring before bud break as a spray directed toward the base of the bush. If applying in the fall, use a 3 fl oz rate and repeat with 3 fl oz prebloom for longer control. If applying in the spring, up to 6 fl oz can be used. Broadleaf weeds controlled include horseweed and common lambsquarter. Tank-mix with an appropriate postemergence herbicide for broad-spectrum control of emerged weeds. Tank-mix with a residual grass herbicide to improved annual grass control. Do not apply more than 6 fl oz of Callisto per acre within one year.

Table 34. Weed management for highbush blueberries in the transplant year and in established plantings.

Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
Annual broadleaf weeds and supression of some annual grasses	(flumioxazin) Chateau WDG	6-12 oz	Add crop oil concentrate to be 1% of spray volume. Apply in late fall after leaf drop or in early spring before bud break. Tank-mix with an appropriate postemergence herbicide for broad-spectrum control of emerged weeds. Tank-mix with a residual grass herbicide to improve annual grass control. Do not allow spray to contact foliage or new green bark. Do not use more than 6 oz/a of product where soil contains more than 80% sand until plants have been in the field for more than 3 years. Follow instructions on label for tank clean-out if any part of the sprayer will be used to spray other crops; otherwise, crop injury may occur. See label for other cautions and restrictions, as even contact with treated residue can cause phytotoxicity.
Broadleaf weeds, some grasses, and suppression of some perennial weeds	(simazine) Princep 4L Caliber 90	2 to 4 qt 2.2 to 4.4 lb	Apply in the spring before bud break and before weeds emerge, or in the fall. Do not apply when fruit is present. For improved control as well as quackgrass suppression apply half in the spring and half after harvest.
	(terbacil) Sinbar 80WP	0.5 to2 lb	Apply in the early spring or in the fall as a directed spray to the base of the plants. Will also control small emerged weeds. Do not contact new shoots and avoid contact with foliage. Spring application must be made before fruit set. Avoid application on plantings low in vigor. Planting must be at least 1 year old before application. Do not apply within 70 days before harvest.
	(hexazinone) Velpar 75DF	1.3 to 2.6 lb	Planting must be established at least 3 years. Apply in the spring to the soil surface PRIOR to blueberry leaf emergence. Use a directed spray to avoid contact with blueberry plants. Controls many perennial weeds and will suppress wild brambles.
	(dichlobenil) Casoron 50WP Casoron 4G	8 lb 100 lb	Apply at temperatures below 50˚F, preferably just before rain or snow. Soil must be settled around established plants. Uniform application is essential. Do not apply during new shoot emergence. The 4G formulation is effective on many perennial weed species. May reduce plant growth in plantings that are young or lacking vigor. High leaching risk. Granules have better activity on perennial grasses and reduce leaching risk.
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds	(paraquat) *Gramoxone Inteon Firestorm 3SC	2-4 pt 1.3-2.7 pt	Contact herbicidewith no translocation or residual activity. Best results occur when weeds are 2 inches tall or less. Regrowth may occur from the root systems of established weeds. Use a surfactant to be 0.25% of the spray solution (1 qt per 100 gallons of spray solution). Combine with recommended preemergence herbicide(s) for residual weed control. Do not allow spray or drift to contact green bark, leaves, or fruit. Crop damage may result. The use of shields, such as grow tubes or paper milk cartons greatly reduces the risk of injury in young plantings. DANGER: Do not breathe spray mist. Read safety precautions on the label.
Emerged annual and most perennial grasses	(sethoxydim) Poast	1 to 2.5 pt	Effective on actively growing grasses. Do not apply to grasses under stress (e.g., drought). Crop oil concentrate must be added to spray tank. Do not cultivate 5 days before or 7 days after application. Do not apply within 30 days before harvest in blueberries. Do not exceed 5 pints per acre per year.
Emerged annual weeds and suppression of perennial weeds	(pelargonic acid) Scythe	3-10% solution	Contact material for burn down only. See Scythe comments in Strawberry section. See label for complete instructions.
Emerged annual and perennial weeds	(glyphosate) Roundup Weather Max	1 to 5 qt	Apply to actively growing weeds. Apply with a wiper or a shielded/directed spray to the base of the plants. Do not permit herbicide solution to contact desirable vegetation, including green shoots, canes, or foliage. Do not cultivate within 7 days after application.

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

***Restricted use pesticide; pesticide applicators license required. ⊗ OMRI listed for organic production**

Table 34.1. Weed management with and without herbicides in a blueberry planting.

Year	Month	Herbicide Options	Non-herbicide Options
Planting year			
	April	Roundup for emerged perennial weeds 30 days before planting. After weed dieback till to prepare for planting.	Frequent tillage
	April-May	Devrinol before seedlings emerge. Till or water in within 24 hours	Hand weed
	Mid-June after planting	Fusilade for perennial grasses	Cultivate/handweed/mulch; mow row middles and borders
	Mid-July	Hand weed or Roundup spot treatments	Cultivate/handweed; mow row middles and borders
	October	Princep at low rate	Cultivate/handweed; mow row middles and borders
	November	Callisto or Chateau for broadleaves. Kerb for grasses before ground freezes. Casoron for grasses and broadleaf weeds. Read labels carefully for specific application requirements	Handweed
Fruiting years			
	March-April	Callisto, Casoron, Chateau, Devrinol, Sinbar, Princep, or Velpar as early spring applications.	Handweed and apply mulch as needed
	Early May	Gramoxone or Scythe before new cane emergence.	Handweed and mow row middles and borders
	Late July after harvest	Poast on actively growing grasses, spot treat with Roundup	Handweed and mow row middles and borders
	September to October	Sinbar (after harvest), Devrinol, Solicam, Surflan, Princep. See labels for restrictions.	Handweed and mow row middles and borders
	November; after crop dormancy	Callisto or Chateau for broadleaves. Kerb for grasses. Casoron if needed for grasses and broadleaves. See labels for restrictions.	Handweed

Adapted from Cornell 2010 Pest Management Guidelines for Berry Crops.

Brambles

General Information

The success of a bramble planting is highly dependent upon its location. The site should have full exposure to sunlight and good air circulation. It should also be somewhat protected, however, as brambles are quite susceptible to winter injury. Temperatures below -20° F will injure most fruit buds above the snow line. Colder temperatures, especially if no snow cover is present, can kill canes to the ground, or damage roots, causing plants to die in the early summer when not enough water can be taken in to support them.

The soil should be well-drained; brambles will not tolerate "wet feet." Wet soils encourage the spread of Phytophthora root rot which will destroy brambles. Do not plant brambles where potatoes, tomatoes, peppers or eggplant have recently been grown, because these crops carry Verticillium, another root rot fungus which can infect brambles. Avoid planting brambles near any wild brambles. Wild raspberries and blackberries harbor insects and virus diseases which will spread to cultivated plants. If possible, destroy all wild brambles within at least 600 feet of your planting.

Always obtain raspberry plants from a reputable nursery which certifies their plants to be virus-free. Raspberries are best planted in the early spring. Plant your rows at least 8 feet apart, preferably 10 to 12 feet apart to ensure adequate air circulation, as well as room for harvesting and pruning operations.

Raspberry plants are shallow-rooted and thus are poor competitors for water and nutrients if weeds are present. A 3 to 6" layer of mulch will help to conserve soil moisture and inhibit weed growth. Coarse sawdust, wood chips or bark make good mulching materials. Pine needles work well, but need replenishing more frequently. Mulching of raspberry plantings is not without risk. The use of a permanent mulch may delay fruit ripening and plant hardening-off in the autumn, increasing the risk of winter damage.

Table 35. Recommended optimal soil characteristics for growing brambles.

Soil Characteristic	Desirable Range*
pH	5.8-6.2
Organic matter	4 to 6 %
Phosphorus	20-30 ppm
Potassium	120- 180 ppm
	Base Saturation >3.0
Magnesium	100-150 ppm
	Base Saturation >5.0
Calcium	1000 - 1500 ppm
	Base Saturation >50.0

*Desirable range will vary with soil types (sand, silt, or clay), soil organic matter, and pH.

Proper pruning is a crucial part of pest management for raspberries. In the late winter, remove old second year canes and thin out weak, spindly first year canes. Thin out the remaining canes, leaving only those with good height, large cane diameters and no symptoms of winter injury, insect or disease damage. Everbearing varieties (e.g., Heritage) may be completely mowed down each year in early spring before growth starts as pruning practice. This will result in only the primocane (Fall) crop being harvested.

Plant rows should be narrowed to a width of 2 feet or less. When finished, there should be no more than 4 or 5 canes per foot of row remaining. Canes which have been cut should be removed from the planting and destroyed. Pruning in this manner will greatly reduce the incidence of most raspberry cane diseases by increasing air circulation and reducing disease inoculum. Check with your Cooperative Extension office for details of proper varieties and cultural techniques for brambles, or see NRAES 35, Raspberry & Blackberry Production Guide available through New England Extension Fruit Specialists. See source page at end of this guide for more information on ordering the Raspberry & Blackberry Production Guide.

Diseases

Fruit and Foliage Diseases

Botrytis Fruit Rot; Gray Mold (Botrytis cinerea): Raspberries are very susceptible to fruit rots caused by fungi, especially during wet weather. To prevent fruit rots from becoming a major problem, encourage air circulation and rapid drying of the plants and fruit by maintaining narrow plant rows, and proper cane thinning. Harvest fruit regularly. Do not allow overripe or rotten fruit to remain on the plants.

Table 36. Number of bramble plants per acre at different spacings.

Feet between	Spacing Between Rows		
plants in row	8 FEET	10 FEET	12 FEET
2	2,722	2,178	1,815
3	1,815	1,452	1,210
4	1,360	1,090	907
5	1,090	870	726
6	907	726	605
8	680	544	453

Table 37. Postplant nitrogen recommendations for brambles.

	IRRIGATED			NON-IRRIGATED		
Year	Sandy	Loamy	Clay	Sandy	Loamy	Clay
FALL-BEARING REDS (NO SUMMER CROPS)*						
1	40	30	25	35	30	25
2	80	70	60	70	65	50
3+	120	100	90	90	80	70
SUMMER-BEARING REDS						
1	35	20	25	30	25	25
2	55	50	45	45	40	35
3+	80	70	60	60	50	40
SUMMER-BEARING BLACKS AND PURPLES						
1	30	25	25	25	20	20
2	45	40	35	35	30	25
3+	60	50	45	45	40	30

Note: Rates should be adjusted according to leaf tissue analysis
*Split the recommended amount into two applications with half at cane emergence and half in mid-July.

Table 38. Critical nutrient values for bramble tissue analysis.

Element	Deficient	Below Normal	Normal	Above Normal	Excessive
N (%)	1.80	2.00	2.50	3.00	>3.50
P (%)	0.23	0.25	0.35	0.40	>0.50
K (%)	1.45	1.50	2.00	2.50	>3.00
Ca (%)	0.57	0.60	1.70	2.50	>3.00
Mg (%)	0.27	0.30	0.70	0.90	>1.00
Mn (ppm)	45	50	150	200	>250
Fe (ppm)	48	50	150	200	>250
Cu (ppm)	6	7	30	50	>60
B (ppm)	28	30	40	50	>60
Zn (ppm)	18	20	35	50	>60

Management: Infections can occur as early as bloom, so preventative fungicide sprays should be applied beginning at that time, and followed-up with additional sprays when wet weather is predicted. See pest management schedule for recommended materials and timing. To prevent molds from developing after harvest, cool the fruit as rapidly as possible after picking and maintain them at about 33˚F until they are sold. Never place raspberries in containers more than 3 fruit deep, and avoid rough handling.

Powdery Mildew (Sphaerotheca macularis): Powdery mildew affects susceptible cultivars of red, black, and purple raspberries. Blackberries and their hybrids are usually not affected. The disease can be severe (varying from year to year) on highly susceptible cultivars, and plants may become stunted and less productive. The infection of flower buds reduces fruit quantity, and infected fruit may be unmarketable as a result of the unsightly covering of the powdery mycelial growth.

Infected leaves develop light green blotches on the upper surface. Generally, the lower surface of the leaf directly beneath these spots becomes covered by white, mycelial growth of the powdery mildew fungus. The leaf spots may appear water-soaked. Infected leaves are often mottled, and if surface growth of the fungus is sparse, they often appear to be infected by a mosaic virus. Infected shoot tips may also become covered with mycelial growth. When severely infected, the shoots become long and spindly (rat-tailed), with dwarfed leaves that are often curled upward at the margins. Infected fruit may also become covered with a white mycelial mat. When the disease is severe, the entire plant may be stunted.

Management: The easiest way to control powdery mildew is to promote good air circulation around canes. Removal of late-formed mildewed suckers in the fall may also delay the start of the disease build-up in the spring. See Pest Management Table 40 for recommended fungicides and rates for controlling powdery mildew.

Orange Rust (Arthuriomyces peckianus and Gymnoconia nitens): Orange rust can be caused by two stages of a single rust fungus, though different names are given to each stage. A. peckianus is the long-cycled state of the rust fungus that produces telia and teliospores and typicaly affects black raspberries. G. nitens is the short-cycled state of the rust fungus that does not produce teliospores and typically affects erect and trailing blackberries. Neither fungus has an alternate host, which is common for other rust diseases of raspberry.

Orange rust affects black raspberry and blackberry, but is not known to affect red raspberry. In early spring when new shoots begin growth, leaves appear stunded, misshapen, and orange spores can be observed on lower leaf surfaces. If conditions are appropriate, brown-black telia and teliospores will also form on the undersides of leaves. These spores will spread the disease to other plants. The fungus infects systemically; once a plant is infected it will not recover. Infected plants will eventually become stunted with bushy growth and produce few fruit.

Management: Orange rust management begins by planting healthy and disease-free blackberry and black raspberry stock. Since wild blackberry and wild black raspberry plants can serve as a reservoir of the disease, remove and destroy these wild plants in the area. Promote good air circulation by keeping weeds down and using good thinning and pruning practices. Inspect plants in the spring for symptoms of the disease, and remove and destroy infected plants as soon as the first symptoms appear. A few chemicals are labeled for control of orange rust and are listed in the pest management schedule in Table 40. However, fungicide controls are generally not considered effective for orange rust management.

Cane Diseases

Anthracnose (Elsinoe veneta): Anthracnose is a fungus disease which first appears as purple spots on the young canes. As the disease develops, the spots enlarge and become sunken. Small, white spots may appear on the leaves, and the fruit may develop brown, scabby areas. Individual drupelets become infected, sunken, and light tan in color; fruit has a bitter flavor. On older canes, the lesions will turn gray and cause the bark to split. Although this disease tends to be worse on black and purple raspberries, heavy infestations can cause serious yield losses in red raspberries. Anthracnose spores spread under wet conditions, so it is important to promote drying by ensuring good air circulation. This can be accomplished through careful pruning each year and removing all infected canes.

Management: This disease can be greatly inhibited by encouraging good air circulation, through maintaining narrow plant rows and good pruning and thinning practices. Early spring sprays of lime sulfur on the canes will help prevent early infections. Lime sulfur should be applied before the emerging buds are 1/2" long, or plant damage will result. See pest management schedule for recommended materials and timing.

Spur Blight (Didymella applanata): Spur blight is a fungus disease which causes brown or purple blotches to appear on the canes, usually centered around a leaf stem. Symptoms appear on new canes in mid to late summer. On second-year canes, the blotches become gray areas on the bark with tiny black spots on them, which are the fruiting structures of the fungus. Leaves on infected canes may show yellow or brown areas which begin at the mid-vein and spread out to the leaf tip. Infected canes are weakened, and produce fewer fruiting branches than healthy canes.

Management: Similar to anthracnose, this disease can be greatly inhibited by encouraging good air circulation through maintaining narrow plant rows and good pruning and thinning practices. Applications of lime sulfur to the canes in the early spring before the new buds are 1/2" long will prevent early infection. See pest management schedule for recommended materials and timing.

Cane Blight (Leptosphaeria coniothyrium): Cane blight is caused by a fungus and is characterized by large brown and purple lesions which form on the canes. Unlike spur blight, these lesions are not typically located at a leaf stem and may involve whole stems. Fruiting laterals exhibit weak growth and may wilt and turn brown. This disease is most common on black raspberries.

Management: Control of cane blight is the same as for anthracnose or spur blight.

Root and Crown Diseases

Verticillium Wilt (Verticillium albo-atrum): Verticillium is a root rot fungus which causes the leaves on raspberry canes to yellow, wilt and fall off, progressing from the bottom of the cane to the top. These symptoms may only appear on one side of the plant and are most frequently observed during hot, dry periods. Young canes may show a purple discoloration starting near the soil line and extending upward. Canes eventually die.

Management: Verticillium attacks a wide range of plants, including potatoes, tomatoes, peppers, squash and strawberries. Do not plant raspberries following any of these crops. Non-host crops such as corn or wheat can help eliminate the fungus if grown for at least 2 years before planting raspberries. Many weed species, including pigweed and lamb's-quarters also carry the disease, so good weed control in the raspberry planting is essential. Preplant soil fumigation can help eliminate this fungus, but is quite costly. This disease is most serious on black raspberries.

Phytophthora Root Rot (Phytophthora spp.): The Phytoph-

thora fungus invades the roots of raspberries and disrupts the vascular system, causing infected plants to produce weak, stunted canes, with small, off-color leaves. When dug up, the roots of these plants may look dead. Symptoms are most obvious in the spring, frequently causing this disease to be misdiagnosed as winter injury. In order to spread throughout a planting, the fungus requires flooded soils.

Management: Good soil drainage is critical for preventing this disease. The varieties Latham and Newburgh seem to have some resistance to Phytophthora, while Titan and Hilton are very susceptible. Soil fungicide drenches in the spring and fall will provide control of Phytophthora, but should not be considered a substitute for good soil drainage and appropriate variety selection. This is only an emergency measure and it is better to move the planting to a more suitable location. See Table 40 for recommendations of specific materials and rates. Planting on raised beds helps with this problem and wet feet in general. Mulching new plantings with straw has been observed to increase the likelihood of Phytophthora infection the following spring.

Crown Gall (Agrobacterium tumefaciens): Crown gall is a widespread disease of all brambles caused by a bacterium. The bacteria induce galls or tumors on the roots, crowns, or canes of infected plants. Galls interfere with water and nutrient flow in the plants. Seriously infected plants may become weakened, stunted, and unproductive.

Young galls are rough, spongy, and wart-like. Galls can be formed each season and vary in size from a pinhead to several inches in diameter. They develop near the soil line or underground in the spring. Cane galls occur almost exclusively on fruiting canes and usually appear in late spring or early summer. Both crown and cane galls become hard, brown to black, woody knots as they age. Some disintegrate with time and other may remain for the life of the plant. The tops of infected plants may show no symptoms, but plants with numerous galls may be stunted, produce dry, poorly-developed berries, break easily and fall over, or show various deficiency symptoms due to impaired uptake and transport of nutrients and water.

Management: Control procedures include: (1) planting only nursery stock which is free of any obvious galls on crowns or roots: (2) not planting into a field where crown gall has occurred previously, unless a non-host crop, such as strawberries or most vegetables, is grown for two or more years before replanting; and (3) minimizing injury to root and crown systems during farm operations such as cultivation.

In addition to be above procedures, a nonpathogenic bacterium, Agrobacterium radiobacter, strain K-84, is commercially available for biological control of crown gall. The biocontrol agent may be applied to roots of healthy plants when they are first set out. After planting, the control becomes established in the soil around the root zone and prevents crown gall bacteria from entering this region. However, the biocontrol agent will not cure plants which are already infected before its application.

Table 39.1. Fungicides registered for use on brambles and their primary uses.

Fungicide	FRAC Group	Botrytis Gray Mold	Spur Blight	Anthracnose	Orange Rust	Phytophthora Root Rot
Abound[a]	11	+	--	--	++	0
Aliette	33	0	--	--	0	+++
Cabrio	11	++	--	--	++	0
Captan	M	++	+	+	0	0
Captevate	17,M	+++	--	--	0	0
Elevate	17	+++	--	--	0	0
Lime sulfur[b]	M	0	++	++	0	0
Orbit, Tilt	3	0	--	--	++	0
Oxidate	--	++	--	--	--	0
Phosphorous Acid	33	0	--	--	0	+++
Pristine	7, 11	+++	--	--	++	0
Rally	3	0	--	--	++	0
Ridomil Gold	4	0	--	--	0	+++
Rovral	2	+++	--	--	0	0
Switch	9, 12	++	--	--	+	0
Tanos	11	--	++	+	0	0

0=not effective, +=poor, ++=good, +++=excellent, --=insufficient data.

FRAC activity groups: 3=demethylation inhibitors(includes tirazoles); 4=acylalanines; 7=carbosamides; 9=anilinopyrimidines; 11=strobilurins; 12=phenylpyrroles; 17=hydroxyanilides; 29=2,6-dinitroanilines; 33=unknown (phosphonates); M=multisite.

[a]This material is very toxic to some varieties of apples; use extreme caution when spraying near apples; do not use same sprayer subsequently on apples.

[b]Use lime sulfur only on dormant plants. **Do not mix with oil.**

***Restricted use material; pesticide applicators license required. ⊗ OMRI certified for organic production**

Table 39.2. Relative hardiness and disease resistance for bramble varieties recommended for New England.

			Disease Resistance			
Variety	**Hardiness Zone**	**Season**	**SB**	**AN**	**VR**	**PH**
Summer Red Raspberries						
Algonquin	4	mid	R	U	R	F
Boyne	3	early	F	S	U	F
Canby	4	mid	U	U	U	S
Encore	4	late	U	U	U	S
Festival	4	late mid	R	U	R	U
K81-6	4	late	R	R	S	S
Killarney	3	early mid	F	S	U	F
Latham	3	mid	S	S	F	U
Lauren	5	early	U	U	F	U
Newburgh	4	mid	F	F	U	G
Nova	3	mid	R	R	R	U
Prelude	4	early	U	U	U	R
Qualicum	5	mid	U	S	R	S
Reveille	4	early	U	U	U	U
Taylor	4	late	S	S	S	S
Titan	5	mid	U	U	U	S
Summer Black Raspberries						
Allen	5	mid	U	U	U	U
Bristol	5	mid	U	S	U	U
Earlisweet	5	early	U	U	U	U
Jewel	5	mid	U	R	U	U
Mac Black	5	late	U	U	U	U
Summer Purple						
Royalty	4	late	U	U	U	U
Fall Red Raspberries						
Autumn Bliss	3	early fall	U	U	F	F
Autumn Britain	3	early fall	U	U	U	G
Caroline	4	early fall	U	U	U	R
Dinkum	5	early fall	U	U	S	S
Heritage	4	mid fall	U	U	S	S
Himbo Top	4	early mid fall	U	U	U	S
Jaclyn	3	early fall	U	U	U	U
Joan J	3	early fall	U	U	U	U
Polana	3	very early	U	U	U	S
Fall Yellow Raspberries						
Anne	4	mid	U	U	U	S
Kiwigold	4	mid	U	U	U	S
Greenhouse						
Tulameen	6	mid	U	U	U	U

SB=Spur blight; AN=Anthracnose; VR=Viruses; PH=Phytophthora

G= good, F= fair, R=resistant, S= susceptible, U= unknown

Hardiness Zone 3=very hardy to 6= very tender

Viruses

Several types of viruses infect raspberry plants causing a variety of symptoms, including mosaic yellow patterning of the leaves, leaf curl and/or crinkle, cane dwarfing and crumbly berries. Once a plant becomes infected with a virus, it cannot be cured. All infected plants, including the roots, should be removed from the planting and destroyed. Viruses are typically spread by aphids, but in some cases (e.g., crumbly berry) nematodes may be responsible. When these creatures feed on infected plants they can take in the virus and then spread it to other plants. In order to prevent the spread of viruses, start with certified, virus-free planting stock. Plant your raspberries away from any wild brambles which may be harboring viruses that could be spread to your plants. A distance of at least 600 feet between cultivated raspberries and any wild brambles is recommended. Controlling the insects which spread these disease is usually not a practical method of preventing infection. However, some raspberry varieties are resistant to aphid feeding and are thus somewhat protected. These varieties include Canby, Titan and Royalty.

Insects

Fruit and Foliage Insect Pests

Raspberry Fruitworm (Byturus rubi): The raspberry fruitworm is a small (1/4") brown beetle which feeds on the flower buds and leaves of raspberry plants during the spring and early summer. Female beetles lay eggs on the flowers and green fruit. The grubs that emerge are yellowish white, and feed on the fruit, attaining about 3/8" in length. Many of the flowers and fruit can be destroyed by this insect, and the larvae may end up in the harvested fruit, greatly reducing customer appeal.

Management: There is some evidence suggesting that this insect is more of a problem in weedy plantings. If early damage is noted, (e.g., small holes chewed in flower buds and skeletonizing of leaves), cover sprays should be applied prior to bloom. Adults (beetles) tend to be most active and noticeable on plants in the early evening hours. See pest management schedule for recommended materials and timing.

Tarnished Plant Bug (Lygus lineolaris): The tarnished plant bug (TPB) is a small (1/4") bronze-colored insect with a triangular marking on its back. The immature stage, or nymph, is smaller and bright green, resembling an aphid, but much more active. Both adults and nymphs feed on the developing flowers and fruit, sucking out plant juices with straw-like mouthparts. This results in deformed fruit, with a few to many drupelets not enlarging, depending on the severity of the damage. Such fruit tend to crumble easily, and are generally unmarketable.

Management: Controlling weeds in and around the planting may reduce populations of this insect, but insecticide sprays may be necessary, applied prebloom and repeated after petal fall. If mowing around fields, do so after insecticides have been applied (to control migrating insects). Avoid planting alfalfa (which attracts high populations of TPB) near raspberries. White sticky traps are available for monitoring tarnished plant bug adults. These traps are used as an indication of when plant bugs begin their activity in the spring and a relative indication of their abundance, not as an indication of when to control this insect. Immature TPB (nymphs) are sampled by shaking flower trusses over a flat white surface. Thirty flower clusters should be sampled evenly from across the field (typically 6 clusters at 5 locations or 5 clusters at 6 locations). If 4 or more flower clusters are infested with nymphs (regardless of how many) a spray is recommended. A follow-up spray application may be made after bloom if TPB are still present in high numbers (check harvest interval before selecting material). See pest management schedule for recommended materials and timing. Do not apply insecticides during bloom.

Strawberry Bud Weevil (Anthonomus signatus): The strawberry bud weevil or "clipper" is an important pest of strawberries, but will also attacck bramable fruit. This insect is a very small beetle (1/8") with a copper-colored body and a black head with a long snout. The female weevil chews a small hole in unopened flower buds and lays an egg in the hole. She then girdles the stem just below the bud. The flower bud dries and dangles from the stem, eventually falling to the ground. The immature weevils, or grubs, develop in the girdled buds, emerging as adults in the early summer, and the migrating to wooded areas. These insects are not always present and may only cause minimal damage in raspberries.

Management: Examine the plants before bloom, and look for dead or clipped-off buds. Insecticides which are applied prebloom for control of raspberry fruitworm may also control this insect. See pest management schedule for recommended materials and timing.

Two-Spotted Spider Mites (Tetranychus urticae): Spider mites are very small (1/50"), insect-like creatures that feed on raspberry foliage, sucking out plant juices and causing a white stippling or bronzing of the leaves. Under heavy infestations, leaves will turn brown and be covered in a fine webbing. Adults may also move onto the fruit, reducing consumer appeal by their presence. There is currently little available for chemical control of this pest. **Management**: There have been some reports that soaking sprays of water applied at relatively high pressure may temporarily suppress mite populations. Several companies now commercially produce predatory mites which feed on spider mites. These predators can be released in raspberry plantings and may provide some control of spider mites, but research is needed to determine appropriate release rates and timing. It is important, however to encourage natural enemies of spider mites by reducing the use of pesticides which harm natural enemies, such as benomyl. See source list at end of this guide for predatory mites. Spider mite outbreaks have

also been associated with high levels of nitrogen fertilization.

Aphids: Aphids are small, pear-shaped, soft bodied insects which feed on plant sap with straw-like sucking mouthparts. Several species of aphids ranging from 1/16" to 1/8" in size, and dull yellow to bright green in color feed on raspberries. Most are wingless and slow moving. These insects tend to congregate on the underside of leaves, where their feeding causes the leaves to curl downward and be deformed. The most damaging aspect of aphid feeding is the spread of viruses. Aphids will take in a virus from infected plants, and later inject it into healthy plants. The virus then spreads throughout the plant, resulting in symptoms such as mosaic, leaf curl or stunting.

Management: To reduce the incidence of aphids and viruses, start with certified virus-free plants; eliminate all wild brambles from within 600 feet of the planting; apply insecticides when aphids are first noted in a planting; and rogue out all plants which exhibit virus symptoms. See pest management schedule for recommended materials and timing. The varieties Canby, Titan and Royalty are resistant to aphid feeding.

Japanese Beetles (Popillia japonica): Japanese beetles are about 1/2" long and copper-colored, with metallic green markings. They feed on raspberry foliage, skeletonizing the leaves during the mid and late summer. The larvae, or grubs, live in the soil, feeding on roots of grasses.

Management: The beetles can be controlled with sprays of carbaryl, malathion or Actara. However, pay close attention to days to harvest restrictions if fruit is present. Traps are available which use a sex and/or feeding attractant to capture the bugs in a can or plastic bag, but such traps gemerally do not provide adequate control. Place traps at least 100' away from the planting. Traps placed within a planting may cause localized damage from beetles which are attracted to, but don't fall into the trap.

Yellowjackets: Yellowjackets (aka hornets or wasps), are black and yellow stinging insects. They are closely related to the larger bald-faced hornets. Both groups of these insects are very aggressive and will sting with little provocation.

There are several species of these wasps found in the Northeast and, depending on the species, may build underground nests large paper nests in trees or on houses. Many scavenge food, often dead insects or pieces of flesh from dead animals. Yellowjackets also have a great fondness for ripe fruit and can be found on pears, apples, raspberries, etc.

This fondness for fruit makes this insect a severe nuisance pest in raspberries. They are a danger and annoyance to pickers. To help discourage the yellowjacket from feeding on raspberries, be sure to harvest berries as soon as they begin to ripen, even though there may be only a few early berries. Once the yellowjackets have discovered the berries, it is almost impossible to discourage them.

Management: Insecticide sprays for control of yellowjackets are not effective or recommended unless you know where a nest is and can eradicate it with a household hornet spray. This is best done in the evening when most of the members of the colony are in the nest. Yellowjackets can be discouraged by sanitation, which is regular and thorough, picking of all berries as soon as they begin to ripen, and frequent removal of overripe fruit and fruit debris.

There are many yellowjacket traps on the market, and various baits have been used with some success. Our (eastern) species of yellowjackets do not respond to trapping as well as western species. Different baits and traps may have to be tried to determine if any traps/baits will work in a particular raspberry planting. If traps are to be used, the key to success is to get the traps out early. Once yellowjackets have found the ripened fruit, the traps will probably not be of much help.

Potato Leafhopper(Empoasca favae): Nymphs and adults are small (1/8") green soft bodied insects. They move very quickly, often sideways, when disturbed. The potato leafhopper feeds on the underside of leaves leaving small chlorotic areas and causing a downward cupping of the leaves. Most feeding is the upper, more succulent leaves on primocanes and often causes a stunting of those canes.

Management: This pest does not overwinter in New England but is brought up every year from the south on storm fronts. Insecticide applications may be needed when damage is observed. Plants recover quickly once these applications are made and normal growth resumes.

Cane Insect Pests

Cane Borers: Raspberries are attacked by two types of cane borers. The **raspberry cane borer** is a 1/2" long, slender black beetle with an orange band just below the head and has long antennae. The female beetles girdle the tips of young raspberry canes by chewing two rings, about a half inch apart, around the stems about 3 to 6" below the top. An egg is inserted into the cane between the two girdled rings. When the larvae, or grubs, emerge, they feed inside the cane, tunneling downward, and eventually destroying the cane. Soon after the cane tips are girdled, they wilt, blacken, and may fall off.

Management: As soon as the wilted tips are noticed, they should be cut off, several inches below the lowest girdle mark. Remove the infested tips from the field and destroy them. Also eliminate any wild brambles near the field which may be harboring this pest.

The **red necked cane borer** is 1/4" long, slender, black with a "coppery" neck. Unlike the raspberry cane borer, it has short antennae. The red necked cane borer also causes a different sort of damage. The females insert an egg into young canes, usually within 10" of the base of the cane. They do not girdle the cane, but the presence of the egg, and later the grub, causes a swelling in the cane which can vary in length from

1/2" to nearly 3". Larvae feeding within the canes weakens them and many may break off. Remove any canes showing swelling near the base.

Root and Crown Insect Pests

Raspberry Crown Borer (Bembica marginata): The adult phase of raspberry crown borer is an attractive clear-winged moth which resembles a wasp. These moths lay eggs on the underside of raspberry leaves in late July and August. When the eggs hatch, the young larvae crawl down the cane and into the soil to overwinter. The following spring, they bore into the base of the raspberry canes and feed on the plant tissue. This feeding interrupts the flow of water and nutrients to the cane, causing them to wilt and become weak and spindly. Early symptoms may include browning of the leaf margins on new canes. Eventually, the entire crown may die.

Management: Elimination of all wild brambles in the area can reduce local populations of this pest.

Table 39.3 Insecticides registered for use on brambles and their primary uses.

Fungicide	IRAC[a] GROUP	Aphids	Leafhoppers	Spider Mites	Japanese Beetle Adults	Tarnished Plant Bugs	Sap Beetles	Thrips
Acramite	25	--	--	+++	0	--	0	--
Actara	4A	+++	+++	--	++	++	--	--
Admire	4A	+++	+++	--	++	--	--	--
*Asana	3	++	--	--	++	--	--	--
Assail	4A	++	--	++	++	++	+	+
⊗ Aza-Direct	18B	--	--	--	+	--	--	--
*Brigade	3	++	++	+	--	+++	+++	--
Confirm	18	--	--	--	0	--	--	--
Delegate	5	--	--	--	--	--	--	++
Dipel	11	--	--	--	0	--	--	--
Intrepid	18	--	--	--	--	--	--	--
Malathion	1B	+++	++	--	+	--	+	++
⊗ M-Pede	--	--	--	--	+	--	--	--
*Mustang	3	--	++	--	++	--	--	--
Provado	4A	+++	+++	--	+++	--	--	+++
⊗ Pyganic	3	+	--	--	+	--	--	--
Savey	10	--	--	+++	0	--	--	--
Sevin	1A	--	++	--	+++	++	++	--
Spintor, ⊗Entrust, Success	5	--	--	--	0	--	--	+++

0=not effective, +=poor, ++=good, +++=excellent, --=insufficient data.

[a] IRAC = Insecticide Resistance Action Committee list; 1A=carbamates; 1B=organophosphates; 2A=chlorinated cyclodienes; 3=pyrethrins and synthetic pyrethroids; 4A=neonicotinoids; 5=spinosyns; 7=juvenile hormone mimics; 11=Bt mircrobials; 18=molting dirsuptors; 21=botanical electron transport inhibitors; 22=voltage dependent sodium channel blocker

***Restricted use material; pesticide applicators license required. ⊗ OMRI certified for organic production**

Table 40. Summer fruiting bramble pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Dormant or Delayed Dormant (prior to budswell)			
Crown borers	*Brigade 2EC, 6.4oz (3)	Apply as soil drench in at least 200 gallons water. During the growing season, destroy dying canes and those showing evidence of infestation. Eradicate wild brambles in the area, because they may harbor the pest.	
Phytophthora root rot	Ridomil Gold EC, 1/4 pt/1000 linear ft. (45) Ridomil Gold GR, 5 lb/1000 linear ft. (45) Phostrol, 4.5 pt (0) ⊗ Actinovate AG, 2-12 oz (0)	Plant only in well-drained soils. Planting on raised beds also significantly reduces Phytophthora incidence. Cultivars 'Latham' and 'Newburgh' appear to be somewhat resistant.	Apply **Ridomil** in 3 ft wide band over the row in early fall; repeat in early spring before growth begins. Apply **Phostrol** in sufficient water to thoroughly wet the foliage. Apply **Actinovate** as soil drench; best if introduced before disease becomes well established.
Anthracnose Spur blight Cane blight	Lime sulfur, 10-12 gal (0) Kocide 3000, 0.75 lb (0)	Prune out all canes which have fruited, thin remaining canes to only 3 to 4 per foot of row. Plant rows should be no wider than 2 feet. Remove and destroy all prunings and diseased canes.	DO NOT apply sulfur after buds are 1/4 inch long or plant damage will result.
New cane emergence			
Anthracnose Spur blight	Kocide 3000, 0.75 lb (0) Copper sulfate 2.5 lb (**) Cabrio EG, 14 oz (0) Pristine WG, 18.5-23 oz (0) Abound 6.2-15.4 oz (0)* Captan 80WDG, 2.5 lb (3) **plus** Tanos, 6-8 oz (0) ***Abound** should be used with extreme caution to avoid phytotoxicity to apples. See label for further information.		Apply when new canes are 6-8 inches tall, repeat when canes are 12-15 inches tall. **Apply pre-bloom and post harvest only. **Cabrio** may only have 4 applications per season and no more than 2 sequential applications.
Pre-bloom to initiation of bloom			
Crown borers	*Brigade 2EC, 6.4oz (3)		Apply as soil drench in at least 200 gallons water. Do not make both soil drench and foliar application pre-bloom.
Raspberry fruit worm Raspberry Sawfly	Sevin XLR Plus, 2 qt (7) Delegate WG, 3-6 oz (1) Spintor 2SC, 4-6oz (1) ⊗ Pyganic EC, 1.4-16 oz (0) ⊗ Entrust 1.25-2 oz (0) ⊗ Aza-direct, 11.5-42 oz (0)	Keep planting free of weeds.	Apply to foliage when blossom buds separate and again when blossoms just begin to open. **Do not spray insecticides during bloom.**
Tarnished plant bug	Sevin XLR Plus, 1.5-2 qt (7) Assail 70WP, 1-2.3 oz (1) Actara 25WDG, 3 oz (3) Pyrenone 0.5 EC , 2-12 oz (0) ⊗ Pyganic EC, 1.4-16 oz (0) ⊗ Aza-direct, 11.5-42 oz (0)	Keep planting free of weeds.Adults migrate to fruit when adjacent fields are mowed. See description of sampling procedures in the description of TPB in the text.	Apply pre-bloom if adults found in planting, but avoid insecticide spays during bloom. Apply sprays in evening.
Strawberry bud weevil	*Brigade 2EC, 6.4oz (3) Sevin XLR Plus, 1-2 qt (7) ⊗ Aza-direct, 12.5-42 oz (0)	Scout planting for live adult weevils or clipped buds, especially at edges near woods and hedgerows.	Brigade application may eliminate natural enemies of spider mites leading to mite outbreak. Spraying late in the day may be more effective than morning sprays.

Table 40. Summer fruiting bramble pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Cane borers	Admire Pro, 10.5-14 oz (7)	Cut off infested tips below girdle marks, remove canes showing swellings. Destroy nearby unmanaged or wild brambles.	Cultural practices are the most important control measures. If an outbreak occurs, direct insecticide spray at lower foliage or base of canes and soil drench. Keep insecticide off blooms and fruiting shoots.
Aphids Thrips	Assail 70WP, 1-2.3 oz (1) Malathion 57EC, 3 pt (1) ⊗ Aza-direct, 11.5-42 oz (0)		
Anthracnose Spur Blight	Captan 80WDG, 2.5 lb (3) Pristine 18.5-23 oz (0) Cabrio EG, 14 oz (0) Abound 6.2-15.4 oz (0) Captan 80WDG, 2.5 lb (3) **plus** Tanos, 6-8 oz (0)		**For resistance management do not make more than 2 sequential applications of fungicides in the same FRAC group. See Table 39.1 for groups.**
Powdery Mildew	Rally 40W, 1.25-2.5 oz (0) Cabrio EC, 14 oz (0) Pristine, 18.5-23 oz (0) Abound 6.2-15.4 oz (0)		
Orange Rust	Rally 40W, 2.5 oz (0) Cabrio EC, 14 oz (0) Pristine, 18.5-23 oz (0)	Red raspberries are immune to this disease.	Spray while orange pustules are visible, on a 10-14 day schedule until temps are >75°F.
Bloom - do not apply insecticides during bloom			
Botrytis fruit rot (gray mold)	Rovral 4F,1-2 pt (0) Elevate 50WDG, 1.5 lb (0) Switch 62.5WG, 11-14 oz (0) Pristine, 18.5-23 oz (0) Captan 80WDG, 2.5 lb (3) Captevate 68WDG, 3.5 lb (3)	Space rows at least 8 feet apart, prune canes to a density of 3 to 4 canes per sq. ft. to improve air circulation.	Apply most fungicides at 5% bloom and again at full bloom. Repeat application only if weather is wet. **For resistance management do not make more than 2 sequential applications of fungicides in the same FRAC group. See Table 39.1 for groups.**
Powdery Mildew	Same as prebloom recommendations		
Orange Rust	Same as prebloom recommendations		
Petal Fall through harvest			
Tarnished plant bug	Same as pre-bloom application		
Aphids	*Asana XL, 4.8-9.6 oz (7) Actara 25WDG, 2-3 oz (3) Provado 1.6F, 8 oz (3) Malathion 57 EC, 3 pt, (1) ⊗ Aza-direct, 12.5-42 oz (0) ⊗ M-Pede, 1-2% sln (0)		Aphids can vecor viruses which pose more risk than feeding damage alone.
Sap beetles	Assail 70WP, 1.9-2.3 oz (1) Malathion 57EC, 1.5-2 pt, (1) Pyrenone, 1-12 oz (0) ⊗ Aza-direct, 12.5-42 oz (0)	Keep planting as clean as possible of over-ripe fruit	Only raspberries labeled for this use.

Table 40. Summer fruiting bramble pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Two-spotted spider mite	Acramite 50WS, 0.75-1 lb (1) *Brigade 2EC, 6.4 oz (3) Savey 50WP, 4-6 oz (3) ⊗ M-Pede, 1-2% solution (0) ⊗ Aza-direct, 11.5-42 oz (0) ⊗ JMS Stylet Oil, 3-6 qt (0)	Predatory mites may help. Avoid use of pesticides which will kill natural enemies of mites. Contact your local Extension Specialist for sources of predatory mites.	**Acramite and Savey** may each only be applied once per season. **Brigade** is a restricted use material and may be applied once pre-bloom and once post-bloom. **JMS Stylet oil** should not be sprayed on wet foliage or when temperatures are below 32°F or above 90°F and may be pytotoxic in combination or applied close to certain other materials. Read the label.
Potato Leafhopper	Sevin XLR Plus, 2 qt (7) Malathion 57EC, 1.5pt (1) Provado 1.6F, 8 oz (3) Actara 25WDG, 2-3 oz (3) Assail 70WP, 1.9-2.3 oz (1)	Scout for stunted growth and downward cupping leaves.	
Japanese beetle	Provado 1.6F, 8 oz (3) Actara 25WDG, 3 oz (3) Sevin XLR Plus, 1-2 qt (7) Malathion 57EC, 3 pt (1) ⊗ PyGanic EC, 1.4-16 oz (0) ⊗ Aza-direct, 12.5-42 oz (0) ⊗ Surround WP, 12.5-50 lb (0)		**For resistance management do not make more than 2 sequential applications of insecticides in the same IRAC group. See Table 39.2 for groups.**
Botrytis fruit rot	Same as bloom application	Same as bloom application	See bloom section. Check labels for harvest restrictions.
Late Leaf Rust	Cabrio EG, 14 oz (0) Pristine 18.5-23 oz (0)	'Nova' resistant; 'Heritage' and 'Festival' susceptible. Plant and prune for good air circulation and drying conditions.	Primarily a problem on fall-bearing types. **For resistance management do not make more than 2 sequential applications of fungicides in the same FRAC group. See Table 39.1 for groups.**
Post harvest and thereafter			
Phytophthora root rot	Ridomil Gold SL, 1/4 pt/1000 linear ft. (45) **Raspberries only** Ridomil Gold GR, 5 lb/1000 linear ft. (45) **Raspberries only** Aliette WDG, 5 lb (60) Phostrol 2.5 - 5 pt (0)	Plant only in well-drained soils. Planting on raised beds also significantly reduces Phytophthora incidence. Cultivars Latham and Newburgh appear to be somewhat resistant.	Apply **Ridomil** in 3 ft wide band over the row in early fall; repeat in early spring before growth begins. Apply **Aliette and Phostrol** in sufficient water to thoroughly wet the foliage. Begin foliar sprays in the spring after bud break and continue spraying on a 45-60 day schedule up to a maximum of 4 sprays during the growing season.
Powdery mildew	Pristine, 18.5-23 oz (0) Abound 6.2-15.4 oz (0) Cabrio EG, 14 oz (0) Nova 40W, 1.25-2.5 oz (0) ⊗ Microthiol, 6-15 lb (0) Kumulus DF, 6 – 12 lb (0) ⊗ JMS Stylet Oil, 3-6 qt (0)	Apply spray at 2-4 week intervals when mildew first appears. Apply each week from first bloom to fruit-set. Repeat as weather requires. **Nova** applications can start @ budbreak and continue @ 10-14 day intervals. **Abound** should be used with extreme caution to avoid phytotoxicity to apples. See label for further information. **For resistance management do not make more than 2 sequential applications of fungicides in the same FRAC group. See Table 39.1 for groups.**	
Orange Rust	Nova 40W, 2.5 oz (0) Cabrio EC, 14 oz (0) Pristine, 18.5-23 oz (0)	Red raspberries are immune to this disease.	Spray while orange pustules are visible, on a 10-14 day schedule until temps are >75°F.

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

***Restricted use pesticide; pesticide applicators license required.** ⊗ **OMRI listed for organic production**

Table 41. Fall bearing (primocane fruiting) bramble pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
When canes are approximately 18 inches tall			
Cane borers	Admire Pro, 10.5-14 oz (7)	Cut off infested tips below girdle marks, remove canes showing swellings	Scout for presence of adults. Adult cane borer activity can occur from early May through early August.
Japanese beetle	Actara 25WDG, 3 oz (3) Sevin XLR Plus, 1-2 qt (7) Malathion 8E, 1-4 pt (1) ⊗ PyGanic 1.4-16 oz (0) ⊗ Aza-direct, 12.5-42 oz (0) ⊗ Surround WP, 12.5-50 lb (0)	Traps may reduce populations. Place traps at least 100 feet away from planting.	Apply spray only if beetles are present. **Surround** will leave noticeable residue on fruit if applied after petal fall. Check labels for specific restrictions.
From petal-fall through the beginning of harvest			
Sap beetles	Malathion 57 EC, 1.5 - 2 pt, (1) ⊗ Aza-direct 12.5 - 42 oz (0) Pyrenone Crop Spray, 2-12 oz (0)	Keep planting clean of over-ripe fruit	**Malathion** labeled for raspberry only, not other bramble fruit.
Tarnished plant bug	Actara 25WDG, 3 oz (3) Sevin XLR Plus, 1.5-2 qt (7) ⊗ Pyganic EC, 1.4-16 oz (0) ⊗ Aza-direct 12.5 - 42 oz (0)	Keep planting free of weeds. Action threshold for nymphs or adults is when 10-20% of canes are infested. Adults migrate to fruit when adjacent fields are mowed.	Apply pre-bloom if adults found in planting, but avoid insecticide spays during bloom. Apply sprays in evening.
Potato Leafhopper	Actara 25WDG, 3 oz (3) Sevin XLR Plus, 2 qt (7) Malathion 57EC, 1.5pt (1)	Scout for stunted growth and downward cupping leaves.	
Botrytis fruit rot (gray mold)	Rovral 4F,1-2 pt (0) Elevate 50WDG, 1.5 lb (0) Switch 62.5WG, 11-14 oz (0) Pristine, 18.5-23 oz (0) Captan 80WDG, 2.5 lb (3) Cabrio EG, 14 oz (0) Elevate 50WDG, 1.5 lb (0)	Space rows at least 8 feet apart, prune canes to a density of 3 to 4 canes per sq. ft. to improve air circulation.	Apply at 5% bloom and again at full bloom. Repeat application only if weather is wet. Overuse of these materials may result in the development of resistance in the fungus.
Fruit rot sprays or special sprays			
Two-spotted spider mite	Savey 50 WP, 4-6 oz (3) M-Pede, 1-2% (0) ⊗ Aza-direct, 11.5-42 (0)	Predatory mites may help. Avoid use of pesticides which will kill natural enemies of mites such as carbaryl or bifenthrin. Avoid excess Nitrogen which can lead to higher mite populations.	**Sulfur** (80% WP) applied at 5-10 lb/100 gal for powdery mildew will provide some suppression. Do not use **M-Pede** within 3 days of a sulfur application. **Savey** may only be applied once per year post harvest.
Phytophthora root rot	Ridomil Gold SL, 1/4 pt/1000 linear ft. (45) Ridomil Gold GR, 5 lb/1000 linear ft. (45) Aliette WDG, 5 lb (60) Phostrol 2.5-5 pt (0)	Plant only in well-drained soils. Planting on raised beds also significantly reduces Phytophthora incidence. Cultivars Latham and Newburgh appear to be somewhat resistant.	Apply **Ridomil** in 3 ft wide band over the row in early fall; repeat in early spring before growth begins. Apply **Aliette and Phostrol** in sufficient water to thoroughly wet the foliage. Begin foliar sprays in the spring after bud break and continue spraying on a 45-60 day schedule up to a maximum of 4 sprays during the growing season.

Table 41. Fall bearing (primocane fruiting) bramble pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Botrytis fruit rot (gray mold)	same as petalfall section		

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

***Restricted use pesticide; pesticide applicators license required.** ⊗ **OMRI listed for organic production**

Bramble Weed Management

The primary goal of weed management is to optimize yields by minimizing competition between the weeds and the crop. Weeds reduce yields by competing with the crop for water, light, and nutrients. Weeds also harbor insects and diseases and encourage vertebrate pests. Timely cultivation, wise use of herbicides, and never permitting weeds to go to seed are integral parts of a good weed management system. Many of the weeds found in these fields are difficult-to-control perennial weeds that are not common in annual crop culture. New plantings usually have fewer perennial weed problems than older plantings. Annual and biennial weeds can also exist in these fields. Fields should be scouted at least twice a year (spring and fall) to determine specific weed problems. The selection of a weed management tool should be based on specific weeds present in each field. Several herbicides are labeled for use in this crop. A list of herbicides and their recommended uses is presented in Table 42.

Herbicides can be broadcast or applied as a directed spray to the base of the crop. With a band treatment, only 1 to 2 feet on either side of the row is treated. The areas between the crop row is usually maintained with a mowed cover of sod, clover, weeds, or a combination of these. This cover is used primarily for erosion control and to improve trafficability in the field. With banding, less herbicide is needed in each acre. For example, a 3 foot band (1.5 feet on either side of the row) where rows are spaced 9 feet apart will require only one third the amount of herbicide normally required for a broadcast treatment.

Cultivation and mulching are sometimes used as weed management tools. All cultivations should be timely and shallow to minimize crop root injury, to minimize loss of soil moisture, and to avoid repositioning new weed seeds to the soil surface. Mulches that are free of weed seeds and placed thickly enough can be very effective at reducing or eliminating most annual weeds from the crop row. They are seldom effective on perennial weeds. If mulches are used in combination with herbicides, use the lowest recommended herbicide rate to avoid crop injury.

Table 42. **Weed management in brambles†.**

Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
TRANSPLANT YEAR			
PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds	(napropamide) Devrinol 50D Devrinol 10G	 8 lb 40 lb	Apply after transplanting to weed-free soil. Devrinol must be activated within 24 hrs by cultivation or enough water by irrigation or rainfall to wet the soil to a depth of 2 to 4 inches. The full rate may not be necessary at transplanting.
	(oryzalin) Surflan 4AS Surflan DF	 2 to 4 qt 2.4-7.1 lb	Do not apply until soil has settled around the plants and no cracks are present. Irrigation or 1 inch of rain is needed within 21 days of application. Shallow cultivation will improve control. May injure newly planted tissue culture plants.
	(norflurazon) Solicam 80DF	 2.5-5 lb	Planting must have been in the ground for at least 12 months before application in order for this material to be used. Apply in late fall or spring to weed-free soil, or add an appropriate postemergence herbicide to kill existing vegetation. Tank-mix with Princep plus a postemergence herbicide in late fall, or Sinbar in the spring, if the planting has been established for at least one year, to improve the control of broadleaf weeds.
Broadleaf weeds and some grasses	(simazine) Princep 4L Caliber 90	 1 to 2 qt 1.1 to 2.2 lb	Use to improve the broadleaf weed activity of Devrinol or Surflan. Consider applying half the maximum rate after planting and half in the fall before winter annuals emerge. Do not use on newly transplanted tissue culture plants.
Broadleaf weeds only	(isozaben) Gallery 75D	 0.66 to 1.33 lb	NON-BEARING USE ONLY. Do not apply within 1 year of the first harvest. Do not apply over the top of plants but as a directed spray to the base of plants after the soil had settled. Does not control emerged weeds. Controls many broadleaf weeds from seed. See label for a complete list.
POSTEMERGENCE WEED CONTROL			
Emerged annual and most perennial grasses	(fluazifop) Fusilade DX	 16 to 24 oz	NON-BEARING USE ONLY. See label for best times to treat specific weeds. Will not control broadleaf weeds or sedges. Do not apply to crops to be harvested within 1 year of application. Do not apply if rainfall is expected within 1 hour or if grasses are under drought stress. Must be used with a crop oil concentrate or non-ionic surfactant.
	(sethoxydim) Poast 1.5EC	 0.75 to 2 pt	See label for best times to treat specific weeds. Will not control broadleaf weeds or sedges. Do not apply to grasses under stress (e.g., drought). Crop oil concentrate must be added to the spray tank. Do not cultivate 5 days before or 7 days after application. Do not apply more than 5 pints per acre per season.
Most grass weed species	(clethodim) Select 2EC Select Max	 6-8 oz 12-16 oz	Use the lower rate to control annual grasses and the perennial grasses listed to the left. Repeat the application if regrowth occurs. Always add oil concentrate to be 1 percent of the spray solution, or a minimum of 1 pint per acre, to Select 2EC. Always add oil concentrate to be 1 percent of the spray solution, or a minimum of 1 pint per acre, or nonionic surfactant to be 0.25 percent of the spray solution to Select Max. Do not tank-mix with any other pesticide unless labeled. Do not apply within 1 hour of rainfall. Do not apply to grasses suffering from drought, heat, cold, or any other stress condition. Select is currently labeled for nonbearing fields only. Do not apply within 12 months of harvest.
Emerged annual weeds and suppression of perrenial weeds	(pelargonic-acid) Scythe	 3-10% solution	Contact material for burn down only. See Scythe comments on page in Strawberry section. See label for complete instructions.
Emerged annual and perennial weeds	(sulfosate) Touchdown	 1 to 5 pt	NON-BEARING USE ONLY. Apply to actively growing weeds during site preparation prior to planting and no later than 1 year before harvest. Apply with a wiper or a shielded/directed spray. Do not allow the spray, spray drift, or mist to contact green foliage, suckers, open wound, or other green parts of the plant. Consult the label for rates for specific weeds and other precautions. Use with a surfactant or wetting agent.

Table 42. **Weed management in brambles†.**

Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
ESTABLISHED PLANTINGS			
PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds	(napropamide) Devrinol 50 DF	8 lb	Apply in the early spring before seedling weeds emerge. Devrinol must be activated within 24 hours by shallow cultivation or with enough rainfall or irrigation to wet the soil to a depth of 2 to 4 inches.
	(oryzalin) Surflan 4AS	2 to 4 qt	Apply to weed-free soil in the spring. Irrigation or 1 inch of rainfall is needed within 21 days of application.
	(norflurazon) Solicam 80DF	2.5 to 5 lb	Apply in early spring when crop is dormant to clean and weed-free soil. May result in temporary bleaching or chlorosis of leaves from which the plant will recover. Do not use on nursery stock.
NOTE: For broad spectrum preemergence weed control, consider applying one of the above three "grass" herbicides (napropamide, oryzalin, or norflurazon) in addition to one of the following "broadleaf" herbicides (simazine, terbacil, or dichlobenil).			
Broadleaf weeds, some grasses, and suppression of some perennial leaves	(simazine) Princep 4L	2 to 4 qt	Apply in the spring before bud break and before weeds emerge, or in the fall. Do not apply when fruit is present. For improved control as well as quackgrass suppression apply half in the spring and half after harvest. May injure 'Royalty' raspberries.
	(terbacil) Sinbar 80WP	0.5 to 2 lb	Apply in the early spring or in the fall as a directed spray to the base of the plants. Will also control small emerged weeds. Do not contact new shoots and avoid contact with bramble foliage. Spring application must be made before fruit set. Avoid application on plantings low in vigor. Planting must be at least 1 year old before application. Do not apply within 70 days before harvest.
	(dichlobenil) Casoron 50 WP Casoron 4G	8 lb 100 lb	Apply at temperatures below 40°F, preferably just before rain or snow. Soil must be settled around established plants. Uniform application is essential. Do not apply during new shoot emergence. The 4G formulation is effective on many perennial weed species. May reduce/delay new shoot emergence in plantings that are young or lacking vigor.
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds.	(paraquat) *Gramoxone Inteon	2 to 4 pt	Contact herbicide. Use with a non-ionic surfactant. Apply as a coarse directed spray to wet the weeds. Apply before emergence of new canes or shoots to avoid injury. Use of a shield is highly recommended.
Emerged annual and most perennial grasses	(sethoxydim) Poast 1.5 EC	0.75 to 2 pt	See label for best times to treat specific weeds. Will not control broadleaf weeds or sedges. Do not apply to grasses under stress (e.g., drought). Crop oil concentrate must be added to the spray tank. Do not cultivate 5 days before or 7 days after application. Do not apply within 45 days before harvest in brambles. Do not apply more than 5 pints per acre per season.
Emerged annual weeds and suppression of perennial weeds.	(pelargonic acid) Scythe	3-10% solution	Contact material for burn down only. See Scythe comments in Strawberry section. See label for complete instructions.
Emerged annual and perennial weeds	(glyphosate) Roundup Weather Max	1 to 5 qt	Apply to actively growing weeds. Apply with a wiper or a shielded/directed spray to the base of the plants. Do not permit herbicide solution to contact desirable vegetation, including green shoots, canes, or foliage. Do not cultivate within 7 days after application.

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

***Restricted use pesticide; pesticide applicators license required.** ⊗ **OMRI listed for organic production**

Table 42.1. Weed management with and without herbicides in a bramble planting.

Year	Month	Herbicide Options	Non-herbicide Options
Planting year			
	April	Roundup for emerged perennial weeds 30 days before planting. After weed dieback till to prepare for planting.	Frequent tillage
	April-early May	Devrinol before weed seedlings emerge. Till or water in within 24 hours	Plant sod in row middles. Use mulch in planting rows for 1st year. Hand weed
	Mid-June after planting	Fusilade for perennial grasses before 6" of growth	Cultivate/handweed/mulch; mow row middles and borders
	Mid-July	Hand weed or Roundup spot treatments	Cultivate/handweed; mow row middles and borders
	October	Princep at low rate	Cultivate/handweed; mow row middles and borders
	Late November	Casoron for grasses and broadleaf weeds. Read label carefully for specific application requirements	Handweed if needed
Fruiting years			
	March-April	Devrinol, Sinbar, Princep, Surflan or Solicam as early spring applications. See labels for specific requirements. Poast for perennial grasses followed by cultivations in 2-3 weeks.	Handweed rows and mow row middles and boarders
	Early May	Aim, Gramoxone or Scythe before new cane emergence.	Handweed and mow row middles and borders
	Mid-Summer	Poast on actively growing grasses	Handweed and mow row middles and borders
	September to October	Sinbar, Devrinol, Solicam, Surflan, Princep. See labels for restrictions.	Handweed and mow row middles and borders
	November	Casoron if needed for grasses and broadleaves. See labels for restrictions.	

Adapted from Cornell 2010 Pest Management Guidelines for Berry Crops.

Currants and Gooseberries

General Information

In the early 1900s, the federal and state governments outlawed the growing of currants and gooseberries to prevent the spread of white pine blister rust (Cronartium ribicola). This fungal disease attacks both Ribes and white pines, which must live in close proximity for the blister rust fungus to complete its life cycle.

Black currants (Ribes nigrum) and white pines (Pinus strobus) are extremely susceptible, and red currants and gooseberries exhibit varying degrees of susceptibility.

Although the federal ban was rescinded in 1966, some northern states still prohibit the planting or cultivation of black currants. At present, Massachusetts still prohibits the cultivation of black currants statewide and limits the planting of red currants and gooseberries in some areas of the state. To determine the status of growing currants and gooseberries in your location go to http://www.mass.gov/agr/legal/regs/. Rhode Island and Maine also continue to regulate the planting of currants and gooseberries while Connecticut, Vermont and New Hampshire allow planting of this crop. Check with your state's Agriculture Department to find out the status of these regulations.

Some black currant types, such as the cultivars 'Consort', 'Crusader', and 'Titania' are hybrids that are resistant to the blister rust fungus. In some cases, they can be planted in areas where other currants and gooseberries are not permitted.

Choosing cultivars

Ribes are a very diverse genus with hundreds of different varieties that differ in plant size and form, and fruit flavor, shape, texture, color and hairiness. While most are hardy to Zone 3 or Zone 4, a few are hardy to Zone 2. Several types of interest include:

Red currants (Ribes rubrum, R. sativum and R. petraeum): Fruits range in color from dark red to pink, yellow, white and beige, and they continue to sweeten on the bush even after they appear to be in full color. Many people consider 'Rovada' to be the best red currant cultivar. Plants are dependable, vigorous, late ripening, and very productive, bearing long-stemmed clusters of large red berries that are easy to pick.

White currants: A type of red currant, white currant cultivars are sold less frequently by nurseries. 'Blanka' is most commonly available. Berries are large and mild in flavor with a pale yellow color. Most people prefer 'White Imperial' or 'Primus' if they are available.

Black currants (Ribes nigrum): Black currants are the type most associated with culinary products and flavorings. As a group they are more susceptible to infection by White Pine Blister Rust. Cultivars such as 'Consort', 'Crusader', and 'Titania', are immune or resistant to this disease.

Gooseberries: There are two types of gooseberry plants -- American (Ribes hirtellum) and European (Ribes uva-crispa).

Cultivars of the American type are smaller but more resistant to mildew. They tend to be healthier and more productive. American cultivars include:

- 'Poorman' - One of the largest of the American cultivars. Productive and vigorous, with medium-sized but high-quality fruit. It is a good cultivar for the home garden.
- 'Oregon Champion' - Medium to large yellow-green berries. Excellent for processing.
- 'Hinnonmaki Red' and 'Hinnonmaki Yellow' - Medium-sized red and green fruit, respectively.
- 'Captivator' - A cross of American and European cultivars, has red, tear-drop-shaped fruit. Nearly thornless and mildew-resistant.
- 'Pixwell' - Easy to propagate, commonly sold and very productive, but its fruit quality is poor and it is hardy only to Zone 5.

The fruits of the European cultivars are larger and better flavored. They include:

- 'Invicta' - Considered by some to be the best gooseberry available in North America. Resistant to mildew, but susceptible to leaf spot. Very large fruit with bland flavor.
- 'Leveller' and 'Careless' - The standards for British fruit production. Yellow- and green-fruited respectively.
- 'Early Sulfur' - Yellow, hairy fruit with good flavor, but susceptible to mildew.
- 'Catherina' - Large green fruit.
- 'Achilles' - Large red fruit.

Sources of gooseberry and currant plants can be found at http://www.fruit.cornell.edu/Berries/nurseries/index.html.

Site Selection and Soil Preparation

Unlike most other fruit crops, currants and gooseberries tolerate partial shade and prefer a cool, moist growing area. Northern slopes with protection from direct sun are ideal. Planting along the side of a building or shady arbor is suitable as well.

Avoid sites with poor air circulation, which increases the incidence of powdery mildew. Sloping ground alleviates this condition. Also avoid light-textured, sandy soils. Rich, well drained soils that have a high moisture holding capacity are best. Incorporate organic matter (compost, peat, or manure) to improve the soil, particularly if it is somewhat sandy. The ideal soil pH is about 6.5.

Planting

Purchase strong, well-rooted plants from a reliable nursery, selecting either one- or two-year-old vigorous stock. Because currants and gooseberries begin growth very early in the spring, you should plant them in the early fall or very early in spring, before the plants begin to grow.

Before planting, remove damaged roots and head back the tops to 6 to 10 inches. Do not allow the root systems to dry out. Set plants as soon as possible in properly prepared soil, slightly deeper than they grew in the nursery. Firm the soil around the roots. Space plants according to the vigor of the cultivar, keeping in mind that plants are more vigorous on very fertile soil. As a general rule, plants should be spaced 3 to 5 feet apart in the row with 8 to 10 feet between rows.

Trellising gooseberries increases air circulation (decreasing disease problems), makes fruit easier to harvest, and allows you to grow more plants in less space. Gooseberries are easily propagated through tip layering or stool bedding (mound layering).

Fertilizing

Currant and gooseberry plants are heavy nitrogen feeders. To give the plants a healthy start, work manure into the soil before planting. Annual top-dressings of composted manure are beneficial as well. If plants are not vigorous, lightly broadcast about .25 to .5 pound of 10-10-10 per plant. Avoid fertilizers containing muriate of potash (potassium chloride).

Mulching

Mulch keeps the soil cool in the summer, retains moisture, and controls weeds. Spread 2 to 3 inches of mulch around plants and replenish it yearly. Suitable mulches include straw, lawn rakings, composted manure, compost, wood chips, or similar materials. Grass clippings make excellent mulch. If you use fresh straw or sawdust, you may need to apply nitrogen fertilizer because these high-carbon mulches tie up nitrogen while they decompose.

Harvest

Remove any flowers so that plants don't develop fruit during their first season of growth. Expect a light crop the second year and a full crop by the third. Currants and gooseberries ripen in June and July, depending on cultivar. Berries do not drop immediately upon ripening, so they usually can be harvested in one or two pickings. Currants can be picked in clusters, and gooseberries are picked as individual fruits. Expect mature plants to yield about 90 to 150 pounds per 100 feet of row. Wait for fruit to turn color before picking. Gooseberries come off easily when they are ripe. Currants require some trial and error to determine the right time.

Pruning

Prune currants and gooseberries when the plants are dormant in late winter or early spring. Remove any branches that lie along the ground as well as branches that are diseased or broken. Ribes species produce fruit at the base of one year old wood. Fruiting is strongest on spurs of two and three year old wood.

After the first year of growth, remove all but six to eight of the most vigorous shoots. At the end of the second growing season, leave the 4 or 5 best one-year-old shoots and up to 3 or 4 two-year-old canes. At the end of the third year, prune so that approximately 3 or 4 canes of each age class should remain. By the fourth year, the oldest set of canes should be removed and the new canes allowed to grow. This system of renewal ensures that the plants remain productive because young canes always replace those that are removed. A strong, healthy, mature plant should have about eight bearing canes, with younger canes eventually replacing the oldest.

Pest Management

Visit http://www.hort.cornell.edu/diagnostic for assistance in diagnosing problems with currants and gooseberries.

Currant aphids, fourlined plant bug, currant borer, leaf spot, white pine blister rust (on susceptible varieties), and powdery mildew are the most common problems that plague currant and gooseberry plantings. All disfigure or damage leaves, and can cause defoliation; except for the currant borer which can weaken and kill canes.

Diseases

Powdery mildew - This fungal disease is a problem particularly on European gooseberries. In early summer, a whitish, powdery growth appears on the surface of leaves, shoots, and branch tips. If left unchecked, the fungus can progress to the berries themselves. Later in summer, the growth may turn from white to brown. Warm, humid conditions with poor air circulation favor powdery mildew. Prune and dispose of infected branch and shoot tips in early spring. Some growers are experimenting with trellising gooseberries to improve disease management and harvestability. Certain horticultural oils (check labels) applied at first sign of mildew can prevent spread.

Management: Sprays are most necessary during humid or wet weather in the spring. Apply when the first signs of powdery mildew are apparent and repeat as necessary. If oil is used, multiple applications may delay ripening or reduce sugar accumulation in the berries. The oil kills powdery mildew colonies on contact, thus, high water volumes and thorough coverage of the leaves and developing fruit are

essential for good results. Many common pesticides (including sulfur) are phytotoxic when applied with or close to oil sprays; check label for specific restrictions.

Anthracnose and leaf spot - These disease can both become serious problems, especially in wet, humid years. Symptoms range from brown spots and yellowing on leaves, young shoots, and stems to early defoliation. Destroy affected leaves, and apply mulch after leaf drop.

Management: Prune and trellis to improve air circulation and promote leaf drying aids in the control of these diseases. Fungicides applied before bloom, after petal fall and after harvest are also recommended. See Table 43 for specific recommendations and rates.

White Pine Blister Rust - Tiny yellow to orange spots appear on less susceptible plants. Larger, angular, yellow to orange spots, approximately 1/4 inch in diameter appear on susceptible plants.

Management: Black currants Ben Sarek, Consort, Crusader, Coronet and Titania are resistant or immune. Gooseberries, red and white currants are generally less susceptible. Ribes species Red Lake, Jumbo Cherry and White Current are known to be less susceptible than Red Jacket, Green Hansa, Poorman and Pixwell. Avoid planting in high-risk areas (Check with your University Extension office for help determining the risk catagory of your site). If Rally fungicide is used for powdery mildew or annthracnose, it should also control white pine blister rust. See Table 43 for additional recommendations.

Insects

San Jose Scale - These insects occasionally infest currant and gooseberry plants. They feed by sucking valuable plant juices, and in severe cases they affect the fruit as well. Scale insects are easily seen on the dormant wood.

Management: Prune out and destroy infested canes before new growth begins in the spring. Certain dormant oils applications (check labels) can help reduce infestations.

Currant aphids - These tiny, soft-bodied insects feed under young leaves toward the shoot tips, causing affected leaves to curl downward, blister, and become reddish. In severe cases, leaves become excessively distorted and fall off and the fruit does not ripen properly.

Management: Insecticidal soap and certain horticultural oils (check labels) can help control aphids. Early bud break insecticide applications can also be made. See Table 43 for details.

Fourlined plant bugs: Nymphs and adults feed on leaves with piercing mouthparts and cause stippling of leaves. The spots may turn from yellow to brown or black. Most damage is seen on the youngest leaves. The feeding injury can be easily confused with leafspot disease. The plant bugs overwinter as eggs which are inserted in the shoots. In Connecticut, egg hatch begins in mid-May. The nymphs are red to yellow with stripes on their wing pads. Adults are yellowish-green with four black stripes, about 1□4 inch long, and appear by early June. There is one generation per year.

Management: The eggs are relatively visible on the canes, usually near bud scales, during the dormant season. These can be pruned off and destroyed. Dormant oil may have some effect on overwintering eggs. Insecticides should be targeted at the nymphal stage. Once the plant bugs become adults they may be harder to kill; they also may have started laying eggs. Malathion, when used for other pests, is very effective on fourlined plant bug nymphs.

Currant borers - Adults are about 1□2 inch long, clear-winged, blue-black, wasplike moths with yellow bands on their abdomen. Adults are active from approximately June 1 to mid-July in Connecticut. The females lay eggs in the stems, particularly around leaf axils. These eggs hatch during the summer and the larvae burrow into the currant and gooseberry canes; where they overwinter until the following spring. Some larvae may take 2 years to complete development. Infested canes put out sickly growth in the spring. Repeated infestations may cause the death of canes.

Management: To prevent the next generation of moths from emerging, remove and destroy infested canes before June 1. Proper pruning to remove old canes is the best control. Insecticides may help with control of adult moths if timed properly. Use pheromone traps to monitor for adult flight activity. Danitol is labeled for currant borer but may cause an increase in two-spotted spider mites due to effects on natural predators. Pyganic has a short residual and may need repeated applications. Bt products may have some effect on young larvae before they enter stems.

Currant stem girdler - This immature sawfly lays eggs on shoot tips and then eats around, or girdles, the tips, which eventually die and fall off.

Management: Cut off affected tips in May or June about 3 to 4 inches below the girdle, or if left until later in the season, about 8 inches below the girdle.

Imported currantworm and other sawflies - The full-grown larva is 3 inches long; it is green with yellowish ends, has a black head, and is covered with black spots. Shortly after the leaves are out in the spring, the worms feed first in colonies and later singly, voraciously stripping the plants of foliage. A second brood occurs in early summer, and a partial third brood may appear depending on the weather. If numerous, they can strip a bush of its foliage in a few days.

Management: Remove leaves harboring eggs by hand. Insecticide applications should be made as soon as larvae are found feeding on the leaves.

Gooseberry fruitworm - This greenish caterpillar feeds in fruit causing it to color prematurely and fall off. The

adult moth lays eggs on the fruit, and the larvae enter the developing berries and feed on the pulp, moving from one fruit to another. Several berries may be tied together by a silken webbing.

Management: In small plantings, handpick infested berries before larvae move to adjacent ones. Insecticides used to control other insects will also help control gooseberry fruitworm.

Twospotted Spider Mite - Feeding by spider mites, which may become particularly apparent later in the season but can develop anytime, will cause white stippling and bronzing of leaves. Also, you may observe webbing. Look on the underside of leaves for the tiny arthropods. Damage from spider mites seems more apparent in warm, dry years.

Management: Regular monitoring is necessary for assessing population growth. Predatory mites, purchased from insectaries, can be released to help control spider mites. Contact suppliers for assistance in determining release rates and timing. In general, though, predatory mites should be released early in the infestation to give them time to control the spider mites. Horticulutral oil applications for controlling powdery mildew may also aid in controling mites.

Table 43. Currant and Gooseberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
DORMANT			
San Jose Scale	Dormant Oil, 4 gal in 100 gallons of water	Light infestations can be pruned out during winter pruning.	Applied before the buds swell and burst in the spring.
Budbreak through full leaf			
Currant Aphid	Malathion 57EC, 3.2 pt (3) Actara, 3-4 oz (3) Provado 1.6F, 3.75 oz (3) Pyrenone, 2-12 oz (0) ⊗ M-Pede, 1-2% sln (0 ⊗ Pyganic 5EC, 4.5-18 oz (0)	Scout plantings for infestations to determine need for control measures.	Use malathion only on currants for this pest. Malathion is also labeled on gooseberries but only for mites, chafers, and Japanese Beetles.
Imported Currant Worm	Malathion 57 EC, 1.6 pt (3) ⊗ Pyganic 5EC, 4.5-18 oz (0)	Scout plantings for adults soon after budbreak	
Currant Stem Girdler		Adult sawflies lay eggs in young, succulent shoot tips, then girdle tips below the eggs. Shoots tips die, reducing cane length. Cut off affected tips below evidence of insect activity.	
Anthracnose Leaf Spots	Rally 40WP, 5 oz (0) Kocide 101, 10 lb (‡) Champ Dry Prill, 7 lb (‡) Cuprofix Dispers, 13 lb (‡)	Prune and trellis to improve air circulation and promote leaf drying. Avoid overhead irrigation Remove or cover fallen leaves (source of overwintering inoculum) with mulch to interrupt disease cycle	‡ Do not apply after bloom, post harvest sprays are permitted.
Powdery Mildew	Rally 40WP, 5 oz (0) Pristine, 18.5-23 oz (0) Abound, 6-15.5 oz (0) Cabrio EG, 14 oz (0) ⊗ Kaligreen, 2.5-3 lb (0) ⊗ Microthiol, 6-15 lb (0)** ⊗ Kumulus DF, 6-15 lb (0)** ⊗ Actinovate AG, 3-12 oz (0) ⊗ JMS Stylet Oil, 3-6 qt (0)	Apply **JMS Stylet Oil** at first signs of powdery mildew; repeat as necessary but with care; multiple applications may delay ripening or reduce sugar accumulation. Thorough coverage is essential. **Abound** is very toxic to some apple varieties. Do not spray in proximity to apple trees or with sprayer also used for apple trees. Many common pesticides are phytotoxic when applied with or close to oil sprays. Excercise caution and read the label. **CAUTION: some gooseberry varieties will be damaged by sulfur sprays, especially during warm weather. Test first if sulfur sensitivity is unknown.	

Table 43. Currant and Gooseberry pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Pre-Bloom			
White Pine Blister Rust	Cabrio EG, 14 oz (0) ⊗ JMS Stylet oil, 3-6 qt (0) ⊗ Serenade Max, 2 lb (0) ⊗ ProPhyt 4L, 4 pt (0)	Plant resistant (immune) varieties whenever possible. Check with nursery supplier for resistance rating of varieties.	Apply at 14 day intervals until green berry stage alternating materials from different FRAC groups to avoid fungicide resistance development. Many common pesticides are phytotoxic when applied with or close to oil sprays. Excercise caution and read the label.
Bloom			
White Pine Blister Rust	same as pre-bloom		
Powdery Mildew	same as budbreak - full leaf		
Anthracnose	same as budbreak - full leaf		
Botrytis	Elevate 50WDG, 1.5 lb (0) Pristine, 18.5-23 oz (0) Rovral 4F, 1-2 pt (0) Switch 62.5WG, 11-14 oz(0) Omega 500DF, 1.25 pt (30) Oxidate 1% sln (0)	Prune and trellis to improve air circulation and promote leaf drying. Avoid overhead irrigation, especially during bloom.	Repeat applications may be needed in wet years. Omega may only be used early due to long pre-harvest interval (30 days). **For resistance management do not make more than 2 sequential applications of fungicides in the same FRAC group. See Table 39.1 for groups.**
From petal-fall through the beginning of harvest			
Currant Borer	*Danitol, 10.67-16oz (21) Bt products, various rates (0) ⊗ Pyganic 5EC, 4.5-18 oz (0)		Treat in June before larvae enter stems and when adults are present (except for Bt which is for larvae only).
Gooseberry Fruit Worm	*Brigade WSB, 5.3-16 oz (1) ⊗ Pyganic 5EC, 4.5-18 oz (0)	Shallow mechanical cultivation under bushes can help expose and kill pupae.	Treat as soon as webbing is seen, usually as the berries are turning color. Repeat at 7 day intervals.
Two-spotted spider mites	⊗ JMS Stylet oil, 3-6 qt (0)	Predatory mites may help. Avoid use of pesticides which will kill natural enemies of mites. Avoid excess Nitrogen which can lead to higher mite populations.	Apply when the first signs of mites are apparent and repeat as necessary but with care; multiple applications may delay ripening or reduce sugar accumulation. Thorough coverage is essential. Many common pesticides are phytotoxic when applied with or close to oil sprays. Exercise caution and read the label.
Powdery Mildew	Same recommendations as Budbreak through full leaf		
White Pine Blister Rust	Cabrio EG, 14 oz (0) ⊗ JMS Stylet oil, 3-6 qt (0)	Plant resistant (immune) varieties whenever possible. Check with nursery supplier for resistance rating of varieties.	

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

***Restricted use pesticide; pesticide applicators license required.** ⊗ **OMRI listed for organic production**

Ribes Weed Management

Adapted from The 2010 MidAtlantic Berry Guide

Good weed control begins years before planting. Begin by identifying perennial weed problems in the field. Eliminate these weeds before planting by rotating to crops in which the target perennial weed can be controlled and by using herbicides registered for the crop that control the target weeds. After harvest of these preceding crop(s), spend extra effort to continue control strategies. Early to mid-fall applications of glyphosate products can be very effective. Use caution when applying residual herbicides as carryover can affect crops the following year. Use cover crops to aid in suppressing weed growth.

A permanent sod such as hard fescue between the rows is effective in controlling weeds in established plantings. Within-row weeds can then be controlled with appropriate herbicides or landscape fabric.

Herbicides labeled for use in bearing and nonbearing currants and gooseberries are certain glyphosate products (Roundup, Touchdown, and others), Gramoxone Max 3SC and Gramoxone Inteon 2.76SC, Rely, and Surflan AS. Devrinol 50DF and Scythe are labeled for use on bearing and nonbearing currants. Fusilade DX, Select 2EC, Gallery 75DF, and Snapshot 2.5TG are labeled for use only on nonbearing currants and gooseberries (plants that won't be harvested for at least one year). Other formulations with the same active ingredients may exist that are labeled for the same uses.

Glyphosate products and Gramoxone, Scythe and Rely are nonselective postemergence materials. Glyphosate products are translocated within and therefore kill the entire plant, even though only a portion of the plant may have come in contact with the herbicide. Fusilade and Select are selective postemergence materials that are also translocated in the plant, but are effective only on grasses. Gramoxone and Scythe are nontranslocated contact herbicides, and kill only the portion of the plant with which they come in contact. Because of this feature, the roots of treated weeds survive, and control of perennial weeds is only temporary. Good coverage is a necessity, as untreated portions of the leaves and stems will continue to live. Rely is partially translocated. Gallery, Surflan, Devrinol, and Snapshot are preemergence materials, so they must be applied before weeds have germinated. Gallery is effective against annual broadleaves, while Suflan and Devrinol are effective against annual grasses and certain annual broadleaves. Snapshot is effective against both annual grasses and annual broadleaf weeds. Before use, always consult the herbicide labels for precautions, reentry intervals, and

Preharvest Intervals

Remember that weeds compete with each other, not just with crop plants. Therefore, controlling a particular weed or group of weeds may allow another weed species to take over, requiring adjustments to your control strategies.

Table 44. Weed Management in Currants and Gooseberries.

Herbicide	Formulation	Rate/Acre	Remarks
oryzalin	Surflan AS Surlan DF	2-6 qt 2.4-7.1 lb	Apply to both bearing and nonbearing plants before weed emergence. Rain or irrigation is needed within 21 days after application.
carfentrazone-ethyl	Aim EC Aim EW	1 – 2 fl oz	May be applied as broad cast application during dormant stage of crop. Use as directed application for post-emergence weed control. Use lower rate for control of small weed seedling (2-3 leaf stage); use higher rate for control of larger weeds (up to 6 leaf stage). Applications beyond 6 leaf stage may result in only partial control. Requires non-ionic surfactant or crop oil concentrate.
napropamide	Devrinol 50DF	8 lb	Apply in late fall or early spring before seedling weeds emerge. Incorporate within 24 hours of application with either cultivation or water. May be applied to newly planted and established crops.
glyphosate	Roundup Weather Max	1 to 5 qt	Preplant or wiper applications only. Do not contact foliage.
glufosinate-ammonium	Rely 200	77 fl oz (weeds< 8") 115 fl oz (weeds >8")	Controls a broad spectrum of emerged annual and perennial grass and broadleaf weeds, and certain woody species. Apply as a broadcast, banded or spot treatment application depending on the situation. Avoid direct drift onto desirable vegetation. Do not apply more than 230 fl oz/A per year. Do not graze, harvest and/or feed treated cover crops to livestock.
*paraquat	*Gramoxone Inteon	2 to 4 pt	Contact herbicide. Use with a non-ionic surfactant. Apply as a coarse directed spray to wet the weeds. Apply before emergence of new canes or shoots to avoid injury. Use of a shield is highly recommended.
pelargonic acid Scythe	annuals: 3-5% perennials: 5-7% max: 7-10%	2.25-20 gal	Apply before new canes emerge in spring or after canes become woody. Do not contact desirable foliage. For use on currants only.

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients.

Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

***Restricted use pesticide; pesticide applicators license required. ⊗ OMRI listed for organic production**

Grapes
General Information

Recent trends indicate a rapidly increasing interest in production of both wine and table grapes. The European grapes, Vitis vinifera, are very sensitive to cold temperatures. Over most of New England, special cultural care must be taken to overwinter V. vinifera varieties. V. labrusca, which includes Concord and Niagara, is hardier and more resistant to endemic disease problems.

Grapes will do best on a well drained loam soil with a pH of 5.5 to 6.5. Potash, manganese, and iron deficiency problems may develop if soil is limed to raise pH above 6.5. Site selection is critical to success. The ideal site will seldom experience winter temperatures below -5°F, provides freedom from late spring frosts, and offers a frost-free growing season of at least 165 to 180 days.

There are many training system options for grapes; but whatever system is used, the selection of canes well exposed to light and the proper severity of pruning (generally determined using the balanced pruning formula for each specific variety) are the keys to productivity and fruit quality.

The use of multiple trunks (and systematic trunk renewal) is highly recommended in New England to minimize the risk of severe low temperature injury and the development of eutypa dieback disease and crown gall. Overcropping will also significantly increase the risk of winter injury.

Table 45. Recommended optimal soil characteristics for growing grapes.

Soil Characteristic	Desirable Range*
pH	5.5-6.5
Organic matter	4 to 6 %
Phosphorus	20-50 ppm
Potassium	120- 150 ppm Base Saturation >3.0
Magnesium	100-150 ppm Base Saturation >5.0
Calcium	1000 - 1500 ppm Base Saturation >50.0

*Desirable range will vary with soil type (sand, silt, or clay), soil organic matter, and pH.

Diseases

Fruit Rots

Black Rot (Guignardia bidwellii): This is probably the most damaging grape disease in New England. Most loss is caused by damage to the berries, though leaves, tendrils and new shoots are also damaged. The fruit is susceptible from fruit set until veraison; resistance increases from pea-size to veraison.

This disease is caused by a fungus which overwinters in mummified berries and stem lesions. Mummies on the soil surface release spores when rain soaks them in the spring. There is a continuous production of spores throughout the spring and summer. These are carried to new plants by wind. Young tissue is infected in less than 12 hours between 60° - 90°F. Spores germinate and produce mycelium resulting in symptoms in 8 to 25 days, depending on the weather. New leaves and half-grown berries are most susceptible. Secondary infections occur when new spores are produced on the current year's infections. Secondary spores are produced into August, and are spread by splashing rain.

On leaves, infections appear as yellowish-tan spots in late spring. These spots enlarge and become reddish-brown with a dark outline. Lesions are roughly circular in shape. Shoots develop sunken, elliptical lesions, black in color up to 2 cm in length. On the berry, symptoms do not appear until the fruit is half grown. Lesions start as a small whitish dot and quickly engulf the whole berry. The infected area develops a reddish brown color. The berry wrinkles and blackens completely within a few days. These fruit become mummies that are very hard and stony, and supply inoculum for the following year.

Management: Sanitation is very important. Destroy all mummies and canes with lesions. Remove infected tendrils from vines. Plant grapes in locations having good air circulation, taking advantage of prevailing winds and sun. Black rot is more likely to occur near woodland borders. It occurs much more

Table 46. Critical nutrient values for grape petiole analysis.

Element	Deficient	Below Normal	Normal	Above Normal	Excessive
N (%)	1.80	2.00	2.50	3.00	>3.00
P (%)	0.24	0.25	0.35	0.40	>0.40
K (%)	1.45	1.50	2.00	2.50	>2.50
Ca (%)	0.59	0.60	1.70	2.50	>2.50
Mg (%)	0.29	0.30	0.70	0.90	>0.90
Mn (ppm)	45	50	150	200	>200
Fe (ppm)	48	50	150	200	>200
Cu (ppm)	6	7	30	50	>50
B (ppm)	24	25	40	50	>50
Zn (ppm)	18	20	35	50	>50

***Source**: Cornell University*

severely in wet years than in dry years. Protectant fungicides offer good control when they are applied initially when the shoots are 10-16 cm long and continued until the berries contain approximately 5% sugar. Abound,Elite, Flint, Sovran and Nova are excellent eradicant and protectant materials. Varietal resistance is another control option. See pest management schedule for recommended materials and timing.

Bitter Rot (Greeneria uvicola): Bitter rot, while most common in southern grape regions, may infect grapes in New England. If 10% of the berries in a wine pressing are infected with bitter rot, the wine can be undrinkable. Bitter rot may be easily confused with black rot. Infected berries first develop brownish, water-soaked lesions. The bitter rot fungus infects ripe grapes, and unlike the black rot fungus, does not infect green berries. Bitter rot susceptibility increases right at veraison. Lesions often have concentric rings in white-fruited varieties. Berries turn brown but retain their shape. In 3 or 4 days black pustules erupt on the berry. If overripe berries become infected, they are not easily detected, because pustules do not form. These berries are the most bitter, and the most likely to be mistakenly harvested.

Warm, humid weather at the time berries ripen favors the disease. The fungus grows rapidly, and can rot berries in 5 to 7 days. Wounding promotes fungal growth.

Management: Good air circulation for good drying in the vineyard. Fungicides used for the control of some of the previously discussed diseases usually will also control bitter rot. If conditions are right for infection, late season sprays should not be omitted. Most varieties have some degree of resistance to the fungus.

Botrytis Bunch Rot (Botrytis cinerea): Botrytis rot can cause serious losses in susceptible varieties. While some rot is acceptable in wine grapes, and may even be desirable, the disease can get out of control. The fungus which causes the disease is present in grape mummies, debris on the vineyard floor and in organic matter around the planting. Spores are released in moist, cool weather in spring, and then throughout the growing season. These first spores infect blossoms at the end of bloom. A second infection occurs at berry maturity. The fungus uses senescing or dead material as a base to spread into healthy tissue. Botrytis-infected berries are at first soft and watery. The berries usually become covered with gray, fuzzy fungal mycelium within a few days. Rotted berries shrivel, then drop to the ground to eventually become mummies.

Management: Good air circulation and vineyard sanitation are helpful. Leaf removal around the clusters has shown excellent control of the disease in California. Protective fungicides (Elevate, Vangard) should be used when wet weather occurs near bloom and berry ripening. White-fruited varieties (particularly Riesling and Seyval) are highly susceptible. See pest management schedule for recommended materials and timing. Fungicides should be used intelligently to avoid development of resistance by the fungus.

Table 47. Grape black rot leaf wetness duration-temperature combinations necessary for grape foliar infection by black rot.

Temperature (˚F)	Minimum leaf wetness duration for light infection (hr)
50	24
55	12
60	9
65	8
70	7
75	7
80	6
85	9
90	12

Ripe Rot (Colletotrichum acutatum, C. gloeosporioides, Glomerella cingulata): Ripe rot is a disease affecting grapes at or near harvest time which has largely been confined to the southeastern U.S. but has caused problems in the past 3-4 years in southern New England. Rotted berries turn uniformly dark-brown over part or all of the berry and sometimes have pink or orange spore masses on the surface. As infected fruit mature, lesions appear as slightly sunken or flattened rotted areas. As lesions expand, the entire grape eventually rots, and may drop or become shriveled or mummified as it decays. Ripe rot infections can occur at any stage of fruit development, but fruit infected in the green (unripe) stages does not rot until it begins to ripen. In these berries the fungus remains in a latent state until conditions allow it to further develop in the tissue. Once infected grapes begin to rot and produce spores in the vineyard, the disease can spread rapidly to other uninfected fruit, within the same bunch or neighboring bunches. The most devastating losses occur on susceptible cultivars during warm rainy harvest seasons. Generally, darker-skinned cultivars are more resistant while white cultivars are more susceptible.

Management: Before spring arrives, remove or disk into the soil overwintered mummies left on the trellis and ground from the previous season. Good canopy management practices are essential for control of the disease. Shoot thinning, leaf removal, pruning, cluster thinning and shoot positioning are all cultural practices that open the vine canopy to air and light, reducing the amount of moisture trapped within the canopy, and allowing better penetration and spray coverage of fungicides. Timely harvesting of all ripe grapes is recommended, to prevent overripe fruit with fungal sporulation from hanging on the vines too long. Where the disease is a problem, fungicide applications are critical during the period between bloom and pre-harvest. Captan and Pristine are the best fungicide choices for control of the disease.

Foliage and Cane Diseases

Downy Mildew (Plasmopara viticola): This disease causes damage primarily by attacking the vine, though all parts of the plant are susceptible to injury. The optimum conditions for the disease are cool to moderate temperatures, and wet weather. The disease is caused by a fungus which needs living tissue as a host. In spring, spores of the fungus come from dead tissue on the ground. Free water is required for infection, and infections may occur during high humidity throughout the season. Splashing water or handling wet plants may readily spread the spores. The spores grow into cottony masses, producing many new spores which can spread the infection. As tissue dies, it falls to the ground where the fungus overwinters. Severe epidemics can defoliate the vine.

On leaves, new infections are difficult to see. They appear first as generally angular, pale-yellow spots delimited by veins which later become brown. On the underside of the leaf the cotton-like 'downy' growth appears. Fruit infection occurs at two times. First, when the berries are the size of small peas, infections will cause berries to turn light brown and soft. Berries will shatter easily. Sometimes the downy growth covers the berries. During the heat of the summer, little fruit infection occurs. The second infections occur in the late summer or early autumn. These berries do not turn soft or develop downy growth, but turn dull green, then purplish-brown. Shoots and tendrils develop water-soaked lesions, become stunted and distorted, and may die.

Management: Remove debris from the vineyard floor. Maximize air circulation to improve drying. European grapes are generally more susceptible than American grapes. The most serious epidemics occur when a wet winter is followed by a wet spring and a warm summer with frequent precipitation. Fungicides should be applied when disease pressure is high. Apply just before bloom; 7-10 days later; 10-14 days later; 3 weeks later. See pest management schedule for recommended materials and timing.

Powdery Mildew (Uncinula necator): Powdery mildew causes loss by infecting leaves and berries. It is primarily a problem on European grape varieties, although American varieties may be damaged. It may be confused with downy mildew. (See above description.) Losses are not generally heavy from the disease, although it can build up over several years.

The fungal pathogen overwinters in specialized structures on or in living tissue. In spring, spores are released which attack new tissue. Rain and free moisture are not important to the spread of powdery mildew, unlike other grape diseases. Wind carries newly produced spores from infected areas into new locations. Dry conditions with low relative humidity favor this disease. Infected tissue, especially on leaves, looks as though a white powder were on the surface. Severely infected leaves curl and defoliation may occur. Leaves of American varieties like Niagara and Concord are very susceptible. Young fruit and blossoms may be misshapen by infections; mature fruit is immune.

Management: Use fungicides where infections are known to occur. Copper and lime sulfur dormant applications provide good early season control. However, there are label restrictions. Check with your state Extension Specialist for recommendations. Some varieties are sensitive to sulfur and it should always be applied at cooler temperatures (<85˚F). Abound, Elite, Flint, Sovran and Nova are also effective, but care should be taken to avoid fungicide resistance by the fungus. See pest management schedule for recommended materials and timing.

Cultural practices can help reduce disease incidence. Planting in sites with good air circulation and sun exposure and the use of appropriate training systems which allow for good air movement are highly advisable.

Eutypa Dieback (Eutypa armeniacae): This disease also has been known as "dead arm." It causes limbs to die back and forms cankers. Recently, it was shown to occur in conjunction with Phomopsis, causing the dead arm symptoms. Cankers are frequently found around old pruning cuts. They are usually under the bark, and show only as a flattened area on the surface. The cankers run lengthwise along the limb. Infections occur on pruning cuts in early spring. Over several years, the infection increases, causing new leaves to emerge small and yellowed. New shoot growth has shortened internodes, leaves are small and cupped and all growth is chlorotic. Eventually the cane dies. After about 5 years, the bark sloughs off. This is seldom seen in vineyards less than 8 years old.

Management: Infected material should be removed. Make cuts well below cankers. Destroy all prunings. Prune directly after a rain because the risk for infection is lowest at this time as the atmospheric spore load has been washed out temporarily. Prune late in the dormant season to promote rapid healing of wounds. Large pruning cuts can be painted with a concentrated benomyl solution to guard against infection. Note: all future sales and registrations of benomyl have been cancelled. Growers may use existing product until December 31, 2003. It may be necessary to remove the whole plant. Multiple trunk systems are recommended on an 8 to 10 year cycle. This helps with both Eutypa dieback and crown gall. All commercial varieties are susceptible.

Phomopsis cane and leaf spot (Phomopsis viticola): This is a fungal disease which causes reddish-brown lesions on canes, leaf spots and fruit rot. Small black spots at the base of developing shoots are the first sign of infection. These areas may crack, and late in the season may appear bleached. Leaf infections appear as small, dark lesions with yellow margins. Usually the lower leaves are affected first. Berry infections are rare, and symptoms are similar to black rot symptoms. The fungus overwinters in lesions in wood. In spring, spores are released and spread by rain. Cool, wet weather promotes spread of the disease.

Management: Prune and destroy infected canes. Late dormant sprays help to kill the overwintering fungal fruiting bodies on the surface of the vine. Two applications of Captan

(at 1" and at 6" shoots) provide good management under normal conditions. Protectant fungicides (especially Abound and Mancozeb) are helpful at preventing infection if they are less susceptible to the fungus. See pest management schedule for recommended materials and timing. Concord, Catawba, Chelois, Delaware, Niagara, and Rougeon are the most susceptible varieties.

Anthracnose (Elsinoe ampelina): This disease, like several of the others discussed, is worst during those growing seasons which are warm, humid and rainy. It reduces the quantity and quality of the berries. Circular "birds-eye" lesions are produced on the leaves with brown to black angular-shaped margins. If infection is severe, numerous lesions may coalesce, making large areas of the leaf necrotic. Often lesions will be concentrated on the veins. Necrotic tissue may drop out, leaving a "shot hole." Youngest leaves are the most susceptible.

Lesions on the stems and shoots may also be numerous; coalescing lesions will split open the tissue into the pith. Margins will be raised and purplish to brown in color. Lesions on the rachis and pedicels of the fruit cluster are similar to the stem lesions. If infections are numerous, berries may drop off entirely, or they may develop cracking. Numerous spores are released from overwintering lesions on stems or berries and are dispersed by rainfall. Spores are infectious over a wide temperature range, but need water in order to penetrate susceptible tissue. Hail injury may especially favor infection by this fungus.

Management: Do not plant highly susceptible varieties in heavy soils with poor drainage. Dormant fungicide sprays help to reduce inoculum of the pathogen. Protectant sprays beginning when shoots are 5-10 cm long and continuing at 2-week intervals are recommended. A fungicide should be applied 24 hours after hail injury.

Root and Trunk or Crown Diseases

Crown Gall (Agrobacterium vitis): Crown gall is a bacterial disease that infects more than 2,000 species of plants (including brambles). Crown gall of grape is a major problem in cold climate regions. Wounds are necessary for infection to occur. Observations suggest that freeze injury and mechanically induced wounds are highly conducive to infection. The disease is particularly severe following winters that result in freeze injury on cold-sensitive cultivars, such as those of Vitis vinifera. Crown gall is characterized by galls or overgrowths that usually form at the base of the trunk. Galls form as high as 3 feet or more up the trunk (aerial galls). Galls generally do not form on roots. The disease affects all grape cultivars. Vines with galls at their crowns or on their major roots grow poorly and have reduced yields. Severe economic losses result in vineyards where a high percentage of vines become galled within a few years of planting.

The disease first appears as small overgrowth or galls on the trunk, particularly near the soil line. Early in their development, the galls are more or less spherical, white or flesh-colored, and soft. Because they originate in a wound, the galls at first cannot be distinguished from callus. However, they usually develop more rapidly than callus tissue. As galls age, they become dark brown, knotty, and rough. The bacterium can survive in the soil for many years even in the absence of grapevines.

Management: Control procedures include: (1) planting only nursery stock which is free of any obvious galls on crowns or roots: (2) not planting into a field where crown gall has occurred previously, unless a non-host crop, such as strawberries or most vegetables, is grown for two or more years before replanting; and (3) minimizing winter injury to root and crown systems.

In addition to be above procedures, a nonpathogenic bacterium, Agrobacterium radiobacter, strain K-84, is commercially available for biological control of grown gall. The biocontrol agent may be applied to roots of healthy plants when they are first set out. After planting, the control becomes established in the soil around the root zone and prevents crown gall bacterium form entering this region. However, the biocontrol agent will not cure plants which are already infected before its application.

Insects

Fruit Pests

Grape Berry Moth (Paralibesia viteana): The moth is about 3/8 - 1/4" long and has a broad gray band across the middle of its wings. The larva is grayish-green and about 3/8" long when full grown. Larvae are found in the blossoms, young fruit clusters, and newly-formed berries; later they are found in green and ripening berries. Larvae feeding in the green and ripening berries cause most losses. Green berries will be seen to have a maroon coloration on one side, especially where the berry comes closest to or contacts a nearby berry in the same cluster. Such coloration indicates that a larva has fed on one berry, burrowed into another, and connected them with webbing. Ripening berries infested with larvae are detected by the wrinkled, shrunken appearance of the fruit.

Management: Remove wild grape plants from areas adjoining the vineyard. Till between rows to bury overwintering larvae. Pheromone traps are available to monitor onset of activity and pressure. Traps should be placed in the vineyard prior to the onset of GBM activity, usually around bloom. Threshold numbers for these traps have not been verified for New England, but they are useful to determine the onset of GBM activity. Mating disruption is being used successfully in some vineyards with the application of Isomate™ pheromone ties. These ties emit GBM pheromones slowly over time and when dispersed throughout the vineyard, make it difficult or impossible for male and female GBM moths to find one another and mate. These ties are recommended for vineyards 5 acres in size or larger. They are available from Pacific Biocontrol in Davis, California and Micro Flo in

Table 48. Effectiveness of fungicides on grape diseases.

Fungicide	FRAC Group	Phomopsis Cane and Leaf Spot	Black Rot	Downy Mildew	Powdery Mildew	Botrytis Rot	Bitter Rot	Anthracnose
Abound[a]	11	++	++++	++++	++++	+	?	++++
Aliette	33	0	0	+++	0	0	0	0
Armicarb	NC	0	0	0	+++	0	0	?
Bordeaux mix[b]	--	++	++	++++	+++	++	?	?
Captan	M4	++++	+	+++	0	+	++	++
Copper & lime	--	+	+	+++	++	0	?	?
Elevate	17	0	0	0	+	++++	0	?
Elite	3	0	++++	0	+++	0	0	++
Endura	7	0	0	0	++++	+++	0	+++
Ferbam	M3	+	+++	+	0	0	++	?
Fixed Copper[c]	--	+	+	+++	++	+	+	?
Flint[a]	11	+	+++	+	+++	++	0	?
⊗JMS Stylet Oil	--	0	0	0	+++	0	0	?
Mancozeb[f]	M	++++	+++	+++	+	0	++	+++
Nova/Rally[d]	3	0	++++	0	+++	0	0	++
Nutrol	NC	0	0	0	++	0	0	?
ProPhyt/Phostrol	33	0	0	+++	0	0	0	?
Pristine	11/7	+++	++++	++++	++++	+++	?	+++
Procure[d]	3	0	++	0	+++	0	0	?
Quintec	13	0	0	0	++++	0	0	0
Ridomil[g]	4	+	++	++++	+	0	++	?
Rovral[e]	2	0	0	0	0	+++	0	?
Rubigan[d]	3	0	++	0	+++	0	0	++
Scala	9	0	0	0	+	++++	0	?
Serenade	--	0	0	0	0	+	?	?
Sovran[a]	11	++	++++	++	++++	++	0	++++
Sulfur[h]	M2	+	0	0	+++	0	0	?
Topsin-M	1	++	+	0	+++	++[i]	++	+++
Vangard	D1	0	0	0	+	++++	0	?
Ziram	M3	++++	+++	++	0	0	0	++

++++=excellent, +++=good, ++=moderate, +=slight, 0=not effective, ?=unknown.

[a] *Do not use azoxystrobin (Abound), kresoxim methyl (Sovran), or trifloxystrobin (flint) continuously. Rotate with other fungicide groups as per label. Abound can cause serious injury to some apple cultivars. Avoid drift to apples and do not spray apples with equipment used for spraying Abound. Flint should not be used on Concord grapes. Sovran can injure some cherry cultivars.*

[b] *Bordeaux mix is a mixture of copper sulfate and hydrated lime; it may be purchased prepacked or mixed fresh by the grower.*

[c] *Fixed copper compounds that are registered for use on grapes include Kocide 101, BCS-Copper Fungicide, Ten-Cop 5E, copper oxychloride sulfate (C-O-C-S), and many other compounds and formulations. The main drawback of copper fungicides is the potential for severe injury to grape foliage, depending on variety and weather conditions, and for reduced vine vigor and yields even in the absence of visible foiar injury. Cool wet weather generally makes copper toxicity worse. Phytotoxicity can be lessened by adding spray loime. One should be very careful mixing other pesticides with preparations containing lime: many of these combiniations are incompatible. Excessive use of copper within 30 days of harvest may interfere with wine makein.*

[d] *Nova, and Elite can control black rot after infection has occurred. For effective control, infection periods must be monitored and funcidie applied within 3 dyas after the start of an infection period. Application of t hese materials and Rubigan and Procure to sporulating lesions of powdery mildew is best avoided to prevent selection of resistant strains of the pathogen. Continuous heavy use of this group of fungicides may result in the development of resistant strains of fungi.*

[e] *Continuous heavy use of this fungicide (iprodione) may result in the development of strains of fungi (esp. Botrytis) that are resistant to it. Iprodione resistant strains of Botrytis have been found in east coast vineyards. Do not routinely apply more than two iprodione sprays per season.*

[f] *Trade names for mancozeb include Manzate 200, Manzate 200 DF, Dithane M45, Dithane F45, Dithane DF, Penncozeb, and Manex II.*

[g] *Ridomil Gold MZ contains 10% mefenoxam plus 48% mancozeb, Ridomil Gold/Copper contains 10% mefenoxam plus 60% copper hydroxide.*

[h] *Sulfur may cause damage to sensitive varieties, it should always be used under cool temperatures.*

[i] *Continuous use of Topsin M may result in the development of strains of Botrytis that are resistant to it. Topsin-M resistant Botrytis has been found in east coast vineyards.*

Table 49. Relative Disease Susceptibility and Chemical Sensitivity for selected grape cultivars.

Cultivar	BR	DM	PM	Bot	PH	EUT	CG	ANT	Sulfur[a]	Copper[b]
Aurore	+++	++	++	+++	+	+++	++	++	no	++
Baco Noir	+++	+	++	++	+	++	+++	+	no	?
Cabernet Franc	+++	+++	+++	+	?	?	+++	++	no	+
Cabernet Sauvignon	+++	+++	+++	+	+++	+++	+++	?	no	+
Canadice	+++	++	+	++	?	?	++	++	?	?
Catawba	+++	+++	++	+	+++	+	+	++	no	++
Cayga White	+	++	+	+	++	+	++	+++	no	+
Chambourcin	+++	+	+++	++	+	?	++	+	yes	?
Chancellor	+	+++	+++	+	+++	+	+++	++	yes	+++
Chardonel	++	++	++	++	+++	++	++	+	no	?
Chardonnay	++	+++	+++	+++	+++	++	+++	+++	no	+
Concord	+++	+	++	+	+++	+++	+	+	yes	+
Corot Noir	+	+++	+	+	++	+	+	+	no	?
Cynthianna/Norton	+	++	+	+	+	?	+	+	yes	?
DeChaunac	+	++	++	+	+++	+++	++	++	yes	+
Deleware	++	+++	++	+	+++	+	+	++	no	+
Einset Seedless	+++	++	+++	+	?	?	+	?	?	?
Fredonia	++	+++	++	+	+++	?	+	+++	no	?
Frontenac	++	+	++	++	+	?	?	+	no	?
Frontenac Gris	++	+	++	++	+	?	?	+	no	?
Gewürtzraminer	+++	+++	+++	+++	?	?	+++	+++	no	+
Himrod	++	+	++	+	+	?	?	+++	no	?
Jupiter	++	+++	+++	+	+	?	?	+	?	?
LaCrecent	++	++	++	+	+	+	+	+	?	?
LaCrosse	+++	++	++	+++	++	?	?	+	?	?
Lemberger	+++	+++	+++	+	?	+++	+++	?	no	?
Leon Millot	+	++	+++	+	+	+	?	+	yes	?
Marchel Foch	++	+	++	+	+	+++	+	++	yes	?
Marquette	+	+	+	+++	?	?	+	?	?	?
Marquis	+	+++	+	+	+++	?	?	+++	?	?
Mars	+	+	+	+	+	?	+	+	?	?
Melody	+++	++	+	+	+++	?	+	+	no	?
Merlot	++	+++	+++	++	+	+++	+++	++	no	++
Moore's Diamond	+++	+	+++	++	?	++	?	?	no	?
Niagara	+++	+++	++	+	+++	+	++	++	no	+
Noiret	++	++	++	+	+	?	++	+	no	?
Pinot Gris	+++	+++	+++	++	?	+++	+++	?	no	+
Pinot Noir	+++	+++	+++	+++	?	?	+++	+	no	+
Reliance	+++	+++	++	+	++	?	?	+++	no	+
Riesling	+++	+++	+++	+++	++	++	+++	+	no	+
St. Croix	?	++	++	++	?	?	?	+	?	?
St. Vincent	+	++	+	+	+	+	+	+	no	?
Seyval	++	++	+++	+++	++	+	++	+	no	+
Steuben	++	+	+	+	+	?	+	+	no	?
Traminette	+	++	+	+	+++	?	++	+	no	?
Vanessa	+++	++	++	+	+	?	+	?	?	?
Vidal Blanc	+	++	+++	+	+	+	++	+++	no	+
Vignoles	+	++	+++	+++	++	++	++	+++	no	?

BR=black rot, DM=downy mildew, PM=powdery mildew, Bot=botrytis bunch rot, PH=phomopsis, EUT=eutypa, CG=crown gall, ANT= anthracnose
+++=highly susceptible or sensitive, ++=moderately susceptible or sensitive, +=slightly susceptible or sensitive

no=not sensitive, yes=sensitive, ?=relative susceptibility or sensitivity not established.

[a]Sulfur injury may occur on tolerant cultivars under high temperatures (85°F or above).

[b]Copper injury may occur under cool, slow drying conditions.

Lakeland, Florida. Contact your local Extension Specialist for help getting Isomate™ ties.

When damage is seen, it is too late to treat. It may be necessary to treat with insecticide the following season. See pest management schedule for recommended materials and timing. Applications should be made post-bloom, 10 days later and again in late July or early August.

Foliage and Cane Pests

Grape flea beetle (Altica chalybea): This is a metallic blue beetle about 3/16 - 1/4" long that jumps when disturbed. It is found on swelling buds during the spring. The flea beetles overwinter as adults and emerge during April. They chew holes in the ends and sides of buds that are beginning to swell. Such damage destroys the capacity of a bud to develop a primary or secondary shoot. Once the buds have grown to a length of 1/2" or more, the beetles cannot cause significant injury.

Management: See pest management schedule for recommended materials and timing.

Grape Phylloxera (Phylloxera vitifoliae): The presence of this soft-bodied insect (about 1/16" or less in length) is indicated by galls or knob-like protrusions on the underside of leaves. It is found primarily on leaves of vinifera varieties, especially after bloom. The damage results from new leaves remaining curled and unproductive on the vine.

Management: Plant resistant rootstocks. Remove infected leaves. Spray applications should be made immediately after bloom and again 10 days later. See pest management schedule for recommended materials and timing.

Grape Leafhopper (Erythroneura comes) and **Potato Leafhopper** (Empoasca fabae): These soft-bodied, elongated insects about 1/8" in length, walk quickly when disturbed and hop when touched. The grape leafhoppers are yellow and white or red and white. The potato leafhopper is light green and has a distinctive side-ways walk. Leafhoppers appear primarily in mid-summer and are found on the underside of leaves, especially young ones. Feeding activity causes white blotches on leaves, leaf curling, and eventual leaf drop.

Management: When 3 or more mature leafhhoppers leaf are found, apply an insecticide. See pest management schedule for recommended materials and timing.

Japanese Beetle (Popillia japonica) and **Rose Chafer** (Macrodactulus subspinosus): These clumsy, large beetles can feed heavily on the foliage of many different plants. Japanese beetles are a shiny copper color, almost round in shape with legs that tend to stick out. They will play dead when disturbed, dropping to the ground. Rose chafers are very similar behaviorally but dull green in color and more oval in shape. They can be found on both leaves and fruit. The feeding damage to leaves results in skeletonizing of the leaves with only the veins left; injured fruit is unsalable. Japanese beetles are about 1/2" long and copper-colored, with metallic green markings. They feed on grape foliage, skeletonizing the leaves during the mid and late summer. The larvae, or grubs, live in the soil, feeding on roots of grasses.

Management: The beetles can be controlled with sprays of Sevin or malathion. Traps are also available which use a sex and/or feeding attractant to capture the adults in a can or plastic bag, but such traps may not provide adequate control. Place traps near, but not in the planting, as traps within a planting may suffer increased localized damage from beetles which are attracted, but do not fall into the trap. See pest management schedule for recommended materials and timing.

Two-spotted spider mite (Tetranychus urticae): Spider mites are very small (1/50"), insect-like creatures that feed on grape foliage, sucking out plant juices and causing a white stippling or bronzing of the leaves. Under heavy infestations, leaves will turn brown and be covered in a fine webbing. Adults may also move onto the fruit, reducing consumer appeal by their presence. There is currently little available for chemical control of this pest. Foliar sprays of diazinon may suppress populations of spider mites, but this chemical may also reduce populations of natural predators which feed on the spider mites.

Management: There have been some reports that soaking sprays of water applied at relatively high pressure may temporarily suppress mite populations. Several companies now commercially produce predatory mites which feed on spider mites. These predators can be released in grape plantings and may provide some control of spider mites, but research is needed to determine appropriate release rates and timing. It is important, however, to encourage natural enemies of spider mites by reducing the use of pesticides which may harm natural enemies. Contact your local Extension Specialist or call (916) 324-4100 for a copy of Suppliers of Beneficial Organisms in North America, an excellent sourcebook for natural enemies such as predatory mites. This reference is also available via the Internet at http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm.

Grapevine Aphid: These aphids are dark brown and about 1/32 - 1/16" in length. They appear on young shoots and leaves during summer months. When abundant, aphids prevent proper extension of shoots, expansion of leaves, and development of fruit.

Management: When present, an overhead irrigation system can be used to reduce aphid numbers on the vines. This is not a "tested" method but has been recommended anecdotally. Similarly, spraying with water at high pressure can have the same result: washing the aphids off the vine.

Vertebrate Pests

Birds: Birds are a major pest problem in grapes. Left unchecked, they can destroy enough of the crop to ruin the profitability of a vineyard. The loss of chemical deterrents has made bird control a more difficult task in recent times, but effective means are still available.

Netting is the most effective way to keep birds out of

Table 50. Effectiveness of insecticides and miticides for management of grape pests.

	IRAC Group	GBM	LH	GCG‡	GFB	JB	GPH	RBLR	SM	CCW
Insecticides										
Actara	4A	-	++	-	-	-	-	-	-	-
Admire	4A	-	++	-	-	-	++	-	-	-
Assail	4A	-	+++	++	-	++	++	-	-	-
*Brigade	3	+++	+++	+++	++	+++	++	++	-	++
*Danitol	3	+++	+++	++	++	+++	++	++	++	+
Delegate	5	+++	-	-	-	-	-	+++	-	-
*Diazinon	1B	++	++	-	-	-	-	-	-	-
Imidan	1B	+++	++	+++	++	+++	-	+++	-	++
Intrepid	18	+++	-	-	-	-	-	++	-	-
Malathion	1B	+	++	-	-	++	-	-	-	-
Movento	23	-	-	-	-	-	+++	-	-	-
Provado	4A	-	+++	-	-	+	++	-	-	-
*Renounce	3	+++	++	++	++	+++	++	-	-	-
Sevin	1A	++	+++	++	+++	+++	-	++	-	+++
SpinTor	5	++	-	-	-	-	-	++	-	-
Miticides										
Acramite	4A	-	-	-	-	-	-	-	+++	-
*Agri-Mek	6	-	+	-	-	-	-	-	+++	-
Apollo	10A	-	-	-	-	-	-	-	++	-
Fujimite	21	-	+	-	-	-	-	-	+++	-
Nexter	21	-	++	-	-	-	-	-	+++	-
Vendex	12B	-	-	-	-	-	-	-	+	-
Zeal	10C	-	-	-	-	-	-	-	+++	-

+++=highly effective; ++= moderately effective; += slightly effective; - = not effective/not labeled

Key to pests: GBM= grape berry moth; LH= leafhoppers; GCG‡= grape cane girdler and grape cane gallmaker; GFB= grape flea beelte; JB= Japanese beetle; GPH= grape phylloxera; RBLR= redbanded leafroller; SM= spider mites; CCW=climbing cutworm.

***restricted use pesticides**

the vineyard. Although initial costs can be high, most netting will last for many years if cared for properly. Netting should be hung over some sort of support structure built around the vineyard. Usually posts are set nine feet above the ground around the perimeter of the vineyard, and wire is run from pole to pole to form a grid over the planting. The netting is hung over this grid when the fruit begins to turn color. Some temporary nine foot poles may be placed within the vineyard at intersections of the grid to keep the netting from drooping. Bury the edges of the netting or anchor it to the ground to keep birds from crawling underneath. Remove the netting when the harvest is complete, and store in a cool, dry place.

Visual scare devices have variable effectiveness on birds. Scarecrows, balloons, kites, or stuffed owls may work on certain bird species in certain areas, but none seem to have widespread dependability. When using scarecrows, "scare eye" balloons, stuffed owls, or snakes, put them in the vineyard only when the fruit begins to ripen, and move them regularly, at least once a day. Six scare-eye balloons per acre are recommended. Take them out of the field as soon as harvest is over. This will reduce the chance of birds becoming accustomed to the devices, and increase the longevity of their effectiveness. Kites and helium-filled balloons positioned high above the planting with a silhouette of a hawk hanging from them have provided good results in some areas.

Noise deterrents, such as propane cannons, alarms and recorded distress calls seem to have the least effect on birds in vineyards, but may greatly annoy neighbors. A combination of noise and visuals may be effective, however. Several operations have hired people to regularly drive motorcycles and/or ATVs through the vineyard when the fruit is ripe, and this seems to keep birds away quite well. Be sure to make drivers aware of where pickers are however, to avoid possible accidents.

Bird Shield™, a new repellent formulated from methyl anthranilate, is currently being registered for use on blueberries, cherries, and grapes. Methyl anthranilate is commonly used as a grape flavoring in human food preparations. Bird avoidance is based on odor quality and irritation. To humans, this chemical has a grape-like or fruit odor and a slightly bitter, pungent taste. Unfortunately, efficacy data do not support recommending this material at this time.

Table 51. Grape pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Dormant			
Anthracnose Phomopsis cane blight	Lime Sulfur, 10 gal (0) Sulforix, 1 gal (0)	Dormant applications may reduce ovewintering inoculum.	
Canker Diseases (Eutypa, Botryosphaeria)	Topsin M 70WSB, 3.2 oz/ gal water	Apply as a paint or directed spray to wounded surfaces after pruning and before the next rain. This recommendation is primarily for large pruning cuts, but has been shown to be beneficial under such conditions.	
Bud Swell (before buds show green)			
European red mite and/or scale insects	Superior Oil, 2.5% sln (0)	Do not apply after growth has started or pytotoxicity may occur.	Thorough coverage is needed to achieve control.
Flea beetle	Sevin 4F, 2 qt (7) *Leverage 2.7SE, 5-8 oz (3)	Scout weekly to determine need for control of these insects.	lower rates for flea beetle, higher rates for cutworm
Climbing Cut Worm	Sevin 4F, 2 qt (7) Belt, 3-4 oz (7) Imidan 70W, 1.3-2 lb (14)		**For resistance management do not make more than 2 sequential applications of insecticides in the same group. See Table 50 for groups.**
Bud Break to 10 inch shoots			
Flea Beetle Climbing Cut Worm Banded Grape Moth Grape Plume Moth	Sevin 4F, 2 qt (7) Belt SC, 3-4 oz (7) Delegate 25WG, 3-5 oz (7) Imidan 70W, 1.3-2 lb (14) *Leverage 2.7SE, 5-8 oz (3) *Danitol 2.4EC, 5.3-21.3oz (21)	Scout weekly to determine need for control of these insects.	**Belt** is not labeled for use against Flea Beetle. **Delegate** is not labeled for use against Flea Beetle.
European Red Mite Two-Spotted Mite	*Agri-Mek 0.15EC, 8-16 oz (28) Apollo 1SC, 4-8 oz (21) Acramite 50WS, 0.75-1lb (14) Fujimite 5EC, 2 pt (14) Nexter 75WP, 4.4-10.7 oz (7) Zeal, 2-3 oz (14) Onager Miticide, 12-24 oz (28) ⊗JMS Stylet Oil, 1-2%, (0)	Scout weekly to determine need for control of these pests. Predatory mite releases may also be useful. See Resource Listing at the end of this guide for predatory mite sources.	Read labels carefully for specific restrictions. Do not use JMS Stylet Oil w/in 14 days of using Captan or phytotoxicity will result.
Black rot Phomopsis Cane and Leaf Spot Downy Mildew	Manzate 75DF, 3-4 lb (66) Dithane DF, 3-4 lb (66) Captan 50WP, 3-4 lb (--) Abound 2SC, 11-15.4 oz (14) Sovran 50WG, 3.2-6.4 oz (14) Rally 40W, 1.5-2 oz (14) Nu-Cop 50DF, 2lb (1)		Check label carefully for reentry interval and pre-harvest interval for various Captan formulations. Captan may cause phytotoxicity in combination with oil or oil based sprays. NuCop and other copper products may cause slight to severe foliar injury to certain varieties. Read label carfully for cautions.
Downy Mildew	Prophyt, 1.8-3.6 pt (0) Phostrol, 2.5-5 pt (0) Dithane DF, 2-4 lb (66) Captan 50WP, 3-4 lb (--) Abound 2SC, 11-15.4 oz (14) Sovran 50WG, 3.2-6.4 oz (14) Presidio 4L, 3-4 oz (21) Revus 2.08L, 8 oz (14) Kocide 101, 2-4 lb (--)	Some cultivars are sensitive to copper and may suffer damage if it is used. Consult the label and Table 46 for information on sensitive cultivars. If in doubt, use on a limited area before spraying widely to determine if damage may occur. **Abound** is very toxic to some apple varieties. Do not spray in proximity to apple trees or with sprayer also used for apple trees. **For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.**	

Table 51. Grape pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Powdery Mildew	**Tank Mix:** Rally 40WP, 3-5 oz (14) or Rubigan 1EC, 3oz (30) or Procure 50WS, 4-8 oz (7) or Elite 45DF, 4 oz (14) or Abound 2SC, 11-15.4 oz (14) or Vintage SC, 3-4 oz (21) or Mettle 125ME, 3-5 oz (14 or Flint 50WG, 1.5-4 oz (14) **PLUS** Sulfur, various products (0) ⊗JMS Stylet Oil, 1-2%, (0) Quintec 2.08F, 3-4 oz (14) Endura 70WG, 4.5 oz (14)	Early control of Powdery Mildew is critical on susceptible cultivars. Infections can be hard to detect and lead to serious problems later in the season.	Some cultivars are sensitive to sulfur and my suffer damage if sulfur is used. Consult the label and table 46 for information on sensitive cultivars. If in doubt, use sulfur on a limited area before spraying widely to determine if damage may occur. **For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.**
Ten Inch Shoots			
Flea Beetle Larvae	Same as for Budbreak to 10" shoots		
Redbanded Leafroller Rose Chafer	*Danitol 2.4EC, 5.3-21.3 oz (21) Sevin 4EC, 2 qt (7) Intrepid 2F, 10-16 oz (30) Assail 30SG, 2.5 oz (7) SpinTor 2SC, 4-8 oz (7) ⊗Entrust 80WP, 1.25-2.5 oz (7)	Scout weekly to determine need for control of these pests. *Pheromone traps for redbanded leafroller will indicate if they are present and help determine the need for control.	Read labels carefully for specific restrictions. Be especially aware of long harvest restrictions. **For resistance management do not make more than 2 sequential applications of insecticides in the same group. See Table 50 for groups.**
European Red Mite Two-Spotted Mite	Same as for Budbreak to 10" shoots		
Phomopsis Cane and Leaf Spot	Captan 80WP, 1.75-2.5 lb (0) Dithane DF, 3-4 lb (66) Ziram 76DF, 3-4 lb (21)	This is an important time to protect from rachis infections on susceptible cultivars.	Be aware of harvest restrictions when selecting spray materials. Do not use Captan with or within 14 days of an oil application.
Black Rot	Dithane DF, 3-4 lb (66) Elite 45DF, 3-4 oz (14) Flint 50WG, 1.5-2 oz (14) Rally 40WP, 4-5 oz (14) Ziram 76DF, 3-4 lb (21)	This is an important time to protect from rachis infections on susceptible cultivars.	Strobilurin fungicides (Abound, Quadris, Sovran, Cabrio, Flint, Pristine,) can be very effective on Black Rot, but are highly susceptible to developing resistance in the target organism and so are best saved for later in the season for high need situations. **Flint** has shown phytotoxicity on some grape cultivars. Use on small area first before treating grapes with unknown susceptibility.
Powdery Mildew	Procure 50WS, 4-6 oz (7) Rubigan 1E, 2-3 oz (21) Elite 45DF, 3-4 oz (14) Rally 40WP, 4-5 oz (14) Nutrol LC, 4 lb (1) ⊗JMS Stylet Oil, 1-2%, (0) ⊗Kaligreen 82, 2.5-5 lb (1) Sulfur, various formulations (0)	This is an important time to protect from rachis infections on susceptible cultivars.	Be aware of harvest restrictions when selecting spray materials. Do not use JMS Stylet Oil with or within 14 days of a Captan application. Some grape cultivars are sensitive to sulfur. See table 46 for a list of sensitive cultivars.

Table 51. Grape pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Downy Mildew	Dithane DF, 3-4 lb (66) Captan 80WP, 1.75-2.5 lb (0) Prophyt, 1.8-3.6 pt (0) Phostrol, 2.5-5 pt (0) Presidio 2SC, 3-4 oz (21) Revus 2.08L, 8 oz (14) Kocide 101, 2-4 lb (--)	This is an important time to protect from rachis infections on susceptible cultivars.	Be aware of harvest restrictions when selecting spray materials. Some cultivars are sensitive to copper and my suffer damage if it is used. Consult the label and Table 49 for information on sensitive cultivars. Treat small areas of varieties where the reaction is unknown before spraying full rows.
Pre-Bloom			
Flea Beetle Larvae Rose Chafer Redbanded Leafroller	Same as 10-inch shoot	*Pheromone traps for grape berry moth and redbanded leafroller will indicate if they are present and help determine the need for control.	
Grape Scale	Malathion 8F, 2-2.5 pt (3)	Not a common pest in New England. Where found, flag scale-infested vines during dormant pruning. In early May begin weekly inspections of flagged vines for scale crawlers. Lift live adult scale covers and look for yellow moving crawlers (use a hand lens with 10x magnification). Protect canes by applying sprays every 10 days as long as you see moving crawlers (2-3 week crawler emergence period).	
Phomopsis Black Rot Powdery Mildew Downy Mildew	**Same as 10-inch shoot or** Pristine 38WG, 8-10.5 oz (14) Sovran 50WG, 3.2-4 oz (14) Abound 2SC, 11-15 oz (14) Flint 50WG, 1.5-2 oz (14)		**For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.** Do not use **Pristine** fungicide on Concord or Noiret varieties as it will cause injury.
Bloom			
Grape Phylloxera (aerial form)	*Danitol 2.4EC, 5.3-21.3 oz (21) Assail 30SG, 2.5 oz (7) Admire Pro, 7-14 oz (30) Movento 2EC Voliam Flexi 40SG, 4.5 oz (14)	Control the root gall form of grape phylloxera by using rootstocks derived from American grapes. Native American grapes (Eastern U.S.) are highly resistant to this pest. Apply when first galls are forming; spray again 10–12 days later. Many varieties can withstand extensive galling. Since bees do not pollinate grapes there is no danger to bees at this time unless they are working on other blooming plants in the area being sprayed. Mow before spraying to eliminate blooms on weeds and protect pollinators.	
Black Rot Phomopsis Downy Mildew Powdery Mildew	Same as Pre-Bloom	If wet weather persists during bloom or if the interval between the pre-bloom and shatter sprays is greater than 7-10 days, a fungicide application during bloom may be needed	
Botrytis Bunch Rot	Topsin M WSB, 1-1.5 lb (14) Rovral 50WP, 1.5-2 lb (7) Vangard 75WG, 10 oz (7) Elevate 50WG, 1 lb (0) Scala 5SC, 18 oz (7)	This spray is critical in vineyards or on varieties (especially French hybrids or Vinifera) where Botrytis bunch rot has been a problem. **For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.**	
Shatter (7-10 days after bloom when unfertilized berries fall from clusters)			
Leafhoppers	*Danitol 10.7 oz (21) Sevin XLR, 1-2 qt (7) Provado 75WSP, 0.75-1 oz (0) Assail 30SG, 2.5 oz (7) Voliam Flexi 40SG, 4.5 oz (14) ⊗M-Pede, 2% solution (0) ⊗JMS Stylet Oil, 1-2%, (0)	Scout vineyard by examining underside of leaves to determine if this pest is present. It may be possible to treat hot-spots and not the whole vineyard following thorough scouting.	**Danitol** is a broad spectrum insecticide and may disrupt populations of beneficial insects and predators such as mite predators resulting in increased pest populations. Read **M-Pede** label prior to use to avoid plant injury. Do not use **Stylet Oil** within 7 days of Captan. Read label for other restrictions.

Table 51. Grape pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Grape Berry Moth	*Danitol 2.4EC, 5.3-21.3 oz (21) *Diazinon AG500, 1-2 pt (28) *Brigade 2EC, 3.2-6.4 oz (30) *Leverage 2.7SE, 5-8 oz (3) *Renounce 20WP, 3-4 oz (3) Altacor 35WDG, 2-4.5 oz (14) Belt SC, 3-4 oz (7) Intrepid 2F, 4-8 oz (30) Delegate 25WG, 3-5 oz (7) Sevin XLR, 2 qt (7) Imidan 70W, 1.3–2.12 lb (14) SpinTor 2SC, 4-8 oz (7) Voliam Flexi 40SG, 4.5 oz (14) ⊗Entrust 80WP, 1.25-2.5 oz (7) ⊗Biobit HP, 0.5-1 lb(0) Isomate GBM, 400 ties (0)	Classify vineyards as low, intermediate, or high risk of grape berry moth attack using http://nysipm.cornell.edu/publications/grapeman/files/risk.pdf. High- and intermediate-risk vineyards receive insecticide treatment at this time. Monitor populations using pheromone traps to identify beginning of flight into vineyards from overwintering sites. This spray is timed to coincide with peak egg-laying of GBM which, in most years, occurs 7–14 days after the mid-bloom period. Good spray coverage of the clusters must be achieved to control grape berry moth. Use of **Isomate GBM** ties for mating disruption can be very effective in larger (>5A) vineyard blocks. See http://nysipm.cornell.edu/publications/grapeman/files/phercon.pdf for guidelines for using mating disruption.	
Japanese Beetle and related asiatic beetles	*Danitol 2.4EC, 10.7 oz (21) *Brigade 2EC, 3.2-6.4 oz (30) Actara 25WDG, 1.5-3 oz (5) Avaunt 30WDG, 5-6 oz (7) Clutch 50WDG, 3 oz (0) Sevin XLR, 1-2 qt (7) Assail 30SG, 2.5 oz (7) Imidan 70WP, 1.3-2.1 lb (14) Platimum 2SC, 8-17 oz (60) Voliam Flexi 40SG, 4.5 oz (14) ⊗ Neemix, 7-16 oz (0) ⊗ Aza-Direct, 1-2 pt (0) ⊗ Pyganic 5EC, 5-18 oz (0) ⊗Surround 95WP, 12.5-50 lb (0)	Use of traps is not recommended as they often draw this pest in from remote locations outside of the vineyard and increasing damage in the vineyard. Mature vines can sustain significant amounts of feeding injury without yield or quality impact. Young vines are the most vulnerable to injury from heavy feeding that can delay the establishment of the vine or even cause vine death. Be sure to check for feeding inside grow tubes in newly planted vineyards. Remove tubes and treat if found. **Danitol** and **Brigade** are broad spectrum insecticides and may disrupt populations of beneficial insects and predators such as mite predators resulting in increased pest populations. **Surround** may leave visible residue on leaves. Neemix and Aza-Direct act as anti-feedant and may require frequent reapplication; see label for specific recommendations. Be aware of pre-harvest restriction on some recommended materials.	
Redbanded Leafroller	*Danitol 10.7 oz (21) Sevin XLR, 1-2 qt (7) Imidan 70W, 1.3–2.12 lb (14) Delegate 25WG, 3-5 oz (7) Intrepid 2F, 4-8 oz (30) SpinTor 2SC, 4-8 oz (7) ⊗Entrust 80WP, 1.25-2.5 oz (7) ⊗Surround 95WP, 12.5-50 lb (0)	**Danitol** is a broad spectrum insecticide and may disrupt populations of beneficial insects and predators such as mite predators resulting in increased pest populations. **Surround** may leave visible residue on leaves.	
Grape Mealybug	*Renounce 20WP, 3-4 oz (3) Admire Pro, 7-14 oz (30) Provado 1.6F, 3-4 oz (0) Assail 30SG, 2.5 oz (7) Venom 20SG, 0.44-0.66 lb (1) Voliam Flexi 40SG, 4.5 oz (14) Fujimite 5EC, 2 pt (14) ⊗JMS Stylet Oil, 1-2%, (0)	Scout vineyard by examining bark scales on trunks and cordons and/or looking for evidence of sooty mold growing on honeydew secreted by this pest; ant may also be abundant where mealybug honeydew is present.	**Admire** is soil applied for systemic control. Do not use **Stylet Oil** within 7 days of Captan. Read label for other restrictions. **Venom** rate for foliar application. See label for soil application rates and restrictions.
Mites	Same as Budbreak to Bloom		

Table 51. Grape pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Black Rot Downy Mildew	Captan 50W, 3-4 lb (14) **or** Prophyt, 1.8-3.6 pt (0) **plus** Ferbam 76W, 3 lb (7) **or** Ziram 76DF, 3-4 lb (14) **or use alone:** Pristine 38WG, 8-10.5 oz (14) Sovran 50WG, 3.2-4 oz (14) Abound 2SC, 11-15 oz (14)	Choose fungicide combinations according to which diseases are of greatest concern. See Table 46 for efficacy of listed fungicides against various diseases. Be sure to read the labels for any cautions on tank mix compatibility. Do not use **Pristine** fungicide on Concord or Noiret varieties as it will cause injury. **For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.**	
Black Rot Downy Mildew Powdery Mildew	Captan 50W, 3-4 lb (14) **or** Prophyt, 1.8-3.6 pt (0) **or** Ziram 76DF, 3-4 lb (21) **or** **plus** Ferbam 76W, 3 lb (7) **or** Rally 40WP, 4-5 oz (14) **or** Elite 45DF, 3-4 oz (14) **or** Endura 70WG, 6-10.5 oz (14)**or** Quintec 2.08F, 3-4 oz (14) Vintage SC, 3-4 oz (21) or **or use alone:** Pristine 38WG, 8-10.5 oz (14) Sovran 50WG, 3.2-4 oz (14) Abound 2SC, 11-15 oz (14) Adament 50WG, 4-7.2 oz (14)	Choose fungicide combinations according to which diseases are of greatest concern. See Table 46 for efficacy of listed fungicides against various diseases. Be sure to read the labels for any cautions on tank mix compatibility. Do not use **Pristine** fungicide on Concord or Noiret varieties as it will cause injury. **Adament** is excellent for control of powdery mildew and black rot, but is weak on downy mildew. Do not apply to Concord grapes as it will cause injury. **For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.**	
First Cover and Subsequent Covers (at 14 day interval)			
Grape Berry Moth Leafhopper Japanese Beetle Mites	Same as Shatter		
Phomopsis Cane and Leaf Spot	Captan 50W, 3-4 lb (14) Ziram 76DF, 3-4 lb (21) Abound 2SC, 11-15 oz (14) Pristine 38WG, 8-10.5 oz (14) Adament 50WG, 4-7.2 oz (14)	Fruit infections can occur from bloom to pea-sized berries and remain dormant until late summer. Severe fruit rot can result especially if wet weather prevails during the ripening period.	Do not use **Pristine** or **Flint** on Concord or Noiret varieties as it will cause injury. Some other varieties may be sensitive. See current labels for warnings. **For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.**
Black Rot	Abound 2SC, 11-15 oz (14) Elite 45DF, 3-4 oz (14) Ferbam 76W, 3 lb (7) Flint 50WG, 1.5-2 oz (14) Rally 40WP, 4-5 oz (14) Pristine 38WG, 8-10.5 oz (14) Adament 50WG, 4-7.2 oz (14) Sovran 50WG, 3.2-4 oz (14) Ziram 76DF, 3-4 lb (21)	This is a critical spray for Black Rot control. Later in development, grape berries become resistant to infection by this pathogen.	
Downy Mildew	Abound 2SC, 11-15 oz (14) Captan 50W, 3-4 lb (14) Prophyt, 1.8-3.6 pt (0) Phostrol, 2.5-5 pt (0) Pristine 38WG, 8-10.5 oz (14)** Sovran 50WG, 3.2-4.0 oz (14) Ridomil Gold MZ, 2.5 lb (66) Presidio 2SC, 3-4 oz (21) Revus 2SC, 8 oz (14) Gavel 75DF, 2.0-2.5 lb (66)	This is an important time for controlling Downy Mildew infections. Weather conditions will dictate fungicide choice, rate, and spray interval. Coverage is very important for control. Weather forecasting models can help identify infection periods for this disease.	**For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.** Do not use **Pristine** fungicide on Concord or Noiret varieties as it will cause injury. Be aware of pre-harvest restriction on some recommended materials.

Table 51. Grape pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Powdery Mildew	Abound 2SC, 11-15 oz (14) Endura 70WG, 4.5 oz (14) Pristine 38WG, 8-10.5 oz (14) Sovran 50WG, 3.2-4.0 oz (14) Quintec 2SC, 3-4 oz (14) Flint 50WG, 1.5-2 oz (14) Rubigan 1EC, 5 oz (21) Rally 40WP, 4-5 oz (14) Elite 45DF, 4 oz (14) Mettle 1ME, 5 oz (14) Procure 50WS, 5-8 oz (7) Armicarb 100, 2.5-5.0 lb (1) Sulfur (various formulations) ⊗JMS Stylet Oil, 1-2%, (0)	This is the most critical time of year for protecting against cluster infections by Powdery Mildew. Weather conditions will dictate fungicide choice, rate, and spray interval. Coverage is very important for control. Weather forecasting models can help identify infection periods for this disease.	**For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.** Do not use **Pristine** or **Flint** on Concord or Noiret varieties as it will cause injury. Some other varieties may be sensitive. See current labels for warnings. Some cultivars are sensitive to **sulfur** and will be damaged by sulfur sprays. Check label for cautions and see Table 46 for ratings for sensitive cultivars.
Botrytis Bunch Rot	Endura 70WG, 4.5 oz (14) Pristine 38WG, 8-10.5 oz (14) Vangard 75WG, 10 oz (7) Elevate 50WG, 1 lb (0) Scala 5SC, 18 fl oz (7) Flint 50WG, 1.5-2 oz (14) Rovral 50WP, 1.5-2 lb (7) Adament 50WG, 4-7.2 oz (14)	Good coverage prior to bunch closure is very important at this time, especially in wet years. Pruning and canopy management to enhance air circulation and good drying conditions are good practices to lessen pressure from this disease.	**For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.** Do not use **Pristine** or **Flint** on Concord or Noiret varieties as it will cause injury. Some other varieties may be sensitive. See current labels for warnings.
Veraison To Harvest			
Grape Berry Moth Grape Leafhopper Grape Rootworm Japanese Beetle Redbanded Leafroller Mites	Same as Cover Sprays	**For resistance management do not make more than 2 sequential applications of insecticides in the same group. See Table 50 for groups.** Be aware of pre-harvest intervals when choosing materials at this time.	
Fruit Flies	Evergreen EC, 6-12 oz (0) ⊗ Neemix, 7-16 oz (0) ⊗ Aza-Direct, 1-2 pt (0)	This pest may become problematic clost to or after harvest and can introduce contamination to wine or juice production or reduce post harvest quality of fresh pack.	
Asiatic Lady Beetle	Clutch 50WDG, 3 oz (0) Venom 20SG, 0.44-0.66 lb (1) Evergreen EC, 6-12 oz (0) ⊗ Neemix, 7-16 oz (0) ⊗ Aza-Direct, 1-2 pt (0)	Scout vineyards several days before harvest to determine the abundance of multicolored Asian lady beetle. The threshold for perceivable taint in wine = 10-12 beetles/lug	
Botrytis Bunch Rot	Elevate 50WG, 1 lb (0) Flint 50WG, 3 0z (14) Rovral 50WP, 1.5-2 lb (7) Scala 5SC, 18 fl oz (7) Vangard 75WG, 10 oz (7) ⊗ Oxidate 1% sln (0)	Tight clustered or highly susceptible cultivars may be more likely to require sprays at this time.	**For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.** Be aware of pre-harvest intervals when choosing materials at this time.
Powdery Mildew Downy Mildew	Same as Cover Sprays	**For resistance management do not make more than 2 sequential applications of fungicides in the same group. See Table 48 for groups.** Be aware of pre-harvest intervals when choosing materials at this time.	
Black Rot	Most cultivars will not need further spray applications after cover sprays because berries develop resistance to infection at this time.		

Table 51. Grape pest management schedule†.

Pest	Spray Material, Rate/A (pre harvest interval PHI)	Cultural Practices and Scouting Notes	Comments
Post Harvest			
Fruit Flies	Evergreen EC, 6-12 oz (0) ⊗ Neemix, 7-16 oz (0) ⊗ Aza-Direct, 1-2 pt (0)	This pest may become problematic clost to or after harvest and can introduce contamination to wine or juice production or reduce post harvest quality of fresh pack.	
Downy Mildew	Copper compounds (several formulations) Prophyt, 1.8-3.6 pt (0) Phostrol, 2.5-5 pt (0)		
Powdery Mildew	Sulfur compounds (several formulations) ⊗JMS Stylet Oil, 1-2%, (0)	Spray only as needed according to field scouting.	

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

***Restricted use pesticide; pesticide applicators license required.** ⊗ **OMRI listed for organic production**

Weed Management

The primary goal of weed management is to optimize yields by minimizing competition between the weeds and the crop. Weeds reduce yields by competing with the crop for water, light, and nutrients. Weeds also harbor insects and diseases and encourage vertebrate pests. Timely cultivation, wise use of herbicides, and never permitting weeds to go to seed are integral parts of a good weed management system. Many of the weeds found in these fields are difficult-to-control perennial weeds that are not common in annual crop culture. New plantings usually have fewer perennial weed problems than older plantings. Annual and biennial weeds can also exist in these fields. Fields should be scouted at least twice a year (spring and fall) to determine specific weed problems. The selection of a weed management tool should be based on specific weeds present in each field. Several herbicides are labeled for use in this crop. A list of herbicides and their recommended uses is presented in Table 52 below.

Herbicides can be broadcast or applied as a directed spray to the base of the crop. With a band treatment, only 1 to 2 feet on either side of the rows is treated. The area between the crop rows is usually maintained with a mowed cover of sod, clover, weeds, or a combination of these. This cover is used primarily for erosion control and to improve trafficability in the field. With banding, less herbicide is needed in each acre. For example, a 3 foot band (1.5 feet on either side of the row) where rows are spaced 9 feet apart will require only one third the amount of herbicide normally required for a broadcast treatment.

Cultivation and mulching are sometimes used as weed management tools. All cultivations should be timely and shallow to minimize crop root injury, to minimize loss of soil moisture, and to avoid repositioning new weed seeds to the soil surface. Mulches that are free of weed seeds and placed thickly enough can be very effective at reducing or eliminating most annual weeds from the crop row. They are seldom effective on perennial weeds. If mulches are used in combination with herbicides, use the lowest recommended herbicide rate to avoid crop injury.

Table 52. Weed management in Grapes[†].

Preemergence

Weed Problem	Material	Rate/Acre (phi)	Comments and Limitations
Annual and perennial grasses and broadleaves	(dichlobenil) Casoron 4G	100-150 lb (0)	**Perennial weeds**: Apply from Nov. 15 to Feb. 15 as a soil surface application. Can also be applied in late fall or early spring before May 1 and incorporated immediately. **Annual Weeds**: Apply in early spring after cultivation before weeds emerge. Rain or irrigation is needed for activation. A shallow incorporation is recommended. Apply 4 weeks after transplanting after soil has completely settled.
Annual broadleaves and suppression of grasses	(flumioxazin) Chateau 51WDG	6-12 oz (60)	Do not apply after bloom unless with a hooded or shielded application. Apply alone preemergence or tank mix with Roundup or Gramoxone postemergence. Do not incorporate. Do not allow drift to contact foliage or green bark. Always add a crop oil at 1% v/v or nonionic surfactant at 0.25% v/v. Max. rate is 24 oz per season. Min. 30 days between applications. Chateau also has postemergence activity. **Age restriction**: Do not apply to vines established less than 2 years unless they are trellised at least 3 ft from the ground or are protected by nonporous wraps, grow tubes, or waxed containers.
Annual broadleaves and suppression of grasses cont.	(oxyflourfen) Goal 2XL	5-8 pt (b)	**Dormant application only**: effective both preemergence and postemergence as a directed spray on weeds less than 4 inches. Do not apply from bud swell to harvest. Can be mixed with other preemergence herbicides, or with Roundup or Gramoxone. Max rate is 8 pt/A/year. **Age restriction**: Do not apply to grapes established less than 3 years unless vines are on a trellis wire a minimum of 3 ft above ground.
Annual grasses and broadleaves	(napropamide) Devrinol 50DF	8 lb (35)	Apply from late fall (prior to soil freeze-up), to early spring (prior to weed emergence). If no rainfall of 1 inch or more occurs within 24 hours after treatment, cultivate or irrigate to activate. Apply alone to weed-free soil or in tank mix with Roundup or Gramoxone. Do not allow spray to contact fruit or foliage.
	(diuron) Karmex 80DF	2-6 lb (0)	**Age restriction**: Use on vineyards established at least 3 years and trunks at least 1.5 inches diameter. Apply as a directed spray to soil under trellis in early spring prior to weed germination. Max. 1 application per year. On soils low in organic matter (1-2%), severe injury may result if heavy rainfall occurs soon after treatment.
	(simizine) Princep 4L	2-4.8 qt (0)	**Are restriction**: Aply to soil under trellis between harvest and eaerly spring before weeds emerge. Use on vineyards established at least 3 years. Apply alone to weed-free soil or tank mix with Roundup or Gramoxone. Max 1 application per year.
	(rimsulfuron) Matrix FVN	4 oz (14)	Apply as a banded application to the base of the vines. Best results are obtained when the soil is moist at the time of application and 0.5 inch of rainfall or sprinkler irrigation occurs within 2 weeks after application. **Age restriction**: Do not apply to vines established less than one year. PHI=14 days.
Most broadleaves	(isoxaben) Gallery 75DF	0.66-1.33 lb (1yr)	**Non-bearing only**: May only be used on crops that will not be harvested within one year of application. Apply in late summer to early fall; or in early spring prior to weed germination or anytime immediately after cultivation. Do not apply to new transplants until soil has settled with no cracks present. Rainfall or irrigation of 0.5 inch is needed within 21 days of application. Not effective on germinated weeds. Min. 60 days between applications. Max rate is 4 lb/A.

Table 52. Weed management in Grapes†.

Preemergence

Weed Problem	Material	Rate/Acre (phi)	Comments and Limitations
Annual and perennial grasses and certain broadleaves	(pronamide) *Kerb 50WP	2-8 lb (c)	Apply as a directed spray in the fall after harvest prior to soil freese-up, or early winter when temperatures are below 55˚F. Rainfall or irrigation are required to activate. Max. 1 application per year and 8 lb/A/year. Kerb also has early postemergence activity. Rate depends on soil texture.
Annual and perennial grasses and certain broadleaves cont.	(pendimethalin) Prowl 3.3EC Prowl H_2O	2.4 qt (1 yr)	**Non-bearing only**: May only be used on crops that will not be harvested within one year of application. Do not apply if buds have started to swell . May be applied preplant incorporated, preplant surface, or preemergence. For best results, rain or irrigation is needed within 21 days of application. Not effective on germinated weeds. Do not allow spray to contact leaves, shoots, or buds. For new plantings, do not apply until soil has settled and no cracks are present.
	(isoxaben + trifluralin) Snapshot 2.5TG	100-200 lb (1yr)	**Non-bearing only**: May only be used on crops that wll not be harvested within one year of application. Rainfall or irrigation of 0.5 inch is needed within 3 days of application. Not effective on germinated weeds. Min. 60 days between applications. Max rate is 600 lb per year.
	(oryzalin) Surflan 4AS	2-6 qt (0)	Make a single band or broadcast spplication to the ground beneath vines before weeds emerge. Apply alone to weed-free soil or postemergence mixed with Roundup or Gramoxone. Min 0.5 inch of rainfall or irrigation is required for activation. Min 2.5 month between applications. Max rate is 12 qt per year.
Annual grasses and broadleaves and suppression of yellow nutsedge	(norflurazon) Solicam DF	1.25-5 lb (60)	Apply as a directed spray to settled and firm soil from fall to early spring before weeds emerge. Rainfall or irrigation is needed within 4 weeks of application. Do not contact fruit of foliage. Do not apply after bud break on sandy loam soils. Check label for maximum amount allowed per year depending on soil type. **Age restriction**: Allow a minimum of 24 months after planting before first application.

Postemergence

Weed Problem	Material	Rate/Acre (phi)	Comments and Limitations
Annual broadleaves	(carfentrazone) Aim 2EC	1-2 oz (3)	Apply any time during the season. Always add nonionic surfactant at 0.5% v/v or crop oil at 1% v/v. Mix with Roundup or Gramoxone or labeled preemergence herbicides for broader weed control. Max. 7.9 oz/A/year. Min. 14 days between applications. **Sucker management**: Apply when suckers are green. Do not allow spray to contact desirable fruit, foliage, or green bark.
	(oxyflourfen) Goal 2XL	5-8 pt (b)	See "Prreemergence" section for details.
Most annual and perennial grasses	(flauzifop) Fusilade DX	16-24 oz (1yr)	**Non-bearing only**: May only be used on crops that will not be harvested within one year of application. Apply as a directed spray to actively growing grasses before tillering. Always add crop oil at 1% v/v or nonionic surfactant at 0.25% v/v. Avoid contact with foliage. Rainfast in 1 hour. Max rate is 72 oz/A/year. Min. 5 days between applications.

Postemergence

Weed Problem	Material	Rate/Acre (phi)	Comments and Limitations
	(clethodim) Select 2EC	6-8 oz (1yr)	**Non-bearling only**: May only be used on crops that will not be harvested within one year of application. Apply as a directed spray to actively growing grasses before tillering. Do not use if rain is expected within 1 hour. Always add nonionic surfactant at 0.25% v/v. Do not use crop oil. May be applied as a spot treatment at 0.32-0.64 oz per gallon. Max rate is 32 oz/A/year.
	(sethoxydim) Poast 1.5EC	1.5-2.5 pt (50)	Aply as directed spray to actively growing grasses before tillering. Always add crop oil at 1% v/v. Max 2.5 pt per application and 5 pt/A/year.
Annual and perennial grasses and broadleaves	(glufosinate) Rely 1L	3-6 qt (14)	**Age restriction**: Do not apply within 1 year of transplanting. Apply as a directed spray to actively growing weeds. Do not apply on desirable foliage or drift on foliage, green, or uncallused bark of vines. Max 18 qt/A/yr for bearing and 12 qt/A/yr for non-bearing vines. For spot applications, mix 1.5-4 oz per gallon. **Sucker control**: a split application approximately 4 weeks apart at 4 qt/A is recommended or spot spray with 3 oz/gallon of water. Suckers should not exceed 12 inches long.
	(pelargonic acid) Scythe4.2E	3-10% solution (0)	For contact nonselective control or burndown of a broad spectrum of actively growing weeds. Use low rate for annual weed control and high rate for maximum vegetative burndown. Use as a directed spray or shielded spray. Can be mixed with Roundup.
Most annual grasses and broadleaves and top kill of perennial weeds	(paraquat) Gramoxone Inteon 2L	2.5-4 pt (0)	Apply as directed spray to actively growin gweeds. Repeat applications are necessary to give sustained control. Avoid contact with desired new whoots, fruit or foliage. Apply as a coarse spray. Always add nonionic surfactant at 0.25% v/v or crop oil at 1% v/v. Best results with flat fan nozzles. Max. 5 applications per year. **Sucker management**: Apply when suckers are less than 8 inches tall. Do not allow spray to contact desirable fruit, foliage, or green bark.
Annuals and some perennial grasses and broadleaves	(glyphosate) Roundup WeatherMax 5.5EC	0.5-5.3 qt (14)	Rate depends on weed species and stage of growth. See label for details. Apply as preplant broadcast application or in fall for control of roots and rhizomes of perennial weeds or as a directed spray or wiper application (20-100% solution) to actively growing weeds in established plantings. Always add ammonium sulfate 8.5-17 lb/100 gal in hard water or drought conditions (see label). Do not allow spray to contact any part other than mature bark. Does not provide residual control; can be mixed with labeled preemergence herbicides.

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

***Restricted use pesticide; pesticide applicators license required.** ⊗ **OMRI listed for organic production**

Appendices

Table 53. Poisoning hazard to honey bees of common small fruit pesticides[†].

Pesticide*	Duration of hazard to honeybees	Pesticide**	Duration of hazard to honeybees
EXTREMELY TOXIC: DO NOT apply on blooming crops or weeds			
Actara (thiamethoxam)	7-14 days	Guthion (azinphos methyl)	4 days
Admire (imidacloprid)	<1 day	Imidan (phosmet)	>3 days
*Agri-Mek EC (abamectin)	1-3 days	Lannate (methomyl)	> 1 day
*Asana **high rate** (esfenvalerate)	1 day	Lorsban (chlorpyriphos)	4-6 days
*Brigade **high rate** (bifenthrin)	> 1 day	Malathion WP (malathion)	2 days
*Danitol (fenpropathrin)	1 day	Malathion Dust (malathion)	7 days
*Diazinon EC, WP (diazinon)	2 days	Provado **high rate** (imidacloprid)	> 1 day
*Dibrom EC, WP (naled)	12-36 hrs	Sevin 4F, WP, (carbaryl)	3-7 days
HIGHLY TOXIC[a]: Apply ONLY during late evening if blooming plants are present.			
Asana **low rate** (esfenvalerate)	8 hours	Malathion EC (malathion)	2-6 hours
*Brigade **high rate** (bifenthrin)	< 8 hours	Provado **low rate** (imidachloprid)	< 8 hours
Confirm (tebufenozide)	< 8 hours	Sevin XLR **low rate** (carbaryl)	8 hours
*Dibrom EC (naled)	16 hours	Thionex **high rate** (endosulfan)	8 hours
MODERATELY TOXIC[a]: Apply ONLY during late evening, night, or early morning if blooming plants are present.			
Assail (acetamiprid)	?	Nexter (pyridaben)	<2 hours
⊗ Aza-Direct (azadiractin)	< 2 hours	Princep (simazine)	?
Formula 40 (2,4-D)	?	Pyrenone (pyrethrin)	< 2 hours
Fusilade (fluazifop-P-butyl)	?	Pyrellin (pyrethrin/rotenone mix)	< 2 hours
Oil sprays (superior types)	< 3 hours	Rotenone (rotenone)	< 2hours
Neemix (azadirachtin)	< 2 hours	SpinTor/ ⊗ Entrust (spinosad)	< 2 hours
		Thionex **low rate** (endosulfan)	2-3 hours

SLIGHTLY TOXIC OR NONTOXIC: Can be applied at any time with reasonable safety to bees.

Bordeaux mixture (copper sulfate + lime)	lime-sulfur
Captan (captan)	⊗ Microthiol (sulfur)
Dipel (Bacillus thuringiensis)	M-Pede (insecticidal soap)
Dithane (mancozeb)	Nova (systhane)
Esteem (pyriproxyfen)	Procure (triflumizole)
Ferbam (ferbam)	Roundup Weather Max (glyphosate)
fixed copper	Savey (hexythiazox)
Fujimite (fenpyroximate)	Sulfur
Goal (oxyflourfen)	Syllit (dodine)
Gromoxone Inteon (paraquat)	⊗ Surround (kaolin clay)
Intrepid (methoxyfenozide)	Thiram (thiram)
⊗ Javelin (B. thuringiensis)	Vendex (fenbutatin-oxide)
Kanemite (acequinocyl)	Zeal WDG (etoxazole)
Kumulus (sulfur)	

And most other fungicides and herbicides.

[†]Sources: 2010 New England Apple Pest Management Guide and Oregon State University Bulleting PNW591 'How to Reduce Bee Poisoning from Pesticides'.

[a] Late evening means after 6-8 PM and assumes that evening temperatures are not unusually high and that bees have stopped foraging. Late evening, night or early mornings means after 6-8 PM, and before 4-7 AM, depending on temperature. Shift time if abnormally high temperatures cause bees to start foraging earlier or continue later than ususal (5:30 AM to 8:00 PM). Few honeybees forage when springtime temperature is below 51°F. Maximum foraging activity occurs at temperatures above 63°F. Evening applications are generally less hazardous to bees than early morning applications.

***Where trade names are used, no discrimination is intended and no endorsement by Cooperative Extension is implied. Not a complete list.*

***Restricted use pesticide; pesticide applicators license required. ⊗ OMRI certified for organic production**

Table 54. Toxicity of pesticides to birds, fish, bees, and beneficials.

(**Source**: 2010 The Mid-Atlantic Berry Guide for Commercial Growers)

	Toxicity to:					
				Mite Predators		Aphid Predators
Pesticide	**Birds**	**Fish**	**Bees**	**N. fallacis**	**Z. mali**	
Insecticides						
Actara	N[a]	N	H	N	N	H
Admire	M	M	H	M	S	S–M
Asana	N	H	H	H	M	H
⊗ Aza-Direct	—	H	N	—	—	S
Brigade/Capture	M	H	H	H	M	H
Confirm	S	H	M	N	N	N
Danitol	H	H	H	H	M	H
Diazinon	H	H	H	M	S	M
*Dibrom	—	—	M	—	—	—
⊗ Dipel (B.t.)	N	N	N	N	N	N
⊗ Entrust/Spintor	H	—	H	S	N	N
Esteem	—	—	N	S	N	M
Imidan	S	H	H	S	S	S
Lannate	H	H	H	H	M	H
*Lorsban	M	H	H	M	M	H
Malathion	M	H	H	S	—	M
M-Pede	N	N	N	S	S	—
Mustang Max	—	H	H	H	M	H
Platinum	—	M	—	—	—	—
Provado	M	M	H	S	S	M
Sevin XLR	S	N	H	M	M	M
*Thionex	H	H	S	S	N	M
Miticides						
Acramite	—	—	H	M	M	S
AgriMek	N	M	H	H	M	—
Kanemite	—	H[b]	—	S	S	S
Kelthane/Dicofol[c]	M	H	N	H	S	S
Oberon	—	H	—	—	—	—
Savey	—	H	N	S	S	N
Vendex	M	M	N	M	M	H
Zeal	—	—	N	M	S	M

a. N = reasonably safe (for bees, apply anytime); S = slightly toxic (for bees, apply in evening after bees have stopped foraging until early morning before they start foraging); M = moderately toxic (for bees, apply in evening after bees have stopped foraging); H = highly toxic (for bees, do not apply to blooming plants); — = insufficient data

b. Toxic to invertebrate aquatic organisms such as oysters.

c . Kelthane use is being discontinued. Growers may continue to use existing stocks for strawberries. VA's 24C label for Kelthane on brambles is no longer in effect.

Table 55. Conversion factors to convert from one unit to another.

To convert from	to	Multiply by
lb/A	lb/100 sq ft	0.0023
tn/A	lb/100 sq ft	4.6
lb/A	kg/ha	1.12
kg/ha	lb/A	0.893
lb	oz	16
qt of fruit	lb of fruit	1.5
qt	pt	2.0
pt	qt	0.5
gal of liquid	lb of liquid	8.3
	STRAWBERRIES	
lb/A	lb/100 ft of row	0.008
yield in lb/100 ft of row	lb/A	125
yield in qt/100 ft of row	b/A	188
	RASPBERRIES	
lb/A	lb/100 ft of row	.0184
lb/A	oz/plant	0.009
yield in lb/100 ft of row	lb/A	55
yield in pt/100 ft of row	lb/A	73
	BLUEBERRIES	
lb/A	oz/plant	0.015
yield in lb/100 ft of row	lb/A	44
yield in qt/100 ft of row	lb/A	58
	CURRANTS AND GOOSEBERRIES	
lb/A	oz/plant	0.012
lb/A	lb/100 ft. of row	0.0184
Yield in lb/100 ft of row	lb/A	55
Yield in pt/100 ft of row	lb/A	73

Resource Materials

GENERAL REFERENCES FOR ALL SMALL FRUITS

The Berry Grower's Companion 2000. B.L. Bowling. Timber Press 133 S.W. Second Avenue, Suite 50, Portland, OR 97204; 503-227-2878 $29.

Cornell Small Fruit Recommendations and Small Fruit Insect/Disease Fact Sheets. Cornell University Resource Center, 7 Cornell Business & Tech. Park, Ithaca NY 14850. Call for prices and order forms 607-255-2080.

Field Guide to On-Farm Composting 1999. Mark Dougherty, ed. NRAES-Natural Resource, Agriculture, and Engineering Service, Cooperative Extension, 152 Riley-Robb Hall, Ithaca, NY 14853-5701. 118 pp. Available from the UMass Extension Bookstore, Draper Hall/UMass, Amherst, MA 01003. 413-545-2717. $14.

Journal of Small Fruit and Viticulture. R. E. Gough, ed. Quarterly Journal. Haworth Press, Inc. 10 Alice St., Binghamton, NY 13904. $34/year.

Mechanical Weed Control for Vegetable Growers, 1996. Vern Grubinger, UVM Extension, 157 Old Guilford Rd., Brattleboro, VT 05301. $12.

Midwest Small Fruit Pest Management Handbook, 2010. M. A. Ellis, and C. Welty, eds. The Ohio State University Cooperative Extension Publications, 385 Kottman Hall, 2021 Coffey Rd., Columbus Ohio 43210, 614-292-1607 $10

On-Farm Composting Handbook 1992. Robert Rynk, ed. NRAES-Natural Resource, Agriculture, and Engineering Service, Cooperative Extension, 152 Riley-Robb Hall, Ithaca, NY 14853-5701. 186 pp. Available from the UMass Extension Bookstore, Draper Hall/UMass, Amherst, MA 01003. 413-545-2717. $20.

The Mid-Atlantic Berry Guide for Commercial Growers. 2010. Kathy Demchak, editor. Pennsylvania State University Collage of Agriculture. Publications Distribution Center, 112 Agricultural Admin. Building, University Park, PA 16802. 814-865-6713. 270 pp. $20

Steel in the Field, A Farmer's Guide to Weed Management, 2001. Greg Bowman (ed.), 122 pages, Sustainable Agriculture Publications, Hills Bldg., UVM, Burlington, VT 05405. $18.

Weeds of the Northeast. 1997. R. H. Uva, J. C. Neal, and J. M. DiTomaso. Cornell University Resource Center, 7 Cornell Business & Tech. Park, Ithaca NY 14850. 607-255-2080. 397 pp. $29.95

Beneficial Organisms

Suppliers of Beneficial Organisms in North America. 1997. Charles D. Hunter. California Environmental Protection Agency, Dept. of Pesticide Regulation, Environmental Monitoring and Pest Management Branch, 1020 N. Street, Rm. 161, Sacramento CA 95814-5624. Free Downloadable from www.cdpr.ca.gov/docs/ipminov/bensuppl.htm. 32 pp.

Koppert Biological Systems
28465 Beverly Road
Romulus, MI 48174
(734) 641-3763
e-mail: info@koppertonline.com
www.koppertonline.com

The Green Spot Ltd.
93 Priest Rd.
Nottingham, NH 03290
(603)942-8925
http://greenmethods.com/site/

Biocontrol Network
5116 Williamsburg Rd.
Brentwood, TN 37027
(800)441-2847
http://www.biconet.com

Sources of IPM Traps, Lures, and Baits

Great Lakes IPM
10220 Church St., NE
Vestaburg, MI 48891
(517)268-5693
http://www.greatlakesipm.com/

Gempler's, Inc
211 Blue Mounds Rd., P.O. Box 270
Mr. Horeb, WI 53572
(800)332-6744
http://www.gemplers.com/

IPM Labs
4230 West Swift, Suite 106
Fresno, CA 93722
(209) 276-4250

Trece, Inc.
7569 Highway 28 West
P.O. Box 129
Adair, OK 74330
(866)785-1313
http://www.trece.com

Sources of Various Field Supplies

Orchard Equipment and Supply Co. (OESCO) (for hand tools, sprayer equipment and replacement supplies, respirators and personal protection equipment, and other farm supplies)
P.O. Box 540. Rte. 116
Conway, MA 01341
(800)634-5557
https://www.oescoinc.com/

BioQuip Products (for aspirators, sweepnets, beating sheets, vials, magnifiers, and other collection supplies)
17803 LaSalle Avenue
Gardena, CA 90248
(310)324-0620
http://www.bioquip.com/PreHome.asp

Forestry Suppliers, Inc. (for magnifiers, optivisors, tally counters, and other field supplies)
P.O. Box 8397
Jackson, MI 39284
(800)752-8460
http://www.forestry-suppliers.com/

Bird-X, Inc. (scare devices, balloons, reflective tape, netting)
300 N. Elizabeth St.
Chicago, IL 60607
(800)860-0473
http://www.brid-x.com

Belle Terre Irrigation (drip irrigation supplies and design)
8142 Champlin Rd.
Sodus, NY 14551
(866)478-3747
http://www.dripsuply.com

Charles W. Harris Co., Inc (drip irrigation supplies and design)
72 Tower Hill Rd.
Brimfield, MA 01010
(413)668-5006
jbpeeler@tmlp.com

Pollinators

Koppert Biological Systems, Inc.
8465 Beverly Road
Romulus, MI 48174-2497
(734) 641-3763
http://www.koppertonline.com

The Green Spot Ltd.
93 Priest Rd.
Nottingham, NH 03290
(603)942-8925
http://greenmethods.com/site/

Entomo-Logic, Inc.
21323 232nd St. SE
Monroe, WA 98272-8982
(425) 280-0423
http://www.entomologic.com

International Pollination Systems USA
16645 Plum Rd.
Caldwell, ID 83605
208-990-1390
http://www.pollination.com/

Strawberry

Compendium of Strawberry Diseases. 1998. John Maas, editor. American Phytopathological Society. St. Paul, MN. 98 pp. $59 1-800-328-7560.

Ohio Strawberry Production, Management and Marketing Manual. Bull. No. 1726-436. Ohio Coop. Ext. Service Publications Office. 258 Kottman Hall, 2021 Cottey Rd., Columbus, OH 43210-1044. 43 pp. $6.55 postpaid.

Strawberry IPM Scouting Procedures: a Guide to Sampling for Common Pests in New York State. 1991. Joseph Kovach, Wayne Wilcox, Arthur Agnello, and Marvin Pritts. Cornell University Resource Center, 7 Cornell Business & Tech. Park, Ithaca NY 14850. 607-255-2080. $10

Strawberry Production Guide. 1998. Marvin Pritts and David Handley, eds. Northeast Regional Agricultural Engineer-

ing Service. Available from the UMass Extension Bookstore, Draper Hall/UMass, Amherst MA 01003. 413-545-2717. 178 pages (115 color photos) $50 postpaid.

Dayneutral Strawberry Production Guide. 1989. Marvin Pritts and Adam Dale. Cornell Cooperative Extension, Distribution Center, 7 Research & Technology Park, Ithaca NY. 14850. $10.

Highbush Blueberry

Compendium of Blueberry and Cranberry Diseases. 1995. Frank L. Caruso and Donald C. Ramsdell, editors. American Phytopathological Society. St. Paul. MN. 87 pp. $59 1-800-328-7560.

Highbush Blueberry Production Guide. 1992. Marvin Pritts and James Hancock, eds. Northeast Regional Agricultural Engineering Service. Available from the UMass Extension Bookstore, Draper Hall/UMass, Amherst MA 01003. 413-545-2717. 200 pages (168 color photos) $45 postpaid.

The Highbush Blueberry and its Management. 1994. Robert E. Gough. Haworth Press, Inc. 10 Alice St., Binghampton NY 13904.

Brambles

Bramble Production Guide. 1989. Marvin Pritts and David Handley, eds. Northeast Regional Agricultural Engineering Service. Available from the UMass Extension Bookstore, Draper Hall/UMass, Amherst MA 01003. 413-545-2717. 189 pages (115 color photos) $38 postpaid.

Brambles-Production, Management and Marketing 1999. R. C. Funt, M. A. Ellis, and C. Welty, eds. The Ohio State University Cooperative Extension Publications, 385 Kottman Hall, 2021 Coffey Rd., Columbus Ohio 43210-1044, 614-292-1607.

Compendium of Raspberry and Blackberry Diseases and Insects. 1991. Michael A. Ellis, Richard H. Converse, Roger N. Williams and Brian Williamson, eds. American Phytopathological Society. St. Paul MN. 100 pp. $35 1-800-328-7560.

Bramble Production: The Management and Marketing of Raspberries and Blackberries, 1995. Perry C. Crandall. Haworth Press, Inc. 10 Alice St. Binghamton NY 13904.

Grape

New York and Pennsylvania Pest Management Recommendations for Grapes. Publications Distribution Center, The PennState Univ., 112 Ag. Admin. Bldg., University Park, PA 16802. 814-865-6713. $5.

Compendium of Grape Diseases. 1988. Roger C. Pearson and Austin C. Goheen, editors. American Phytopathological Society. St. Paul, MN. 93 pp. $35 1-800-328-7560.

Grape IPM in the Northeast. Cornell University Resource Center, 7 Cornell Business & Tech. Park, Ithaca NY 14850. 607-255-2080. $30

Wine and Juice Grape Varieties for Cool Climates. 1993. Bruce Reisch, et al., Cornell Cooperative Extension, Finger Lakes Grape Program, 110 Court St., Penn Yan NY 14527. $4.75.

Table Grape Varieties for Cool Climates. 1993. Bruce Reisch, et al., Cornell Cooperative Extension, Finger Lakes Grape Program, 110 Court St., Penn Yan NY 14527. $4.75.

Videos

Vegetable Farmers and Their Weed-Control Machines. The Center for Sustainable Agriculture at the Univ. of VT, 590 Main St., Burlington, VT 05405. 802-656-5459. 76 minutes. $10.

Farmers and Their Diversified Horticultural Marketing Strategies. The Center for Sustainable Agriculture at the Univ. of VT, 590 Main St., Burlington, VT 05405. 802-656-5459. 120 minutes. $15

Unusual Small Fruits

Uncommon Fruits Worthy of Attention. 1991. Lee Reich. Addison-Wesley Pub. Co., Inc. $10.

Currants and Gooseberries Culture Guide, 1997. Monique Audette and Michel Lareau, CPVQ, 845 rue Marie-Vicorin, Saint-Nicholas Quebec, Canada. G7A 3S8 (418)831-7474. $10

The Lingonberry: a versatile Wild Cranberry, 1996. Richard St. Pierre. Dept. of Hort Science, Univ. of Saskatchewan, Saskatoon, Saskatchewan Canada.

Currants, Gooseberries and Jostaberries, A Guide for Growers, Marketers, and Researchers in North America, 2005. Daniel Barney and Kim Hummer, Haworth Press. $34.95.

Organic Small Fruit Production:

Strawberry -
http://attra.ncat.org/attra-pub/PDF/strawberry.pdf
http://www.nysipm.cornell.edu/organic%5Fguide/strawberry.pdf

Blueberry -
http://attra.ncat.org/attra-pub/PDF/blueberry.pdf
http://www.nysipm.cornell.edu/organic%5Fguide/blueberry.pdf

Raspberry -
http://attra.ncat.org/attra-pub/PDF/bramble.pdf

Grape -
http://attra.ncat.org/attra-pub/PDF/grapes.pdf

Ohio Organic Small Fruit Disease Mgt Guidelines -
http://www.oardc.ohio-state.edu/fruitpathology/organic/

Sample Plant Diagnostic Submission Form

Name _____ Date: _____
Address: _____ Phone/Fax: _____
_____
E-mail: _____
( ) homeowner ( ) grower ( ) landscaper/arborist ( ) other

SAMPLE FOR:
( ) Insect Identification
( ) Disease Diagnosis
( ) Weed Identification
( ) Cultural Information:
( ) General ( ) Pruning
( ) Fertilizing
( ) Other _____

PLANT/CROP NAME: _____
_____
(scientific or common name) (cultivar or variety)

FOR PLANT DISEASES: Description of problem:
_____
_____
_____
_____

Symptoms:
Plant Part(s) Affected:
( ) wilting ( ) leaf spot
( ) yellowing ( ) stems
( ) flowers
( ) blight ( ) streak
( ) leaf drop ( ) roots
( ) fruit
( ) galls
( ) mosaic ( ) marginal burn
( ) leaves ( ) entire plant
( ) rot
( ) other:_____

Distribution of Problem:

Nature of Planting:
( ) entire planting ( ) edge of planting
( ) field
( ) nursery
( ) random
( ) low areas
( ) yard
( ) orchard
( ) wet areas
( ) high areas
( ) forest ( ) greenhouse
( ) dry areas
( ) sunny areas
( ) indoors ( )_____
( ) shaded areas
( )_____

Soil Type:
Drainage:
Watering:
( ) sandy ( ) clay
( ) good
( ) never
( ) loamy
( ) mulch ( ) fair
( ) daily- morning
( ) potting mix
( ) poor
( ) daily- evening
( ) _____
( ) _____
( ) _____

t( ) none applied
( ) rate and date(s) applied: _____

Make additional copies of this form and send with submission to diagnostic clinic listed in the General Information Section of the New England Small Fruit Pest Management Guide or contact appropriate clinic for a copy of their form(s) and fee information.

Spray Mixture Compatibility Notes

This information is offered only as a general guide, and does not apply to pesticidal efficacy of mixtures. Read the label for specific crops or situations. Compatibilities indicated may be changed by certain adjuvants, different formulations, combinations of more than 2 materials, and environmental factors such as temperature and humidity.

- When potential compatibility is indicated, mini-mum agitation should be provided in all cases.
- Designations apply to at least one formulation of specified products. In cases where compatibility differs among formulations, the most conservative designation has been given. Defer to respective labels in all cases.
- Unless otherwise noted on the label, use soon after mixing, preferably in systems with continuous agitation.
- Physical compatibility: Although there may be no chemical incompatibility between the active ingredients of 2 given pesticides, some formulations of these products may not be physically compatible. This is particularly true whenmixing at high concentrations and when mixing wettable powders with emulsifiable concentrates. It is recommended that a small batch of a proposed mixture be prepared before making tank combinations, to check for unacceptable physical reactions.

Directions

- Each product is assigned its own number, which appears to the left of the product name along the left-hand side of the chart.
- The product numbers (but not their names) are also listed along the top of the chart.
- To find the symbol representing our best information about compatibility of two products, find one product's number along the side and the other along the top, and trace the perpendicular lines to intersect in the table body.
- The compatibility values, which are highlighted in alternate rows and columns for ease in counting, are defined in the Key at the bottom. Also note the following footnotes:
  - —§Bt products include Agree, Biobit, Deliver, Dipel, and Javelin, among others.
  - —§Fixed copper products include C-O-C-S, Kocide, Champ, Cuprofix Disperss, and Tenn-Cop, among others.
- The "Mancozeb/+rams" category includes Dithane, Manzate, Penncozeb, as well as Thiram and Ziram.
- The "Pyrethroids" category refers primarily to Ambush and Pounce (permethrin).
- "Sterol Inhibitors" includes Rubigan, Nova, Indar, Orbit, Procure, and Elite.

Suggested Mixing Sequence

Always mix different spray materials in the following order, starting with:

1. water soluble bags (WS)
2. water dispersible granules and dry flowables (WDG, DF)
3. wettable powders (WP)
4. liquid flowables (L, F, FC)
5. sprayable concentrates (S, SC, LC)
6. emulsifiable concentrates (EC)
7. surfactants, oils, and adjuvants Do not add oils, surfactants, or emulsifiable concentrates prior to dry formulations, or lumping may occur.

Table 56. Spray Mixture Compatibility

(*Courtesy of The Pennsylvania State University*)

	PRODUCT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	Acramite	-	1	1	1	1	1	1	1	1	4	1	1	1	4	1	1	1	1	1	1	4	4	1
2	Actara	1	-	1	1	1	1	1	1	1	4	1	1	1	4	1	1	1	1	1	1	4	4	1
3	Apollo	1	1	-	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	4	4	1
4	*Asana	1	1	1	-	1	1	1	1	1	4	1	1	1	4	1	1	1	1	1	1	4	4	1
5	Assail	1	1	1	1	-	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	4	4	1
6	*AgriMek	1	1	1	1	1	-	1	1	1	4	1	1	1	4	1	1	1	1	1	1	4	4	1
7	Avaunt	1	1	1	1	1	1	-	1	1	4	1	1	1	4	1	1	1	1	1	1	4	4	1
8	*azinphosmethy	1	1	1	1	1	1	1	-	1	4	1	1	1	4	1	1	1	1	1	1	1	1	1
9	§Bt	1	1	1	1	1	1	1	1	-	3	1	1	1	1	1	1	3	1	1	1	3	1	1
10	§Bordeaux mix	4	4	4	4	4	4	4	4	3	-	3	1	3	1	1	4	3	3	3	4	2	1	4
11	captan	1	1	1	1	1	1	1	1	1	3	-	1	1	1	1	1	1	1	5	1	1	4	1
12	carbaryl	1	1	1	1	1	1	1	1	1	3	1	-	1	1	1	1	1	1	4	1	1	1	1
13	*Carzol	1	1	1	1	1	1	1	1	1	3	1	1	-	1	1	1	1	4	1	1	1	4	1
14	chlorothalonil	4	4	1	4	1	4	4	4	1	1	1	1	1	-	1	1	1	1	4	4	5	4	1
15	chlorpyrifos	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	1	1	1	1	1	1
16	*Danitol	1	1	1	1	1	1	1	1	1	4	1	1	1	4	1	-	1	1	1	1	4	4	1
17	*diazinon	1	1	1	1	1	1	1	1	3	3	1	1	1	4	1	1	-	1	1	1	1	2	1
18	dimethoate	1	1	1	1	1	1	1	1	1	3	1	1	4	1	1	1	1	-	1	1	2	4	1
19	*endosulfan	1	1	1	1	1	1	1	1	1	3	5	4	1	4	1	1	1	1	-	1	1	1	1
20	Esteem	1	1	1	1	1	1	1	1	1	4	1	1	1	4	1	1	1	1	1	-	4	4	1
21	ferbam	4	4	4	4	4	4	4	1	1	2	1	1	1	5	1	4	1	2	1	4	-	1	1
22	§fixed copper	4	4	4	4	4	4	4	1	1	1	4	1	4	4	1	4	2	4	1	4	1	-	4
23	*Imidan	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1	4	-
24	*Intrepid	1	1	1	1	1	1	1	1	1	4	1	1	1	4	1	1	1	4	1	1	4	4	1
25	Kelthane	1	1	1	1	1	1	1	1	1	4	1	1	1	4	1	1	1	4	1	1	4	4	1
26	*Lannate	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	4	1	4	1	1
27	lime	4	4	4	4	4	4	4	3	1	1	3	3	3	1	1	4	4	3	3	4	2	1	3
28	malathion	1	1	4	1	4	1	1	1	1	3	5	1	4	1	1	1	1	1	1	1	1	1	1
29	mancozeb/rams	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1
30	Nexter	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1
31	§oil	1	1	1	1	1	1	1	5	4	1	3	4	1	1	1	1	1	4	4	1	1	4	6
32	*Provado	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1
33	*pyrethroids	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	4	4	1
34	Rovral	4	4	4	4	4	4	1	1	1	1	1	1	1	1	4	1	1	1	1	4	1	1	1
35	Savey	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	4	4	1
36	Spintor	1	1	1	1	1	1	1	1	1	4	1	1	1	4	1	1	1	1	1	1	4	4	1
37	sterol inhibitors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
38	§sulfur	1	1	1	1	1	1	5	1	3	1	6	1	1	1	1	1	1	1	1	1	1	1	1
39	*Supracide	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
40	§Surround	1	1	1	1	1	1	1	1	1	3	1	1	1	4	1	1	1	1	1	1	4	4	1
41	Syllit	1	1	1	1	1	1	1	5	1	3	1	1	1	4	4	1	1	1	5	1	1	4	1
42	Topsin	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1	3	1
43	*Vendex	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	4	1	1	1	4	1
44	*Vydate	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
45	*Warrior	1	1	1	1	1	1	1	1	4	1	1	1	1	4	1	1	1	1	1	1	1	1	4

KEY:
1 = Potentially compatible, if used as directed
2 = Decomposes on standing, residual action reduced
3 = Not compatible or causes general injury
4 = CAUTION: Compatibility not clear, or questionable or not known
5 = Use wettable powder forms
6 = May cause injury; refer to comments in "Fruit Crop Protectants" or crop's "General Pest Management Considerations"

Table 56. Spray Mixture Compatibility (continued)

(*Courtesy of The Pennsylvania State University*)

	PRODUCT	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
1	Acramite	1	1	1	4	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1
2	Actara	1	1	1	4	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1
3	Apollo	1	1	1	4	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1
4	*Asana	1	1	1	4	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1
5	Assail	1	1	1	4	4	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1
6	*AgriMek	1	1	1	4	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1
7	Avaunt	1	1	1	4	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1
8	*azinphosmethyl	1	1	1	3	1	1	1	5	1	1	1	1	1	1	5	1	1	5	1	1	1	1
9	§Bt	1	b	1	1	1	1	1	4	1	1	1	1	1	1	3	1	1	1	1	1	1	4
10	§Bordeaux mix	4	1	3	1	3	1	1	1	3	3	1	4	4	1	1	1	3	3	3	3	1	1
11	captan	1	4	1	3	5	1	1	3	1	1	1	1	1	1	6	1	1	1	1	1	1	1
12	carbaryl	1	1	1	3	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	*Carzol	1	1	1	3	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	chlorothalonil	4	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	4	4	1	1	1	4
15	chlorpyrifos	1	4	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1	4	1	1	1	1
16	*Danitol	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	*diazinon	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	dimethoate	4	4	1	3	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1	4	1	1
19	*endosulfan	1	1	4	3	1	1	4	4	1	1	1	1	1	1	1	1	1	5	1	1	1	1
20	Esteem	1	1	1	4	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1
21	ferbam	4	1	4	2	1	1	1	1	1	4	1	4	4	1	1	1	4	1	1	1	1	4
22	§fixed copper	4	4	1	1	1	1	1	1	4	4	1	4	4	1	1	1	4	4	3	4	1	4
23	*Imidan	1	1	1	3	1	1	1	6	1	1	1	1	1	1	1	4	1	1	1	1	1	1
24	*Intrepid	-	1	1	4	1	1	1	4	1	1	1	1	1	1	4	1	1	1	1	1	1	1
25	Kelthane	1	-	1	2	4	1	1	4	1	1	4	1	1	1	4	4	1	1	1	1	1	1
26	*Lannate	1	1	-	3	4	4	1	4	1	4	1	1	1	1	4	1	1	4	1	1	1	1
27	lime	4	2	3	-	3	1	1	1	3	3	1	4	4	1	1	1	4	3	3	4	1	4
28	malathion	1	4	4	3	-	5	1	1	1	1	1	4	1	1	1	1	1	1	1	6	1	1
29	mancozeb/rams	1	1	4	1	5	-	1	4	1	4	1	1	1	1	1	1	1	1	1	1	1	1
30	Nexter	1	1	1	1	1	1	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	§oil	4	4	4	1	1	4	1	-	4	1	1	1	4	1	3	1	1	1	1	1	1	1
32	*Provado	1	1	1	3	1	1	1	4	-	1	1	1	1	1	1	1	1	1	1	1	1	1
33	*pyrethroids	1	1	4	3	1	4	1	1	1	-	1	1	1	1	4	1	1	4	1	1	4	1
34	Rovral	1	4	1	1	1	1	1	1	1	1	-	4	4	1	1	1	4	1	1	1	4	4
35	Savey	1	1	1	4	4	1	1	1	1	1	4	-	1	1	1	1	1	1	1	1	1	1
36	Spintor	1	1	1	4	1	1	1	4	1	1	4	1	-	1	4	1	1	1	1	1	1	1
37	sterol inhibitors	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	3	1	1	1	1	1
38	§sulfur	4	4	4	1	1	1	1	3	1	4	1	1	4	1	-	1	1	6	1	1	1	1
39	*Supracide	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	-	4	1	1	1	1	1
40	§Surround	1	1	1	4	1	1	1	1	1	1	4	1	1	3	1	4	-	1	1	1	1	1
41	Syllit	1	1	4	3	1	1	1	1	1	4	1	1	1	1	6	1	1	-	1	1	1	1
42	Topsin	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	1
43	*Vendex	1	1	1	4	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	4	1
44	*Vydate	1	1	1	1	1	1	1	1	1	4	4	1	1	1	1	1	1	1	1	4	-	1
45	*Warrior	4	1	1	4	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	-

KEY:

1 = Potentially compatible, if used as directed
2 = Decomposes on standing, residual action reduced
3 = Not compatible or causes general injury
4 = CAUTION: Compatibility not clear, or questionable or not known
5 = Use wettable powder forms
6 = May cause injury; refer to comments in "Fruit Crop Protectants" or crop's "General Pest Management Considerations"

Tips for Laundering Pesticide-Contaminated Clothing

Air

Hang garments outdoors to air.

Prerinse

Use one of three methods:
1. Hose off garments outdoors.
2. Rinse in separate tub or pail.
3. Rinse in automatic washer at full water level.

Pretreat (heavily soiled garments)

Use heavy-duty liquid detergent.

Washer Load

Wash garments separate from family wash.
Wash garments contaminated with the same pesticide together.

Load Size

Wash only a few garments at once.

Water Level

Use full water level.

Water Temperature

Use hot water, 140 ˚F or higher.

Wash Cycle

Use regular 12-minute wash cycle.

Laundry Detergent

Use a heavy-duty detergent.
Use amount recommended on package or more for heavy soil or hard water.

Rinse

Use a full warm rinse.

Dry

Line drying is preferable, to avoid contaminating dryer.

Clean Washer

Run complete, but empty, cycle.
Use hot water and detergent.

Rewash

Rewash contaminated garments two or three times before reuse for more complete pesticide removal.

Other Tips

Remove contaminated clothing before entering enclosed tractor cabs.

Remove contaminated clothing outdoors or in an entry. If a granular pesticide was used, shake clothing outdoors. Empty pockets and cuffs.

Save clothing worn while handling pesticides for that use only. Keep separate from other clothing before, during, and after laundering.

Wash contaminated clothing after each use. When applying pesticides daily, wash clothing daily.

Never use the "sudsaver" feature on your machine when laundering pesticide-soiled clothes.

Clean gloves, aprons, boots, rigid hats, respirators, and eyewear by scrubbing with detergent and warm water.

Rinse thoroughly and hang in a clean area to dry.

Take these precautions when handling contaminated clothing:

- Ventilate area.
- Avoid inhaling steam from washer or dryer.
- Wash hands thoroughly.
- Consider wearing chemical-resistant gloves.
- Keep out of reach of children and pets.

(***Source:*** *2010 New England Tree Fruit Pest Management Guide*)

In case of suspected pesticide poisoning get prompt medical attention!

POISON INFORMATION CENTER TELEPHONE NUMBER

The previous numbers for state poison control centers have been replaced by a national toll-free Poison Information number. The equipment automatically detect the area code you are calling from, and connects to your state's center.

Some Poison Information Center numbers will eventually be terminated. In the event of a PESTICIDE POISONING, please use the new number:

1-800-222-1222

YOUR LOCAL AMBULANCE _____

YOUR LOCAL HOSPITAL _____

YOUR DOCTOR _____

YOUR LOCAL FIRE DEPARTMENT _____

State contact # to report pesticide spill _____

For Chemical Information:

Animal Poison Control Center 1-800-548-2423 ($45 fee)
National Pesticide Information Center 1-800-858-7378 (9:30 am - 7:30 pm EST)
EPA Emergency National Response Center 1-800-424-8802
EPA Emergency Treatment - Spills 1-617-223-7265
CHEMTREX - for emergency spill, fire, leak, and explosion 1-800-424-9300