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

MAINE
The Analytical Laboratory (1,2,3)
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)
West Experiment Station
Univ. of Massachusetts
Amherst MA 01003
Telephone: 413-545-2311
Email: bodine@pssci.umass.edu

NEW HAMPSHIRE
University of NH Analytical Services Lab (1,2,3)
Spaulding Hall, Room G-54, 38 College Rd.
Durham NH 03824
Telephone: 603-862-3210
Email: soil.testing@unh.edu
Website: http://aslan.unh.edu/asl

VERMONT
UVM Agricultural & Environmental
Testing Laboratory (1,2,3,4)
219 Hills Building, UVM
Burlington VT 05405
Telephone: 802-656-3030, 800-244-6402
Email: ecarr@zoo.uvm.edu
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
Email: weblink@woodsend.org.
Website: http://woodsend.org/

Crop Production Services (1)
Elm St.
South Deerfield, MA 01373
Telephone: 413-665-2115

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

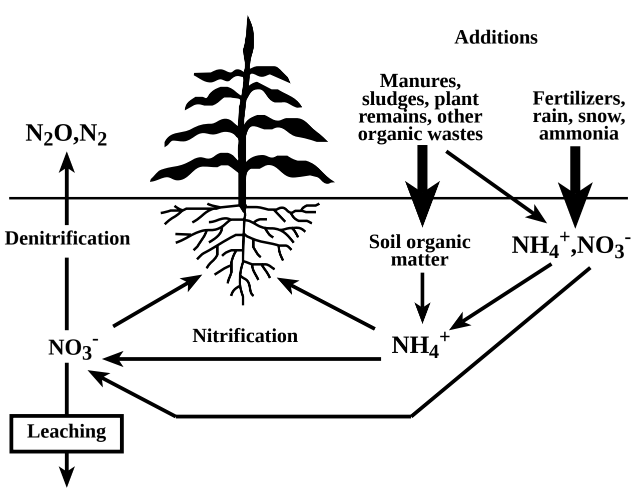
Nitrogen

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. The rates of most N inputs are difficult to accurately estimate.

Figure 1. The nitrogen cycle.



Nitrogen Inputs

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

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

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

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

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

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

In cage layer poultry manure, a higher percentage of the total N in the manure is converted to plant-available forms in the year of application. Consequently, there is relatively little carry-over of N to crops in succeeding years. This is due to the nature of the organic N compounds in poultry manure. This does not mean, however, that there is never any carry-

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

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 70½ F) that are moist, but well aerated, with a pH between 6 and 7. Mineralization of nutrients will proceed rapidly under these conditions.

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

Adding to Soil Organic Matter

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

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

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

Carbon-To-Nitrogen Ratio

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

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

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 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

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

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 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

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		Soil should be adjusted to pH=4.5 prior to planting
	1	15 lb/A	ammonium sulfate or urea	
	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

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
http://www.state.ct.us/caes/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
1-800-287-0279 (within Maine)
(207)581-3880
Cost: free to Maine residents

MASSACHUSETTS
Nematode Assay and Disease Diagnostic Laboratory (D,N)
Attn: Dr. Rob Wick
Dept. of Microbiology/UMass
Fernald Hall, Rm 109
Amherst, MA 01003
(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/agplhlth.htm
Cost: $12

RHODE ISLAND
University of Rhode Island Cooperative Extension Education Center (D,I)
3 East Alumni Avenue
Kingston, RI 02881
(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/index.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 multi-tactic or integrated approach to pest management. Although the term ‘pest’ means ‘insects’ to many people, in IPM the term ‘pest’ is usually used in a broader sense that includes disease-causing microorganisms and weeds as well as certain insects, mites, birds, and mammals.

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

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

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

Monitoring Pests and Making Control Decisions

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 imitations of pheromones are commercially available as lures that can be placed in traps. Most commercial pheromones are imitations of secretions from unfertilized adult female insects, which are used to attract male insects of the same species. Most commercial pheromones are used to monitor various species of moths. Some of the fruit pests that can be monitored with pheromone traps are the grape berry moth, red-banded leafroller, grape root borer, Sparganothis fruitworm, variegated cutworm, and black cutworm.

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

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

Insect pheromone trapping guidelines:

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

Sources of traps and lures, weather and other monitoring supplies are listed on page 106 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 (biorational 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. Contact your local Extension Specialist for information on other such products.

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 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 or call (916) 324-4100 for a copy of Suppliers of Beneficial Organisms in North America, an excellent sourcebook for natural enemies such as predatory mites. Also available via the Internet at http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm.

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.

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.

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 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.

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.

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

Trade Name(tm)	Common Name	Signal Word[††]	Reentry Interval (REI)
INSECTICIDES			
*Agri-mek	abamectin	Warning	12 hrs
*Brigade	bifenthrin	Warning	12 hrs
Cythion	malathion	Caution	12 hrs
*Danitol	fenpropathrin	Danger	24 hrs
*D•z•n diazinon	diazinon	Warning[z]	24 hrs
Dipel	Bacillus thuringiensis	Caution	4 hrs
Dibrom	naled	Danger	24 hrs
*Guthion	azinphos methyl	Danger	****
Imidan	phosmet	Warning	24 hrs
Kelthane	dicofol	Warning[z]	12 hrs
*Lannate	methomyl	Danger[z]	48 hrs**
*Lorsban	chlorpyrifos	Warning[z]	24 hrs
Malathion	malathion	Caution	24 hrs
Phaser	endosulfan	Danger-Poison	24 hrs
Pyrenone Crop Spray	pyrethrins	Caution	12 hrs
Rotenone	rotenone	Danger[z]	24 hrs
Sabadilla	sabadilla	Caution	12 hrs
Sevin	carbaryl	Warning	12 hrs
*Sniper	azinphos methyl	Danger-Poison	24 hrs
Sunspray Ultrafine Oil	Paraffinic oil	Caution	12 hrs
Thiodan	endosulfan	Danger	24 hrs
Vendex	hexakis	Danger	48 hrs
FUNGICIDES			
Abound	azoxystrobin	Caution	12 hrs
Aliette	fosetyl-aluminum	Caution	12 hrs
Bayleton	triadimefon	Caution	12 hrs
Benlate	benomyl	Caution	24 hrs
Captan	captan	Danger	4 days***
Dithane	mancozeb	Caution	24 hrs
Elevate	fenhexamid	Caution	4 hrs
Kocide	copper hydroxide	Danger	48 hrs
Manzate 200	mancozeb	Caution	24 hrs
Nova	systhane	Danger[z]	24 hrs
Penncozeb	mancozeb	Caution	24 hrs
Procure	triflumizole	Caution	12 hrs
Ridomil	metalaxyl	Caution	12 hrs
Ronilan	vinclozolin	Caution	12 hrs
Rovral	iprodione	Caution	12 hrs
Rubigan	fenarimol	Warning[z]	12 hrs
Sulfur	sulfur	Caution	24 hrs
Syllit	dodine	Danger	48 hrs
Thiolux	sulfur	Caution	24 hrs
Topsin-M	thiophanate-methyl	Caution	12 hrs
Trilogy	neem oil	Caution	4 hrs
Vanguard	cyprodinil	Caution	12 hrs
Ziram	ziram	Danger	48 hrs
HERBICIDES			
Casoron	dichlobenil	Caution	12 hrs
Dacthal	DCPA	Caution	12 hrs
Devrinol	napropamide	Caution	12 hrs
Formula 40	2,4-D	Danger	48 hrs
Fusilade	fluazifop	Caution	12 hrs
Goal	oxyfluorfen	Warning	24 hrs
*Gramoxone Extra	paraquat	Danger	12 hrs
Karmex	diuron	Caution	12 hrs
*Kerb	pronamide	Caution	24 hrs
Poast	sethoxydim	Caution	12 hrs
Princep	simazine	Caution	12 hrs
Prowl	pendimethalin	Caution	12 hrs
Roundup	glyphosate	Caution	4 hrs
Sinbar	terbacil	Caution	12 hrs
Solicam	norflurazon	Caution	12 hrs
Surflan	oryzalin	Caution	12 hrs
Touchdown	ulfosate	Caution	4 hrs

(tm)Where trade names are used, no discrimination is intended and no endorsement is implied. Not a complete list.
[†]Based on 1999/2000 Label Registrations.
[††]See page 22 for description of toxicity class and signal word.
[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.
**** REI varies up to 21 days for different crops and different activities. Check the label.

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.

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 80½ F), dry, well-ventilated area that is not accessible to children and others who do not know or understand the safe and proper use of pesticides.

Any restricted pesticide or container contaminated by restricted pesticides must be stored in a secure, locked enclosure while unattended. That enclosure must bear a "pesticide storage" warning sign readable at a distance of 20 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

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 (50½to 80½F, or 10½C). 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.

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 22 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. 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, reduc-

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	8 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 pints	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

ing 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 non-ionic 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

Table 9. Fumigant rates and spectrums of activity.

			LEVELS OF CONTROL[a]			
Common Name	Trade Name	Rates/A	nematodes	fungi	weeds	Comments
D-D Mixture[b]	Telone II	16-20 gal	4	1	0	Slight suppression of some soil-born organisms
methyl isothiocyanate compounds	Vapam Basamid 99G	50-100 gal 250-350 lb	4 4	4 4	4 3	Most effective when applied through overhead irrigation; incorporate thoroughly in soil.
methyl bromide	Brom-O-Gas	275-350 lb	5	4	4-5	Requires a plastic seal; weak against some Pythium specie
methyl bromide + chloropicrin	Terr-O-Gas 67	275-350 lb	5	5	4-5	Most effective for control of weeds, soil-born diseases; nematodes, and insects; requires plastic seal; highly toxic.

[a] 0=no control; 5= excellent control;
[b] Mixture of dichloropropanes and dichloropropenes in various ratios.
Courtesy of Rutgers University

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

Water Table: High water tables are especially vulnerable to contamination because little time is required for chemicals to reach groundwater.

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

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

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

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

Know Your Water

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

FUMIGATION: MATERIALS AND RISKS

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

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

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, 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. 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. 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 80½ or 73½ 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 Seedbed Technique

In many cases, choice of herbicides for use in small fruit crop production is limited or even nonexistent. 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, Scythe or flaming. Except for cool early spring conditions, when weeds may be slow to germinate, this method, termed the stale seedbed technique, can mean the difference between good weed control and poor or no weed control. Here are the steps:
- Prepare the soil as if you are about to seed or transplant. 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 or Roundup (if registered for the crop) to the soil surface before transplanting. Transplant the crop (without dragging any additional soil off the bed) and then apply any preemergence herbicide, which you would normally use, to the soil surface.
- If the crop will be seeded, the Gramoxone, Scythe or Roundup (if registered for the crop) or flaming may be applied just before or just after seeding (see the label). After seeding, apply any preemergence herbicide, which you would normally use, to the soil surface. **CAUTION:** the crop has already been seeded; be careful that the flaming process does not injure the crop seed or the unemerged crop seedling.

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 50½ F at a depth of 2") must be present. Gramoxone, Roundup, 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 or Roundup is registered for use in that crop.

Finally, in cases where Roundup 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.

Preparing 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 after seeding 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. Purselane 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.