Strawberries

GENERAL INFORMATION

Strawberries are attacked by a variety of pests, including insects, mites, pathogens and weeds. While much of this publication deals with chemical controls, the best overall approach to pest management integrates chemicals with other methods. Where possible, cultural practices that may help in managing these pests are presented. The single most important factor in controlling pathogens is the maintenance of vigorously growing plants. Weeds compete with strawberries for essential water and nutrients. Weeds also promote pest injury by acting as alternate 'homes' for pathogens and insects, inhibiting spray penetration, and maintaining high humidity in the strawberry leaf canopy.

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

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

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

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

Leaf tissue analysis is a good way to determine nutrient levels actually in the plant rather than what is in the soil. Sometimes the nutrients in the soil are not available to the plant due to pH, organic matter content, or some other reason. Leaf tissue analysis tells you what the plant is getting and what the plant is lacking. The samples are taken after bed renovation in the summer from the first fully expanded new leaves. At least 50 complete leaves per planting should be

Table 10. Recommended optimal soil characteristics for growing strawberries.

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

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

taken, rinsed, and allowed to dry completely before processing. Contact your regional fruit specialists for the exact protocol, processing instructions, and fees. Standards are available for comparison to determine if your results indicate the need for corrective measures. See Table 12.

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

Strawberries are a cool weather crop, producing most of their growth in the spring and fall. Growth is greatly slowed during the hot, dry summer months, resulting in a shallow root system. During the growing

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

In Row Spacing	Spacing Between Rows 36 inch	40 inch	42 inch
3 inches	58,080	52,293	49,783
6 inches	29,040	26,241	24,891
12 inches	14,520	13,120	12,446
18 inches	9,680	8,712	8,297
24 inches	7,260	6,540	6,223

Table 12. Critical nutrient values for strawberry tissue analysis.

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

Source: PennState University

Table 13. Critical freeze temperatures for strawberries based on stage of growth.

Stage of Development	Approx. Critical Temperature
Tight bud	25½F
"Popcorn"	28½F
Open Blossom	30½F
Fruit	28½F

season (April, May, August, September and October) applying 1-1/2" of water every 12 to 14 days will aid in maximum growth and fruit bud development. During fruiting, adequate moisture (1/2 to 3/4" of water per week) will maintain fruit size and production.

Irrigation can also eliminate frost damage to flowers during early bloom periods. If sprinklers are turned on before the temperature at ground level drops to 32½F and continued until air temperature is above freezing and **all ice has melted off the plants,** the blossoms will be protected. (Remember, the first blossoms to open will bear the largest berries.) The sensitive, actively growing tissue in the crown will also be protected from freezing injury that would make it more susceptible to pathogen attack.

DISEASES

Fruit Rots

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

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

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

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

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

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

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

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

This fungus had not previously been reported to cause fruit rot in New England but is an extremely important pathogen of strawberries in the Southeast. In addition to fruit, this fungus may also attack stolons, petioles, and strawberry crown tissues. The same fungus has been reported to cause fruit rots of crops such as apples, blueberries, raspberries, grapes, peppers and tomatoes.

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

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

Foliar Diseases

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

Inoculum for the first lesions in the spring comes from infected dead leaves. The bacteria are very resistant to drying and other harsh conditions, and may survive for a long time in the old leaves or in buried plant tissue in the soil. The pathogen does not move in the soil, or survive free in the soil. The bacteria may move from new lesions to other plants. It can be spread by rain or irrigation, or carried from plant to plant when fields are being worked. Wet, cool weather in the spring encourages the bacteria to build up to damaging levels. Long periods of rain, or frequent irrigation at times when the day temperatures are around 65½ F, and night temperatures near 35½ F, will encourage growth and spread of this disease.

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

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

Leaf Spots

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

The three major leaf fungal pathogens have a similar life cycle. Leaf spot, leaf scorch, and leaf blight all overwinter in infected dead or living leaves, produc-

ing spores and new infections during moist, warm conditions.

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

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

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

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

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

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

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

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

This fungus overwinters on living infected leaves. Infection periods are favored by dry weather and temperatures between 58½ and 68½F. Thus, if a severe foliar infection occurs, it does so late in the season. Controlling these foliar infections with fungicides does not apparently increase yields. However, by controlling foliar infections, the amount of inoculum available to infect the spring growth is reduced. Crop losses occur as a result of flower and fruit infections.

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

Root Rots

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

Structural roots are produced from the crown during the current year. Transient feeder roots consisting of primary tissues are produced from both structural and perennial roots. They may only live a few weeks and are replaced during the growing season; they are constantly dying back and being replaced. The transient roots function to absorb water and nutrients; the perennial roots cannot. Thus, all types of roots are important in maintaining healthy plants and good yields. Death to transient rootlets by pathogens or unfavorable soil conditions is not as damaging to plant vigor if the plant is able to replace them. However, often the structural and perennial roots also become

infected. When this happens, the plant is greatly weakened, producing little or no fruit. Plants may suddenly wilt, or plants which were healthy the previous season may develop slowly in the spring. Proper diagnosis of soil-borne problems requires careful examination of the roots and crown.

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

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

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

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

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

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

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

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

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

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

is recommended to help break up the disease cycle and avoid alternate hosts of this disease.

Soil fumigation for controlling black root rot can work well, but can also fail under certain conditions. Fumigation sterilizes the soil of pathogens and beneficial organisms. Organisms reintroduced in this "clean" soil grow rapidly in the absence of competition or predators. Pathogens, even in very small quantities, in soil from non-fumigated areas carried into fumigated areas on shoes, equipment or roots of strawberry transplants, may allow pathogens to build up to high levels. Thus, soil fumigation runs the risk of favoring

Table 14. Strawberry cultivar descriptions.

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

[a] I=intermediate, PR= partially resistant, R= resistant, S= susceptible, T= tolerant, U= unknown. [b]Includes leafscorch and leafspot.

Adapted from Pennsylvania State University, Small Fruit Production and Pest Management Guide. Used by permission.

Table 15. Efficacy of fungicides for strawberry disease management.

Fungicide[a]	Gray mold	Leather rot	Leaf spot	Powdery mildew	Anthracnose	Red Stele
Alone						
Aliette[b] (fosetyl-Al)	-	+++	-	-	-	++
Benlate[c] (benomyl)	-	-	+++	+++	++	-
Captan	++	+	++	-	++	-
Elevate (fenhexamid)	+++	-	-	-	-	-
Ridomil Gold (metalaxyl)	-	+++	-	-	-	+++
Topsin-M[c] (thiophanate-methyl)	+++	-	+++	+++	++	-
Thiram	++	+	++	-	+	-
Sulfur	-	-	-	+++	-	-
In Combination						
Benlate or Topsin-M plus captan	+++	+	+++	+++	+++	-
Benlate or Topsin- M plus thiram	+++	+	+++	+++	++	-
Elevate plus captan	+++	+	++	-	++	-
Elevate plus thiram	+++	+	++	-	+	-

Efficacy rating system: +++=highly effective; ++=moderately effective; +=slightly effective; - =not effective or not labeled for this use.

[a] This is not a complete listing of the fungicides used for strawberry disease management.

[b] Limited efficacy data available for Aliette.

[c] Fungicide that is prone to develop resistant strains of fungi For resistance management, Benlate, Topsin-M, and Elevate are recommended only in combination with an unrelated fungicide such as; captan or thiram.

Black Root Rot rather than controlling it. Moving to a planting site which has not grown strawberries recently, and is well-drained is the best method of managing this disease.

Virus Diseases

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

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

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

INSECTS

Fruit Damaging Insects

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

Management: Controlling weeds in and around the planting may reduce populations of this insect, but insecticide sprays may be necessary. If mowing around fields, do so after insecticides have been applied (to control migrating insects). Avoid planting strawberries near alfalfa which attracts high populations of TPB. White sticky traps are available for monitoring tar-

Table 16. Monitoring for tarnished plant bug in strawberry.

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

*Primarily for processing fruit.

Source: N. J. Bostanian, Agriculture and Agri-Food Canada, St. Jean-sur-Richelieu, P. Q. Courtesy Pam Fisher, Ontario Ministry of Food and Agriculture.

nished plant bug adults. These traps are used as a indication of when plant bugs begin their activity in the spring and a relative indication of their abundance, not as an indication of when to control this insect. Immature TPB (nymphs) are sampled by shaking flower trusses over a flat white surface. Thirty flower clusters should be sampled evenly from across the field (typically 6 clusters at 5 locations or 5 clusters at 6 locations). If 4 or more flower clusters are infested with nymphs (regardless of how many) a spray is recommended. A follow-up spray application may be made after bloom if TPB are still present in high numbers (check harvest interval before selecting material).

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

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

Table 17. Revision to monitoring procedure for strawberry bud weevil (clipper).

	Old Method	New Method	New Method
Unit examined	Flower buds	Flower Clusters	Flower buds
Assessment	Clipped buds or Not clipped	Cluster highly damaged* or Cluster with low amounts of damage	Clipped buds or Not clipped
Threshold	2 clipped buds/m	3 highly damaged clusters/m	3 clipped 1½ buds/m or 30 clipped 2½ or 3½ buds/m

*highly damaged= 1 clipped primary (1½) bud, or 2 clipped secondary (2½) bud, or 3 clipped tertiary (3½) buds

Courtesy Pam Fisher, Ontario Ministry of Food and Agriculture

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

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

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

Management: Check for presence of clipper by examining new flower trusses as they first emerge from the crowns in April or May. The weevils will sometimes crawl in among the unopened buds for shelter. They are most likely to be in rows near woods or hedgerows. Later, look for shot-holes in opened flower petals and/or clipped buds of unopened flowers. In the past, the IPM action threshold for this insect is 1 clipped bud per 2 ft. of row or one live adult. Research done in recent years suggests that many more clipped buds can be tolerated without significant yield loss. A comparison of old and new sampling methods done by researchers at Cornell University (Hortscience 34 (1): 109-111. 1999) can be seen in Table 17 below. Sample at least 5 locations in the field. If you determine that the infestation is limited to the edge of a field, you may only need to spray the border rows. If you see evidence of clipper and determine a spray application is necessary, follow recommendations for materials and timing in the strawberry pest management schedule.

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

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

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

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

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

Table18. Tentative guidelines for thrips in strawberries.

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

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

Leaf Damaging Insects and Mites

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

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

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

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

Management. Mites should be monitored weekly by sampling the field in 510 locations. Five to ten leaves should be sampled at each location for a total of 60 leaves. Examine the underside of the leaves for the presence or absence of TSSM. Record the information on a field map so that “hot spots” can be identified and treated. A miticide application is recommended if 25% or more of a 60 leaf sample is infested with TSSM. See pest management schedule for recommended materials and timing.

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

Several companies sell predatory mites, including N. fallacis, for release in various crops. However, the benefit of releasing commercially reared mites has not been demonstrated in the northeast, where natural populations of N. fallacis are pervasive. It is important to encourage natural enemies of spider mites by reducing the use of broad-spectrum pesticides (especially carbamate and pyrethroid insecticides) which harm natural enemies. One strategy that has worked exceptionally well has been the early-season use of 1% oil with a mist blower. This inexpensive treatment is highly selective: it kills TSSM, but not predatory mites. The resulting imbalance between predators and TSSM allows predators to “mop-up” the remaining TSSM. Please note that oil-incompatible pesticides should not be applied prior to the oil spray. See the Table 48 at the end of this guide for toxicity of pesticides to beneficial insects. Contact your local Extension Specialist or call (916) 324-4100 for a copy of Suppliers of Beneficial Organisms in North America, an excellent sourcebook for natural enemies such as predatory mites. This reference is also available via the Internet at http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm. Also, see Integrated Pest Management for Strawberries in the Northeastern United States (listed at the end of this guide) for more details on life cycles and biological control of twospotted spider mites.

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

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

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

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

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

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

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

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

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

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

Root Damaging Insects

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

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

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

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

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

No threshold is established for this insect. Feeding injury, as with all the root-feeding insects, is most

damaging if root diseases (i.e. black root rot) infect the plants as a result of wounding. Therefore, it is advisable to keep the root-feeding population low. See pest management schedule for recommended materials and timing.

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

These insects damage strawberries primarily by weakening the root systems which are then more susceptible to winter injury and disease infection. Root feeding is done by the larvae (grubs) of these weevils. The grubs are whitish and crescentshaped, ranging in size from 1/4" to 1/2". They have no legs. Adult weevils feed on leaves from May through August, causing notching of the leaf margins. Adults in heavily infested fields can contaminate harvested berries. Adult feeding generally does not cause serious injury to the plants unless the plants are already weakened from previous feeding of larvae on the crown. It is the root and crown feeding that is most injurious. Under heavy infestation by root weevils, the plants decline, appear stunted and bear poorly. Infestations are generally in patches in the field.

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

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

White Grubs of Asiatic Garden Beetle, European Chafer, Japanese Beetle, and Oriental Beetle (Maladera castanea, Popilla japonica, Rhizotrogus majalis, **and** Exomala orientalis): While not considered major pests of strawberry, it appears that many growers are experiencing leaf and root damage from these scarab beetles, collectively also called white grubs. Root feeding by larvae dramatically weakens the plant and also provides an entry site for root diseases like black root rot.

All of these species overwinter as a grub in the soil, emerging in late May through July in the Northeast. The adult Japanese beetle is copper-brown and -green in color and approximately 1/2" long. They are often found feeding during the day on leaves in small groups. Asiatic garden beetles (AGB) are small (3/8") and a velvety cinnamon brown color, showing a faint green iridescence in the sunlight. AGB feed at night on the foliage and hide during the day under plants. Feeding by Japanese beetle or AGB is easily distinguished from root weevil feeding because these scarabs principally skeletonize leaves (making holes within the leaves), rather than notching the leaf edge. Leaf feeding typically occurs in June through midAugust. Oriental

beetle and European chafer adults are rarely observed because they do not feed much. Oriental beetles are slightly smaller than Japanese beetles, and are usually tan and mottled with darker spots. European chafers are slightly more than 1/2" long and are a uniform tan.

The larvae (or grubs) of these insects look quite similar to one another and are called white grubs. They are c-shaped, have 3 sets of legs, grow up to 1/2" long. They are easily distinguished from the larvae of root weevils, which have no legs. White grubs are very difficult to manage after a strawberry bed has been planted.

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

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

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

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

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

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

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

Table 20. Strawberry pest management schedule†.

Early Spring, Pre-bloom (New leaves are expanding and blossom buds are visible)			
Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Strawberry bud weevil (clipper)	°Lorsban 4E, 2 pt (21) Methoxychlor 50WP, 2-3 lb (14) Sevin 50WP, 2 - 4 lb (7) *Sniper 50PVA, 1 lb (5) *Brigade WSB, 6.4 to 32.0 oz (0) Pyrenone Crop Spray, 12 oz (0)	Spot treatments can be made if infestation is localized to field perimeter. See text on bud weevil above for details of scouting methods.	All of these insecticides are toxic to mite predators. Lorsban can only be used pre-bloom and is limited to two applications per season. Follow-up first spray with a second spray 10-14 days later.
Tarnished plant bug only	Dibrom 8EC, 1 pt (1) Sabadilla 0.8WP, 6 lb (0)	See text on tarnished plant bug above for details of scouting and sampling methods.	Brigade, with 0 days to harvest (12 hr REI), and Dibrom, with only a 1 day harvest interval may be very useful for day neutral varieties.
Tarnished plant bug and/or Spittlebug	Thiodan 3EC, 1.3 qt (4) Phaser 3EC, 1.3 qt (4) Phaser 50WSB, 2 lb (4) Malathion 57EC, 1.5-3 pt (3) Cythion 8E, 1.5-2 pt (3) °Danitol 2.4 EC, 10 2/3 oz (2) *Brigade WSB, 6.4 - 32 oz (0) Pyrenone Crop Spray, 12 oz (0)		Thiodan may not be applied more than twice in a 35 day period when fruit is present; you must wait 15 days between applications.
Spittlebug only	Guthion Solupak 50WP, 1 lb (5) °Sniper 50 PVA, 1 lb (5) Methoxychlor 50WP, 2-3 lb (14)	Suggested action threshold is 1 spittle mass per square foot of row.	Spittlebugs generally do not damage fruit but make them less appealing to pickers. Guthion has 48 hr REI for mowing, irrigating, and scouting; and 4 day REI for all other activities.
Two-spotted spider mite (TSSM)	Vendex 4 L, 1 pt (1) Kelthane 35WP, 1-3 lb (2) °Agri–Mek 0.15EC, 16 oz (3) Sunspray Ultra-Fine Oil, 1% (0) Stylet Oil, 3 qts (0) Trilogy (Neem) 1-2% solution (0) Predatory mite release, rate varies (0)	Scout for presence of TSSM by randomly sampling 60 leaves from whole field. Treat field with miticide or release mite predators if TSSM are found on more than 25% of leaves sampled. Contact your local Extension Specialist or call (916) 324-4100 for a copy of Suppliers of Beneficial Organisms in North America, an excellent sourcebook for natural enemies such as predatory mites. Also availabe via the Internet at http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm	Consult your Extension Specialist for help identifying mite predators and/or finding a source of predators for release. Adjust spray volume and nozzle placement to assure maximum coverage of tops and undersides of leaves. Agri–Mek applied at a lower rate (6 oz.) selectively kills spider mites. The full rate (16 oz.) kills predatory mites. Sun Spray Ultra-fine oil and Stylet Oil require direct contact to kill mites and their eggs. Spray oils at no less than 400 psi. Oils are phytotoxic in combination with captan or Morestan residues and should not be used in a spray program with Kelthane or within 14 days of a sulfur application.

Table 20 continued. Strawberry pest management schedule†.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Early Spring, Pre-bloom (New leaves are expanding and blossom buds are visible)			
Leaf spot Leaf scorch Leaf blight	Combine either: Benlate 50WP, 8 oz (1) or Topsin-M 70WP, 8 oz (1) plus Captan 50WP, 3 lb (0) or Thiram 65WP, 3.5 lb (3) Or, use alone: Syllit 65W, 1.5 - 2 lbs. (14)	Improve air circulation by narrowing row width, increasing distance between rows, and raising beds. This will allow faster drying after rain, irrigation, and dew. Remove or thoroughly incorporate leaf debris from field at renovation. This helps disrupt the disease cycle of these fungi. Avoid excess Nitrogen application that promotes dense foliage and poor air circulation.	Treatment not needed unless infection is severe. Fungicide applications for gray mold will usually manage leaf spots as well. Benlate: The current Benlate label specifically states that Benlate is "not for use in home plantings nor once any commercial crop is turned into U-pick, Pick Your Own, or similar operation." Consult with your state's pesticide office for the relevant interpretation of this restriction. Captan has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period. Syllit (dodine) must be applied with sufficient water (250-300 gal) for thorough plant coverage.
Red Stele	Ridomil Gold EC, 1 pt (0) Aliette WDG, 2.5 - 5 lb (0)		Early spring or fall applications are recommended for control of red stele. Use sufficient water to move the Ridomil into the root zone. There is no preharvest interval for this application.
Spring, Pre-bloom to Early-bloom (From bud expansion to 10% bloom)			
Tarnished plant bug (TPB)	Same as Early Spring, Pre-bloom treatments shown above	See text on tarnished plant bug above for details of scouting and sampling methods.	DO NOT SPRAY INSECTICIDES DURING BLOOM. In case of an emergency, use only those materials listed as having low toxicity to pollinators. See Table 48 at end of guide on toxicity of pesticides to beneficial insects.
Anthracnose	Captan 50WP, 6 lb (0) or Thiram 65WP, 5 lb (3)		Becoming more prevalent in many southern New England locations Captan has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Botrytis gray mold	combine either: Topsin-M 70WP, 8 oz (1) or Elevate 50WDG, 1.5 lb (0) plus Captan 50WP, 3-4 lb (0) or Thiram 65WP, 2.5 lb (3) or, use alone: Captan 50WP, 6 lb (0) Elevate 50WDG, 1.5 lb (0) Stylet Oil, 3 qts. (0) Trilogy (Neem), 1-2% solution (0)	Improve air circulation by narrowing row width, increasing distance between rows, and raising beds. This will allow faster drying after rain, irrigation, and dew. Remove or thoroughly incorporate leaf debris from field at renovation. This helps disrupt the disease cycle of the Botrytis fungus. Avoid excess Nitrogen application that promotes dense foliage and poor air circulation.	• Blossom protection is the most important component of successful Botrytis control. An early bloom application should be made at 10% bloom and followed up at mid and late bloom if conditions are wet. Captan has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period. Neither Elevate nor Topsin-M should be used alone for season long control of Botrytis to avoid developing resistance. Do not apply more than 6 lbs of Elevate per acre per season.
Full-bloom (From 10% bloom until no blossoms remain)			
Tarnished plant bug (TPB)	No spray - may reduce pollinators	Do not mow hay or alfalfa in adjacent fields if possible since this will encourage plant bugs to move into strawberry field.	DO NOT SPRAY INSECTICIDES DURING BLOOM
Botrytis gray mold	Same as Spring, Pre-bloom to early-bloom treatments above	See above.	See above.
Early Summer (Fruit-set to harvest)			
Tarnished plant bug (TPB)	Same as Early Spring, Pre-bloom treatments shown above	See text on tarnished plant bug above for details of scouting and sampling methods.	
Sap beetle	Diazinon 50WP, 1 lb (5) Malathion 57EC, 1.5-2 pt (3) Cythion 8E, 1.5-2 pt (3) °Brigade WSB, 6.4-32 oz (0) Pyrenone Crop Spray, 12 oz (0)	Bait baskets with overripe fruit or balls of bread dough at intervals around edges of field to catch beetles as they migrate in. Brigade can be applied up to 12 hrs before harvest.	
Spittlebugs	Dibrom 8E, 1 pt (1) Thiodan 3EC, 1.3 qt (4) Guthion Solupak 50WP, 1 lb (5) Methoxychlor 2EC, 2-3 qt (14) °Sniper 50 PVA, 1 lb (5) °Danitol 2.4EC, 10 2/3 oz (2) °Brigade WSB, 6.4 - 32.0 oz (0)	Suggested action threshold is 1 spittle mass per square foot of row.	Spittlebugs generally do not damage fruit but make them less appealing to pickers. See note on Thiodan under tarnished plant bug comments. Guthion has 48 hr REI for mowing, irrigating, and scouting; and 4 day REI for all other activities.

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

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Early Summer (Fruit-set to harvest)			
Botrytis gray mold	Same as Spring, Pre-bloom to early-bloom treatments above	Do not allow fruit to become over-ripe. Harvest regularly. Spray only if weather is wet or very humid during this period to control secondary infections.	If good coverage was made during bloom, further fungicide applications may not be needed. Pay strict attention to re-entry periods and harvest intervals for materials used.
Anthracnose	Same as Spring, pre-bloom to early bloom	See above.	See above.
Leather rot	Ridomil 2E, 2 qt (0) Aliettte WDG, 2.5 - 5 lb (0)	Make sure to maintain a good mulch layer around plants to reduce puddling and splashing around plants from rain or irrigation.	For control of leather rot apply Ridomil during the growing season at fruit-set.
Leaf spot Leaf scorch Leaf blight	No fungicides until after renovation	Fungicides are usually not applied at this time for leaf spot diseases. Materials used for Botrytis management should alleviate leaf spot symptoms until after renovation. Improve air circulation by narrowing row width, increasing distance between rows, and raising beds. This will allow faster drying after rain, irrigation, and dew. Remove or thoroughly incorporate leaf debris from field at renovation. This helps disrupt the disease cycle of these fungi.	
Harvest (Within 4 days of harvest through harvest)			
Botrytis gray mold	Same as Spring, Pre-bloom to early-bloom treatments above	Do not allow fruit to become over-ripe. Harvest regularly.	Fungicide applications at this time are for emergency situations. Good coverage at infection periods during bloom should make late season sprays unnecessary. Be sure to follow label instructions for both REI and PHI restrictions.
Anthracnose	Same as Spring, pre-bloom to early bloom See above.	See above.	See above.

Summer (Post-harvest)

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Strawberry root worm; adult	°Guthion 50WP, 1 lb (5) Sevin 50WP, 2-4 lb (7)	Scout field for 'shot-hole' feeding injury on leaves. If found, look in duff around plants for small copper-colored beetle.	Apply post harvest only when foliar damage is noticed and beetles positively identified. Larvae feed on roots causing general loss of vigor and possible collapse of plant.
Root weevils (various species)	°Brigade WSB, 8-16 oz (0) Steinernema spp., 3 billion/A (0) Heterorhabditis spp., 1/2 - 1 billion/A (0)	Rotate to non-susceptible crop for 3 years. Plow under old beds as soon as possible to avoid spread of the insect to new beds. Adult beetles hide in the soil during the day and feed at night.	The highest rate (16 oz.) of Brigade is needed to obtain control of black vine weevil. Apply nematodes in early- to mid-May or mid- to late-August as a band treatment. Application rates are given for the treated area. Irrigate prior to and following the nematode spray. Contact your local Extension Specialist or call (916) 324-4100 for a copy of Suppliers of Beneficial Organisms in North America, an excellent sourcebook for natural enemies such as predatory mites. Also availabe via the Internet at http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm
Two-spotted spider mite (TSSM)	Vendex 50WP, 1.5-2 lb (1) Kelthane 35WP, 1-3 lb (2) °Agri–Mek 0.15EC, 16 oz (3) Sunspray Ultra-fine Oil 1% (0) Stylet Oil, 3 qts. (0) Trilogy (Neem), 1-2% solution (0)	Scout for presence of predator mite Neoseiulus fallacis; release 5-10,000 per acre if TSSM population exceeds 2/leaf and no predators are found. Contact your local Extension Specialist or call (916) 324-4100 for a copy of Suppliers of Beneficial Organisms in North America, an excellent sourcebook for natural enemies such as predatory mites. Also availabe via the Internet at http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm	Consult your Extension Specialist for help identifying mite predators. Agri–Mek applied at a lower rate (6 oz.) selectively kills spider mites. The full rate (16 oz.) kills predatory mites. Sun Spray Ultra-fine oil requires direct contact to kill mites and their eggs. Oil is phytotoxic in combination with captan or Morestan residues.

Table 20 continued. Strawberry pest management schedule†.

Summer (Post-harvest)			
Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Cyclamen Mites	Thiodan 3EC, 2.6 qt (4) Kelthane 35WP, 4-6 3/4 lb (2) Kelthane 50WP, 1.5 - 4 3/4 lb (2)	Predator mites may be effective against cyclamen mites. Check source list in the back for suppliers.	High gallonage (400) gal/A), wetting agent and foliar agitation usually needed for satisfactory control.
Leafhopper	Malathion 57EC, 1.5 - 3 pt (3) Cythion 5E, 1.5 - 2.5 pts (3) Sevin 50W, 2-4 lbs (7)	Plants may be able to tolerate some of this injury without long-lasting damage.	Leafhoppers can infest new or old planting and symptoms show up especially well during runner production.
Aphid	Thiodan 50WP, 2 lb (4) Malathion 57EC, 1.5 - 3 pt (3) Cythion 5E, 1.5 - 3pts (3) Diazinon 50WP, 1 lb (5) Pyrenone Crop Spray, 12 oz (0)		Aphids are significant vectors of virus diseases. If virus spread is of concern, aphids should be controlled in the spring and fall when winged forms are building up. See note on Thiodan under tarnished plant bug comments.
Powdery Mildew	Combine either: Benlate 50DF, 8 oz (1) or Topsin-M 70WP, 8 oz (1) plus Captan 50WP, 3-4 lb (0) Or, use alone: Stylet Oil, 3 qts. (0) Kumulus (sulfur), 5-10 lbs (0)	Plant beds in such a way as to maximize the air circulation and drying of foliage.	Cultivars vary in their susceptibility to powdery mildew. Benlate: The current Benlate label specifically states that Benlate is “not for use in home plantings nor once any commercial crop is turned into U-pick, Pick Your Own, or similar operation.” Consult with your state’s pesticide office for the relevant interpretation of this restriction. Captan has a 0 day phi, but the REI of 24 hrs requires that PPE be worn during this period.
Leaf spot Leaf scorch	Captan 50WP, 3 lb (0) Thiram 65WP, 2.5 lb (3) Kocide 101, 2-3 lb (0) NuCop 3L, 1 1/3 - 4 pts (0)	Improve air circulation by narrowing row width, increasing distance between rows, and raising beds. This will allow faster drying after rain, irrigation, and dew. Remove or thoroughly incorporate leaf debris from field at renovation. This helps disrupt the disease cycle of these fungi.	Fungicide applications for gray mold will treat leaf spots as well. Captan requires protective clothing be worn in field for 24 hrs following application.

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Leaf blight Red Stele	Ridomil Gold EC, 1 pt (0) Aliette WDG, 2.5 - 5 lb (0)	Proper site selection and preparation to avoid prolonged periods of "we tfeet" should be the primary control stratagy for this disease.	Early spring or fall applications are recommended for control of red stele in emergency situations only. Use sufficient water to move the Ridomil into the root zone. There is no preharvest interval for this application. Routine or preventative application of these materials in not recommended.

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

°Restricted use pesticide.

Other Pests

Slugs: Slugs are dark grey, black, yellow-gray or brown worm-like mollusks. They may also be covered with spots and range in size from 1-1/2 to 7" long. Slugs feed mainly at night, eating ragged holes in leaves and/or fruit. They also leave a trail of slime in their paths. Damage occurs primarily on fruit.

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

WEED MANAGEMENT

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

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

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

Yellow Wood Sorrel (Oxalis, **spp.):** This weed is perhaps the most troublesome for many strawberry growers. Several species exist. Some are perennials and some are winter annuals. Seed production usually occurs during harvest with the plants "spitting" their seeds across the strawberry rows. This, of course, allows free spreading of this weed across the field. As with the above-mentioned weed species, germination

can take place over several months making control difficult. 2,4-D provides good control of oxalis plants if they are small and not hidden under the strawberry foliage. Therefore a late fall application, prior to mulching over dormant strawberry plants, can be at least partially effective. A 2,4-D application prior to renovation is usually not effective since seed dispersal has already taken place. Sinbar[tm] also has some activity on this weed. Splitting the annual use rate of Sinbar[tm] into a renovation and late fall (dormant) application can also provide some control. This weed usually shortens the life of a planting due to its quick spreading habit.

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

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

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

TRANSPLANT YEAR			
Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
PREPLANT WEED CONTROL			
Many annual broadleaf weeds	(oxyflourfen) Goal 2XL	1 to 2 pt	Must be applied at least 30 days prior to transplanting. The soil must be worked to a depth of at least 2.5 inches prior to transplanting the crop. The use of a preemergence herbicide after transplanting is also recommended.
Emerged annual and perennial weeds	(glyphosate) Roundup Ultra	1 to 5 pt	Must be applied at least 30 days prior to transplanting. Provides control of most annual and perennial weeds. Application to perennial weeds should take place the fall prior to transplanting for best control.
PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds	(DCPA) Dacthal W 75	8 to 12 lb	Weak on ragweed, smartweed, and galinsoga. Apply at transplanting or after cultivating. Irrigation, rainfall, or shallow cultivation after application will improve control. This product is no longer being manufactured.
	(napropamide) Devrinol 50WP Devrinol 50 DF	 2 to 4 lb 2 to 4 lb	Apply to weed-free soil after strawberry plants become established. Heavy rate after planting may inhibit rooting of daughter plants. Application in late summer will control winter annuals. Application in late fall will control annual grasses and volunteer grains until harvest. This material must be activated with rainfall, irrigation, or shallow cultivation within 24 hrs. Consider using the 2 to 4 lb rate twice, once in late summer and again just prior to mulching in late fall.

TRANSPLANT YEAR

Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds between rows after plant establishment	(paraquat) °Gramoxone Extra	1.5 pt	Contact herbicide. Use with a non-ionic surfactant. Direct spray between rows using a shield to prevent contact with strawberry plants. Do not apply within 21 days before harvest or more than 3 times in a season.
Emerged annual and most perennial grasses	(sethoxydim) Poast	1 to 2.5 pt	Effective on small actively growing grasses. Do not apply to grasses under stress (e.g. drought). Add 1 qt of crop oil concentrate per acre. Application within 6 weeks of Sinbar may cause leaf injury. Applications on days that are unusually hot and humid will likely cause leaf burn. Avoid applications on these hot and humid days or delay application until late evening.
Emerged annual weeds and suppression of perennial weeds.	(pelargonic acid) Scythe	3-10% solution	Contact material for burn down only. See Scythe comments below this table. See label for complete instructions.

ESTABLISHED PLANTINGS

PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds.	(DCPA) Dacthal W 75	8 to 12 lb	Weak on ragweed, smartweed, and galinsoga. Apply to weed-free soil in early spring after mulch removal or in late fall. Irrigation, rainfall, or shallow cultivation after application will improve control. Do not apply between first bloom and harvest. May be less effective on cool heavy soils. This product is no longer being manufactured.
	(napropamide) Devrinol 50WP Devrinol 50 DF	 4 to 8 lb 4 to 8 lb	Apply to weed-free soil. Heavy rate after renovation may inhibit rooting of daughter plants. Application in late summer will provide preemergence control of winter annuals. Application prior to mulching will control annual grasses and volunteer grains until harvest. This material must be activated with rainfall, irrigation, or shallow cultivations within 24 hrs. May be applied more than once per year but do not exceed a total of 8 lbs per acre per year. Do not apply from bloom through harvest. Consider the 4 lb rate twice. Once in late summer and again just prior to mulching in late fall.
Broadleaf weeds, some grasses, and some suppression of perennial weeds.	(terbacil) Sinbar 80WP	2 to 6 oz	Will also provide early postemergence weed control. Apply at renovation, immediately after mowing and tilling but before new growth begins. A second application may be made in late fall, after strawberry plants become dormant, for additional control of winter annual weeds. DO NOT USE AT ANY OTHER TIMINGS AS PLANT DEATH MAY RESULT. Do not apply more than 8 oz of Sinbar per acre per growing season. Use only on plants established 6 months or longer. Do not use on soils with less than 2% organic matter. Some varieties may be sensitive to Sinbar. Read label for other restrictions.
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds between rows.	(paraquat) °Gramoxone Extra	1.5 pt	Contact herbicide. Use with a non-ionic surfactant. Direct spray between rows using a shield to prevent contact with strawberry plants. Do not apply within 21 days before harvest or more than 3 times in a season.

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

ESTABLISHED PLANTINGS			
Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
POSTEMERGENCE WEED CONTROL			
Emerged annual and most perennial grasses	(sethoxydim) Poast	1 to 2.5 pt	Effective on small actively growing grasses. Do not apply to grasses under stress (e.g., drought). Add 1 qt of crop oil concentrate per acre. Application within 6 weeks after Sinbar may cause leaf injury. Avoid applications on days that are unusually hot and humid. Do not apply within 7 days before harvest or use more than 2.5 pints per acre per season.
Most emerged broadleaf weeds including dandelion	(2,4-D) Formula 40	2 to 3 pt	Apply at renovation, immediately after last harvest. Wait 3 to 5 days before mowing. Can also be used in late fall after strawberries are dormant for control of certain winter annual and biennial, and perennial weeds. Be sure that strawberry plants are dormant (i.e., no new growth and reddened leaves).
Emerged annual weeds and suppression of perennial weeds.	(pelargonic acid) Scythe	3-10% solution	Contact material for burn down only. See Scythe comments below this table. See label for complete instructions.

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

Dacthal (DCPA) Note: Dacthal is currently not being manufactured. However, manufacture is expected to resume in 2000-20001. The greatest impact of the temporary loss of Dacthal will be on newly set transplants. When supplies are exhausted, growers should consider preplant fumigation or a combinaiton of light cultivations and hand weeding for the first few weeks after planting. Consult with your local Extension Specialists on the resumption of availability of this product.

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

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

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

SEE THE LABEL FOR COMPLETE DETAILS!

Table 22. Transplant year strawberry herbicide calendar.

TREATMENT TIMING	TREATMENT	RATE
SPRING OR FALL PRIOR TO PLANTING		
Weeds and other pests	Fumigation or	See label
Perennial weeds	Roundup 4S	1 - 5 qt (see label)
Many annual weeds	Goal 2XL	1 - 2 pt (see label)
AT PLANTING		
Planting (April - June)	Dacthal 75WP	8 - 12 lb
POST PLANT (3 NEW LEAVES OF 6 WEEKS AFTER DACTHAL APPLICATION)		
Preemergence control of grasses, small seeded broadleaf weeds and some winter annuals	Devrinol 50DF	2 - 4 lb (8 lb max/year)
Postemergence control of grasses	Poast 1.53EC	1 - 2.5 pt (2.5 pt max/year)
Postemergence control of emerged annual weeds between rows	Gramoxone extra	1.5 pt/acre
FALL		
Preemergence control of volunteer grains in mulch (apply just before mulching)	Devrinol 50DF	2 - 4 lb (8 lb max/year)
Postemergence control of grasses	Poast 1.53EC	1 - 2.5 pt (2.5 pt max/year)
Preemergence control of broadleafs	Sinbar 80WP	2 - 6 oz (strawberries must be established for at least 6 months and dormant)

Table 23. Herbicide efficacy against common weeds in strawberries.

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

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

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

[2] 2,4-D; systemic broadleaf herbicide. Typically used just before renovation; allow 5 days before mowing; also can be used when strawberries are dormant on winter annuals and perennial broadleaf weeds. Never use an ester or low-volatile ester formulation.

[3] Poast; systemic grass herbicide; use on actively growing grasses; will not kill old established grasses. Use with crop oil, avoid applying on hot humid days.

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

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

[6] Sinbar; selective preemergent herbicide. Moisture is required to activate the chemical; also provides early postemergence control. Apply at renovation immediately after mowing or in dormant season, use only on established plantings, no more than 8 oz. per growing season, read label for other restrictions, some varieties may be sensitive, especially at higher rates.

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

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