UC IPM
Pest Management Guidelines: Strawberry

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An illustrated version of this guideline is available online at www.ipm.ucdavis.edu/PMG/selectnewpest.strawberry.html
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Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM World Wide Web site for information on updates. Note to readers: These guidelines represent the best information currently available to the authors and are intended to help you in making the best choices for an IPM program. Not all formulations or registered materials are mentioned. Always check the label and with local authorities for the most up-to-date information regarding registration and restrictions on pesticide use. Check with your agricultural commissioner for latest restricted entry intervals.

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To be used with UC ANR Publication 3351,
Integrated Pest Management for Strawberries
## General Information

### CHARACTERISTICS OF STRAWBERRY CULTIVARS COMMONLY GROWN IN CALIFORNIA (6/05)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Day length</th>
<th>Planting season</th>
<th>Area¹</th>
<th>Supplemental storage²</th>
<th>Fruit characteristics</th>
<th>Plant characteristics</th>
<th>Susceptibility to pests and disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albion</td>
<td>neutral</td>
<td>fall</td>
<td>CC</td>
<td>10 days to 2.5 weeks</td>
<td>large; excellent flavor; red internal and external color</td>
<td>moderately vigorous plant; high productivity; very long season; avoid overchilling, which causes excessive runner production</td>
<td>tolerant of major soil pathogens; moderately susceptible to powdery mildew</td>
</tr>
<tr>
<td>Aromas</td>
<td>neutral</td>
<td>fall</td>
<td>CC</td>
<td>10 days to 3 weeks</td>
<td>medium size; dark red color; good flavor</td>
<td>very high yields; long production season</td>
<td>misshapen fruit occasionally a problem, especially early in season; generally good tolerance to root and crown diseases</td>
</tr>
<tr>
<td>Camarosa</td>
<td>short</td>
<td>fall</td>
<td>CC, SC</td>
<td>none to 1 week</td>
<td>large; good flavor; excellent shelf life; good for fresh market and freezer pack; relatively resistant to rain damage</td>
<td>vigorous plant; high-yielding; early production; adapted to early fall planting</td>
<td>tendency to produce misshapen fruit; susceptible to Verticillium</td>
</tr>
<tr>
<td>Camino Real</td>
<td>short</td>
<td>fall</td>
<td>CC</td>
<td>7 to 14 days</td>
<td>large; very good flavor; highly tolerant of rain damage</td>
<td>not early; compact plant that needs adequate nursery chilling; good cultivar for Santa Maria Valley</td>
<td>sensitive to sulfur sprays; relatively tolerant to Phytophthora and Verticillium</td>
</tr>
<tr>
<td>Chandler</td>
<td>short</td>
<td>summer</td>
<td>SJV</td>
<td>NA</td>
<td>medium size; very good flavor; somewhat tender skin; soft when temperatures are high</td>
<td>moderate yields</td>
<td>—</td>
</tr>
<tr>
<td>Diamante</td>
<td>neutral</td>
<td>fall</td>
<td>CC, SC</td>
<td>10 days to 3 weeks</td>
<td>large; very good flavor; light color; sensitive to rain damage</td>
<td>moderately vigorous plant; high productivity; long season, open canopy, easy harvest</td>
<td>highly susceptible to Phytophthora</td>
</tr>
<tr>
<td>Ventana</td>
<td>short</td>
<td>fall</td>
<td>CC, SC</td>
<td>none to 1 week</td>
<td>large; good flavor; good color but lighter than Camarosa; relatively resistant to rain damage</td>
<td>vigorous plant with heavy early production; adapted to early fall planting; good pollinator under adverse weather conditions; excellent for winter-spring fresh market</td>
<td>susceptible to Phytophthora root and crown rot; fruit is susceptible to powdery mildew</td>
</tr>
</tbody>
</table>

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¹ CC = Watsonville/Salinas and Santa Maria Valley; SC = South Coast region from San Diego to Ventura County; SJV = San Joaquin Valley.

² Approximate amount of chilling at 34° F (1° C) after fall digging needed for optimal vigor, yield, and fruit quality.

Acknowledgments: This table was prepared with information from K.D. Larson, Dept. of Plant Sciences, UC Davis, South Coast Research & Extension Center, Irvine; D.V. Shaw, Dept. of Plant Sciences, UC Davis; M.P. Bolda, UC Cooperative Extension, Santa Cruz County; and O. Daugovish, UC Cooperative Extension, Ventura County.
DRIP FUMIGATION (Updated 4/05)

Drip fumigation with an application of chloropicrin mixed with 1,3-dichlororopropene (InLine) followed by metam sodium or chloropicrin alone followed by metam sodium are the most effective registered chemical alternatives to methyl bromide/chloropicrin fumigation in strawberry for the control of pathogens, nematodes, and weed seeds. Because chloropicrin and 1,3-dichlororopropene are less volatile than methyl bromide, they can be applied to raised beds through drip irrigation systems and have been shown to be as effective in controlling soilborne pathogens and most weed seeds, resulting in comparable strawberry yields.

Currently, over 25% of the California strawberry acres are drip fumigated. Drip fumigation is desirable because workers are not required to be in the field during application. However, successful drip fumigation requires adequate soil preparation, a well-designed drip irrigation system, dependable chemigation equipment, and timeliness of the process to accommodate longer plant-back time.

**Soil Preparation**

As with all soil fumigation, the first step is to properly prepare and till the soil. Current soil preparation and bed listing practices used after methyl bromide fumigation are generally adequate. Following this, firmly pack the beds and eliminate any dirt clods. If the soil is dry, it may be necessary to preirrigate with enough water to initiate weed seed germination.

Uniform water distribution is necessary in a drip irrigation system and is easiest to obtain on fairly level terrain. On steep or hilly grounds, create beds that follow soil contour lines at grades that do not exceed 4 ft. uphill or 8 ft. downhill from the beginning of the drip line.

When laying the plastic tarp, remove any shanks or chisels to avoid creating channels in the soil, which can result in poor water and fumigant distribution in the soil bed. Repair any holes or tears in the plastic tarp. Avoid embossed tarpers to reduce loss of fumigants through volatilization. The use of virtually impermeable film (VIF) will enhance weed control in the bed. However, VIF holds fumigants in the soil for longer periods than the standard tarp and longer plant-back time or bed ventilation for 2 weeks before planting may be required (refer to the pesticide label).

**Amount of Water**

If chloropicrin or 1,3-dichlororopropene is applied simultaneously with metam sodium, they react and rapidly degrade in the irrigation water. Instead, they should be applied sequentially with the first application consisting of 1,3-dichlororopropene plus chloropicrin or chloropicrin alone followed 5 to 7 days later with an application of metam sodium. Applying the materials in this order helps to maximize their effectiveness because 1,3-dichlororopropene and chloropicrin are most effective in drier soils whereas metam works best in moist soils.

1. 1,3-Dichlororopropene and/or Chloropicrin. It is important to use the appropriate amount of water so that the fumigant is evenly distributed throughout the target soil treatment zone. Table 1 lists the recommended amount of water needed to fumigate various soil types to 2 feet of soil depth. For example, in a sandy loam soil 2 inches of water in the soil bed is recommended to fumigate down to 24 inches. With two drip tapes, this provides a 40-inch lateral spread as well (10 inches on each side of a tape).

If irrigation time is limited, cutting back to 1.75 inches on sandy loam soils is often acceptable because fumigants move 3 to 5 inches beyond the wetting front and control should extend down to the 2-foot depth. Although the fumigant will volatilize and move beyond the wetted zone, the best treatment appears to occur within the wetted area. If the irrigation amount is cut back to the minimum recommendation of 1.5 inches for sandy loam soils, the soil profile will be wetted down to 18 inches with 6 to 8 inches horizontal spread on both sides of each drip tape.

Drip fumigation with recommended amounts of irrigation water will provide good fumigant distribution in soil and reduce fumigant volatilization losses by increasing the amount of fumigant in the water phase and decreasing the total air space available for fumigant diffusion in soil. If too little water is used (less than 1.5 inches), the fumigant will be poorly distributed and more likely to volatize, resulting in less effective control and lower strawberry yields. In addition, with insufficient water and without an emulsifier, fumigants such as 1,3-D or chloropicrin may precipitate in the irrigation pipelines if the concentrations exceed their solubility limits of 2,000 parts per million (ppm).
Using too much water may lower the fumigant concentration in the main line below 500 ppm, which may also reduce the fumigant effectiveness. Also, beds can become unstable and collapse with excessive water application amounts. Bed stability may limit the volume or application rate of water that can be applied.

Metam Sodium or Metam Potassium. Metam sodium and metam potassium are water soluble and generate the active ingredient methyl isothiocyanate (MITC) after being applied to the soil. A minimum of one inch of water is recommended for the sequential application of metam to most soil types.

Drip Tape Flow Rate and Spacing
In drip fumigation, the rate of water flow and the spacing of drip tapes are critical to the even distribution of the fumigant throughout the field as well as in the soil treatment zone. While a water distribution uniformity of 90% is possible in a well designed and operated drip system, at least 80% is necessary for acceptable fumigation.

Drip tapes with a flow rate between 0.3 to 0.7 gpm (gallons per minute)/100 ft are appropriate for most strawberry soils in California (see Table 1). Low-flow drip tape requires longer application time that may become inconvenient. Avoid high-flow drip tape (greater than 0.7 gpm/100 ft) if it causes any wetting of the furrows or run off, or if it causes the beds to collapse. High-flow tape is not commonly used in California and is not recommended except for soils with high water permeability.

To achieve adequate water distribution uniformity, the pressure in the drip tape throughout the field should not vary more than 3 psi (i.e., from 6 to 9 psi). In addition, the system must be free of leaks and clogged emitters and be flushed and pressure tested before fumigation. It is imperative to use good quality irrigation components and drip tape. Leaks cause fumigant loss and possibly odor and emissions problems.

It may be necessary to reconfigure drip tape in order to obtain good water coverage across the soil bed. For most strawberry beds (sandy loam soils), one drip tape can cover up to 10 inches on each side. Therefore, two drip tapes are recommended for drip fumigation of most strawberry beds. In the two-row strawberry beds (narrow beds with two tapes near the center), spread the tapes as far apart as possible so that the edge of the bed is covered. In the four-row strawberry beds (wide beds with two tapes close to the shoulder), move the tapes a few inches towards the center to treat the middle of the bed. A third drip tape in the center may be needed if the bed top is wider than 40 inches. A third drip tape is also recommended in wide beds on sandy and loamy sand soils where limited lateral water movement may limit fumigant distribution.

Determining the Fumigant Concentration in Irrigation Water
Fumigant concentration in the main line may vary from 500 to 1600 ppm, depending on the soil, fumigant type, and water application rate. Below 500 ppm, the efficacy of chloropicrin and 1,3-dichloropropene (InLine) to control soilborne pathogens may become insufficient. Also, because the solubility of chloropicrin and 1,3-D in water is less than 2000 ppm at 20°C, exceeding 1500 ppm may result in precipitation of these fumigants in the irrigation pipelines.

Fumigant concentration in water can be calculated as follows:
• Chloropicrin: ppm chloropicrin = 119,826 x (# pounds chloropicrin / # gallons water)
• InLine: ppm (chloropicrin + 1,3-D) = 87,872 x (# pounds InLine / # gallons water)

Table 2 shows chloropicrin concentrations as a function of application rate and water volume. A similar table can be prepared for 1,3-dichloropropene/chloropicrin (InLine) (one gallon weighs 11.2 lb or 6.57 lb 1,3-D and 3.73 lb chloropicrin) but is not provided here because 1,3-dichloropropene requires a special permit to apply.

Other Important Calculations Needed for Drip Fumigation
• Determine the actual treated (bed) area, the total volume of water, and the weight of fumigants to be applied. Strawberry beds usually occupy 50-70% of the total area in the acre. Because only the beds are treated, this calculation can be important in determining how much fumigant is necessary for the treatment.
• Calculate the time required for application based on the flow rate of the drip tape.
Table 1 provides the application time for one particular type of bed configuration (40-inch wide with two drip tapes).
Chemigation Equipment for Drip Fumigation

The fumigant cylinders are pressurized with nitrogen gas and metered directly into the irrigation pipeline or manifold. The meter can be a precision needle valve and flow meter, a needle valve and a scale, or a computer-controlled positive displacement meter. Fumigants are injected at low-flow rates and accurate calibration of injection equipment is essential for proper application. Fumigant concentration in the main line may vary from 500 to 1600 ppm, depending on the soil, fumigant type, and water application rate. Refer to the pesticide label for appropriate concentration rates.

Good fumigant mixing with water in the irrigation pipelines is essential. A static mixing device is recommended to be installed after the point of injection to thoroughly mix fumigants with water before being distributed into the irrigation system laterals and drip tape.

The irrigation system must have a standard, single-check valve, a low-pressure drain, and a vacuum-relief valve (a “chemigation” valve) upstream from the injection point to prevent possible contamination of the water source by fumigants. The fumigant injector must be equipped with a check valve to prevent water from flowing back into the fumigant tank and an automatic quick-closing valve to stop fumigant injection when water flow is interrupted or loses pressure. The fumigant automatic shut-off valve can be electrically or hydraulically activated and should be normally closed at the injector. For more information on chemigation equipment, refer to the California Department of Pesticide Regulation Web site: (www.cdpr.ca.gov/docs/gwp/chem/chemdevices.htm) and the Agricultural Commission Office in your county.

Flushing the Pipeline Following Treatment

Many of the fumigants, including chloropicrin and 1,3-dichlororopropene (InLine), can damage PVC if left in the pipelines. This does not occur during application of the diluted fumigants but can occur if the lines are not well flushed at the end of the application and the fumigant settles out and accumulates in low points of the distribution system. For this reason, it is critical to flush lines at the end of each application. The required amount of water needed to flush the system can be estimated as three times the volume of the mainline and laterals. Avoid excessive flushing because it will dilute the fumigants around the drip tape.

Safety Rules

Read and understand the fumigant label and follow County Permit Conditions before starting the fumigation. Know the symptoms and emergency treatments for exposure to the fumigants. Monitor the application system and the field during application.

Table 1. Estimated water amount needed to treat two feet of soil depth using two drip tapes when applying 1, 3-dichlororopropene and/or chloropicrin.¹

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Amount of application water inches per acre (gallons)²</th>
<th>Application time using 2 tapes (hours)</th>
<th>Drip tape flow rate (gpm/100ft)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine sand and loamy fine sand</td>
<td>1.6 (27,000)</td>
<td>0.20 13.9 8.2 5.5 4.1</td>
<td>Pre-irrigation with one inch of water is needed</td>
<td></td>
</tr>
<tr>
<td>Sandy loam and fine sandy loam</td>
<td>2.0 (34,000)</td>
<td>0.34 17.3 10.2 6.9 5.2</td>
<td>Minimum of 1.5 inches is recommended</td>
<td></td>
</tr>
<tr>
<td>Sandy clay loam and loam</td>
<td>2.6 (44,000)</td>
<td>0.50 22.5 13.4 9.0 NR</td>
<td>Split application may be required</td>
<td></td>
</tr>
<tr>
<td>Clay, clay loam, and silt clay loam</td>
<td>3.2 (54,000)</td>
<td>0.67 27.7 16.3 11.1 NR</td>
<td>Soils not common in strawberry production</td>
<td></td>
</tr>
</tbody>
</table>

¹Application time and water volume based on 40-inch average bed width (64 inches center-to-center).
²One broadcast acre-inch of water is about 27,000 gallons. One acre-inch of water for a 40-inch wide bed is about 17,000 gallons.
NR = not recommended
Table 2. Chloropicrin concentration (ppm)\(^1\) during drip application.

| Gallons of water per acre | 150 | 160 | 170 | 180 | 190 | 200 | 210 | 220 | 230 | 240 | 250 | 260 | 270 | 280 | 290 | 300 |
|---------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 190000                    | 946 | 1009| 1072| 1135| 1198| 1261| 1324| 1387| 1451| 1514| 1577|     |     |     |     |     |
| 200000                    | 899 | 959 | 1019| 1078| 1138| 1198| 1258| 1318| 1378| 1438| 1498| 1558|     |     |     |     |     |
| 210000                    | 856 | 913 | 970 | 1027| 1084| 1141| 1198| 1255| 1312| 1369| 1427| 1484| 1541|     |     |     |     |
| 220000                    | 817 | 871 | 926 | 980 | 1035| 1089| 1144| 1198| 1253| 1307| 1362| 1416| 1471| 1525|     |     |     |
| 230000                    | 781 | 834 | 886 | 938 | 990 | 1042| 1094| 1146| 1198| 1250| 1302| 1355| 1407| 1459| 1511|     |     |
| 240000                    | 749 | 799 | 849 | 899 | 949 | 999 | 1048| 1098| 1148| 1198| 1248| 1298| 1348| 1398| 1448| 1498|     |
| 250000                    | 719 | 767 | 815 | 863 | 911 | 959 | 1007| 1054| 1102| 1150| 1198| 1246| 1294| 1342| 1390| 1438|     |
| 260000                    | 691 | 737 | 783 | 830 | 876 | 922 | 968 | 1014| 1060| 1106| 1152| 1198| 1244| 1290| 1337| 1383|     |
| 270000                    | 666 | 710 | 754 | 799 | 843 | 888 | 932 | 976 | 1021| 1065| 1105| 1154| 1198| 1243| 1287| 1331|     |
| 280000                    | 642 | 685 | 728 | 780 | 813 | 856 | 899 | 941 | 984 | 1027| 1070| 1113| 1155| 1198| 1241| 1284|     |
| 290000                    | 620 | 661 | 702 | 744 | 785 | 826 | 868 | 900 | 950 | 992 | 1033| 1074| 1116| 1157| 1198| 1240|     |
| 300000                    | 599 | 639 | 679 | 719 | 759 | 799 | 839 | 879 | 919 | 959 | 999 | 1038| 1078| 1118| 1158| 1198|     |
| 310000                    | 580 | 618 | 657 | 696 | 734 | 773 | 812 | 850 | 889 | 928 | 966 | 1005| 1044| 1082| 1121| 1160|     |
| 320000                    | 562 | 599 | 637 | 674 | 711 | 749 | 786 | 824 | 861 | 899 | 936 | 974 | 1011| 1048| 1086| 1123|     |
| 330000                    | 545 | 581 | 617 | 654 | 690 | 726 | 763 | 799 | 835 | 871 | 908 | 944 | 980 | 1017| 1053| 1089|     |
| 340000                    | 529 | 564 | 599 | 634 | 670 | 705 | 740 | 775 | 811 | 846 | 881 | 916 | 952 | 987 | 1022| 1057|     |
| 350000                    | 514 | 548 | 582 | 616 | 650 | 685 | 719 | 753 | 787 | 822 | 856 | 890 | 924 | 959 | 993 | 1027|     |
| 360000                    | 533 | 566 | 599 | 632 | 666 | 699 | 732 | 766 | 799 | 832 | 865 | 899 | 932 | 965 | 999 | 1027|     |
| 370000                    | 518 | 551 | 583 | 615 | 648 | 680 | 712 | 745 | 777 | 810 | 842 | 874 | 907 | 939 | 972 |     |     |
| 380000                    | 536 | 568 | 599 | 631 | 662 | 694 | 725 | 757 | 788 | 820 | 851 | 883 | 914 | 946 |     |     |     |
| 390000                    | 522 | 553 | 584 | 614 | 645 | 676 | 707 | 737 | 768 | 799 | 830 | 860 | 891 | 922 |     |     |     |
| 400000                    | 539 | 569 | 599 | 629 | 659 | 689 | 719 | 749 | 779 | 809 | 839 | 869 | 899 |     |     |     |     |
| 410000                    | 526 | 555 | 585 | 614 | 643 | 672 | 701 | 731 | 760 | 789 | 818 | 848 | 877 |     |     |     |     |
| 420000                    | 542 | 571 | 599 | 628 | 656 | 685 | 713 | 742 | 770 | 799 | 827 | 856 |     |     |     |     |     |
| 430000                    | 529 | 557 | 585 | 613 | 641 | 669 | 697 | 725 | 752 | 780 | 808 | 836 |     |     |     |     |     |
| 440000                    | 545 | 572 | 599 | 626 | 654 | 681 | 708 | 735 | 763 | 790 | 817 |     |     |     |     |     |     |

\(^1\) ppm = parts per million
### RELATIVE TOXICITIES OF INSECTICIDES AND MITICIDES USED IN STRAWBERRIES TO NATURAL ENEMIES AND HONEY BEES (4/05)

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Chemical class</th>
<th>Mode of Action</th>
<th>Selectivity</th>
<th>Predatory mites</th>
<th>General predators</th>
<th>Parasites</th>
<th>Honey bees</th>
<th>Duration of impact to natural enemies</th>
</tr>
</thead>
<tbody>
<tr>
<td>abamectin (Agri-Mek)</td>
<td>M</td>
<td>6</td>
<td>moderate (mites, leafminers)</td>
<td>M/H</td>
<td>L</td>
<td>M/H</td>
<td>II</td>
<td>long to predatory mites and affected insects</td>
</tr>
<tr>
<td>acequinocyl (Kanemite)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Bacillus thuringiensis ssp. aizawai</td>
<td>M</td>
<td>11B1</td>
<td>narrow (caterpillars)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>IV</td>
<td>short</td>
</tr>
<tr>
<td>Bacillus thuringiensis ssp. kurstaki</td>
<td>M</td>
<td>11B2</td>
<td>narrow (caterpillars)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>IV</td>
<td>short</td>
</tr>
<tr>
<td>bifenthrin (Capture, Brigade)</td>
<td>P</td>
<td>3</td>
<td>broad (insects, mites)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I*</td>
<td>long</td>
</tr>
<tr>
<td>carbaryl (Sevin) bait</td>
<td>C</td>
<td>1A</td>
<td>narrow (cutworms, army-worms, grasshoppers, etc.)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>IV</td>
<td>short</td>
</tr>
<tr>
<td>chlorpyrifos (Lorsban)</td>
<td>OP</td>
<td>1B</td>
<td>broad (insects, mites)</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate</td>
</tr>
<tr>
<td>cinnamaldehyde (Cinnacure)</td>
<td>—</td>
<td>—</td>
<td>narrow (aphids, mites)</td>
<td>M/H</td>
<td>M</td>
<td>L/M</td>
<td>IV</td>
<td>short</td>
</tr>
<tr>
<td>diazinon–folic</td>
<td>OP</td>
<td>1B</td>
<td>broad (insects, mites)</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate to long</td>
</tr>
<tr>
<td>diazinon–granular</td>
<td>OP</td>
<td>1B</td>
<td>narrow (soil insects)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>IV</td>
<td>short</td>
</tr>
<tr>
<td>dicofol (Kelthane)</td>
<td>—</td>
<td>20</td>
<td>narrow (pest mites and mites)</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>IV</td>
<td>long to beneficial mites</td>
</tr>
<tr>
<td>endosulfan (Thionex, Thiodan)</td>
<td>OC</td>
<td>2A</td>
<td>broad (insects, mites)</td>
<td>L/M</td>
<td>M</td>
<td>M</td>
<td>II*</td>
<td>short</td>
</tr>
<tr>
<td>etoxazole (Zeal)</td>
<td>IGR</td>
<td>10B</td>
<td>narrow (mites)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>IV</td>
<td>short</td>
</tr>
<tr>
<td>fenbutatin oxide (Vendex)</td>
<td>OT</td>
<td>12B</td>
<td>narrow (pest mites)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>IV</td>
<td>short</td>
</tr>
<tr>
<td>fenpropatrin (Danitol)</td>
<td>P</td>
<td>3</td>
<td>broad (insects, mites)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate to long</td>
</tr>
<tr>
<td>hexythiazox (Savey)</td>
<td>CA</td>
<td>10A</td>
<td>narrow (mites)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>IV</td>
<td>short to moderate</td>
</tr>
<tr>
<td>imidacloprid (Admire)</td>
<td>N</td>
<td>4A</td>
<td>narrow (sucking insects, beet armyworm, cutworms)</td>
<td>—</td>
<td>L</td>
<td>L</td>
<td>II</td>
<td>—</td>
</tr>
<tr>
<td>insecticidal soap (M-Pede)</td>
<td>CON</td>
<td>—</td>
<td>broad (exposed insects, mites)</td>
<td>L/M</td>
<td>M</td>
<td>M</td>
<td>IV</td>
<td>short to none</td>
</tr>
<tr>
<td>malathion</td>
<td>OP</td>
<td>1B</td>
<td>broad (insects, mites)</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>II</td>
<td>moderate</td>
</tr>
<tr>
<td>methomyl (Lannate)</td>
<td>C</td>
<td>1A</td>
<td>broad (insects, mites)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>III</td>
<td>moderate</td>
</tr>
<tr>
<td>methyl bromide</td>
<td>—</td>
<td>8A</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>naled (Dibrom)</td>
<td>OP</td>
<td>1B</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>paraffinic oil (JMS Stylet Oil)</td>
<td>CON</td>
<td>—</td>
<td>broad (exposed insects, mites)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>III</td>
<td>short to none</td>
</tr>
<tr>
<td>petroleum oil</td>
<td>CON</td>
<td>—</td>
<td>broad (exposed insects, mites)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>III</td>
<td>short to none</td>
</tr>
<tr>
<td>pyrethrin (PyGanic)</td>
<td>B</td>
<td>3</td>
<td>broad (insects)</td>
<td>—</td>
<td>M</td>
<td>M</td>
<td>III</td>
<td>short</td>
</tr>
<tr>
<td>pyrethrin/piperonyl butoxide (Pyreneone)</td>
<td>B/S</td>
<td>3</td>
<td>broad (insects)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>III</td>
<td>short to moderate</td>
</tr>
<tr>
<td>pyriproxyfen (Esteem)</td>
<td>IGR</td>
<td>7C</td>
<td>narrow (whiteflies, etc.)</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>IV</td>
<td>long</td>
</tr>
<tr>
<td>rosemary oil (Hexacide)</td>
<td>B</td>
<td>—</td>
<td>broad (exposed insects, mites)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>IV</td>
<td>—</td>
</tr>
<tr>
<td>spinosad (Entrust, Success)</td>
<td>M</td>
<td>5</td>
<td>narrow (caterpillars, thrips, whiteflies, fruit flies, leafminers)</td>
<td>L</td>
<td>M</td>
<td>L/M</td>
<td>III</td>
<td>short to moderate</td>
</tr>
</tbody>
</table>

H = high  M = moderate  L = low  — = no information
1 Chemical class: B = botanical; C = carbamate; CA = carboxamid; CE = carboxylic acid ester; CON = contact including smothering and barrier effect; M = microbial; N = neonicotinoid; OC = organochloride; OP = organophosphate; OT = organotin; P = pyrethroid; S = synergist

Continued on next page…
Relative Toxicities of Insecticides and Miticides Used in Strawberries to Natural Enemies and Honey Bees Cont.

2 Modes of action are important in preventing the development of resistance to pesticides. Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode of action is assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at www.irac-online.org/.

3 Selectivity: Broad means it affects most groups of insects and mites; narrow means it affects only a few specific groups.

4 Generally, toxicities are to *Phytoseiulus persimilis*.

5 Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific chemical depends on the species of predator or parasite, environmental conditions, and application rate.

6 Ratings are as follows: 1-Do not apply to blooming plants; 2-Apply in evening after bees have stopped foraging; 3-Apply in late evening after bees have stopped foraging until early morning before they begin to forage again; and 4-Apply at any time with reasonable safety to bees. If marked with an asterisk (*), the rating is the next higher rating for low label rates. For more information, see *How to Reduce Bee Poisoning From Pesticides*, Pacific Northwest Extension Publication PNW518.

7 Duration: Short means hours to days; moderate means days to two weeks; and long means many weeks or months.

8 Toxic against some natural enemies (predatory thrips, syrphid fly larva) when sprayed and shortly after (8-24 hrs.).

Acknowledgments: This table was compiled based on research data and experience of University of California scientists working on a variety of crops.
Insects and Mites

APHIDS (4/05)

Scientific Names: Green peach aphid: *Myzus persicae*
Melon aphid: *Aphis gossypii*
Potato aphid: *Macrosiphum euphorbiae*
Strawberry aphid: *Chaetosiphon fragaefolii*

DESCRIPTION OF THE PESTS
Strawberry aphid is pale green to yellowish in color. Both adults and nymphs appear to have transverse striations across the abdomen and are covered with knobbed hairs that are readily seen with a hand lens. These striations and hairs are not found on any of the other aphid species infesting strawberry.

Melon aphid is small, globular, and varies in color from yellowish green to greenish black. This species is often the first to migrate into the strawberry fields each season and is the most difficult to control with insecticides.

Green peach aphid and potato aphid are less common in strawberries than the other species. The green peach aphid is green to greenish yellow in color and is more streamlined than the rounded melon aphid. Winged adults typically have a black spot on the top of the abdomen that is easy to observe with a hand lens.

The potato aphid is much larger than the other species and has both a pink form and a green form in California. The long legs on this species gives it a characteristic spiderlike appearance.

DAMAGE
Populations of aphids usually peak during late March in central and southern California and undergo a natural decline to noneconomic levels during May and June. (In high elevation nurseries, populations peak in mid- to late-summer.) Populations may continue to increase to damaging levels when spring temperatures are moderate and humidity is high. In California strawberry production fields, aphids rarely reach damaging levels but occasionally cause yield losses because of honeydew production. Honeydew deposits on fruit cause sooty molds to develop and the white skins shed by aphid nymphs to stick to the fruit. This contamination renders the fruit unmarketable as fresh fruit.

Aphids transmit several viruses that can cause significant economic losses in strawberries if the planting remains in the field for several years. While not a serious problem in annual production plantings, aphid transmission of viruses is a major concern for nursery production.

MANAGEMENT
While biological control can help to keep aphid populations low, treatments may be necessary in southern California, and occasionally in Central Coast fields, if spring weather is conducive to their development. Treatments are also applied in strawberry nurseries to prevent aphid buildup and virus spread. In other strawberry fruit production areas, aphids rarely reach damaging levels and are not treated.

Biological Control
A complex of at least seven species of primary parasites have been reared from aphids infesting strawberry plants. Unfortunately, the parasites themselves are attacked by a large group of hyperparasites (parasites of the parasites) that limits the buildup of primary parasites. Predators such as syrphid fly or green lacewing larvae often provide a greater level of control. Naturally occurring biological controls can keep aphid densities below economically damaging levels, such as with the case of the melon aphid in southern California strawberry-growing regions, so consider parasite and predator densities before any treatment decision is made.
Cultural Control
Some row covers (plastic tunnels or Remay-type enclosures) have reduced aphid populations to below economic levels, but the costs are substantial and the economic viability for large- or even small-scale plantings has not been established. Controlling dust is important to facilitate parasite and predator activity. Aphid populations tend to be especially large in plants that receive an excess of nitrogen fertilizer.

Organically Acceptable Methods
Cultural and biological controls and sprays of insecticidal soap are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions
• In southern California, start taking weekly samples when the first leaf is fully expanded. Remove the oldest trifoliate leaf and record if any aphids are present. Randomly sample 40 trifoliate leaves per acre and calculate the percent of leaves that have aphids. Treat if the infestation level reaches 30%.

• In strawberry nurseries, consider controlling aphids as soon as they appear to reduce the spread of virus, especially for the earliest generations.

• In Central Coast fields, aphids rarely reach damaging levels. If aphid numbers appear to be increasing, an insecticidal soap spray will help reduce the aphid populations with minimal damage to beneficials. Take a newly unfolded leaf from each plant sampled for mites and count the number of aphids. If populations reach an average of 10 per leaf, treat with insecticidal soap.

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. INSECTICIDAL SOAP# (M-Pede)</td>
<td>2.5 oz/gal water</td>
<td>5</td>
</tr>
<tr>
<td>COMMENTS: Do not make more than 2 applications/season or phytotoxicity may occur. A single application should reduce aphid populations about 50%. Also kills about 50% of predatory mite eggs, but does not affect motile mites and populations should recover.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. DIAZINON® 50WP</td>
<td>1 lb</td>
<td>5</td>
</tr>
<tr>
<td>COMMENTS: May injure mite predators, resulting in increase of twospotted spider mites. Provides longer residual activity than soap does. Apply in 100 gal water/acre. Diazinon has been found in surface waters at levels that violate federal and state water quality standards. Avoid runoff into surface waters or choose alternative materials.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

+ Preharvest interval. Do not apply within this many days of harvest.
* Permit required from county agricultural commissioner for purchase or use.
# Acceptable for use on organically grown produce.
BEET ARMYWORM  (4/05)
Scientific Name:  *Spodoptera exigua*

DESCRIPTION OF THE PEST
The beet armyworm adult is a gray and brown moth that lays its masses of round, pale-colored eggs beneath a covering of hairlike fluff collected from their wings. Newly hatched armyworms are often green in color and feed in groups, skeletonizing the undersides of leaves. Older beet armyworm larvae are green and smooth skinned with light stripes lengthwise along their sides. They commonly have a black spot on their side above the second leg.

DAMAGE
Moths from overwintering larvae lay eggs in spring, and young larvae feed on foliage and crowns before attacking berries. Greatest damage can occur in southern California and Santa Maria growing areas if larvae feed in the crowns of newly transplanted strawberry plants. Feeding at this time can kill the young transplants. Damage also can occur to summer-planted strawberries. Fall populations of armyworm moths will often fly into strawberry fields to lay eggs. Newly hatched armyworms feed on foliage, skeletonizing the upper or lower leaf surfaces next to their egg mass. Beet armyworm populations can build within second-year plantings and damage fruit in spring in southern California and later elsewhere. Larger armyworms feed directly into the berries; smaller armyworms will often feed on the shoulder of the berry beneath the calyx sepals.

MANAGEMENT
As with lygus and cutworm management, weed control is an important aspect of managing armyworms. Treatments may be necessary in southern California if beet armyworm populations are high around the time of transplanting. At other times, evaluate the level of parasitism and mortality from disease before making a decision to treat for beet armyworm.

Biological Control
Young beet armyworms can be heavily parasitized by the ichneumonid parasite, *Hyposoter exiguae*. This parasite can easily be monitored in the armyworm populations by simply pulling young worms apart and looking for the parasite larva inside. In addition, armyworms often become diseased with a virus that can cause high mortality; larvae turn black when killed by the virus. High natural mortality translates to few mature larvae surviving to cause further damage.

Cultural Control
Because adult moths are attracted to weeds for egg laying, good weed control helps minimize armyworm populations.

Organically Acceptable Methods
Cultural and naturally occurring biological controls, and sprays of *Bacillus thuringiensis* ssp. *aizawai* or the Entrust formulation of spinosad are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions
In southern California and the Santa Maria growing areas, plants are most vulnerable to beet armyworms soon after transplanting when larval feeding in the crown can kill the young transplants. Monitor beet armyworms flights with pheromone traps just before and after transplanting. If trap catches indicate a lot of beet armyworm activity, examine young strawberry plants for egg masses and time treatments to egg hatch.

At other times of the year and in other areas, if large numbers of predators, parasites, or virus are present, delay treating to determine if the armyworms might be controlled by the natural enemies.
The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies.

A. SPINOSAD (Entrust)#
   (Success)
   1.25–1.5 oz 1
   6 fl oz 1
   COMMENTS: Most effective against younger larvae. Rotate to an insecticide with a different mode of action after two successive applications. Maintaining proper pH of the spray tank water is critical for maximum efficacy.

B. BACILLUS THURINGIENSIS ssp. AIZAWAI#
   (Xentari)
   0.5–2 lb 0
   COMMENTS: Treat when armyworms are still small. To be effective, Bt must be applied no later than the 2nd instar.

C. METHOMYL* (Lannate)
   SP
   1 lb 3 – fresh, 10 – processing
   COMMENTS: Only use when beet armyworm populations are high or when most of the larvae present are large because this material can disrupt natural enemies of spider mites and other insects. Do not apply more than 4.5 lb a.i./acre/crop for all uses.

+ Preharvest interval. Do not apply within this many days of harvest.
# Acceptable for use on organically grown produce.
* Permit required from county agricultural commissioner for purchase or use.
CABBAGE LOOPER (4/05)
Scientific Name: Trichoplusia ni

DESCRIPTION OF THE PEST
Loopers are green caterpillars that have a narrow, white stripe along each side and several narrow lines down the back; they move with a characteristic arching or looping motion. Eggs are similar in appearance to corn earworm eggs but flatter and laid singly on the undersides of leaflets. Adult moths have brown, mottled forewings marked in the center with a small, silver figure 8.

DAMAGE
Young larvae feed primarily on the undersides of leaves, skeletonizing them. High populations can damage fruit but this is very uncommon.

MANAGEMENT
Treatments for loopers are seldom necessary in strawberries because they are frequently controlled by naturally occurring parasitic wasps. If treatments are necessary, time them to egg hatch.

Biological Control
Loopers are commonly controlled by parasitic wasps Hyposoter exiguae, Copidosoma truncatellum, and Trichogramma spp., and by outbreaks of nuclear polyhedrosis virus.

Organically Acceptable Methods
Biological controls, as well as sprays of Bacillus thuringiensis, are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions
Cabbage looper has only recently become a pest in strawberries, especially those planted next to lettuce fields. There are no established treatment thresholds for cabbage loopers in strawberries. If treatment is necessary, the preferred practice is to apply Bacillus thuringiensis just after egg hatch. Eggs are often found when monitoring mites with a leaf-brushing machine. Save a few leaves with eggs and observe when egg hatch begins and apply a treatment. When monitoring other pests, look for signs of looper feeding such as leaflets with holes, feces, and caterpillars feeding at the edge of a hole. If larvae are larger instars, an organophosphate such as diazinon may be needed to control them.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. BACILLUS THURINGIENSIS ssp. KURSTAKI# (various products) Label rates</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>B. DIAZINON* 50WP</td>
<td>2 lb</td>
<td>5</td>
</tr>
</tbody>
</table>

COMMENTS: Use when loopers are in the 1st or 2nd instar. Apply to plants when they are dry. COMMENTS: Do not use unless loopers pose a serious threat to the crop; diazinon is harmful to mite predators and outbreaks of twospotted spider mites may occur following its use.

+ Preharvest interval. Do not apply within this many days of harvest.
* Permit required from county agricultural commissioner for purchase or use.
# Acceptable for use on organically grown produce.
CORN EARWORM (4/05)
Scientific Name: Helicoverpa (=Heliothis) zea

DESCRIPTION OF THE PEST
Other names for the corn earworm are tomato fruitworm and cotton bollworm. Adult corn earworms are grayish brown moths with a wingspan of about 1.5 inches. In coastal southern California, the only strawberry-producing region where the corn earworm is a problem, adults emerge from overwintering pupae in large numbers each spring, often about mid-April. Each female produces between 500 and 3000 spherical eggs with rows of ridges along the sides. The eggs, which are usually laid singly on the undersides of younger leaves, are initially white, but then develop a brown ring near the top before hatching. In the warm temperatures common in southern California, eggs may hatch within 2 days. A newly hatched corn earworm has a black head and rows of dark-colored tubercles and bristles along the body; older larvae exhibit a wide variation in color, ranging from green, pink, or brown to nearly black. The time needed to complete a generation is temperature dependent but often takes about 1 month.

DAMAGE
Corn earworms damage strawberries by burrowing into fruit. Although there are several generations each season, only larvae of the first generation attack winter strawberries. Entrance holes made by early instar larvae are not visible, and the fruit must be cut to determine their presence. Larvae typically feed in the air pocket at the fruit’s center; mature fruit containing large larvae appear seedy and develop a shrunken surface with one or more brown patches. Contamination of the fruit prevents it from being marketed as whole fruit; federal tolerance currently requires downgrading to juice stock if a single 7 mm or larger larva is found per 44 pounds of fruit (about 1,100 berries).

MANAGEMENT
Management of corn earworm is occasionally necessary in South Coast strawberries, especially following a mild winter. Monitor for healthy and parasitized eggs in spring to determine the need for treatment.

Biological Control
A number of predaceous insects and parasites will feed on corn earworm eggs. A tiny parasitic wasp, Trichogramma pretiosum, has been found developing in Helicoverpa eggs on strawberries, but the percent parasitization from natural populations appears to be low. Trichogramma can be purchased from commercial sources for augmentative release. The frequency of release and release rates to effect control, however, have not been determined on strawberries. The minute pirate bug is a predator that has been observed to feed on corn earworm eggs. While both of these biocontrol agents can provide some pest suppression, the very low tolerance for insect contamination in strawberries makes this control option less attractive when populations are high.

Cultural Control
Plant a very early maturing sweet corn cultivar around strawberry fields to provide significant reductions in strawberry contamination by the earworm. Female moths strongly prefer to oviposit on corn and only lay eggs on strawberries if corn or other preferred hosts are not readily available.

Organically Acceptable Methods
Biological and cultural control methods and sprays of Bacillus thuringiensis are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions
Monitor the first generation of this pest in South Coast strawberries. Use Texas-style Heliothis pheromone traps to monitor emergence and flight activity of moths in late February/early March. Begin surveying strawberries or trap crops for eggs when flight activity peaks (i.e., when 10 or more adults are trapped in 1 week). If unparasitized eggs are found in the strawberry field, consider spraying. Outbreaks of corn earworms often occur in years when warm air currents associated with El
Niño conditions allow moths to migrate from the south; extra monitoring is advised during these years until harvest is complete.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies.*

A. METHOMYL* (Lannate) LV (Lannate) SP
   2–3 pt 1 lb 3 - fresh 10 - processing
   COMMENTS: Use may result in mite problems. Also controls aphids. Do not apply more than 4.5 lb a.i./acre/crop. Do not make more than 10 applications/crop.

B. BACILLUS THURINGIENSIS ssp. KURSTAKI# (various products)
   Label rates 0
   COMMENTS: Most effective against newly hatched larvae and not very effective against large larvae and those that have already entered the fruit to feed. Carefully time treatments to egg hatch. Because residual activity is short, it may be necessary to repeat applications at 4- to 7-day intervals during extended periods of peak egg hatch.

+ Preharvest interval. Do not apply within this many days of harvest.
* Permit required from county agricultural commissioner for purchase or use.
# Acceptable for use on organically grown produce.
CUTWORMS (4/05)

Scientific Names: Black cutworm: Agrotis ipsilon  
Roughskinned cutworm: Athetis mindara  
Variegated cutworm: Peridroma saucia

DESCRIPTION OF THE PESTS
The black cutworm, also called the greasy cutworm, is the primary cutworm pest of strawberries in most growing areas but other species are found in damaging numbers on occasion. Cutworm adults are large moths, usually brown or gray, about 1.5 inches long. Mature larvae are robust, nearly 1.5 inches long, and their smooth skin is either mottled brown or gray. Larvae tend to fall to the ground and curl up into a C-shape when they are disturbed.

Cutworms are active night feeders and can be found hidden in the soil at the base of the plant during the day. Most cutworms overwinter in strawberries as young larvae, maturing and pupating in spring. Since there are only a limited number of hosts in fall for adult moths to lay eggs on, they tend to move into newly planted strawberry fields. Migration of adult moths can also occur following harvest of other hosts, such as lettuce, in nearby fields.

DAMAGE
Early season damage by newly hatched cutworms generally appears as small, webless perforations in the newly expanding crown leaves. As larvae grow, they begin their characteristic stem cutting along with chewing larger, irregular holes in the foliage. At times serious damage can occur to the plant crown when the central growing point of young plants is eaten.

Damage often occurs along the edges of fields adjacent to backyards or to more favored crops such as lettuce or beans. Most damage occurs in fall and spring, with the fall attack being more destructive. During harvest, cutworms can cause rather pronounced holes in the fruit. Damaged berries tend to be concentrated in localized areas of one to several plants around each active cutworm.

MANAGEMENT
Watch edges of fields to detect cutworm invasions. Controlling weeds in and around the field is an important aspect of managing this pest. If damage is occurring, use baits or make spot treatments.

Biological Control
Other than birds, there isn’t much significant biological control known. The most important control is cultural.

Cultural Control
Weed control is paramount to preventing a serious cutworm problem. Weedy fields tend to attract more moths to lay their eggs. Annual planting and thorough pruning of second-year plantings reduce survival of overwintering larvae.

Organically Acceptable Methods
Cultural controls and sprays of Bacillus thuringiensis or the Entrust formulation of spinosad are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions
There is no specific threshold for treating cutworms. Damage tends to be localized, so spot treating is recommended if using foliar sprays. When using baits, make applications immediately after weeding when evidence of substantial leaf and/or stem cutting is noted in order to prevent migration to the crop plants.
Cutworms

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies.

A. CARBARYL
   (Sevin) 5% bait
   Amount/Acre: 40 lb
   P.H.I.+ (days): 7
   COMMENTS: Apply preventively to beds only around the base of plants when feeding damage is observed.

B. SPINOSAD
   (Entrust)#
   Amount/Acre: 1.25–1.5 oz
   (Success)
   Amount/Acre: 6 fl oz
   P.H.I.+ (days): 1
   COMMENTS: Apply against younger larvae or when fruit feeding is observed. Rotate to an insecticide with a different mode of action after two successive applications.

C. BACILLUS THURINGIENSIS ssp. KURSTAKI#
   (various products)
   Label rates
   P.H.I.+ (days): 0
   COMMENTS: Treat when young larvae present. Good coverage at relatively low dilution is essential.

+ Preharvest interval. Do not apply within this many days of harvest.
# Acceptable for use on organically grown produce.
CYCLAMEN MITE (4/05)

Scientific Name: *Phytonemus pallidus*

DESCRIPTION OF THE PEST
At low population densities, cyclamen mites are usually found along the midvein of young, unfolded leaves and under the calyx of newly emerged flower buds; when populations increase, these mites can be found anywhere on nonexpanded plant tissue. They are not visible to the naked eye, and when mature they measure only about 0.01 inch long. Mature mites are pinkish orange and shiny. The hind legs are thread- or whiplike in the female and grasping or pincerlike in the male. Eggs are translucent and comparatively large. Adult females lay about 90 eggs, 80% of which develop into females. During summer, newly hatched mites develop into mature adults within 2 weeks. Populations build rapidly soon after a field becomes infested. Cyclamen mites overwinter as adult females in the strawberry crown and can be present on transplants if the nursery field was infested.

DAMAGE
Cyclamen mites are primarily pests in fall-planted and second-year plantings, but they can be transplanted into first-year fields and the damage symptoms become apparent on leaves as the season progresses. Leaves heavily infested with cyclamen mites become severely stunted and crinkled, resulting in a compact leaf mass in the center of the plant. Feeding on flowers can cause them to wither and die. Fruit on infested plants is dwarfed, and the seeds stand out on the flesh of the berry. When uncontrolled, this mite can prevent plants from producing fruit.

MANAGEMENT
Management of cyclamen mite requires carefully timed sprays of miticides that do not harm natural enemy populations. Prevent its introduction into strawberry fields by following good cultural practices. Propagating nursery stock free of cyclamen mites is essential to prevent introducing populations to fruit-producing fields.

Biological Control
Two naturally occurring predatory mites of cyclamen mite are *Typhlodromus bellinus* and *T. reticulatus*, but their populations build up too slowly to provide economic control. Early season releases of the commercially available predatory mite, *Amblyseius californicus*, may be able to control this pest mite. *Amblyseius cucumeris* releases have not proven to be effective.

When pest populations become large, the sixspotted thrips, minute pirate bugs, and western predatory mite (*Galendromus occidentalis*) all feed on cyclamen mites.

Cultural Control
Cyclamen mites can easily be transferred from one location to another by pickers, bees, birds, and equipment, including strawberry freezer trays. It may be worthwhile to dip trays in a hot water bath to prevent infestation. Infested nursery plants are the major source of this pest in annual plantings; be sure to use uninfested nursery stock. When transplants are known to be infested, treat them in hot water at 100°F for 30 minutes before planting. Avoid second-year plantings in problem areas. To slow the spread of infestations, rogue infested plants as soon as symptoms appear.

Organically Acceptable Methods
Biological and cultural control methods are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions
If any damage symptoms are observed, be sure to monitor the rest of the field carefully to determine the extent of the infestation. Monitor newly unfolding leaves and treat the area of the field believed to be infested when densities of one cyclamen mite in 10 leaves are found. To control cyclamen mites, a high rate of water per acre (300–500 gal) is necessary to soak the unfolded leaves and immature flower buds located in the crowns. Effective control requires a high rate of kill because populations of this mite can
increase rapidly. Roguing and treating infested hot spots with a hand-sprayer can be useful in suppressing infestations without having to treat the entire field. In nurseries, early season control before plant canopy closes over is critical.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
</table>

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies.

A. **ABAMECTIN* (Agri-Mek) 0.15 EC**  
   16 fl oz  
   3  
   COMMENTS: Toxic to predatory mites and relatively toxic to parasites, but fairly safe for general predators. Apply in up to 600 gal water/acre to soak the material into the crown of the plant. Works poorly under cold weather conditions. Make 2 applications 7–10 days apart when mites reach detectable levels under warmer temperatures in late winter/spring. Repeat this sequence of applications if necessary to maintain cyclamen mite control. Do not exceed 16 fluid oz/application or 64 fl oz (4 applications)/acre in a growing season. Do not repeat treatment within 21 days of 2nd application. Not registered for strawberry nurseries.

B. **DICOFOL (Kelthane) 50WSP**  
   3–4 lb/acre  
   3  
   COMMENTS: Apply with a wetting agent. Toxic to predaceous mites and relatively toxic to general predators and parasites. Do not make more than 2 applications/season.

C. **ENDOSULFAN* (Thionex) 3EC**  
   2.66 qt in 400–600 gal water  
   4  
   COMMENTS: Do not reapply within 35 days. Use of this product may not be allowed in some counties; cannot be applied in any situation where run-off may occur. Consult county agricultural commissioner for local restrictions. Do not make more than 3 applications/year or exceed 3 lb a.i./acre/year.

D. **FENPROPATHRIN* (Danitol) 2.4EC**  
   10.66 fl oz  
   2  
   COMMENTS: Use of this material is limited to 2 applications/year (totaling 2.66 pt/acre), but to reduce the pressure for resistance development, make no more than 2 applications of all pyrethroids to the crop each year.

+ Preharvest interval. Do not apply within this many days of harvest.  
* Permit required from county agricultural commissioner for purchase or use.
EUROPEAN EARWIG (4/05)
Scientific Name: *Forficula auricularia*

DESCRIPTION OF THE PEST
Earwigs feed at night and can be found hidden inside split fruit and around crowns of plants during the day. They are slender brown insects, about 0.5 to 0.75 inch long. They have a conspicuous pair of pincers attached to the back end of the abdomen. The adults’ wing covers are short and leathery. The pest becomes most destructive as nymphs approach maturity from April to July.

DAMAGE
Earwig feeding results in small deep holes in the fruit that can only be distinguished from slug damage by the absence of slime. They will also inhabit catfaced or open-ended fruit.

MANAGEMENT
To control earwigs, destroy rubbish near strawberry fields. In South Coast areas, earwigs may become a problem when they are present inside split fruit at harvest. If a lot of fruit splitting occurs, look for earwigs and apply bait if they are present. If fruit splitting is not occurring, there is no need for treatment.

Earwigs can be monitored using inverted containers that are filled with shredded paper and have holes located near their bases. Examine the containers by removing the shredded paper to look for earwigs that have sought shelter. You can also use small cans, about one-third filled with vegetable oil containing a small amount of bacon grease or fish oil. Earwigs are attracted by the bacon grease or fish oil, fall into the vegetable oil, and suffocate. If significant numbers of earwigs are present, apply bait to the tops of beds, between plants.

Organically Acceptable Methods
Keeping strawberry fields clear of rubbish and plant debris is an organically acceptable control method.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. CARBARYL BAIT (Sevin 5%)</td>
<td>40 lb</td>
<td>7</td>
</tr>
</tbody>
</table>

+ Preharvest interval. Do not apply within this many days of harvest.
GARDEN SYMPHYLAN (4/05)
Scientific Name: Scutigerella immaculata

DESCRIPTION OF THE PEST
Garden symphylans are slender and white, they have 10 to 12 pairs of legs and a pair of antennae. They run rapidly when exposed to light. They occur mainly in moist soils with good structure and a high organic matter content and are often associated with debris from a previous crop that is not completely decomposed. They return to damage the same area every season so infestations spread slowly.

DAMAGE
Garden symphylans damage plants by feeding on roots, thus retarding plant growth. They are usually only a problem in fields that were not fumigated, or if the fumigation was ineffective.

MANAGEMENT
Soil fumigation for pathogen and weed seed control will kill symphylans. In nonfumigated fields and fields with large amounts of crop residue from a previous crop, continuous flooding for 3 weeks in the summer helps reduce infestations and discing in a crop of sorghum has been reported to reduce infestations in other crops.

Research from other areas of the country indicates that symphylans can be detected with bait trapping. Either carrots or potatoes can be used as the bait. Cut the bait in half longitudinally and scratch the cut surface just before placing it on the soil to ensure that the surface is moist. Cover the bait with a pot. Use at least a dozen bait traps in the field. After 2 to 5 days, examine the cut surface and the soil upon which it was resting for evidence of symphylans. If they are detected, consider a treatment. Because the recommended treatment is best applied before transplanting, bait traps for symphylans a few weeks before transplanting.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. DIAZINON AG 500</td>
<td>1 qt, 2 lb</td>
<td>5, 5</td>
</tr>
</tbody>
</table>

COMMENTS: Only registered product that will afford some control. Broadcast before transplanting and incorporate into top 4 inches of soil. Treatment after transplanting is less effective, and material must be well watered into the soil.

+ Preharvest interval. Do not apply within this many days of harvest.
GARDEN TORTRIX (4/05)

Scientific Name: Ptycholoma (=Clepsis) peritana

DESCRIPTION OF THE PEST
The adult has the typical bell-shaped tortricid moth wings while at rest. It is buff-brown and about 0.25 inch long. Each of the forewings is marked with a dark brown diagonal stripe and a marginal spot producing a chevron pattern when at rest. The anterior edge of the brown stripe is bordered by a faint whitish line. This character and the overall lighter color distinguishes adult garden tortrix from moths of the orange tortrix.

The slender larvae are nearly 0.5 inch long when mature. Larvae have light brown-green bodies and light brown heads. The head has a small, distinct dark brown spot on each side. Larvae and pupae overwinter in trash around the base of the plant.

Adults aren’t usually seen until March or April. Larvae hatching from eggs laid in spring on older leaves move down into the trash where they feed on dead and decaying leaves. They construct shelters by tying bits of trash together. As a result of overlapping generations, all stages are generally present in spring and summer.

DAMAGE
Larvae feed on dead and decaying leaves and fruit most of the time and generally cause no significant damage. However, as the population increases and the plant canopies close in, more ripening berries settle down into the trash among the tortrix larvae. When this happens, larvae will often spin a nest in creases along the berry’s surface and may chew small, shallow holes in the berry, incidental to their scavenging. Thus, with the higher populations often attained by late spring or early summer, significant fruit losses can result from both larval contamination and secondary rots invading the feeding holes.

Contamination of South Coast fields just before the berries are sent to the processors during late June and July can be a serious problem. Up until the point when garden tortrix begins feeding on or webbing against the fruit, this insect serves a valuable function in breaking down and recycling old leaf and fruit litter.

MANAGEMENT
In areas with a chronic tortrix problem, such as the South Coast, it may be feasible to remove accumulated trash in spring around the plants with either blowers or suction devices to limit the potential for a large population buildup. In severe situations, extra help may be required to sort out contaminated or damaged berries during harvest.

Treatments may be required in May to early July if large populations are present, but larvae are difficult to control with sprays because they are located in the litter beneath the protective canopy of strawberry leaves. Directed sprays that penetrate the foliage canopy at sufficient volume are recommended. Because of overlapping generations, there is no best timing period.

Organically Acceptable Methods
Cleaning strawberry fields of dead vegetation as well as sprays of Bacillus thuringiensis are acceptable for use on organically certified strawberries.
<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount / Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. BACILLUS THURINGIENSIS ssp. KURSTAKI# (various products)</td>
<td>Label rates</td>
<td>0</td>
</tr>
</tbody>
</table>

**COMMENTS:** Can be applied up to and including day of harvest.

+ Preharvest interval. Do not apply within this many days of harvest.

# Acceptable for use on organically grown produce.
LYGUS BUG (4/05)
Scientific Name: Lygus hesperus

DESCRIPTION OF THE PEST
Lygus bugs are a serious pest in Central Coast strawberry-growing areas where strawberries are typically grown past May and through the summer months, but they are rarely pests in southern California and the Central Valley where fresh market berry harvest is generally complete by the end of June. However, lygus is an occasional problem in this area on second-year plantings and berries held through the summer.

Adults are about 0.25 inch long, oval, and rather flattened. They are greenish or brownish and have reddish brown markings on their wings. In the center of their back is a distinct, but small, yellow or pale green triangle that helps distinguish them from other insects. The immature forms are pale green and look similar to an aphid. They can be distinguished from aphids by their more rapid movements.

Nymphs of the third and later instars are green and characterized by five black dots on the back – two on the segment immediately behind the head, two on the next segment, and one in the middle of the abdomen. A similar nonpest species that may be confused with lygus, Calocoris, frequently is found when monitoring weed and legume crop hosts for lygus. Calocoris has two prominent black dots on the back, just behind the head, and dark wing tips. Lygus adults have no black dots on the back. Both nymphs and adults of Calocoris are longer and narrower than lygus.

DAMAGE
Lygus bugs are one of the causes of irregularly-shaped, cat-faced strawberries; another cause may be poor pollination, which results in small undeveloped seeds. Lygus bugs damage fruit by puncturing individual seeds; this, in turn, stops development of the berry in the area surrounding the feeding site. Straw-brown seeds that are large and hollow are a good indication of lygus bug damage. Lygus bug damage is more of a problem in strawberry-growing areas where fruit production continues through summer and fall.

MANAGEMENT
Successful management of lygus includes control of weed hosts in winter, monitoring for the appearance of lygus nymphs on weed hosts and adults on strawberries in spring, and timing insecticide sprays to control lygus nymphs before they cause significant damage. Sprays must be timed to kill the earliest instars of nymphs because registered materials are not very effective on adults. It is important to limit the number of treatments for lygus, because most of the materials that are effective against lygus disrupt natural enemies of spider mites. Control actions for lygus in strawberries generally are needed only in growing areas of the Central Coast, and the management activities described below apply to these areas. Once flower development begins in Central Valley strawberries, you can watch for the appearance of lygus adults during other routine monitoring activities.

Biological Control
A parasitic wasp, Anaphes iole, which attacks lygus eggs, is available commercially and can be used for inoculative releases. It can reduce lygus populations in strawberry fields; but because thresholds for this pest are very low and adults moving into the field from external sources are not controlled, economically acceptable results may not be achieved. Naturally occurring predators that feed on the nymphal stages of lygus bug include bigeyed bugs (Geocoris spp.), damsel bugs (Nabis spp.), minute pirate bugs (Orius tristicolor), and several species of spiders.

Cultural Control
Controlling weeds along roadways, ditches, and field borders near strawberry fields to help prevent spring buildup of lygus bugs is fundamental to lygus management in strawberries. Overwintered lygus bugs lay eggs in weeds in January that hatch in March. Carry out weed control measures in March and early April while lygus are still nymphs. Once adults are present on weeds, they will migrate into
strawberries when the weeds dry or are removed. Spraying adults or weeds to prevent movement is not very effective. To avoid adult migration in spring, mow or disc under cover crops, especially legumes, before they flower and while lygus are still in the nymphal stages.

One cultural approach is to grow flowering plants in or adjacent to fields to attract lygus bug adults, but this approach requires careful monitoring and management to prevent an even greater problem from occurring. Adult lygus will lay eggs on the flowering plants, and nymphs will emerge from late March through April. The nymphs must be controlled at this time before they become adults and move to the strawberry plantation. Destroying the plants by discing or mowing is the most effective method of removing the infested, flowering plants. It is also possible to apply pesticides registered for use on strawberries for control of nymphs; however, none of the registered pesticides will provide complete control of the nymphs. If the plants are allowed to flower later into the season, carefully monitor the plants for the presence of lygus nymphs and take appropriate actions to prevent their movement into strawberries. This approach generally targets local populations of lygus and does not adequately impact longer range lygus migration from drying foothill weeds.

Growers have experimented with suction devices (bug-vacs) to control lygus bug for many years. Research has shown that an efficient bug-vac can reduce adult populations by 75% and nymphs 9 to 50%, but efficiency can vary considerably depending on the machine. If lygus bug population levels are moderate to heavy, use of vacuum machines alone will not reduce damage to acceptable levels. Vacuums may increase problems with powdery mildew and gray mold by spreading the pathogens that cause these diseases. Additionally, they may remove a disproportionately large portion of the general predator population.

Organically Acceptable Methods
Biological and cultural controls and insecticidal soap sprays are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions
In February, monitor for the first appearance of lygus nymphs on plant hosts around the field to determine when these plants should be destroyed and to establish the first biofix for the degree-day model. Important plants and the key times to monitor them are outlined in the following table:

<table>
<thead>
<tr>
<th>Important Plant Hosts of Lygus Bugs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant host Common name (scientific name)</td>
</tr>
<tr>
<td>--------------------------------------</td>
</tr>
<tr>
<td>California burclover (Medicago polymorpha)</td>
</tr>
<tr>
<td>California poppy (Eschscholzia spp.)</td>
</tr>
<tr>
<td>chickweed (Stellaria media)</td>
</tr>
<tr>
<td>common groundsel (Senecio vulgaris)</td>
</tr>
<tr>
<td>curly dock (Rumex crispus)</td>
</tr>
<tr>
<td>filaree (Erodium spp.)</td>
</tr>
<tr>
<td>lambsquarters (Chenopodium album)</td>
</tr>
<tr>
<td>little mallow (cheeseweed) (Malva parviflora)</td>
</tr>
<tr>
<td>lupines (Lupinus spp.)</td>
</tr>
<tr>
<td>milk thistle (Silybum marianum)</td>
</tr>
<tr>
<td>mustards (Brassica spp.)</td>
</tr>
<tr>
<td>pineapple-weed (Chamomilla suaveolens)</td>
</tr>
<tr>
<td>redmaids (Calandrinia ciliata)</td>
</tr>
<tr>
<td>shepherd's purse (Capsella bursa-pastoris)</td>
</tr>
<tr>
<td>wild radish (Raphanus rapanistrum)</td>
</tr>
</tbody>
</table>

I = lygus present
L = lygus present in higher numbers

Begin monitoring the strawberry plants in mid-April to detect when adults first appear in the field. Establishing when adults first enter the field also serves as the biofix for part of the degree-day model.
described later. Continue monitoring the field regularly after this time to establish whether or not lygus densities are economically important and exceed the treatment threshold.

Threshold levels for lygus bugs depend on the monitoring method used. When a beat sheet (12-inch embroidery hoop with muslin or other device of similar size) is used, divide the field into blocks and sample four 200-foot lengths of row in each block. Sample one plant in each 20 feet of row by placing the beating tray under the plant and beating it with your hand. Apply sprays when one lygus nymph is found in 20 plants sampled. The Allen-Vac (a modified leaf blower that sucks lygus from the plant into a screen or net placed within the device) is a more efficient sampling device; the threshold to be used when sampling with it is one lygus per 10 plants. Continue weekly monitoring as long as fruit are being harvested for fresh market or freezer pack.

Currently registered insecticides are most effective against young first- and second-instar nymphs. Insecticides applied to later nymphal stages and adults are not very effective. Adult lygus that are not killed by sprays may migrate from the field to nearby weeds when pesticides are applied, but can return.

Calculating degree-days (DD) is an effective way of determining the time of egg hatch, which occurs just before best treatment times for lygus nymphs. This information can greatly improve the timing of lygus sprays and weed abatement in central coast areas, where damage from lygus is an annual problem. Accumulate degree-days for lygus bug using a lower threshold of 54°F. There are two primary periods when lygus migrate from weeds into strawberries. Use degree-days to determine when peak egg hatch occurs following each migration. The first migration is by the overwintered adults; it usually occurs in April. Not all fields will have damaging levels of lygus at this time. If treatment thresholds are exceeded, apply the first spray 252 DD from the date you find the first adult in the field after April. This will generally be from late May to early June. The second treatment period is at 799 DD (late June/early July) from the date the first nymphs are found in strawberries. A third treatment period corresponds to the emergence of nymphs that come from both adults that have established in the field and those that have migrated to strawberries during the summer; it is about 799 DD (early August) after the first spray. (For assistance in calculating degree-days, see "Degree-days," on the UC IPM Project Web site at www.ipm.ucdavis.edu).

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. FENPROPATHRIN</strong> (Danitol) 2.4 EC</td>
<td>10.66 fl oz</td>
<td>2</td>
</tr>
</tbody>
</table>

Comments: Synthetic pyrethroids are the most effective materials currently registered for lygus control in strawberries but the potential for the development of resistance is high. Therefore, although this material can suppress spider mites, it should be used primarily to control lygus. Use of this material is limited to 2 applications/year (totaling 2.66 pt/acre), but to reduce the pressure for resistance development, make no more than 2 applications of all pyrethroids to the crop each year. To delay resistance and to avoid the severe spider mite outbreaks that result from application of pyrethroids, it is preferable to target the summer generation of lygus in areas where fruit is produced throughout the summer. See label for harvest restrictions.
### Lygus Bug (4/05)

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount / Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. BIFENTHRIN* (Brigade) WSB</td>
<td>Label rates 0</td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Synthetic pyrethroids are the most effective materials currently registered for lygus control in strawberries but the potential for the development of resistance is high. Therefore, although this material can suppress spider mites, it should be used primarily to control lygus. Use of this material is limited to 2 applications/year, but to reduce the pressure for resistance development, make no more than 2 applications of all pyrethroids to the crop each year. To delay resistance and to avoid the severe spider mite outbreaks that result from application of pyrethroids, it is preferable to target the summer generation of lygus in areas where fruit is produced throughout the summer. See label for harvest restrictions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. MALATHION 8E</td>
<td>1.5–2 pt 3</td>
<td></td>
</tr>
<tr>
<td>5EC</td>
<td>1.5–3 pt 3</td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Only effective against first 3 nymphal instars. Very high levels of resistance to this material have been identified in some growing areas. Check the California Strawberry Commission pink sheets for annual information on this.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. METHOMYL* (Lannate) SP</td>
<td>1 lb 3 – fresh</td>
<td></td>
</tr>
<tr>
<td>(Lannate) LV</td>
<td>3 pt 10 – processing</td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Disruptive of beneficials. Use when lygus populations are high (such as 1 lygus/plant by vacuuming or an average of 0.5 lygus/plant by beat sheet). Do not apply more than 4.5 lb a.i./acre/crop. Do not make more than 10 applications/crop.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. NALED (Dibrom) 8EC</td>
<td>1 pint 1</td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not use when temperature exceeds 85°F. Because naled is an organophosphate like malathion, it is not effective in some growing areas because of resistance. Do not apply more than 5 pt/acre/season.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. INSECTICIDAL SOAP# (M-Pede)</td>
<td>2.5 oz/gal water</td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not exceed 1 application a month or 2 per season to reduce the risk of phytotoxicity. A single application will reduce nymphal populations by no more than 50% and will have little effect on adults. Also kills about 50% of predatory mite eggs, but does not affect motile mites and populations should recover.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

+ Preharvest interval. Do not apply within this many days of harvest.
* Permit required from county agricultural commissioner for purchase or use.
# Acceptable for use on organically grown produce.
ROOT BEETLES  (5/05)

Scientific Names:  Black vine weevil: Otiornynchus sulcatus  
Cribrate weevil: Otiorhynchus cribicollis  
Fuller rose weevil: Pantomorus cervinus  
Woods weevil: Nemocestes incomptus  
Hoplia beetle: Hoplia dispar, H. callipyge

DESCRIPTION OF THE PESTS
Root beetles are occasional problems on California strawberries. They feed at night and hide around the crowns of plants during the day and, with the exception of adult hoplia beetles, they cannot fly. The adults, nearly all females, emerge in late spring or summer, feed on strawberry foliage, and lay their eggs around the crowns about 1 month after emergence. After hatching, the larvae work their way into the soil and feed on strawberry roots and crowns through the fall.

Root weevil larvae have curved, white or pink bodies that are about 0.38 inch long when fully grown. They have distinct brown heads and no legs. In spring, they resume feeding and can cause extensive damage before they pupate. Root weevils have a single generation each year. The Fuller rose weevil can be distinguished from the other weevils by an oblique, white band on the side of each wing cover. In addition, their larvae have pale, almost white heads. The black vine weevil is the largest and has a distinct black color. The woods weevil is the smallest of the group.

Hoplia are scarab beetles that are brown and 0.40 inches long. Adults emerge in mid-April and are active for about 1 month. They are attracted to strawberry flowers, where they feed on petals. Eggs are laid on the soil or on strawberry crowns; the resulting larvae enter the soil to feed on roots and are found associated with the roots from fall through spring. The larvae are 0.45 inches long and characteristically C-shaped. They feed for 2 years before pupating. Hoplia beetles are primarily a problem in San Joaquin Valley plantations that have not been fumigated.

DAMAGE
Larvae of all of these beetles feed on the roots of strawberry plants and can completely devour small rootlets and destroy the bark and cortex of larger roots. Soon after feeding begins, plants wilt because the roots can no longer provide moisture for leaves. Hoplia larvae will severely stunt and eventually kill infested plants. It is not uncommon to find beetle larvae that have penetrated into the lower portion of the plant’s crown.

Adult weevils feed on foliage and remove large scallops from the leaves. Such leaf damage is a good indication that weevils are present but is not economically damaging to the plants. Adult hoplia beetles feed on flower petals, but it is not known if this injures young fruit.

MANAGEMENT
The rapid removal of plantings following harvest and preplant fumigation destroy beetle larvae and pupae in the soil. Sticky barriers can help prevent the migration of weevils into the field and crop rotation can also be practiced to reduce populations in fields. Soil solarization may be effective for hoplia beetles in the Central Valley.

Biological Control
Parasitic nematodes that target immature insects in the soil are available commercially. Preliminary research in using them for control of beetle larvae infesting strawberry roots, however, has not proven successful.

Cultural Control
Annual plantings reduce the likelihood of high populations building up in fields. Rotating to a nonhost crop (such as lettuce or cole crops) will further help reduce population levels in the soil. Sticky barriers can be used to prevent movement of adult weevils from infested, second-year berries and host areas to
newly fumigated plantings, but this approach will not work for hoplia beetles because hoplia adults can fly.

**Organically Acceptable Methods**
Cultural controls, especially the use of annual plantings, soil solarization for hoplia beetles, and crop rotation, are acceptable for use on organically certified strawberries.

**Monitoring and Treatment Decisions**
None of the currently registered chemicals provide good control of weevil larvae once they infest the roots. Soil fumigation for weed and disease control will destroy larvae and pupae in the soil, and root weevils and hoplia beetle do not appear to become problems in fumigated fields.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PREPLANT FUMIGATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequential application of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. 1,3-DICHLOROPROPENE*/CHLOROPICRIN* (Telone C35)</td>
<td>9-12 gal (shank)</td>
<td>9-12 gal (shank)</td>
</tr>
<tr>
<td>COMMENTS: Effective for control of nematodes, soilborne fungal pathogens, and insects. One gallon of product weighs 11.1 lb.</td>
<td>COMMENTS: Effective for control of nematodes, soilborne fungal pathogens, and insects. Requires plastic mulch. Using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. One gallon of product weighs 11.2 lb.</td>
<td></td>
</tr>
<tr>
<td>...or...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,3-DICHLOROPROPENE*/CHLOROPICRIN* (InLine)</td>
<td>28-33 gal (drip)</td>
<td>28-33 gal (drip)</td>
</tr>
<tr>
<td>COMMENTS: Effective for control of nematodes, soilborne fungal pathogens, and insects. Requires plastic mulch. Using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. One gallon of product weighs 11.2 lb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>...or...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,3-DICHLOROPROPENE* (Telone II)</td>
<td>9-12 gal (shank)</td>
<td>9-12 gal (shank)</td>
</tr>
<tr>
<td>COMMENTS: Liquid that diffuses as a gas through soil. Effective against nematodes and insects. Rates very with soil texture and efficacy strongly affected by soil moisture and temperature. One gallon of product weighs 10.1 lb.</td>
<td>COMMENTS: Liquid that diffuses as a gas through soil. Effective against nematodes and insects. Rates very with soil texture and efficacy strongly affected by soil moisture and temperature. One gallon of product weighs 10.1 lb.</td>
<td></td>
</tr>
<tr>
<td>...or...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHLOROPICRIN* (MetaPicrin)</td>
<td>15-30 gal (shank)</td>
<td>15-30 gal (shank)</td>
</tr>
<tr>
<td>(Tri-Clor)</td>
<td>15-22 gal (drip)</td>
<td>15-22 gal (drip)</td>
</tr>
<tr>
<td>COMMENTS: A liquid that diffuses as a gas through soil. Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. One gallon of product weighs 13.7 lb.</td>
<td>COMMENTS: A liquid that diffuses as a gas through soil. Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. One gallon of product weighs 13.7 lb.</td>
<td></td>
</tr>
<tr>
<td>Followed 5-7 days later by</td>
<td></td>
<td></td>
</tr>
<tr>
<td>METAM SODIUM* (Vapam HL, Sectagon 42)</td>
<td>37.5-75 gal</td>
<td>37.5-75 gal</td>
</tr>
<tr>
<td>...or...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>METAM POTASSIUM* (K-Pam HL)</td>
<td>30-60 gal</td>
<td>30-60 gal</td>
</tr>
<tr>
<td>COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.</td>
<td>COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.</td>
<td></td>
</tr>
</tbody>
</table>

**POSTHARVEST**
A. CHLORPYRIFOS* (Lorsban) 4E | 1 qt | 21 |
| COMMENTS: Apply as a soil drench postharvest in fall for second-year plantings if root weevils or Hoplia beetle infestations have been found. Chlorpyrifos has been found in surface waters at levels that violate federal and state water quality standards. Because runoff into waterways is a concern, apply well before winter rains begin. Do not make more than 2 applications/season. | COMMENTS: Apply as a soil drench postharvest in fall for second-year plantings if root weevils or Hoplia beetle infestations have been found. Chlorpyrifos has been found in surface waters at levels that violate federal and state water quality standards. Because runoff into waterways is a concern, apply well before winter rains begin. Do not make more than 2 applications/season. |

+ Preharvest interval. Do not apply within this many days of harvest.
* Permit required from county agricultural commissioner for purchase or use.
SALTMARSH CATERPILLAR (4/05)

Scientific Name: Estigmene acrea

DESCRIPTION OF THE PEST
Adult moths are white with orange abdomens and black spots on their wings. Unlike females, the hind wings of male moths are orange. Larvae, or caterpillars, are black with many tufts of long orange, black, and white hairs, and tend to curl up in a ball when disturbed. Very young caterpillars feed in a large, gregarious mass for the first two to three instars before dispersing. Mature caterpillars are almost 2 inches long.

Overwintering mature caterpillars pupate in spring. Emerging moths lay their round, shiny eggs in several rows forming a neat cluster on the undersides of leaves. There are several generations each year.

DAMAGE
When saltmarsh caterpillars first hatch, they remain clustered and feed on the undersides of the leaves where the eggs were laid. They skeletonize the foliage of plants adjacent to the egg mass. As caterpillars grow and disperse, they eat small holes (0.25-0.4 inch diameter) in the leaves. This type of damage is generally of little or no concern, but the caterpillars can also make superficial bites in the fruit, causing losses.

MANAGEMENT
Biological control generally keeps populations of saltmarsh caterpillar low. If late summer populations develop, a spot treatment may adequately control these caterpillars.

Biological Control
Young larvae have a high mortality rate, perhaps from a naturally occurring virus, which helps to limit populations. There are also a number of natural enemies, including parasitic wasps and flies that help to control this pest.

Cultural Control
Caterpillars migrating from adjacent fields or uncultivated areas can be stopped by physical barriers such as a plowed ditch, a ditch of water, or a slippery, vertical aluminum foil fence several inches tall.

Organically Acceptable Methods
Cultural and biological controls, as well as the use of Bacillus thuringiensis sprays, are acceptable for use on organically certified strawberries.

Treatment Decisions
Sprays are best applied while the young caterpillars are still in the gregarious, skeletonizing phase. They are most susceptible to Bacillus thuringiensis at this time. Because populations are localized, spot treatments are recommended.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. BACILLUS THURINGIENSIS ssp. KURSTAKI# (various products)</td>
<td>Label rates</td>
<td>0</td>
</tr>
</tbody>
</table>

COMMENTS: Treat by ground only when caterpillars are small.

+ Preharvest interval. Do not apply within this many days of harvest.
# Acceptable for use on organically grown produce.
SLUGS  (4/05)

**Scientific Names:** Garden slug: *Arion hortensis*
  Little gray slug: *Deroceras reticulatum*
  and other species

**DESCRIPTION OF THE PESTS**
Slugs have no shell, are slimy and have bodies that are flexible in shape. They move by gliding along on a muscular "foot." This muscle constantly secretes mucus, which later dries to form the silvery slime trail that signals the presence of these pests. Slugs can be found on the plant at night and in the early morning, and under the plastic or other mulch during the day. They are sensitive to dryness, and will seek out moisture, making the humid environment under the mulch of strawberries attractive to them.

The garden slug is larger than the little gray slug. It measures about 1 to 1.5 inch in length and is gray to dark brown in color. Living for about one year, the garden slug is sexually mature in about 3 weeks. This slug is sensitive to cold and not many will survive a cold winter.

The little gray slug measures about 0.5-0.75 inches in length and has a mottled gray color. It takes from 3 to 4 months for the little gray slug to reach maturity. This slug is less sensitive to cold than the garden slug and is better able to survive mild winters in high numbers.

Peak egg-laying for both slugs occurs from late September through early November. Most eggs deposited before late October hatch during fall; those deposited in November hatch from late February through spring.

**DAMAGE**
Slugs feed on ripe fruit and produce rough holes that render the fruit unmarketable. These holes may be invaded by a number of secondary pests such as sowbugs, earwigs, and small beetles. Slugs also feed on the leaves of strawberries, and the effects of the rasping feeding are ragged holes in the leaves.

**MANAGEMENT**
Cleaning up debris in fields to make them less hospitable to slugs can help prevent large numbers from developing. If damaging populations of slugs are present, baits can be applied in nonorganic fields.

**Cultural Control**
The elimination of hiding places such as rocks, weeds, logs and boards will assist in reducing the numbers of slugs, because of the removal of habitat. Furthermore, growers can seek to plant away from areas with lots of debris, such as leaves and ground covers.

**Organically Acceptable Methods**
Cultural controls are acceptable for use on organically certified strawberries.

**Treatment Decisions**
Apply baits during fall and spring when slugs are most mobile on the ground surface in search of food and mates. Adverse weather conditions keep the slugs, especially the juveniles, inactive and they do not consume enough bait. The efficacy of metaldehyde baits may also be reduced by cool, wet weather because slugs produce less mucus during these periods.
The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. METALDEHYDE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Deadline) 4% bait</td>
<td>10–20 lb/acre</td>
<td>0</td>
</tr>
<tr>
<td>(Trails End) 3.5% bait</td>
<td>10–20 lb/acre</td>
<td>0</td>
</tr>
<tr>
<td>(Metaldehyde) 4 bait</td>
<td>10–20 lb/acre</td>
<td>6</td>
</tr>
<tr>
<td>COMMENTS: Use higher rate for heavy infestation. This bait has minimal impact on other organisms in the field. Avoid contacting the fruit with bait.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| B. IRON PHOSPHATE        |             |               |
| (Sluggo) G              | 24–44 lb    | 0             |
| COMMENTS: Apply using standard fertilizer granular spreader. If ground is dry, wet it before applying bait. Reapply as bait is consumed or at least every 2 weeks. |

+ Preharvest interval. Do not apply within this many days of harvest.
SPIDER MITES (4/05)

Scientific Names: Twospotted spider mite: *Tetranychus urticae*

Carmine spider mite: *Tetranychus cinnabarinus*

DESCRIPTION OF THE PESTS

Twospotted spider mite eggs are laid on the undersides of leaves and are spherical, clear, and colorless when laid but become pearly white as hatch approaches. Nymphs, adult males, and reproductive adult females are oval shaped and generally yellow or greenish in color. There are one or more dark spots on each side of their bodies, and the top of the abdomen is free of spots. Adult female twospotted spider mites may cease to reproduce during the coldest winter months in production areas of colder inland valleys. Diapause is indicated by a change in color to bright orange. In coastal growing areas it is rare to have a significant proportion of the population undergo diapause. Mating and egglaying typically occur year round in all coastal strawberry-growing regions.

Carmine spider mite, a close relative of the twospotted spider mite, is bright red in color. It is commonly found at low densities in southern California and San Joaquin Valley growing regions. Populations usually decline as temperatures warm in spring.

Take care to correctly identify these mites in the field, particularly in winter. Twospotted spider mites in diapause and carmine mite may be mistaken for the predaceous mite *Phytoseiulus persimilis*. However, the predaceous mite can be distinguished from these two mites by its much faster movement.

DAMAGE

Twospotted spider mite and carmine spider mite damage to strawberries appears as stippling, scarring, and bronzing of the leaves and calyx. Twospotted spider mite feeding is particularly damaging during the first 4 to 5 months following transplanting in late summer or fall, and yield loss is detectable at all mite infestation levels exceeding one mite per leaflet. Mite feeding during this critical period of plant growth substantially reduces berry number per plant and overall plantation yield.

Plants are less sensitive to mite feeding after initial berry set; substantial yield loss results from densities of 15 to 20 mites per mid-tier leaflet at this time. Plants that sustain infestations of greater than 75 mites per leaflet may become severely weakened and appear stunted, dry, and red in coloration. The highest twospotted mite populations are often observed following the peak spring fruit harvest, and this peak is typically followed by a rapid, natural decline in mite density when the plant enters a vegetative growth cycle. Twospotted mite densities may again increase later in summer as fruit production by day-neutral cultivars again increases.

MANAGEMENT

Cultural practices that favor vigorous plants are key to minimizing damage from spider mites. In addition, protect populations of natural enemies as much as possible by choosing insecticides and miticides that are least harmful to beneficials. If necessary, populations of natural enemies can be supplemented with the release of predatory mites. When treating for mites, choose the most selective miticide and alternate it with a miticide of a different chemistry or mode of action to avoid the development of resistance.

Biological Control

Predator mites such as *Phytoseiulus persimilis*, *Galendromus occidentalis*, *Amblyseius californicus*, and *Neoseiulus fallacis* are commercially available for release. Of the commercially available predatory mites, *Phytoseiulus persimilis* is most commonly used for suppressing spider mite populations. It is an aggressive feeder, and it multiplies and spreads rapidly. They will leave the field, however, if spider mite densities become too low to sustain the predator population.

Make predatory mite releases early in the season before spider mite populations begin to build or following winter spider mite treatments intended to reduce overwintering populations. On the central coast, spider mite populations are often first observed in January-February, while further south spider mite infestations may first develop in fall. Applying a short-residual miticide to reduce spider mite
densities before a predator release may improve biological control under some conditions. Monitor fields on a regular basis to determine spider mite population densities.

Following releases of predator mites, it is important to monitor spider mite densities closely to evaluate the effectiveness of the predatory mites in maintaining the pest mites below economically injurious levels. Insecticides, miticides, and fungicides that are not selective will kill the predators. Make releases only after residues are below lethal levels following any pesticide application. Phytoseiulus persimilis has become established in most coastal strawberry-growing areas, and naturally occurring populations often move into spider mite-infested fields on their own. Amblyseius californicus has also been found to naturally infest strawberry plantations in some growing areas and can effectively maintain spider mite densities that are below threshold levels. Another predator mite, Phytoseiulus macropilus, occasionally occurs in strawberries early in spring.

Other natural enemies include minute pirate bug (Orius tristicolor), a small, black lady beetle (Stethorus spp.), a small, black rove beetle (Oligota oviformis), big eyed bugs (Geocoris spp.), brown lacewings (Hemerobius spp.), green lacewings (Chrysopa spp.), sixspotted thrips (Scolothrips sexmaculatus), damsel bugs (Nabis spp.), a cecidomyiid fly maggot (Feltiella acarivora), and a predaceous midge.

Cultural Control

Strawberry cultivars vary in susceptibility to twospotted spider mite infestation and tolerance of twospotted spider mite feeding. When transplanted in fall, short-day cultivars are generally less tolerant of mite feeding than day-neutral cultivars, particularly later in the fruit-production season. When transplanted in summer, short-day cultivars are relatively tolerant of mite feeding.

Vernalization directly promotes plant vigor. Fall transplant, nursery location, preharvest chilling, nursery harvest date, and length of pretransplant supplemental cold storage can all affect a plant’s vernalization. Plants with low amounts of chilling will have low vigor and will often develop intolerable mite infestations. Excessive chilling will promote increased vigor and reduce mite abundance, but other production factors are adversely affected (i.e., delayed flowering, large plant size, increased vegetative runner production). Be sure transplants have received adequate chilling and receive proper irrigation and fertilization.

Other controllable factors that can be used to promote plant vigor are soil preparation and fumigation, use of polyethylene plastic mulch, and proper irrigation to prevent water stress. Road dust control is also important in inhibiting mite infestations. Cultivars and cultural practices vary between production regions. Obtain information on cultivars and cultural practices pertinent to a particular growing region from your University of California County Cooperative Extension office or from cooperatives before making planting decisions.

Organically Acceptable Methods

Cultural and biological controls, including releases of predatory mites, and sprays of rosemary oil or organic stylet oil are acceptable for use on organically certified strawberries.

Miticide Resistance

Twospotted spider mites have a history of rapidly developing resistance to miticides when a miticide is repeatedly applied to the same population. Alternating miticides that have different modes of action may reduce development of resistance to a specific miticide. Avoid unnecessary spraying and treat only infested portions of the plantation. Organophosphate, carbamate, and pyrethroid insecticide applications can induce twospotted spider mite outbreaks. If possible, avoid early-season insecticide applications or apply insecticides that are less disruptive to beneficial arthropods. Careful selection and use of insecticides early in the season can potentially reduce the number of miticide applications.

Monitoring and Treatment Decisions

Vigorous plant growth during the first 4 months following fall transplant is a key factor in strawberry production. Monitor mid-tier leaves during this critical period when mite feeding is extremely
Once harvest begins, strawberries become more tolerant of mite feeding and treatment thresholds increase to an average of 15 to 20 mites per mid-tier leaflet. Treatment thresholds may vary somewhat depending on location, time of season, cultivar, overall plant vigor, yield potential, and the availability of an effective miticide.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bifenazate (Acramite) 50WS</td>
<td>0.75–1 lb</td>
<td>1</td>
</tr>
<tr>
<td>Etoxazole (Zeal)</td>
<td>2-3 oz</td>
<td>1</td>
</tr>
<tr>
<td>Abamectin* (Agri-mek) 0.15EC</td>
<td>16 fl oz</td>
<td>3</td>
</tr>
<tr>
<td>Narrow Range Oil# (Omni Oil) 6E</td>
<td>1–2%</td>
<td>0</td>
</tr>
<tr>
<td>Phytoseiulbus Persimilis#</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies.

A. **Bifenazate** (Acramite) 50WS: 0.75–1 lb. Chemical Class/IRAC Mode of Action: Carboxylic acid ester/25. COMMENTS: Do not make more than 1 application per harvested crop. Two sprays may be made per year if more than 1 crop is harvested each year; minimum period between application is 21 days. A good resistance management strategy is to use bifenazate as the winter spray (if needed) and as a rotational pesticide with abamectin and hexythiazox during the season. It has low toxicity to predatory mites and predatory insects. Bifenazate can be used once per year in strawberry nurseries.

B. **Etoxazole** (Zeal): 2-3 oz. Chemical Class/IRAC Mode of Action: Etoxazole/10B. COMMENTS: A mite growth regulator that is most effective against eggs and immatures. Most effective when applied before populations develop large numbers, but it will eventually control even a large population. Effective against both twospotted and carmine spider mites but not against cyclamen mite. Do not apply more than 3 oz/acre/season.

C. **Abamectin* (Agri-mek) 0.15EC**: 16 fl oz. Chemical Class/IRAC Mode of Action: Microbial/6. COMMENTS: Abamectin is less effective under cold weather conditions than in warm weather because movement into the leaf does not readily occur. Abamectin is most effective when used in paired applications 7–10 days apart when mites reach detectable levels under warmer temperatures in late winter/spring. Repeat the paired applications if necessary to maintain twospotted spider mite control. Do not exceed 16 fluid oz/application or 64 fl oz (4 applications)/acre in a growing season. Do not apply in less than 100 gal water/acre (200 gal/acre is optimal). Do not repeat treatment within 21 days of 2nd application. Abamectin is not registered for strawberry nurseries.

D. **Narrow Range Oil# (Omni Oil) 6E**: 1–2%. COMMENTS: Acceptable for use on organically grown crop only when fruit are not present. Apply in 60 gal water/acre with air-assist, low-volume ground equipment or 200 gal water/acre with standard ground spray equipment. Use this material for low-to-moderate population levels; higher levels of mite infestation require treatment with more effective miticides. Make applications only during winter months when plants are semi-dormant to reduce the risk of phytotoxicity. Do not use oil from peak bloom through fruiting period or when air temperatures are expected to exceed 75°F within several days following application. Do not apply from Jan 16 to May 30 in Orange and San Diego counties or the Oxnard Plains; do not apply from Feb 1 to Jun 15 in the Santa Maria Valley; and do not apply from Mar 1 to Jun 30 in Monterey and Santa Cruz counties.

E. **Phytophthora lus Persimilis#**. COMMENTS: Be sure to wait 4 days after applying a miticide before releasing predaceous mites. If low spider mite populations are present in localized areas, make spot releases. Although research is lacking, experience suggests release rates of an average of 2–3 predators/plant when pest populations are low and an average of 5 predators/plant when the pest mite population is at threshold level. For more widespread infestations early in the season when spider mite populations are low, releases can be made of about 30,000/acre (about 1.5 predatory mite/plant) either as a single, large release or as three smaller releases of 10,000/acre, depending on severity of weather conditions and spider mite population density in the field. Once mite densities increase to threshold levels, inundative releases may reduce twospotted spider mite infestations, but these must be made at release rates exceeding 100,000/acre because once spider mite populations begin to increase, it is difficult for predators to contain their densities below economic thresholds. Follow all releases of predatory mites with close monitoring of the spider mite population.
<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F.</strong> HEXYTHIAZOX* (Savey) 50WP</td>
<td>6 oz</td>
<td>3</td>
</tr>
<tr>
<td>Chemical Class/IRAC Mode of Action: carboxamide/10A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Limited to 1 application/season. Follow label directions for last date material can be applied because this varies by region. Most effective against eggs and nymphs, so best used when mites begin to actively reproduce. Not registered for nurseries.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G.</strong> ACEQUINOCYL (Kanemite) 15 SC</td>
<td>21–31 fl oz</td>
<td>1</td>
</tr>
<tr>
<td>Chemical Class/IRAC Mode of Action: —/—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not use less than 100 gal water/acre and do not apply more than twice/year. Allow a minimum of 21 days between treatments. Crops other than strawberries may not be rotated for at least 1 year following treatment.</td>
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<tr>
<td><strong>H.</strong> ROSEMARY OIL# (Hexacide)</td>
<td>0.75–1 qt</td>
<td>0</td>
</tr>
<tr>
<td>Chemical Class/IRAC Mode of Action: botanical/—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Danger of phytotoxicity when used at higher rates and when temperatures are warm. Do not apply in less than 50 gal water/acre. No residual activity, so repeat applications at 10-day intervals while mite populations are increasing.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I.</strong> FENBUTATIN-OXIDE* (Vendex) 50WP</td>
<td>1.5–2 lb</td>
<td>1</td>
</tr>
<tr>
<td>Chemical Class/IRAC Mode of Action: organotin/12B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Pest resistance to fenbutatin-oxide has been widely reported and persists within a population. Two applications of 1–2 lb/acre can be effective at suppressing twospotted spider mites following an extended period of no use in controlling a given population, but resistance will again become prevalent in the surviving twospotted spider mite population. Fenbutatin-oxide is more effective in warm weather conditions and appears to work in some areas of the Central Valley. Do not apply more than 3 applications per season or more than 9 lb/acre/season.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>J.</strong> STYLET OIL (Organic JMS Stylet Oil)# (JMS Stylet Oil)</td>
<td>72 fl oz in 75 gal</td>
<td>0</td>
</tr>
<tr>
<td>COMMENTS: There is a danger of phytotoxicity when oils are applied incorrectly. Use of ceramic spray nozzles is recommended by the manufacturer. Make applications at a minimum pressure of 400 PSI. Lower pressures lead to larger droplet sizes, increasing the potential for phytotoxicity. Only organic JMS Stylet oil is acceptable for use on organically certified produce.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>K.</strong> DICOFOL (Kelthane) WSP</td>
<td>1–2 lb</td>
<td>3</td>
</tr>
<tr>
<td>Chemical Class/IRAC Mode of Action: —/20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Resistance to dicofol has been widely reported in many twospotted spider mite populations. Recent observations indicate that dicofol can be effective at controlling twospotted spider mites for 1 or 2 applications following an extended period of no use. Because this material is one of the few remaining miticides registered for use on and effective against cyclamen mite, it is best to not apply dicofol for twospotted spider mites and to use it sparingly for cyclamen mite control. Dicofol is toxic to predaceous mites but is relatively nontoxic to beneficial insects.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

— Information not available.
+ Preharvest interval. Do not apply within this many days of harvest.
* Permit required from county agricultural commissioner for purchase or use.
# Acceptable for use on organically grown produce.
1 Modes of action are important in preventing the development of resistance to pesticides. In general, rotate chemicals with different modes of action indexes and do not use products with the same mode of action index more than twice per season. Mode of action index is assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at irac-online.org/.
VINEGAR FLY (4/05)

Scientific Names: Drosophila melanogaster and other species

DESCRIPTION OF THE PESTS
Vinegar flies, also known as fruit or pomace flies, are small, yellowish flies that are commonly attracted to fermenting fruit of all kinds. Populations may build up as the freezer harvest season progresses and temperatures become warmer, especially in southern California. The 0.25 inch long larva can be found in very ripe cull and damaged fruit in the fields. Adults lay 700 to 800 eggs in a life span that ranges from 7 to 8 days in summer to 20 to 30 days at other times. Ideal temperatures for development of this insect are in the low 80°F (27°C to 30°C). The flies do not lay eggs at temperatures below 54°F (12°C) or above 91°F (33°C).

DAMAGE
Vinegar flies are primarily a problem in strawberries picked for freezing. Because this fruit is allowed to ripen in the field to allow easy removal of the calyx and core of the strawberry during picking, the harvest interval is increased and the fruit becomes more susceptible to infestation. Vinegar flies are attracted to very ripe or damaged fruit in the field where they lay their eggs. Eggs and larvae are primarily a contamination problem.

MANAGEMENT
When conditions favor population buildup of vinegar flies, remove as much overripe fruit from the field as possible, or bury it, and follow good sanitation practices in areas around the field. Monitor vinegar flies with sticky traps to help detect infestations as early as possible.

Cultural Control
Limit breeding sites for fruit flies. Make certain that ripe fruit are completely removed from the plants. When possible, shorten harvest intervals as temperatures increase. Practice good sanitation in and around the field. Identify and try to clean up external sources of flies such as cull piles of strawberries or other rotting fruit and nearby citrus groves where old fruit may be on the ground.

Organically Acceptable Methods
Cultural controls, especially field sanitation, and pyrethrin sprays are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions
Although no monitoring or treatment guidelines exist for vinegar flies in strawberries, yellow sticky cards can be used to monitor adult fly populations. Adults and their offspring may also be monitored using fermented fruit traps consisting of a container filled with overripe fruit covered with an inverted funnel. High populations of vinegar flies are found in May and June in southern California, so start checking for flies at the end of April in these areas. It may be possible to treat portions of fields or obvious sources of flies with pyrethrins to control adult flies.

Vinegar fly eggs and larvae in the berries cannot be killed using insecticides. Apply treatments to target adult flies. Adult flies are most active in the early morning and late afternoon; this is also the time they will have greater exposure to an insecticide application. Best time to treat for adults is between 8 and 11 A.M. and between 5 and 7 P.M.
The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. MALATHION 5EC</td>
<td>1.5–3 pt</td>
<td>3</td>
</tr>
<tr>
<td>B. METHOMYL* (Lannate) LV</td>
<td>2–3 pt</td>
<td>3 – fresh</td>
</tr>
<tr>
<td></td>
<td>1 lb</td>
<td>10 – processing</td>
</tr>
<tr>
<td>C. DIAZINON* 50WP</td>
<td>2 lb</td>
<td>5</td>
</tr>
<tr>
<td>D. PYRETHRIN# (PyGanic) 1.4EC</td>
<td>16–64 oz</td>
<td>0</td>
</tr>
<tr>
<td>E. PYRETHRIN / PIPERONYL BUTOXIDE (Pyrenone)</td>
<td>Label rates</td>
<td>0</td>
</tr>
</tbody>
</table>

+ Preharvest interval. Do not apply within this many days of harvest.
* Permit required from county agricultural commissioner for purchase or use.
# Acceptable for use on organically grown produce.
WESTERN FLOWER THRIPS (4/05)

Scientific Name: Frankliniella occidentalis

DESCRIPTION OF THE PEST
Western flower thrips are slender, very small insects, about 0.03 inch long when mature. Adults have feathery wings and vary in color from yellow to dark brown; nymphs are white or yellowish with small dark eyes. In spring, flower thrips populations build up on alfalfa, weeds, ice plant, and other vegetation and move from these hosts when they are cut, stop flowering, or dry up.

Strawberry plantations often have a mixed population of thrips that includes a low percentage of the onion thrips, Thrips tabaci.

DAMAGE
Thrips feeding on strawberry blossoms causes the stigmas and anthers to turn brown and wither prematurely, but not before fertilization has occurred. Although often numerous on berries when cat-facing occurs, western flower thrips do not cause cat-facing, which is a result of lygus bug feeding and possibly other factors. As fruit develops, thrips feeding may cause a russetting (Type I bronzing) of the fruit around the cap, but this injury is seldom economic. (Other types of bronzing are associated with phytotoxicity from sulfur and other types of sprays (Type II) and from plant physiological factors (Type III). The most severe bronzing that covers the entire fruit is believed to have a physiological cause that is associated with hot temperatures occurring from May through July.)

MANAGEMENT
Populations of the western flower thrips build up on a number of crops and weeds. They may migrate into strawberries when other crops are harvested, when second-year strawberries or other perennial hosts stop flowering, or when weeds dry up in spring. Control is not usually necessary because western flower thrips rarely cause economic damage at densities that typically occur in strawberry fields. Sprays applied to control thrips disrupt biological control of other pests such as twospotted spider mites, lygus bugs, whiteflies, and other insects. In addition, because western flower thrips feed on spider mite eggs, at low populations levels they can be beneficial. If treatment is necessary, choose the least disruptive insecticide to preserve biological controls agents.

Biological Control
Naturally occurring minute pirate bugs (Orius spp.) feed on thrips. Orius are also available commercially, but release rates and timing have not been determined.

Organically Acceptable Methods
Sprays of the Entrust formulation of spinosad are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions
Consider treating only if populations reach 10 thrips per blossom when flowers are shaken onto a flat surface and thrips counted. A better way to sample thrips is to place randomly collected flower blossoms into a glass container with several drops of either ethyl acetate or methyl isobutyl ketone (or with a small amount of either of these materials soaked into cotton or other absorbent material). After at least one-half hour, count the thrips by removing the blossoms and shaking them onto black paper. Because more thrips will be found with this method, the treatment threshold is greater than that indicated for shaking flowers.
The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies.

<table>
<thead>
<tr>
<th>Material</th>
<th>Amount/Acre</th>
<th>P.H.I.+</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPINOSAD (Entrust)#</td>
<td>1.25–1.5 oz</td>
<td>1</td>
</tr>
<tr>
<td>SPINOSAD (Success)</td>
<td>6 fl oz</td>
<td>1</td>
</tr>
<tr>
<td>METHOMYL*</td>
<td>1 lb</td>
<td>3 – fresh</td>
</tr>
<tr>
<td>METHOMYL* (Lannate SP)</td>
<td>3 pt</td>
<td>10 – processing</td>
</tr>
<tr>
<td>NALED (Dibrom) 8EC</td>
<td>1 pt</td>
<td>1</td>
</tr>
<tr>
<td>MALATHION 5EC</td>
<td>2–3 pt</td>
<td>3</td>
</tr>
<tr>
<td>MALATHION 8E</td>
<td>1.5–2 pt</td>
<td>3</td>
</tr>
<tr>
<td>PYRETHRIN/PIPERONYL BUTOXIDE (Pyrenone)</td>
<td>Label rates</td>
<td>0</td>
</tr>
<tr>
<td>PYRETHRIN# (PyGanic) 1.4EC</td>
<td>16–64 oz</td>
<td>0</td>
</tr>
</tbody>
</table>

**COMMENTS:**
- Rotate to an insecticide with a different mode of action after two successive applications. Can be toxic to some natural enemies (e.g. predatory mites, syrphid fly larvae) when sprayed and shortly thereafter (8-24 hours).
- Very disruptive to beneficials so use only when thrips densities are very high. Do not apply more than 4.5 lb a.i./acre/crop, or more than 10 applications per year.
- Do not use when temperature exceeds 85°F.
- Residual activity only about 1 week.
- Variable efficacy. Not as disruptive of natural enemies as some other options.
- Has a restricted-entry interval of 12 hours. Apply in sufficient water for thorough coverage.

+ Preharvest interval. Do not apply within this many days of harvest.
# Acceptable for use on organically grown produce.
* Permit required from county agricultural commissioner for purchase or use.
WHITEFLIES (5/05)

Scientific Names: Greenhouse whitefly: *Trialeurodes vaporariorum*
Iris whitefly: *Aleyrodes spiroeoides*
Strawberry whitefly: *Trialeurodes packardi*

DESCRIPTION OF THE PESTS
Populations of iris whiteflies and, to a lesser extent, strawberry whiteflies have always been present in low numbers in strawberry fields in California. These species are usually kept below damaging levels by naturally occurring beneficial insects. In recent years, however, a third species, the greenhouse whitefly, has become a major pest in certain areas on the Central Coast and in southern California. The greenhouse whitefly has a large host range including alfalfa, avocados, beans, blackberries and other berries, cucumbers, eggplants, grapes, lettuce, melons, peas, peppers, potatoes, tomatoes, and many ornamentals, and these alternate hosts serve as sources for whiteflies that enter strawberry fields.

Whiteflies go through six stages in their development: eggs; first, second, third, and fourth instar immatures; and the adult. Eggs are microscopic and laid on the underside of leaves. Whiteflies do not have a true pupal stage, but the last part of the fourth instar, when the red eyes of the adult whitefly begin to appear, is often referred to as the “pupa.” Only adults and the newly hatched nymphs (i.e., crawlers) are mobile. Greenhouse whiteflies tend to build up in fall, reaching peak densities in late fall through winter in central coast plantings. In warm weather, whiteflies can complete a generation in as little as 18 days.

Whiteflies are easy to distinguish from other insect pests: adults of all species are about 0.01 inch in size with four membranous wings that are coated with white powdery wax. Whitefly species are most reliably identified from each other by examining the late fourth instar or red-eyed “pupal” stage. The greenhouse whitefly has long, waxy filaments around the margins in this stage. When seen from the side, the greenhouse whitefly “pupae” are circular with flat tops, with the filaments emerging from the tops. Adult greenhouse whiteflies are solid white and hold their wings parallel (flat) to the top of the body. Both adults and nymphs look similar to the strawberry whitefly, but the strawberry whitefly nymphs never have the long filaments often found on the greenhouse whitefly “pupae.” Iris whitefly “pupae” also lack long filaments but have short waxy ones around their bodies. Iris whitefly adults hold their wings flat over their backs and have a dot on each wing.

DAMAGE
Whiteflies may reduce crop yields directly through their feeding on leaf tissue, which removes plant sap, stunts plant growth, and decreases sugars in fruit. They also produce sticky honeydew that they excrete during feeding. The honeydew may cover plants and support the growth of black sooty mold fungus. Greenhouse whitefly can also transmit diseases and is known to vector pallidosis-related decline of strawberry in California.

MANAGEMENT
Successful management of greenhouse whiteflies requires an integrated program that focuses on prevention and relies on cultural and biological control methods when possible. Treatments are often necessary if strawberries are grown so that continuous plantings are present in areas where greenhouse whiteflies have become established (summer plantings or second-year plantings adjacent to new plantings), if whitefly biological controls are disrupted by the use of a nonselective pesticide, or if adult whiteflies invade the strawberry plantations from adjacent crop hosts or from backyards. No precise treatment threshold has yet been developed for greenhouse whiteflies on strawberries, but even feeding at relatively low densities after transplanting can result in yield loss. Treatment may be necessary when honeydew or moderate to heavy whitefly populations are apparent during periods of warmer weather for summer- and fall-planted berries. Select treatments carefully and use them only when monitoring indicates a need.
Biological Control
In most crops, greenhouse whiteflies and iris whiteflies are generally kept under control by naturally occurring parasitic wasps and general predators. Their natural enemies include parasitic wasps of the genera Encarsia, Eretmocerus, and Prospaltella, bigeyed bugs, pirate bugs, and lacewing larvae. In summer, in certain areas on the Central Coast and in Ventura County, 30 to 40% of greenhouse whiteflies are parasitized by native parasites.

Encarsia formosa is used worldwide for greenhouse whitefly suppression in greenhouses, but more research is necessary to determine if the release of this or other parasites can be helpful in preventing whiteflies from increasing in numbers.

Cultural Control
For summer-planted strawberries, the practice of topping in spring helps to reduce overwintering immature populations. Monitor whiteflies on adjacent hosts and initiate control there, if possible, before these crops are harvested to prevent the whiteflies from moving to strawberries. Minimizing dust by keeping field roads watered or oiled allows biological control to work effectively.

The source of infestation for new plantings on the central coast appears to be adjacent strawberry fields that are being maintained for a second year of berry production. It is important that berries being held for a second year are monitored beyond the last day of harvest. If whitefly populations are observed, the plants need to be treated to protect new plantings in adjacent areas. Early pruning may be beneficial to reduce source populations. When berries are pruned it is important that the discarded material is removed from the field. It may not be economically feasible to maintain second-year plantings when severe infestations have been experienced in new plantings in previous years.

Organically Acceptable Methods
Preserving naturally occurring biological control agents, cultural controls, sprays of narrow range oil, azadirachtin (Neemix), and insecticidal soaps, and releases of Encarsia formosa into hot spots against low-to-moderate populations of greenhouse whitefly are acceptable for use on organically certified strawberries.

Monitoring and Treatment Decisions
There are two monitoring methods for whiteflies: yellow sticky traps and leaf counts. Sticky cards are useful for detection of whitefly infestation and determining relative infestation levels, but the number of whiteflies may not correlate closely with the number of immature whiteflies on leaves. Back up sticky trap counts by inspecting strawberry foliage throughout the field on a weekly basis. Place one yellow sticky trap every ten acres and next to field edges to catch adult whiteflies as they move into the strawberry fields. Put the sticky cards vertically on stakes, just above the crop canopy. Count the number of adults trapped on each card weekly and record counts to track population numbers. Replace sticky cards as necessary.

Monitor plants by counting the number of adults on 20 midtier leaflets in each quarter of a field and determine the average number. Also examine nymphs to determine what proportion of the nymphs are black, indicating they are parasitized.

When monitoring indicates that adult populations are increasing rapidly and nymphs that are detected on leaves have no indication of parasitism (i.e., are not black in color), begin treatments with products that control adult whiteflies. Insecticides (except imidacloprid), oils, and soaps are most effective against adults and early instar whiteflies but not against eggs. Very few materials are effective against the fourth instar “pupal stage.” Try to time treatments when monitoring indicates that most of the population is in the adult and first-, second-, or third-instar stage.

If there is high risk of new plantings from nearby summer plantings or second-year fields that already have whiteflies, consider a preventative application of imidacloprid (Admire) at planting by injection into the planting hole or through the drip system. If application is through drip irrigation, it is best to
preirrigate to make sure that the soil profile is well watered, then apply enough water to move the material into the root zone. Imidacloprid (Admire) must be taken up by the plant to be effective.

Good coverage of the underside of leaves is essential for effective use of insecticides against whiteflies, but dosage applied is also important. When treating whiteflies, use lower volumes of water than would normally be used against pests like spider mites and drive the sprayer more slowly over the field if possible. An air-assist sprayer might help. More than one application may be required for heavy populations or if monitoring indicates that populations are continuing to increase. Rotating between chemical classes when making multiple applications is recommended to reduce the development of resistance.

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount/Acre</th>
<th>P.H.I.+</th>
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<tbody>
<tr>
<td>(trade name)</td>
<td>(days)</td>
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</table>

A. **IMIDACLOPRID**
   (Admire) 2F
   
   **COMMENTS:** A neonicotinoid insecticide. Best used as a preventive treatment. Can be applied through drip lines; see label for restrictions. When applying through drip, preirrigate so soil is moist. This material must move into the root zone and be taken up by the plants to be effective, so sufficient water must be applied to promote its movement through the soil. Only one application/year but has a long residual activity; more moves into plant with each irrigation.

B. **FENPROPATHRIN**
   (Danitol) 2.4EC
   **PLUS...**
   DIAZINON* 50WP
   
   **COMMENTS:** Fenpropathrin is a pyrethroid and diazinon is an organophosphate. Use of fenpropathrin is limited to 2 applications/year and multiple applications of pyrethroids can lead to resistance in target populations, so use the material only when population levels warrant its use. Applications made early in the season can lead to severe mite outbreaks later on. Diazinon has been found in surface waters at levels that violate federal and state water quality standards; avoid runoff into surface waters or choose alternative materials.

C. **PYRIPROXYFEN**
   (Esteem) 0.86EC
   
   **COMMENTS:** Check with your county agricultural commissioner about use of this material under a Section 18 registration. Apply after an application of imidacloprid (Admire) and when whitefly populations just begin to increase. Control of adult whitefly populations will take about 2-3 weeks following application so apply before populations build.

D. **METHOMYL**
   (Lannate SP)
   
   **COMMENTS:** A carbamate insecticide. Do not apply more than 4.5 lb a.i./acre/crop

E. **ENDOSULFAN**
   (Thionex) 3EC
   
   **COMMENTS:** An organochlorine insecticide. Use of this material may not be allowed in some counties; cannot be applied in any situation where run-off may occur. Consult county agricultural commissioner for restrictions. Do not reapply within 35 days. Do not make more than 3 applications/year or exceed 3 lb a.i./acre/year.

F. **NARROW RANGE OIL**
   (Omni Oil) 6E
   
   **COMMENTS:** Apply in 60 gal water/acre with air-assist, low-volume ground equipment or 200 gal water/acre. Moderately effective against low to moderate populations when coverage is excellent. Make applications only during winter months when plants are semi-dormant to reduce the risk of phytotoxicity. Do not use oil from peak bloom through fruiting period or when air temperatures are expected to exceed 75°F within several days following application. Do not apply from Jan 16 to May 30 in Orange and San Diego counties or the Oxnard Plains; do not apply from Feb 1 to June 15 in the Santa Maria Valley, and do not apply from Mar 1 to Jun 30 in Monterey and Santa Cruz counties.
| Common name | Amount/Acre | P.H.I.+
<table>
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<th></th>
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</thead>
<tbody>
<tr>
<td>(trade name)</td>
<td>(days)</td>
<td></td>
</tr>
<tr>
<td>G. INSECTICIDAL SOAP#</td>
<td>2.5 oz/gal water</td>
<td>0</td>
</tr>
<tr>
<td>(M-Pede)</td>
<td></td>
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</tbody>
</table>

**COMMENTS:** Do not exceed 1 application/month or 2/season. Can burn plants so apply only when temperatures are cool. Moderately effective against nymphs only. Requires excellent coverage.

+ Preharvest interval. Do not apply within this many days of harvest.
# Acceptable for use on organically grown produce.
* Permit required from county agricultural commissioner for purchase or use.
Diseases

ANGULAR LEAF SPOT (4/05)
Pathogen: *Xanthomonas fragariae*

SYMPTOMS
Infection first appears as minute, water-soaked spots on the lower surface of leaves. The lesions enlarge to form translucent, angular spots that are delineated by small veins and often exude a viscous ooze of bacteria and bacterial exudates, which appears as a whitish and scaly film after drying. As the disease progresses, lesions coalesce and reddish brown spots, which later become necrotic, appear on the upper surface of the leaves. A chlorotic halo usually surrounds the infected area.

COMMENTS ON THE DISEASE
This bacterium is not free living in soil. It can, however, overwinter in soil on previously infected plant material. Transmission is by splashing water. It is host-specific and highly resistant to degradation—it can persist in the soil for long periods of time. It is killed by methyl bromide/chloropicrin mixture used as a preplant fumigant, so it is very likely that most initial infections in fields that have been fumigated originate from contaminated plants. Lesions on the leaf surface serve as a source for secondary inoculum and cells are dispersed by splashing rain or overhead irrigation. The disease is favored by cool, moist days with cold nights near freezing.

*Xanthomonas fragariae* can cause vascular collapse, although this is uncommon in California. This symptom initially appears as a water-soaked area at the base of newly emerged leaves. Shortly after, the whole plant suddenly dies, much like plants infected with crown rot. *Xanthomonas fragariae* is also associated with strawberry blossom blight in California.

Angular leaf spot generally has a minor impact on fruit yields in California. However, it is a concern at strawberry nurseries, which may be subject to quarantine regulations for angular leaf spot on nursery stock for export.

MANAGEMENT
Angular leaf spot is kept to a minimum by using certified planting materials. Chemical controls are typically ineffective against this pathogen. Copper-containing compounds are registered but have caused phytotoxicity with repeated applications. Rotate crops to avoid infesting fields, and avoid overhead irrigation when possible.

Organically Acceptable Methods
Using certified planting materials and rotating crops are acceptable management strategies for use in an organically grown crop.
**ANTHRACNOSE**  (5/05)

**Pathogen:** Colletotrichum acutatum

**SYMPTOMS**
The most obvious symptom of anthracnose in the field may be the wilting and collapse of plants, but stem lesions or characteristic crown symptoms usually precede the collapse of affected plants. Stem lesions appear as dark brown or black lens-shaped spots on petioles and runners. Under warm, humid conditions, salmon-colored masses of spores may form on lesions.

When crown tissue is infected and becomes decayed, the entire plant may wilt and die. Like Phytophthora crown rot, the internal crown tissue is discolored, but stem and foliage lesions are not produced by Phytophthora sp.

Fruit decay caused by anthracnose is common in production areas. If infected plants are present, decay can develop following periods of warm, rainy weather. Fruit at any stage of ripeness can be affected. Small, sunken, oval-to-round brown spots develop and may expand to cover most or all of the fruit surface. Under high humidity, salmon or orange-colored spores commonly occur on the lesions. Decayed tissue is firm and dry.

**COMMENTS ON THE DISEASE**
The pathogen that causes anthracnose can survive in soil for at least 9 months without host plants. In addition to strawberry, several weeds are known to host this pathogen including chickweed, fiddleneck, and vetch. If strawberries are planted in infested soil, they become infected when soil containing spores is splashed onto crowns or stems by rain or irrigation water. In fields that have been fumigated, the disease usually originates on infected nursery stock. In addition, inoculum can come from contaminated soil on field equipment or be blown in from nearby weeds.

**MANAGEMENT**
Soil fumigation destroys most soil inoculum of Colletotrichum. In warm, inland fields where fumigation is not desirable, soil solarization can be effective in destroying inoculum. Hot water treatments can be used to eliminate most inoculum from infected transplants that are to be planted in nurseries but is not recommended for transplants going into fruit production areas. Follow good cultural procedures to prevent disease inoculum from entering the field, and rotate to nonhost crops where fumigation and solarization is not feasible. Fungicide dips can be used on transplants before planting in production fields. Foliar fungicides are available for use on plants when the disease is present and conditions are ideal for disease development.

**Cultural Control**
Using drip or furrow irrigation and clean planting stock are important components of managing this disease. Thoroughly washing all soil from plants before planting has been shown to significantly reduce disease of crowns and fruit. Clean field equipment before using it in a field to ensure that contaminated soil and plant parts are not transported into a field or from an infested part of the field to a noninfested section. Crop rotation with a nonhost crop can also help in reducing levels of this pathogen in the soil. Also important is good weed management in and around the field to destroy any weeds that may harbor the pathogen.

**Soil Solarization**
In warmer areas of the state, solarization has been shown to be effective for the control of soilborne pathogens and weeds. Solarization is carried out after the beds are formed and can be effective if weather conditions are ideal (30-45 days of hot weather that promotes soil temperatures of at least 122°F). The effectiveness of solarization can be increased by solarizing after incorporating the residue of a cruciferous crop, in particular broccoli or mustards, into the soil or following an application of metam sodium (40 gal/acre). For more details on how to effectively solarize soil, see Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds, UC ANR Publication 21377.
Organically Acceptable Methods
Cultural controls, including soil solarization, washing soil from crowns before planting, and crop rotation, are acceptable for use in an organically grown crop.

Monitoring and Treatment Decisions
If drip fumigation is planned, good results have been obtained with a sequential application of chloropicrin (200 lb/acre) or 1,3-dichloropropene/chloropicrin (300 lb/acre) followed 7 days later with metam sodium (45 gal/acre) or metam potassium (37 gal/acre).

At planting, fungicide dips can be used on transplants before planting in production fields.

During the growing season, watch for anthracnose symptoms during routine monitoring for spider mites and other pests. Pay close attention to developing fruit on day-neutral cultivars. If fruit disease appears in a small area of the field or before the plant canopy is well developed, foliar fungicides may help prevent further spread of the disease and reduce crown infections. Thorough coverage of the fruit is important.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount/Acre**</th>
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<tbody>
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<td>(trade name)</td>
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</table>

**PREPLANT FUMIGATION**

Sequential application of

- **A. 1,3-DICHLOROPROPENE*/CHLOROPICRIN* (Telone C35)**
  - 9-12 gal (shank)
  - COMMENTS: Effective for control of nematodes, soilborne fungal pathogens, and insects. One gallon of product weighs 11.1 lb.

  …or…

- **1,3-DICHLOROPROPENE*/CHLOROPICRIN* (InLine)**
  - 28-33 gal (drip)
  - COMMENTS: Effective for control of nematodes, soilborne fungal pathogens, and insects. Requires plastic mulch. Using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. One gallon of product weighs 11.2 lb.

  …or…

- **CHLOROPICRIN* (MetaPicrin)**
  - 15-30 gal (shank)
  - **(Tri-Clor)**
  - 15-22 gal (drip)
  - COMMENTS: A liquid that diffuses as a gas through soil. Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. For drip fumigation the use of VIF will improve both nematode and weed control. One gallon of product weighs 13.7 lb.

  Followed 5-7 days later by

- **METAM SODIUM* (Vapam HL, Sectagon 42)**
  - 37.5-75 gal

  …or…

- **METAM POTASSIUM* (K-Pam HL)**
  - 30-60 gal
  - COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.

**AT PLANTING**

- **A. AZOXYSTROBIN (Abound)**
  - 5-8 oz/100 gal
  - COMMENTS: Dip plants for 2-5 minutes and plant as quickly as possible. Most effective if transplants are washed to remove excess soil before dipping.
**FOLIAR FUNGICIDES**

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount/Acre**</th>
</tr>
</thead>
<tbody>
<tr>
<td>(trade name)</td>
<td></td>
</tr>
</tbody>
</table>

A. **CAPTAN 50WP**
   
   **COMMENTS:** Do not apply in combination with, immediately before, or closely following oil sprays.

B. **AZOXYSTROBIN**
   (Abound)
   
   **COMMENTS:** Do not apply more than 2 consecutive foliar applications before switching to alternative chemistry. Do not apply more than 1 lb a.i./acre/season.

C. **CYPRODINIL/FLUDIOXONIL**
   (Switch) 62.5WG
   
   **COMMENTS:** Do not apply more than 2 consecutive applications. Do not exceed 56 oz of product/acre/year.

** Apply all materials in 200 gal water/acre to ensure adequate coverage.

* Permit required from county agricultural commissioner for purchase or use.
BOTRYTIS FRUIT ROT (4/05)
Pathogen: Botrytis cinerea

SYMPTOMS
The fungus that causes Botrytis fruit rot, also known as gray mold, is widespread in the environment. It can infect strawberry flowers when spores landing on them are exposed to free water and cool temperatures. Infections can either cause flowers to rot or Botrytis can become dormant in floral tissues. Dormant infections resume activity on the berry later in the season anytime before or after harvest when sugars increase and conditions become favorable to disease development.

Infections first appear as small brown lesions under the calyx. Lesions begin to sporulate within a day after resumption of activity, and spore structures appear under the calyx as tiny stalks with clusters of spores at their tips. Lesion size increases rapidly. Both green and red berries are susceptible, but ripening berries rot faster. Infected berries maintain their original shape and take on a velvety, gray-brown coat of mycelium and spores. Initially, rotted areas are soft and mushy, becoming leathery and dry in the absence of high humidity. Millions of spores are produced on each berry and become airborne at the slightest touch or breeze.

Direct infection of the berries also occurs if berries are exposed to free water. These infections develop in the same manner as flower-infected berries, but differ in that multiple initial lesions may appear anywhere on the berry’s surface. Green berries tend to be more resistant than those that are softer and higher in sugar content.

COMMENTS ON THE DISEASE
During the growing season, the fungus is constantly present and is often found in new plantings. Nothing can be done to escape the presence of this fungus, but the level of inoculum in a particular field can be reduced by removing dead leaves and infected fruit. After harvest, the fungus survives in the soil as small, black, inactive sclerotia on tilled-in leaves and fruit. In addition, the fungus lives on decomposing, dead organic matter of many plant species in and around the growing area.

MANAGEMENT
Presently, control of Botrytis fruit rot ranges from repetitive fungicide treatments with no cultural control to intensive cultural methods with no fungicide applications. Environmental conditions in various microclimates play an important role in determining control strategies.

Cultural Control
Remove and destroy dead or infected plant material to help reduce the amount of inoculum capable of producing new infections. Also, remove all ripe fruit during harvest as well as any fruit with signs of decay or rain damage. Use of plastic mulches prevents berry-soil contact, thus reducing disease.

In addition, some cultivars have flowers and fruit that develop with an upright stature, which allows fruit to be exposed to better air movement and sunlight and reduces the risk of infection. Look for cultivars that have this and other advantages.

Organically Acceptable Methods
Select fields that are isolated from conventional growing areas and have environmental conditions that are not conducive to disease development. Use mulches that provide optimum air circulation; use varieties that are suited to the growing area; and remove all fruit after spring and summer rains and all plant residue after harvest.

Monitoring and Treatment Decisions
In areas without heavy coastal summer fog, inoculum levels may be low enough in clean fields that early sprays in spring can be omitted. In dry areas, the humidity seldom gets high enough to cause epidemics and some growers are finding it possible to grow berries without fungicides when strict
sanitation practices are adhered to. In humid areas, inoculum density and environmental conditions conducive to disease development (i.e., rain, fog, and cool temperatures) should always determine when to apply fungicides. Because these conditions are usually seasonal, use a protective fungicide to prevent germination of spores when conditions ideal for disease development are anticipated. Thereafter, set spray schedules according to disease pressure and environmental conditions.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount/Acre**</th>
<th>P.H.I.+</th>
</tr>
</thead>
<tbody>
<tr>
<td>(trade name)</td>
<td>(days)</td>
<td></td>
</tr>
<tr>
<td>A. IPRODIONE</td>
<td>1.5 lb</td>
<td></td>
</tr>
<tr>
<td>(Rovral) 4F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: A dicarboximide fungicide. Do not make more than 1 application/season to reduce the likelihood of resistance development. Do not apply after first fruiting flower.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. THIRAM</td>
<td>Label rates</td>
<td>3</td>
</tr>
<tr>
<td>COMMENTS: A carbamate (DMDC) fungicide. Good coverage of buds, blossoms, and fruits required for best results.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. CAPTAN 50WP</td>
<td>4 lb</td>
<td></td>
</tr>
<tr>
<td>COMMENTS: A phthalamide fungicide. Restricted entry interval: 1 day. Do not apply in combination with, immediately before, or closely following oil sprays. Do not apply more than 48 lb/year.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. THIOPHANATE-METHYL</td>
<td>0.75–1.0 lb</td>
<td>1</td>
</tr>
<tr>
<td>(Topsin-M)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: A benzimidazole fungicide. Tank mix with fungicide of different chemistry to reduce resistance problems. Do not apply more than 4 lb/acre/year.</td>
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<td></td>
</tr>
<tr>
<td>E. FENHEXAMID</td>
<td>1.5 lb</td>
<td>0</td>
</tr>
<tr>
<td>(Elevate) 50WDG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: A hydroxyanilide fungicide. Begin applications at early bloom before disease development begins; continue applications at 7- to 10-day intervals when conditions favor disease development but do not make more than 2 consecutive applications before alternating with a fungicide of a different chemistry for at least 2 applications. May be applied alone, or under light to moderate disease pressure it can be tank mixed at a rate of 1–1.5 lb/acre. Do not exceed 6 lb/acre/season.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. CYPRODINIL/FLUDIOXONIL</td>
<td>11–14 oz</td>
<td>0</td>
</tr>
<tr>
<td>(Switch) 62.5WG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Cyprodinil is an anilinopyrimidine fungicide and fludioxonil is a phenylpyrrole fungicide. Begin applications at or before bloom and continue on a 7- to 10-day interval as long as conditions favor disease development. Do not plant rotational crops other than strawberries or onions for 12 months following last application and do not exceed 56 oz/acre/year.</td>
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<td></td>
</tr>
<tr>
<td>G. PYRACLOSTROBIN/BOSCALID</td>
<td>18.5–23 oz</td>
<td>0</td>
</tr>
<tr>
<td>(Pristine)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Pyraclostrobin is a strobilurin and boscalid is a carboxanilide fungicide. Begin applications at bloom and alternate with cyprodinil/fludioxonil (Switch) or fenhexamid (Elevate).</td>
<td></td>
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</tbody>
</table>

** Apply all materials in 200 gal water/acre to ensure adequate coverage.
+ Preharvest interval. Do not apply within this many days of harvest.
COMMON LEAF SPOT (5/05)

Pathogen: *Ramularia tulasneii*

**SYMPTOMS**
Common leaf spot first appears as small, deep purple spots on the upper surface of leaves. Spots enlarge to 3 to 6 mm in diameter with the center portion of the lesion turning brown then gray to white, depending on the age of the leaf and environmental conditions. Numerous spots may coalesce to kill the leaf.

On petioles, stolons, calyces, and fruit trusses, elongated sunken lesions may form and interfere with water transport in the plant, weaken the structure, or allow invasion by secondary organisms.

**COMMENTS ON THE DISEASE**
Common leaf spot is the most important of the strawberry leaf spot diseases in California. The pathogen is introduced into fruit production fields as small, black sclerotia on infected nursery material. Germination of sclerotia is initiated by fall and winter rains or sprinkler irrigation. Spores are dispersed by wind-driven rain.

**MANAGEMENT**
Taking steps to reduce inoculum in soil and on planting stock greatly reduces the likelihood of disease development. Soil fumigation destroys most *Ramularia* in the strawberry planting bed. Solarization of formed beds may be effective in areas where adequate heating can be obtained. Hot water treatment can be used for transplants to be planted in nurseries. Foliar fungicides can be used to limit the spread of leaf spot in the field. To reduce the likelihood of resistance building up, use fungicides only when monitoring indicates they are necessary.

**Cultural Control**
Use resistant cultivars and drip irrigation, remove infected leaves when practical, and be sure planting stock is clean. Choose a growing area with environmental conditions that are not conducive to disease development.

**Soil Solarization**
In warmer areas of the state, solarization has been shown to be effective for the control of soilborne pathogens and weeds. Solarization is carried out after the beds are formed and can be effective if weather conditions are ideal (30-45 days of hot weather that promotes soil temperatures of at least 122°F). The effectiveness of solarization can be increased by solarizing after incorporating the residue of a cruciferous crop, in particular broccoli or mustards, into the soil or following an application of metam sodium (40 gal/acre). For more details on how to effectively solarize soil, see *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds*, UC ANR Publication 21377.

**Organically Acceptable Methods**
Cultural controls, including soil solarization, are acceptable for use on an organically certified crop.

**Treatment Decisions**
Fumigate soil before planting to kill overwintering sclerotia. If drip fumigation is planned, good results have been obtained with a sequential application of chloropicrin (200 lb/acre) or 1,3-dichloropropene/chloropicrin (300 lb/acre) followed 7 days later with metam sodium (45 gal/acre) or metam potassium (37 gal/acre). During the growing season, apply protective fungicides before the anticipated arrival of warm, damp weather.
PREPLANT FUMIGATION
Sequential application of

A. 1,3-DICHLOROPROPENE*/CHLOROPICRIN*<br>   (Telone C35)  9–12 gal (shank)<br>   COMMENTS: Effective for control of nematodes, soilborne fungal pathogens, and insects. One gallon of product weighs 11.1 lb.<br>   …or…<br>   1,3-DICHLOROPROPENE*/CHLOROPICRIN*<br>   (InLine)  28–33 gal (drip)<br>   COMMENTS: Effective for control of nematodes, soilborne fungal pathogens, and insects. Requires plastic mulch. Using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. One gallon of product weighs 11.2 lb.<br>   …or…<br>   CHLOROPICRIN*<br>   (Tri-Clor, MetaPicrin)  15-30 gal (shank)  15-22 gal (drip)<br>   COMMENTS: A liquid that diffuses as a gas through soil. Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. One gallon of product weighs 13.7 lb.<br>

Followed 5-7 days later by<br>METAM SODIUM*<br>   (Vapam HL, Sectagon 42)  37.5–75 gal<br>   COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 4.26 lb of metam sodium.<br>   …or…<br>METAM POTASSIUM*<br>   (K-Pam HL)  30–60 gal<br>   COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.

GROWING SEASON
A. MYCLOBUTANIL<br>   (Rally)  40W  2.5–5 oz  0<br>   COMMENTS: Apply in a minimum of 50 gal water/acre. Do not apply more than 30 oz/acre/year.

** Apply all materials in 200 gal water/acre to ensure adequate coverage.<br>+ Preharvest interval. Do not apply within this many days of harvest.<br>* Permit required from county agricultural commissioner for purchase or use.
LEATHER ROT  (5/05)
Pathogen: Phytophthora cactorum

SYMPTOMS
All stages of fruit are susceptible to leather rot. Infected fruit develop diseased areas that are brown to shades of purple in color. The decay often expands throughout the fruit, resulting in a brown, leathery berry. The external infected area becomes tough while the internal tissue is somewhat softer. The central hollow cavity of the fruit may contain the white mycelium of the pathogen, and the fruit tastes bitter.

COMMENTS ON THE DISEASE
The leather rot pathogen requires splashing rain to transport the zoospores (motile spores) to the fruit, or in very wet conditions (i.e., standing water or pools of water on beds) the zoospores can swim to the plant.

MANAGEMENT
Leather rot is not common on annual plantings of strawberries in California because it is usually controlled by preplant fumigation and plastic mulches. Cultural practices play an important role in disease prevention; soil solarization may also provide control. Plantings held for 2 or 3 years, however, could be infected by the leather rot pathogen.

Cultural Control
Ensure that fields are prepared so that they have adequate water drainage. Remove diseased fruit and use plastic mulches. Avoid overhead irrigation; use drip irrigation. Straw mulch has been effective in controlling this disease in the eastern United States.

Soil Solarization
In warmer areas of the state, solarization has been shown to be effective for the control of soilborne pathogens and weeds. Solarization is carried out after the beds are formed and can be effective if weather conditions are ideal (30-45 days of hot weather that promotes soil temperatures of at least 122°F). The effectiveness of solarization can be increased by solarizing after incorporating the residue of a cruciferous crop, in particular broccoli or mustards, into the soil or following an application of metam sodium (40 gal/acre). For more details on how to effectively solarize soil, see Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds, UC ANR Publication 21377.

Organically Acceptable Methods
Field sanitation, proper irrigation, soil solarization, and mulches are acceptable management tools in an organically certified crop.

Treatment Decisions
If drip fumigation is planned, good results have been obtained with a sequential application of chloropicrin (200 lb/acre) or 1,3-dichloropropene/chloropicrin (300 lb/acre) followed 7 days later with metam sodium (45 gal/acre) or metam potassium (37 gal/acre). During the growing season, research data from the eastern United States indicate that mefenoxam (Ridomil Gold) and fosetyl-aluminum are effective in controlling this disease. Treat before the advent of splashing rains or very damp conditions.
Common name (trade name)  Amount/Acre**

**PREPLANT FUMIGATION**

*Sequential application of*

A. 1,3-DICHLOROPROPENE* / CHLOROPICRIN*
   (Telone C35) 9-12 gal (shank)
   **COMMENTS:** Effective for control of nematodes, soilborne fungal pathogens, and insects. One gallon of product weighs 11.1 lb.

   …or…

1,3-DICHLOROPROPENE* / CHLOROPICRIN*
   (InLine) 28-33 gal (drip)
   **COMMENTS:** Effective for control of nematodes, soilborne fungal pathogens, and insects. Requires plastic mulch. Using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. One gallon of product weighs 11.2 lb.

   …or…

CHLOROPICRIN*
   (Tri-Clor, MetaPicrin) 15-30 gal (shank)
   15-22 gal (drip)
   **COMMENTS:** A liquid that diffuses as a gas through soil. Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. One gallon of product weighs 13.7 lb.

**Followed 5-7 days later by**

METAM SODIUM*
   (Vapam HL, Sectagon 42) 37.5-75 gal
   **COMMENTS:** Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 4.26 lb of metam sodium.

   …or…

METAM POTASSIUM*
   (K-Pam HL) 30-60 gal
   **COMMENTS:** Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.

**GROWING SEASON**

A. FOSETYL-ALUMINUM
   (Aliette) WDG  Label rates

B. MEFENOXAM
   (Ridomil Gold) EC  Label rates

** Rates are per treated acre; for bed applications, the rate per acre may be lower.

* Permit required from county agricultural commissioner for purchase or use.
MUCOR FRUIT ROT  (4/05)
Pathogen: *Mucor* spp.

**SYMPTOMS**
Like the fungus that causes *Rhizopus* fruit rot, *Mucor* spp. invade the fruit through the slightest wound. The fungus secretes an enzyme that rapidly results in a leaky fruit rot. Under conditions of high humidity, the berry becomes covered with a coat of tough, wiry mycelium and black, spherical spore-bearing structures.

**COMMENTS ON THE DISEASE**
The fungus produces millions of airborne spores that are favored by warm, moist conditions. Because the fungus lives on dead and decaying organic matter, field sanitation is important.

**MANAGEMENT**
Remove all ripe fruit and plant debris from the fields. Remove and destroy all ripe and near-ripe fruit from fields after rains. Use plastic mulch to keep fruit from contacting soil. Use protective, broad-spectrum fungicides. Practice good sanitation during harvest, packing, transport, and storage, and avoid damaging fruit at all times. Unlike *Rhizopus*, some *Mucor* species such as *M. mucedo* and *M. piriformis* are not inhibited by cold temperatures.

**Organically Acceptable Methods**
Keeping fields free of ripe fruit and plant debris, the use of plastic mulch, and the proper handling of fruit at harvest are acceptable control strategies in an organically certified crop.

**Treatment Decisions**
Treat before the advent of cool to warm, moist weather after fruit set has begun.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A.</strong> IPRODIONE (Rovral) 4F</td>
<td>1.5 lb</td>
</tr>
<tr>
<td><strong>B.</strong> CAPTAN 50WP</td>
<td>1–4 lb</td>
</tr>
</tbody>
</table>

**COMMENTS:** Restricted entry interval: 1 day. Do not apply in combination with, immediately before, or closely following oil sprays.

**Apply all materials in 200 gal water/acre to ensure adequate coverage.**
PALLIDOSIS-RELATED DECLINE OF STRAWBERRY (5/05)

Pathogens: Virus complex consisting of whitefly-transmitted viruses, *Strawberry pallidosis associated virus* (SPaV) or *Beet pseudo yellows virus* (BPYV), in combination with any one of several non-whitefly transmitted viruses.

SYMPTOMS
Symptoms of this virus disease resemble those of nutritional deficiencies and other abiotic disorders and can be difficult to diagnose and confirm in the field. Leaves of strawberry plants with pallidosis-related decline turn purple to red in color. New growth may appear in the center of plants with young leaves that remain green. Plants affected early in their development are often stunted. Diseased plants have greatly reduced fruit production, and roots are brittle with reduced numbers of small absorptive rootlets.

Outbreaks of pallidosis-related decline are usually associated with the presence of the greenhouse whitefly vector, *Trialeurodes vaporariorum*, as well as aphids that can transmit many of the other viruses associated with this disease. Disease can occur in the absence of whitefly, however, because some transplants may already be infected with whitefly-transmitted viruses before planting.

COMMENTS ON THE DISEASE
The presence of BPYV or SPaV alone or together will not cause this disease. For pallidosis-related decline to occur, strawberry plants must be infected with SPaV or BPYV as well as any of several non-whitefly transmitted viruses.

SPaV and BPYV are members of the genus *Crinivirus*. SPaV has a narrow host range and is primarily limited to strawberry and related species but can also infect a few common weeds. BPYV has an extensive host range and infects many plants in addition to strawberry, including cucurbits and numerous weeds common in coastal production areas. Confirmation of virus infection requires testing plant material with molecular or serological techniques. Interestingly, strawberry plants are usually symptomless if infected with only SPaV or BPYV. Increased field populations of the greenhouse whitefly have been correlated with increased disease incidence in coastal strawberry fields in recent years.

Other viruses such as *Strawberry latent ringspot* and *Fragaria chiloensis latent viruses* were recently identified in California strawberry plantings. Their potential roles in pallidosis-related decline, along with the importance of other non-whitefly transmitted viruses, are being examined.

MANAGEMENT
When available, use transplants that are not infected with SPaV or BPYV. Control the greenhouse whitefly and aphid vectors as best as possible. Remove weeds, which may be virus reservoirs.
PHYTOPHTHORA CROWN ROT (5/05)
Pathogens: Phytophthora cactorum, P. citricola, P. parasitica, and P. megasperma

SYMPTOMS
Initially, symptoms typically include plant stunting and small leaves. As the season progresses, plant collapse may occur rapidly or slowly. When infected plants are cut open, a brown discoloration can be seen in the crown vascular tissue or throughout the crown tissue. The same Phytophthora species also attack roots, causing a brown to black root rot.

COMMENTS ON THE DISEASES
Of the Phytophthora species involved, P. cactorum is the most common; the others are much less prevalent on strawberry. Phytophthora is soilborne. When the soil becomes saturated with water, the pathogen can produce and release zoospores, which swim through water-filled pores to infect plant tissue. Phytophthora species also produce resilient spores (chlamydospores, oospores) that enable them to survive in soil for long periods without a host or under adverse conditions. Infections can occur during cool to moderate temperatures, which are typical throughout coastal fruit-production cycles.

MANAGEMENT
Soil fumigation and good cultural practices provide adequate control of Phytophthora in production fields. Good cultural practices include the use of certified transplants, avoiding poorly drained soils, and preparing fields to provide good soil drainage during wet weather. Phytophthora can be moved in water that has drained from infested fields, so avoid using runoff water for irrigation or for wetting down field roads for dust control. In fields that are prone to Phytophthora problems, you may want to plant less susceptible cultivars. Even with tolerant cultivars, however, it is important to follow good cultural practices.

Cultural Control
Use raised beds and carefully managed drip irrigation; plant in noninfested soils that have good drainage. Also, use clean plant stock and consult your farm advisor about cultivar susceptibility. Soil solarization can also provide control.

Soil solarization. In warmer areas of the state, solarization has been shown to be effective for the control of soilborne pathogens and weeds. Solarization is carried out after the beds are formed and can be effective if weather conditions are ideal (30-45 days of hot weather that promotes soil temperatures of at least 122°F). The effectiveness of solarization can be increased by solarizing after incorporating the residue of a cruciferous crop, in particular broccoli or mustards, into the soil or following an application of metam sodium (40 gal/acre). For more details on how to effectively solarize soil, see Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds, UC ANR Publication 21377.

Organically Acceptable Methods
Good cultural practices can be used to manage Phytophthora crown rot in an organically certified crop.

Treatment Decisions
If drip fumigation is planned, good results have been obtained with a sequential application of chloropicrin (200 lb/acre) or 1,3-dichloropropene/chloropicrin (300 lb/acre) followed 7 days later with metam sodium (45 gal/acre) or metam potassium (37 gal/acre). Preplant dips and foliar sprays with fosetyl-aluminum or postplant ground or drip applications of mefenoxam are advisable when Phytophthora-susceptible cultivars are used or when field history or environmental conditions suggest significant disease risk.
### PREPLANT FUMIGATION

**Sequential application of**

<table>
<thead>
<tr>
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<th>Amount/Acre**</th>
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</thead>
<tbody>
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<td>A. 1,3-DICHLOROPROPENE*/CHLOROPICRIN* (Telone C35)</td>
<td>9-12 gal (shank)</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Effective for control of nematodes, soilborne fungal pathogens, and insects. One gallon of product weighs 11.1 lb.</td>
<td></td>
</tr>
<tr>
<td><strong>…or…</strong></td>
<td></td>
</tr>
<tr>
<td>1,3-DICHLOROPROPENE*/CHLOROPICRIN* (InLine)</td>
<td>28-33 gal (drip)</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Effective for control of nematodes, soilborne fungal pathogens, and insects. Requires plastic mulch. Using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. One gallon of product weighs 11.2 lb.</td>
<td></td>
</tr>
<tr>
<td><strong>…or…</strong></td>
<td></td>
</tr>
<tr>
<td>CHLOROPICRIN* (Tri-Clor, MetaPicrin)</td>
<td>15-30 gal (shank)</td>
</tr>
<tr>
<td></td>
<td>15-22 gal (drip)</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> A liquid that diffuses as a gas through soil. Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. One gallon of product weighs 13.7 lb.</td>
<td></td>
</tr>
</tbody>
</table>

**Followed 5-7 days later by**

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount/Acre**</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. METAM SODIUM* (Vapam HL, Sectagon 42)</td>
<td>37.5-75 gal</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 4.26 lb of metam sodium.</td>
<td></td>
</tr>
<tr>
<td><strong>…or…</strong></td>
<td></td>
</tr>
<tr>
<td>METAM POTASSIUM* (K-Pam HL)</td>
<td>30-60 gal</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.</td>
<td></td>
</tr>
</tbody>
</table>

### DURING AND AFTER PLANTING

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount/Acre**</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. FOSETYL-ALUMINUM (Aliette) WDG</td>
<td>2.5 lb/100 gal for plant dips or 2.5-5 lb/acre for postplant foliar sprays</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> May be applied as a preplant dip and as a foliar spray, beginning 14–21 days after planting and continuing at 30- to 60-day intervals when conditions favor disease development. See manufacturer precautions on product label regarding copper, buffering, adjuvants, and surfactants.</td>
<td></td>
</tr>
<tr>
<td>B. MEFENOXAM (Ridomil Gold) EC</td>
<td>1 pt</td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> May be applied with ground application equipment or through drip irrigation systems. In fruit production fields, apply just after planting; up to 2 additional applications may be made according to label guidelines. Do not use more than 1.5 qt/acre/year.</td>
<td></td>
</tr>
</tbody>
</table>

**Rates are per treated acre; for bed applications, the rate per acre may be lower.**

**Permit required from county agricultural commissioner for purchase or use.**
POWDERY MILDEW (4/05)
Pathogen: Sphaerotheca macularis

SYMPTOMS
Leaves infected with powdery mildew initially have small, white powdery colonies on the undersides of leaves. These colonies enlarge to cover the entire lower leaf surface, causing the edges of the leaves to roll up. Purple reddish blotches appear on the upper and lower surface of leaves. Infected flowers produce deformed fruit or no fruit at all. Severely infected flowers may be completely covered by mycelium and killed. Infected immature fruits become hardened and desiccated. Infected mature fruits become seedy in appearance and support spore-producing colonies that look powdery and white.

COMMENTS ON THE DISEASE
The disease overwinters as mycelium on leaves in California, so it is most likely introduced into the field through planting material or spores from neighboring fields. Spores are wind disseminated and short-lived. The pathogen also survives as mycelium and cleistothecia on plants coming from nurseries. Ideal conditions for infection are dry leaf surfaces, high relative humidity, and cool to warm air temperatures. Accordingly, the disease is mostly limited to the coastal growing regions and northern nurseries and causes very little damage in inland growing regions.

MANAGEMENT
To control powdery mildew, apply fungicides at the first sign of disease. This is especially important for protectants such as sulfur. During routine field surveys, watch for the leaf distortion and discoloration that are the first signs of powdery mildew, especially in fall and spring. Controlling powdery mildew in the fall reduces the amount of disease that develops the following spring, and controlling foliar disease helps prevent fruit infections. The standard practice of removing leaves from transplants during harvest and packing helps minimize introduction of the disease, although inoculum may still be present on crowns. Cultural practices are important in helping to prevent disease buildup.

Cultural Control
Avoid overhead irrigation and use resistant cultivars where practical.

Organically Acceptable Methods
Applications of mined sulfur or insecticidal soap are acceptable on organically certified strawberries. Use resistant cultivars where practical. Select field sites where environmental conditions are not conducive to disease development.

Treatment Decisions
Apply fungicides about 1 month after planting and again 3 to 4 weeks later. Make additional treatments when plants begin to bloom.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount/Acre**</th>
<th>P.H.L+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. MYCLOBUTANIL (Rally) 40W</td>
<td>2.5–5.0 oz</td>
<td>0</td>
</tr>
<tr>
<td>COMMENTS: Apply in a minimum of 100 gal water/acre. Do not apply more than 30 oz/acre/year.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. CINNAMALDEHYDE (Cinnacure)</td>
<td>1–2 gal</td>
<td>0</td>
</tr>
<tr>
<td>COMMENTS: Precede all applications with a phytotoxicity check to ensure that the material is safe for the particular variety. Apply at 10-day intervals, but after two applications rotate to a product from a different chemical class for at least two applications.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common name</td>
<td>Amount/Acre**</td>
<td>P.H.L.+ (days)</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>C. TRIFLUMAZOLE</td>
<td>4–8 oz</td>
<td>1</td>
</tr>
<tr>
<td>(Procure) 50WS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply in sufficient water to ensure complete and thorough coverage of foliage, flowers, and fruit. Do not exceed 32 oz product/acre/season.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. AZOXYSTROBIN</td>
<td>6.2–15.4 fl oz</td>
<td></td>
</tr>
<tr>
<td>(Abound)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not apply more than 2 consecutive foliar applications before switching to alternative chemistry. Do not apply more than 1 lb a.i./acre/season.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. MICRONIZED SULFUR#</td>
<td>5–10 lb</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Sulfur application during high temperatures may burn foliage. Do not apply within 3 weeks of an oil application.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. INSECTICIDAL SOAP#</td>
<td>2.5 oz/gal</td>
<td>0</td>
</tr>
<tr>
<td>(M-Pede)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not use on new transplants, unrooted cuttings, or water-stressed plants. Avoid applying when leaf temperature exceeds 90°F. Thorough coverage is important. Avoid spraying when blossoms are present.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. PYRACLOSTROBIN/BOSCALID</td>
<td>18.5–23 fl oz</td>
<td>0</td>
</tr>
<tr>
<td>(Pristine) WG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: To limit the potential for development of resistance do not make more than 5 applications of strobilurin or anilide fungicides per season. Do not make more than 3 sequential applications of this fungicide before rotating to a fungicide with a different mode of action.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Apply all materials in 200 gal water/acre to ensure adequate coverage.
+ Preharvest interval. Do not apply within this many days of harvest.
* Permit required from county agricultural commissioner for purchase or use.
# Acceptable for use on organically grown produce.
RED STELE 5/05
Pathogen: Phytophthora fragariae var. fragariae

SYMPTOMS
Symptoms of red stele include severe stunting, occasionally followed by death of plants. Symptoms first appear on plants located in low, poorly drained parts of the field. Affected plants become stunted as older leaves die and are replaced by smaller, younger leaves with short petioles. Young lateral roots are often completely rotted. New crown roots die from their tips back, producing a symptom called “rat tail.” Splitting affected roots reveals the red stele symptom (red coloration in the core of the root above the rotted end) from which the disease gets its name.

COMMENTS ON THE DISEASE
Most infections are limited to winter and early spring in California. Optimum conditions for disease development occur when the soil is saturated and temperatures are cool. Under these conditions the pathogen produces zoospores (motile spores) that swim to the roots and infect them. Well-drained soil can minimize disease incidence and severity.

MANAGEMENT
Disease incidence and severity can be minimized by locating strawberry fields on well-drained soil, planting annually with certified transplants, fumigating the soil before planting, and using raised beds to provide optimum drainage. The use of systemic fungicides may be helpful. Avoid excessive or insufficient amounts of irrigation water. There are no commercially available California strawberry cultivars with resistance to the pathogen that causes red stele.

Cultural Control
Use raised beds and carefully managed drip irrigation; plant in noninfested soils that have good drainage. Also, use clean plant stock and consult your farm advisor about cultivar susceptibility. Soil solarization can also provide control.

Soil solarization. In warmer areas of the state, solarization has been shown to be effective for the control of soilborne pathogens and weeds. Solarization is carried out after the beds are formed and can be effective if weather conditions are ideal (30-45 days of hot weather that promotes soil temperatures of at least 122°F). The effectiveness of solarization can be increased by solarizing after incorporating the residue of a cruciferous crop, in particular broccoli or mustards, into the soil or following an application of metam sodium (40 gal/acre). For more details on how to effectively solarize soil, see Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds, UC ANR Publication 21377.

Organically Acceptable Methods
Control red stele in an organically certified crop with cultural controls.

Treatment Decisions
If drip fumigation is planned, good results have been obtained with a sequential application of chloropicrin (200 lb/acre) or 1,3-dichloropropene/chloropicrin (300 lb/acre) followed 7 days later with metam sodium (45 gal/acre) or metam potassium (37 gal/acre). Preplant dips and foliar sprays with fosetyl-aluminum or postplant ground or drip applications of mefenoxam are advisable when field history or environmental conditions suggest significant disease risk.
**PREPLANT FUMIGATION**

Sequential application of

A. 1,3-DICHLOROPROPENE* / CHLOROPICрин*  
   (Telone C35) 9-12 gal (shank)  
   COMMENTS: Effective for control of nematodes, soilborne fungal pathogens, and insects. One gallon of product weighs 11.1 lb.

   ...or...

A. 1,3-DICHLOROPROPENE* / CHLOROPICрин*  
   (InLine) 28-33 gal (drip)  
   COMMENTS: Effective for control of nematodes, soilborne fungal pathogens, and insects. Requires plastic mulch. Using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. One gallon of product weighs 11.2 lb.

   ...or...

A. CHLOROPICрин*  
   (Tri-Clor, MetaPicrin) 15-30 gal (shank)  
   15-22 gal (drip)  
   COMMENTS: A liquid that diffuses as a gas through soil. Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. One gallon of product weighs 13.7 lb.

Followed 5-7 days later by

METAM SODIUM*  
   (Vapam HL, Sectagon 42) 37.5-75 gal  

   ...or...

METAM POTASSIUM*  
   (K-Pam HL) 30-60 gal  
   COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.

**DURING AND AFTER PLANTING**

A. FOSETYL-ALUMINUM  
   (Aliette) WDG 2.5 lb/100 gal for plant dips  
   or 2.5–5 lb/acre for postplant foliar sprays  
   COMMENTS: May be applied as a preplant dip and as a foliar spray, beginning 14 to 21 days after planting and continuing at 30- to 60-day intervals as long as conditions favor disease development. See manufacturer precautions on product label regarding copper, buffering, adjuvants, and surfactants.

B. MEFENOXAM  
   (Ridomil Gold) EC 1 pt  
   COMMENTS: May be applied with ground application equipment or through drip irrigation systems. In fruit production fields, apply just after planting; up to two additional applications may be made according to label guidelines. Do not apply more than 1.5 qt/acre/year.

** Rates are per treated acre; for bed applications, the rate per acre may be lower.
* Permit required from county agricultural commissioner for purchase or use.
RHIZOPUS FRUIT ROT (4/05)

Pathogen: Rhizopus spp.

SYMPTOMS
Initial infections of Rhizopus fruit rot appear as discolored, water-soaked spots on fruit. These lesions enlarge rapidly, releasing enzymes that leave the berry limp, brown, and leaky. Under conditions of high relative humidity, the berry rapidly becomes covered with a coat of white mycelium and sporangiophores. The sporangiophores develop black, spherical sporangia, each containing thousands of spores. When disrupted, these sporulating berries release a cloud containing millions of spores.

COMMENTS ON THE DISEASE
The fungus is an excellent saprophyte that lives on and helps break down decaying organic matter. It invades strawberries through wounds and secretes enzymes that degrade and kill the tissue ahead of the actual fungal growth. The fungus is active most of the year in California and survives cold periods as mycelium, spores, or small, black, inactive sclerotia on organic debris. The pathogen has a large host range and is prevalent worldwide.

MANAGEMENT
Rhizopus stops growing at temperatures below 46°F to 50°F (8°C to 10°C), so rapid postharvest cooling of fruit is essential for disease control. Field sanitation also is extremely important: do not leave discarded plant refuse or berries in the furrows, and be sure to remove all ripe fruit from the field. There are some benefits to the use of protective fungicides, but unless the disease is widespread throughout the field, this pathogen should not cause excessive damage.

Cultural Control
Field sanitation is extremely important. Handle fruit with care at all times. Remove all ripe fruit from the field at harvest. Be sure when fruit is being picked that the entire fruit is removed from the stem, not leaving behind the fleshy receptacle of the fruit as it can serve as a site for invasion by fungus. Cultivars with thick cuticles are less susceptible to Rhizopus fruit rot because they are better able to resist infection.

Organically Acceptable Methods
Sanitation, cultivar selection, and rapid postharvest cooling are acceptable for use in an organically certified crop.

Treatment Decisions
Fungicide treatment is generally not recommended.
VERTICILLIUM WILT  (5/05)

Pathogen: Verticillium dahliae

SYMPTOMS
Initially infected plants may be stunted. Outer leaves exhibit marginal and interveinal browning, followed by eventual collapse. Inner leaves remain green but are stunted and exhibit brownish black streaks or blotches. This last symptom sometimes helps to distinguish this disease from Phytophthora crown rot.

COMMENTS ON THE DISEASE
The fungus is not host-specific and infects many weed species and crops worldwide. It is especially destructive in semi-arid areas where soils are irrigated. Inoculum densities may be high following planting of susceptible crops. Disease severity is greater when high levels of nitrogen are used.

MANAGEMENT
Preplant fumigation is an important component of managing Verticillium wilt in strawberry fields. If fumigation is not desirable, select fields isolated from established growing areas, avoiding any fields with detectable levels of the pathogen or with a history of susceptible crops. Crop rotation with broccoli has been shown as an effective way to reduce Verticillium in the soil. Solarization of formed beds may be used to reduce pathogen levels in areas that get adequate amounts of sunshine and warm weather during summer months, although the usefulness of this technique for reducing Verticillium wilt in strawberries is unknown.

Cultural Control
If infested fields cannot be avoided and fumigation is not feasible, either solarize the soil or implement a crop rotation program. Cover crops of cereal rye or ryegrass can help to reduce soil levels of Verticillium. Use relatively tolerant strawberry cultivars when practical. Also, use drip irrigation and avoid excess amounts of nitrogen fertilizer.

Soil Solarization. In warmer areas of the state, solarization has been shown to be effective for the control of soilborne pathogens and weeds. Solarization is carried out after the beds are formed and can be effective if weather conditions are ideal (30-45 days of hot weather that promotes soil temperatures of at least 122°F). The effectiveness of solarization can be increased by solarizing after incorporating the residue of a cruciferous crop, in particular broccoli or mustards, into the soil or following an application of metam sodium (40 gal/acre). For more details on how to effectively solarize soil, see Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds, UC ANR Publication 21377.

Crop Rotation. Rotating strawberries with broccoli can significantly reduce levels of the Verticillium pathogen in the soil and has been shown to be an economically viable option under moderate levels of Verticillium wilt disease pressure.

Organically Acceptable Methods
Select fields isolated from established growing areas. If fields have detectable levels of the pathogen or a history of susceptible crops, plan to solarize the soil, preferably after incorporating the crop residue from broccoli or mustards. Use drip irrigation and practice crop rotation with a nonsusceptible crop such as broccoli. Avoid high nitrogen fertilizers.

Treatment Decisions
If drip fumigation is planned, good results have been obtained with a sequential application of chloropicrin (200 lb/acre) or 1,3-dichloropropene/chloropicrin (300 lb/acre) followed 7 days later with metam sodium (45 gal/acre) or metam potassium (37 gal/acre).
**PREPLANT FUMIGATION**

*Sequential application of*

A. **1,3-DICHLOROPROPENE*/CHLOROPICRIN*  
   *(Telone C35)*  
   **Amount/Acre**  
   9-12 gal (shank)  
   **COMMENTS:** Effective for control of nematodes, soilborne fungal pathogens, and insects. One gallon of product weighs 11.1 lb.
   ...
or...
   **1,3-DICHLOROPROPENE*/CHLOROPICRIN*  
   *(InLine)*  
   **Amount/Acre**  
   28-33 gal (drip)  
   **COMMENTS:** Effective for control of nematodes, soilborne fungal pathogens, and insects. Requires plastic mulch. Using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. One gallon of product weighs 11.2 lb.
   ...
or...
   **CHLOROPICRIN**  
   *(Tri-Clor, MetaPicrin)*  
   **Amount/Acre**  
   15-20 gal (shank)  
   15-22 gal (drip)  
   **COMMENTS:** A liquid that diffuses as a gas through soil. Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. One gallon of product weighs 13.7 lb.

*Followed 5-7 days later by*

**METAM SODIUM**  
*(Vapam HL, Sectagon 42)*  
**Amount/Acre**  
37.5-75 gal  
**COMMENTS:** Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 4.26 lb of metam sodium.
   ...
or...
   **METAM POTASSIUM**  
*(K-Pam HL)*  
**Amount/Acre**  
30-60 gal  
**COMMENTS:** Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.

**Rates are per treated acre; for bed applications, the rate per acre may be lower.**

**Permit required from county agricultural commissioner for purchase or use.**
Nematodes (5/05)

Scientific Names: Foliar nematode: *Aphelenchoides fragariae*  
Northern root knot nematode: *Meloidogyne hapla*

DESCRIPTION OF THE PESTS

Plant parasitic nematodes are microscopic, unsegmented roundworms. The two species most commonly associated with damage in California strawberries are the foliar nematode, *Aphelenchoides fragariae*, and the northern root knot nematode, *Meloidogyne hapla*. The northern root knot nematode is found in the soil or as a sedentary endoparasite in roots. The foliar nematode is a parasite of aboveground plant parts and may be endo- or ectoparasitic. Symptoms caused by *A. fragariae* are sometimes called spring crimp, spring dwarf, or strawberry crimp. However, these names are misleading and should not be used in California because nematodes and associated symptoms may be present during seasons other than spring and other symptoms may be more important than crimp in recognizing the presence of the nematode.

Although *A. fragariae* and *M. hapla* have been most frequently associated with damage in California, strawberries are also hosts for the following nematodes: root lesion (*Pratylenchus penetrans*), stem (*Ditylenchus dipsaci*), dagger (*Xiphinema americanum*), needle (*Longidorus elongatus*), foliar (*A. ritzemabosi, A. besseyi*), and root knot (*M. incognita* and *M. javanica*). All of these nematodes are potential pathogens to strawberries in California and their identification in strawberry plantings or in land to be planted to strawberries should be cause for concern.

DAMAGE

The presence of either foliar or northern root knot nematodes may result in plant stress and reductions in yield. Under current practices of fumigating strawberry fields with methyl bromide and using certified nursery stock, these nematodes are rarely found causing significant damage in California production areas. However, with the increasing use of organic methods, which include no use of fumigants, infestations and damage may become more common. Control of these two pests by nursery stock producers is critical because an infestation will prevent their receiving government certification, thereby greatly reducing the value of the planting stock.

SYMPTOMS

Plant symptoms can be indicative of a nematode problem but are not diagnostic because similar symptoms could result from other problems as well. The symptoms may either be widespread or may appear in small patches within a field.

Aboveground symptoms of foliar nematode include stunted growth, reddened leaves, small curled or crinkled leaves (crimp), deformed buds and flowers, and a reduction in flowering and fruiting. Recent research conducted in California on Chandler, Douglas, Fern, Pajaro, and Selva cultivars indicates that a reduction in flowering and fruiting may more reliably distinguish a foliar nematode infestation from insect infestations, which produce leaf symptoms similar to those described above. There are no reported belowground symptoms with this species.

Aboveground symptoms of root knot nematodes include wilting during hot days, stunting, chlorosis, and suppression of fruit yields. Root galls formed near the root tips and abundant branching at and above these galls are the primary belowground symptoms of this pest.

FIELD EVALUATION

To make management decisions, it is important to determine which nematode species are present. Take plant and/or soil samples and send them to a diagnostic laboratory for identification.
In an existing strawberry crop, examine the field for symptoms described above. Dig up the entire suspected plant, place the plant and surrounding soil into a plastic bag. Take a separate sample from an area without symptoms for comparison.

In fallow fields or fields in other crops, visually divide the field into sampling blocks that represent differences in soil texture, drainage patterns, or cropping history, but are not larger than 5 acres in size. Take a separate sample from each block so that each can be managed individually. Sample when the soil is moist and sample at the rooting depth of the current or previous crop. Collect subsamples from several places in the field. Mix these subsamples well and place about 1 quart of soil into a plastic bag. If possible, place roots from the crop in the bag with the soil.

Seal bags, place a label on outside of the bag, keep the sample cool (do not freeze), and transport as soon as possible to a diagnostic laboratory. Inform the laboratory that you want to know if the nematodes listed as pests above are present so they can use appropriate extraction techniques. Request a diagnosis to species. Keep in mind that nematode sampling and extraction techniques are typically 30 to 50% effective in finding species that might be present. Therefore, a negative finding does not rule out the possible presence of plant parasitic nematodes.

**MANAGEMENT TECHNIQUES**

The use of certified planting stock (produced in fumigated fields) combined with fumigation of fields has been the primary management technique for plant pathogens, weeds, and nematodes on strawberries. For growers not satisfied with the degree of nematode control that has been achieved with the standard techniques, use of additional techniques (such as hot water treatment of planting stock) could increase the level of control obtained. For growers wishing to minimize the use of chemical nematicides, using a combination of other techniques should provide a degree of nematode control. However, the same dollar input will probably not equal the control or yields achieved with certified planting stock and fumigation, although the costs could perhaps be offset by higher returns for organically produced strawberries. Alternative techniques often require more advanced planning than the use of traditional chemical management techniques, may not be applicable to all growing situations, and should first be attempted on a small scale.

Potential nonchemical alternatives fall into the following categories: selection of planting site, cleaning equipment to minimize nematode transfer, avoidance of nematode-infested irrigation water, hot water treatments of planting stock, planting when environmental conditions are unfavorable for nematodes, roguing, crop rotation with broccoli and incorporating the crop residue into the soil, fallowing the field, use of resistant and tolerant cultivars, and biological control. It is not possible to provide guidelines applicable statewide for using combinations of these techniques that might provide adequate nematode control. Growers wanting to utilize nonchemical management techniques should discuss possible solutions with their local farm advisors.

**Fumigation.** With the phase out of methyl bromide, the most effective soil fumigation is a sequential application of chloropicrin or 1,3-dichloropropene/chloropicrin followed 5 to 7 days later by an metam sodium or metam potassium. This combination of materials can provide effective control of weeds as well as soilborne pathogens, soil insects and nematodes.

<table>
<thead>
<tr>
<th>Common name (trade name)</th>
<th>Amount to Use**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PREPLANT</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sequential application of</strong></td>
<td></td>
</tr>
<tr>
<td>A. 1,3-DICHLOROPROPENE* / CHLOROPICRIN*</td>
<td>9-12 gal (shank)</td>
</tr>
<tr>
<td>(Telone C35)</td>
<td></td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Effective for control of nematodes, soilborne fungal pathogens, and insects. One gallon of product weighs 11.1 lb.</td>
<td></td>
</tr>
<tr>
<td>...or...</td>
<td></td>
</tr>
<tr>
<td>Common name</td>
<td>Amount to Use**</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>1,3-DICHLOROPROPENE*/CHLOROPICRIN*</td>
<td>28-33 gal (drip)</td>
</tr>
<tr>
<td><em>(InLine)</em></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Effective for control of nematodes, soilborne fungal pathogens, and insects. Requires plastic mulch. Using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. One gallon of product weighs 11.2 lb.</td>
<td></td>
</tr>
<tr>
<td>…or…</td>
<td></td>
</tr>
<tr>
<td>1,3-DICHLOROPROPENE*</td>
<td>9-12 gal (shank)</td>
</tr>
<tr>
<td><em>(Telone II)</em></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Liquid that diffuses as a gas through soil. Effective against nematodes and insects. Rates very with soil texture and efficacy strongly affected by soil moisture and temperature. One gallon of product weighs 10.1 lb.</td>
<td></td>
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<tr>
<td>…or…</td>
<td></td>
</tr>
<tr>
<td>CHLOROPICRIN*</td>
<td>15-30 gal (shank)</td>
</tr>
<tr>
<td><em>(Tri-Clor, MetaPicrin)</em></td>
<td>15-22 gal (drip)</td>
</tr>
<tr>
<td>COMMENTS: A liquid that diffuses as a gas through soil. Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. One gallon of product weighs 13.7 lb.</td>
<td></td>
</tr>
</tbody>
</table>

*Followed 5-7 days later by*

| METAM SODIUM*                  | 37.5-75 gal |
| *(Vapam HL, Sectagon 42)*     |             |
| …or…                           |             |
| METAM POTASSIUM*               | 30-60 gal  |
| *(K-Pam HL)*                   |             |
| COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium. |

* Permit required from county agricultural commissioner for purchase or use.
Weeds

INTEGRATED WEED MANAGEMENT (4/05)

Strawberries are highly susceptible to weed competition immediately after planting when the plants are small and frequent irrigation provides ideal conditions for weed germination. Most weeds that invade strawberries are annuals. During stand establishment, little mallow, burclover, sweet clover, and filaree are common weeds because their seeds survive fumigation. Once strawberries are in the bearing stage of growth, grasses and broadleaf weeds with windblown seeds, including sowthistle and common groundsel, may become problems. In certain sites, perennial weeds such as field bindweed and bermudagrass may require control, especially in fields where the crop is carried over into a second year of production. In areas where strawberries are carried over for 2 years, weed management during the second winter consists of a combination of preemergent herbicides, mulches, and hand-weeding.

In conventional strawberry fields, effective weed management requires a combination of cultural practices, preplant soil fumigation, and additional herbicide applications when necessary. Proper field and bed preparation is essential for a good weed control program. For weed and pathogen control, fumigation with a mixture of 1,3-dichloropropene/chloropicrin or chloropicrin alone, followed by an application of metam sodium or metam potassium, in conjunction with the use of opaque plastic mulches, is emerging as the best alternative method of weed control in California strawberries in response to the phase out of methyl bromide. The use of virtually impermeable film (VIF) enhances weed control provided by 1,3-dichloropropene/chloropicrin (see DRIP FUMIGATION). For weeds that escape preplant controls, hand-hoeing and/or selective herbicides are used.

As an alternative to fumigation, some growers use soil solarization in warmer, inland areas. However, the use of soil solarization is not effective in cool, coastal strawberry districts, where the best alternative method of weed control is the use of black, brown, or green mulch films. In some cases, organic mulches have been used instead of plastic ones.

MONITORING and FIELD SELECTION
Select sites with good drainage in areas with good quality water. Survey intended fields for perennial weeds. Soil fumigation allows for the use of land that may have a weedy history, but less weedy sites are preferred. Certain weeds (e.g., hairy nightshade) host soilborne diseases (Verticillium wilt); by avoiding land infested with these weeds, one would expect a lower incidence of soilborne diseases.

During the early stages of plant establishment, check frequently for weeds (at least once every 3 weeks during the first 3 to 4 months after planting). Send weeding crews through fields, as needed, to remove perennials and purslane.

MANAGEMENT BEFORE PLANTING
Soil fumigation has been widely used to control weeds in California strawberries. If fumigation is not used, cultivation, mulches, or soil solarization can also provide weed control. These strategies can also be used in conjunction with soil fumigation to further enhance weed, pathogen, and nematode control.

Crop Rotation. Rotational crops can be an important part of a weed control program. Rotations can be cash crops such as lettuce or cole crops, or small grains (barley, cereal rye, oats, or wheat) grown as cover crops or green manure crops. Where the cropping cycle permits, sudangrass may be included in the rotation cycle as a summer annual green manure crop. Intensive cultivation of a vegetable crop rotation such as lettuce or a cole crop helps control many problem weeds. A densely planted cereal rye cover crop or small grain crop is highly competitive with weeds and provides better weed control than a legume cover crop. In addition, alternative herbicides are available in rotations. In small grains for example, translocated broadleaf herbicides can help to control infestations of field bindweed, and contact herbicides can control broadleaf annuals that are not controlled by soil fumigation.
Cultivation. Following bed formation, sprinkler irrigate to germinate weeds, thus reducing the weed seed reservoir in the soil. After weeds have germinated, remove the seedlings with minimal soil disturbance. Cultivation equipment may be used for furrows, but the sides and tops of beds must be hand-weeded. Avoid cultivating too deeply to reduce the risk of bringing up weed seeds from lower depths. Because most California strawberries are planted in the fall, this practice can be accomplished mid-to-late summer in coastal climates where soil temperatures are usually cool enough for winter weeds to germinate year round. In the warm interior valleys, winter annuals may not germinate during this period.

Opaque Mulches. Opaque mulches are usually some type of opaque plastic. These may be brown, black, or green, but they must restrict light from penetrating the film to be effective. Clear plastic is often used in summer in warmer areas to solarize the soil, but in winter it serves as a greenhouse and encourages both weed growth and strawberry plant growth. The use of clear plastic is standard practice on South Coast winter plantings because it promotes early yield (colored mulches delay fruit production). Growers that choose to use clear plastic in winter must use effective fumigants to ensure that most weed seeds are killed.

When using opaque mulches, secure them to the soil before transplanting. Place strawberry plants in the soil after cutting a hole into the plastic at the desired spacing. Weed growth is greatly reduced with opaque mulches, but weeds will still grow in the hole where the strawberry plant is and need to be removed by hand. Use the smallest possible hole to minimize weed growth around the strawberry plants. Planting through slits in the mulch helps to minimize weed growth.

Soil Solarization. In summer, clear plastic applied to preshaped beds several weeks before planting will solarize the soil and reduce the number of weed seeds and soilborne disease organisms. On the central coast, this practice requires at least 12 to 15 weeks in order to obtain pest management benefits; consequently, solarization is usually not practical in this region. Solarization is much more effective in areas of the state where temperatures are consistently (30-45 days) hot enough in summer to produce soil temperatures of at least 122°F. Solarization can be even more effective if the residue of a cruciferous crop (especially broccoli or mustards) is incorporated into the soil just before the plastic is installed, or following an application of metam sodium (40 gal/acre). For more details on how to effectively solarize soil, see Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds, UC ANR Publication 21377. For optimum results, check the plastic for good adhesion to the soil and for any holes that might have developed and need repair.

Fumigation. With the phase out of methyl bromide, the most effective soil fumigation is a sequential application of chloropicrin or 1,3-dichloropropene/chloropicrin followed 5 to 7 days later by an metam sodium or metam potassium. This combination of materials can provide effective control of weeds as well as soilborne pathogens, soil insects and nematodes.

Fumigation with methyl bromide, 1,3-dichloropropene (1,3-D) plus chloropicrin mixture (Telone C35, Inline), chloropicrin, and metam sodium before bed preparation kills the seeds of most weeds and the reproductive structures of some perennials. Nearly all fumigant applications are either immediately covered with plastic mulch or are injected through the drip irrigation system under plastic mulch. Drip injection of fumigants such as 1,3-D plus chloropicrin mixture or chloropicrin often improves the weed control compared to shank fumigation. However, it is important to thoroughly wet the bed during fumigant injection to ensure weed control on the edges of the bed. Where drip fumigation is used, only the bed is treated, and the row middles are left unfumigated. Soil-applied herbicides such as napropamide can be used to control weeds in the row middles.

Soil fumigants control weeds by killing both germinating seedlings and ungerminated seeds. Methyl bromide, chloropicrin, 1,3-D plus chloropicrin mixture (Inline, Telone C35), and metam sodium kill weed seedlings and seeds by respiration inhibition. However, to kill weed seeds, fumigants must be able to penetrate the seed coat and kill the seed embryo. It is more effective to kill moistened seed, because the seed tissues swell with water and allow the fumigant to penetrate more thoroughly. Moist seeds
also have higher respiration rates and are more susceptible to fumigants than dry seed with low respiration rates. Proper irrigation before fumigation is one of the keys to effective weed control with all fumigants. Soil temperature must be above 55°F for effective absorption of water by seeds. Preirrigation allows nondormant weed seeds to germinate, and germinating weed seedlings are readily killed by fumigation. Among the seeds that are difficult to kill with fumigation are burclover and little mallow seed. These seeds have impermeable seed coats that limit moisture and chemical penetration, and they remain dormant in the soil.

See DRIP FUMIGATION for additional information on this process.

**Herbicides.** Oxyfluorfen is registered in California as a fallow bed treatment that can be used before planting a strawberry field. It is useful for controlling weeds such as filaree and little mallow, which are not controlled well by the fumigants. This treatment is compatible with drip-applied fumigants because it can be applied after the beds are formed but before the tarps are installed. It must be applied 30 days before transplanting.

Oxyfluorfen herbicide has the potential for “lift off” or codistillation. Lift off is not drift, but instead is the movement of the herbicide with water vapor. Lift off can move oxyfluorfen from the soil surface to susceptible strawberry foliage. Oxyfluorfen-treated soil can also be moved onto susceptible strawberry foliage as splash from sprinkler irrigation or rainfall. To ensure safety to the strawberry plants, only use oxyfluorfen if plastic mulch will be installed before strawberry transplanting.

Pelargonic acid (Scythe) is a postemergent herbicide that provides contact control or burn down of a wide spectrum of weeds. It can be applied to control weeds in the row middles both before and after transplanting.

**MANAGEMENT AFTER PLANTING**
During the early stages of plant establishment, mechanical removal (mostly by hand if drip tape is placed in the bed) is the most practical means for control. Timely removal of weeds is essential to minimize competition.

If strawberry leaves are pruned in winter, an opaque plastic mulch can be used to control weeds. This provides good control for much of the harvest period. Organic mulches could also be applied at this period. To effectively control weeds, at least 2 inches of mulch are necessary and must be maintained to keep weeds from growing through the mulch. However, organic mulches may increase problems with snails, slugs, earwigs, and possibly other insects.

**Herbicides.** Several herbicides are currently registered for use in newly planted strawberries. Napropamide (Devrinol) and DCPA (Dacthal) are preemergent herbicides that may be applied at transplanting or during the early stage of strawberry development. Sethoxydim (Poast) and clethodim (Prism), postemergent herbicides registered for use in strawberries, are systemic grass herbicides that can be applied to control grass weeds after they have emerged. Pelargonic acid (Scythe) is a contact herbicide that controls a broad range of weeds and is useful in fumigated fields to provide weed control in the row middles.

Each herbicide has certain time restrictions that apply to its preharvest interval. When using any herbicide always read the label for specific instructions.

If the soil is preplant fumigated, weeds that have a hard seed coat (little mallow, burclover, and filaree) may require additional control measures. Napropamide is effective on little mallow and filaree if applied before the weeds have emerged. If the application is delayed until the planting is established, emerged weeds must be removed before application.

For second-year strawberries, napropamide and DCPA can be applied following winter pruning. Overhead irrigation or rainfall is essential to incorporate the herbicides into the soil.
Strawberry tolerance to napropamide has been evaluated on several strawberry varieties. When strawberries are grown on sandy soils, maximum label rates of napropamide have caused strawberry runner inhibition and some reduction in the development of the strawberry plant. Limit initial use to obtain the benefit associated with this herbicide, while minimizing the risks.

Sethoxydim and clethodim are effective on many annual and perennial grassy weeds, but sethoxydim does not control annual bluegrass.
# COMMON AND SCIENTIFIC NAMES OF WEEDS (4/05)

<table>
<thead>
<tr>
<th>Common Names</th>
<th>Scientific Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>barley, hare</td>
<td>Hordeum murinum subsp. leporinum</td>
</tr>
<tr>
<td>barnyardgrass</td>
<td>Echinochloa crus-galli</td>
</tr>
<tr>
<td>bermudagrass</td>
<td>Cynodon dactylon</td>
</tr>
<tr>
<td>bindweed, field</td>
<td>Convolvulus arvensis</td>
</tr>
<tr>
<td>bluegrass, annual</td>
<td>Poa annua</td>
</tr>
<tr>
<td>burclovers</td>
<td>Medicago spp.</td>
</tr>
<tr>
<td>chickweed, common</td>
<td>Stellaria media</td>
</tr>
<tr>
<td>filarees</td>
<td>Erodium spp.</td>
</tr>
<tr>
<td>goosefoot, nettleleaf</td>
<td>Chenopodium murale</td>
</tr>
<tr>
<td>groundsel, common</td>
<td>Senecio vulgaris</td>
</tr>
<tr>
<td>lambquarters, common</td>
<td>Chenopodium album</td>
</tr>
<tr>
<td>mallow, little (cheeseweed)</td>
<td>Malva parviflora</td>
</tr>
<tr>
<td>nettle, burning</td>
<td>Urtica urens</td>
</tr>
<tr>
<td>nutsedge, yellow</td>
<td>Cyperus esculentus</td>
</tr>
<tr>
<td>pigweeds</td>
<td>Amaranthus spp.</td>
</tr>
<tr>
<td>pineapple-weed</td>
<td>Chamomilla suaveolens</td>
</tr>
<tr>
<td>puncturevine</td>
<td>Tribulus terrestris</td>
</tr>
<tr>
<td>purslane, common</td>
<td>Portulaca oleracea</td>
</tr>
<tr>
<td>ryegrass, Italian</td>
<td>Lolium multiflorum</td>
</tr>
<tr>
<td>sowthistles</td>
<td>Sonchus spp.</td>
</tr>
<tr>
<td>sweetclovers</td>
<td>Melilotus spp.</td>
</tr>
</tbody>
</table>

Common and Scientific Names of Weeds (4/05) 72
### SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL (4/05)

<table>
<thead>
<tr>
<th>FUMIGANTS</th>
<th>PREEMERGENCE</th>
<th>POSTEMERGENCE</th>
<th>CULTURAL CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>13D/CHL</td>
<td>CHL</td>
<td>MEP</td>
<td>MET*</td>
</tr>
<tr>
<td><strong>ANNUAL WEEDS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>barley, hare</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>barnyardgrass</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>bluegrass, annual</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>burclovers</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>chickweed, common</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>filarees</td>
<td>N</td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>goosefoot, nettleleaf</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>groundsel, common</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>lambsquarter, common</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>mallow, little (cheeseweed)</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>nettle, burning</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>pigweeds</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>pineapple-weed</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>puncturevine</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>purslane, common</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>ryegrass, Italian</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>sowthistles</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>sweetclovers</td>
<td>N</td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>volunteer grains</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td><strong>PERENNIAL WEEDS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bermudagrass (regrowth)</td>
<td>T</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>bermudagrass (seedling)</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>bindweed, field (regrowth)</td>
<td>N</td>
<td>N</td>
<td>T</td>
</tr>
<tr>
<td>bindweed, field (seedling)</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>nutsedge, yellow</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

13D/CHL = 1,3-dichloropropene/chloropicrin (InLine, Telone C35)
CHL = chloropicrin (Tri-Clor, MetaPicrin)
CLE = clethodim (Prism)
DCP = DCPA (Dacthal)
MEP = metam potassium (K-Pam HL, Sectagon-K)
MET* = metam sodium (Vapam HL, Sectagon)
NAP = napropamide (Devrinol)
OXY = oxyfluorfen (Goal)
PAR = paraquat* (Gramaxone Extra)
PEL = pelargonic acid (Scythe)
SET = sethoxydim (Poast)

T = top kill only
C = control
P = partial control
N = no control
— = no information

* Permit required from county agricultural commissioner for purchase or use.
## HERBICIDE TREATMENT TABLE (4/05)

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount to Use</th>
<th>P.H.I+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PREPLANT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. OXYFLUORFEN</td>
<td>0.5 lb a.i.</td>
<td>1–2 pt</td>
</tr>
<tr>
<td>(Goal) 2XL (GoalTender) 4F</td>
<td></td>
<td>0.5–1 pt</td>
</tr>
<tr>
<td>Comments: Use allowed under a special 2(ee) recommendation. If applied in fields where drip fumigation will be done, apply after beds are formed but before tarps are installed. Apply at least 30 days before transplanting for effective control of little mallow (cheeseweed) and filaree, which are not controlled well by the fumigants. To prevent injury to strawberry plants, do not use unless a plastic mulch will be installed at the time of strawberry transplanting. Water the treated soil with a light sprinkler irrigation before mulch installation to activate the herbicide (see 2(ee) label for other options).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sequential application of**

| B. 1,3-DICHLOROPROPENE*/CHLOROMICRIN* (Telone C35) | 9–12 gal (shank) |
| 1,3-DICHLOROPROPENE*/CHLOROMICRIN* (InLine) | 28–33 gal (drip) |
| CHLOROMICRIN* (Tri-Clor, MetaPicrin) | 15–30 gal (shank) |
| CHLOROMICRIN* | 15–22 gal (drip) |
| Comments: Effective for control of nematodes, soilborne fungal pathogens, and insects. Requires plastic mulch. Using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed and nematode control. One gallon of product weighs 11.2 lb. |

Followed 5-7 days later by

| METAM SODIUM* (Vapam HL, Sectagon 42) | 37.5–75 gal |
| METAM POTASSIUM* (K-Pam HL) | 30–60 gal |

After weeds emerge

<p>| PELARGONIC ACID (Scythe) | 3–5% volume/volume |
| PARAQUAT* (Gramoxone Max) | 0.47 lb a.i. |
| Comments: Apply before transplanting; use of a nonionic surfactant or crop oil is recommended. Ground application 20 gal water/acre; air application 5 gal water/acre. Do not apply more than 3 times/season. |</p>
<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount to Use</th>
<th>P.H.I.+ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSTPLANT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before weeds emerge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. NAPROPAMIDE</td>
<td>2–4 lb a.i.</td>
<td></td>
</tr>
<tr>
<td>(Devrinol)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: May be applied to newly transplanted and established crop. Do not apply after 1st bloom. May inhibit runners. Good for controlling weeds in the row middles following drip fumigation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. DCPA</td>
<td>6–9 lb a.i.</td>
<td>8–12 lb</td>
</tr>
<tr>
<td>(Dacthal) W-75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: For new plantings apply 12 lb product/acre; for established plantings apply 8-12 lb product/acre in late summer or early fall. Do not apply from first bloom through harvest. Must be applied as banded applications over the rows. Applications can be made over strawberry plants without injury. Does not control emerged weeds.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After weeds emerge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. SETHOXYDIM</td>
<td>0.28–0.47 lb a.i.</td>
<td>7</td>
</tr>
<tr>
<td>(Poast)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Grass weed size is critical for control, but varies with species; see label. Only 1 application allowed/season. Not for aircraft application.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. CLETHODIM</td>
<td>0.095–0.12 lb a.i.</td>
<td>4</td>
</tr>
<tr>
<td>(Prism)</td>
<td>13–17 fl oz</td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply for control of annual grasses including annual bluegrass. For repeat applications, the minimum interval between applications is 14 days. Use 1% volume by volume crop oil concentrate in the finished spray mix.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. PELARGONIC ACID</td>
<td>3–5% volume/volume</td>
<td></td>
</tr>
<tr>
<td>(Scythe)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Good for controlling weeds in the row middles following fumigation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. PARAQUAT</td>
<td>0.47 lb a.i.</td>
<td>21</td>
</tr>
<tr>
<td>(Gramoxone Max)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply as a directed spray to the furrow bottoms using shields to prevent contact with crop plants. Avoid windy conditions. Use of a nonionic surfactant or crop oil is recommended. Do not allow contact with strawberry plants as injury or excessive residues may result. Ground application 20 gal water/acre. Do not apply more than 3 times/season.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

+ Preharvest interval. Do not apply within this many days of harvest.
* Permit required from county agricultural commissioner for purchase or use.
PRECAUTIONS FOR USING PESTICIDES

Pesticides are poisonous and must be used with caution. READ THE LABEL BEFORE OPENING A PESTICIDE CONTAINER. Follow all label precautions and directions, including requirements for protective equipment. Apply pesticides only on the crops or in the situations listed on the label. Apply pesticides at the rates specified on the label or at lower rates if suggested in this publication. In California, all agricultural uses of pesticides must be reported. Contact your county agricultural commissioner for further details. Laws, regulations, and information concerning pesticides change frequently. This publication reflects legal restrictions current on the date next to each pest’s name.

Legal Responsibility. The user is legally responsible for any damage due to misuse of pesticides. Responsibility extends to effects caused by drift, runoff, or residues.

Transportation. Do not ship or carry pesticides together with food or feed in a way that allows contamination of the edible items. Never transport pesticides in a closed passenger vehicle or in a closed cab.

Storage. Keep pesticides in original containers until used. Store them in a locked cabinet, building, or fenced area where they are not accessible to children, unauthorized persons, pets, or livestock. DO NOT store pesticides with foods, feed, fertilizers, or other materials that may become contaminated by the pesticides.

Container Disposal. Dispose of empty containers carefully. Never reuse them. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Consult your county agricultural commissioner for correct procedures for handling and disposal of large quantities of empty containers.

Protection of Nonpest Animals and Plants. Many pesticides are toxic to useful or desirable animals, including honey bees, natural enemies, fish, domestic animals, and birds. Crops and other plants may also be damaged by misapplied pesticides. Take precautions to protect nonpest species from direct exposure to pesticides and from contamination due to drift, runoff, or residues. Certain rodenticides may pose a special hazard to animals that eat poisoned rodents.

Posting Treated Fields. For some materials, restricted entry intervals are established to protect field workers. Keep workers out of the field for the required time after application and, when required by regulations, post the treated areas with signs indicating the safe re-entry date. Check with your county agricultural commissioner for latest restricted entry interval.

Preharvest Intervals. Some materials or rates cannot be used in certain crops within a specified time before harvest. Follow pesticide label instructions and allow the required time between application and harvest.

Permit Requirements. Many pesticides require a permit from the county agricultural commissioner before possession or use. When such materials are recommended, they are marked with an asterisk (*) in the treatment tables or chemical sections of this publication.

Processed Crops. Some processors will not accept a crop treated with certain chemicals. If your crop is going to a processor, be sure to check with the processor before applying a pesticide.

Crop Injury. Certain chemicals may cause injury to crops (phytotoxicity) under certain conditions. Always consult the label for limitations. Before applying any pesticide, take into account the stage of plant development, the soil type and condition, the temperature, moisture, and wind. Injury may also result from the use of incompatible materials.

Personal Safety. Follow label directions carefully. Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. NEVER eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care IN ADVANCE as required by regulation.

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