UNIVERSITY OF MASSACHUSETTS EXTENSION

NEW ENGLAND
Small Fruit
PEST MANAGEMENT GUIDE

MANAGING DISEASES, INSECTS, AND WEEDS ON SMALL FRUITS
2003 - 2004

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NEW ENGLAND
SMALL FRUIT PEST MANAGEMENT GUIDE
2003-2004

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Contents

GENERAL INFORMATION 1
Table 1. General information for some small fruit crops. 1
SOIL FERTILITY MANAGEMENT 1
PLANT NUTRIENTS— MAJOR AND MINOR 4
Figure 1. The nitrogen cycle. 4
Table 2. Nitrogen credits for previous crops. 5
Table 3. Nitrogen credits from manure incorporated before planting. 5
SOIL ORGANIC MATTER 7
Table 4. Typical carbon-to-nitrogen ratios. 8
COVER CROPS AND GREEN MANURES 8
Table 5. Pre-plant cover-crop seeding dates and rates. 9
GUIDELINES FOR ORGANIC FERTILIZATION 10
Table 6. Nutrient recommendations for small fruit crops. 11
ORGANIC CERTIFICATION 12
ABOUT PEST MANAGEMENT 12
INTEGRATED PEST MANAGEMENT (IPM) 14
BIOLOGICALS 18
NATURAL ENEMIES AND PREDATORS 18
PESTICIDE SAFETY AND USE 19
Table 7. Toxicity information for some pesticides commonly used in small fruits. 21
Table 8. Approximate dilutions for small volumes of spray mixes 24
WATER 25
FUMIGATION: MATERIALS AND RISKS 26
Table 9. Fumigant rates and spectrums of activity. 26
WEED MANAGEMENT GENERAL NOTICE 27
WEED MANAGEMENT 27
STRAWBERRIES 30
GENERAL INFORMATION 30
Table 10. Recommended optimal soil characteristics for growing strawberries. 30
Table 11. Number of strawberry plants per acre at different spacings. 31
Table 13. Critical nutrient values for strawberry tissue analysis. 31
Table 12. Critical freeze temperatures for strawberries based on stage of growth. 31
DISEASES 32
Table 14. Strawberry cultivar descriptions. 36
Table 15. Efficacy of fungicides for strawberry disease management. 37
INSECTS 37
Table 16. Monitoring for tarnished plant bug in strawberry. 38
Table 17. Revision to monitoring procedure for strawberry bud weevil (clipper). 38
Table18. Tentative guidelines for thrips in strawberries. 39
Table 19. Efficacy of common insecticides and miticides used in strawberries. 43
Table 20. Strawberry pest management schedule. 45
WEED MANAGEMENT 51
Table 21. Weed management in strawberries during the transplant and establishment years. 52
Table 22. Transplant year strawberry herbicide calendar. 55
Table 23. Herbicide efficacy against common weeds in strawberries. 56
HIGHBUSH BLUEBERRIES 57
GENERAL INFORMATION 57

Table 24. Recommended optimal soil characteristics for growing blueberries. 57
Table 25. Amount of sulfur (in lb/100 sq ft)a required to lower soil pH for blueberries. 57
Table 26. Number of blueberry plants per acre at different spacings. 58
Table 27. Critical nutrient values for blueberry tissue analysis. 58
DISEASES 58
Table 28. Highbush blueberry variety descriptions for New England. 59
Table 29. Fungicides registered for use on blueberries and their primary uses. 62
INSECTS 64
VERTEBRATE PESTS 66
Table 30. Highbush blueberry pest management schedule. 68
WEED MANAGEMENT 71
Table 31. Weed management for highbush blueberries 72
BRAMBLES 74
GENERAL INFORMATION 74
Table 32. Recommended optimal soil characteristics for growing brambles. 74
Table 33. Number of bramble plants per acre at different spacings. 74
Table 34. Postplant nitrogen recommendations for brambles. 75
Table 35. Critical nutrient values for bramble tissue analysis. 75
DISEASES 75
VIRUSES 77
Table 36. Relative hardiness and disease resistance for bramble varieties. 78
INSECTS 79
Table 37. Bramble pest management schedule. 81
Table 38. Fall bearing (primocane fruiting) bramble pest management schedule. 84
WEED MANAGEMENT 86
Table 39. Weed management in brambles. 87
GRAPES 89
GENERAL INFORMATION 89
Table 41. Critical nutrient values for grape petiole analysis. 89
Table 40. Recommended optimal soil characteristics for growing grapes. 89
DISEASES 90
Table 42. Grape black rot infection table. 90
Table 43. Effectiveness of fungicides on grape diseases. 93
INSECTS 94
Table 44. Effectiveness of insecticides for management of grape insects. 95
Table 45. Grape pest management schedule. 97
WEED MANAGEMENT 101
Table 46. Weed management in grapes during the planting year and in established vineyards. 102
RISK MANAGEMENT INFORMATION 105
Introduction to Risk Management for Berry Growers 105
New England Fruit Crop Insurance Fact Sheet 106
New England Companies Offering Crop Insurance 107
Adjusted Gross Revenue Pilot Program 108
Insurance Coverage for Organic Crops 110
APPENDICES 111
Table 47. Poisoning hazard to honey bees of common small fruit pesticides. 111
Table 48. Relative toxicity of pesticides to mite predators 112
Table 49. Conversion factors to convert from one unit to another. 113
RESOURCE MATERIALS 113
SAMPLE PLANT DIAGNOSTIC FORM 116

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.

Table 1. General information for some small fruit crops.

	Strawberries	Summer Red Raspberries	Blackberries	Blueberries
Expected yield	10,000-20,000 lb/A	2,000-7,000 lb/A	3,000-7,000 lb/A	6,000-12,000 lb/A
Age to maturity	2 years	3 years	3 years	6-8 years
Life of planting	5 years	6 years or more	6 years or more	More than 50 years
Hardiness	-35˚F	-20˚F	0˚F	- 20˚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)
Spacing	18" x 48"	2' x 8' to 3' x 12'	3' x 10' to 5' x 12'	4' x 10' to 5' x 12'
Plants/Acre	7,260	1,210-2,722	726-1,452	726-1,089

Source: Cornell University

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

CONNECTICUT
Soil Testing Lab (1)
2019 Hillside Rd.
Storrs, CT 06269
Telephone: 860-486-4274
www.canr.uconn.edu/plsci/stlab.htm

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

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

NEW HAMPSHIRE
University of NH Analytical Services Lab (1,2,3,4)
Spaulding Hall, Room G-54, 38 College Rd.
Durham NH 03824
Telephone: 603-862-3210
www.ceinfo.unh.edu/agriculture/documents/soiltest.htm

VERMONT
UVM Agricultural & Environmental Testing Laboratory (1,2,3,4)
219 Hills Building, UVM
Burlington VT 05405
Telephone: 802-656-3030, 800-244-6402
Website: http://pss.umv.edu/ag_testing/

PRIVATE
Woods End Research Lab, Inc. (1,3,4)
1850 Old Rome Rd., P.O. Box 297
Mt. Vernon, ME 04352
Telephone: 207-293-2457
Website: http://woodsend.org/

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

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.

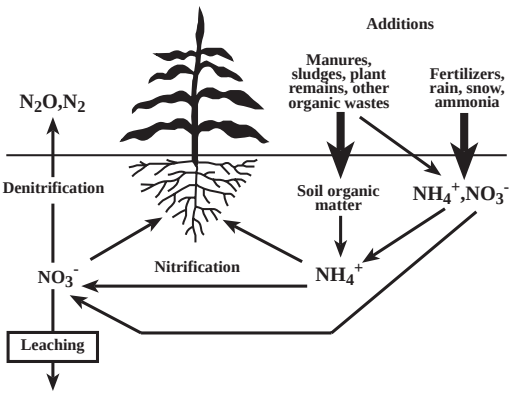

Figure 1. The nitrogen cycle.

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

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

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.

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.

Table 3. Nitrogen credits from manure incorporated before planting.

	TIME(S) OF APPLICATION (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.

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.

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 magnesium 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

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

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 5 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.

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

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

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 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

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 nitrate or calcium nitrate	Be sure plants are growing well prior to application
	1+	70 lb/A at renovation, 30 lb/A early Sept.	ammonium nitrate or urea	Adjust fall amount based on leaf analysis
RASPBERRIES (summer bearing)				
	0	25-35 lb/A 4 weeks after planting	calcium nitrate	Avoid touching plants with fertilizer
	1	35-55 lb/A in May, or split between May and June	urea, ammonium nitrate	Use higher amount on sandier soils or if irrigation is used
	2+	40-80 lb/A in May, or split between May and June	urea, ammonium nitrate	Use higher amount on sandier soils or if irrigation is used
RASPBERRIES (fall bearing)				
	0	25 lb/A 4 weeks after planting and 25 lb/A in August	calcium nitrate	Avoid touching plants with fertilizer
	1	50-80 lb/A split between May and June	urea, ammonium nitrate	Use higher amount on sandier soils or if irrigation is used
	2+	70-100 lb/A split between May and June	urea, ammonium nitrate	Use higher amount on sandier soils or if irrigation is used Adjust with leaf analysis
BLUEBERRIES				
	0	Do not fertilize newly planted blueberries		
	1	15 lb/A	ammonium sulfate or urea	Soil should be adjusted to pH=4.5 prior to planting
	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

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 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. This market is increasingly looking for certification to substantiate product claims. Federal legislation will soon require certification of food products that are labeled as organic except for producers who gross under $5,000.

It is likely that many state groups currently administering organic certification programs will continue to do so with USDA approval in the future. In New England, NOFA (Natural Organic Farmers Association) and MOFGA (Maine Organic Farmers and Gardeners Association) have certification programs; in some cases, these programs are operated in conjunction with the cooperation of a state agriculture department. If you are considering organic production, you should obtain and examine the written standards that detail the allowable practices and materials. These are available from your state certification contact, listed below.

CT	Pat Beardsley, P.O. Box 11, Gaylordsville, CT 06755 (203) 929-3080
MA	Ed McGlew, 140 Chestnut St., W. Hatfield, MA 01088 (413) 247-9264
ME	MOFGA, P.O. Box 2176, Augusta, ME 04338 (207) 622-3118
NH	Vickie Smith, NHDAMF, P.O. Box 2042, Concord, NH 03302-2042 (603) 271-3685
RI	Dan Lawton, Div. of Ag., 22 Hayes St., Providence RI 02908 (401) 222-2771
VT	NOFA, P.O. Box 697, Bridge St., Richmond, VT 05477 (802) 434-4122

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 management of a pest problem 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=plant disease identification, I=insect identification, N=nematode analysis, W=weed identification)

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
www.caes.state.ct.us/Plantoffice/plantoffice.htm
(203)974-8601
Cost: call to inquire

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)581-3880
Cost: call to inquire

MASSACHUSETTS

Nematode Assay and Disease Diagnostic Laboratory (D,N)
Dept. of Microbiology/UMass
Fernald Hall, Rm 109
Amherst, MA 01003

www.umassvegetable.org/grower_services/diagnostics_lab.html
(413)545-1045
Cost $25

NEW HAMPSHIRE

The Plant Diagnostic Lab (D,I,W)
Plant Biology Dept.
241 Spaulding Hall/UNH
Durham, NH 03824
(603)862-3200
http://ceinfo.unh.edu/agriculture/documents/agplhlth.htm
Cost: $12

RHODE ISLAND

University of Rhode Island Cooperative Extension Education Center (D,I)
3 East Alumni Avenue
Kingston, RI 02881

www.uri.edu/ce/ceec/plantclinic.html
(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/services.htm
Cost: $15

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 multitactic 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

From:*1999 Midwest Small Fruit Pest Management Handbook,* Bulletin 861

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 imita-

tions 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.

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

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 degrees F for many insect species or 43 degrees 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 degrees F and the average temperature for the day is 70 degrees 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 degrees F and the low was 60 degrees 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 degrees 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 degrees F
   threshold temperature = 50 degrees 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 degrees F
   low daytime temperature = 45 degrees F
   threshold temperature = 50 degrees F
   The threshold temperature of 50 degrees 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 degrees F optimum temperature = 95 degrees F

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

Biologicals

There are a number of natural products and biological control agents that can be used to manage insect pests of small fruit. Biological pesticides (bio-rational pesticides) are formulated products that use toxins produced by plants (such as rotenone, pyrethrum, sabadilla, ryania, and azadirachtin), or by microorganisms (bacteria, fungi, and viruses). **Rotenone** is extracted from the roots of leguminous plants in the genera Derris spp. (Far East), or Lonchocarpus spp. (Amazon basin, South America). Indigenous people use crude extracts that contain rotenone to kill fish in streams and lakes for harvest, so be careful when using this material around fish bearing waters. *Pyrethrum* is extracted from the flowers of *Chrysanthemum coccineum* and *C. carneum.* The primary source of pyrethrum today is Kenya. Pyrethrum is a complex of chemicals that attack the peripheral nervous system, and for this reason it is quick acting. *Sabadilla* is extracted from the seeds of the lily-like Schoenocaulon officinale plant from Venezuela. The principal ingredients of sabadilla are two alkaloids, cevadine and veratridine. **Ryania** is extracted from ground stemwood of Ryania speciosa. These botanical insecticides have broad-spectral activity, and are harmful to insect pests and their natural enemies, while azadirachtin is toxic to insect pests and relatively nontoxic to biological control agents. **Azadirachtin** is one of a complex of chemicals (over 20 active ingredients) extracted from the foliage and seeds of the neem tree (*Azadirachta indica*).

There are different strains of ***Bacillus thuringiensis*** that produce different Cry toxins. These toxins must be ingested to be effective, and are most effective against small larvae, and for this reason timing of applications is critical. Toxins from B.t. aizawai (Cry 1C) and B.t. kurstaki (Cry 1Aa, 1Ab, & 1Ac) are toxic to Lepidoptera larvae (caterpillars), while the B.t. tenebrionis (Cry 3A) toxin is specific to Colorado potato beetle larvae, and a few other leaf feeding beetles that attack trees. Formulated products may contain toxins from one or more strains of Bt. There are other products derived from toxins produced by microorganisms.

Spinosyns are a naturally derived group of chemicals produced by an Actinomycete fungus, Saccharopolyspora spinosa, and formulated as **SpinTor**. This product is very effective against a wide range of insect pests, yet relatively harmless to natural enemies. Avermectin B1a (80%) and B1b (20%) are formulated as **Agri-Mek**. The avermectins are derived from another Actinomycete fungus, Streptomyces avermitilis. Agri-Mek is very effective against spider mites, and relatively harmless against natural enemies.

Several bio-rational products have been developed by reacting oleic acid with potassium hydroxide to produce potassium oleate, or soap. Potassium oleate used to be available as "Castile Soap." This soap was made from olive oil, while the insecticidal soaps are made from oleic acid extracted from animal fat. The insecticide product is **Safer's Soap**, and the herbicide is **Scythe**.

Natural Enemies and Predators

There are a wide range of insect natural enemies, such as other insects, nematodes, fungi, and viruses that can be used to control insect pests of small fruits. Many of these biological control agents are mass-produced and available for purchase. The cost-effectiveness of using biological control agents varies significantly from one situation to another. Often, inundative releases of purchased organisms are quite expensive and may not "pay-off" if another alternative is available. It is best to take advantage of existing populations of natural enemies and to engage in practices that protect these agents. To this end, it is important to use "soft insecticides," i.e. insecticides that are toxic to the target pest, but relatively nontoxic to natural enemies, or to use other practices that disrupt the pest's biology, such

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 immediately in a safe manner and place. Contact your state Department of Agriculture for current regulations.

as crop rotation, delayed planting, early harvest, etc. However, if a release of a commercially reared natural enemy, predator, parasite, or competitive agent is desired, contact your local Extension Specialist for recommended sources.

Pesticide Safety and Use

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 the current label.

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

Label Formulations

The recommendations within this publication list only one formulation of a given pesticide. Growers should be aware of other formulations. The rates to be applied are on the product label.

Before Using Pesticides

Read and post safety rules and list of poison control centers. See instructions on safe storage of pesticides on page 22. 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 page 20.

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.

Poison Control Centers for the New England states are listed on the back cover. **For an emergency, EPA maintains a 24-hour medical consultation service in case of pesticide poisoning: 1-800-424-8802.** DO NOT use this number on a regular basis; use it only in an emergency! It is set up primarily for consultation with physicians and other health professionals needing assistance in the treatment of pesticide poisonings.

Reentry Period

Be sure all treated areas are posted to keep out unauthorized persons.

Persons must not be allowed to enter the treated area until after sprays have dried or dusts have settled and until sufficient time has passed to insure that there is no danger of excessive exposure. Follow label reentry restrictions. At no time during the reentry period are farm workers allowed to enter the treated area to engage in activity requiring substantial contact with the treated crop. Protective clothing and safety equipment may be needed for all persons, including farm workers, entering the treated areas.

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 usually 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: Before applying a pesticide on a target pest not listed on the label for a given crop, contact your regional and state Extension specialist for clarification.

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 the label: Contact your state pesticide regulatory agency for instructions on disposal of chemicals.

Farm Worker Protection Standards for Pesticides

According to EPA regulations, it is the responsibility of the owner or employer to protect regular farm workers as well as pesticide handlers, crop advisers, and the other people performing tasks on the farm from exposure to pesticides.

Employers are required to post the location of the nearest emergency medical facility and information about each pesticide application including location and description of treated area, product name, EPA number, active ingredient(s), time and date of application, and the restricted entry interval (REI). Pesticide information must remain posted for 30 days after the REI expires, and workers must be informed about the location of the posting. Commercial handlers must inform employers and provide the appropriate posting information before they apply pesticides.

Employers must make prompt transportation available in the case of suspected pesticide poisoning. Information from the pesticide label and about how the exposure occurred must also be provided by the employer. Decontamination sites must be provided to workers and handlers. Supplies for washing, including sufficient water, soap and towels must be available within one-quarter mile of workers. Eye-flush water must be immediately available if protective eyewear is required.

Nontrained and unprotected workers must be kept out of treated areas by the employer. Employees must protect early-entry workers by taking protective actions including waiting at least four hours after the application before entering and providing clean personal protective equipment and instruction in its use. Unless they are certified applicators, all workers must be provided training specified by the worker protection standards if they enter treated areas during part of the REI.

Oral or posted warnings must advise each worker who might enter within one-quarter mile of a treated area during application or an REI. Warning signs must be visible at all usual entrances, include specific warning words and symbols, and be a certain size and color.

Handlers who mix, load, flag, apply, assist with application or dispose of pesticides are protected by

Table 7. Toxicity information for some pesticides commonly used in small fruits[†].

Trade Name[(tm)]	Common Name	Manufacturer	EPA Reg #	Signal Word	REI	Crops (PHI)
INSECTICIDES/MITICIDES						
Acramite	bifenzate	Uniroyal	400-503	Caution	12 hrs	S(1), G(14)
*Agri-mek	abamectin	Syngenta	100-898	Warning	12 hrs	S(3), G(21)
*Asana	esfenvalerate	DuPont	352-515	Warning	12 hrs	B(14)
Aza-Direct	azadirachtin	Gowan	71908-1-10163	Caution	4 hrs	S(0), B(0), R(0), G(0)
Biobit	*Bacillus thuringiensis*	Valent	73049-54	Caution	4 hrs	S(0), R(0), G(0)
*Brigade	bifenthrin	FMC Corp.	279-3108	Warning	4 days[a]	S(0), R(3)
*Capture	bifenthrin	FMC Corp.	279-3069	Warning	4 days[a]	R(3)
Confirm	tebufenozide	Dow AgroSciences	707-238	Caution	4 hrs	B(14), R(14)
*Danitol	fenpropathrin	Valent	59639-35	Warning	24 hrs	S(2), G(21)
*Diazinon	diazinon	Various	Various	Caution[z]	24 hrs	S(5), G (28)
Dipel	*Bacillus thuringiensis*	Valent	73049-39	Caution	4 hrs	S(0), B(0), R(0), G(0)
Dibrom	naled	Amvac	5481-479	Danger/Poison	48-72hrs	S(1), G(3)
*Guthion	azinphos methyl	Bayer CropScience	264-733	Danger/Poison	2-21 days[Δ]	S(5), B(7), R(14), G(21)
Imidan	phosmet	Gowan	10163-169	Warning	24 hrs	B(3), G(14)
Kelthane	dicofol	Dow AgroSciences	62719-414	Danger[z]	48 hrs	S(3), G(7)
*Lannate	methomyl	DuPont	352-342	Danger[z]	2 - 7 days**	S(3), B(3), G(14)
*Lorsban	chlorpyrifos	Dow AgroSciences	62719-220	Warning	24 hrs	S(21)
M-Pede	insecticidal soap	Dow AgroSciences	53219-6	Warning	12 hrs	S(0), B(0), R(0), G(0)
Malathion	malathion	Various	Various	Warning	12hrs	S(3), B(1), R(1), G(3)
Phaser	endosulfan	Bayer CropScience	264-638	Danger/Poison	24 hrs	S(4), B(PH), G(7)
PyGanic	pyrethrins	MGK Co.	1021-1771	Caution	12 hrs	S(0), B(0), R(0), G(0)
Pyrellin	pyrethrins/rotenone	Webb Wright Corp.	30573-2	Caution	12 hrs	S(0), B(0), R(0), G(0)
Pyrenone	pyrethrins	Bayer CropScience	432-1033	Caution	12 hrs	S(.5), B(.5), R(.5), G(.5)
Savey	hexythiazox	Gowan	10163-250	Caution	12 hrs	S(3), R(3)
Sevin	carbaryl	Various	Various	Caution	12 hrs	S(7),B(7), R(7), G(7)
*Sniper	azinphos methyl	UAP - Platte	34704-691	Danger/Poison	2-21 days[Δ]	S(5), B(7), R(14), G(21)
Spintor	spinosad	Dow AgroSciences	62719-294	Caution	4 hrs	S(1), B(3),R(1), G(7)
Stylet Oil (JMS)	Paraffinic oil	JMS Flower Farms	65564-1	Caution	4 hrs	S(0), B(0), R(0), G(0)
Surround	kaolin	Engelhard Corp.	70060-14	Caution	4 hrs	B, R, G[b]
Thiodan	endosulfan	Universal Crop Protection		1386-338-72693	Warning	48 hrs S(4)
Vallero	cinnemaldehyde	Emerald BioAgricultre	58866-12-65626	Caution	4 hrs	S(0), B(0), R(0), G(0)
*Vendex	hexakis	Griffin	1812-413	Danger/Poison	48 hrs	S(1), G(28)
FUNGICIDES						
Abound	azoxystrobin	Syngenta	100-1098	Caution	4 hrs	B(0), G(14)
Armicarb	potassium bicarbonate	Helena	5905-541	Caution	4 hrs	S(0), B(0), R(0), G(0)
Aliette	fosetyl-aluminum	Bayer CropScience	264-516	Caution	12 hrs	S(0), B(0), R(60)
Bayleton	triadimefon	Bayer CropScience	3125-320	Caution	12 hrs	G(14)
Bravo Ultrex	chlorothalonil	Syngenta	50534-201-100	Danger	12hrs	B(42)
Cabrio	pyraclostrobin	BASF	7969-187	Caution	24 hrs	S(0), B(0), R(0)
Captan	captan	Various	Various	Danger	4 days***	S(0), B (0), G(0)
Dithane	mancozeb	Dow AgroSciences	707-241	Caution	24 hrs	G(66)
Elevate	fenhexamid	Arvesta	66330-35	Caution	12 hrs	S(0), B(0), R(0), G(0)
Elite	tebuconazole	Bayer CropScience	264-749	Warning	12 hrs	G(14)
Ferbam	ferbam	UCB Chemical Corp.	45728-7	Caution	24 hrs	G(7)
Flint	trifloxystrobin	Bayer CropScience	264-777	Caution	12 hrs	G(14)
Kaligreen	potassium bicarbonate	Nichimen America	70231-1	Caution	4 hrs	S(1), B(1), R(1),G(1)
Kocide	copper hydroxide	Griffin	1812-334	Danger	24 hrs	S(0), B(0), R(0)
Kumulus	sulfur	Micro Flo Co.	51036-352	Caution	24 hrs	S(0), B(0), R(0), G(0)
Lime Sulfur	calcium polysulfide	UAP - West	34704-321	Danger	48 hrs	B(0), R(0)
Manzate	mancozeb	Griffin	1812-415	Caution	24 hrs	G(66)
Nova	systhane	Dow AgroSciences	62719-411	Warning[z]	24 hrs	S(0), R(0), G(14)
Oxidate	hydrogen dioxide	Biosafe Systems	70299-2	Danger	0	S(0), B(0), R(0), G(0)
Procure	triflumizole	Uniroyal	400-431	Caution	12 hrs	S(1), G(7)
Quadris	azoxystrobin	Syngenta	100-1098	Caution	4 hrs	S(0),
Ridomil	mefenoxam	Syngenta	100-801	Caution	48 hrs	S(30), B(30), G(45)
Ronilan	vinclozolin	BASF	7969-85	Caution	12 hrs	R(9)
Rovral	iprodione	Bayer CropScience	264-453	Caution	24 hrs	S(PB), B(0), R(0), G(7)
Rubigan	fenarimol	Gowan	62719-134	Warning[z]	12 hrs	G(30)
Serenade	*Bacillus subtillis*	AgraQuest	69592-7	Caution	4 hrs	B(0), G(0)
Stylet Oil (JMS)	paraffinic oil	JMS Flower Farms	65564-1	Caution	4 hrs	S(0), B(0), R(0), G(14)
Sulfur	sulfur	Various	Various	Caution	24 hrs	S(0), B(0), R(0), G(0)
Switch	cyprodinil/fludioxonil	Syngenta	100-953	Caution	12 hrs	S(0)

Table 7. Toxicity information for some pesticides commonly used in small fruits[†].

Trade Name[(tm)]	Common Name	Manufacturer	EPA Reg #	Signal Word	REI	Crops (PHI)
FUNGICIDES CONTINUED...						
Syllit	dodine	UAP - Platte	55260-5-34704	Danger	48 hrs	S(14)
Thiolux	sulfur	UAP West	100-835	Caution	24 hrs	S(0), B(0), R(0), G(0)
Thiram	thiram	UCB Chem Corp.	45728-24	Caution	24 hrs	S(3)
Topsin-M	thiophanate-methyl	Cerexagri	4581-403	Caution	12 hrs	S(1)
Trilogy	neem oil	Certis USA	70051-2	Caution	4 hrs	S(0), B(0), R(0), G(0)
Vanguard	cyprodinil	Syngenta	100-828	Caution	12 hrs	G(7)
Ziram	ziram	Cerexagri	4581-140	Danger	48 hrs	B(ns), G(21)
HERBICIDES						
Casoron	dichlobenil	Uniroyal	400-168	Caution	12 hrs	B(ns), G(ns)
Dacthal	DCPA	Amvac Chem. Co.	5481-490	Caution	12 hrs	S(ns)
Devrinol	napropamide	United Phosphorus Inc.	100-1035-70506	Caution	12 hrs	S(ns), B(ns), R(ns), G(ns)
Formula 40	2,4-D	Nufarm Americas	228-357	Danger	48 hrs	S(ns)
Fusilade	fluazifob	Syngenta	100-1070	Caution	12 hrs	S(nb), B(nb), R(nb), G(nb)
Gallery	isoxaben	Dow AgroSciences	62719-145	Caution	12 hrs	B(nb), R(nb), G(nb)
Goal	oxyfluorfen	Dow AgroSciences	62719-424	Danger	24 hrs	S(pp), G(nb)
*Gramoxone Extra	paraquat	Syngenta	10182-280	Danger	24 hrs	S(21), B(21), R(21), G(ns)
Karmex	diuron	Griffin	1812-362	Caution	12 hrs	B(ns), R(ns), G(ns)
*Kerb	pronamide	Dow AgroSciences	707-159	Caution	24 hrs	B(ns), R(ns), G(ns)
Poast	sethoxydim	BASF	7969-58	Warning	12 hrs	S(7), B(30), R(45), G(50)
Princep	simazine	Syngenta	100-526	Caution	12 hrs	B(pf), R(pf), G(pf)
Rely	glufosinate ammonium	Bayer CropScience	264-652	Warning	12 hrs	G(14)
Roundup	glyphosate	Monsanto	524-445	Warning	12 hrs	B(14), R(14), G(14)
Scythe	pelargonic acid	Dow AgroSciences	53219-7	Warning	12 hrs	S(0), B(0), R(0), G(0)
Select	clethodim	Valent	59639-3	Warning	24 hrs	S(4), B(nb)
Sinbar	terbacil	Dupont	352-317	Caution	12 hrs	S(70), B(70), R(70)
Solicam	norflurazon	Syngenta	100-849	Caution	12 hrs	B(60), R(60), G(60)
Surflan	oryzalin	Dow AgroSciences	62719-112	Caution	24 hrs	B(ns), R(ns), G(ns)
Touchdown	sulfosate	Syngenta	100-1117	Caution	12 hrs	B(30), R(30), G(30)

[(tm)]Where trade names are used, no discrimination is intended and no endorsement is implied. Not a complete list.
[†]Based on 2003 Label Registrations.

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

[†††] potassium salts of fatty acids

[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.
* Restricted Use Pesticide.
**REI for Grapes is 7 days
***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.

standards similar to those just listed, as well as by the requirement of voice contact at specified intervals in some cases.

For more information, contact your State Pesticide Coordinator, local EPA office or your Cooperative Extension Specialist.

Toxicity of Pesticides

All pesticides are poisonous. However, some are more toxic and/or hazardous than others. The toxicity of the pesticide is usually stated in the precaution on the label. For example, a skull and crossbones figure is always found on the label of highly toxic (Toxicity Class I) materials. Those of medium toxicity (Toxicity Class II) carry less severe warning statements.

The toxicity of a pesticide is expressed in terms of oral and dermal LD_{50}. LD_{50} 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 animal (mg/kg of body weight). The lower the LD_{50} value, the more toxic the material. Oral LD_{50} is the measure of the toxicity of pure pesticide when administered internally to test animals. Dermal LD_{50} is the measure of the toxicity of pure pesticide when applied to the skin of test animals. Generally, an oral application is more toxic than a dermal application.

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.

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

Poisoning Information

Adapted from the *1999 Ohio Vegetable Production Guide*

Poison Control Centers are listed on back page. Make sure your doctor has a copy of this list and 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.

Table 7 lists pesticides that are commonly recommended for small fruit, insect, disease and weed control along with their signal word (warning, caution, danger) and re-entry interval (REI).

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 adsorb to other pesticides.

Store pesticides in a cool (between 40 and 80˚ F), dry, well-ventilated area that is not accessible to

Formulation	General Signs of Deterioration
Emulsifiable Concentrate (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.
Wettable Powders, Suspendable Powders (WP, SP)	Excessive lumping; powder does not suspend in water.
Dry Flowable, Granular (DF,G)	Excessive lumping or caking.

After freezing, place pesticides in warm storage (50˚to 80˚F, or 10˚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.

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 feet. 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. See chart at the bottom of page 23 for signs of quality deterioration.

Sprayer Calibration

- Clean sprayer and replace all worn parts.
- Fill tank with clean water.
- Adjust spray pressure and speed of tractor for nozzle size and output, using manufacturer's recommendations.
- Spray 1/8 acre (5,445 sq ft). Distance of travel will vary with boom width. For example, a 22-ft boom must travel 248 feet to cover 1/8 acre, or an air blast sprayer covering a 44-ft swath must travel 124 feet to cover 1/8 acre. Note: There are several potential disadvantages in using air-blast sprayers.

Table 8. 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

Contact Cooperative Extension for more information.
- Measure amount of water needed to refill tank. The above amount was applied to 1/8 acre; thus, eight times this amount is the gallonage per acre.
- Adjustment in gallonage may be made either by varying tractor speed or changing nozzle sizes or pressure. Recalibrate after making an adjustment.
- Calculate acres to be covered by tank of spray mixture and add required amount of pesticide for total area to be sprayed.

Calibrate your spray equipment frequently and regularly.

Adjuvants

Adjuvants are nonpesticide chemicals that are added to pesticides or to pesticide spray mixtures to improve their chemical or physical characteristics. Adjuvants can reduce or eliminate many spray application problems by performing specific functions. These functions include spreading, wetting, sticking, reducing drift, buffering, improving compatibility, reducing foaming and improving the effectiveness of certain pesticides. Although several adjuvants perform more than one function, no one adjuvant can perform all of these functions.

The most important source of information you have to determine whether or not to use an adjuvant is the pesticide label. Some prohibit the use of adjuvants. Sometimes the use of an adjuvant will cause severe crop injury or loss. Some labels provide no mention of adjuvants; in this case, consult the manufacturer or pesticide dealer.

The most common types of adjuvants are nonionic surfactants, crop oil concentrates, spreader/stickers, drift control agents, buffering agents, compatibility agents and foam-reducing agents.

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

Table 9. Fumigant rates and spectrums of activity.

			LEVELS OF CONTROL			
Common Name	Trade Name	Rates/A	nematodes	fungi	weeds	Comments
metam-sodium	Vapam HL	37.5-75.0 gal	yes	yes	yes	Water-soluble liquid that decomposes to a gaseous fumigant. Efficacy affected by soill moisture, temperature, texture, and organic matter content.
dazomet	Basamid	265-350 lb	yes	yes	yes	Granular product. Incorporate thoroughly in soil. Toxic gasses released following absorption of soil moisture by product. Affected by same factors as metam-sodium. 365 days-to-harvest limitation.
1,3 dichloropropene	Telone II	15-27 gal (annual plantings) 27-35 gal (perennial plantings)	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]	Most effective for control of weeds, soil-born diseases; nematodes, and insects; requires plastic seal; highly toxic.

[a] Sealing with plastic and/or using higher rates may also result in good weed control

Courtesy of PennState University’s 2002-2004 Commercial Berry Production & Pest Management Guide

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.

Weed Management General Notice

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.

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.

Weed Management

Herbicides

Herbicides 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 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.

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. 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 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. On sandy, loamy or high organic matter soils, the soil should not crust and modern seeders should still work satisfactorily. On heavy clay soils, crusting could make this technique unusable.
- If you're using transplants, 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 seeding or 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 after seeding or transplanting, 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, in cases where Roundup or Touchdown is registered, it can also be used for control of perennial weeds, such as quackgrass and dock, prior to soil preparation. After application, delay tillage for three to five days. There is no residual weed control. Rates vary considerably. See the label for directions. 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 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 prior to crop emergence 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 pathogens and insects, inhibiting spray penetration, and maintaining high humidity in the strawberry leaf canopy.

Good soil and air drainage are essential. 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, 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 by 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 carefully. 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 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

Table 10. 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.*

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 13.

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.

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.

Table 11. Number of strawberry plants per acre at different spacings.

In Row Spacing	Spacing Between Rows 36 inch	40 inch	42 inch
3 inches	58,080	52,293	49,783
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 12. Critical freeze temperatures for strawberries based on stage of growth.

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

Table 13. 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	>0.40
K (%)	1.20	1.50	2.00	2.50	>2.50
Ca (%)	0.60	0.70	1.50	1.70	>1.70
Mg (%)	0.25	0.30	0.45	0.50	>0.50
Mn (ppm)	40	50	150	250	>250
Fe (ppm)	50	60	150	250	>250
Cu (ppm)	5	7	10	20	>20
B (ppm)	20	30	60	70	>70
Zn (ppm)	15	20	35	50	>50

Source: PennState University

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.

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 had not previously been reported to cause fruit rot in New England but 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 caused by *Xanthomonas fragariae*. Relatively little is known about the disease. It is not thought to be a consistent annual problem. Rather, it has only recently appeared in New England. 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 soilborne 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

Table 14. Strawberry cultivar descriptions.

		— DISEASE RESISTANCE[a] —				
CULTIVAR	SEASON	VERTICILLIUM WILT	RED STELE	LEAF DISEASES[b]	POWDERY MILDEW	COMMENTS
Earliglow	Early	R	R	R	PR	Standard for early varieties; small berry size; excellent flavor, moderate production.
Veestar	Early	R	S	S	S	Early, good flavor and appearance, berry size medium to small, productive.
Sable	Early	U	R	U	U	Early, good flavor, productive. Berry size medium.
Annapolis	Early	R	R	S	S	Large fruit, good flavor but soft, moderate yields.
Mohawk	Early	R	R	R	R	Fruit size may be small, and yields low in far northern areas.
Northeaster	Early	R	R	R	S	Large fruit, strong flavor. Moderate plant vigor.
Honeoye	Early-mid	S	S	PR	S	Large fruit, productive; has performed well in New England, but lack of red stele resistance a concern. Tends to become soft in hot weather; flavor distinctive.
Guardian	Mid	R	R	R	S	Very productive, firm large fruit, sometimes rough (uneven) looking. Botrytis is generally more prevalent. Tends to get a "long neck" which breaks down and is an easy entry for slugs and sap beetles.
Redchief	Mid	PR	R	R	R	Productive, with good color and size. Flavor average. Excellent disease resistance.
Lester	Mid	S	R	R	R	Productive good berry size though size tends to "run down" quickly. Flavor is good. Lacks adequate winter hardiness for northern New England.
Cavendish	Mid	R	R	R	U	Mid-season, productive. Disease resistant, uneven ripening habit.
Kent	Mid	S	S	PR	S	Extremely productive berry with large firm fruit. Tends to yield fruit in middle of rows, resulting in high rot, so keep rows narrow. Flavor average.
Jewel	Mid	S	S	R	PR	Large soft fruit, can be very dark. Tends to soften in hot weather.
Mira	Mid	S	R	R	R	Large fruit, good quality.
Allstar	Mid-late	R-T	R	T	T	Productive, elongated flavorful berries. Has a lighter color than most berries. Good fruit size.
Seneca	Mid-late	S	S	U	U	Fruit large, irregular and firm; plants moderately vigorous.
Mesabi	Mid-late	R	R	PR	U	Productive with good berry size, scarlet color, good flavor. Plants compact, resistant to 5 races of red stele.
Winona	Mid-late	S	R	R	R	Large fruit, vigorous plant.
Lateglow	Late	R	R	PR	S	Productive, good berry size and flavor. First berries extremely large. Low yields in northern New England.
Tribute	Day Neutral	PR	R	T	R	Slightly later than 'Tristar,' with larger fruit. Flavor not as strong, and plants are more vigorous.
Tristar	Day Neutral	R	R	T	R	Bears an early crop, smaller than 'Tribute,' flavor is excellent. Flesh and skin firm. Moderate vigor. Size reduced when weather is too hot.

[a] I=intermediate, PR= partially resistant, R= resistant, S= susceptible, T= tolerant, U= unknown. [b]Includes leafscorch and leafspot.
Adapted from Pennsylvania State University, Small Fruit Production and Pest Management Guide. Used by permission.

Table 15. Efficacy of fungicides for strawberry disease management.

Fungicide[a]	Gray mold	Leather rot	Leaf spot	Powdery mildew	Anthracnose	Red Stele
Alone						
Aliette[b]	-	+++	-	-	-	++
Cabrio	++	?	+++	+++	++++	?
Captan	+++	+	+++	-	+++	-
Elevate[c]	++++	-	-	-	-	-
Quadris[d]	+	+	+++	+++	++++	-
Ridomil Gold	-	+++	-	-	-	++++
Sulfur	-	-	-	+++	-	-
Switch[e]	++++	-	-	-	++	-
Thiram	+++	+	++	-	+++	-
Topsin-M[c]	+++	-	+++	++	+	-
In Combination						
Topsin-M plus captan	+++	+	+++	+++	+++	-
Topsin- M plus thiram	+++	+	+++	+++	++	-
Elevate plus captan	+++	+	++	-	++	-
Elevate plus thiram	+++	+	++	-	+	-

Efficacy rating system: ++++= excellent; +++=good; ++=moderate; +=poor; - =not effective or not labeled for this use; ?+ unknown.

[a] *This is not a complete listing of the fungicides used for strawberry disease management.*
[b] *Limited efficacy data available for Aliette.*
[c] ..... *Fungicide that is prone to develop resistant strains of fungi For resistance management, Topsin-M, and Elevate are recommended only in combination with an unrelated fungicide such as; captan or thiram.*
[d] *This material is extremely phytotoxic to McIntosh and some other apple varieties and should not be used near apples or in a sprayer also used on apples.*
[e] *Note restrictive plant back regulations ont his product.*

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.

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

Table 16. Monitoring for tarnished plant bug in strawberry.

	NUMBER OF FLOWER CLUSTERS INFESTED			
NUMBER OF CLUSTERS EXAMINED	CONTROL NOT REQUIRED	KEEP SAMPLING	CONTROL REQUIRED	
			Low threshold 0.15 nymphs/cluster =2% damage	High threshold* 0.25 nymphs/cluster =4% 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.*
Source: N. J. Bostanian, Agriculture and Agri-Food Canada, St. Jean-sur-Richelieu, P. Q. Courtesy Pam Fisher, Ontario Ministry of Food and Agriculture.

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 *Integrated Pest Management for Strawberries in the Northeastern United States* for more detail on tarnished plant bug life cycle and sampling (ordering information at the end of this guide). See pest management schedule for recommended materials and timing. Do not apply insecticides during bloom.

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 above, 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 fine 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

Table 17. Revision to monitoring 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

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 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 mouthparts 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.

Table18. Tentative 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 trhips/50 fruit for shipping berries
	2 thrips/berry = 20% damage

***Source**: Kevin Lynch, New Brunswick Agriculture, 1995. Courtesy Pam Fisher, Ontario Ministry of Food and Agriculture*

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 48 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) infect the plants as a result of wounding. 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 by weakening the root systems which are then more susceptible to winter injury and disease infection. Root feeding is done by the larvae (grubs) of these weevils. The grubs are whitish and crescentshaped, 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 to the plants unless the plants are already weakened from previous feeding of larvae on the crown. It is the root and crown feeding that is most injurious. 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 availabe 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. 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, Popilla japonica, Rhizotrogus majalis*, 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 plant and also provides an entry site for root 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 midAugust. 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 sets of legs, grow up to 1/2" 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 very difficult, though Heterorhabditis spp. nematodes may 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

Table 19. Efficacy of common insecticides and miticides used in strawberries.

Insecticide	Aphid	Clipper	Cyclamen mite	Leafhopper	Leaf-roller	Root weevil	Root-worm	Sap beetle	Spittlebug	Thrips	TSSM	TPB	White grub
Agri-mek (abamectin)	-	-	+	-	-	-	-	-	-	-	+++	-	-
Brigade (bifenthrin)	*	++	-	-	*	+	-	++	+++	-	+	+++	-
Cythion (malathion)	*	-	-	*	*	*	-	+	-	*	*	++	-
Danitol (fenpropathrin)	-	-	-	-	-	-	-	-	+++	-	+	+++	-
Dibrom (naled)	*	-	-	-	*	-	-	-	*	*	*	+++	-
Guthion (azinphosmethyl)	*	++	-	-	+++	-	-	-	++	-	-	-	-
Kelthane (dicofol)	-	-	++	-	-	-	-	-	-	-	+++	-	-
Malathion (malathion)	*	-	-	*	*	*	-	-	-	-	-	++	-
Phaser (endosulfan)	*	-	+++	-	-	-	-	-	*	-	-	*	-
Sevin (carbaryl)	-	*	-	-	++	-	-	-	++	-	-	*	*
Sniper (azinphosmethyl)	*	++	-	-	+++	-	-	-	++	-	-	-	-
Thiodan (endosulfan)	+++	-	+++	-	-	-	-	-	+++	-	-	+++	-
Vendex (fenbutatinoxide)	-	-	-	-	-	-	-	-	-	-	+++	-	-

*+++= Highly effective; ++=moderately effective; +=slightly effective; *= labeled but insufficient data; -=not labeled.*

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 7" 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 20. Strawberry pest management schedule†.

Early Spring, Pre-bloom (New leaves are expanding and blossom buds are visible)			
Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Strawberry bud weevil (clipper)	*Lorsban 4E, 2 pt (21) Sevin 50WP, 2 - 4 lb (7) Sniper 50PVA, 1 lb (5) Brigade WSB, 6.4 to 32.0 oz (0) PyGanic EC 1.4, 16oz (0)	Spot treatments can be made if infestation is localized to field perimeter. See text on bud weevil above for details of scouting methods.	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) Sabadilla 0.8WP, 6 lb (0)	See text on tarnished plant bug for details of scouting and sampling methods.	**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/or** Spittlebug	Thiodan 3EC, 1.3 qt (4) Phaser 3EC, 1.3 qt (4) Phaser 50WSB, 2 lb (4) Malathion 57EC, 1.5-3 pt (3) Cythion 8E,1.5-2 pt (3) *Danitol 2.4 EC, 10 2/3 oz (2) Brigade WSB, 6.4 - 32 oz (0) PyGanic EC 1.4, 16oz (0)		**Thiodan** 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**	Guthion Solupak 50WP, 1 lb (5) *Sniper 50 PVA, 1 lb (5)	Suggested action threshold is 1 spittle mass per square foot of row.	Spittlebugs generally do not damage fruit but make them less appealing to pickers. **Guthion** has 48 hr REI for mowing, irrigating, and scouting; and 4 day REI for all other activities.
Two-spotted spider mite (TSSM)	Vendex 4 L,1 pt (1) Kelthane 35WP, 1-3 lb (2) *Agri–Mek 0.15EC, 16 oz (3) Sunspray Ultra-Fine Oil, 1% (0) JMS Stylet Oil, 3 qts (0) Trilogy (Neem) 1-2% solution (0) Predatory mite release, rate varies (0)	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.	Adjust spray volume and nozzle placement to assure maximum coverage of tops and undersides of leaves. **Agri–Mek** applied at a lower rate (6 oz.) selectively kills spider mites. The full rate (16 oz.) kills predatory mites. **Sun Spray Ultra-Fine Oil** and **JMS Stylet Oil** require direct contact to kill mites and their eggs. Spray oils at no less than 400 psi. Oils are phytotoxic in combination with captan or Morestan residues and should not be used in a spray program with Kelthane or within 14 days of a sulfur application.

Table 20 continued. Strawberry pest management schedule[†].

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Early Spring, Pre-bloom (New leaves are expanding and blossom buds are visible)			
Leaf spot Leaf scorch Leaf blight	**Combine**: Topsin-M 70WP, 8 oz (1) *plus* Captan 50WP, 3 lb (0) *or* Thiram 65WP, 3.5 lb (3) **Or, use alone**: Syllit 65W, 1.5 - 2 lbs. (14) Cabrio EG 12-14 oz (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. **Syllit** (dodine) must be applied with sufficient water (250-300 gal) for thorough plant coverage.
Red Stele	Ridomil Gold EC, 1 pt (0) Aliette WDG, 2.5 - 5 lb (0)		Early spring or fall applications are recommended for control of red stele. Use sufficient water to move the **Ridomil** into the root zone. There is no preharvest interval for this application.
Spring, Pre-bloom to Early-bloom (From bud expansion to 10% bloom)			
Tarnished plant bug (TPB)	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 48 at end of guide on toxicity of pesticides to beneficial insects.
Anthracnose	Quadris F, 6.2-15.4 oz (0) Cabrio EG 12-14 oz (0) Captan 50WP, 6 lb (0) Thiram 65WP, 5 lb (3)	This disease is becoming more prevalent in many southern New England locations **Quadris F** may be applied no more than 4 times per year and must be alternated with a fungicide with a different mode of action. **Quadris F** will cause injury to McIntosh and other apple varieties if subject to drift of if the same sprayer is used. **Use extreme caution to avoid crop damage to apples.** Do not make more than two (2) sequential applications of **Cabrio EG** before alternating to a non-strobilurin fungicide with another mode of action. **Captan** has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period.	

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Botrytis gray mold	**combine either**: Topsin-M 70WP, 8 oz (1) *or* Elevate 50WDG, 1.5 lb (0) **plus** Captan 50WP, 3-4 lb (0) *or* Thiram 65WP, 2.5 lb (3) **or, use alone:** Elevate 50WDG, 1.5 lb (0) Switch 62.5 WG,11-14 oz(0) Captan 50WP, 6 lb (0) Stylet Oil, 3 qts. (0) Trilogy, 1-2% solution (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 the Botrytis fungus. 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 conditions are wet. No more than 4 applilcations/ year of **Switch 62.5WG** may be made. See label for other restrictions. **Captan** has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period. Neither **Elevate** nor **Topsin-M** should be used alone for season long control of Botrytis to avoid developing resistance. Do not apply more than 6 lbs of Elevate per acre per season.
Thrips	SpinTor 2SC, 4-6 oz (1)	See text for scouting information.	
Full-bloom (From 10% bloom until no blossoms remain)			
Tarnished plant bug (TPB)	**No spray** - may be lethal to pollinators	Do not mow hay or alfalfa in adjacent fields if possible since this will encourage plant bugs to move into strawberry field.	DO NOT SPRAY INSECTICIDES DURING BLOOM
Botrytis gray mold	Same as Spring, Pre-bloom to early-bloom treatments above	See above.	See above.
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	Malathion 57EC, 1.5-2 pt (3) Cythion 8E,1.5-2 pt (3) *Brigade WSB, 6.4-32 oz (0) PyGanic, 16oz (0)	Bait baskets with overripe fruit or balls of bread dough at intervals around edges of field to catch beetles as they migrate in. Brigade can be applied up to 12 hrs before harvest.	
Spittlebugs	Dibrom 8E, 1 pt (1) Thiodan 3EC, 1.3 qt (4) Guthion Solupak 50WP, 1 lb (5) *Sniper 50 PVA, 1 lb (5) *Danitol 2.4EC, 10 2/3 oz (2) *Brigade WSB, 6.4 - 32.0 oz (0)	Suggested action threshold is 1 spittle mass per square foot of row.	Spittlebugs generally do not damage fruit but make them less appealing to pickers. See note on **Thiodan** under tarnished plant bug comments. **Guthion** has 48 hr REI for mowing, irrigating, and scouting; and 4 day REI for all other activities.

Table 20 continued. Strawberry pest management schedule[†].

Early Summer (Fruit-set to harvest)			
Pest	**Spray Material, Rate/A (pre-harvest interval)**	**Cultural Practices and Scouting Notes**	**Comments**
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	See Spring, pre-bloom to early bloom.	See Spring, pre-bloom to early bloom.
Leather rot	Ridomil Gold EC, 1 pt (0) Aliettte WDG, 2.5 - 5 lb (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.
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.**	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 above.	See Spring, pre-bloom to early bloom above.	See Spring, pre-bloom to early bloom above.

Summer (Post-harvest)

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Strawberry root worm; adult	*Guthion 50WP, 1 lb (5) 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.
Root weevils (various species)	*Brigade WSB, 8-16 oz (0) *Steinernema* spp., 3 billion/A (0) *Heterorhabditis* spp., 1/2 - 1 billion/A (0)	Rotate to non-susceptible crop for 3 years. Plow under old beds as soon as possible to avoid spread of the insect to new beds. Adult beetles hide in the soil during the day and feed at night.	The highest rate (16 oz.) of **Brigade** is needed to obtain control of black vine weevil (best if applied at night). 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. Contact your local Extension Specialist information about obtaining biologicals.
Two-spotted spider mite (TSSM)	Kelthane 35WP, 1-3 lb (3) *Agri–Mek 0.15EC, 16 oz (3) Savey 50WP, 6 oz (3) Vendex 50WP, 1.5-2 lb (1) Sunspray Ultra-fine Oil 1% (0) Stylet Oil, 3 qts. (0) Trilogy (Neem), 1-2% solution (0)	Scout for presence of predator mite *Neoseiulus fallacis*; release 5-10,000 per acre if TSSM population exceeds 2/leaf and no predators are found. Contact your local Extension Specialist for sources of predatory mites.	Consult your Extension Specialist for help identifying mite predators. **Agri–Mek** applied at a lower rate (6 oz.) selectively kills spider mites. The full rate (16 oz.) kills predatory mites. **Savey 50WP** may be used for only one application per year. **Sun Spray Ultra-fine oil** and **Stylet Oil** require direct contact to kill mites and their eggs. Oil is phytotoxic in combination with captan residues.
Cyclamen Mites	Thiodan 3EC, 2.6 qt (4) Kelthane 35WP, 4-6 3/4 lb (2)	Predator mites may be effective against cyclamen mites. Check source list in the back for suppliers.	High gallonage (400) gal/A), wetting agent and foliar agitation usually needed for satisfactory control.
Leafhopper	Malathion 57EC, 1.5 - 3 pt (3) Cythion 5E, 1.5 - 2.5 pts (3) Sevin 50W, 2-4 lbs (7)	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.

Table 20 continued. Strawberry pest management schedule†.

Summer (Post-harvest)			
Pest	**Spray Material, Rate/A (pre-harvest interval)**	**Cultural Practices and Scouting Notes**	**Comments**
Aphid	Thiodan 50WP, 2 lb (4) Malathion 57EC, 1.5 - 3 pt (3) Cythion 5E, 1.5 - 3pts (3) Pyrenone Crop Spray, 12 oz (0)		Aphids are significant vectors of virus diseases. If virus spread is of concern, aphids should be controlled in the spring and fall when winged forms are building up. See note on **Thiodan** under tarnished plant bug comments.
Powdery Mildew	Topsin-M 70WP, 8 oz (1) **plus** Captan 50WP, 3-4 lb (0) **Or, use alone:** Stylet Oil, 3 qts. (0) Kumulus (sulfur), 5-10 lbs (0) Quadris, 6.2-15.4 oz (0)	Plant beds in such a way as to maximize the air circulation and drying of foliage.	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. **Quadris** may be applied no more than 4 times/year and must be alternated with a fungicide with a different mode of action. Do not use near apple tree or in a sprayer that is also used on apple trees or severe injury may occur on some apple varieties.
Leaf spot Leaf scorch Leaf blight	Captan 50WP, 3 lb (0) Thiram 65WP, 2.5 lb (3) Kocide 101, 2-3 lb (0) NuCop 3L, 1 1/3 - 4 pts (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.	Fungicide applications for gray mold will treat leaf spots as well. **Captan** requires protective clothing be worn in field for 24 hrs following application.
Red Stele	Ridomil Gold EC, 1 pt (0) Aliette WDG, 2.5 - 5 lb (0)	Proper site selection and preparation to avoid prolonged periods of “we tfeet” should be the primary control stratagy for this disease.	Early spring or fall applications are recommended for control of red stele in emergency situations only. 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.

†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.**

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 21. 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 to 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 Ultra	1 to 5 pt	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.
PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds	(DCPA) Dacthal W 75	8 to 12 lb	Weak on ragweed, smartweed, and galinsoga. Apply at transplanting or after cultivating. Irrigation, rainfall, or shallow cultivation after application will improve control. This product is no longer being manufactured.
	(napropamide) Devrinol 50 DF	2 to 4 lb	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.
Broadleaf weeds, some grasses, and some suppression of perennial weeds	(terbacil) Sinbar 80 WP	2 to 8 oz	The supplemental label for strawberries has been revised to allow use during the transplant year as well as on soils with between 0.5% and 2% organic matter. 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 weeds.

TRANSPLANT YEAR

Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds between rows after plant establishment	(paraquat) *Gramoxone Max	1.3 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 to 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 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.
Emerged annual weeds and suppression 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

PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds.	(DCPA) Dacthal W 75	8 to 12 lb	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 50 DF	4 to 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.
Broadleaf weeds, some grasses, and some suppression of perennial weeds.	(terbacil) Sinbar 80WP	2 to 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 new supplemental label for additional information, rates, precautions, etc.

Table 21 continued. Weed management in strawberries during the transplant and establishment years.

ESTABLISHED PLANTINGS			
Weed Problem	**Herbicide**	**Rate/Acre**	**Comments and Limitations**
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds between rows.	(paraquat) *Gramoxone Max	1.3 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 to 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.
Most emerged broadleaf weeds including dandelion	(2,4-D) Amine 4	2 to 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 and biennial, and perennial weeds. Be sure that strawberry plants are dormant (i.e., no new growth and reddened leaves).
Emerged annual weeds and suppression 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.**

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 Burndown: 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!

Table 22. Transplant year strawberry herbicide calendar.

TREATMENT TIMING	TREATMENT	RATE
SPRING OR FALL PRIOR TO PLANTING		
Weeds and other pests	Fumigation or	See label
Perennial weeds	Roundup Ultra 4S	1 - 5 qt (see label)
Many annual weeds	Goal 2XL	1 - 2 pt (see label)
AT PLANTING		
Planting (April - June)	Dacthal 75WP or	8 - 12 lb
	Sinbar 80 WP	2 - 3 oz
POST PLANT (3 NEW LEAVES OF 6 WEEKS AFTER PLANTING)		
Preemergence control of grasses, small seeded broadleaf weeds and some winter annuals	Devrinol 50DF	2 - 4 lb (8 lb max/year)
Preemergence control of broadleafs	Sinbar 80 WP	2 - 6 oz
Postemergence control of grasses	Poast 1.53EC	1 - 2.5 pt (2.5 pt max/year)
Postemergence control of emerged annual weeds between rows	Gramoxone Max	1.3 pt/acre
FALL		
Preemergence control of volunteer grains in mulch (apply just before mulching)	Devrinol 50DF	2 - 4 lb (8 lb max/year)
Postemergence control of grasses	Poast 1.53EC	1 - 2.5 pt (2.5 pt max/year)
Preemergence control of broadleafs	Sinbar 80WP	2 - 4 oz (strawberries must be established for at least 6 months and dormant)
Postemergence control of broadleafs	Amine 4	2 - 3 pt (strawberries must be dormant)

Sinbar 80 WP (terbacil) - The supplemental label for strawberries has been revised to allow use during the transplant year as well as on soils with between 0.5% and 2% organic matter. 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.

Table 23. Herbicide efficacy against common weeds in strawberries.

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

[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 Ultra**; 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, Sonia Schloemann at the University of Massachusetts Extension in Amherst, Massachusetts, or William Lord at the New Hampshire Cooperative Extension in Durham, New Hampshire.

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 24. 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.

Table 25. 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 26. 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 27. Critical nutrient values for blueberry tissue analysis.

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

Source: PennState University

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 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.

Table 28. Highbush blueberry variety descriptions for New England.

Variety	Hardiness	Comments
Berkeley	limited	Late mid-season; productive, easy to propagate, large, light blue fruit.
Bluecrop	hardy	Midseason; med. size, firm berries; some resistance to virus and mummy berry.
Bluegold	hardy	Late mid-season; very productive, firm, round fruit, sky blue, small scar.
Bluejay	hardy	Early to midseason; med. size, firm fruit; some resistance to virus and mummy berry.
Blueray	very hardy	Midseason; large, dark fruit, good flavor, spreading habit, branches may bend to ground with fruit.
Bluetta	moderate	Early season; large fruit, good quality; some resistance to mummy berry.
Brigitta Blue	limited	Late mid-season; Berries medium large, light blue, slightly tart, small dry scar, firm; stores well.
Collins	hardy	Early mid-season; moderate production, large, firm fruit, with good flavor and small scar.
Coville	limited	Late season; large firm fruit, medium scar, good tart flavor. Erratic production, suitable for mechanical harvest.
Darrow	limited	Late season; very large fruit, light blue, firm, with a large scar, excellent tart flavor.
Duke	mod/hardy	Early season; vigorous, very productive. Fruit is large, light blue, firm, mild flavor.
Earliblue	moderate	Early ripening; large, firm fruit with fair flavor; upright, vigorous growth.
Elliott	hardy	Very late-season; heavy producer of medium size, powder blue, very firm, slightly tart fruit; small, dry scar.
Jersey	hardy	Mid to late season; med. size berries, firm with fair flavor; tall, upright plants.
Lateblue	very hardy	Late season; moderate yield, flavor and scar are good.
Meader	hardy	Midseason; large, firm fruit, good flavor; erect, vigorous growth
Nelson	very hardy	Mid to late season; large, firm fruit with good flavor; productive, upright plants.
Northblue	very hardy	Mid-season; semi-dwarf bush, fruit large, dark blue, with a “wild” blueberry flavor.
Northcountry	very hardy	Mid late-season; medium sized fruit, sweet and mild, moderate vigor.
Northland	very hardy	Early mid-season; semi-dwarf bush, fruit medium blue, medium size, very sweet. Bush very productive.
Northsky	very hardy	Mid late-season; fruit sky blue, small to medium in size, stores well.
Patriot	very hardy	Early to midseason; large, firm fruit, good flavor; growth is slow, small plants; some resistance to root rot.
Spartan	hardy	Early season; fruit very large, high quality, excellent flavor; well adapted to machine harvest.
St.Cloud	very hardy	Mid late-season; tallest of the half-highs, moderate yields, fruit medium blue, medium sized , well flavored, with a small dry scar. Stores well.
Toro	hardy	Mid-season; fruit large, firm, exceptional color and flavor, concentrated ripening.

***Sources**: J. Hancock and E. Hanson, Blueberry Varieties for Michigan*

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*): 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. Infested 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 fungus, *Colletotrichum gloeosporioides*, overwinters 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. Berkeley, Coville, Bluecrop, Blueray, and Jersey are particularly susceptible to the disease. Varieties in which the fruit hangs ripe for a long time on the bush prior to picking are especially susceptible. No varieties may be resistant when the weather conditions are favorable for the disease.

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. Weymouth may be the most susceptible variety.

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, Jersey, 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 sunscalded 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

Table 29. Fungicides registered for use on blueberries and their primary uses.

Fungicide	Mummyberry		Phomopsis	Fusicoccum	Alternaria	Anthracnose	Botrytis	Phytophthora
	Primary	*Secondary*						
Abound	+/++	+/++	++	?	+	++++	+	?
Aliette	0	0	++/+++	?	++/+++	+++	?	+++
Bravo	++***	+	+++	+++	+	+++	++	0
Cabrio	+/++	+/++	+++	?	+	++++	+***	?
Captan	+	+/++	+++	+	+	++/+++	+	0
Elevate	+	++	+	?	0	0	++++	0
Indar**	+++	+++	+++/++++	?	+	0	?	0
Lime sulfur*	?	?	++*	?	?	?	?	0
Rovral	0	0	0	0	0	0	++++	0
Ridomil	0	0	0	0	0	0	0	++++
Ziram	++	++	+++	++/+++	++	+++	++	0

0=not effective, +=poor, ++=fair, +++=good, ++++=excellent, ?=not known.

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

***Indar is allowed in blueberries under Section 18 Emergency Exemptions on a state by state basis. Check with your Extension Specialist.*

**** suppression only.*

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 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 not been reported in New England, but a description is provided here so that growers will be on the lookout for it. It is localized to fields in New Jersey (it was originally found in a field in the Sheep Pen Hill area), although a similar disease termed blueberry scorch has been found in Oregon and Washington. These two diseases are related but not identical to each other. 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 particle (probably a virus), and it may be vectored by a leafhopper, although this is merely conjecture at this point. The sole control strategy is to remove affected bushes.

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* (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 (*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.

Management: Good pruning is the first step in control of scales on blueberries. Prune out weakened canes. During dormancy or delayed 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 below.) 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 eight 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 most 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. Currently, there are no insecticides registered for soil application against white grubs on blueberries. 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.

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 high-bush 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 30. Highbush blueberry pest management schedule[†].

Dormant and Delayed Dormant			
Pest	**Spray Material, Rate/A (pre-harvest interval)**	**Cultural Practices and Scouting Notes**	**Comments**
Scale Insects	Superior oil, 3% (0) SunSpray Ultra-fine Oil, 3% (0)	Prune out old, weakened canes.	Treat from March 1 to first bloom using 250 to 300 gallons of spray (at 300 to 400 psi) per acre. Apply oil only when no danger of freezing temperatures within 24 hours.
Blueberry Blossom (aka Cranberry) weevil	No insecticides labeled against this pest.	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)** Bravo Ultrex, 2.7-3.6 lb (42) Abound F, 6.2-15.4 oz (0) Cabrio EG, 14 oz (0) **Individual New England States may have Section 18 Emergency Exemption labels for early season fungicides to control Mummyberry. Check with your state's Extension Specialist.	Before mummy cups appear (about March 20), disk between rows and rake, sweep, and hoe under plants. As first mummy cups appear, apply 200 lbs of 50% Urea prills. Cultivation and Urea application are most effective when both are used.	*__Indar__ is labeled for this use under a Section 18 Emergency Exemption on a state by state basis. Check with your state's officials on the current status of this label. **Abound** should be used with **extreme caution** to avoid phytotoxicity to apples. See label for futher information. **Cabrio** is labeled for mummyberry suppression only. Only 4 applications allowed per season, NO MORE than 2 sequential applications.
Phomopsis twig blight Fusicoccum canker	Lime Sulfur, 5 gal (0) Ziram 76DF, 1.5 lb (**)	Prune out affected canes. Weymouth, Berkeley, Coville, and Jersey cultivars are particularly susceptible to Phomopsis twig blight. 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.	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. **Apply **Ziram** at loose bud scale stage, followed 7 days later. Do not apply later than 3 weeks after full bloom.
Phytophthora root rot	Ridomil Gold EC (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) Ridomil Gold WSP (45)* New Plantings, 4 lb broadcast at or before time of planting (repeat once) Established Plantings, 1/4 lb/ 1000 ft of row, (repeat once) Aliette WDG, 5 lb (0.5)	• 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	

Pre-bloom

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Blueberry Blossom (aka Cranberry) weevil	No insecticides labeled against this pest.	Disking between rows and raking /hoeing under plants helpful.	Eradication of wild blueberries in the vicinity of the blueberry planting is advised.

Early to mid-bloom

Mummy berry Botrytis blight Anthracnose	Indar 75WSP, 2 oz (30)** Bravo Ultrex, 2.7-3.6 lb(42) Abound F, (6.2-15.4 oz (0) Rovral 4F, 1-2 pt (0) Ziram 76DF, 3 lb (***) Captan 50WP, 5 lb (0) Captec 4L, 2.5 qt (0) ****Indar** is labeled for this use under a Section 18 Emergency Exemption on a state by state basis. Check with your state's officials on the current status of this label.	This treatment will cover for all three diseases (plus Phomopsis for Ziram). Rotate among these fungicides to avoid resistance development. For mummyberry, this spray is designed to prevent flower infections. It is necessary only if primary infections (shoot blight) were not adequately controlled earlier. **Bravo Ultrex** is only labeled for suppression of mummy berry. **Abound** should be used with **extreme caution** to avoid phytotoxicity to apples. See label for futher information. **Rovral** is only labeled for control of Botrytis. Additional applications can be made at 14 day intervals. Do not make more than 4 applications per year. ***Apply **Ziram** at loose bud scale stage followed 7 days later. Do not apply later than 3 weeks after full bloom. **Captan** has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period. See label or section on Worker Protection Standards for details. **DO NOT** combine (tank mix) **diazinon** and **captan** formulations together because berries and leaves will be injured.	

Petal Fall (remove honey bees before spraying)

Cherry fruitworm Cranberry fruitworm	Guthion Solupak 50W, 1-1.5 lb (7) Asana XL, 4.8-9.6 0z (14) Imidan 70W, 1 1/3 lb (3) *Lannate 90, 0.5 - 1 lb (3) Malathion 57 EC, 1.6 pt (1) Sevin 50WP, 3-4 lb (7) Pyrenone Crop Spray 0.5EC, 2-12 oz (0) Biobit 1.6 FC 1-2 pt (0) DiPel 1.9 ES-NT 1-2.5 pt (0) Confirm 2F, 16 oz (14)	Disking between rows and raking and hoeing under plants is helpful for fruit-worm management. In small plantings remove and destroy infested fruit (which cam 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. **Guthion** has 48 hr REI for mowing, irrigating, and scouting; and 4 day REI for all other activities. **Asana XL** - do not apply more than 38.4 oz of product per acre per season. **Lannate** restricted use; do not apply more than 3.6 ai per acre or make more than 4 applications. **Biobit, DiPel** and **Confirm** 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.

Table 30 continued. Highbush blueberry pest management schedule†.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Petal Fall (remove honey bees before spraying)			
Botrytis Anthracnose Alternaria Fruit Rot Fusicoccum Canker Phomopsis Canker Phomopsis Twig Blight	Aliette WDG, 5 lb (0.5) Cabrio EG, 14 oz (0) Indar 75 WSP, 2 oz (30)** Abound F, 6.2-15.4 (0) Captec 4L, 2.5 qt (0) ****Indar** is labeled for this use under a Section 18 Emergency Exemption on a state by state basis. Check with your state's officials on the current status of this label.	**For Botrytis** - Repeat at 7-10 day intervals during bloom if long rainy periods predicted. **For Anthracnose** - Occurs only sporadically and especially during seasons with frequent rain and warm temperatures. Spray for control in such seasons if a history of this disease has been noted recently. **Abound** should be used with **extreme caution** to avoid phytotoxicity to apples. See label for futher information. **Captan** has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period. Check all labels for further restriction on these materials.	
First cover (about 10 days after Petal Fall; some berries begin to color)			
Anthracnose	Aliette WDG, 5 lb (12 hrs) Cabrio EG, 14 oz (0) Captec 4L, 2.5 qt (0) Captan 50WP, 5 lb (0)		See comments above.
Cherry fruitworm Cranberry fruitworm	Same as petal fall		Apply 7 to 12 days after petal fall
Blueberry Maggot	Malathion 25WP, 4 lb (1) Guthion Solupak, 1-1.5 lb (7) Imidan 70 W, 1 1/3 lb (3) Pyrenone Crop Spray 0.5EC, 2-12 oz (0)	Use sticky traps (red spheres or yellow rectangles; See source listing in appendix) to monitor population and activity. Apply insecticide when one fly is captured. 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. **Gution** has 48 hr REI for mowing, irrigating, and scouting; and 4 day REI for all other activities Second and additional covers - (10 days from previous cover, repeat as needed).
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	Sevin 50WP, 3 lb (0) Imidan 70W 1.3 lbs (3)	Remove webbed twigs and webworm caterpillars. Remove beetles.	The use of **Sevin** may result in the build up of aphids due to the elimination of natural predators.
Anthracnose	Aliette WDG, 5 lb (12 hrs) Cabrio EG, 14 oz (0) Captan 50WP, 5 lb (0)		See **Captan** comments in Petal Fall Section.

Post-harvest			
Pest	**Spray Material, Rate/A (pre-harvest interval)**	**Cultural Practices and Scouting Notes**	**Comments**
Sharp-nosed leafhopper	*Lannate LV, 1.5 pt (3) Asana XL, 4.8-9.6 oz (14) Malathion 57 EC, 2.8-3.2 pt (1) Sevin 50W, 2-4 lb (0)	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	Thiodan 3EC, 2 qt (**) Phaser 3EC, 2 qt (**)		Apply immediately after harvest is complete and repeat according to label instructions. ** Do not apply **Thiodan** or **Phaser** after buds are well formed; do not apply more than 2 times per year; do not exceed 3.0 lbs active ingredient per acre per year.
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.**

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 31 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 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 on 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 31. Weed management for highbush blueberries in the transplant year and in established plantings.

TRANSPLANT YEAR			
Weed Problem	**Herbicide**	**Rate/Acre**	**Comments and Limitations**
PREEMERGENCE WEED CONTROL			
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.
POSTEMERGENCE WEED CONTROL			
Emerged annual and most perennial grasses	(fluazifop) Fusilade DX	16 to 24 oz	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.
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

Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
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 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, or dichlobenil).			
Broadleaf weeds, some grasses, and suppression of some perennial weeds	(simazine) Princep 4 L	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.
	Caliber 90	2.2 to 4.4 lb	
	(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 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	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 plant growth in plantings that are young or lacking vigor. High leaching risk.
	Casoron 4G	100 lb	
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds	(paraquat) *Gramoxone Max	1.3 to 2.7 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 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 Ultra	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.

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, 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. Straw, (free from weed seed), or 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.

Proper pruning is a crucial part of pest management for raspberries. Remove old second year canes in the fall and also thin out weak, spindly first year canes. In the early spring, 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.

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, ***Bramble Production Guide*** available through New England Extension Fruit Specialists. See source page at end of this guide for more information on ordering the ***Bramble Production Guide***.

Table 32. 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.

Table 33. 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
10	544	435	362

Table 34. 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
Courtesy Cornell University.

Table 35. Critical nutrient values for bramble tissue analysis.

Element	Deficient	Below Normal	Normal	Above Normal	Excessive
N (%)	1.80	2.00	2.50	3.00	>3.00
P (%)	0.23	0.25	0.35	0.40	>0.40
K (%)	1.45	1.50	2.00	2.50	>2.50
Ca (%)	0.57	0.60	1.70	2.50	>2.50
Mg (%)	0.27	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)	28	30	40	50	>50
Zn (ppm)	18	20	35	50	>50

Source: PennState University

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.

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 these plants may be stunted and less productive. The infection of flower buds reduces fruit quantity, and infected fruit may be lower in quality or unmarketable as a result of the unsightly covering of 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 avoid planting susceptible cultivars. If susceptible cultivars are planted, cultural methods to promote good air circulation around canes will reduce disease severity. Removal of late-formed mildewed suckers in the fall may also delay the start of the disease build-up in the spring. Most fungicides currently registered for use on raspberries are not effective against powdery mildew, nor is chemical control usually warranted.

Cane Diseases

Anthracnose (*Gloeosporium venetum*): 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 fragariae*): The *Phytophthora* 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 drenches with Ridomil 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. 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 *Agrobacterium tumefaciens*. 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 bacterium from entering this region. However, the biocontrol agent will not cure plants which are already infected before its application.

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 and Titan.

Table 36. Relative hardiness and disease resistance for bramble varieties recommended for New England.

Variety	HD	SB	AN	VR	PH	Comments
Algonquin	F	R	U	R	F	Spineless canes, upright growth; med. size fruit, good quality.
Anne						5-7 days earlier than Heritage, tall moderately vigorous canes with few thorns. Fruit medium-large, light yellow with white bloom, very good quality.
Autumn Bliss	F	U	U	F	F	Everbearing; vigorous plants; med. to large fruit, good quality.
Autumn Britain	G	U	U	U	G	Everbearing, vigorous plants, med. to large fruit, good quality.
Boyne	E	F	S	U	F	Early ripening; small dark fruit, good quality; most reliably hardy.
Canby						Tall, midseason, nearly thornless, moderate hardiness. Med-large fruit, good quality. Limited success in cold climates.
Caroline						5-7 days earlier than Heritage, tall vigorous canes, large fruit, very good quality.
Dinkum						5-10 days earlier than Heritage, similar to Autumn Bliss, tall canes with moderate vigor, large fruit with good quality.
Earlisweet						Vigorous plants with hardiness similar to Jewel. Fruit ripens early and is medium to large with good quality.
Encore						Very late for a summer-bearing type, hardy, vigorous canes. Med-large fruit with good quality and yield.
Festival	G	R	U	R	U	Midseason; short plants; med. size fruit, good quality; very susceptible to leaf rust.
Jewel						Early, tall vigorous canes, thorny. Fruit are medium size, good quality. Hardiest of the blacks, but only moderately hardy compared to reds. Some disease resistance.
Heritage	F	U	U	S	S	Everbearing; second crop late; vigorous plants; med. to large fruit, good quality.
K81-6	G	R	R	S	S	Tall, vigorous canes; late season, large fruit, good quality.
Killarney	E	F	S	U	F	Early ripening; med. size fruit, good quality and yield.
Latham	G	S	S	F	U	Midseason; med. size fruit, crumbly, fair quality.
Lauren	F	U	U	F	U	Large fruit, productive, early season.
Newburgh	G	F	F	U	F	Midseason; med. size fruit, yields and quality fair.
Nova	G	R	R	R	U	Midseason; vigorous plants; med. size fruit, good quality.
NY 7	G	U	U	U	F	Spineless canes, vigorous; large, firm fruit, extended harvest season.
NY 1009	G	U	U	U	U	Everbearing, but use for very early summer crop. Large, firm fruit.
Polana						10-14 days earlier than Heritage. Short, vigorous, thorny canes. Fruit is medium-sized, not uniform (lots of doubles), but good quality.
Prelude						Very early floricane (summer) crop, moderate to good vigor, medium-sized fruit, dark, but good quality. Late primocane crop.
Reveille	U	U	U	U	U	Early to midseason; med. to large fruit, good flavor but soft.
Taylor	F	S	S	S	S	Mid to late season; vigorous plants, med. to large fruit, excellent quality.

HD: Hardiness; SB: Spur blight; AN: Anthracnose; VR: Viruses; PH: Phytophthora

E= excellent G= good F= fair R=resistant S= susceptible U= unknown

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 attack raspberries. 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. 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 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.

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 and Titan 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 or malathion. Traps are also available which use a sex and/or feeding attractant to capture the bugs in a can or plastic bag, but such traps may not provide adequate control. Place traps near, but not in 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, sometimes called hornets or wasps, are large, up to one inch or more, black and yellow stinging insects. Their closely related cousins are black and white and are known as whitejackets and bald-faced hornets. Both groups of these insects are very aggressive and will sting with little provocation.

There are several species of this group of wasps found in the Northeast. Depending on the species, the yellow jacket builds its nest underground or in hollow/rotten logs or builds a large paper nest in trees or on houses. The workers scavenge food, often meat such as insects or pieces of flesh from dead animals. However, yellowjackets also have a great fondness for ripe or injured fruit. These insects can be found on pears, apples, raspberries, etc., using these fruit for sugar and moisture which, like the meat, is taken back to the nest to feed the larvae.

This fondness for fruit makes this insect a severe nuisance pest in raspberries. They are a danger and annoyance to pickers. Pickers frequently refuse to harvest when yellowjackets are present, thus allowing the crop to get overripe and attracting more wasps. 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.

Traps may be put up around the perimeter of the planting before the berries begin to ripen. There are many yellowjacket traps on the market, and various baits (fish, meat, jam, honey, beer, yeast, etc.) 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. Some plantings may be infested with species of yellowjackets that do not respond to any of the commercially available traps. Fish traps, made with a fish suspended over a tub of soapy water, can be effective against all species. 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.

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". These canes become weakened and may break off.

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: If this insect is noticed in the field, it can be controlled by drenching around the base of the plants with diazinon in the spring before bud break, or with Sniper™ before harvest. Elimination of all wild brambles in the area can also reduce local populations of this pest.

Table 37. Bramble pest management schedule†.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Early spring, prior to bud swell			
Phytophthora root rot	Ridomil Gold EC, 1/4 pt/1000 linear ft. (45) Ridomil Gold GR, 5 lb/1000 linear ft. (45) Aliette 80 WDG, 5 lb (60)	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** 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.
Crown borers	*Sniper 2E, 4-8pt (4)		Apply **Sniper** as heavy drench before harvest.
Early spring to bud swell			
Anthracnose Spur blight Cane blight	Lime sulfur, 10-20 gal (0) Kocide 101, 4 lb (0) Cabrio EG, 14 oz (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 after buds are 1/2 inch long or plant damage will result. **Cabrio** Fungicide is labeled for Anthracnose and spur blight. Only 4 applications allowed per season, NO MORE than 2 sequential applications.

Table 37 continued. Bramble pest management schedule†.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
New cane emergence			
Anthracnose Spur blight	Cabrio EG, 14 oz (0)		Apply when new canes are 6-8 inches tall, repeat when canes are 12-15 inches tall. **Cabrio** may only have 4 applications per season and no more than 2 sequential applications.
Pre-bloom to initiation of bloom			
Raspberry fruit worm	Pyrellin EC, 1 – 2 pt (0) Sevin XLR Plus, 2 qt (7) 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) Pyrenone Crop Spray 0.5EC, 2-12 oz (0) Aza-direct, 11.5-42 oz (0)	Keep planting free of weeds. See description of sampling procedures in the description of TPB in the text. 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.
Strawberry bud weevil	Pyrenone Crop Spray 0.5EC, 2-12 oz (0) 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.	Spraying late in the day may be more effective than morning sprays.
Cane borers	Pyrellin EC, 1-2 pt (0.5)	Cut off infested tips below girdle marks, remove canes showing swellings.	Cultural practices are the most important control measures. If an outbreak occurs, direct insecticide spray at lower foliage of canes. Keep insecticide off blooms and fruiting shoots.
Japanese beetle	Sevin XLR Plus, 1-2 qt (7) Malathion 57EC, 1.5 pt (1) Pyrenone Crop Spray 0.5EC, 2-12 oz (0) Aza-direct, 12.5-42 oz (0) Surround WP, 12.5-50 (0)	Traps may reduce populations. Place traps at least 50 feet away from planting.	Apply spray only if beetles are present. Check labels for specific restrictions. **Surround** labeled for suppression of Japanese Beetle **only** on fruit to be used for processing. Must maintain good film to maximize benefits.
Aphids	Guthion Solupak, 5/8 - 1 lb (14) Malathion 57EC, 3 pt (1) *Sniper 2E, 1 1/4 - 2 pt (14) Pyrenone Crop Spray 0.5EC, 2-12 oz (0) Aza-direct, 11.5-42 oz (0)	Lady bird beetles can devour great numbers of aphids. These beneficial insects should be conserved by using insecticides only when necessary and by using recommended rates. Contact your local Extension Specialist for help locating sources of beneficial insects. **Guthion** has 48 hr REI for mowing, irrigating, and scouting; and 4 day REI for all other activities.	
Orange Rust	Nova 40W, 2.5 oz(0)		Spray while orange pustules are visible, on a 10-14 day schedule until temps are >75˚F.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Bloom—do not apply insecticides during bloom			
Botrytis fruit rot (gray mold)	Rovral 50WP,1-2 lb (0) Ronilan DF, 2 lb (9) 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 most fungicides 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. **Ronilan** application limited to no more than 8 lb per season. **Elevate** allowed by supplemental label (EPA reg. no. 66330-35). Begin applications at 10% bloom and continue as needed through harvest, avoiding 2 consectutive applicaitons.
Fruiting			
Tarnished plant bug	Same as pre-bloom application	See pre-bloom section	See pre-bloom section
Sap beetles	Malathion 57 EC, 1.5 - 2 pt, (1) Pyrenone Crop Spray 0.5EC, 2-12 oz (0) Aza-direct, 12.5-42 oz (0)	Keep planting as clean as possible of over-ripe fruit	**Cythion** and **malathion** labeled for raspberry only, not other bramble fruit.
Two-spotted spider mite	*Capture 2 EC, 6.4 oz (3) Savey 50WP, 4-6 oz (3) Aza-direct, 11.5-42 oz (0) Valero, 1-2 gal (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.	**Capture** is a restricted use material and may be applied once pre-bloom and once post-bloom. **Savey** may only be applied once per season. Pre-test **Valero** for phytotoxicity to specific varieties. **JMS Stylet oil** should not be sprayed on wet foliage or when temperatures are below 32˚F or above 90˚F within 48 hrs.
Botrytis fruit rot	Same as bloom application	See bloom section	See bloom section. Check labels for harvest restrictions.
Post harvest and thereafter			
Phytophthora root rot	Ridomil Gold EC, 1/4 pt/1000 linear ft. (45) Ridomil Gold GR, 5 lb/1000 linear ft. (45) Aliette WDG, 5 lb (60)	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** 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.
New cane emergence			
Powdery mildew	Microthiol Special, 6-15 lb (0) Kumulus DF, 6 – 12 lb (0) Cabrio EG, 14 oz (0) Nova 40W, 1.25-2.5 oz (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.

Table 37 continued. Bramble pest management schedule†.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Japanese beetle	Same as under pre-bloom section.		
Two-spotted spider mites	Same as under fruiting section.	Contact your local Extension Specialist for help locating sources for beneficial insects.	

†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.

Table 38. Fall bearing (primocane fruiting) bramble pest management schedule†.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
When canes are approximately 18 inches tall			
Cane borers		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	Sevin XLR Plus, 1-2 qt (7) Malathion 57EC, 1.5 pt (1) Pyrenone Crop Spray 0.5EC, 2-12 oz (0) Aza-direct, 12.5-42 oz (0) Surround WP, 12.5-50 lb (0)	Traps may reduce populations. Place traps at least 50 feet away from planting.	Apply spray only if beetles are present. 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)	Keep planting clean of over-ripe fruit	**Malathion** labeled for raspberry only, not other bramble fruit.
Tarnished plant bug	Sevin XLR Plus, 1.5-2 qt (7) Pyrenone Crop Spray 0.5EC, 2-12 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.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
From petal-fall through the beginning of harvest			
Botrytis fruit rot (gray mold)	Rovral 50WP,1-2 lb (0) Ronilan DF, 2 lb (9) 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. **Elevate** is permitted under a supplemental label. Do not make more than 2 consecutive applications and do not usemore than 6 lb per season.
Fruit rot sprays or special sprays			
Two-Spotted spider mite	M-Pede, 1-2% (0) Aza-direct, 11.5-42 (0) Savey 50 WP, 4-6 oz (3)	Predatory mites may help. Avoid use of pesticides which will kill natural enemies of mites such as carbaryl.	**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 EC, 1/4 pt/1000 linear ft. (45) Ridomil Gold GR, 5 lb/1000 linear ft. (45) Aliette WDG, 5 lb (60)	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** 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.
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.

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 39.

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 39. 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 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)		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.
	Princep 4L	1 to 2 qt	
	Caliber 90	1.1 to 2.2 lb	
POSTEMERGENCE WEED CONTROL			
Emerged annual and most perennial grasses	(fluazifop) Fusilade DX	16 to 24 oz	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.
Emerged annual weeds and suppression of perennial 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.
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.

Table 39 continued. Weed management in brambles†.

ESTABLISHED PLANTINGS			
Weed Problem	**Herbicide**	**Rate/Acre**	**Comments and Limitations**
PREEMERGENCE WEED CONTROL			
	(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 or 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. 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	100 lb 8 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 Max	1.3 to 2.7 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 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 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 Ultra	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.

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Restricted use pesticide; pesticide applicators license required.

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 40. 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.

Table 41. 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*

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 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.

Table 42. 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

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.

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.

Table 43. Effectiveness of fungicides on grape diseases.

Fungicide	Phomopsis Cane and Leaf Spot	Black Rot	Downy Mildew	Powdery Mildew	Botrytis Rot
Abound[a]	++++	++++	++++	+++	-
Aliette	-	-	++++	-	-
Armicarb	-	-	-	+++	-
Bayleton[d]	-	++++	-	++++	-
Bordeaux mix[b]	++	++	++++	+++	++
Captan	+++	+	+++	-	+
Copper & lime	+	+	+++	++	+
Elevate	-	-	-	-	+++
Ferbam	++	+++	++	-	-
Fixed Copper[c]	++	++	+++	++	+
Flint[a]	++	++++	+++	++++	-
JMS Stylet Oil	-	-	-	+++	-
Mancozeb[f]	+++	+++	+++	-	-
Messenger	?	?	?	?	?
Nova[d]	+	++++	-	++++	-
Nutrol	-	-	-	+++	-
Procure[d]	-	++	-	++++	-
Ridomil Gold MZ[g]	-	+	++++	-	-
Ridomil/Copper[g]	+	+	++++	++	+
Rovral[e]	-	-	-	-	+++
Rubigan[d]	-	++	-	++++	-
Serenade	-	-	-	-	+
Sovran[a]	++	++++	+++	++++	++
Sulfur[h]	+	-	-	+++	-
Topsin-M	-	++	-	+++	+[i]
Va guard	-	-	-	-	+++
Ziram	++	+++	++	-	-

++++=excellent, +++=good, ++=moderate, +=slight, -=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] *Bayleton, 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 Pricure 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.*

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 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.

Table 44. Effectiveness of insecticides for management of grape insects.

	PESTS								
Material	**GBM**	**LH**	**GP**	**GCGL, JB**	**GCGR**	**GFB, CW**	**GMB**	**M**	**RC**
Agrimek (abamiectin)	++	?	?	0?	0?	0?	?	++	0?
Ecozin (azadirachtin)	?	++	?	++	?	+	++	+	++
*Guthion (azinphos-methyl)	+++	+	?	++	+++	++	?	0	++
Dipel (*Baccilus thurengiensis*)	++	0	0	0	0	0	?	0	0
Sevin (carbaryl)	+++	+++	0	+++	0	+++	?	0	+++
JMS Stylet Oil (parafinic oil)	?	?	?	?	?	?	+++	+++	?
Diazinon (diazinon)	0	++	0	0	0	0	?	0	0
Kelthane (dicofol)	0	0	0	0	0	0	?	+++	0
*Thiodan (endosulfan)	?	++	+++	?	?	?	?	0	?
Vendex (fenbutatin-oxide)	0	0	0	0	0	0	?	+++	0
Danitol (fenpropathrin)	+++	+++	+	+++	?	++	++	++	?
M-PEDE (insecticidal soap)	0	++	0	0	0	0	?	?	0
Pyramite (pyridaben)	0	++	0	0	0	0	?	+++	0
Provado (imidacloprid)	0	+++	?	0	0	0	+++	0	0
*Lannate (methomyl)	++	++	?	?	?	?	?	?	?
Imidan (phosmet)	+++	+	?	+	++	?	?	0	+

+++=highly effective; ++= moderately effective; += slightly effective; 0= not effective/not labeled; ?= effectiveness unknown

Key to pests: GBM= grape berry moth; LH= leafhoppers; GP= grape phylloxera; GCGL= grape cane gallmaker; JB= Japanese beetle; GCGR= grape cane girdler; GFB= grape fleabeetle; CW= cutworm; GMB= grape mealy bug; M= mites; RC= rose chafer.

***restricted use pesticides**

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 leafhoppers number 3 or more per leaf, apply an insecticide (preferably when most of the nymphs have hatched). 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 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 45. Grape pest management schedule†.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Dormant			
Anthracnose	Lime sulfur solution, 5-10 gal (0)		This dormant application is aimed at reducing overwintering inoculum on canes.
Bud swell (before buds show green)			
Eutypa dieback	Benlate 50WP, 3.2 oz/gal, (50)**	Prune out infected wood early in the season; make cuts well below cankers. Renew trunks every 8-10 years.	Paint or spray on immediately after pruning, before rain, dew, and spores some in contact with fresh wood. **Existing stocks of **Benlate** may be used until Dec. 31, 2003.
European red mite and/or scale insects	Superior oil, 2 gal (70-second viscosity) Cythion 8EC, 1 pt (3)	Vinifera and French Hybrids are more susceptible to mites; scout for mites from bud break to 10-inch shoot.	Do not exceed a maximum of 2-3/4 pt of **Cythion** per acre per year.
Flea beetle	Imidan 70W, 1-1/3 to 2-1/8 lb (14) Sevin 50WP, 2-4 lb (7)		Scout planting for presence of flea beetle before spraying to avoid unnecessary sprays.
Bud break to pre-bloom (after 1/2 inch new shoot growth)			
Black rot	Dithane DF, 1.5-4 lb (66) Elite 45 DF, 4 oz (14) Flint 50 WG, 11-12 oz (14) Abound 2SC, 11.0-15.4 oz (14) Sovran 50 WG, 3.2-4.8 oz (14) Nova 40W, 1.5-2.0 oz	Early control of black rot is important where this disease has been a problem in the past.	**Abound**: see label for comments on resistance management and toxicity to apple trees. **Elite** and **Nova** can be used both as preventative and post infection materials. See label for details and restrictions. Strobilurin fungicides like **Flint**, **Abound** and **Sovran** should not be applied more than 3 time in succession to avoid the development of resitant fungi.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Bud Break to Pre-bloom (after 1/2" new shoot growth)			
Phomopsis cane and leaf spot Downy mildew	Captan 50WP, 2-4 lb (0) Dithane DF, 1.5 – 4 lb (66) Abound 2SC, 3-4 lb (14) Sovran, 4.0-6.4 oz (14) Nu-Cop 50 DF, 2 lb (1)		Strobilurin fungicides such as **Sovran** and **Abound** should not be used more than 3 times in succession to avoid the development of resistant fungi. **Nu-Cop** may cause slight to severe foliar injury to certain varieties. See label for this and other restrictions.
Powdery mildew	Nova 40WP, 3-5 oz (14) Rubigan EC, 3 oz (30) Procure 50 WS, 4-6 oz (7) Elite 45 DF, 3-4 oz (14)		This early spray is needed on varieties that are highly susceptible to powdery mildew.
Grape Cane Gall-Maker	Imidan 70 WSB, 1.3 – 2 lb (1)		**Imidan** will also control grape cane borer at this time if present – read label.
Flea beetle	Same as budswell		Scout planting for presence of flea beetle before spraying to avoid unnecessary sprays.
Ten-inch shoot (when new shoots are about 10 inches long)			
Redbanded leafroller Rose chafer	Imidan 70W, 1 1/3-2 1/8 lb (14) Sevin 50WP, 2 -4 lb (7) *Sniper 2E, 1-2 pt (0-28)	Pheromone traps available for red banded leafroller and grape berry moth to monitor populations in the vineyard and determine the need for spray.	Pre-harvest interval for **Sniper** depends on rate applied. Higher rate requires longer PHI. Read the label. Redbanded leafroller, and rose chafer infestations may occur starting at 4 inch shoot growth.
Grape cane girdler	Gution solupak, 1.5 lb (7)		
European red mite Two-spotted spider mite	Vendex 50WP, 0.5-1 lb (28) Kelthane 35 WP, 1-1.5 lb (1) M-Pede, 1-2% (0)	Mite predators may be effective in controlling pest mites. Contact your local Extension Specialist for information on using predatory mites.	**M-Pede** may be tank-mixed with **Vendex** or **Kelthane**. Note: the use of **mancozeb** fungicides can reduce predatory mite populations.
Flea beetle larvae	Same as bud swell		Flea beetle larvae infestations may occur starting at 4 inch shoot growth.
Pre-bloom			
Phomopsis cane and leaf spot Black rot	Captan 50WP, 2-4 lb (0) Dithane DF, 1.5 – 4 lb (66) Abound 2SC, 3-4 lb (14) Sovran, 4.0-6.4 oz (14) Nova 40WP, 3-5 oz (14) Flint 50 WG 3.2-4.0 oz (14) Elite 45 DF, 3-4 oz (14)		Strobilurin fungicides such as **Sovran** and **Abound** should not be used more than 3 times in succession to avoid the development of resistant fungi. **Captan** labeled only for use against Phomopsis. **Dithane**, **Abound** and **Sovran** labeled for use against both Phomopsis and Black rot. **Nova**, **Flint** and **Elite** labeled only for use against Black rot.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Pre-Bloom (cont.)			
Downy mildew	Captan 50WP, 2-4 lb (0) Dithane DF, 1.5 – 4 lb (66) Abound 2SC, 3-4 lb (14) Sovran, 4.0-6.4 oz (14) Prophyt 0.3%, (0)		Strobilurin fungicides such as **Sovran** and **Abound** should not be used more than 3 times in succession to avoid the development of resistant fungi.
Powdery mildew	Nova 40WP, 3-5 oz (14) Rubigan EC, 3 oz (30) Procure 50 WS, 4-6 oz (7) Elite 45 DF, 3-4 oz (14)		Refer to **Rubigan** label for further recommendations on rates.
Flea beetle larvae	same as 10 inch spray		
Grape berry moth	3M Sprayable Pheromone, 2 oz (0)	**Isomate™** Grape berry moth mating disruption ties are recommended for vineyard blocks of 5 acres or larger. See information under grape fruit pests above for more details. **Pheromone traps** available for grape berry moth to monitor populations in the vineyard and determine the need for spray postbloom.	Apply **3M Sprayable Pheromone** twice per generation in sufficient water to obtain good coverage. First application against spring generation should commence earlier (immediate prebloom to bloom) than traditional insecticide applications are applied (immediate postbloom) followed by a second application 2-3 weeks later.
Bloom			
Black rot	Penncozeb 80WP, 1.5-4.0 lb (66) Nova 40WP, 4-5 oz (14)		If using **Nova** for post-infection control of black rot, apply at the high label rates during bloom.
Downy mildew Powdery mildew	Procure 50WS, 4-6 oz (7) Captan 50WP, 2-4 lb (0)		**Procure** is primarily for use against the mildews. DO NOT use more than 32 oz. of Procure 50WS/acre/season. This is a complex label. Read it thoroughly before using.
Botrytis bunch rot	Rovral 50WP, 1.5-2 lb (7) Vangard WG, 10 oz (7) Elevate 50 WDG, 1 lb (0) Flint 50 WG, 3 oz (14)		**Rovral** should be applied no more than 4 times. See label for specifications. If tank mixing **Vanguard** with another fungicide, use 5-10 oz/acre. DO NOT apply more than 20 oz per acre per year. Do not apply more than 3 lbs of **Elevate** per acre per season. Do not apply **Flint** to Concord grapes or crop injury may occur.
Grape phylloxera (leaf form)‡	*Thiodan 50 WP, 2lb (7)	Remove infected leaves.	Apply Thiodan when galls are detected and again 10-12 days later. Use only the WP formulation of Thiodan. Thiodan may cause injury to and should not be used on Concord, Cascade, Baco, Colobel, Chambourcin and Chancellor grape varieties.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Petal-fall (immediately after bloom or 10 days after last spray)			
Black rot Downy mildew Powdery mildew Botrytis bunch rot	same as bloom		
Grape berry moth	3M Sprayable Pheromone, 2 oz (0) Guthion Solupak, 1.5-2 lb (0-10) Sniper 2E, 1-2 pt (0-28) Sevin 50W, 2-4 lb (7) Biobit HP, 0.5-1 lb (0)	Pheromone traps available for red banded leafroller and grape berry moth to monitor populations in the vineyard and determine the need for spray.	See comment under bloom on **3M Sprayable Pheromone**. Pre-harvest interval for **Guthion** and **Sniper** depends on rate applied. Higher rate requires longer PHI. Read the label. **Guthion** and **Sniper** REI varies from 48 hrs to 21 days depending on activity; read the label. **Biobit** and related B.t. insecticides must be applied as soon as larval feeding begins in order to be effective.
Grape Leafhoppers	Sevin 50W, 2-4 lb (7) M-Pede, 1-2% (0) Danitol 2.4 EC, 5.3-6.6 oz (21)	Examine underside of leaves for presence of leafhoppers.	
Grape mealybug	Imidan 70W, 1 1/3-2 1/8 lb (14)		
Mites	Vendex 50WP, 0.5 - 1 lb (28) Kelthane 35 WP, 1- 1.5 lb (1) M-Pede, 1-2% (0)	Conserve mite predators by avoiding use of carbamate or pyrethroid insecticides.	**Vendex** should not be used after this time due to pre-harvest interval limitation of 28 days. **M-Pede** should not be used after 6-7 mm berry size.
Mid-summer sprays: first cover to veraison (berry coloring)			
Black rot Downy mildew Powdery mildew	Captan 50WP, 1.5 lb (0) Ferbam 76WP, 3-4 lb (7) Ridomil/Copper 70W, 1-2 lb (66) Ridomil MZ 58, 1.5-2.0 lb (66) Procure 50WS, 4-8 oz (7) Kocide 101, 2 lbs Bayleton 50WP, 1 - 2 oz (14) Nova 40WP, 4-5 oz (14)	**Kocide 101** is a fixed copper fungicide. Some grape varieties are sensitive to copper. Test for sensitivity or add the recommended amount of hydrated lime according to the label instructions.	**Ferbam** may be applied once in the midsummer if it was not used in the second post-bloom sprays. Ferbam may be used no more than three times during the season. **Fixed copper** fungicides should provide good control of downy mildew, but only moderate control of black rot and powdery mildew. These materials can cause damage to leaves and fruit, especially under cool temperatures and slow drying conditions.
Grape berry moth Leafhopper Redbanded leafroller Rose chafer Grape mealybug	Same petal fall; repeat as needed to harvest according to label instructions; check for harvest restrictions		See Petal Fall section above
Japanese beetle adults	Imidan 70W, 1 1/3-2 1/8 lb (14) Sevin XLR Plus, 1-2 lb (7)		Repeat as needed to harvest according to label instructions. After beetles appear in early to mid-July, damage is mostly cosmetic if vine growth is vigorous.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Dormant and Delayed Dormant			
Mites	Kelthane 35 WP, 1-1.5 lb (1)		
Veraison to harvest			
Powdery mildew	Sulfur 95 MFW , 2.5 oz (0) Nova 40WP, 1.5 - 2.5 oz (14) Rubigan 1 EC, 3 oz (30)		**Sulfur** may cause injury of certain grape cultivars, especially if temperatures exceed 85˚F. Do not apply more than 1.5 lbs of **Nova** per acre per season. Do not apply more than 6 fl. oz. of **Rubigan** EC per acre per application or more than 19 fl. oz. per season. Read the label carefully.
Botrytis bunch rot	same as bloom section		
Downy mildew	Captan 50WP, 1.5 lb (0) Fixed copper (consult label for use instructions)		Consult the label for harvest restrictions.
Black rot	As berries reach full size and sugar content starts to increase, they become resistant to infection by the black rot fungus. In general, berries are no longer susceptible to black rot after veraison (6-8% sugar content)		

‡ Root form controlled by using rootstocks derived from American grapes.
† Where brand names for chemicals are used, it is for the reader's information. Not endoresement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety.
**** Restricted use material; pesticide applicator license required.***

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 46 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 46. Weed management in grapes during the planting year and in established vineyards†.

TRANSPLANT YEAR			
Weed Problem	**Herbicide**	**Rate/Acre**	**Comments and Limitations**
PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds	(napropamide) Devrinol 50DF	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. Do not make more than one application per season.
	(pendimethalin) Prowl 4EC	2 to 4 qt	Apply to weed-free soil directly beneath vines. Do not apply if buds have started to swell. For non-bearing vines only.
Broadleaf weeds, some grasses, and some perennial weeds	(dichlobenil) Casoron 4G	150 lb	Apply in late fall or winter for best results. Incorporate lightly for best results. The soil must be settled and the plants recovered from transplant shock before application. May cause injury in young plants or where vigor is not excellent.
POSTEMERGENCE WEED CONTROL			
Emerged annual and most perennial grasses	(fluazifop) Fusilade DX	16 to 24 oz	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 of 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.
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 grasses and broadleaf weeds. Suppression of emerged perennial weeds	(paraquat) *Gramoxone Max	1.7 to 2.7 pt	Contact herbicide. Use with a non-ionic surfactant. Apply as a coarse directed spray on a warm calm day to wet the weeds. Avoid application to foliage or green shoots. Use of a shield is highly recommended.
	(glufosinate) Rely	4 to 6 qt	Contact herbicide. Apply in at least 20 gallons of water per acre at no more than 30 psi. Apply as a coarse directed spray on a calm day to wet the weed foliage or green shoots. For spot sprays use 1.5 ounces per gallon of water. May also be used for sucker control. See label.

Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
POSTEMERGENCE WEED CONTROL			
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 wounds, or other green parts of the vine. 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 6 qt	Apply to weed-free soil in the spring. Irrigation or 1 inch of rainfall is needed within 21 days of application. Do not make more than 1 application per year.
	(norflurazon) Solicam 80DF	1.25 to 5 lb	Apply in early spring when crop is dormant to clean and weed-free soil. Do not apply after budbreak. Do not apply to coarse soils. Do not use on nursery stock. VINES MUST BE TWO YEARS OLD BEFORE APPLICATION.
	(pronamide) *Kerb 50WP	2 to 8 lb	Apply in early spring for preemergence control of weeds or as a directed fall application after harvest but prior to leaf drop and soil freeze-up. Do not apply to vines less than 1 year old.
NOTE: For broad spectrum preemergence weed control, consider applying one of the above four “grass” herbicides (napropanide, oryzalin, norflurazon, or pronamide) in addition to one of the following “broadleaf” herbicides (simazine, diuron, oxyfluorfen, or dichlobenil). CHECK VINEYARD AGE RESTRICTION BEFORE USING ANY HERBICIDE.			
Broadleaf weeds, some grasses, and some perennial weeds	(simazine) Caliber 90 Princep 4L	4.4 lb 4 qt	VINEYARD MUST BE ESTABLISHED AT LEAST 3 YEARS. Do not replant to other crops for 2 years. Apply from late winter to early spring. Do not apply on gravelly, sandy, or loamy sand soils or injury may result.
	(diuron) Karmex 80 DF	2 to 6 lb	VINEYARD MUST BE ESTABLISHED AT LEAST 3 YEARS. Apply in Spring just prior to germination of annual weeds.
	(dichlobenil) Casoron 4G	100 to 150 lb	Use at temperatures below 40˚F. May cause injury if plants are not well established. Apply in late fall or winter for best results. Effective on many perennial weeds.
	(oxyfluorfen) Goal 1.6E	2.5 to 10 pt	VINEYARD MUST BE ESTABLISHED AT LEAST 3 YEARS. Use a minimum of 40 gallons of water per acre, directed to the soil at the base of vines. Soil surface should be smooth and free of trash. Apply only to dormant vines. Do not apply to vines that are not staked or trellised.

Table 46 continued. Weed management in grapes during the planting year and in established vineyards†.

ESTABLISHED PLANTINGS			
Weed Problem	**Herbicide**	**Rate/Acre**	**Comments and Limitations**
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds.	(paraquat) *Gramoxone Max	1.7 to 2.7 pt	Contact herbicide. Use with a non-ionic surfactant. Apply as a coarse directed spray on a warm calm day to wet the weeds. Avoid application to foliage or green shoots. Use of a shield is highly recommended.
	(glufosinate) Rely	4 to 6 qt	Contact herbicide. Apply in at least 20 gallons of water per acre at no more than 30 psi. Apply as a coarse directed spray on a calm day to wet the weed foliage or green shoots. For spot sprays use 1.5 ounces per gallon of water. May also be used for sucker control. See label.
Emerged annual and perennial broadleaf weeds and grasses	(glyphosate) Roundup Ultra	1 to 5 qt	Do not allow spray, drift, or mist, to contact green bark, suckers, or vines. Suckers within spray zone should be removed before application to reduce risk of crop damage. Use of a shield is highly recommended. Applications must be made prior to the end of bloom stage unless a wick applicator or shielded sprayer is used. Do not apply within 14 days before 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 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 the tank. Do not cultivate 5 days before or 7 days after application. Do not apply within 50 days before harvest or exceed 5 pints per acre per year.

Restricted use pesticide;pesticide applicator license required.

Introduction to Risk Management and Crop Insurance Options for New England Small Fruit Growers

United States Department of Agriculture
Risk Management Agency
June 2003

The following pages have been inserted into this guide as a service funded by the USDA Risk Management Agency (RMA) and its regional cooperators. The New England states have been identified as among several "underserved states" by RMA, primarily because our farmers have not been significant users of the insurance products developed by the Federal Crop Insurance Corporation (FCIC).

Most of the New England states are entering their second or third year of reaching out to growers and agricultural professionals to make sure they understand the opportunities offered by crop insurance – as well as some of the current barriers. The end result of this process will be to increase the use of crop insurance through awareness - and through product modification to better suit the particular needs of our growers.

Although apple growers in our region have been among the higher users, the product fit has not been conducive for small fruit growers to this point. Several changes are on the horizon that we think will make FCIC products more attractive to you, and there are some existing options that might make good sense if you fully understand them. The enclosed information on AGR, Organic coverage and the option to purchase non-listed crops insurance under a "written agreement" are worth a good look.

We encourage you to review these pages, check out the RMA website and, most importantly, make an inquiry to one of the agencies listed in this appendix. Crop Insurance Agents, who are not actually directly related to RMA or FCIC, are the ones with on-the-ground experience on what works and what doesn't in your particular situation. Part of the effort to improve service in New England includes increased communications with well informed agents. Your unique scenarios will help this to happen, whether or not you actually buy coverage.

Crop Insurance products can be a very good value if the coverage fits your needs. Due to significant ongoing subsidies from the Federal Government – and some even more advantageous special programs – farmers are not expected to pay for the full cost of coverage.

However, we do see a trend away from the regionally common "disaster based programs" that have sometimes provided free "insurance" in areas where losses are catastrophic. Congress now appears to be under increasing pressure to share the insurance management of risk with the farmer. Lenders also see crop insurance as a means to reduce their exposure (and increase your eligibility for better terms). The sooner you at least look into purchasing farm-specific crop insurance, the more likely it is that you will be ready when having this type of coverage is the primary protector, even in a disaster situation.

We will be attending some of your winter meetings and doing some direct mail as products and rates change. Due to the lead time on many policies, we encourage you to find out more on your own as soon as possible. If coverage makes sense for you in the 2004 growing season, many applications must be completed in the late summer or early fall of this year.

***This information is provided by**: The United States Department of Agriculture's Risk Management Agency, The Massachusetts Department of Food & Agriculture, The New England Small Farm Institute, University of Massachusetts Extension, University of Maine Cooperative Extension, University of Vermont Extension, University of Connecticut Cooperative Extension, University of New Hampshire Cooperative Extension and University of Rhode Island Cooperative Extension cooperating.*

New England Fruit Crop Insurance Fact Sheet

United States Department of Agriculture
Risk Management Agency
June 2003

The Risk Management Agency offers a **federally subsidized crop insurance program** through private insurance companies. Crop insurance covers disasters such as drought, hail, frost, hurricanes, excessive moisture, fire, insects & plant disease and wildlife damage. This fact sheet points out only certain features about various crop insurance programs and is not intended to be all-inclusive. For more specific information on a particular crop, contract your local crop insurance agent or visit our website at **www.rma.usda.gov**.

What Crops Are Insurable?

Sales Closing Date	Crop
November 20	Apples
	Blueberries
	Cranberries
	Peaches

Sales closing dates are in place as the deadline to purchase an insurance plan for a particular crop. An application must be submitted to a crop insurance company representative by this date or else the insurance policy will not attach and your crop losses will not be covered.

What If I Have A Crop That Is Not Listed As Insurable?

You may still be eligible to request crop insurance through a "**written agreement**". The written agreement is a document designed to provide crop insurance in counties without an established program for the crop or an organic crop. See your crop insurance agent regarding documentation requirements. Note, written agreements are not issued for pilot crops.

Are Other Crops Being Considered?

Yes! The RMA is consistently developing new programs. Our agency is working with contractors, universities and researchers to identify local farmer needs and develop new crop programs. New England currently has a pilot program for Blueberries in Maine. Crops usually stay in a pilot program until the insurance plan is deemed fundamentally sound. Check with your insurance agent to see if a pilot crop is available in your county.

How Much Does It Cost?

A $100 administrative fee, per crop per county, will apply for a catastrophic (CAT) insurance plan. The premium on CAT coverage is paid by the Federal government. Catastrophic coverage pays 55 percent of the established price of the commodity on crop losses in excess of 50 percent. Limited resource farmers may have this fee waived. CAT coverage is not available on written agreements. Check with your crop insurance agent to see if you qualify as a limited-resource farmer or for CAT availability.

Are Higher Coverage Levels Available?

Yes. The cost for buy-up levels of insurance coverage is a $30 administrative fee, per crop per county, plus the premium. Simply select the amount of your Actual Production History (APH) yield you wish to insure; from 55 to 75 percent (in some areas up to 85 percent).

Can I Get Another Type of Insurance Plan?

Yes! The agency offers a different insurance plan.

- Adjusted Gross Revenue: This is a whole farm insurance program providing insurance coverage for multiple agricultural commodities under one insurance product using income tax information from your operation. A

farm report is created to determine coverage eligibility. Covered farm revenue includes income from most crops and agricultural commodities. A limited amount of income (not to exceed 35%) from livestock, animal products, and aquaculture products raised in a controlled environment may also be covered.

Who Can I Call For More Information?

The Raleigh Regional Office services the New England States. Crop specialists are available to answer specific questions. Call or write the Raleigh Regional Office, 4407 Bland Road, Suite 160, Raleigh, North Carolina 27609, telephone (919) 875-4880.

Visit the RMA Web Site

For the latest crop insurance and agricultural risk management information, visit our website at **http://www.rma.usda.gov**

New England Insurance Companies Offering Crop Insurance

The following companies have standard reinsurance agreement contacts with the Federal government and are authorized to sell USDA's crop insurance programs. To find an insurance agent in your State contact:

Company	Company
Ace Property and Casualty Insurance Company (Rain and Hail L.L.C.) Serving: CT, ME, MA, NH, RI & VT 9200 Northpark Drive, Suite 300 Johnston, Iowa 50131-3006 *Toll-Free:* 1-800-776-4045 *Phone:* 515-559-1000 *Fax:* 515-559-1001 http://www.rainhail.com	**Alliance Insurance Company** (North Central Crop Insurance Company) Serving: MA 1825 North Clairemont Eau Claire, Wisconsin 54703 *Toll-Free:* 800-826-7090 *Phone:* 715-834-8155 *Fax:* 715-834-1899 http://www.nccinet.com
Crop Growers Insurance Services Serving: CT, ME, MA, NH, RI & VT 4059 West Road Cortland, NY 13045 *Toll-Free:* 1-800-234-7012 *Phone:* 315-655-3485 *Fax:315-655-3485* http://www.firstpioneer.com	**Hartford, The** Serving: CT, ME, MA, NH, RI & VT 2625 South 158th Plaza Omaha, Nebraska 68103 *Toll-Free:* 1-800-295-1815 *Phone:* 402-952-0501 *Fax:* 402-952-0629 http://www.agribizexpress.com
Rural Community Insurance Services Serving: CT, ME, MA, NH, RI & VT 3501 Thurston Avenue Anoka, Minnesota 55303-1060 *Toll-Free:* 1-800-328-9143 *Phone:* 763-427-0290 *Fax:* 763-427-1591 http://www.rcis.com	

Crop insurance situations vary significantly due to individual crop, county/region, weather conditions, etc.
Farmers are encouraged to review their policy and consult with their crop insurance representatives, routinely.

2003

Risk Management Agency

Raleigh Regional Office

"Serving the Mid-Atlantic and Northeastern States"

AGR

4407 Bland Road, Suite 160
Raleigh, NC 27609

November 2002

Phone: (919) 875-4880
Fax: (919) 875-4915

ADJUSTED GROSS REVENUE

PILOT PROGRAM

Non-traditional Risk Management Tool

The USDA Risk Management Agency (RMA) has partnered with grower associations, cooperative extension specialists, and insurance companies to develop a whole farm insurance program called **Adjusted Gross Revenue (AGR)**. The AGR plan:

① Provides insurance coverage for multiple agricultural commodities under one insurance product;

② Uses income tax information from the producer's agricultural operations as a basis to provide a level of guaranteed revenue for the insurance period;

③ Creates an AGR farm report that will be used to determine coverage eligibility; and

④ Reinforces program credibility by using IRS forms and regulations to ensure compliance.

AGR Protection

AGR provides protection against revenue loss due to unavoidable natural disasters or market fluctuations. Covered farm revenue includes income from most crops and agricultural commodities.

A limited amount of income (not to exceed 35%) from livestock, animal products, and aquaculture products raised in a controlled environment may also be covered. The value of any crop production fed to livestock will be counted as livestock income.

Availability

The AGR Pilot Program is available in the following mid-Atlantic and northeastern states for 2003:

Delaware: Kent, New Castle, Sussex

Maryland: Anne Arundel, Baltimore, Calvert, Caroline, Carroll, Cecil, Charles, Dorchester, Frederick, Harford, Howard, Kent, Montgomery, Prince George's, Queen Anne's, St. Mary's, Somerset, Talbot, Wicomico, and Worcester counties; Baltimore city

New England: All counties in Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont

New Jersey: All counties

New York: Cayuga, Chautauqua, Erie, Genesee, Monroe, Niagara, Onondaga, Ontario, Orange, Orleans, Oswego, Seneca, Suffolk, Ulster, Wayne, and Yates counties

Pennsylvania*: Berks, Carbon, Columbia, Crawford, Erie, Fayette, Lackawanna, Lancaster, Lehigh, Monroe, Northampton, Schuylkill, Westmoreland, and York counties

Virginia: Accomack, Caroline, Charles City, Chesterfield, Essex, Gloucester, Hanover, Henrico, Isle of Wight, James City, King and Queen, King George, King William, Lancaster, Mathews, Middlesex, New Kent, Northampton, Northumberland, Prince George, Richmond, Southampton, Surry, Sussex, Westmoreland, and York counties; Chesapeake, Colonial Heights, Franklin, Hampton, Hopewell, Newport News, Norfolk, Petersburg, Poquoson, Portsmouth, Richmond, Suffolk, Virginia Beach, and Williamsburg cities.

* A new limited-liability alternative plan called AGR-Lite will be available in all Pennsylvania counties (except Philadelphia County) for 2003.

AGR Time-Line

Sales Closing Date: January 31, 2003 (This is also the cancellation date for existing policies.)

Beginning of Insurance Period: January 1, 2003 for calendar year tax filers. (For the first year, coverage will not begin until at least ten (10) days after the company receives a properly completed application.)

Insurance Year: The Calendar or Fiscal Year that corresponds to the producer's IRS tax year.

Claims: Claims will be settled after filing with the IRS.

Shared Interest

AGR insurance is provided against a revenue loss *ONLY for the person named on the AGR application* and will not extend to any other person having a share in the operation. A separate contract will be required for each qualifying person.

AGR Producer Eligibility

- An AGR applicant's agricultural operation must be located in one of the pilot counties listed above, but may include some income from contiguous non-pilot counties;
- Insured must have filed federal income tax returns under the same tax entity for the past five years

and the insurance year (unless at least 90 percent of a previous farming operation was transferred to the current tax entity);

• If more than 50 percent of expected income will be derived from a crop or combination of crops currently insurable under existing plans (except for pilot programs), individual policies on those crops must be purchased if available;

• No more than 35 percent of expected allowable income can be from animals or animal products;

• An administrative fee of $30 will be charged in addition to the premium.

***NOTE**: AGR complements other insurance plans by coordinating the protection and benefits with your other plans. If you are required to purchase other crop insurance policies in addition to AGR, your AGR base premium will be reduced accordingly, but will not be less than 50% of the full, original AGR premium.*

Causes of Loss and Exclusions

Coverage is provided against loss of farm revenue due to unavoidable natural disaster or market fluctuations occurring during the insurance year. Payments will be not be made for losses resulting from negligence, mismanagement, or wrongdoing by the insured or members of the insured's family; failure to follow recognized good farming practices; abandonment or other excluded causes as listed in the AGR insurance policy.

Amount of Coverage

The applicant selects a coverage level (65, 75, or 80%) and a payment rate (75 or 90%). The dollar guarantee is equal to AGR amount X coverage level X payment rate.

Loss Payment

A loss payment is made whenever adjusted gross income for the insured year falls below the AGR times the coverage level. Once a loss is triggered, the producer is paid an indemnity equal to the revenue shortfall times a payment rate of either 75% or 90%, as selected by the producer before the policy went into effect

65% Coverage Level

75% or 90% Payment Rate

(For the 90% payment rate you must produce a minimum of two crops or commodities, with each contributing at least a certain percentage of total expected allowable income.)

75% Coverage Level

75% or 90% Payment Rate

(You must produce a minimum of two crops or commodities, each contributing at least a certain percentage of total expected allowable income.)

80% Coverage Level

75% or 90% Payment Rate

(You must produce a minimum of four crops or commodities, each contributing at least a certain percentage of total expected allowable income.)

Loss Payment Example

Assume AGR Income:

Year	Dollar Amount
1997	$91,500
1998	$119,000
1999	$89,000
2000	$90,000
2001	$85,000
	$474,500

AGR average = $94,900

Assume AGR Expenses:

Year	Dollar Amount
1997	$66,500
1998	$75,200
1999	$57,000
2000	$59,100
2001	$59,800
	$317,600

Average Expenses = $63,520

Let's assume the insured's adjusted gross income for the insurance year is **$21,000** due to drought. At the 80% coverage level with a payment rate of 90%, the insured's indemnity would be calculated as follows:

Average AGR **$94,900** times 80% coverage level equals a trigger level of **$75,920.** Subtract **$21,000** revenue from $75,920 for a shortfall of **$54,920**. Multiply that by **90%** payment rate for an indemnity payment of **$49,428**, less premium. (**75%** payment rate results in indemnity of **$41,190**.)

***NOTE:** If the insured's allowable expenses for the insurance year are below 70% of the average expenses (i.e., below $44,464), the approved AGR will be reduced accordingly.*

Disclaimer

This fact sheet points out only certain features of the AGR plan and is not comprehensive. The information presented here neither modifies nor replaces terms and conditions of the basic policy, the AGR provisions, or county actuarial documents. Contact a crop insurance agent for further details (see below).

Where to Purchase AGR

AGR insurance policies are available through private crop insurance agents. A list of agents is available at your local USDA Farm Service Agency office or you may visit the RMA web site at:

www.rma.usda.gov

Additional Information

Questions may be addressed to:

Larry N. Atkinson, Director
Raleigh Regional Office
Risk Management Agency, USDA
4407 Bland Road, Suite 160
Raleigh, NC 27609
919-875-4880

(*This fact sheet was originally created and designed by Jo Lynne Seufer, Spokane Regional Office, RMA, USDA.*)

RISK MANAGEMENT AGENCY (RMA)
RALEIGH REGIONAL OFFICE
"Serving the Mid-Atlantic and Northeastern States"

INSURANCE COVERAGE FOR ORGANIC CROPS

October 2002

USDA SETS GUIDELINES TO PROVIDE CROP INSURANCE FOR ORGANIC FARMING PRACTICES

The Agricultural Risk Protection Act of 2000 (ARPA) provides that organic farming practices be recognized as good farming practices. Prior to this ruling, crop insurance policies may not have covered production losses when organic insect, disease, and/or weed control measures were used and such measures were not effective.

WRITTEN AGREEMENTS

The Federal Crop Insurance Corporation (FCIC) is currently revising the Basic Provisions to reflect the modifications made by ARPA. Until specific insurance program procedures are set in place and for the crop year 2003, USDA's Risk Management Agency (RMA) will recognize organic farming practices as good farming practices by providing coverage for organic producers by **Written Agreement.** Written Agreements are not available for catastrophic risk, income protection, revenue assurance plans of coverage or for pilot program crops, unless permitted by the crop provision.

COVERAGE AVAILABILITY

Coverage for organic acreage for crop year 2003 will be available for both transitional and certified organic acreage in accordance with approved underwriting guidelines and procedures. Insurable damage caused by insects, disease, or weeds will be covered if recognized organic farming practices fail to provide an effective control. Damage caused by the failure of organic farming practices to control weeds due to an insured cause of loss is also covered. If any acreage does not qualify as a certified organic acreage or transitional acreage location within the unit by the final acreage reporting date, such acreage will be insured under the provisions of the standard policy and applicable rates and coverages for the conventional practice or type in effect on the final acreage reporting date.

PRICE ELECTION or DOLLAR AMOUNT of INSURANCE

The price elections or dollar amounts of insurance applicable to both certified organic acreage and transitional acreage will be the price elections or dollar amounts of insurance published by RMA for the crop for the current crop year. **Price elections will not increase for the organic practice.** The insured is required to maintain separate APH databases for "conventional and transitional or certified organic acreage." Premiums will be adjusted to recognize any additional risk associated with covering organic crop acreage.

CROP LOSSES

If a Written Agreement is not requested for organic farming practices, loss adjustment procedures for conventionally grown crops will be applicable. Appraisals for uninsured causes of loss will be applied when conventional farming practices would have prevented damage due to insects, disease, or weeds.

ADDITIONAL INFORMATION/QUESTIONS

Producers should consult their crop insurance agent to obtain specific information and applicable deadlines. A list of crop insurance agents is available at all USDA Service Centers throughout the U.S. or at the website address: www3.rma.usda.gov/tools/agents/

USDA is an equal opportunity provider and employer.

Appendices

Table 47. 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			
*Agri-Mek EC (abamectin)	1 day	Imidan (phosmet)	1-4 days
Asana (esfenvalerate)	1 day	Lannate (methomyl)	> 1 day
*Brigade (bifenthrin)	> 1 day	Lorsban (chlorpyriphos)	4-6 days
*Danitol (fenpropathrin)	1 day	Malathion WP (malathion)	2 days
*Diazinon (diazinon)	2 days	Malathion Dust (malathion)	7 days
Guthion (azinphos methyl)	2.5 days	Sevin (carbaryl)	3-7 days
HIGHLY TOXIC[a]: Apply ONLY during late evening if blooming plants are present.			
Confirm (tebufenozide)	< 8 hours	Sevin XLR (carbaryl)	> 1 day
Dibrom EC (naled)	16 hours	Thiodan 50WP (endosulfan)- high rate	8 hours
Provado (imidachloprid)	< 8 hours	Phaser (edosulfan)	8 hours
MODERATELY TOXIC[a]: Apply ONLY during late evening, night, or early morning if blooming plants are present.			
Formula 40 (2,4-D)	?	Princep (simazine)	?
Azatin (azadiractin)	< 2 hours	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	Thiodan 50WP (endosulfan) - low rate	2-3 hours
SLIGHTLY TOXIC OR NONTOXIC: Can be applied at any time with reasonable safety to bees.			
Benlate (benomyl)		lime-sulfur	
Bordeaux mixture (copper sulfate + lime)		Microthiol (sulfur)	
Captan (captan)		M-Pede (insecticidal soap)	
Dipel (*Bacillus thuringiensis)*		Nova (systhane)	
Dithane (mancozeb)		Procure (triflumizole)	
Ferbam (ferbam)		Roundup Ultra (glyphosate)	
fixed copper		Savey (hexythiazox)	
Goal (oxyflourfen)		Sinbar (terbacil)	
Gromoxone Max (paraquat)		Sulfur	
Javelin (*B. thuringiensis*)		Syllit (dodine)	
Kelthane (dicofol)		Thiram (thiram)	
Kumulus (sulfur)		Vendex (hexakis)	
And most other fungicides and herbicides.			

[†]Sources: 2003 New England Apple Pest Management Guide and 2003 PennState Commercial Berry Produciton and Pest Management Guide.

[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 material; pesticide applicators license required.

Table 48. Relative toxicity of pesticides to mite predators *Neoseiulus fallacis, Typhlodromus pyri, Zetzelia mali* and *Stethorus punctum* (ladybird beetle).

Trade Name (common name)*	TOXICITY RATING				
	General Predators[1]	**N. fallacis[2]**	**T. pyri**	**Z. mali**	**S. punctum**
INSECTICIDES AND MITICIDES					
Agri-Mek (abamectin)	no data	++	++	++	++
Asana (esfenvalerate)	+++	+++	+++	++	+++
Biobit (Bacillus thuringiensis)	0	+	+	0	0
Brigade (bifenthrin)	no data	+++	+++	no data	no data
Confirm (tebufenozide)	0	+	+	0	0
Dipel (Bacillus thuringiensis)	0	+	+	0	0
Guthion (azinphosmethyl)	++	+	+	+	+
Imidan (phosmet)	+	+	+	+	+
Lannate (methomyl)	+++	+++	+++	++	++
Lorsban (chlorpyrifos)	++	++	++	++	+
Kelthane (dicofol)	+	++	+	+	+
Savey (hexythiozox)	0	+	+	+	+
Sevin (carbaryl)	++	++	+	++	+++
Spintor (spinosad)	0	+	+	0	0
Superior oil	++	++	++	++	+
Thiodan (endosulfan)	++	+	+	no data	++
Vendex (hexakis)	+	+	+	+++	+
FUNGICIDES					
Captan (captan)	0	+	+	+	+
Dithane (mancozeb)	0	++	++	+	+
Ferbam (ferbam)	no data	no data	no data	no data	no data
Nova (myclobutanil)	0	+	+	+	+
Procure (triflumizole)	no data	no data	no data	no data	no data
Ronilan (vinclozolin)	no data	+	no data	no data	no data
Rovral (iprodione)	no data	+	no data	no data	no data
Rubigan (fenarimol)	no data	+	+	no data	no data
Sulfur	no data	+	+	no data	no data
Syllitt (dodine)	no data	+	+	no data	no data
Thiram (thiram)	no data	+	no data	no data	+
Topsin-M (thiophanate-methyl)	0	+	+	++	+
Ziram (ziram)	0	++	++	+	+

0=no impact on population, +=low impact on population (less than 30% mortality in 48 hours), ++=moderate impact on population (between 30% and 70% mortality after 48 hours), +++=severe impact on population (over 70% mortality after 48 hours).

**Where trade names are used, no discrimination is intended and no endorsement by Cooperative Extension is implied. Not a complete list.*

[1]General predator group includes coccinellids, lacewings, syrphid fly larvae, minute pirate bugs, and mullein plant bugs.

[2]Formerly Amblysieus fallacis.

Adapted from 2003 New England Apple Pest Management Guide.

Table 49. 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, 1997. 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, 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.

PennState Commercial Berry Production and Pest Management Guide. 2002-2004. Kathy Demchak, editor. Pennsylvania State University Collage of Agriculture. Publications Distribution Center, 112 Agricultural Admin. Building, University Park, PA 16802. 814-865-6713. 130 pp. $10

Small Fruit and Crop Management. 1990. Gene Galletta and David G. Himelrick, eds. Prentice-Hall, Englewood Cliffs, NY 07632.

Steel in the Field, A Farmer's Guide to Weed Management, 1997. 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

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.

What you should know about controlling pest mites with predatory mites. 1993. Central Coast Insectary, 391 Hames Rd., Watsonville CA 95076 32.pp.

Sources of IPM Traps, Lures, and Baits

Great Lakes IPM
10220 Church St., NE
Vestaburg, MI 48891
(517)268-5693

Gempler's, Inc
211 Blue Mounds Rd., P.O. Box 270
Mr. Horeb, WI 53572
(800)332-6744

AgriSense
4230 West Swift, Suite 106
Fresno, CA 93722
(209) 276-4250

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

BioQuip Products (for aspirators, sweepnets, beating sheets, vials, magnifiers, and other collection supplies)
17803 LaSalle Avenue
Gardena, CA 90248
(310)324-0620

Forestry Suppliers, Inc. (for magnifiers, optivisors, tally counters, and other field supplies)
P.O. Box 8397
Jackson, MI 39284
(800)752-8460

Strawberry

Compendium of Strawberry Diseases. 1998. John Maas, editor. American Phytopathological Society. St. Paul, MN. 98 pp. $35 1-800-328-7560.

Integrated Pest Management for Strawberries in the Northeastern United States. 1994. Daniel Cooley, Sonia Schloemann, Arthur Tuttle, eds. Available from the UMass Extension Bookstore, Draper Hall/UMass, Amherst MA 01003. 413-545-2717. Bulletin C211. 52pp. $7.

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 Engineering 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

Blueberry Culture. 1989. Paul Eck and Norman F. Childers, eds. 4th edition. Rutgers Univ. Press, New Brunswick, NJ.

Compendium of Blueberry and Cranberry Diseases. 1995. Frank L. Caruso and Donald C. Ramsdell, editors. American Phytopathological Society. St. Paul. MN. 87 pp. $35 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

Integrated Pest Management in Strawberries: a training video for growers. 1993. Minnesota Fruit and Vegetable Growers Association, 1207 Constance Blvd NE, Ham Lake MN 55304. 17.5 minutes $16.50.

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 Hor Science, Univ. of Saskatchewan, Saskatoon, Saskatchewan Canada.

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:
( ) wilting ( ) leaf spot ( ) yellowing
( ) blight ( ) streak ( ) leaf drop
( ) galls ( ) mosaic ( ) marginal burn
( ) rot ( ) other:_____

Plant Part(s) Affected:
( ) stems ( ) flowers
( ) roots ( ) fruit
( ) leaves ( ) entire plant

Distribution of Problem:
( ) entire planting ( ) edge of planting
( ) random ( ) low areas
( ) wet areas ( ) high areas
( ) dry areas ( ) sunny areas
( ) shaded areas ( )_____

Nature of Planting:
( ) field ( ) nursery
( ) yard ( ) orchard
( ) forest ( ) greenhouse
( ) indoors ( )_____

Soil Type:
( ) sandy ( ) clay
( ) loamy ( ) mulch
( ) potting mix
( ) _____

Drainage:
( ) good
( ) fair
( ) poor
( ) _____

Watering:
( ) never
( ) daily- morning
( ) daily- evening
( ) _____

Chemicals and Fertilizers:
( ) 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.

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Hospital (emergency): _____

Hospital's phone number: _____

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Connecticut Poison Control Center
263 Farmington Ave.
University of CT Health Center
Farmington, CT 06032
1-800-222-1222

Maine
Maine Poison Control Center
Maine Medical Center
22 Bramhall Street
Portland, ME 04102
1-800-222-1222

Massachusetts
Mass. Poison Control System
300 Longwood Avenue
Boston, MA 02115
1-800-222-1222

New Hampshire
New Hampshire Poison Center
Lebanon DHMC
1 Medical Center Drive
Lebanon, NH 03756
1-800-222-1222

Rhode Island
Rhode Island Poison Center
593 Eddy Street
Providence, RI 02903
1-800-222-1222

Vermont
Vermont Poison Center
Fletcher Allen Health Care
111 Colchester
Burlington, VT 05401
1-800-222-1222

FOR CHEMICAL INFORMATION

National Pesticide Information Center: 1-800-858-7378; npic@ace.orst.edu

http://npic.orst.edu

EPA Emergency National Response Center: 1-800-424-8802

www.epa.gov/superfund/programs/er/

CHEMTREX: for emergency spill, fire, leak and explosion
Pesticide Emergency Network: 1-800-424-9300