# Section 1: Title Page

## CALIFORNIA WINEGRAPE PEST MANAGEMENT ALLIANCE EVALUATION


PRINCIPLE INVESTIGATOR

**KAREN ROSS, PRESIDENT**

**CALIFORNIA ASSOCIATION OF WINEGRAPE GROWERS**



CONTRACT NUMBER: 99-0193



EVALUATION PREPARATION

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March 8, 2000

Prepared for the California Department of Pesticide Regulation

## Section 2. Disclaimer

**Disclaimer:** The statements and conclusions in this report are those of the contractor and not necessarily those of the California Department of Pesticide Regulation. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

# Section 3. Acknowledgements

The California Winegrape Pest Management Alliance Program is guided by the following steering committee and technical advisors:

| | | |
|---|---|---|
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## Section 3 Acknowledgements, Continued

The pesticide use data used in this report is based on the Department of Pesticide Regulation's (DPR) 1998 Pesticide Use Report. Dr. Susan Bassein produced the overall analysis of individual pesticides by major winegrape production regions from the data provided by DPR.

This Winegrape PMA Evaluation includes a significant amount of material from the *Crop/Pest Profile for Wine Grapes in California* published in November 1999. We would like to acknowledge the organizations and individuals that contributed to the production of this crop/pest profile. This includes the California Grape Advisory Team composed of the following individuals: Jenny Broome, Associate Director, UC SAREP; Paul (Augie) Feder, Agricultural Policy Specialist, U.S. EPA Region 9; Karen Ross, President, California Association of Winegrape Growers (CAWG); Joe Kretsch, Project Coordinator, Sun-Maid Raisin Best Management Practices Program; Rick Melnicoe, CA PIAP, US Department of Agriculture; Linda Herbst, CAPIAP, US Department of Agriculture; Charlie Goodman, Research Manager, Office of Pesticide Analysis and Consultation, California Department of Food and Agriculture (CDFA); John Steggall, Office of Pesticide Consultation and Analysis, CDFA; Mike Vail, Viticulturist, Vino Farms, Inc.; Frank Zalom, Director, UC Statewide IPM Program; Jennifer Curtis, Environmental Policy Consultant to the Natural Resources Defense Council (NRDC); Richard Matoian, California Grape and Tree Fruit League. The pest management summaries in the crop/pest profile are also based on publications and documentation from the UC Division of Agriculture and Natural Resources, the UC Sustainable Agriculture Research and Education Program, California's Department of Pesticide Regulation, the Lodi-Woodbridge Winegrape Commission, the Central Coast Vineyard Team, and other sources of documentation on grape pest management.

The following individuals reviewed sections of the crop/pest profile in their area of expertise: Drs. Jeffrey Granett and Amir Omer (phylloxera), Dr. Kent Daane (mealybugs), Dr. Alex (Sandy) Purcell (sharpshooters), Dr. Mike McKenry (nematodes), Dr. Doug Gubler (powdery mildew, measles) and Dr. Tim Prather (weeds).

This report was submitted in fulfillment of DPR contract 99-0193 for the California Winegrape Pest Management Alliance Evaluation project by the California Association of Winegrape Growers under the partial sponsorship of the California Department of Pesticide Regulation. Work was completed as of March 8, 2000.

# Section 4. Table of Contents

# Section 5. Abstract

**Abstract.** The purpose and scope of the California Winegrape Pest Management Alliance Evaluation include: (1) conduct a detailed analysis of the Department of Pesticide Regulation's 1998 Pesticide Use Report (PUR) for winegrapes; (2) provide an overview of chemical, cultural, and biological controls for major insect, mite, weed, disease, nematode and vertebrate winegrape pests; and (3) present an overview of the pest management challenges and innovations in winegrapes.

The analysis of the 1998 PUR data includes graphical and tabular results for percent acres treated, median number of applications per site, and median application rates by major winegrape regions as well as statewide totals. The four major winegrape regions and the approximate percentage of statewide production include North Coast (10%), Central Coast (8%), Northern San Joaquin Valley (20%), and Southern San Joaquin Valley (60%).

This project is guided by a steering committee and technical advisors that include representatives from nine regional winegrape associations (Calaveras Wine Association, Central Coast Vineyard Team, Clarksburg Wine Growers Association, Lodi-Woodbridge Winegrape Commission, Mendocino Winegrowers Alliance, Monterey County Grape Growers, Napa Valley Grape Growers, North Coast Grape Growers, and Sonoma County Grape Growers), the California Association of Winegrape Growers, American Vineyard Foundation, Robert Mondavi Winery, Allied Grape Growers, Department of Pesticide Regulation, UC Sustainable Agricultural Research and Education Program, UC Pesticide Impact Assessment Program, and US EPA Region 9.

# Section 6: Body of Report

## A. Production

California ranks first in US winegrapes accounting for over 90% of all production—the 1999 crop has been valued at approximately $1.6 billion (MKF Research, 2000). Winegrapes are grown in 42 of California's 58 counties on over 427,000 acres (CAWG, 2000). There are over 4,400 winegrape growers and 847 wineries that contribute to making wine the number one finished agricultural product in California with an estimated overall economic impact of $33 billion per year as a sum of total spending (MKF Research, 2000). Organic acreage accounts for about 1.5% of the total grape growing acreage, though this acreage is increasing (CCOF, 1999).

California's top six red winegrape varieties by acreage planted as reported in 1998 include Cabernet Sauvignon (12%), Zinfandel (12%), and Merlot (10%). The state's top white winegrape varieties include Chardonnay (22%), French Colombard (11%), and Chenin Blanc (5%) (CAWG, 2000). Thompson seedless grapes represented 15% of the wine grape crush.

The total cost to produce an acre of grapes ranges significantly with region, variety, end-user, ranging from $1,200 to $4,000 per acre including production and harvesting costs, land costs excluded (Crop/Pest Profile for California Wine Grapes, 1999).

## B. Production Regions

There are four major winegrape production regions in California. Over 80% of the crushed tonnage is from the northern and southern San Joaquin Valley regions, 10% from the north coast region and 8% from the central coast region (See **Table 1**). In addition, there are other smaller areas of winegrape production including the South Coast (San Diego and Riverside counties) and Coachella Valley (Riverside, Imperial, and San Bernadino counties).

## C. Cultural Practices

California produces about 100 different varieties of wine grapes, grown both in inland valleys with high temperatures and low humidity, and coastal valleys with cooler temperatures and higher humidity. There are more than 39 varieties of white wine grapes crushed for wine and more than 59 varieties of red wine grapes crushed in California.

Vines are pruned during the dormant season and, for cane-pruned varieties, canes are tied to the trellis wires before spring growth starts. Nitrogen and zinc fertilizers are applied in the spring, with potassium and boron fertilizers applied in fall through winter. Drip irrigation has recently become the preferred method of irrigation, though furrow irrigation still dominates in the southern San Joaquin Valley. Other production practices include canopy management (i.e., vine training, shoot positioning, leaf pulling, and trunk suckering), vineyard floor management (i.e., cover cropping, cultivation and mowing), pest management, and harvesting. Cultural practices such as irrigation and floor management can play a role in pest management. Once harvested, the grapes are transported to wineries where they are graded and crushed.

**Table 1.** Major winegrape production regions in California.

- **North Coast**: *About 10% of wine grape production.* Includes Lake, Mendocino, Napa, and Sonoma Counties. The North Coast region is located north of San Francisco and includes the region from Napa to Ukiah. This region is dominated by relatively flat valley floor vineyards prone to frost, with silty, clay loam soils relatively high in organic matter. The hillsides above the valley floor consist of steep to rolling land with variably shallow or rocky soils requiring contour planting or contour terracing to control erosion.

- **Central Coast**: *About 8% of wine grape production.* Includes Alameda, Monterey, San Luis Obispo, Santa Barbara, San Benito, Santa Cruz, and Santa Clara Counties. The Central Coast Region is located south of San Francisco, from Livermore to Santa Ynez. This area is comprised of rolling hillsides or benchlands with soils ranging from sandy loams to gravelly clay loams relatively high in organic matter.

- **Northern San Joaquin Valley**: *About 20% of wine grape production.* Includes San Joaquin, Calaveras, Amador, Sacramento, Merced, Stanislaus and Yolo Counties, with production almost exclusively focused on wine, but with a very small amount of raisin and table grape production. The Northern San Joaquin Valley region is the inland region from Sacramento to Merced. Light to medium textured soils with low organic matter predominate this region. Most vineyards are planted on flat land.

- **Southern San Joaquin Valley**: *About 60% of wine grape production.* Includes Fresno, Kings, Tulare, Kern, and Madera Counties. This region focuses more on a mixture of grape production, with table and raisin grapes being produced in addition to wine grapes. The Southern San Joaquin Valley region is the inland region from south of Merced to the Tehachapi Mountain Range. Light to medium textured soils with low organic matter predominate this region. Most vineyards are planted on flat land.

From *Crop/Pest Profile for California Wine Grapes*, 1999.

## D-L: Pest Management

In 1998 and 1999, the California Grape Advisory Team and their consultants worked to produce a comprehensive report titled *Crop/Pest Profile for Wine Grapes in California*. This 113-page report was published in November 1999. The report includes extensive information on pest biology, current management practices, promising alternatives, and recommendations for increasing the adoption of IPM and research needs. The document includes a statewide analysis of DPR's 1997 Pesticide Use Report (PUR) data.

This Winegrape PMA Evaluation focuses on analyzing the recently available DPR 1998 PUR data by major production regions to add value to the existing body of knowledge on winegrape pest management including: the *Crop/Pest Profile for Wine Grapes in California,* UC IPM Pest

Management Guidelines for Grapes (www.ipm.ucdavis.edu), and other published winegrape pest management resources. Following the analysis of the 1998 winegrape PUR data, significant portions of the *Crop/Pest Profile for Wine Grapes in California* are included in this pest management evaluation to insure a comprehensive winegrape pest management evaluation. The entire *Crop/Pest Profile for Wine Grapes in California* report can be downloaded from the CAWG web site at www.cawg.org.

**Pest Management Overview and Analysis of 1998 Pesticide Use Reports**

An overview of major grape pests, commonly used pesticides for their management, and key concerns potentially impacting the future use and availability of some of these materials is presented in **Table 2**. In addition, grapes have a number of vertebrate pests including birds, rodents, deer, and coyotes.

Three distinct outputs from the 1998 winegrape PUR data are presented in tabular (**Tables 3-7**) and graphical (**Figures 2-14**) formats including: (1) percent acres treated, (2) median number of applications per site (*graphs produced only when some of the values are greater than 1*), and (3) median application rate in lbs./acre. Graphical results are presented in two different formats: (a) chemical material grouped by production region and sorted from highest to lowest use based on percent acres treated, and (b) Four major regions and statewide total for the most commonly used materials sorted by highest to lowest use based on percent acres treated. The percent acres treated results are based on a maximum estimate of the total acres treated by assuming multiple application overlap as little as possible in the data cleaning algorithms.

**Figure 1** presents an overview of the data analysis protocols and resulting outputs from DPR's 1998 winegrape PUR data. A full description of data cleaning algorithms and assumptions can be found in **Appendix 1**. A full set of the processed 1998 PUR data by major production region can be found in **Appendix 2**.

**Table 2.** Major pests of grapes, commonly used pesticides, and potential pesticide key concerns in brackets

| Pests | Most Commonly Used Pesticides (Key Concerns) |
|---|---|
| **A. Insects** | |
| • Omnivorous leafroller (OLR) (Lepidoptera: Tortricidae) | • Cryolite (Wineries), Bt, Imidan (FQPA I), Sevin (FQPA I) |
| • Leafhoppers (*Erythroneura* spp., Homoptera: Cicadellidae) | • Provado, Dimethoate (FQPA I), Sevin (FQPA I) |
| • Sharpshooters (Homoptera: Cicadellidae) | • Provado, Dimethoate (FQPA I) |
| • Other Lepidoptera (Orange Tortrix, others) | • Cryolite (Wineries), Bt, Sevin (FQPA I) |
| • Grape phylloxera (Homoptera: Phylloxeridae) | • Furadan (FQPA I), Enzone |
| • Mealybugs (Homoptera: Pseudococcidae) | • Lorsban (FQPA I), Lannate (FQPA I), Admire |
| • Thrips (Thysanoptera: Thripidae) | • Dimethoate (FQPA I), Sevin (FQPA I) |
| **B. Mites** | |
| • Spider mites (Acari: Tetranychidae) | • Omite (FQPA I), Kelthane (FQPA I), Vendex |
| **C. Weeds** | |
| • Over 24 commonly found weed species | • Round-up, Goal (FQPA I), Simazine (Water Quality & FQPA I), Gramoxone (FQPA I), Surflan (FQPA I), Diuron (Water Quality), Solicam (Water Quality), Treflan (FQPA I), Prowl (FQPA I), Poast, Devrinol, Fusilade, 2,4-D (FQPA I), Visor |
| **D. Diseases** | |
| • Powdery mildew (*Uncinula necator*) | • Sulfur dust (DPR), Rally (FQPA I), Wettable Sulfur, Rubigan, Abound, Procure (FQPA I), Kaligreen, Copper Hydroxide, Bayleton (FQPA I), AQ 10 |
| • Botrytis and other bunch rots (*Botrytis cineria, other species*) | • Rovral (FQPA I), Dithane (FQPA I), , Vangard, Benlate (FQPA I), Botran, Manex, Copper Hydroxide, Captan (Wineries, FQPA I) |
| • Pierce's disease (*Xylella fastidiosa)* | • Some materials used for vector control |
| • Phomopsis *(Phomopsis viticola*) | • Sulfur, Abound, Dithane (FQPA I), Lime-Sulfur, Copper Hydroxide, Ziram, Captan (Wineries, FQPA I) |
| • Eutypa and other canker diseases (*Eutypa late, Botryodiplodia theobromae*) | • Benlate (FQPA I) |
| • Measles (*Phaeoacremonium* spp.) | |
| **E. Nematodes** | |
| • Root knot nematode (*Meloidogyne* spp.), Citrus nematode *(Tylenchulus semipenetrans),* Root lesion nematode *(Pratylenchus vulnus),* Dagger nematode (*Xiphenema* spp.)Ring nematode (*Criconemella xenoplax*), | • Enzone, Nemacur (FQPA I), Furadan (FQPA I), Ditera, Methyl Bromide, Vapam, Telone. |

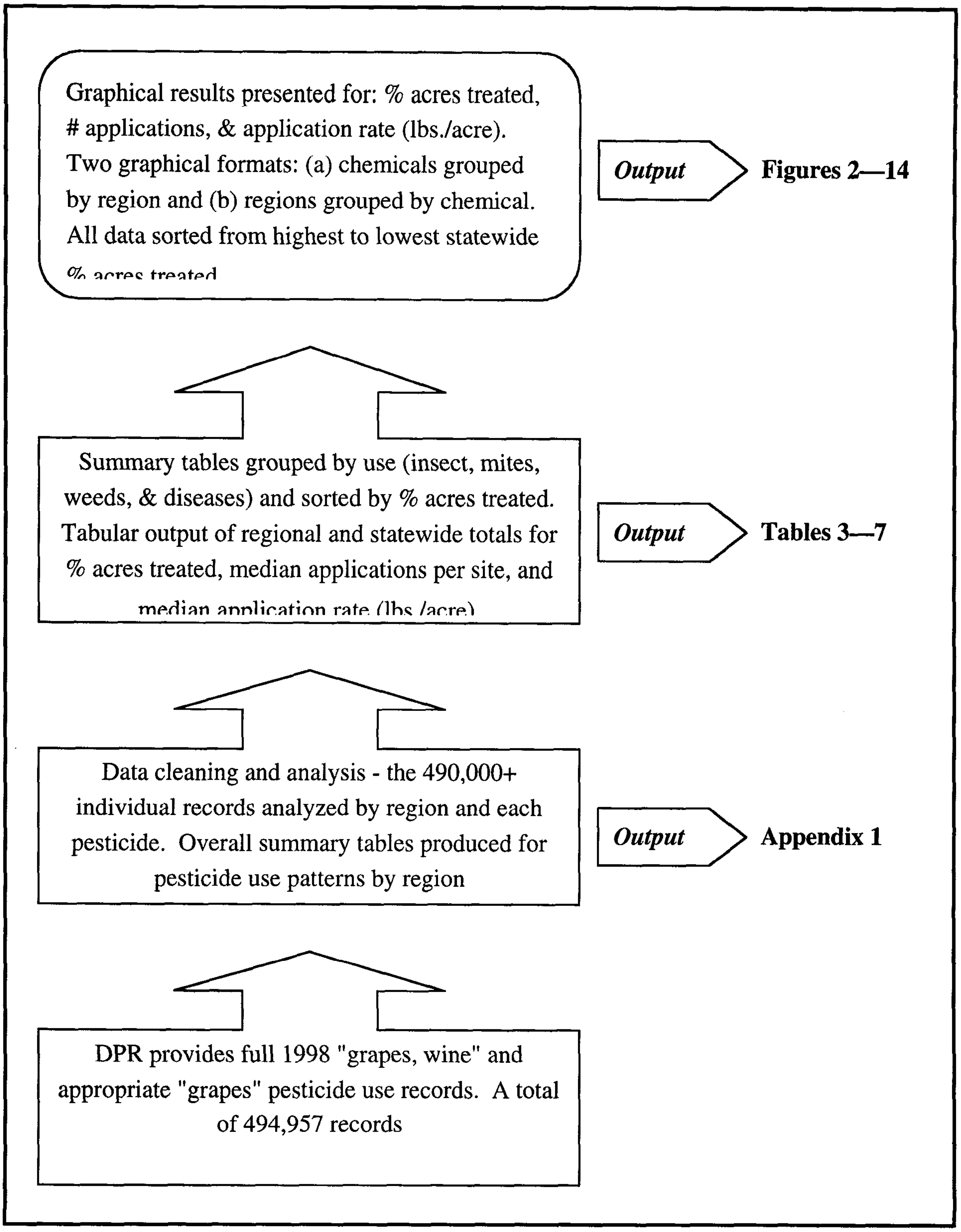


**Figure 1.** Overview of the data analysis protocols and resulting outputs from DPR's 1998 winegrape PUR data.

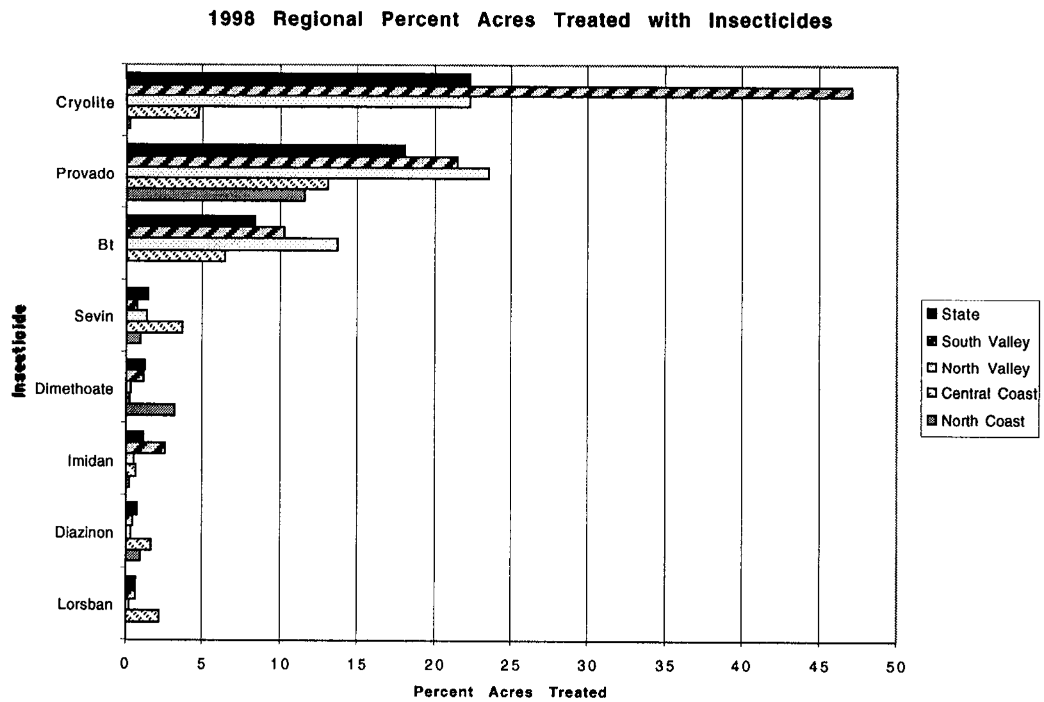


**Figure 2a.** 1998 regional ***percent acres treated*** grouped by insecticide.

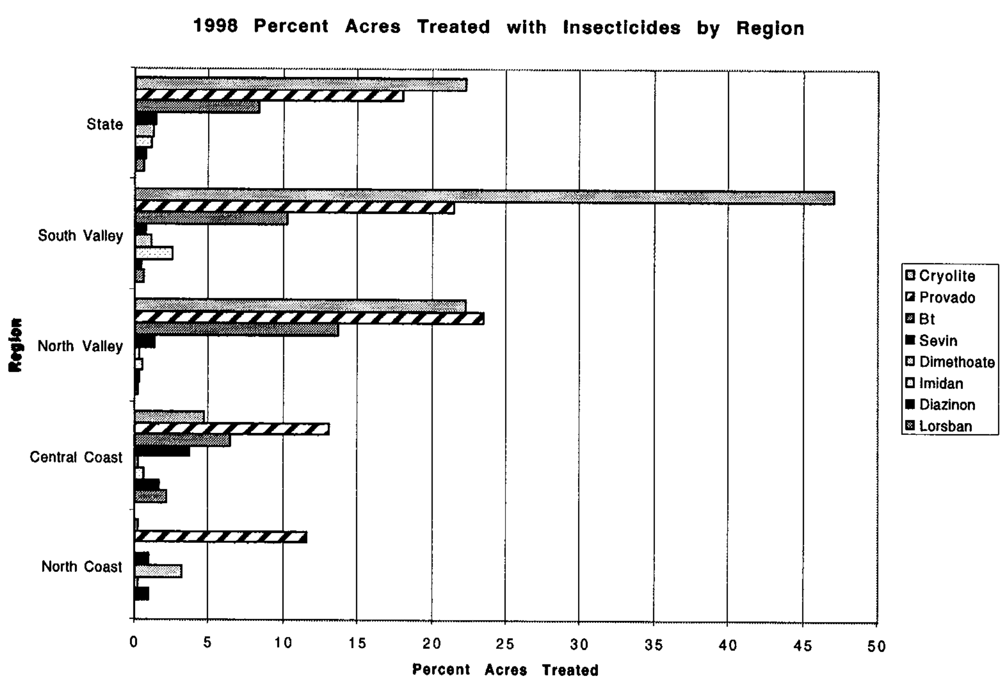


**Figure 2b.** 1998 ***percent acres treated*** with insecticides grouped by region.

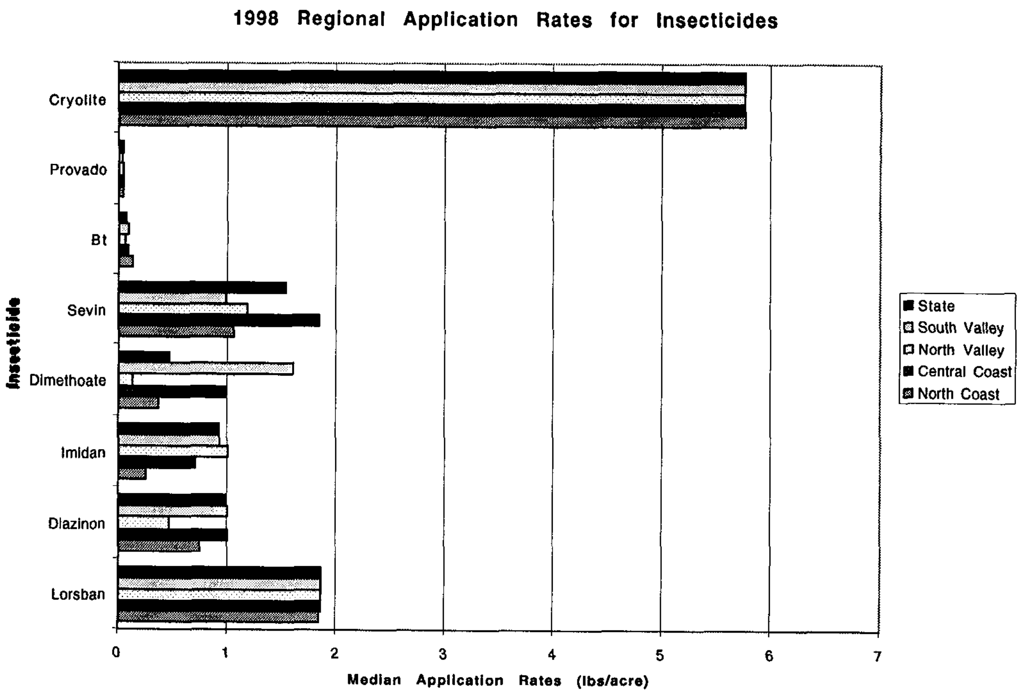


**Figure 3a.** 1998 regional median ***application rate*** (lbs./acre) for insecticides.

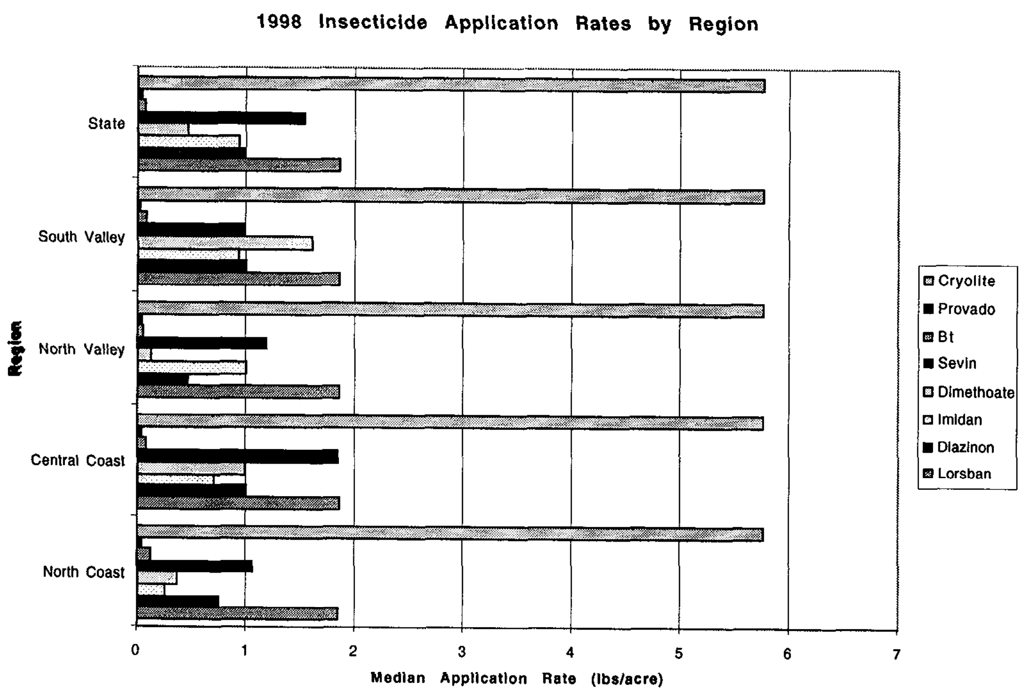


**Figure 3b.** 1998 median ***application rate*** (lbs./acre) by insecticides grouped by region.

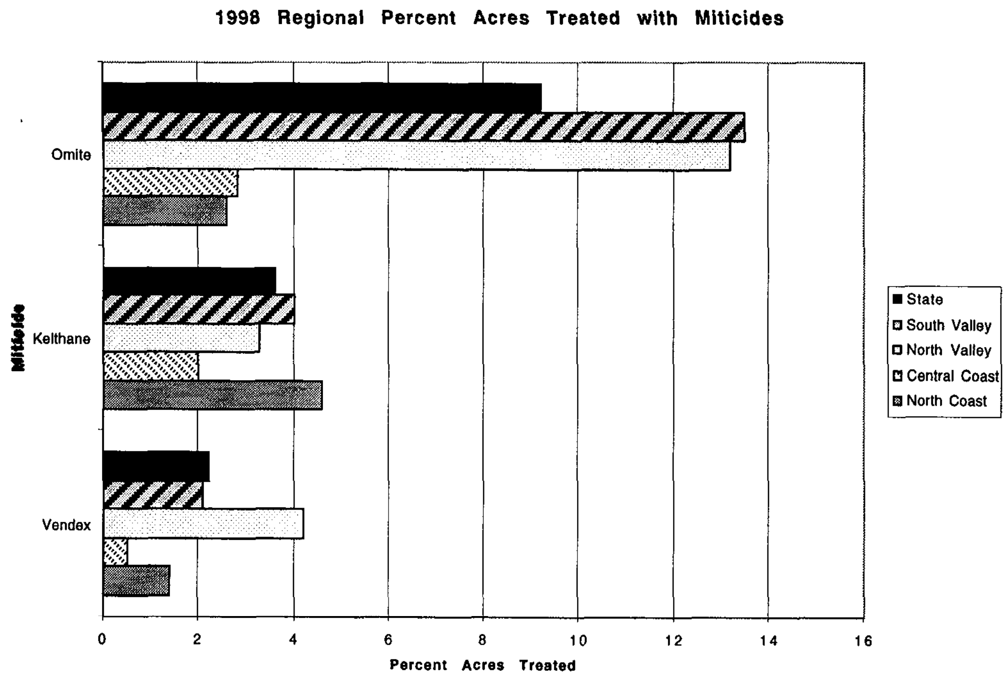


**Figure 4a.** 1998 regional ***percent acres treated*** grouped by miticide.

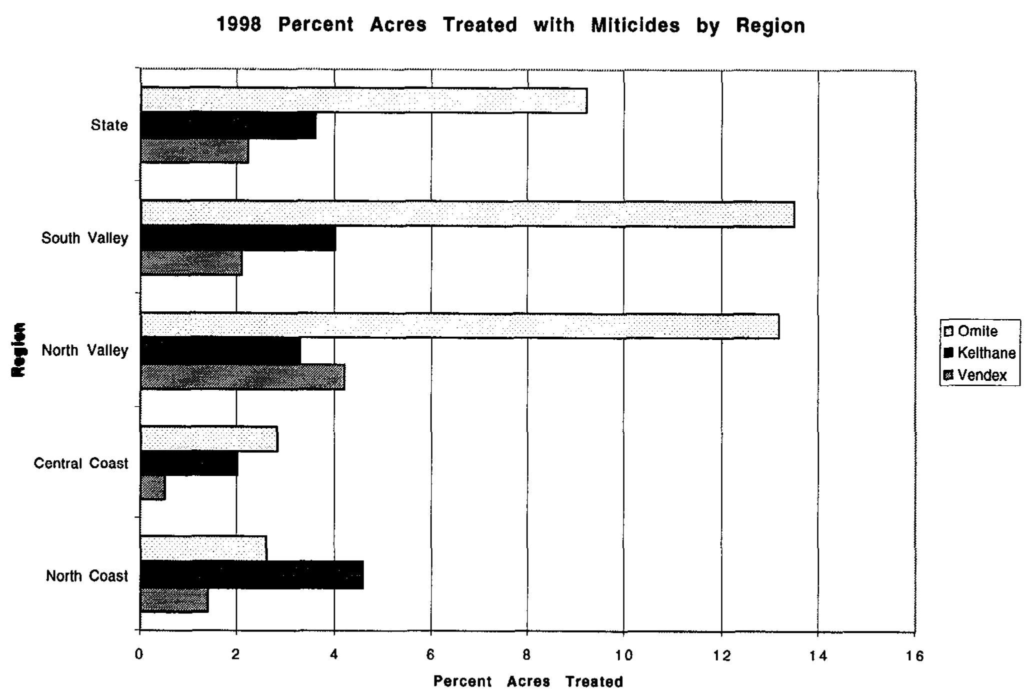


**Figure 4b.**. 1998 ***percent acres treated*** with miticides grouped by region.

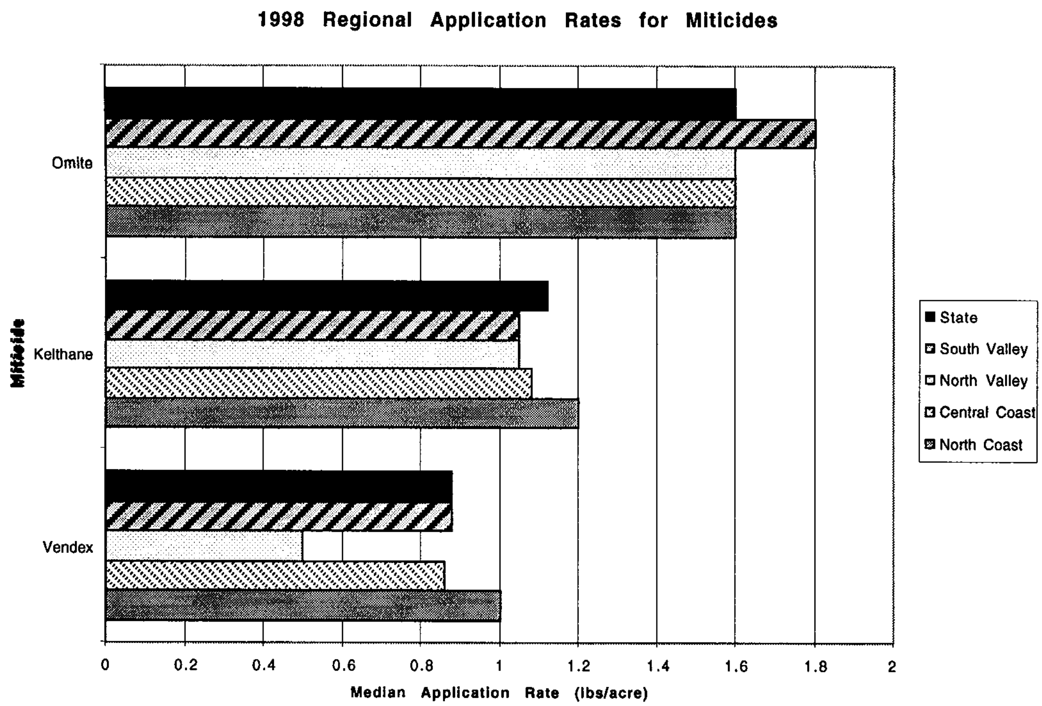


**Figure 5a.** 1998 regional median ***application rate*** (lbs./acre) by miticides

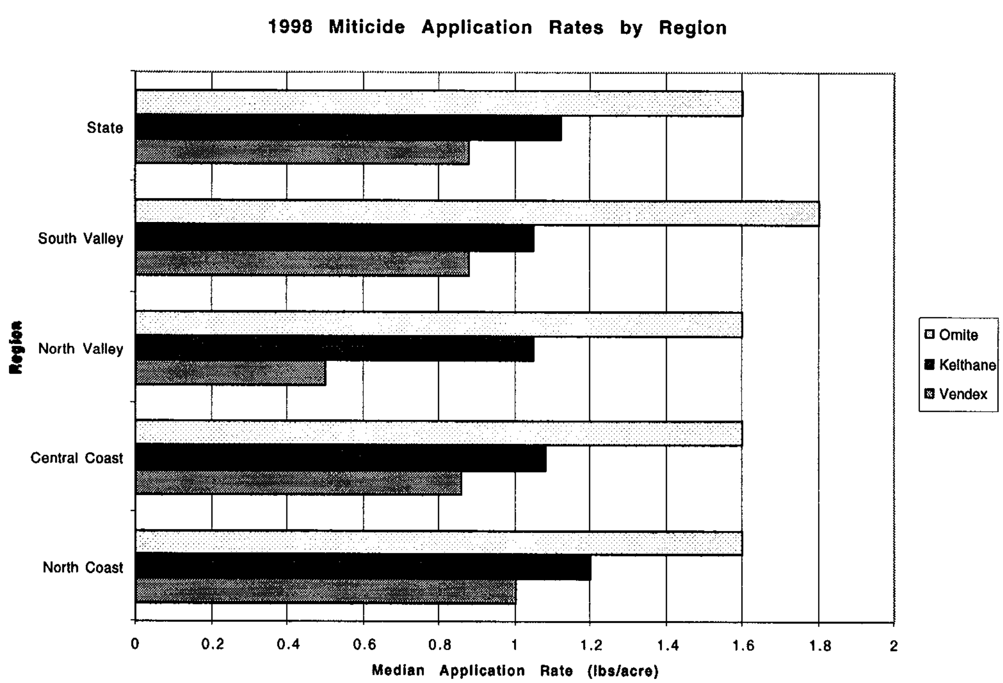


**Figure 5b.** 1998 median ***application rate*** (lbs./acre) by insecticides grouped by region.

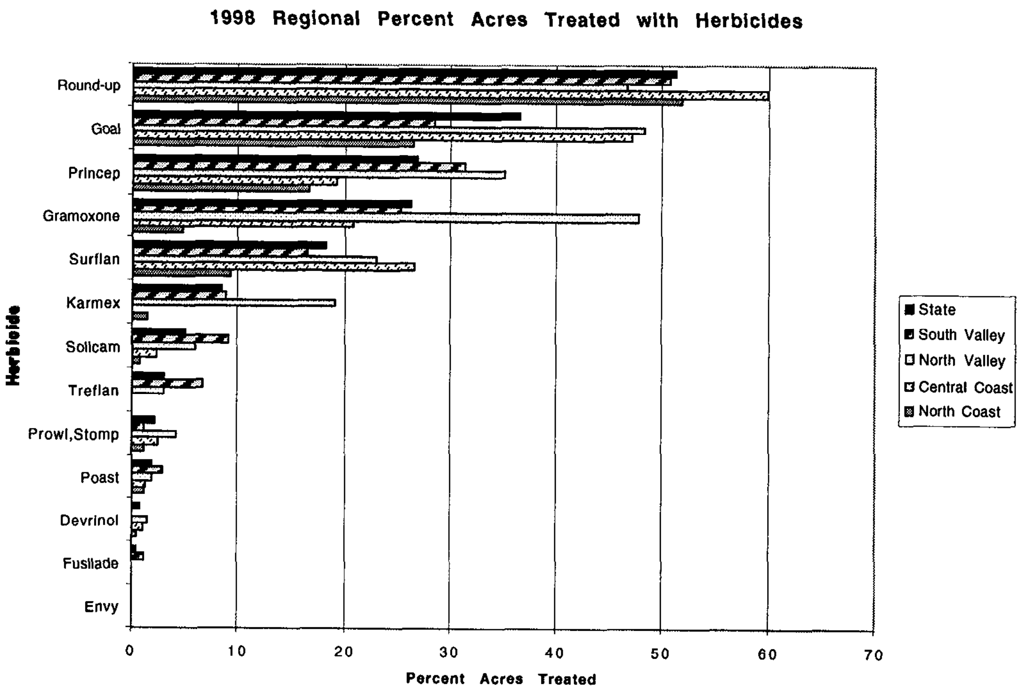


**Figure 6a.** 1998 regional ***percent acres treated*** for weeds grouped by material.

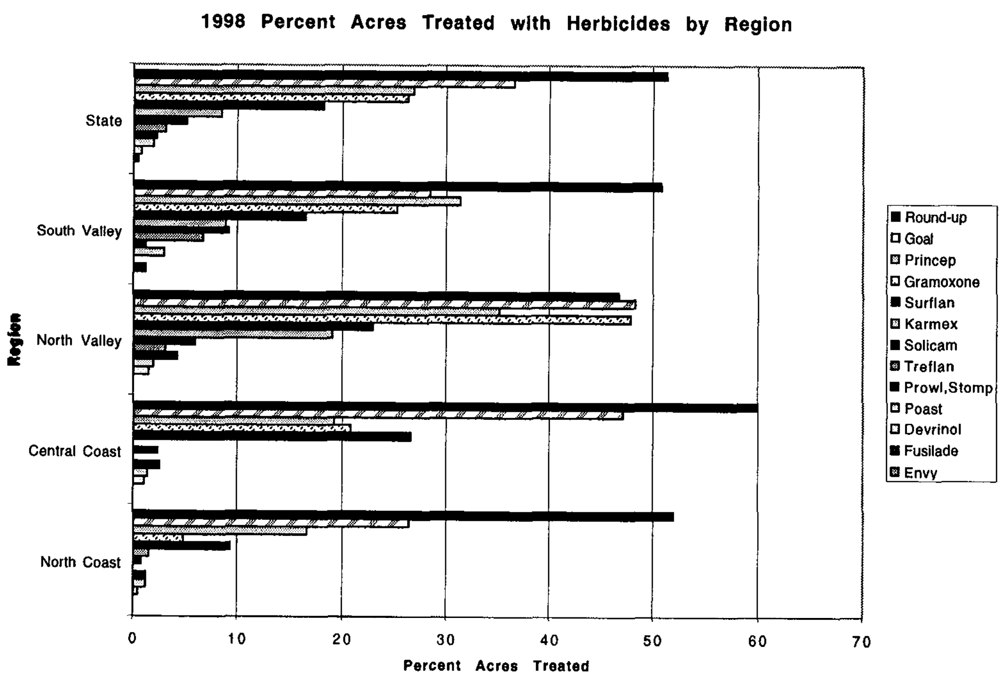


**Figure 6b.** 1998 ***percent acres treated*** for weeds grouped by region.

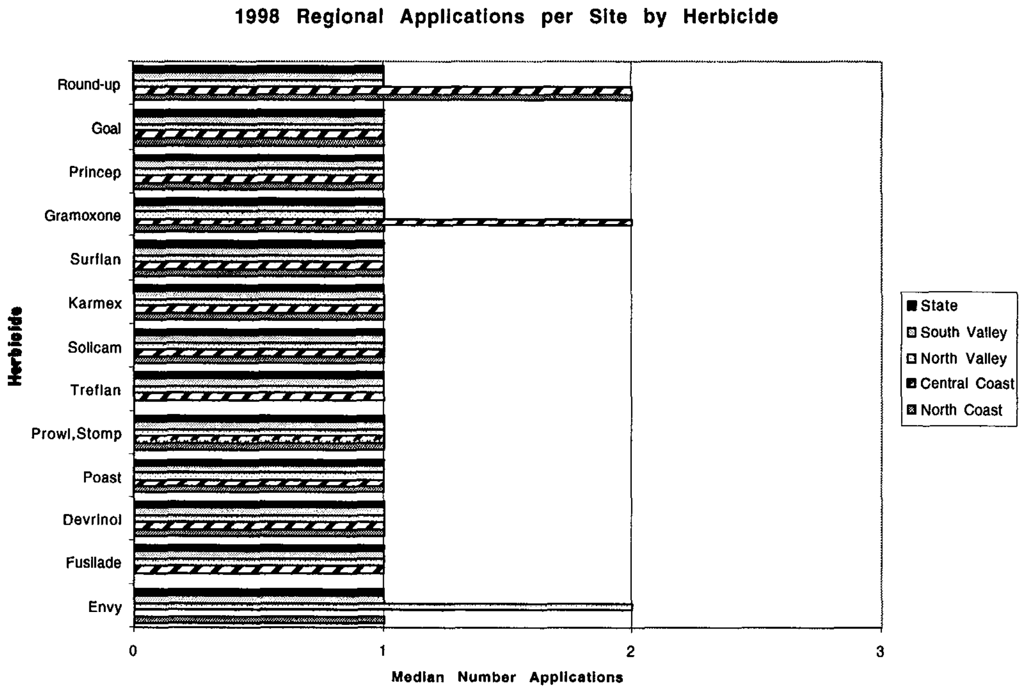


**Figure 7a.** 1998 regional median number of ***applications per site*** weeds by material.

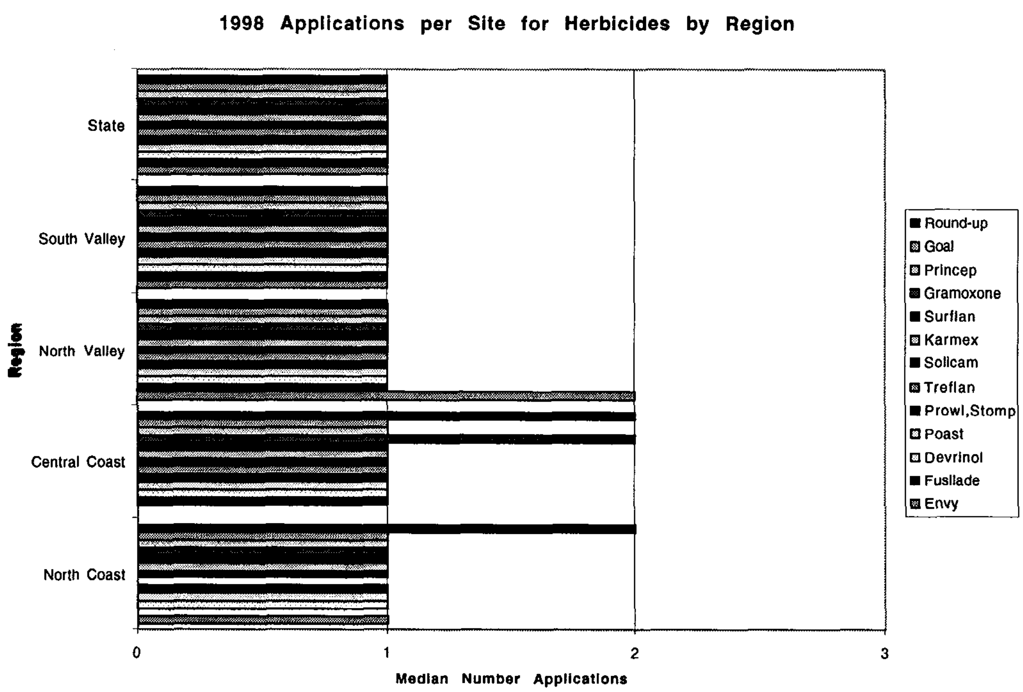


**Figure 7b.** 1998 median number of ***applications per site*** for weeds grouped by region.

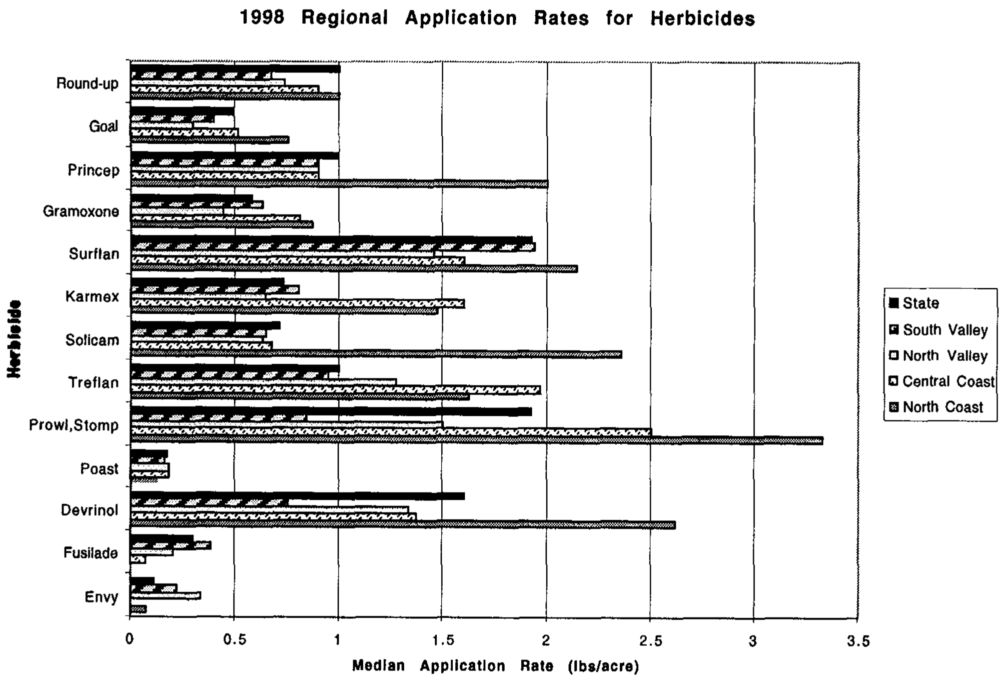


**Figure 8a.** 1998 regional median ***application rate*** (lbs./acre) for herbicides.

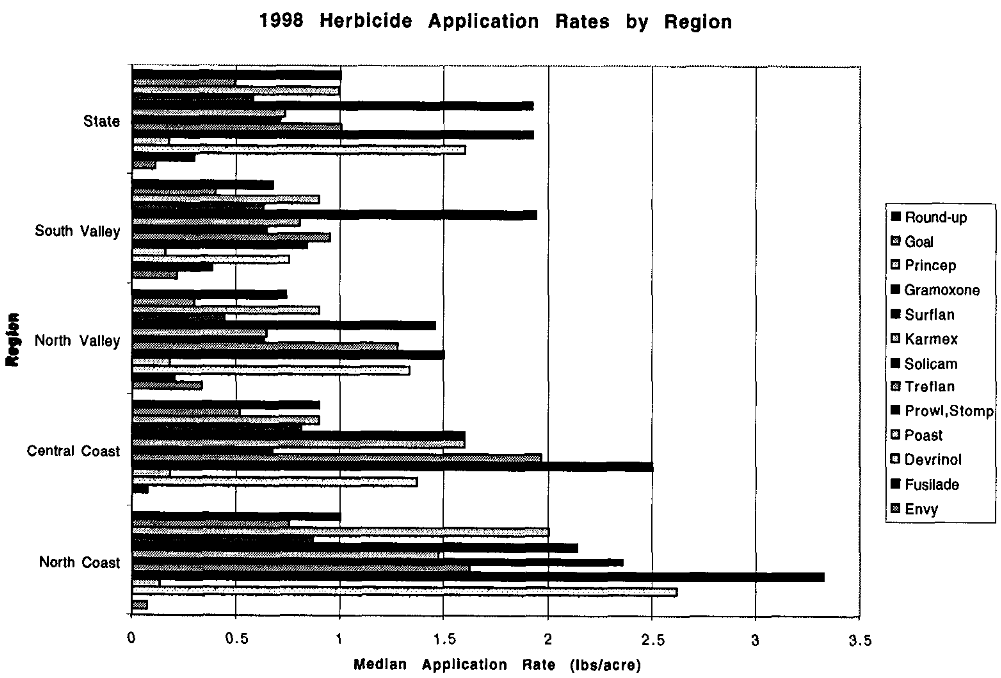


**Figure 8b.** 1998 median ***application rate*** (lbs./acre) for herbicides grouped by region.

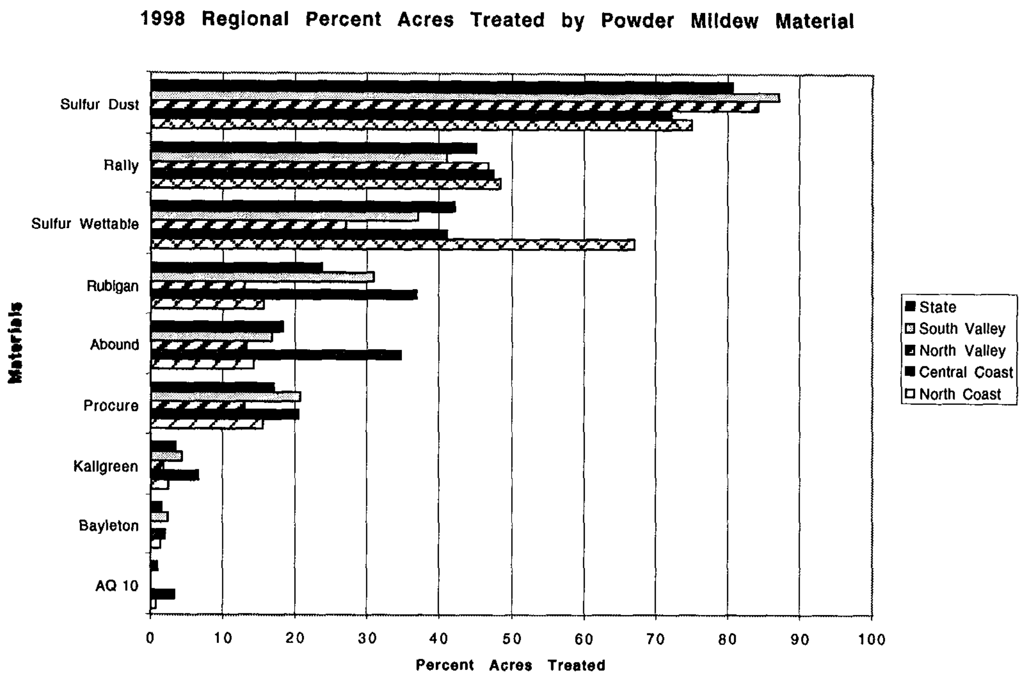


**Figure 9a.** 1998 regional *percent acres treated* grouped by powdery mildew materials.

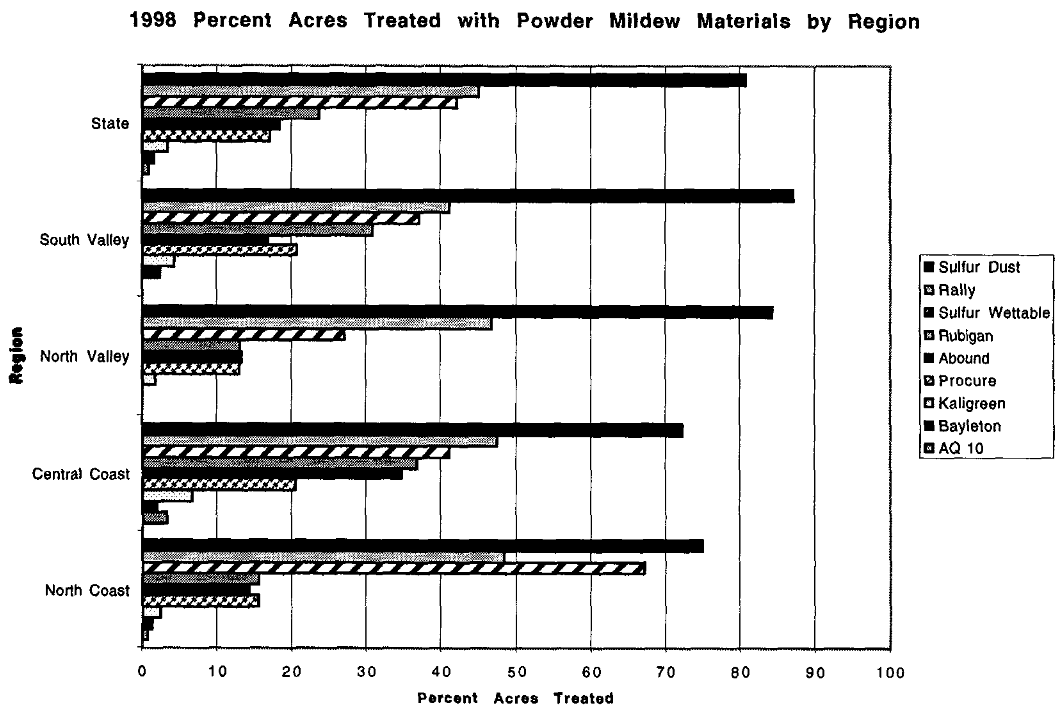


**Figure 9b.** . 1998 *percent acres treated* by powdery mildew materials grouped by region.

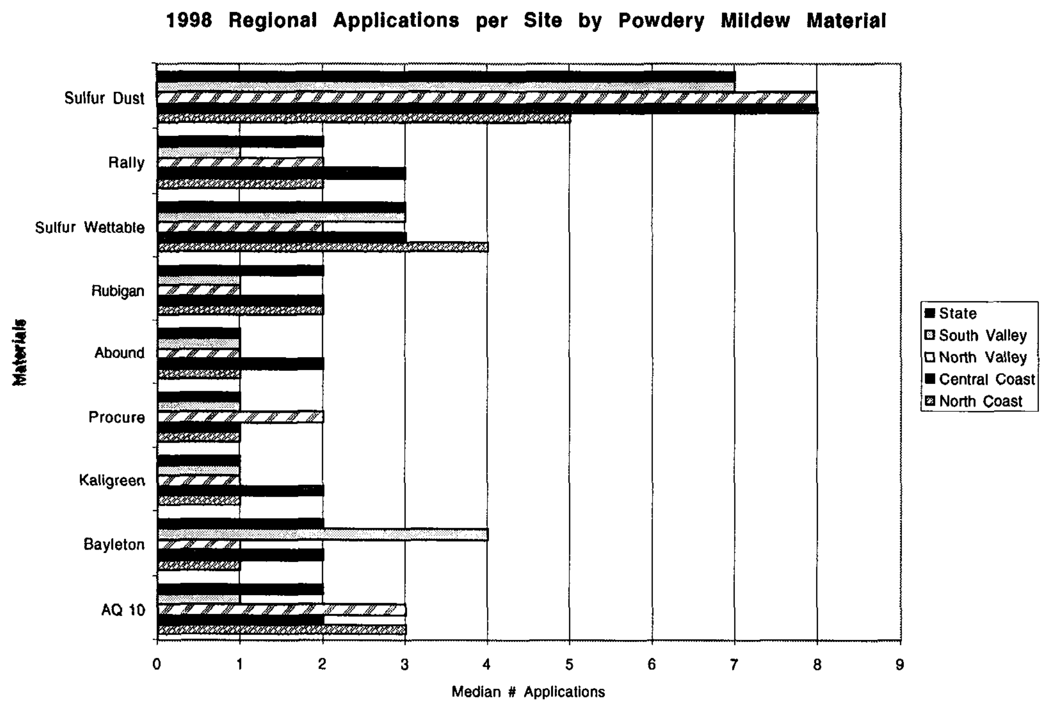


**Figure 10a.** 1998 regional median number of ***applications per site*** for powdery mildew materials.

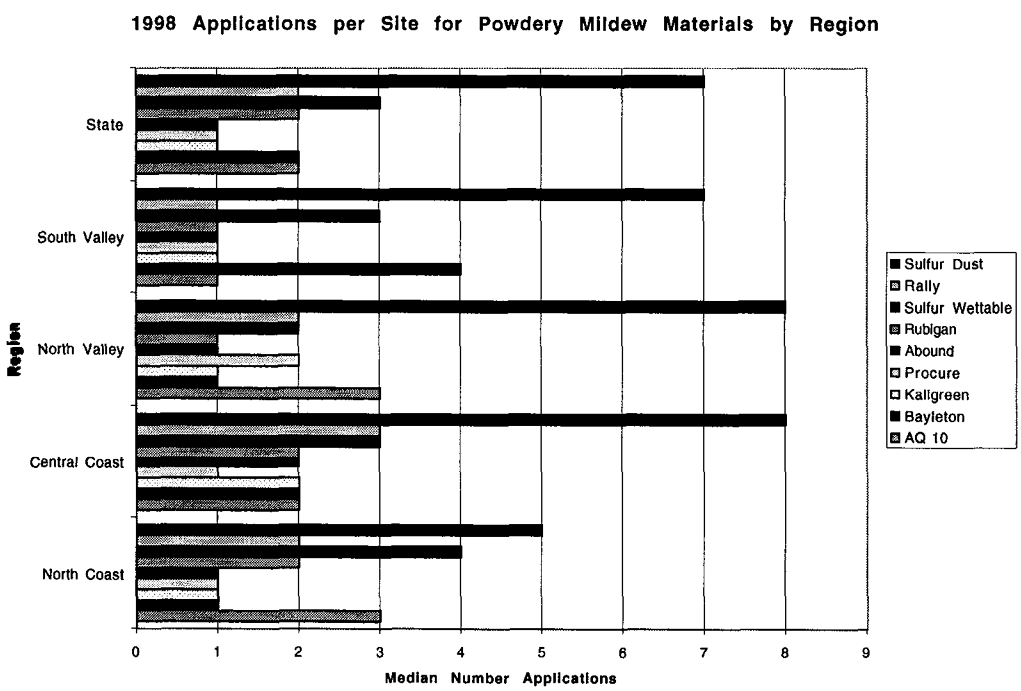


**Figure 10b.** 1998 median number of ***applications per site*** for powdery mildew materials grouped by region.

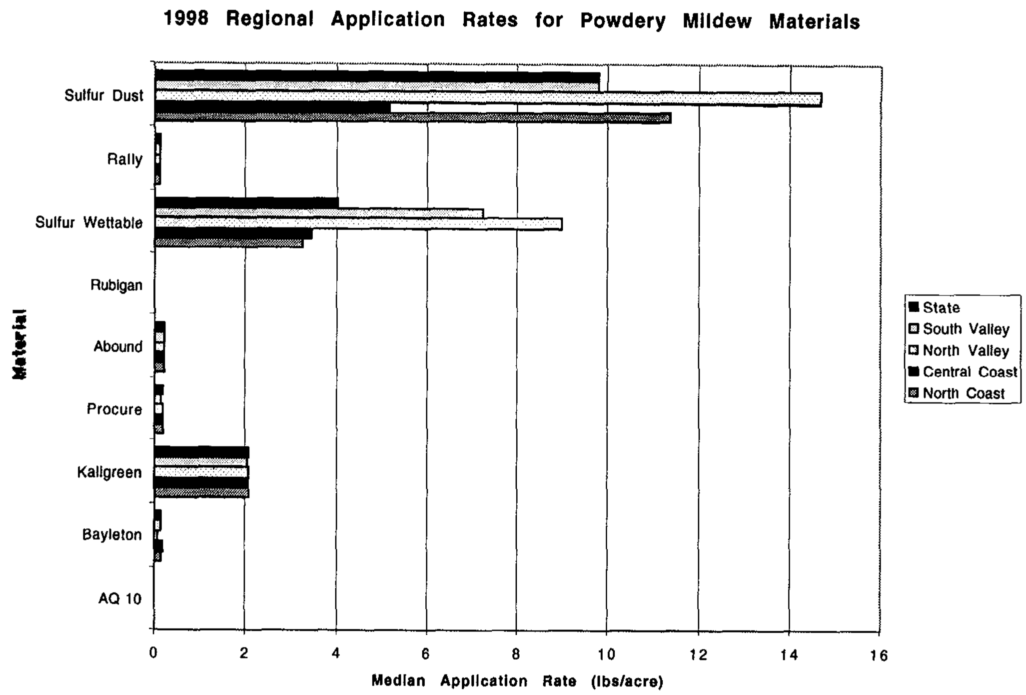


**Figure 11a.** 1998 regional median ***application rate*** (lbs./acre) for powdery mildew materials.

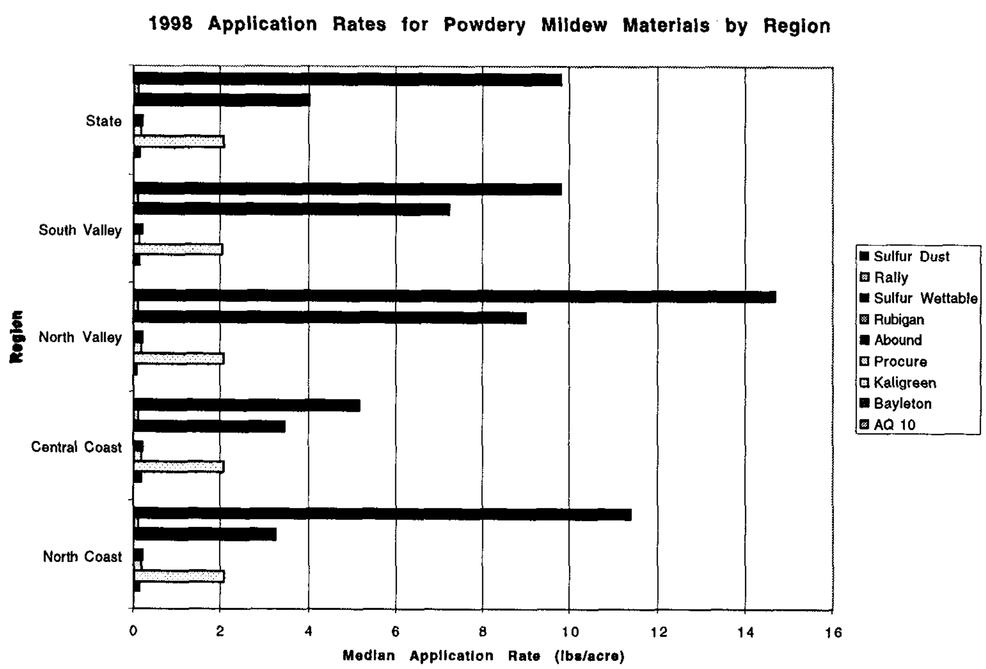


**Figure 11b.** 1998 median ***application rate*** (lbs./acre) for powdery mildew materials grouped by region.

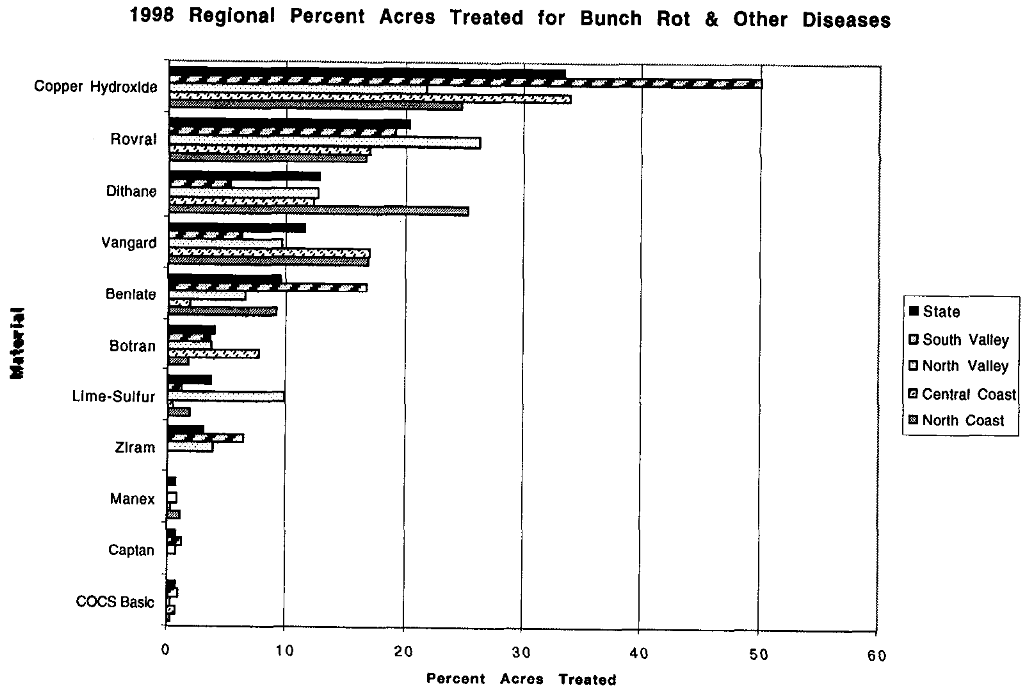


**Figure 12a.** 1998 regional ***percent acres treated*** for Bunch Rot and other diseases.

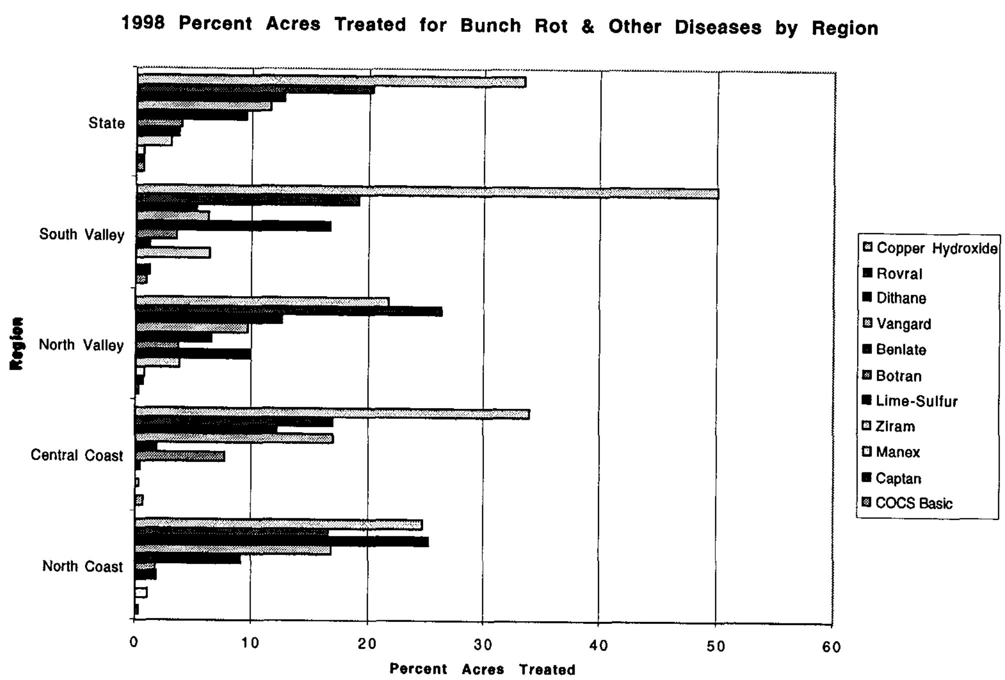


**Figure 12b.** 1998 ***percent acres treated*** for Bunch Rot and other diseases grouped by region.

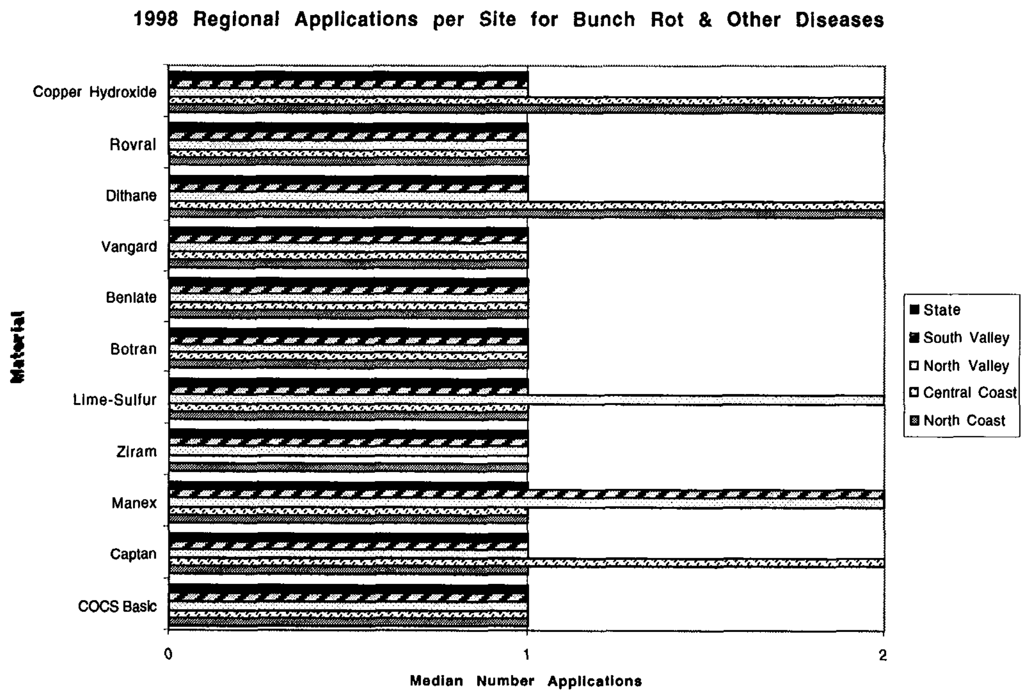


**Figure 13a.** 1998 regional median number of ***applications per site*** for Bunch Rot and other diseases.

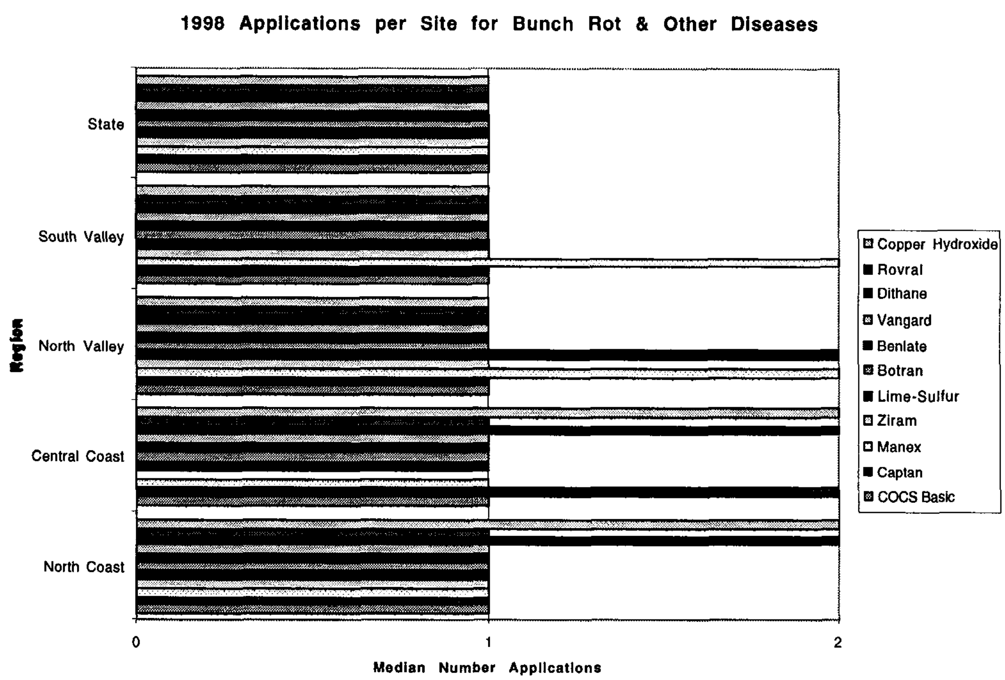


**Figure 13b.** 1998 median number of ***applications per site*** for Bunch Rot and other diseases grouped by region.

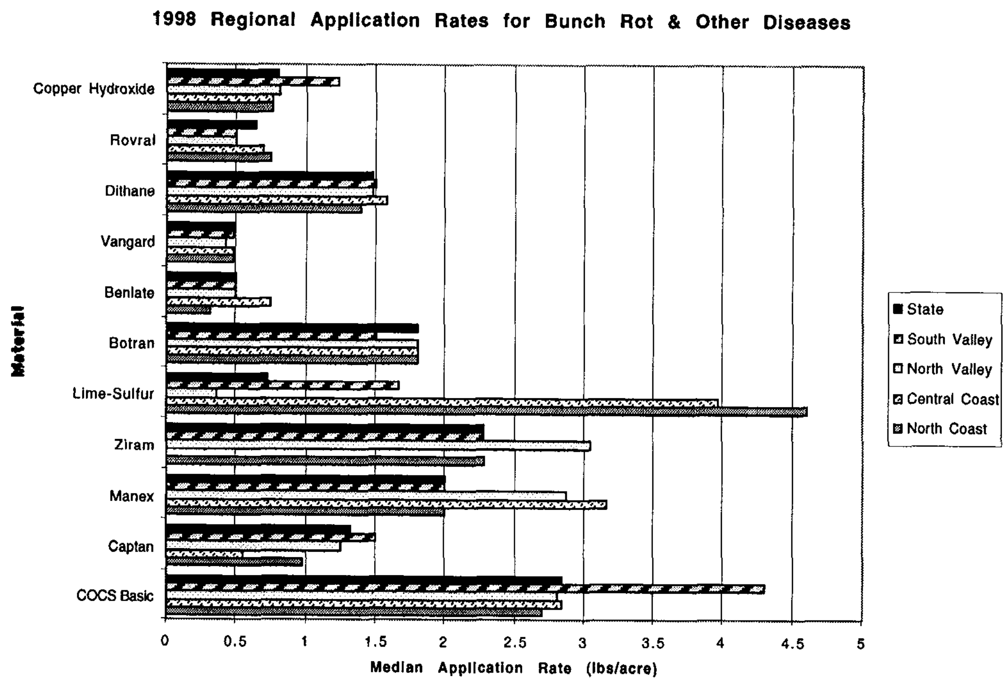


**Figure 14a.** 1998 regional median ***application rate*** (lbs./acre) for Bunch Rot and other diseases.

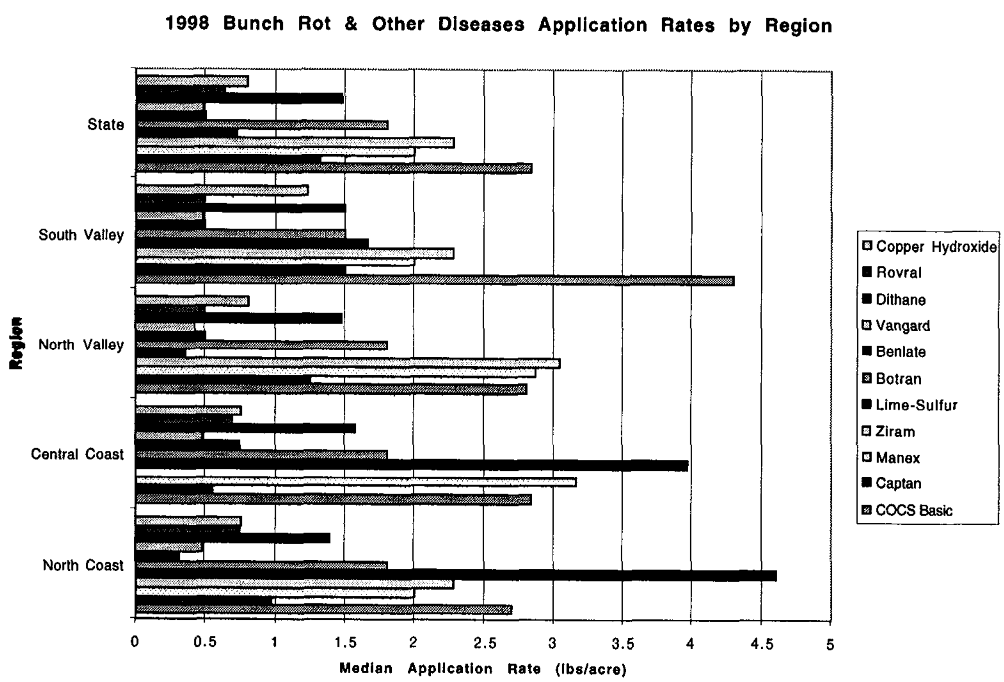


**Figure 14b.** 1998 median ***application rate*** (lbs./acre) for Bunch Rot and other diseases grouped by region.

**Table 3.** (A) Percent acres treated, (B) number of applications per site, and (C) application rate for the most commonly used insecticides

**A. Percent Acres Treated**

| Region | Cryolite | Imidacloprid, Provado | Bt | Carbaryl, Sevin | Dimethoate, Clean Crop | Phosmet, Imidan | Diazinon | Chlorpyrifos, Lorsban |
|---|---|---|---|---|---|---|---|---|
| North Coast | 0.2 | 11.5 | 0 | 0.9 | 3.1 | 0.2 | 0.9 | 0.1 |
| Central Coast | 4.7 | 13.1 | 6.4 | 3.6 | 0.2 | 0.6 | 1.6 | 2.1 |
| North Valley | 22.3 | 23.5 | 13.7 | 1.3 | 0.3 | 0.5 | 0.3 | 0.2 |
| South Valley | 47.1 | 21.5 | 10.2 | 0.7 | 1.1 | 2.5 | 0.4 | 0.6 |
| **State** | **22.3** | **18** | **8.3** | **1.4** | **1.2** | **1.1** | **0.7** | **0.6** |

**B. Median Number of Applications per Site**

| Region | Cryolite | Imidacloprid, Provado | Bt | Carbaryl, Sevin | Dimethoate, Clean Crop | Phosmet, Imidan | Diazinon | Chlorpyrifos, Lorsban |
|---|---|---|---|---|---|---|---|---|
| North Coast | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Central Coast | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| North Valley | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| South Valley | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **State** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |

**C. Median Application Rate (lbs./acre)**

| Region | Cryolite | Imidacloprid, Provado | Bt | Carbaryl, Sevin | Dimethoate, Clean Crop | Phosmet, Imidan | Diazinon | Chlorpyrifos, Lorsban |
|---|---|---|---|---|---|---|---|---|
| North Coast | 5.76 | 0.04 | 0.13 | 1.05 | 0.37 | 0.25 | 0.75 | 1.84 |
| Central Coast | 5.76 | 0.04 | 0.08 | 1.85 | 0.98 | 0.7 | 1 | 1.86 |
| North Valley | 5.76 | 0.04 | 0.05 | 1.19 | 0.12 | 1 | 0.46 | 1.86 |
| South Valley | 5.76 | 0.03 | 0.08 | 0.99 | 1.6 | 0.93 | 1 | 1.86 |
| **State** | **5.76** | **0.04** | **0.07** | **1.53** | **0.46** | **0.93** | **0.99** | **1.86** |

**Table 4.** (A) Percent acres treated, (B) number of applications per site, and (C) application rate for all miticides

**A. Percent Acres Treated**

| Region | Propargite, Omite | Fenbutatin-oxide, Vendex | Dicofol, Kelthane |
|---|---|---|---|
| North Coast | 2.6 | 1.4 | 4.6 |
| Central Coast | 2.8 | 0.5 | 2 |
| North Valley | 13.2 | 4.2 | 3.3 |
| South Valley | 13.5 | 2.1 | 4 |
| **State** | **9.2** | **2.2** | **3.6** |

**B. Median Number of Applications per Site**

| Region | Propargite, Omite | Fenbutatin-oxide, Vendex | Dicofol, Kelthane |
|---|---|---|---|
| North Coast | 1 | 1 | 1 |
| Central Coast | 1 | 1 | 1 |
| North Valley | 1 | 1 | 1 |
| South Valley | 1 | 1 | 1 |
| **State** | **1** | **1** | **1** |

**C. Median Application Rate (lbs./acre)**

| Region | Propargite, Omite | Fenbutatin-oxide, Vendex | Dicofol, Kelthane |
|---|---|---|---|
| North Coast | 1.6 | 1 | 1.2 |
| Central Coast | 1.6 | 0.86 | 1.08 |
| North Valley | 1.6 | 0.5 | 1.05 |
| South Valley | 1.8 | 0.88 | 1.05 |
| **State** | **1.6** | **0.88** | **1.12** |

**Table 5.** (A) Percent acres treated, (B) number of applications per site, and (C) application rate for the most commonly used herbicides

**A. Percent Acres Treated**

| Region | Glyphosate, Round-up | Oxyfluorfen, Goal | Simazine, Princep | Paraquat, Gramoxone | Oryzalin, Surflan | Diuron, Karmex | Norflurazon, Solicam | Trifluralin, Treflan |
|---|---|---|---|---|---|---|---|---|
| North Coast | 51.8 | 26.4 | 16.6 | 4.8 | 9.3 | 1.5 | 0.70 | 0 |
| Central Coast | 59.9 | 47.1 | 19.2 | 20.8 | 26.5 | 0.1 | 2.30 | 0.1 |
| North Valley | 46.6 | 48.2 | 35.1 | 47.8 | 23 | 19.1 | 5.90 | 3 |
| South Valley | 50.7 | 28.5 | 31.3 | 25.2 | 16.4 | 8.8 | 9.10 | 6.6 |
| **State** | **51.3** | **36.5** | **26.8** | **26.2** | **18.2** | **8.4** | **5.10** | 3 |

**B. Median Number of Applications per Site**

| Region | Glyphosate, Round-up | Oxyfluorfen, Goal | Simazine, Princep | Paraquat, Gramoxone | Oryzalin, Surflan | Diuron, Karmex | Norflurazon, Solicam | Trifluralin, Treflan |
|---|---|---|---|---|---|---|---|---|
| North Coast | 2 | 1 | 1 | 1 | 1 | 1 | 1 | Missing data |
| Central Coast | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 |
| North Valley | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| South Valley | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **State** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |

**C. Median Application Rate (lbs./acre)**

| Region | Glyphosate, Round-up | Oxyfluorfen, Goal | Simazine, Princep | Paraquat, Gramoxone | Oryzalin, Surflan | Diuron, Karmex | Norflurazon, Solicam | Trifluralin, Treflan |
|---|---|---|---|---|---|---|---|---|
| North Coast | 1.00 | 0.75 | 2 | 0.87 | 2.14 | 1.47 | 2.36 | 1.62 |
| Central Coast | 0.90 | 0.51 | 0.9 | 0.81 | 1.6 | 1.6 | 0.67 | 1.97 |
| North Valley | 0.74 | 0.3 | 0.9 | 0.44 | 1.45 | 0.64 | 0.63 | 1.27 |
| South Valley | 0.67 | 0.4 | 0.9 | 0.63 | 1.94 | 0.8 | 0.64 | 0.95 |
| **State** | **1.00** | **0.49** | **0.99** | **0.58** | **1.92** | **0.73** | **0.71** | 1 |

**Table 6.** (A) Percent acres treated, (B) number of applications per site, and (C) application rate for the most commonly used fungicides to manage powdery mildew

**A. Percent Acres Treated**

| Region | Sulfur Dust | Myclobutanil, Rally | Sulfur Wettable | Fenarimol, Rubigan | Azoxystrobin, Abound | Triflumizole, Procure | Potassium bicarbonate, Kaligreen | Triadimefon, Bayleton | AQ 10 |
|---|---|---|---|---|---|---|---|---|---|
| North Coast | 75 | 48.5 | 67 | 15.5 | 14.2 | 15.5 | 2.3 | 1.3 | 0.6 |
| Central Coast | 72.1 | 47.3 | 40.9 | 36.8 | 34.6 | 20.3 | 6.5 | 2 | 3.1 |
| North Valley | 84.2 | 46.7 | 27 | 13 | 13.1 | 13 | 1.8 | 0.1 | 0 |
| South Valley | 87.1 | 41 | 37 | 30.7 | 16.8 | 20.6 | 4.2 | 2.3 | 0.2 |
| **State** | **80.7** | **45** | **42** | **23.6** | **18.3** | **17** | **3.5** | **1.4** | **0.8** |

**B. Median Number of Applications per Site**

| Region | Sulfur Dust | Myclobutanil, Rally | Sulfur Wettable | Fenarimol, Rubigan | Azoxystrobin, Abound | Triflumizole, Procure | Potassium bicarbonate, Kaligreen | Triadimefon, Bayleton | AQ 10 |
|---|---|---|---|---|---|---|---|---|---|
| North Coast | 5 | 2 | 4 | 2 | 1 | 1 | 1 | 1 | 3 |
| Central Coast | 8 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 |
| North Valley | 8 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 3 |
| South Valley | 7 | 1 | 3 | 1 | 1 | 1 | 1 | 4 | 1 |
| **State** | **7** | **2** | **3** | **2** | **1** | **1** | **1** | **2** | **2** |

**C. Median Application Rate (lbs./acre)**

| Region | Sulfur Dust | Myclobutanil, Rally | Sulfur Wettable | Fenarimol, Rubigan | Azoxystrobin, Abound | Triflumizole, Procure | Potassium bicarbonate, Kaligreen | Triadimefon, Bayleton | AQ 10 |
|---|---|---|---|---|---|---|---|---|---|
| North Coast | 11.36 | 0.1 | 3.23 | 0.03 | 0.2 | 0.16 | 2.05 | 0.13 | 0 |
| Central Coast | 5.16 | 0.1 | 3.44 | 0.03 | 0.21 | 0.16 | 2.05 | 0.16 | 0 |
| North Valley | 14.7 | 0.1 | 8.98 | 0.03 | 0.21 | 0.16 | 2.05 | 0.06 | 0 |
| South Valley | 9.8 | 0.1 | 7.24 | 0.04 | 0.21 | 0.15 | 2.02 | 0.13 | 0 |
| **State** | **9.8** | **0.1** | **4** | **0.03** | **0.21** | **0.16** | **2.05** | **0.13** | **0** |

**Table 7.** (A) Percent acres treated, (B) number of applications per site, and (C) application rate for the most commonly used fungicides to manage Botrytis bunch rot and other grape diseases

**A. Percent Acres Treated**

| Region | Copper Hydroxide | Iprodione, Rovral | Mancozeb, Dithane | Cyprodinil, Vangard | Benomyl, Benlate | Dicloran, Botran | Lime-Sulfur | Ziram | Maneb, Manex | Captan |
|---|---|---|---|---|---|---|---|---|---|---|
| North Coast | 24.7 | 16.5 | 25.2 | 16.8 | 9.1 | 1.7 | 1.8 | 0 | 1 | 0.1 |
| Central Coast | 33.9 | 17 | 12.2 | 17 | 1.8 | 7.6 | 0.4 | | 0.3 | 0 |
| North Valley | 21.7 | 26.3 | 12.5 | 9.6 | 6.5 | 3.6 | 9.8 | 3.8 | 0.8 | 0.7 |
| South Valley | 50 | 19.2 | 5.2 | 6.2 | 16.7 | 3.5 | 1.2 | 6.3 | 0.1 | 1.2 |
| **State** | **33.4** | **20.3** | **12.7** | **11.5** | **9.4** | **3.9** | **3.6** | **3** | **0.6** | **0.6** |

**B. Median Number of Applications per Site**

| Region | Copper Hydroxide | Iprodione, Rovral | Mancozeb, Dithane | Cyprodinil, Vangard | Benomyl, Benlate | Dicloran, Botran | Lime-Sulfur | Ziram | Maneb, Manex | Captan |
|---|---|---|---|---|---|---|---|---|---|---|
| North Coast | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Central Coast | 2 | 1 | 2 | 1 | 1 | 1 | 1 | | 1 | 2 |
| North Valley | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 |
| South Valley | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| **State** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |

**C. Median Application Rate (lbs./acre)**

| Region | Copper Hydroxide | Iprodione, Rovral | Mancozeb, Dithane | Cyprodinil, Vangard | Benomyl, Benlate | Dicloran, Botran | Lime-Sulfur | Ziram | Maneb, Manex | Captan |
|---|---|---|---|---|---|---|---|---|---|---|
| North Coast | 0.76 | 0.75 | 1.39 | 0.47 | 0.31 | 1.8 | 4.6 | 2.28 | 2 | 0.97 |
| Central Coast | 0.76 | 0.69 | 1.58 | 0.47 | 0.75 | 1.8 | 3.96 | | 3.16 | 0.55 |
| North Valley | 0.81 | 0.5 | 1.48 | 0.42 | 0.5 | 1.8 | 0.36 | 3.04 | 2.87 | 1.25 |
| South Valley | 1.23 | 0.5 | 1.5 | 0.47 | 0.5 | 1.5 | 1.66 | 2.28 | 2 | 1.5 |
| **State** | **0.8** | **0.64** | **1.48** | **0.47** | **0.5** | **1.8** | **0.72** | **2.28** | **2** | **1.32** |

The following material is an edited version—to match the report format requested by DPR for the Pest Management Evaluation—of the material that appears in *Crop/Pest Profile for Wine Grapes in California.*

# Insect/Mite Control

### OMNIVOROUS LEAFROLLER
***Platynota stultana***

**Damage.** The omnivorous leafroller (OLR) is a moth whose larval stage can cause serious damage in the Northern and Southern San Joaquin Valley regions. It is a major pest of winegrapes. It feeds on leaves, flowers, and developing berries. Damage to post-veraison berries allows rot organisms to enter the fruit.

**Life History of the Pest.** OLR larvae overwinter in old grape clusters (mummies) and vineyard weeds. In spring, the larvae complete their development and moths emerge and lay shingle-like egg masses on grape leaves. After about 5 days these eggs hatch, and larvae web together leaves or cluster parts to form a nest in which they feed.

**Monitoring.** Growers and PCAs monitor for OLR by examining grape bunches. Critical periods for monitoring are during the critical treatment window for each of the first two generations. Pheromone traps are used to catch male moths and provide the bio-fix dates. 700-900 degree days past biofix is the recommended treatment window for OLR.

<u>CHEMICAL CONTROLS</u>
Because the most widely used insecticides for OLR (cryolite and Bt, see below) are stomach poisons which need to be eaten by OLR larvae to be effective, spray timing and coverage are extremely important. However, because of winery restrictions on using cryolite after June 1, many growers feel compelled to treat for first brood OLR, even though recent research indicates that in some cases second brood treatments may be more effective (Coviello and Costello, 1998). There are many cases in which OLR was not present in the vineyard in spring, but migrated in later in the season (M.J. Costello, personal observation). In these cases, broad spectrum OPs or carbamates are used for late-season control.

**Cryolite.** 30 day PHI. Cryolite (PROKIL OR KRYOCIDE) is a mineral (sodium aluminofluoride) which must be ingested by OLR for it to be effective. Most wineries require that applications be made before full bloom or before June 1, and limit the total seasonal application to six lb ai per acre. The reentry period is 12 hours.

***Bacillus thuringiensis* (Bt).** 0 day PHI. Bt is a bacterium which must be consumed by OLR in order to be effective. This material is approved for use on organically grown grapes. Bt is effective only against young larvae.

**OLR Pheromone.** 0 day PHI. Pheromones (NO-MATE, CHECKMATE) can be sprayed or hand-placed in vines at label rates to disrupt the mating of adult OLR. There is no restricted reentry period. This pheromone is approved for certified organic production.

**Methomyl.** 14 day PHI for wine grapes. Methomyl (LANNATE) is an oxime carbamate. Methomyl is highly disruptive to the predators of spider mites. There is a 7-day reentry period.

**Carbaryl.** 7 day PHI (0 day PHI for dust). Carbaryl (SEVIN) is a carbamate and has a restricted-entry interval of 24 hours. Use of carbaryl encourages mite buildup, as it is very disruptive to the natural enemies of mites.

**Phosmet.** 7 day PHI. Phosmet (IMIDAN) is an organophosphate. The restricted interval for phosmet is 5 days.

**Diazinon.** 28 day PHI. Diazinon is an organophosphate. It is very disruptive to natural enemies. The restricted entry interval for diazinon is 5 days.

## CULTURAL CONTROL PRACTICES

**Weed Control.** Many weeds are also hosts of OLR, including mare's tail, panicle willow herb, and lamb's quarters. Growers should ensure that these and other host weeds are controlled by French plowing, discing or herbicides.

**Sanitation.** Old clusters which fall on the berm or end up in the middles after pruning should be destroyed. Berm sweeping or berm-blowing will move these mummies out into the middles where they can be shredded or disced. In-row cultivation with a French plow or other cultivator will bury the mummies.

## BIOLOGICAL CONTROLS

**General Predators and Parasites.** More than 10 species of parasites have been recovered from omnivorous leafroller. However, overall parasitism is usually low. Spiders are potentially good predators of OLR.

# LEAFHOPPERS

## Grape leafhopper: *Erythroneura elegantula*
## Variegated leafhopper: *Erythroneura variabilis*

**Damage.** Leafhoppers (Homoptera: Cicadellidae) are major pests of grapes throughout California. The grape leafhopper is a major pest of grapes north of the Tehachapi Mountains, especially in the San Joaquin (primarily Northern San Joaquin Valley Region), Sacramento Valley, and Napa Valleys (North Coast Region). It is occasionally a problem in coastal valleys (Central and South Coast Regions). The variegated leafhopper is a major pest of grapes in Southern California (Southern San Joaquin Valley, South Coast, and Coachella Valley regions). Variegated leafhopper is a major pest as far north as San Joaquin County (Northern San Joaquin Valley region). Actual pest damage varies according to location of the vineyard, variety, plant vigor, market use of the variety, and season. Substantial infestations result in loss of yield and/or quality. Large numbers of flying adults can cause significant worker annoyance, which can lower productivity.

As leafhoppers feed on leaves and injury increases, photosynthetic activity decreases. Heavily damaged leaves lose their green color, dry up, and may fall off the vine. This can result in fruit sunburn and can weaken the vine for the following season. Feeding can also delay berry sugar accumulation and leafhopper production of "honeydew" (excess carbohydrates) can result in spotting of fruit (mold which grows on the honeydew).

**Life History of the Pest.** Leafhoppers overwinter as adults, and are found in spring on newly emerged grape leaf tissue, cover crops and weeds. Eggs of the first brood are laid in leaf epidermal tissue in April and May. Both adults and nymphs feed on leaves by puncturing leaf cells and sucking out the contents.

**Monitoring.** Growers and pest control advisors monitor for leafhoppers by counting the number of nymphs per leaf and by visual assessment of leaf damage. The most critical period is during the second leafhopper generation, because it is then that leafhoppers are feeding primarily on photosynthetically active foliage. Economic loss probably does not occur until at least 20% of the photosynthetically active leaf area is damaged, which is roughly equivalent to 15-20 nymphs per leaf for Thompson Seedless in the San Joaquin Valley.

### CHEMICAL CONTROLS

Although leafhoppers infest most vineyards in California, they may not require chemical treatment because most vineyards can tolerate fairly high populations without harm. Grape leafhopper populations are easier to tolerate than variegated leafhoppers. On the average, less than 50% of wine and raisin grape vineyards require treatment, while most table-grape vineyards require at least one treatment a year. In some cases, chemical treatment of leafhoppers may exacerbate a mite problem if predatory mites are disrupted. Methomyl, carbaryl and dimethoate, all of which are registered for control of leafhoppers, are highly toxic to predatory mites. At present, imidacloprid is an extremely effective and long lasting material for leafhoppers and has little effect on natural enemies.

**Imidacloprid**. 0 day PHI. Imidacloprid (PROVADO) is the most popular chemical treatment for leafhoppers. Imidacloprid is in the chloronicotinyl chemical family. Provado® is a wettable powder formulation. Single applications per season are often effective. If pest pressure requires additional treatment, growers are required to allow 14 days before reapplication. The restricted - entry interval for imidacloprid is 12 hours.

**Naled.** 3 day PHI. Naled (DIBROM), an organophosphate, is applied to the wine grape acreage to kill adult leafhoppers just before harvest. Post-bloom applications of naled may cause fruit russeting. Naled may not be effective in all areas due to resistance. The restricted-entry interval for naled is 24 hours.

**Pyrethrins/PBO in Combination.** 1 day PHI. Pyrethrin and piperonyl butoxide (PBO) PYRENONE, PYRELLIN or equivalent) is applied alone or in combination with narrow range oils to treat first generation leafhoppers. It has a restricted-entry interval of 12 hours. This strategy may cause a secondary problem with a mite flare up.

**Endosulfan**. 7 day PHI. Endosulfan (THIODAN) is an organochlorine. Endosulfan may not be effective in all areas due to resistance. The restricted-entry interval for endosulfan is 2 days.

**Methomyl.** 14 day PHI for wine grapes. Methomyl (LANNATE) is an oxime carbamate. This product is often disruptive to beneficial mites and parasites of leafhoppers. There is a 7 day re-entry period.

**Insecticidal Soaps.** 0 day PHI. Insecticidal soaps are partially effective on low leafhopper populations if applied when nymphs are small. Insecticidal soaps may be more effective if used in combination with oil. The restricted entry interval for insecticidal soaps is 12 hours.

**Carbaryl.** 7 day PHI (0 day PHI for dust). Carbaryl (SEVIN) is a carbamate and has a restricted-entry interval of 24 hours. Use of carbaryl may encourages mite buildup as it is very disruptive to the natural enemies of mites. It may not be effective in all areas due to resistance.

**Dimethoate.** 28 day PHI. Dimethoate (CLEAN CROP) is an organophosphate and has a restricted reentry interval of 2 days. Dimethoate may disrupt leafhopper natural enemies. It may not be effective in all areas due to pest resistance.

**Narrow Range Oil.** 0 day PHI. Narrow range oils were applied to approximately 1% of treated acres of grape vineyards, but part of this treatment is for spider mites. Approved for use on organically grown grapes. The restricted-entry interval is 4 hours.

## CULTURAL CONTROL PRACTICES

**Basal Leaf Removal.** Leaf removal is primarily performed to control botrytis and other bunch rots, but it can also help control leafhoppers. Removing basal leaves (up to the cluster) at the first generation nymphal peak (usually between bloom and berry set) should result in a substantial reduction in density of second generation leafhoppers. Also, leaf removal improves coverage and the effectiveness of pesticides.

**Limiting Vine Growth.** Because leafhoppers prefer vigorous, lush vegetation (Daane et al., 1995), preventing overly vigorous vine growth may help manage leafhoppers.

**Cover Crops.** There is no evidence that spring or summer cover crops make a significant contribution to leafhopper control by encouraging populations of beneficial insects or spiders. However, cover crops may reduce vine vigor through competition for water and/or nutrients (Daane & Costello, 1998).

**Weed Control.** Because weeds and cover crops are an overwintering location for leafhoppers, theoretically removal of vegetation on the vineyard floor and in surrounding areas helps reduce numbers of adults that might disperse to new grape foliage. Pre-budbreak discing of floor vegetation during early morning hours (before temperatures warm up to above the leafhopper flight threshold) may be effective in reducing populations of overwintering adults, although this has never been tested experimentally.

**Sticky Tape.** Yellow sticky tape can trap overwintering adults before they lay eggs, theoretically reducing first brood leafhopper infestations. It has never been tested experimentally. This is a labor intensive practice in that the tape needs to be put up and taken down by hand.

**Alternative Hosts for *Anagrus*.** Border plantings of blackberries and French prunes have been tested as a way to enhance numbers of the leafhopper parasite *Anagrus*. However, attempts to implement such plantings on a commercial scale have not been successful (K.M. Daane, personal communication.

## BIOLOGICAL CONTROLS

Several natural enemies of the grape leafhopper are considered important in biological control strategies. Use of broad spectrum insecticides can negatively affect these natural enemies and may exacerbate a leafhopper problem.

***Anagrus* spp.** The most important natural enemy of the grape and variegated leafhoppers is a microscopic wasp in the genus *Anagrus* (Hymenoptera: Mymaridae), most commonly *Anagrus erythroneurae* Triapitsyn. These wasps lay their eggs within leafhopper eggs. Immature *Anagrus* develop within and entirely consume leafhopper eggs. Growers and PCAs can examine grape leaves and monitor for parasitized leafhopper eggs, which are red compared to clear unparasitized eggs. Even a minimal level of parasite activity on eggs of the first generation may result in economic control of the grape leafhopper during the second and third generations (B.C. Murphy, unpublished data). *Anagrus* is not as effective on variegated leafhopper as it is on grape leafhopper, and economic control of variegated leafhopper is usually not achieved by parasitism alone.

**Other predators.** General predators of leafhoppers include green lacewings (*Chrysopa* spp.), minute pirate bugs (*Orius* spp.), nabid bugs (*Nabis americoferus*), big-eyed bugs (*Geocoris* spp.), lady beetles (*Hippodamia convergens*.), and the predatory mite, *Anystis agilis.* However, these predators are found at very low densities in the San Joaquin Valley (Costello and Daane, 1999), and have not been thoroughly documented in other areas. Spiders are the dominant predator on grapes in the San Joaquin Valley, but little effective relationship has been found between spiders and leafhoppers (Costello and Daane, 1998).

## SHARPSHOOTERS

**Blue-green sharpshooter: *Graphocephala atropunctata***
**Green sharpshooter: *Draeculacephala minerva***
**Red-headed sharpshooter: *Carneocephala fulgida***
**Glassy-winged sharpshooter: *Homalodisca coagulata***

**Damage.** Sharpshooters vector the bacterium *Xylella fastidiosa*, which causes Pierce's disease (see section on disease) in grapes, one of the few grapevine diseases that can kill vines. Sharpshooters (Homoptera: Cicadellidae) are leafhoppers, but belong to a subfamily that feeds on the water conducting vessels of the plant (the xylem). The blue-green sharpshooter is the most important vector of Pierce's disease in coastal grape-growing areas (Purcell, 1975), whereas the green sharpshooter and the red-headed sharpshooter are the primary vectors in the South and North San Joaquin Valley regions. The glassy-winged sharpshooter is a relatively new pest that has established high populations in southern California since the early 1990s, and was detected in the San Joaquin Valley in 1998 (Phillips, 1999).

**Life History of Pest.** The blue-green sharpshooter feeds, reproduces, and is often abundant on cultivated grapes. In late winter and early spring, adults become active when temperatures warm above 15°C. Some begin moving into nearby vineyards when grape shoots are several inches long, but blue-green sharpshooters are usually more abundant in natural habitats than in vineyards.

The green sharpshooter and the red-headed sharpshooter prefer grasses for feeding and breeding, and can often be found in pastures, weedy alfalfa fields, and on roadside weeds. Grapes are only accidental hosts of these grass-feeding sharpshooters. The overwintering adults do not live long, thus it is probably the second generation that migrates to the vineyard.

The glassy-winged sharpshooter is a native of the southeastern U.S. which invaded southern California in the early 1990s (Phillips, 1999), and was detected in the San Joaquin Valley in 1998. It is considered a greater threat to vineyards than any of the other sharpshooter species because of its wide host range and strong flying ability.

**Monitoring.** In addition to visual observations using sweep nets, sticky traps can be placed in areas adjacent to vineyards that serve as habitat for the blue-green and glassy-winged sharpshooters. Sticky traps are not effective monitoring tools for the green and red-headed sharpshooters. Insecticidal treatment of vector source areas may warranted (with prior approval through the County Agricultural Commissioner in Napa and Sonoma Counties) where blue-green sharpshooter is the main vector near riparian or ornamental landscapes. Treatments should be applied if after several successive warm days there is a sharp increase in the number of sharpshooters trapped, or if visual inspections reveal more than one sharpshooter per vine. Sweep nets and trapping should also be used to monitor populations in non-crop vegetation adjacent to vineyards after treatment.

## CHEMICAL CONTROLS

**Imidacloprid.** 0 days PHI. Imidacloprid (PROVADO) is a wettable powder formulation. Growers are required to allow 14 days before reapplication. The restricted entry interval for imidacloprid is 12 hours.

**Dimethoate.** 28 day PHI. Dimethoate (CYGON) is an organophosphate. Treatment to border (riparian) vegetation may be made by permit from the county agricultural commissioner under a special local needs permit. Applications may be made with a ground rig-handgun sprayer to a band of natural vegetation about 50-100 ft wide along the vineyard edge. When sharpshooters have migrated into the vineyard and there is more than a couple of inches of new shoot growth on the vines, the first 200-300 ft in from the edge of the vineyard is also treated. The restricted entry interval is 2 days.

## CULTURAL CONTROL PRACTICES

**Neighboring Crops/Wildlands.** Riparian areas bordering vineyards are often an important source of blue-green sharpshooters in coastal vineyards. In the San Joaquin Valley, the greatest amount of disease spread is usually near pastures, weedy hay fields, or other grassy areas. Growers should consider the presence of neighboring hay fields or permanent pastures or riparian areas when planting a vineyard. Though often not feasible, in some instances properties adjacent to vineyards are purchased or leased, and managed in such a way that does not encourage sharpshooter populations. Management of riparian woodlands and environmental restoration plantings with non-host species is a newly developed method that requires careful planning and advance approval by governmental agencies.

**Weed Control.** Perennial weedy grasses should be eliminated from areas adjacent to vineyards, such as along roads, ditches, and ponds. Bermuda grass and water grass are especially favored sharpshooter hosts. Alfalfa fields can be sources of sharpshooters if grass weeds are present. Annual weeds in vineyards that begin to grow after April or May usually do not support high sharpshooter populations.

## BIOLOGICAL CONTROLS

Few biological control agents have been identified that are specific to sharpshooters. The most common parasitoids of sharpshooters are parasitic wasps in the families Mymaridae and Trichogrammatidae that attack sharpshooter eggs.

## PHYLLOXERA

*Daktulosphaira vitifoliae*

**Damage.** Grape phylloxera is an aphid-like insect (Homoptera: Phylloxeridae) which damages grapevines by feeding on roots, either on growing rootlets, which then swell and turn yellowish, or on larger roots, which also swell and may decay (Granett et al., 1992). Feeding injury causes vines to become stunted, produce less fruit and eventually die. Recent work suggests that several soil borne fungi may play a role in phylloxera damage by infecting roots at sites of phylloxera feeding (Graneet et al., 1998). Phylloxera prefers heavy, clay soils that are found in the cooler grape-growing regions of the state such as Napa, Sonoma, Lake, Mendocino, and Monterey counties, as well as the Sacramento Delta and the foothills. It will also take advantage of vines that are stressed or have a limited root area. Although phylloxera is present in the heavier soils of the San Joaquin Valley (mostly the foothill areas), damage is not as severe, possibly because soils are deeper and water more plentiful, or because phylloxera do not do well in the warm summer temperatures of the valley. Phylloxera is not a pest on sandy soils.

**Life History of the Pest.** Phylloxera adults are wingless and reproduce without males, laying up to several hundred eggs per female. Eggs hatch in about a week into nymphs which grow and molt four times to become adults. Grape phylloxera overwinter as small nymphs on roots, and in spring, they start feeding and developing. Once established on a root, phylloxera feed in groups. Infested vineyard areas expand concentrically, and may do so rapidly at a rate of two- to four-fold a year. Satellite infestations frequently establish downwind or along water channels from larger infested areas. In fall when soil temperatures decrease, all life stages die except the small nymphs (58). There are three to five generations each year.

**Monitoring.** Initial infestations of grape phylloxera appear as a few weakened vines. Therefore, monitoring vines in an area of the vineyard that has consistently displayed weaker growth is necessary. Aerial photography can be useful in detecting weak spots in vineyards (Johnson et al., 1996). In North Coast vineyards infected vines may initially exhibit potassium deficiency symptoms.

### CHEMICAL CONTROLS

A pesticide treatment will not eradicate phylloxera populations because of the difficulties in penetrating the heavy soils that this pest prefers. Populations may rebound rapidly after a chemical treatment, and it may be difficult or impossible to stop overall vine decline(Weber et al., 1996).

**Carbofuran.** 200 day PHI. Carbofuran (FURADAN) is applied post-harvest. Applications are made via drip irrigation between harvest and early December. This product is available for use under a special local needs permit. Reentry interval is 48 hours.

**Sodium Tetrathiocarbonate.** 14 day PHI. Sodium tetrathiocarbonate (ENZONE) applications may only be made to crops at least one year old or injury may occur. It can be applied anytime during the growing season by metering it into irrigation water in drip or furrow irrigation systems. It has a restricted-entry interval of 4 days.

**Fenamiphos.** 2 day PHI. Fenamiphos (NEMACUR) is an organophosphate. The restricted entry interval is 48 hours.

## CULTURAL CONTROL PRACTICES

**Resistant Rootstocks.** Resistant rootstocks are the only completely effective means for phylloxera control in the most severely affected areas. For durable protection against phylloxera, it is necessary for growers to use rootstocks that have strong resistance to phylloxera, i.e., of native American parentage and no *Vitis vinifera* parentage. Unfortunately, in order to use this method infested vineyards must be replanted at a substantial investment to the grower. Replanting affected vines is best done by block, though this approach is most expensive.

**Sanitary Practices.** Sanitary practices are critical when planting a new vineyard, using only clean propagating material from a certified nursery. Even though resistant to phylloxera, young resistant rootstock vines will support some phylloxera and may be stunted if replanting occurs in heavily infested soils. Equipment should also be cleaned to remove soil before moving between vineyards.

**Water and Fertility Management.** Phylloxera damage may be reduced by good water management, fertilization, and other cultural practices that help limit plant stress.

**Increased Organic Matter.** Some growers have found the use of compost and other sources of organic matter resulted in continued production in areas with phylloxera.

## BIOLOGICAL CONTROLS

There are no specific biological controls targeting grape phylloxera.

## MEALYBUGS

**Grape Mealybug: *Pseudococcus maritimus***
**Longtailed mealybug: *Pseudococcus longispinus***
**Obscure mealybug: *Pseudococcus viburni***
**Vine Mealybug: *Planococcus ficus***

**Damage.** Mealybugs (Homoptera: Pseudococcidae) are not a major pest of wine grapes in California, with the exception of the obscure mealybug in the southern Central Coast region (Daane et al, 1996), and the vine mealybug, which until recently had been confined to the Coachella Valley but is now present in the San Joaquin Valley (Bentley, 1998). Mealybugs can damage grapes by feeding on leaves and by contaminating clusters with honeydew which supports the growth of black sooty mold. In addition, all mealybugs tested have been shown to vector leafroll viruses. Feeding by mealybugs can be severe enough to stunt vine growth, but this only commonly occurs with obscure and vine mealybugs. Because cosmetics is not usually a concern for wine grapes, grape mealybug is not often a pest. The exception to this is the Eastern fresh pack market, where mealybug contamination is not allowed. Cluster contamination by mealybugs is related to variety and pruning method. It can be worse on spur pruned varieties and on varieties that produce a high percentage of clusters close to the base of the shoot, resulting in clusters that touch old wood. Mealybugs also take advantage of tight clustered varieties, where there are better hidden. The vine mealybug can, potentially, cause far greater damage than the other vineyard mealybugs. By the end of the season, vine mealybugs can be found on the leaves, grape bunches, canes and roots. The vine mealybug produces far greater amounts of honeydew and may have up to 8 generations per year in the San Joaquin Valley (compare with 2-4 for the grape mealybug).

**Life History of the Pest.** Mealybugs overwinter as adults, eggs (in white, cottony egg sacs) and first instar crawlers. Most of the overwintering population is found underneath the bark, quite often on the upper trunk sections, cordons and spurs. Crawlers emerge in late winter and make their way to buds, where they begin feeding once bud break occurs. Adult females return to the bark to lay eggs of the next generation, which, when hatched, colonize grape bunches.

**Monitoring.** Growers and PCAs can most easily monitor for the presence of mealybugs in the winter. Just prior to budbreak the crawlers will be active, and their numbers can be estimated by recording mealybug presence under bark on spurs. Double sided tape wrapped around spurs can be used to trap crawlers, but this is a less reliable method than direct counts. However, there are no established treatment thresholds for these methods. Early summer infestation can be estimated by counting mealybugs on spurs, and late-season evaluation consists of analyzing clusters which are not free hanging (touching the cordon, trunk or stake) and recording by presence/absence. There are no reliable methods of monitoring for parasitism.

## CHEMICAL CONTROLS

### Delayed Dormant

**Chlorpyrifos.** 45 day PHI. A pre-budbreak (delayed dormant) application of chlorpyrifos (LORSBAN) in combination with a dormant oil is recommended to control mealybugs. Oil provides better coverage and penetration, and therefore better kill than chlorpyrifos alone. Chlorpyrifos can also be sprayed onto the soil surface during spring to kill ants. The restricted entry interval for chlorpyrifos is 24 hours.

### In-season

**Imidacloprid**. 0 day PHI. Imidacloprid (PROVADO, ADMIRE) is in the chloronicotinyl chemical family. Provado® is a wettable powder formulation. Growers are required to allow 14 days before reapplication. Admire® received a special local needs registration in February 1999 for use on leafhoppers (including sharpshooters) and mealybugs in California, and is a flowable intended for use in drip systems. Because imidacloprid is a systemic, it will be taken up by the vine. Recommended application timing is between budbreak and pea-berry stage, at a rate of 0.25 to 0.50 lb ai/acre. The restricted -entry interval for imidacloprid is 12 hours.

## CULTURAL CONTROL PRACTICES

Pruning/training. Because grape mealybug prefers to feed on grape berries which touch old wood, pruning which helps clusters hang free can reduce infestation. Training vines so that spurs are positioned horizontally and leaving long spurs helps clusters hang free. Cane pruned varieties are less susceptible because clusters are produced on canes far from the old wood.

**Ants.** Because ants feed on mealybug honeydew, ants play an important role in the development of mealybug pest populations. Ants physically move young mealybugs to desirable feeding areas of the vine in order to collect mealybug honeydew. The spread of mealybugs can be slowed if ant populations are controlled.

**Irrigation Control.** Drip irrigation favors ant populations since this leaves large areas of dry soil on the berm, which tends to be a good, safe habitat for ants.

## BIOLOGICAL CONTROLS

**Parasitoids**. Several species of parasitic wasps (Hymenoptera: Encyrtidae) attack mealybugs in California. The impact of the different species varies from time to time and place to place. The most significant parasites of grape mealybug are, *Acerophagus notativentris*, *Pseudaphycus angelicus*, and *Zarhopalus corvinus* (Daane et al., 1996). These parasites may attack longtailed mealybug as well. Two parasites (*Pseudaphycus flavidulus* and *Leptomastix epona*) have been imported from Chile for the obscure mealybug, and four parasitoids (*Anagyrus pseudococci*, *Leptomastidea abnormalis*, *Coccidoxenoides peregrinus*, and *Leptomastix dactylopii*) were imported from Argentina, Spain, Israel, or Turkmenistan for the vine mealybug (Gonzalez, 1998). Recently, *Anagyrus* sp. (possibly *A. pseudococci*) has been recovered from vine mealybug in the South San Joaquin Valley.

**Other Predators.** Mealybug predators include a ceciodomyiid fly (*Diadiplosis californica* Felt) and a lady beetle called the mealybug destroyer, *Cryptolaemus montrouzieri*. The mealybug destroyer was originally collected in northern Australia, where winter temperatures are warmer than in most of California's grape growing regions. For this reason, populations of the mealybug destroyer dramatically decline or disappear altogether during the winter. To "re-inoculate" the vineyard, insectary-purchased beetles must be released.

Natural enemies can keep mealybugs under control in some cases, but mealybug parasites are very sensitive to broad spectrum insecticides. It is generally recommended that if chemical treatment is necessary, some areas of the vineyard should be left untreated as a refuge for parasite populations. Controlling ants will also help parasites control mealybugs.

## ORANGE TORTRIX
### *Argyrotaenia citrana*

**Damage.** Orange tortrix (Lepidoptera: Tortricidae) is found in all coastal grape growing areas. Orange tortrix (OT) causes the same kind of damage on the coast as the omnivorous leafroller in inland areas. On rare occasions, early spring damage occurs from larvae feeding on buds and newly emerging shoots, but primarily, damage occurs when larvae feed on bunches and make nests of webbing among the berries. This feeding allows entry of bunch rot disease organisms.

**Life History of the Pest.** OT overwinters as larvae, and feed throughout the winter on old grape clusters and weeds. In spring the larvae pupate and emerge as adults, mate, and lay eggs. There are three generations per year.

**Monitoring.** Pheromone traps can be used to determine a biofix date, and should be placed in the vineyard in December. Chemical treatments should be timed to correspond to 1000 degree days F from the biofix date. Monitoring for OT larvae is done by visual inspection of the clusters in spring and summer.

## CHEMICAL CONTROLS

If stomach poisons are used, good coverage is essential for control. OPs and carbamates are used late in the season if the population is high.

**Cryolite.** 30 day PHI. Cryolite (PROKIL OR KRYOCIDE) is a mineral (sodium aluminofluoride) which must be ingested by OLR for it to be effective. Most wineries require that applications be made before full bloom or before June 1, and limit the total seasonal application to six lb ai per acre. The reentry period is 12 hours.

***Bacillus thuringiensis*** **(Bt).** 0 day PHI. Bt is a bacterium which must be consumed by OT in order to be effective. This material is approved for use on organically grown grapes. Bt is most effective against young larvae.

**Carbaryl.** 7 day PHI. Carbaryl (SEVIN) is a carbamate and has a restricted-entry interval of 24 hours. Disruptive to predators of mites and parasites of leafhoppers so product should not be used where mites are a chronic problem. The restricted-entry interval is 24 hours. Carbaryl is extremely toxic to honeybees.

## CULTURAL CONTROL PRACTICES

**Weed Control.** Many weeds are also hosts of OT, including mallow, curly dock, mustard, filaree, lupine, and California poppy. Growers should ensure that these and other host weeds are controlled by French plowing, discing or herbicides.

**Sanitation.** Old clusters which fall on the berm or end up in the middles after pruning should be destroyed. Berm sweeping or berm-blowing will move these mummies out into the middles where they can be shredded or disced. In-row cultivation with a French plow or other cultivator will bury the mummies.

## BIOLOGICAL CONTROLS

***Exochus*** **Wasp.** In the Salinas Valley the dominant parasite of orange tortrix is *Exochus nigripalpus subobscurus*. The adult *Exochus* wasp is about 0.25 inch (6 mm) long, with a black head and body and yellow legs. This internal larval parasite emerges after the larva pupates. Moderate to heavy parasitism in late spring has resulted in season long biological control in the Salinas Valley.

**Coyote Brush.** There are indications that coyote brush grown near vineyards in the Salinas Valley will increase parasitism by this parasite by allowing the parasite to overwinter on orange tortrix and other hosts found in the coyote brush.

**Other Parasites and Predators.** At least two other wasp species and one fly parasite are known to attack orange tortrix. Spiders may also feed on larvae.

## SPIDER MITES

**Willamette mite: *Eotetranychus willamette***
**Pacific mite: *Tetranychus pacificus***
**Twospotted mite: *Tetranychus urticae***

**Damage.** Webspinning spider mites (Acari: Tetranychidae) are a major pest of wine grapes. The Pacific mite is the most important mite species in the San Joaquin Valley regions. Pacific mite damage begins as yellow spots, and as damage progresses, these spots may turn brown (necrotic). High populations may cause leaf burning, which can decrease photosynthesis and accumulation of vine energy reserves. Willamette mite feeding causes foliage to turn yellowish bronze or red (depending upon the variety), but usually no burn occurs unless vines are weak. Willamette mites are primarily a problem in the northern growing regions (i.e., Central and Northern Coast Regions) and wine grapes in Northern San Joaquin Valley region. Willamette mite is seldom a pest of wine grapes in the South San Joaquin Valley region.

**Life History of the Pest.** Although it can cause damage early in the season, Pacific mite generally prefers the hotter, dryer part of the season. Willamette mite is an early season mite in the Southern San Joaquin Valley, where it prefers the cooler parts of the plant and is found mostly in the shady parts of the vine. Willamette mite is active throughout the season in the coastal areas and can cause significant damage. The twospotted mite, *Tetranychus urticae,* is only occasionally found on grapes in California and rarely causes damage.

**Monitoring.** Monitoring is conducted to determine the intensity of the mite population in relation to the treatment threshold. Typically, monitoring is accomplished by a binomial (presence-absence) sampling method, whereby infestation is estimated by the percentage of leaves which have 1 or more mites. Treatment is recommended if 50% or more of the leaves are infested and there are no predatory mites present.

## CHEMICAL CONTROL

**Propargite.** 21 day PHI. Propargite (OMITE) is an organosulfur. Resistance to propargite is showing up in some chronically affected areas of the state. Propargite has a restricted-entry interval of 30 days in California and label restrictions allow no more than 2 applications per season.

**Dicofol.** 7 day PHI. Dicofol (KELTHANE) is an organochlorine. It has a restricted-entry interval of 12 hours. Dicofol is disruptive to predaceous mites and lady beetles. It may not be effective in all areas due to pest resistance.

**Narrow Range Oil.** 0 day PHI. For Pacific mite, it is applied at a 1-2% solution with enough water to thoroughly cover the vines. It is a contact material with almost no residual, and may have to be applied repeatedly to maintain control. Approved for use on organically grown grapes. The restricted-entry interval is 4 hours.

**Fenbutatin-oxide.** 28 day PHI. Fenbutatin-oxide (VENDEX) may not be applied more than twice per season. The restricted-entry interval is 48 hours.

**Cinnamaldehyde.** O day PHI. Cinnamaldehyde (VALERO) was registered for use on grapes in California on July 1999. It is used at a rate of one to three gallons per acre in 100-150 gallons of water per acre. It is a contact material that requires good coverage for control. The restricted-entry interval is 4 hours.

**Insecticidal Soap.** 0 day PHI. Soap (M-Pede) is applied at a 2% solution in enough water to cover the vines. Approved for use on organically grown grapes. The restricted-entry interval for insecticidal soaps is 12 hours.

## CULTURAL CONTROL PRACTICES

**Dust Reduction.** Spider mite outbreaks frequently occur where vines are dusty. Roads may be oiled, watered, gravelled or left untilled to reduce dust on vineyard edges. When possible, a weedy cover can be maintained in the summer to further reduce dust.

**Irrigation.** Water stressed vines are highly susceptible to mite build up. Therefore, maintaining adequate vine water status will decrease the risk of spider mite outbreaks. This can be done by frequent irrigations, and by ensuring that the soil chemistry is conducive to good water infiltration. Overhead watering has been shown to reduce mite problems, although it can also increase some disease problems.

## BIOLOGICAL CONTROL

***Galendromus occidentalis*.** The western predatory mite, *Galendromus occidentalis* (*Metaseiulus occidentalis*), is commonly present in vineyard and preys upon all stages of spider mites. It can be effective in reducing spider mite populations. Disruptive sprays may reduce numbers of this beneficial mite. Predator mites are available commercially to augment populations in the field.

**General Predators.** Other predators, including sixspotted thrips (*Scolothrips sexmaculatus*), minute pirate bugs (*Orius* spp.) and the spider mite destroyer (*Stethorus picipes*) can also be important, but are not as common because they usually do not overwinter within vineyards. To preserve these natural enemies, growers should avoid using disruptive materials, especially carbaryl, dimethoate, dicofol, and methomyl.

# Weed Control

**Weed Management**. Weeds reduce vine growth and yields by competing for water, nutrients, and sunlight, and typically are controlled to enhance the establishment of newly planted vines and to maintain growth and yield of established vines. Competition is most severe during the first 2 to 3 years of the vine's life or where root growth is limited. For mature vines, competition is greatest under drip irrigation with decreasing competition under furrow and basin flood irrigation. Annual weeds are more easily controlled than perennial weeds. Perennials typically are less susceptible to herbicides and to cultivation. Weeds have impacts other than competition and include interference with harvest because of a tall growth habit (examples: prickly lettuce and horseweed), seed contaminant in the crop (examples: sandbur in raisins and black nightshade in mechanically harvested grapes), and finally, interference with pesticide applications for insect and disease control. However, weeds can also provide some benefits if carefully managed. They can provide erosion control on steep hillsides. Weeds can keep the dust down, especially along roadsides, and can also improve soil structure by adding organic matter, providing root channels and exuding soil stabilizing gums, all of which can improve water infiltration. In areas with intense sunlight, weeds can cut down on reflected light from the vineyard floor, which can potentially sunburn grapes. However the long-term benefits of using weeds as a vineyard floor cover are unclear since these weeds are a continued source for weed colonization of the vine row.

Weed management is part of an overall vineyard management system. Plants on the vineyard floor influence other vineyard pests such as insects, mites, nematodes, diseases and vertebrates. As an example, bermudagrass, dallisgrass, and many other grassy weeds have been identified as host reservoirs of the Pierce's disease bacterium. This pathogen can be vectored to grapevines by sharpshooter leafhoppers that have fed on host reservoirs. Many species of broadleaf weeds and perennial grasses are hosts to nematodes that also infest grapevines. Some weeds are alternative hosts for insects such as OLR and orange tortrix. Gophers are most prevalent in non-tilled vineyards and are common where broadleaf weeds predominate. They feed on vine roots and can kill young vines. Weeds provide a good habitat for field mice or voles, which can girdle and kill vines.

**Monitoring.** Weed surveys, at least once a year, allows growers to identify the spectrum of weed present within the vineyard and to develop a weed management strategy for control. These surveys are the basis for decisions about herbicide choice or cultivation equipment and practices. In season monitoring aids decision making for timing of postemergent herbicide applications. Proper postemergent herbicide timing allows application of the lowest dose while maintaining control.

## CULTURAL CONTROL PRACTICES

### Cultivation

For young vineyards, many pre-emergent and contact herbicides pose too great a risk of damage because young vine roots are shallow and because foliage is close to the ground. Hand cultivation can be used effectively to control weeds in newly established vineyards. A wide variety of cultivation implements are used in mature vineyards. Cultivation between rows (the middles) is relatively simple, requiring only a disk harrow, and is by far the most common method of between-row weed control in California. In-row cultivation is less common, but increasing in popularity as the types of implements available increases. In-row mechanical control of weeds is best achieved when done on young, immature weeds, so frequent passes are advised. Mowing is a very common method of between-row control, and is essential for managing cover crops. Some growers are using in-row mowers as well. Recently, propane flamers have been designed for use in vineyards.

**Knives or blades**. (BEZZERIDES, L&H MFG.) Knives or blades sweep across the berm and cut or scrape weeds just below soil line. Some are fit with a spring loaded retractor for moving around the vine trunk.

**Berm sweepers**. (L&H MFG, REDHEAD MFG.) Berm sweepers consist of rotating rubber paddles which clear away vegetation on the berm.

**Rotary hoes**. (KIMCO). Rotary hoes stir the soil, uprooting vegetation. Travel time is faster compared to the French plow.

**Flaming.** (RED DRAGON MFG.) This flamer uses propane as the fuel source. Burners are trained on the berm and the heat produced disrupts membranes and cuticles causing dessication.

**Plows.** (L&H MFG., BEZZERIDES, KIMCO).
Perennial weeds such as Johnsongrass are not easily controlled with cultivation or herbicides. Plowing has been an effective control method for weeds like Johnsongrass. The French plow is the standard in-row plow for vineyards and has been used for decades with success. It consists of a moldboard plow with a spring loaded attachment which pulls the plow around the vine trunks. One pass is usually made just prior to or at budbreak, which opens up a furrow within the row, and some weeks later, the soil is moved back into the row. For added control of sprouting rhizomes, Treflan can be incorporated into the plowed soil prior to reforming the berms. A major drawback to French plowing is the time it takes: Usually only one-half of a row can be done at a time. Recently, innovations have been made which allow two plows to be operated at the same time. In addition, French plows can uproot vines if rows are not perfectly straight. Other manufacturers have constructed systems which move soil extensively in the vine row. Some have small plows that work within the row like the French plow. Others use rotating plates with heavy cables attached that churn soil in the row. Still others use a form of rotovation in the row (Rotary Hoe).

**Cover Crops.** Most cover crops are grown as cool season annuals, which means they are planted in the fall and disced under in the spring (usually March or April). Most well managed cover crop species, whether grasses or legumes, will be competitive enough to crowd out weeds during this period, but once the cover crop is turned under, summer weeds usually take over. The cover crops have predictable growth habits and usually have a low percentage of dormant seed that make them easily managed. Using resident vegetation rather than a managed cover crop does not have a predictable growth habit and the weeds present in this mixture of species allows for continual colonization of the berm area that is normally maintained without any vegetation. Perennial cover crops, once established, can provide good weed control all year long, but most perennials available (e.g., perennial ryegrass, orchardgrass, white clover) are too competitive with the vines. Interest has been shown recently in the use of perennial native grasses, which can crowd out weeds once established, but go dormant during the growing season and not compete severely with the vines. Some growers are experimenting with the use of perennial native grasses for in-row weed control.

**Mulches.** Weeds growing in the vine row can also be controlled with mulches made of natural or synthetic materials. Natural mulches can consist of wood chips, ground almond hulls or vegetation from the vineyard middles which has been "mown and thrown"(Elmore et al., 1998).

Synthetic mulches of polyethylene, polypropylene, or polyester can be used as well. Synthetic mulches maintain uniform moisture conditions, which promotes young vine growth. Synthetic mulches allow water to penetrate but prevent weeds from growing up through the mulch. Synthetic mulches are expensive, but may last for as much as ten years. Natural mulches need to be continually amended, and may provide a good habitat for voles, field mice, and snakes. These mulches add organic matter to the soil and can be used to delay maturity of some varieties in order to take advantage of market price fluctuations. However, natural mulches also lower soil temperature and so they may slow development of the root system of young vines.

## BIOLOGICAL CONTROLS

Few vineyard weed biological controls have been identified, although there are biological control agents for puncturevine and yellow starthistle.

## CHEMICAL CONTROLS

Herbicides registered for use in vineyards vary in their mode of action, soil persistence, and the timing and method of application. Pre emergent herbicides are applied directly on the soil surface before seed germination and growth of the weeds. Weeds are killed as they germinate. This type of treatment does not typically control established weeds or dormant weed seed. Herbicides applied to established, growing weeds are called post-emergent herbicides. Post emergent herbicides may kill tissue directly contacted (contact herbicides) or they may translocate within the plant (systemic herbicides).

### *Postemergent*

**Fluazifop Butyl.** 0 day PHI. Fluazifop butyl (FUSILADE) is an aryloxyphenoxy propionate. It is a systemic herbicide intended to control perennial grasses in nonbearing dormant or growing grapes. It cannot be applied to vines from which grapes will be harvested within 1 year. This product is not effective against broadleaf plants and sedges. The residual period for fluazifop butyl is less than 1 month. The restricted entry interval is 12 hours.

**Glyphosate.** 14 day PHI. Glyphosate (ROUNDUP, GLYPHOS, TOUCHDOWN) is a postemergent herbicde that translocates to vine growing points. It may be used as a preplant or postplant postemergence herbicide in the vineyard. It is applied with a controlled application or with low pressure flat fan nozzles. Glyphosate is sometimes tank mixed with one or more of the following pre-emergent herbicides: diuron, napropamide, norflurazon, oxyfluorfen, oryzalin, or simazine. The restricted entry interval is 4 hours.

**Oxyfluorfen.** Oxylfluorfen (GOAL) is a diphenyl ether compound. It has both pre- emergent and contact properties. It must not be disturbed mechanically or poor weed control will result. The residual period is 4 to 10 months. It is often used in combination with oryzalin to broaden control. Oxyfluorfen can damage grapevines if applied close to budbreak and heavy spring rains occur. The restricted entry interval is 24 hours.

**Paraquat Dichloride.** 0 day PHI. Paraquat dichloride (GRAMOXONE) is a bipyridilium herbicide used for postemergence weed. Paraquat dichloride is often combined with oxylfluorfen to broaden the spectrum of weeds controlled. The restricted entry interval is 2 days.

**Sethoxydim.** 50 day PHI. Sethoxydim (POAST) is a cyclohexanedione. It is a systemic herbicide that may be applied to nonbearing and bearing vines. Sethoxydim controls many annual and perennial grasses, but not broadleaves. The restricted entry interval is 12 hours.

**2,4-D.** 2,4-D (ENVY) is an arkyloxyalkanoic acid. It may only be applied to vineyards that are 3 or more years old. It is prohibited from use in some areas of the state due to the potential to drift onto susceptible crops. The residual period for 2,4-D is 4 to 6 weeks. The restricted entry interval is 2 days.

**Soap**. Pelargonic acid + related C6-C12 fattyacids (SCYTHE) is applied at rates of 1-2 lb a.i. acre. It is a contact herbicide.

***Preemergent***

**Diuron.** 0 day PHI. Diuron (KARMEX) is a phenylurea. It is applied in a 2 to 4 foot wide band in the vine row, and is only applied in vineyards where the vine trunk is at least 1.5 inches in diameter. Once applied to the soil, it must be incorporated into the soil by rainfall or irrigation to be effective. The residual period for diuron is 8 to 12 months. The restricted-entry interval for diuron is 12 hours.

**Napropamide.** 35 day PHI. Napropamide (DEVRINOL) is an amide. It is applied to the soil and must be incorporated with 7 days of application or sprinkler irrigated. It may be applied in combination with a postemergent herbicide, such as glyphosate, to broaden the control. The residual period is 4 to 10 months. The restricted entry interval is 12 hours.

**Norflurazon.** Norflurazon (SOLICAM) is a pyridazinone. Due to the risk of ground water contamination it may not be used on coarse textured soils or south of Monterey, Kings, and

Tulare counties. May not be used on sandy loam soils after budbreak. Apply in 20-100 gal water/acre. Residual period: 6-12 months. The restricted-entry interval is12 hours.

**Oryzalin.** 0 day PHI. Oryzalin (SURFLAN) is a 2,6-dintroaniline compound. It is incorporated to the soil by rain or irrigation. The treated area must be clear of vegetation in order to provide effective control. Oryzalin may be applied in combination with other herbicides, such as glyphosate, for broader control. The residual period is 6 to 12 months. The restricted entry interval is 12 hours.

**Oxyfluorfen.** Oxylfluorfen (GOAL) is a diphenyl ether compound. It has both pre- emergent and contact properties. It must not be disturbed mechanically or poor weed control will result. The residual period is 4 to 10 months. It is often used in combination with oryzalin to broaden control. Oxyfluorfen can damage grapevines if applied too close to budbreak and heavy spring rains occur. The restricted entry interval is 24 hours.

**Simazine.** 0 day PHI. Simazine (PRINCEP) is a 1,3-5-triazine compound. It is applied in a 2 to 4 foot wide band in the vine row any time between harvest and early spring in vineyards where the vine trunk is at least 1.5 inches in diameter. Once applied to the soil, it must be moved into the soil by rainfall or irrigation to be effective. It is sometimes applied at lower rates in combination with other pre-emergence herbicides, such as diuron to broaden the spectrum of control. It is also commonly applied with glyphosate, which kills the existing weeds at the time of application. Simazine is relatively inexpensive and is more effective than diuron in controlling wild oats, henbit and groundsel, although some groundsel populations have now become resistant. This product should not be used on extremely sandy or gravelly soils where product may move to root zone and cause damage to grapevines. It is important that growers consult the pesticide management zones established by the Department of Pesticide Regulation to assure that the product does not leach into ground water. Residual period is 8 to 12 months. The restricted-entry interval is 12 hours.

**Trifluralin.** 60 days PHI. Trifluralin (TREFLAN) is a 2,6-dintroaniline compound. Trifluralin must be mechanically incorporated into the top 2 to 6 inches of the soil after application. It may be applied to vineyards with newly planted vines. It is effective in controlling grass species, including broadleaf weeds. The residual period is 4 to 12 months. The restricted-entry interval is 12 hours.

**Pendimethalin.** Pendimethalin (PROWL, STOMP) is a 2,6-Dintroaniline compound applied to dormant nonbearing vines. The residual period for pendimethalin is 4 to 10 months. The restricted entry interval is 12 hours.

# Disease Control

## POWDERY MILDEW
***Uncinula necator***

**Damage.** Powdery mildew is the most significant disease affecting grapes in California. The mycelia (fungal strands) penetrate into leaf, stem and berry tissue. Whereas severely affected leaves may have reduced photosynthetic rates, most damage occurs because mildewed berries may be stunted, crack and collapse, and lead to secondary bunch rot . Sugar accumulation may be delayed in severely affected vines, and off flavors may be produced in wines. It is estimated that powdery mildew is present in virtually all vineyards each year, the only variable being the severity of the infection between vineyards. Central Coast region vineyards commonly have extremely high powdery mildew pressure, because weather conditions are often ideal for development of the disease. Approximately 90% of the grape acreage in California (88% in 1996) is treated for powdery mildew. The non-treated acreage is largely non-bearing acreage.

**Description of Symptoms and Disease Cycle.** In coastal regions and in the Northern San Joaquin Valley, powdery mildew overwinters as ascospores (sexually produced spores) within cleistothecia (fruiting bodies) on the bark, canes and spurs. Ascospores require free moisture to germinate, and are released onto new grape leaves with spring rains or sprinkle irrigation. Mycelial growth takes on a white, web-like appearance. As conidia (asexual spores) are produced, the colony takes on a white, powdery appearance. Optimal temperatures for hyphal growth and conidia production are between 70 and 86%F. Free moisture plays a negative role and relative humidity plays a minor role in the asexual phase of powdery mildew in California. Ascospores are produced in the fall and winter.

**Monitoring.**_ Powdery mildew can be monitored directly in the field by visual inspection and by using weather data and disease risk models. Because it is such an explosive disease, most growers still base their disease control program on prevention and maintaining grapevine coverage from early in the season until berry softening. All fungicides have standard treatment intervals, based largely on the residual activity of the material. Preventive treatments for powdery mildew are necessary as long as temperatures are conducive to growth and development. In coastal regions, this generally occurs from late spring through harvest, whereas in the San Joaquin Valley this period occurs from shortly after budbreak through early July. Wet springs can extend the release period of ascospores. There is increasing use of localized, weather data combined with disease risk models for scheduling of chemical applications. Several risk models exist, the most recent of which, the Gubler-Thomas model, assists the grower in determining when weather conditions indicate a higher risk of disease outbreak. Risk is higher when temperatures fall between 70 and 86% F, and risk decreases sharply when temperatures exceed 95% F. When this risk is high, the interval between treatments is shortened, whereas if the risk is low, intervals can be lengthened. It has been estimated that weather data is being collected and the model being used to time applications on approximately 80,000-100,000 acres (Gubler and Thomas, 1999).

## CULTURAL CONTROL PRACTICES

**Vine Training.** Trellising, cane cutting and training techniques which create a more open canopy can improve coverage of materials for powdery mildew.

**Leaf Removal.** Leaf removal at berry set improves coverage for chemical treatments.

**Varieties.** Grape varieties vary in susceptibility to powdery mildew. Theoretically, treatment intervals on varieties which exhibit more resistance (e.g., Merlot, Sauvignon blanc, Malbec, Johannesburg Riesling, etc.) can be lengthened relative to susceptible varieties (e.g., Cabernet Sauvignon, Carignane, Chardonnay, etc.).

## BIOLOGICAL CONTROL

*Ampelomyces quisqualis* is a naturally occurring fungal hyperparasite of powdery mildew, which has recently been registered under FIFRA as a pesticide (AQ10), and is also listed below under chemical controls for powdery mildew. *A. quisqualis* has been found to provide some natural control on the east coast. Under California conditions AQ10 has been shown to give excellent diseases control when used early in the spring and applied prior to disease onset. It also has been shown to give excellent control of powdery mildew when used during periods of low disease pressure (Gubler, 1998).

## CHEMICAL CONTROLS

Powdery mildew materials can be classified as preventatives or contacts. The vast majority of materials used are preventatives. Late season control is dependent upon early season disease control and reduction in inoculum and subsequent infection. Sterol-inhibiting fungicides (SIs, also called demethylation inhibitors or DMIs), such as triadimefon, myclobutanil, and fenarimol, triflumizole(BAYLETON, RALLY, AND RUBIGAN, Procure respectively), as well as sulfur or copper are not used as an eradicants, but as protectants before infection is present. Lime sulfur is sometimes used during the dormant season to kill ascospores. DMIs are systemic, but only for 1 or 2 cm around each spray droplet. Therefore, thorough coverage is critical for efficacious disease control. Oil, soaps, potassium bicarbonate (KALIGREEN) and cinnemaldehyde (VALERO) are contact materials that kill mildew spores on contact but cannot prevent colonization. The only true eradicant for powdery mildew is oil used as a 2% spray. Treatments for powdery mildew may be discontinued for wine grapes when fruit reaches 10 to 12% Brix.

***Preventatives***

**Sulfur.** 0 day PHI. Sulfur is applied at label rates to over 80% of wine grapes in California, the vast majority of which is for control of powdery mildew. Sulfur dust rates being higher (10 to 12 lb ai per acre) and wettable sulfur rates being lower (typically 3 to 5 lb ai per acre). It is the most commonly used pesticide in California's grape industry. Approximately 80% of the sulfur applications are as the dust, with 20% being the wettable powder formulations. Treatment is initiated at bud-break to 2-inch shoot growth and is reapplied at 7 to 10-day intervals. Re-application is necessary if the sulfur is washed off by rain or irrigation. Sulfur can cause injury to foliage and fruit when applied just before or on days when the temperature exceeds 100%F. Use of sulfur is approved for organically grown produce. Reentry interval is 24 hours in most counties however in some counties in the Southern San Joaquin Valley region the restricted-entry interval is 3 days.

**Myclobutanil.** 14 day PHI. Myclobutanil (RALLY) is a DMI that is applied only for the control of powdery mildew. The restricted-entry interval is 1 day.

**Fenarimol.** 30 day PHI. Fenarimol (RUBIGAN) is a DMI. The restricted-entry interval for fenarimol is 12 hours.

**Triflumizole.** 7 day PHI. Triflumizole (PROCURE) is a DMI that is applied only for control of powdery mildew. The restricted reentry interval for triflumizole is 12 hours.

**Copper Hydroxide.** 0 day PHI. Copper hydroxide is a resistance management tool used in rotation with other products. Copper hydroxide is used to control several diseases in addition to powdery mildew such as phomopsis and downy mildew, as well as for frost management. Use of copper hydroxide may burn grape leaves.

**Triadimefon.** 14 day PHI. Triadimefon (BAYLETON) is a DMI and a substantial amount of resistance has been built up to this active ingredient and, therefore, its use has greatly decreased in recent years. The restricted-entry interval is 12 hours.

**Azoxystrobin.** 14 day PHI. Preventative and contact. Azoxystrobin (ABOUND) is a natrual product derived from from mushrooms which is a good broad spectrum material (also effective against phomopsis and downy mildew. The restricted entry interval is 12 hours.

***Contact materials***

**Narrow Range Oil.** Narrow range oil is an eradicant that kills mildew hyphae and spores on contact. Narrow range oil should be used at a 2% rate, with enough volume to ensure good coverage (100-150 gallons of water/acre). It can be used in rotation with one of the sterol inhibitors. Applications are made at 14- to 18-day interval. Most narrow range oils are approved for organic production. The restricted-entry interval is 12 hours.

**Insecticidal soaps.** 0 day PHI. Insecticidal soap kills mildew on contact. It is applied at rates of 1.5 to 2% in 100 to 150 gallons of water per acre. Complete coverage of upper and lower leaf surfaces, as well as grape clusters, is essential for control. Insecticidal soap may also be alternated with the sterol inhibitors, but should not be applied within 3 days of a sulfur application. It can be used in rotation with one of the sterol inhibitors. Soaps are also used for control of soft bodied insects such as leafhoppers. The restricted-entry interval is 12 hours.

**Potassium Bicarbonate.** 1 day PHI. Potassium bicarbonate (KALIGREEN) is applied at rates of 2.5 to 3 lb per acre. The restricted entry interval is 4 hours.

**Cinnamaldehyde**. O day PHI. Cinnamaldehyde (VALERO) was registered for use on grapes in California on July 1999. It is used at a rate of one to three gallons per acre in 100-150 gallons of water per acre. The restricted-entry interval is 4 hours.

**Azoxystrobin.** 14 day PHI. Preventative and contact. The restricted entry interval is 12 hours.

## BOTRYTIS BUNCH ROT

***Botrytis cinerea***

**Damage.** Botrytis is a fungal disease which can infect grape leaves, shoots and berries (Marois et al., 1992). Because its optimal temperature is 72%F and it does not grow above 90%F, and because its spores require free moisture for germination, it is a more serious problem in the coastal regions, especially if there is rainfall in the weeks prior to harvest. Once berries are infested with Botrytis, they may split and leak, allowing new spores to germinate on neighboring clusters. Spores from infected fruit can directly infect intact berries, but also enter through wounds caused by insect, bird or other mechanical damage, or damage caused by powdery mildew. Tight clustered (e.g., Zinfandel) or thin skinned (e.g., Sauvignon blanc) varieties are particularly susceptible. The risk of external berry infection increases with berry sugar.

**Description of Symptoms and Disease Cycle.** Botrytis overwinter as dormant structures called sclerotia. With spring rains, sclerotia germinate and produce gray spores (conidia). Early season shoot, leaf and flower blight may occur following spring rains. The infection resembles a brown lesion. "Latent infections" can occur when flowers become infected during bloom, and the fungus lays dormant within the berry until sugar concentration increases. The fungus then resumes growth and spreads throughout the berry. The skin of infected berries will slip off easily. The production of conidia gives the fungus its characteristic fuzzy gray appearance.

**Monitoring.** Botrytis can be monitored by visual inspection for grey mold symptoms on leaves, shoots, flowers, and/or clusters. In the past, fungicide treatments were largely based on prevention and a calendar or plant growth based timing of fungicide applications Recent work out of UC Davis with Californian and Chilean grapes have shown that weather conditions can be monitored to estimate the risk of infection and to time chemical treatments based on the temperature and wetness requirements of the fungus (Broome et al., 1995). Botrytis infection increases with longer periods of wetness from rain or dew, and temperatures within its wide developmental range of 1% to 30% C (35%- 86% F) with a temperature optimum of around 18%-20% C (65%- 68% F).

### CHEMICAL CONTROLS

There are two key treatment periods if wet weather conditions occur: 1) bloomtime and 2) pre-harvest. Preventive treatments are commonly applied at bloomtime, pre-close (late-June to mid-July, and veraison (early to late-July). Thorough coverage is essential for all fungicide treatments.

**Benomyl.** 50 day PHI. Benomyl (BENLATE) is a carbamate. It is applied principally for botrytis bunch rot control. Benomyl may not be as effective in areas of the state where benomyl-resistant pathogens are present. The restricted-entry interval is 1 day.

**Iprodione.** 7 day PHI. Iprodione (ROVRAL) is a dicarboximide fungicide applied mainly to control Botrytis bunch rot. The addition of a narrow range oil (1%) may increase the effectiveness of this material. Iprodione has a restricted-entry interval of 12 hours.

**Captan 50 WP.** 0 day PHI. Captan is a phthalimide fungicide and it may be applied alone or in combination with benomyl. Applications of captan should not be made immediately before or closely following oil sprays. Captan is restricted by many wineries. The restricted reentry period is 4 days.

**Mancozeb.** 0 day PHI. Mancozeb (DITHANE) is an alkylenebis (dithocarbamate) applied for spring foliar treatment and should not be applied after bloom. The restricted reentry interval is 24 hours.

**Dicloran (DCNA).** 10 day PHI. Dicloran (BOTRAN) is an aniline. Applications are made at the onset of bloom or soon after shatter. The restricted-entry interval for dicloran is 12 hours.

**Narrow Range Oil.** Used at a 2% rate with enough water volume (100-150 gallons/acre) to ensure good coverage. Should not be used within two weeks of a sulfur or captan treatment as foliage may burn.

**Fenhexamid.** 0 Day PHI. Fenhexamid (ELEVATE) was registered for use in California in June, 1999. Since the active ingredient is in a new chemical class the products will be of immediate importance to resistance management. The reentry interval is 4 hours.

**Cyprodinil.** Cyprodinil (VANGARD) is a new fungicide that was registered in California in April, 1998.

## CULTURAL CONTROL PRACTICES

**Canopy Management.** Good control has been achieved using canopy management and leaf removal in particular. Removal of four to five basal leaves (the leaves around the clusters) when berries are approximately "pea size" has resulted in significantly reduced incidence and severity of disease (Pence and Grieshop, 1991; Stapleton et al, 1990). In addition, use of vertical trellis systems with shoot positioning wires can provide excellent air and sunlight exposure and reduced disease pressure.

**Irrigation.** Over irrigation should be avoided because lush vine growth can decrease air circulation, and because too much water can increase berry size and increase the risk of splitting.

## BIOLOGICAL CONTROLS

***Trichoderma.*** *Trichoderma* spp. (TRICHODEX) is being used in other countries as an experimental biological control of botrytis. This microbial control agent has been recently registered as a pesticide under FIFRA and is registered in California.

## SUMMER BUNCH ROT (SOUR ROT)

***Aspergillus niger, Alternaria tenuis, Botrytis cinerea, Cladosporium herbarum, Rhizopus arrhizus, Penicillium* spp., and others.**

**Damage.** The summer bunch rot complex consists of secondary microbial invaders that take advantage of mechanical damage to berries. Berries may split due to tight clusters or powdery mildew, or may be damaged by insects (especially OLR) or birds. Damaged berries are quickly colonized by fungi and bacteria, and once a single berry becomes infected, bunch rot can spread throughout an entire cluster. Dripping juice from a rotting cluster can spread infection to adjacent healthy clusters. Masses of spores develop on the surface of infected berries. Bunch rot often culminates in sour rot, especially in the central and southern San Joaquin Valley. Sour rot is caused by a variety of microorganisms, including Acetobacter bacteria, which are spread by vinegar flies attracted to the rotting clusters.

**Description of Symptoms and Disease Cycle.** As berries ripen and sugar content exceeds 8%, injured fruit become increasingly susceptible to invasion by a wide variety of naturally-occurring microorganisms. Invasion occurs at the point of injury caused by insect or bird feeding, mechanical or growth cracks, or lesions resulting from powdery mildew or black measles. The resulting rot can be severe as it progresses beyond the original injury. A characteristic vinegar smell is present if sour rot organisms are present.

**Monitoring.** Growers and PCAs should monitor for rotting clusters by visual inspections between veraison and harvest.

## CHEMICAL CONTROLS

**Copper/sulfur dust.** 0 day PHI. Copper/sulfur dust (COCS) is applied at an median rate of 7 lb ai per acre.

## CULTURAL CONTROL PRACTICES

**OLR Management.** Feeding damage by OLR creates wounds that are entry points.

**Leaf Removal.** Removal of leaves between berry set and "pea size" increases air flow and decreases humidity around the clusters. This has provided equivalent control to any chemical treatment (Stapleton et al, 1990).

**Irrigation Management.** Over-irrigation can contribute to increased berry size and tight clusters, making them more prone to splitting.

**OLR Management.** Feeding damage by OLR creates wounds which are entry points for bunch rot organisms. Therefore, control of OLR can decrease the incidence bunch rot.

## BIOLOGICAL CONTROLS

There are some promising biologicals for use as antagonists against the bunch rot complex. The bacterium *Pseudomonas fluorescens* (BlightBan®) has performed well in this manner (R.A. Duncan, personal communication), but is as yet not registered for use on grapes.

# PHOMOPSIS CANE AND LEAFSPOT

***Phomopsis viticola***

**Damage.** *Phomopsis* is a fungal disease that is most severe when spring rainfall is high (Gubler and Leavitt, 1992). It is common in northern grape growing regions where spring rains are common after bud break. Splashing rain is required for infection. Basal leaves with heavy infection become distorted and usually never develop to full size. Canes may be stunted or break off at the base, and infected buds may not open. Severe infections may cause clusters to shrivel and dry up. On cane pruned varieties, stunted canes may not allow enough fruiting wood for the following year's crop.

**Description of Symptoms and Disease Cycle.** *Phomopsis* overwinters as fruiting bodies called pycnidia. In spring, spores are exuded from the pycnidia, and infections can occur anytime that rain splashes spores onto green leaf tissue. Tiny dark to brown spots with yellowish margins occur on leaf blades and veins, appearing several weeks following rain. On shoots, black scabby streaks appear. Infected canes appear bleached during the dormant season. Severely affected cane or spurs exhibit an irregular dark brown to black discoloration intermixed with whitish bleached areas.

**Monitoring.** Growers and PCAs should look for bleached out canes to determine overwintering inoculum potential and to prune out infected canes or spurs.

## CHEMICAL CONTROLS

In all areas, spring foliar treatments may be advisable if the risk of rain after budbreak is high, or if overhead water is used for frost protection. Apply materials before the first rain after bud-break and before 0.5 inch shoot length (and again when shoots are 5 to 6 inches in length).

**Azoxystrobin.** 14 day PHI. Azoxystrobin (ABOUND) is in a class of compounds called the strobilurines. The restricted entry interval is 12 hours.

**Copper Hydroxide.** 0 day PHI. Copper hydroxide is a resistance management tool used in combination with wettable sulfur and in rotation with other products. It is also used for other fungal diseases such as downy mildew, summer bunch rot, and for frost management. Use of copper hydroxide may burn grape leaves. Copper hydroxide is approved for organic production of grapes.

**Captan.** 0 day PHI. Captan is applied for spring foliar treatment for this disease and botrytis bunch rot. Applications of captan should not be made immediately before or closely following oil sprays. There is a 1 day reentry period.

**Mancozeb.** 0 day PHI. Mancozeb (DITHANE) is an alkylenebis (dithocarbamate) applied for control of this disease and botrytis bunch rot. Mancozeb should not be applied after bloom. There is a 24 hour reentry period.

**Sulfur.** 0 day PHI. Sulfur is applied to over 80% of wine grapes in California, the vast majority of which is for control of powdery mildew. Most of this sulfur is for controlling powdery mildew and not phomopsis. For phomopsis control, wettable sulfur is often combined with copper hydroxide. In some counties the restricted-entry interval for sulfur is 3 days. Sulfur can cause injury to foliage and fruit when applied just before or on days when the temperature exceeds 100%F. Use of sulfur is approved for organically grown produce.

**Ziram.** 0 day PHI. Ziram is a dithicarbamate. The restricted entry interval is 48 hours.

## CULTURAL CONTROL PRACTICES

**Pruning.** Spur and cane lesions provide most of the inoculum for new infections. Reducing the source of the disease is important. Growers can prune out badly infected canes to reduce the carryover of spores.

## PIERCE'S DISEASE
*Xylella fastidiosa*

**Damage.** The bacterium that causes Pierce's disease lives in the water-conducting system of plants (the xylem) and is spread from plant to plant by xylem-feeding sharpshooters (Goodwin and Purcell, 1992) (see Sharpshooters in Major Insect Pests). Symptoms of Pierce's disease first appear as water stress in midsummer and are caused by blockage of the water-conducting system by the bacteria. Leaves become slightly yellow or red along margins in white and red varieties, respectively, and eventually leaf margins dry or die in concentric zones. By mid-season some or all fruit clusters on infected canes may wilt and dry. Tips of canes may die back, and roots may also die back. Vines may deteriorate rapidly after appearance of symptoms.

**Description of Symptoms and Disease Cycle.** Sharpshooters are active in the spring after average temperatures warm up above 59%F, and can transmit the bacterium to the vines anytime thereafter. Usually only one or two canes on a vine will show Pierce's disease symptoms in the same season that infection has occurred, and this happens late in the season. Symptoms gradually spread along the cane from the point of infection out towards the end and more slowly towards the base. In the following year, some canes or spurs may fail to bud out. New leaves become chlorotic (yellow) between leaf veins and scorching appears on older leaves. From late April through summer infected vines may grow at a normal rate, but the total new growth is less than that of healthy vines. Not all vines which have been infected will develop the disease. The probability of recovery depends on variety, the date of infection and the age of the vineyard. Recovery is high in Sauvignon blanc, Chenin blanc, Sylvaner, Ruby Cabernet, and White Riesling, but low in Barbera, Chardonnay, Mission, and Pinot Noir. Once the vine has been infected for over a year (i.e., bacteria survive the first winter) recovery is much less likely. Young vines are more susceptible than mature vines, probably because during the training period, much less wood is pruned off than mature vines. Infections are often removed with pruning. Rootstock species and hybrids vary greatly in susceptibility. The date of infection strongly influences the likelihood of recovery. Late infections (after June) are least likely to persist the following growing season.

**Monitoring.** Growers and PCAs can monitor for insect vectors such as sharpshooters (see Sharpshooters in Major Insect Pests), and can make visual observations for symptoms of Pierce's disease.

## CHEMICAL CONTROLS

**Removal of Disease Vector.** Insecticide treatments aimed at controlling the vector in areas adjacent to the vineyard have reduced the incidence of Pierce's disease by reducing the numbers of sharpshooters immigrating into the vineyards in early spring. The degree of control, however, is not promising for very susceptible varieties such as Chardonnay and Pinot Noir.

## CULTURAL CONTROL PRACTICES

**Neighboring Crops/Wildlands.** Riparian areas bordering vineyards are often an important source of Pierce's disease in coastal vineyards. In the San Joaquin Valley, the greatest amount of disease spread is usually near pastures, weedy hay fields, or other grassy areas. Growers should consider the presence of neighboring hay fields or permanent pastures or riparian areas when planting a vineyard. Though often not feasible, in some instances properties adjacent to vineyards are purchased or leased, and managed in such a way that does not encourage sharpshooter populations. Management of riparian woodlands and environmental restoration plantings with non-host species is a newly developed method that requires careful planning and advance approval by governmental agencies. Non-host plant species include alder, cottonwood, spicebush, toyon and walnut. Systemic hosts include big leaf maple, buckeye, California blackberry, and wild grape (A.S. Purcell, personal communication).

**Weed Control.** Perennial weedy grasses should be eliminated from areas adjacent to vineyards, such as along roads, ditches, and ponds. Bermuda grass and water grass are especially favored sharpshooter hosts. Alfalfa fields can be sources of sharpshooters if grass weeds are present. Annual weeds in vineyards that begin to grow after April or May do not support high sharpshooter populations.

**Tolerant Varieties.** If a vineyard is near an area with a history of Pierce's disease, varieties that are less susceptible to this disease can be planted.

**Vine Removal.** Vines that have had Pierce's symptoms for more than one year should be removed as they area source of infection.

## BIOLOGICAL CONTROLS

No biological controls are known for Pierce's disease.

## EUTYPA AND OTHER CANKER DISEASES

### Eutypa Dieback: *Eutypa lata*

### Bot canker: *Botryodiplodia theobromae*

**Damage.** Eutypa and other canker diseases are caused by two species of fungi, *Eutypa lata* and *Botryodiplodia theobromae* (Gubler and Leavitt, 1992). Eutypa dieback is an important problem in the Northern San Joaquin Valley and coastal regions, but is also found in the Southern San Joaquin Valley. Bot canker is the main cause of arm and cordon death in the southern San Joaquin Valley region. It is an occasional problem in the South Coast region. Both Eutypa and Bot canker enter the vine through pruning wounds, and move slowly towards the roots. The fungi form cankers in the permanent wood of the vine, and eventually cause death of spurs, cordons, and ultimately, the entire vine.

**Description of Symptoms and Disease Cycle.** Eutypa survives in diseased wood and produces fruiting bodies (perithecia) in old, affected host tissue under conditions of high moisture. Eutypa spores are produced in the northern part of California in grapevines, apricots, cherries, kiwi, manzanita and *Ceanothus*. Ascopores are discharged from perithecia soon after rainfall. Bot canker produces fruiting bodies (pycnidia) on the surface of the canker, which produce spores. Spores of both diseases are carried with winter storms, and infection on grapes occurs through pruning wounds. Symptoms in the wood of both diseases are similar in appearance, characterized by wedge-shaped, darkened cankers that develop in the vascular tissue. Eutypa dieback delays shoot emergence in the spring, and causes shoot stunting and a "witch's broom" appearance. Leaves are chlorotic and tattered. No foliar symptoms have been associated with Bot canker. Disease is not generally visible in vines younger than 5 to 6 years old and is seen most frequently in vineyards established for 10 or more years.

**Monitoring.** Eutypa and bot canker can be detected by observing dead sections of cordon. Growers and PCAs should monitor for Eutypa by looking for symptoms in late spring before stunted shoots can be masked by growth from adjacent shoots.

### CHEMICAL CONTROLS

Chemical treatments are most effective if applied directly to the pruning wounds immediately after pruning.

**Benomyl.** Benomyl (BENLATE) has a restricted-entry interval of 1 day. Should be re-applied every two weeks for most effective control.

## CULTURAL CONTROL PRACTICES

**Training and Pruning**. The most effective method of managing Eutypa and bot canker is to minimize the amount of inoculum entering the vine, both in space and time. Spatially, the number and size of pruning cuts should be minimized, and vines should be properly trained initially to avoid the large cuts necessary in re-training efforts. Pruning should occur as late in the dormancy period as possible, after most rains have reduced the spore load. Late pruning also encourages quick wound healing, minimizing the amount of time that the vines are vulnerable to infection. Pruning wounds remain susceptible for some 4-5 weeks in December, but only for about 7-10 days in February. Cutting out dead sections of cordons can be done, but it is probably more cost effective to simply retrain a cane from an uninfected part of the vine to replace dead cordons.

**Pre-Pruning.** Recently, vineyardists have been employing pre-pruning, where a mechanized pruner is used once in the fall, leaving canes of 2 feet or more. The vines are then hand pruned in the late-dormant period. The brush removed by the mechanized pre-pruning allows for much more rapid hand pruning in the spring.

## BIOLOGICAL CONTROLS

A few fungal antagonists to Eutypa have been identified and applied experimentally to pruning wounds to control it. Research in California has shown that *Fusarium lateritium* and *Cladosporium herbarum* can colonize pruning wounds and provide control of Eutypa (Munkvold and Marois, 1993), but no fungal antagonistic products are available commercially.

## DOWNY MILDEW
*Plasmopara viticola*

**Damage.** Downy mildew is a fungus which is common in areas with high summer rainfall (eastern USA and Europe), but was unknown in California until 1995. It was problematic in several South San Joaquin Valley vineyards in the wet springs of 1995 and 1998. It has so far not shown up in the coastal regions or the Northern San Joaquin Valley. Oily lesions develop on the upper sides of the leaves, and the fungus sporulates in a dense white fluffy growth within the lesions. Severely infected berries and clusters may completely shrivel within weeks.

**Description of Symptoms and Disease Cycle.** The fungus overwinters as oospores in leaf litter and soil, as well as in buds and shoot tips on the vine. Spring rains splash the spores onto green tissue. Downy mildew attacks all green parts of the vine. Lesions can be yellowish and oily or angular and yellow to reddish brown, depending on leaf and lesion age. Infected shoot tips thicken, curl and become white with sporulation, eventually dying. Young berries are more susceptible to the disease than more mature berries.

**Monitoring.** Growers and PCAs should be on the lookout for signs of the disease, especially during wet springs. Eradicative treatments can be applied at the first sign of the disease.

## CHEMICAL CONTROLS

Materials for downy material can be classified as preventatives or contacts. No systemic materials are registered (some systemic fungicides against downy mildew are used in other countries).

*Preventatives*

**Copper Hydroxide.** 0 day PHI. Copper hydroxide is a preventative, and a resistance management tool used in rotation with other products. Copper hydroxide is used to treat several diseases such as phomopsis, botrytis bunch rot and frost management. Use of copper hydroxide may burn grape leaves.

**Basic Copper Sulfate.** 0 days PHI. Applications with basic copper sulfate, also known as BORDEAUX mixture, are initiated when shoots are 0.5 inches long and then repeated every two weeks as needed. It is a preventative material. The reentry period is 1 day.

**Mancozeb** (DITHANE). 66 day PHI. The reentry period is 1 day.

**Azoxystrobin.** 14 day PHI. Preventative and contact. Azoxystrobin (ABOUND) is a relatively new chemical tool to California. The restricted entry interval is 12 hours.

*Contact materials*

**Azoxystrobin.** 14 day PHI. Preventative and contact.

## CULTURAL CONTROL PRACTICES

**Disease Free Plants.** Use of disease-free planting materials reduces the introduction of downy mildew to a new vineyard.

## BIOLOGICAL CONTROLS

No biological practices have been identified for this disease.

# Nematode Control

**Root Knot Nematodes:**
***Meloidogyne incognita, M. javanica, M. arenaria,* and *M. hapla***
**Ring Nematode: *Criconemella xenoplax***
**Dagger Nematodes: *Xiphinema americanum* and *X. index***
**Root Lesion Nematode: *Pratylenchus vulnus***
**Citrus Nematode: *Tylenchulus semipenetrans***

Plant parasitic nematodes are microscopic, unsegmented roundworms that feed on plant roots by puncturing and sucking the cell contents. They live in soil and within or on plant tissues. Of the many genera of plant parasitic nematodes detected in soils from California vineyards, root knot, ring, dagger, root lesion and citrus nematodes are the most important (McKenry, 1992). Other nematodes associated with grape in California include stubby root nematode, *Paratrichodorus minor*; spiral nematode, *Helicotylencus pseudorobustus*; and needle nematode, *Longidorus africanus*. Of these, only needle and spiral nematodes have been found to be damaging to grapes in California. Pin nematode, *Paratylenchus hamatus,* is frequently found in vineyards but is not thought to cause damage.

Dagger, ring, and root lesion nematodes are most prevalent in north and central coast vineyards, and in the San Joaquin Valley. Root knot and citrus nematodes occur most commonly in the San Joaquin Valley and southern California. The needle nematode is found mainly in southern California. Presence of species, soil texture, grape cultivar, cropping history, weed spectrum, and growing region are the determining factors as to which nematode is present in which vineyard as well as the extent of damage they will cause.

**Damage.** Plant parasitic nematodes feed on roots, reducing water and nutrient uptake, and ultimately, vigor and yield of grapevines. Nematodes fall into two categories with respect to feeding: some feed externally on roots (ectoparasitic nematodes), and some penetrate into roots and feed internally (endoparasitic nematodes). Damage is often associated with soil textural differences. Root knot nematode (RKN) *(Meloidogyne* spp.) is most damaging on coarse-textured soils (sands, loamy sands and sandy loams). R.N. penetrates into roots and induces giant cell formation, usually resulting in root galls. Giant cells and galls disrupt uptake of nutrients and water, and interfere with plant growth. Ring nematode (RN) (*Criconemella xenoplax*) can be damaging on coarse or fine-textured soils, but does not do well on fine sandy loam soils. RN feeds externally. The dagger nematode, *X. index*, can cause yield reduction in some varieties, but is more important for its transmission of grapevine fanleaf virus. A closely related species, X. *americanum*, is the most common species of dagger nematode, weakening the vine by feeding just behind the root tip and vectoring yellow vein virus (also known as tomato ringspot virus). Root lesion nematode restricts the growth of roots as it feeds and migrates in and out of roots; it can be especially damaging to newly planted vines. Citrus nematodes establish feeding sites with their heads embedded in cortical tissue and their posterior ends outside the roots.

**Life History of the Pest.** Juvenile RKN and other endoparasitic nematode species penetrate roots and establish feeding sites in the vascular tissues. Their development stimulates the vine to produce galls, which may be occupied by one or several adult female RKN. Upon maturity, the sedentary RKN female may lay up to 1,500 eggs apiece. RN and other ectoparasitic species remain in the soil during their entire life cycle.

**Monitoring.** To make management decisions, it is important that growers know the nematode species present and have an estimate of their population level. Growers and PCA's may take soil samples and have them assayed for nematodes. Soil and root samples should be taken within the row, preferably one to two feet from the trunk, down to a depth of 3 feet (McKenry, 1992). Samples may be taken any time of the year, but the economic threshold will vary.

## CHEMICAL CONTROLS

Vineyards planted in fumigated ground are known to have improved growth and yields compared to those planted on nonfumigated ground.

### *Pre-plant treatments*

**Methyl Bromide.** In any one year, only a small percent of vineyard land is fumigated. It is applied to soil at an average rate of 350 lb ai per acre. Higher rates are recommended for fine textured soils. The restricted-e ntry interval for methyl bromide is 48 hours. Methyl bromide is being phased out and will no longer be available after 2005.

**Metam Sodium.** Metam sodium (VAPAM) is applied at average rates of about 200 to 325 lb ai per treated acre. It is seldom applied to grapes. Metam sodium is a restricted use material and may only be applied by permit from a county agricultural commissioner. It is seldom as effective as methyl bromide because it is difficult to get 4-5 ft down from the surface and is a poor root penetrant. Pre-application soil preparation is critical to the effectiveness of the treatment. Before applying this material, growers must thoroughly cultivate the area to be treated to break up clods and deeply loosen the soil. After cultivation and 1 to 2 weeks before treatment, the field is wetted to as deep as 5 feet.. Treatments are designed to transport water and vapam to the 5 ft depth. After treatment, planting should not occur for 30 days to 60 days.

Soils which do not infiltrate 6 inches of water in 8 hours or less are not suitable candidates for this treatment. The restricted-entry interval for metam sodium is 48 hours.

**1,3-Dichloropropene.** 1,3-Dichloropropene (TELONE) is an organochlorine . This preplant restricted-use material may only be applied by permit from the county agricultural commissioner. There is a cap placed on acreage use per township in California. This cap essentially limits treatments to about 300 acres per township per year. The restricted-entry interval is 72 hours.

***Post-plant treatments***

**Sodium Tetrathiocarbonate.** Sodium Tetrathiocarbonate (ENZONE). This product is an even poorer root penetrant than metam sodium, thus its use as a preplant treatment is very limited. ENZONE is most effective against ectoparasitic nematodes such as RN and dagger nematodes, and less effective against RKN in the San Joaquin Valley. The restricted-entry interval is 4 days.

**Fenamiphos.** Fenamiphos (NEMACUR) is an organophosphate that is applied postplant. It is a restricted use material that is applied by permit from the county agricultural commission. This product is typically used against endoparasitic nematodes such as RKN, and is useful against ectoparasitic nematodes only when used at higher rates. It is also only effective when applied via drip irrigation. The restricted-entry interval is 48 hours. This product has become less useful as the application procedures now demand several hours of water only following a one hour injection of product.

**Carbofuran.** 200 day PHI. Carbofuran (FURADAN) is a restricted use carbamate that may only be applied by permit from a county agricultural commissioner. The restricted-entry interval is 2 days. Carbofuran is most effective against ectoparasitic nematodes such as RN and dagger nematodes, and less effective against RKN in the San Joaquin Valley.

***Myrothecium verrucaria.*** A toxin produced by the fermentation of the fungus *Myrothecium verrucaria* (DITERA) has recently been registered under FIFRA to control nematodes. Products with this active ingredient have been registered in California since 1996. Currently, these products are being used primarily by growers to determine how these products can be optimized for field-use conditions. There are no data on the extent of DITERA's use by the grape industry during the few years since it was registered in California. The restricted entry period is 4 hours. The fungus is heat-killed after the toxin is produced.

## CULTURAL CONTROL PRACTICES

**Fallow Periods.** Fallow periods of up to 10 years can be used to manage nematode populations, but is not considered an economically feasible option for most growers. This time period is required to allow old roots to decompose and nematode numbers to decrease. This will reduce initial populations but will not prevent re-infestation.

**Resistant Varieties.** No single commercially available rootstock is resistant to all nematode species. Broadest resistance is present in Ramsey, Freedom, and several rootstocks in the Teleki series (McKenry, 1999). However, their resistance mechanisms are not thought to be permanent. Several new rootstocks exhibiting broader nematode resistance are under study.

**Soil and Water Management.** Any measures taken which can minimize vine stress can increase vine tolerance to nematode attack. Soil management practices include preventing soil compaction and stratification, improve soil structure through the addition of compost, manure, cover crops, gypsum and other soil amendments, and proper fertilizer rates and timing. Irrigations should be scheduled to ensure as few water stress periods as possible. Drip irrigation systems allow precise water timing.

**Cover Crops.** In addition to the effect of cover crops on soil structure, which may help ultimately reduce vine stress, most cover crops grown in the same site for too many years can build nematode populations. Several have also been shown to be relatively safe with regards to nematode build-up, including Cahaba white vetch, Barley turned under by mid March, Blando Brome Grass and Rye Grass (M.. McKenry, personal communication). Cover crops exhibiting antagonism to nematode populations are not at this time useful in vineyards.

## BIOLOGICAL CONTROLS

There are many soil dwelling organisms that will feed on nematodes, including predatory species of nematodes. However, they usually do not provide enough mortality to control plant parasitic nematode populations. Predatory nematodes are considered to have low survivorship in agricultural fields. They reside in the shallower depths of the soil and do not penetrate roots.

# Vertebrate Control

**Overview.** A number of vertebrate species may move into or live near grape vineyards and seek the vineyards for food or shelter. The potential for damage by vertebrates varies from region to region. Migratory and resident birds can cause significant damage. Vineyards located near rangeland, wooded areas or other uncultivated areas are more likely to be invaded or re-invaded by certain vertebrates. Predators, diseases and food sources all may influence a vertebrate populations. Predators such as coyotes, foxes, snakes, hawks and owls feed on rodent and rabbit species. Growers cannot, however, rely on predators to prevent rodents or rabbits from becoming agricultural pests.

**BIRDS**
**House Finch:** ***Carpodacus mexicanus***
**Robin:** ***Turdus migratorius***
**Starling:** ***Sturnus vulgaris***
**Long-billed Curlew:** ***Numenius americanus***

**Damage.** Several species of birds can cause severe damage when they feed on ripening berries in vineyards. House finches are one of the most troublesome bird pest in grapes. They are residents in all grape growing regions and may feed on berries whenever ripe fruit is present. Robins are a common pest in grape vineyards feeding on ripening berries. Starlings may feed in vineyards any time ripening fruit are present. Long-billed curlews move through vineyards on the central and southern coast. They are large birds with a wingspan of about 2 feet, that have long legs and are characterized by a long bill that curves downward at the tip. Curlews feed in flocks of 10 to 20 and tend to return to the same areas each spring.

**Monitoring.** The best strategy for reducing bird damage depends on the species feeding on the crop. Growers and PCAs should identify the birds that are causing damage before choosing controls. Keeping records of bird problems and the time of year they occur helps growers to plan control actions.

## CULTURAL CONTROL PRACTICES

**Habitat modification**. Birds such as house finches will make use of nesting and perching sites such as weedy ditches, power lines, brush piles, etc. If these can be eliminated or reduced if will reduce the risk of damage. Because power line removal is usually not feasible, other control efforts might have to be concentrated in areas next to power lines.

**Flags.** Mylar stake flags are placed in fields to frighten away finches. Noisemakers are not effective against this species. When the finch population is high, trapping is an effective alternative, but may only be done with permit from the U.S. Fish and Wildlife Service. Visual frightening devices such as mylar stake flags can also be used to reduce damage from robins.

**Noise.** Starlings can be controlled effectively with noisemakers. However, starlings quickly become accustomed to one type of noise, and therefore a combination of noisemakers (propane exploders and shell crackers) are necessary to achieve control. Growers start using noisemakers as soon as the birds begin feeding in the vineyard. Occasional shooting may be used, which increases the effectiveness of other noise making devices. Curlews are usually easily frightened. Noisemakers, such as shell crackers fired from shotguns are an effective control. Distress call recordings are available for some bird species.

**Trapping.** Starlings can be trapped in modified Australian crow traps or converted cotton trailers placed near feeding or roosting sites.

**Netting**. Netting can be draped over high risk areas. In most cases, the expense of netting and the labor involved in installing and removing it does not justify its use over the entire vineyard.

## CALIFORNIA GROUND SQUIRREL
***Spermophilus beecheyi***

**Damage.** Ground squirrels are primarily a nuisance in vineyards, but can be a serious problem if populations build up to high levels. The squirrels gnaw on vine trunks, sometimes girdling and killing young vines. They may also feed on shoots and fruit sometimes damage polyethylene irrigation hoses.

**Monitoring.** Growers monitor for ground squirrels by checking the perimeter of the vineyard about once per month for animals or their burrows. If monitoring indicates that a squirrel population is moving in, they can be controlled with traps, fumigants, or toxic bait.

### CHEMICAL CONTROLS
**Strychnine.** Strychnine bait is applied at label rates to control ground squirrels. Baiting by hand is probably the most effective method. Single dose baits can also be placed in traps and in burrows. Strychnine is not the most effective bait for squirrels. Acceptable for organic production if grower demonstrates continued research into alternatives.

**Aluminum Phosphide.** Aluminum phosphide (PHOSTOXIN), is a fumigant used to control burrowing rodents. It works best in early spring when moist soil helps retain a high toxic gas level in the burrows. The burrows are checked after about three days. Where squirrels have dug out, re-treatment is necessary. Aluminum phosphide is rarely used in vineyards.

**Diphacinone.** Diphacinone is an anti-coagulant rodenticide bait intended to control ground squirrels. It is applied at labeled rates to traps or in bait stations. Baiting by hand is one of the most effective control mechanisms. Baits can also be placed at intervals in the main tunnel. Diphacinone is a restricted use material that may only be applied with a permit from a county agricultural commissioner..

**Zinc Phosphide.** Zinc phosphide is a bait that can be used to treat ground squirrels. It is rarely used in California.

## CULTURAL CONTROL PRACTICES

**Trapping.** Trapping ground squirrels works well in small areas or for a small number of squirrels. Box type traps are baited and the squirrels are trapped when passing through. Ground squirrels are classified as non-game mammals and can be eliminated at any time if injuring crops. Trapped animals must be either destroyed, or, a permit must be obtained to release them elsewhere.

## POCKET GOPHER
***Thomomys bottae***

**Description of Pest.** Pocket gophers are important vertebrate pests. They gnaw on root systems and girdle vines below the soil line. Their burrows run through the vineyard, diverting water and contributing to soil erosion.

**Monitoring.** Growers monitor for gophers by inspecting vines near the borders of the vineyard where gophers may move in from adjacent fields. Gophers should be controlled as soon as they are detected.

## CHEMICAL CONTROLS

**Strychnine.** Baiting by hand and single dose baits can also be placed in traps and in burrows.

**Aluminum Phosphide.** Aluminum phosphide (PHOSTOXIN) is a fumigant used to control burrowing rodents.

**Zinc Phosphide.** Zinc phosphide is a bait that can be used to treat ground squirrels

## CULTURAL CONTROL PRACTICES

**Trapping.** Trapping or baiting by hand are the most effective control mechanisms, although also the most laborious. Traps are placed in the main tunnel between two fresh mounds. The traps should be checked daily. Pocket gophers are classified as non-game mammals and can be eliminated at any time if injuring crops.

**Owl Boxes.** Increasingly, owl boxes are set up in vineyards to help control gophers.

**Floor management.** Gophers are more attracted to weeds and cover crops with a taproot. Leguminous cover crops will provide better gopher habitat than grasses.

# MEADOW VOLE
## *Microtus* spp.

**Damage.** Meadow voles, which are also referred to as meadow mice or field mice, inhabit roadsides, meadows, canal banks, fence-rows and many field crops. When mouse populations reach high levels in their native grassy habitats, they invade and occupy neighboring vineyards, gnawing on trunks and cordons.

**Description.** Full-grown meadow voles are larger than house mice but smaller than rats. They feed on grasses, so grassy areas are a good food source as well as habitat for them. Well-established populations can be recognized by the network of small runways through the grass or other cover and the openings of numerous shallow burrows. Meadow voles are active year round, day and night.

**Monitoring.** Growers monitor the vineyards by visually looking for active runways and burrows. Snap traps baited with a mixture of peanut butter and oats are also used to monitor vole populations.

Meadow voles are classified as non-game mammals and may be eliminated in any manner at any time if they are injuring crops.

## CHEMICAL CONTROLS

**Diphacinone.** Diphacinone is an anti-coagulant rodenticide bait applied at labeled rates. Baiting by hand is one of the most effective control mechanisms. Baits can also be placed at intervals in an active runway, or burrow entrance. Diphacinone is a restricted use material that may only be applied with permit from a county agricultural commissioner.

**Zinc Phosphide.** Zinc phosphide is a bait used to treat meadow voles at labeled rates. It is rarely used in grape vineyards in California

## CULTURAL CONTROL PRACTICES

**Eliminate Habitats.** Preventative measures are taken by growers to eliminate favorable mouse habitats adjacent to vineyards. Growers can clear grass, brush and weeds around vine trunks, long fence lines, field margins and irrigation and drainage ditches.

# DEER

**Damage.** Deer feed on vines and berries in vineyards located near good deer habitat. Deer are most likely to be a problem from late spring to midsummer in low-elevation vineyards. Deer feed at night and early in the morning.

**Monitoring.** Growers identify deer pests by footprints in the field and deer droppings.

## CULTURAL CONTROL PRACTICES

**Fencing**. Fencing is the only reliable method to prevent damage by deer.

**Elimination.** Depredation permits may be obtained from the California Department of Fish and Game to eliminate a few animals. This is a temporary solution.

# COYOTES

***Canis latrans***

**Damage.** Coyotes damage drip irrigation hoses.

## CULTURAL CONTROL PRACTICES

**Elimination.** Depredation permits may be obtained from the California Department of Fish and Game to eliminate a few animals.

## RABBITS

### Primarily Jackrabbits: *Lepus californicus*

**Damage.** Rabbits can cause problems in new vineyards. Rabbits feed on the leaves and stems of young plants. Jackrabbits are the primary pest though cottontail and brush rabbits also cause adverse affects.

**CULTURAL CONTROL PRACTICES**

**Grow Tubes.** Grow tubes are used to protect young vines from rabbit damage.

**Fencing.** Fencing can be an effective control for smaller vineyards.

## M & N. Challenges to Implementing Change and Innovations

The California winegrape industry currently faces a number of pest management challenges. The implementation of the Food Quality Protection Act (FQPA) may limit the availability of some commonly used materials, particularly several herbicides and fungicides. The challenge will be to have viable alternatives (chemical, cultural and biological controls) in place if some of these materials are lost due to regulatory actions. Surface and group water concerns for a few commonly used herbicides also presents a challenge to the winegrape community. In addition, recent concern over sulfur dust drift could pose significant challenges to growers.

Another key challenge is the introduction into California and spread of the glassy-winged sharpshooter. Sharpshooters vector the bacterium *Xylella fastidiosa*, which causes Pierce's disease in grapes, one of the few grapevine diseases that can kill vines. The glassy-winged sharpshooter invaded southern California in the early 1990s and is now detected in the San Joaquin Valley. It is considered a greater threat to vineyards than other sharpshooter species because of its wide host range and strong flying ability.

However, the winegrape community's active involvement in seeking solutions to challenges via research, implementation, and public policy has resulted in a number of existing innovations available or soon to be available to winegrape growers.

An overall summary of winegrape pests, key challenges and innovations is presented in **Tables 8-12**. Key challenges in the tables are coded as follows: Food Quality Protection Act Group I materials = (**FQPA I**), surface and/or ground water concerns = (**WQ**), worker safety concerns = (**WS**), winery concerns = (**WY**), and drift concerns = (**DR**).

**Table 8.** Insect pests, key challenges, and innovations in California winegrapes.

| Pest(s) | Key Challenges | Innovations | |
|---|---|---|---|
| | | **Management Practices & Reduced Risk Materials** | **Alternative Materials Pending Registration** |
| ***Omnivorous Leafroller*** | •Methomyl (Lannate®) **FQPA I**<br>•Carbaryl (Sevin®) **FQPA I**<br>•Phosmet (Imidan®) **FQPA I**<br>•Diazinon **FQPA I, WQ**<br>•Cryolite (Prokil®, Kryocide®) **WY** | •Pheremone mating disruption<br>•Use of OLR model<br>•Sanitation/weed control<br>•Bt (Various trade names) | •Spinosad®<br>•Confirm® |
| ***Leafhoppers*** | •Methomyl (Lannate®) **FQPA I**<br>•Carbaryl (Sevin®) **FQPA I**<br>•Dimethoate (Clean Crop®) **FQPA I**<br>•Naled (Dibrom®) **FQPA I**<br>•Endosulfan (Thiodan®) **FQPA I** | •New tools/methodology to expedite monitoring<br>•Vine water status<br>•Sticky tape<br>•*Anagrus* monitoring<br>•Imidacloprid (Provado®)<br>•Imidacloprid (Admire®)<br>•Narrow range oil<br>•Pyrethrin (Pyrenone®)<br>•Insecticidal soap (M- pede®)<br>•Neem (Neemix®) | •Buprofezin (Applaud®)<br>•Kaolin (Surround®) |
| ***Sharpshooters*** | •Dimethoate (Clean Crop®) **FQPA I** | •Weed control<br>•Monitoring & thresholds<br>•Imidacloprid (Provado®)<br>•Imidacloprid (Admire®) | •Kaolin (Surround®) |
| ***Mealybugs*** | •Chlorpyrifos (Lorsban®) **FQPA I** | •Trellising/pruning<br>•Monitoring<br>•Imidacloprid (Admire®)<br>•Imidacloprid(Provado®) | •Applaud® |

* Adapted from Tables 2 & 3 in *Crop/Pest Profile for California Winegrapes*, 1999

**Table 9.** Mite pests, key challenges, and innovations in California winegrapes

| Pest(s) | Key Challenges | Innovations: Management Practices & Reduced Risk Materials | Innovations: Alternative Materials Pending Registration |
|---|---|---|---|
| *Spider Mites* | •Propargite (Omite®) **FQPA I, WS**<br>•Dicofol (Kelthane®) **FQPA I** | •New tools/methodology to expedite monitoring<br>•Soil, irrigation, & dust management<br>•Reduce sulfur use<br>•Monitoring and use of action thresholds<br>•Release of predatory mites<br>•Narrow range oil<br>•Cinnamaldehyde (Valero®)* | •Avermectin (Agri-mek®)<br>•Pyridaben (Pyramite®)<br>•Biomite®<br>•Alert®<br>•Clofentazin (Apollo®) |

* Adapted from Tables 2 & 3 in *Crop/Pest Profile for California Winegrapes*, 1999

**Table 10.** Weeds, key challenges, and innovations in California winegrapes

| Pest(s) | Key Challenges | Innovations: Management Practices & Reduced Risk Materials | Innovations: Alternative Materials Pending Registration |
|---|---|---|---|
| *Weeds* | •Oxyflurofen (Goal®) **FQPA I**<br>•Simazine (Princep®) **FQPA I, WQ**<br>•Paraquat dichloride (Gramoxone®) **FQPA I**<br>•Oryzalin (Surflan®) **FQPA I**<br>•Trifluralin (Treflan®) **FQPA I**<br>•Pendimethalin (Prowl®) **FQPA I**<br>•2, 4-D (Envy®) **FQPA I**<br>•Diuron (Karmex®) **WQ**<br>•Norflurazon (Solicam®) **WQ** | •Low volume application technologies<br>•In-row cultivation<br>•Mulches: Synthetic and organic<br>•Subsurface drip irrigation<br>•Improved monitoring protocols<br>•Cover crops<br>•Glyphosate (Roundup®, Touchdown®)<br>•Sethoxydim (Poast®)<br>•Napropamide (Devrinol®)<br>•Fluazifop (Fusilade®)<br>•Herbicidal soap(Scythe®)<br>•Isoxaben (Gallery®)<br>Thiazopyr (Visor®) | •Milestone® |

* Adapted from Tables 2 & 3 in *Crop/Pest Profile for California Winegrapes*, 1999

**Table 11.** Diseases, key challenges, and innovations in California winegrapes

| Pest(s) | Key Challenges | Innovations | |
|---|---|---|---|
| | | **Management Practices & Reduced Risk Materials** | **Alternative Materials Pending Registration** |
| ***Powdery Mildew*** | •Myclobutanil (Rally®) **FQPA I**<br>•Triflumizole (Procure®) **FQPA I**<br>•Triademefon (Bayleton®) **FQPA I**<br>•Sulfur (various trade names) **DR, WS** | •Monitoring and timing- use & improve mildew model<br>•Canopy & nutrient management<br>•Improved application equipment for sulfur<br>•Sulfur (various trade names)<br>•Fenarimol (Rubigan®)<br>•Narrow range oil<br>•Insecticidal soap (M- pede®)<br>•Azoxystrobin (Abound®)*<br>•*Ampelomyces quisqualis* (AQ10®)*<br>•Potassium bicarbonate (Kaligreen®)* | •Chitosan (Elexa®)<br>•Serenade®<br>•Flint®<br>•Sovran® |
| ***Botrytis Bunch Rot*** | •Iprodione (Rovral®) **FQPA I**<br>•Mancozeb (Dithane®) **FQPA I**<br>•Benomyl (Benlate®) **FQPA I**<br>•Captan **FQPA I, WY** | •Leafing/canopy management & trellising<br>•Use of botrytis model<br>•Regulation of crop load<br>•Irrigation management<br>•Dicloran/DCNA (Botran®)<br>•Narrow range oil<br>•Cyprodinil (Vanguard®)<br>•Fenhexamid (Elevate®) | •Elexa®<br>•Serenade®<br>•Trichodex® |

* Adapted from Tables 2 & 3 in *Crop/Pest Profile for California Winegrapes*, 1999

**Table 12.** Nematodes, key challenges, and innovations in California winegrapes

| Pest(s) | Key Challenges | Innovations | |
|---|---|---|---|
| | | **Management Practices & Reduced Risk Materials** | **Alternative Materials Pending Registration** |
| Nematodes | •Fenamiphos (Nemacur®) **FQPA I**<br>•Carbofuran (Furadan®) **FQPA I**<br>•Methy bromide **WY** | •Soil/water/fertility management<br>•Resistant rootstocks<br>•Soil amendments (cover crops, compost)<br>•1,3-Dichloropropene (Telone®)<br>•Sodium Tetrathiocarbonate (Enzone®)<br>•*Myrothecium verrucaria* (DiTera®)<br>•Oxycom® | •Imidacloprid (Admire®) |

* Adapted from Tables 2 & 3 in *Crop/Pest Profile for California Winegrapes*, 1999

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# Section 8: Glossary of Terms, Abbreviations, and Symbols

| | |
|---|---|
| A.I. | Active Ingredient |
| CAWG | California Association of Winegrape Growers |
| CDFA | California Department of Food and Agriculture |
| DPR | Department of Pesticide Regulation |
| DR | Drift |
| EPA | Environmental Protection Agency |
| FQPA | Food Quality Protection Act |
| lbs. | Pounds |
| PUR | Pesticide Use Report |
| UC IPM | University of California Integrated Pest Management Program |
| UC SAREP | University of California Sustainable Agriculture Research and Education Program |
| WQ | Water Quality |
| WS | Worker Safety |
| WY | Winery |

# Section 9: Appendices

**Appendix 1. Description of the Cleaning Algorithms**
By Dr. Susan Bassein, Data analysis & Presentation

The number of records in file for "grapes" and "grapes, wine" supplied by DPR = 494,957. Started with all grape records because some sites are listed as "grapes" and "grapes, wine" in different sites. Classify a site as "grapes, wine" if there is any record classifying it at such during the season. Further, sites in San Joaquin County are (almost) all classified as "grapes". However, almost all grapes in San Joaquin County are, in fact, "grapes, wine", so classify all sites in San Joaquin County as "grapes, wine".

Some records supplied by DPR are not "production ag reports" or have missing entries in a record. Some compounds have an associated "other related compound" record for each primary record. After the invalid records were deleted and the "other related" records were combined with the corresponding primary records, there were 490,971 records.

Number of sites before site location id corrections and record deletions = 18,524. There are some typos in site location id's which make the same site appear as different sites. For example, a "2" may be entered as a "Z" on some records but not on others. These are corrected by converting all letters to numbers. Also, dashes and leading zeros of numerical parts of the site location id's are deleted. Further, some sites have acres planted exceeding the size of a section: sites with more than 1,280 acres are deleted. Further, some sites have varying acres planted over the season; the acres planted for these sites are replaced by the median value for the site over the season. 18,502 sites remain at this point in the cleaning.

Number of growers before record deletions = 6,734; number after is 6,732.

Exact duplicate records (every entry identical) are removed; 485,412 records remain.

Records on same day with same active ingredient (a.i.) which make the cumulative acres treated on that day > acres planted are deleted. All records for the same a.i. on the same day are combined. 457,075 records remain.

Treatments of the same a.i. on the same site on up to 2 consecutive days are combined. Final treatment count is 435,847.

## Algorithm for Dealing with Monterey Site Location Ids

Some sites in Monterey County appear to have different site location id's for different applications to the same site. If one site location id is a "prefix" of another, i.e., is contained entirely as an initial substring of the other, then the second site location id is truncated to equal the first and the records are considered to be to the same site. This brought the original total acres planted of 57,147 down to 50,597, which is closer to the figure of 39,901 reported by the ag commissioner.

## Report Pounds of Active Ingredients (LBS A.I.)

The figure most susceptible to large errors in the PUR is the sum of the lbs a.i. for a given geographical region because a misplaced decimal point in one record can significantly affect the total. I compute the median application rate (lbs/acre) for a smaller geographical region -- a section or a township-range -- and then multiply that by the total acres treated for that smaller geographical region. The result is robust against gross errors, but can be biased because the median does not equal the mean. The computed lbs a.i. can then be compared with the summed lbs a.i.; if they differ substantially, then there is most likely a gross error in the sum.

## Appendix 2. 1998 Winegrape PUR Analysis by Chemical and Region

GUIDE TO TABLES.

North Coast (1NCW) Lake, Mendocino, Napa, and Sonoma Counties.

Central Coast (2CCW) Alameda, Monterey, San Luis Obispo, Santa Barbara, San Benito, Santa Cruz, and Santa Clara Counties.

Northern San Joaquin Valley (3NSW) San Joaquin, Calaveras, Amador, Sacramento, Merced, Stanislaus and Yolo Counties.

Southern San Joaquin Valley (4SSW) Fresno, Kings, Tulare, Kern, and Madera Counties.

All California (CALI) All 58 California counties.

N SITE = number of distinct site location ids
ACRPLNT = total acres planted
MIN TRT = minimum estimate of total acres treated (assumes multiple applications overlap as much as possible)
MAX TRT = maximum estimate of total acres treated (assumes multiple applications overlap as little as possible)
CUM TRT = total of acres treated for all applications (may exceed acres planted)
MIN% = percent acres planted based on MIN TRT estimate
MAX% = percent acres planted based on MAX TRT estimate
COMP LBSAI = computed total lbs a.i. protected against errors but my be biased (for each township-range-section, multiply median application rate by total acres treated)
SUM LBSAI = sum of all lbs a.i. reported (not protected against errors; if much larger than COMP LBSAI, use COMP LBSAI)
N APPS = total number of (up to 2 consecutive day) applications
MED = median number of (up to 2 consecutive day) applications per site
MEDAPPR = median application rate (lbs/acre)

NOTE: a.i. names have been compressed to save space. The following requested a.i.'s were not present:

- Dichlobenil CASORON
- Methyl Parathion
- OLR Pheromone NO-MATE an d CHECKMATE
- Trichoderma. Trichoderma spp. TRICHODEX

The following combination was so rare it is not reported on in the tables:

- Mefenoxam + Copper Hydroxide RIDOMIL GOLD

| | N SITE SUM | ACRPLNT SUM |
|---|---|---|
| 1NCW | 3111 | 113213 |
| 2CCW | 1315 | 90581 |
| 3NSW | 2459 | 143873 |
| 4SSW | 2276 | 167282 |
| CALI | 9539 | 526195 |

AI=13DICHLOROPROPENE

| | | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2CCW | 233 | 233 | 233 | 0.3 | 0.3 | 71276 | 71276 | 5 | 1 | 291.27 |
| | 3NSW | 149 | 149 | 149 | 0.1 | 0.1 | 12333 | 12307 | 7 | 1 | 9.73 |
| | 4SSW | 204 | 204 | 204 | 0.1 | 0.1 | 66822 | 66822 | 4 | 1 | 334.35 |
| | CALI | 586 | 586 | 586 | 0.1 | 0.1 | 150430 | 150405 | 16 | 1 | 288.93 |

AI=24D

| | | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1NCW | 47 | 47 | 47 | 0.0 | 0.0 | 3 | 3 | 6 | 1 | 0.07 |
| | 3NSW | 33 | 38 | 38 | 0.0 | 0.0 | 12 | 12 | 3 | 2 | 0.33 |
| | 4SSW | 196 | 196 | 196 | 0.1 | 0.1 | 37 | 37 | 6 | 1 | 0.22 |
| | CALI | 276 | 281 | 281 | 0.1 | 0.1 | 52 | 52 | 15 | 1 | 0.11 |

AI=AMMONIUMTALLOILFATTYACIDSOAP

| | | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1NCW | 90 | 125 | 132 | 0.1 | 0.1 | 38 | 38 | 13 | 2 | 0.28 |
| | 3NSW | 4 | 8 | 8 | 0.0 | 0.0 | 5 | 5 | 2 | 2 | 0.56 |
| | CALI | 94 | 133 | 140 | 0.0 | 0.0 | 43 | 42 | 15 | 2 | 0.28 |

AI=AMPELOMYCESQUISQUALIS

| | | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1NCW | 598 | 694 | 907 | 0.5 | 0.6 | 0 | 0 | 39 | 3 | 0.00 |
| | 2CCW | 2502 | 2764 | 4504 | 2.8 | 3.1 | 1 | 23 | 144 | 2 | 0.00 |
| | 3NSW | 54 | 64 | 276 | 0.0 | 0.0 | 0 | 0 | 16 | 3 | 0.00 |
| | 4SSW | 391 | 391 | 391 | 0.2 | 0.2 | 0 | 0 | 3 | 1 | 0.00 |
| | CALI | 3846 | 4217 | 6749 | 0.7 | 0.8 | 2 | 24 | 228 | 2 | 0.00 |

AI=AZINPHOSMETHYL

| | | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2CCW | 25 | 25 | 25 | 0.0 | 0.0 | 19 | 19 | 1 | 1 | 0.75 |
| | CALI | 25 | 25 | 25 | 0.0 | 0.0 | 19 | 19 | 1 | 1 | 0.75 |

AI=AZOXYSTROBIN

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 13166 | 16072 | 21253 | 11.6 | 14.2 | 5122 | 5138 | 802 | 1 | 0.20 |
| 2CCW | 24818 | 31323 | 52194 | 27.4 | 34.6 | 11130 | 14677 | 1083 | 2 | 0.21 |
| 3NSW | 17217 | 18841 | 25576 | 12.0 | 13.1 | 5071 | 6062 | 414 | 1 | 0.21 |
| 4SSW | 27228 | 28098 | 36199 | 16.3 | 16.8 | 11894 | 11889 | 462 | 1 | 0.21 |
| CALI | 84152 | 96090 | 137508 | 16.0 | 18.3 | 33631 | 38179 | 2821 | 1 | 0.21 |

AI=BACILLUSTHURINGIENSIS

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 52 | 52 | 52 | 0.0 | 0.0 | 6 | 6 | 3 | 1 | 0.13 |
| 2CCW | 4912 | 5775 | 11505 | 5.4 | 6.4 | 3765 | 3734 | 425 | 1 | 0.08 |
| 3NSW | 18645 | 19768 | 35512 | 13.0 | 13.7 | 1908 | 1884 | 301 | 1 | 0.05 |
| 4SSW | 16328 | 17104 | 26553 | 9.8 | 10.2 | 1936 | 2060 | 437 | 1 | 0.08 |
| CALI | 40982 | 43823 | 74789 | 7.8 | 8.3 | 7696 | 7765 | 1187 | 1 | 0.07 |

AI=BENOMYL

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 7076 | 10251 | 11343 | 6.2 | 9.1 | 3953 | 3930 | 598 | 1 | 0.31 |
| 2CCW | 1559 | 1613 | 2198 | 1.7 | 1.8 | 1588 | 1607 | 110 | 1 | 0.75 |
| 3NSW | 8529 | 9400 | 11868 | 5.9 | 6.5 | 5539 | 5215 | 260 | 1 | 0.50 |
| 4SSW | 27279 | 27974 | 29593 | 16.3 | 16.7 | 18616 | 18716 | 350 | 1 | 0.50 |
| CALI | 44566 | 49361 | 55126 | 8.5 | 9.4 | 29764 | 29537 | 1328 | 1 | 0.50 |

AI=CAPTAN

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 58 | 58 | 58 | 0.1 | 0.1 | 60 | 60 | 2 | 1 | 0.97 |
| 2CCW | 10 | 20 | 20 | 0.0 | 0.0 | 11 | 11 | 2 | 2 | 0.55 |
| 3NSW | 673 | 1040 | 1097 | 0.5 | 0.7 | 1540 | 1484 | 41 | 1 | 1.25 |
| 4SSW | 1958 | 2014 | 2393 | 1.2 | 1.2 | 3304 | 3298 | 58 | 1 | 1.50 |
| CALI | 2761 | 3195 | 3647 | 0.5 | 0.6 | 5029 | 4967 | 110 | 1 | 1.32 |

AI=CARBARYL

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 958 | 1055 | 1061 | 0.8 | 0.9 | 1589 | 1446 | 76 | 1 | 1.05 |
| 2CCW | 2834 | 3223 | 3223 | 3.1 | 3.6 | 4741 | 5032 | 43 | 1 | 1.85 |
| 3NSW | 1751 | 1861 | 2081 | 1.2 | 1.3 | 2273 | 2251 | 55 | 1 | 1.19 |
| 4SSW | 1207 | 1207 | 1890 | 0.7 | 0.7 | 3209 | 3209 | 33 | 1 | 0.99 |
| CALI | 6776 | 7379 | 8291 | 1.3 | 1.4 | 11880 | 11983 | 214 | 1 | 1.53 |

AI=CARBOFURAN

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 2CCW | 4787 | 6081 | 7622 | 5.3 | 6.7 | 25688 | 22553 | 93 | 2 | 3.20 |
| 3NSW | 1262 | 1282 | 2246 | 0.9 | 0.9 | 9375 | 8803 | 61 | 1 | 3.20 |
| CALI | 6051 | 7365 | 9870 | 1.1 | 1.4 | 35067 | 31359 | 155 | 1 | 3.20 |

AI=CHLORPYRIFOS

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 57 | 57 | 57 | 0.1 | 0.1 | 104 | 104 | 1 | 1 | 1.84 |
| 2CCW | 1590 | 1896 | 2032 | 1.8 | 2.1 | 3404 | 8971 | 55 | 1 | 1.86 |
| 3NSW | 342 | 342 | 342 | 0.2 | 0.2 | 636 | 636 | 5 | 1 | 1.86 |
| 4SSW | 992 | 992 | 1012 | 0.6 | 0.6 | 1853 | 1854 | 35 | 1 | 1.86 |
| CALI | 3003 | 3309 | 3465 | 0.6 | 0.6 | 6030 | 11598 | 98 | 1 | 1.86 |

AI=COPPER

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 2184 | 2714 | 6110 | 1.9 | 2.4 | 1437 | 1569 | 162 | 3 | 0.27 |
| 3NSW | 7660 | 7858 | 8040 | 5.3 | 5.5 | 21380 | 21632 | 64 | 1 | 3.00 |
| 4SSW | 11123 | 11301 | 15800 | 6.6 | 6.8 | 33691 | 33749 | 94 | 1 | 1.80 |
| CALI | 20966 | 21873 | 29949 | 4.0 | 4.2 | 56508 | 56950 | 320 | 1 | 1.04 |

AI=COPPERHYDROXIDE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 20746 | 27998 | 41712 | 18.3 | 24.7 | 33942 | 34389 | 1718 | 2 | 0.76 |
| 2CCW | 24940 | 30677 | 63963 | 27.5 | 33.9 | 41234 | 42471 | 1141 | 2 | 0.76 |
| 3NSW | 28097 | 31275 | 48094 | 19.5 | 21.7 | 45436 | 44881 | 889 | 1 | 0.81 |
| 4SSW | 81838 | 83658 | 124244 | 48.9 | 50.0 | 143192 | 144890 | 1894 | 1 | 1.23 |
| CALI | 157498 | 175553 | 281406 | 29.9 | 33.4 | 274024 | 276849 | 5756 | 1 | 0.80 |

AI=COPPERNAPHTHENATE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 81 | 81 | 81 | 0.1 | 0.1 | 1040 | 1040 | 2 | 1 | 12.83 |
| CALI | 81 | 81 | 81 | 0.0 | 0.0 | 1040 | 1040 | 2 | 1 | 12.83 |

AI=COPPEROXIDE(OUS)

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 155 | 238 | 305 | 0.1 | 0.2 | 342 | 324 | 17 | 1 | 1.13 |
| 2CCW | 138 | 275 | 275 | 0.2 | 0.3 | 310 | 310 | 2 | 2 | 1.13 |
| 3NSW | 1917 | 2580 | 4973 | 1.3 | 1.8 | 4437 | 4307 | 91 | 1 | 1.13 |
| 4SSW | 1235 | 1237 | 1558 | 0.7 | 0.7 | 1764 | 1764 | 37 | 1 | 1.13 |
| CALI | 4836 | 5877 | 9546 | 0.9 | 1.1 | 9605 | 9458 | 167 | 1 | 1.13 |

AI=COPPEROXYCHLORIDE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 192 | 199 | 534 | 0.2 | 0.2 | 3254 | 3267 | 17 | 1 | 14.96 |
| 2CCW | 559 | 559 | 596 | 0.6 | 0.6 | 7784 | 7404 | 39 | 1 | 14.96 |
| 3NSW | 431 | 438 | 462 | 0.3 | 0.3 | 6378 | 6319 | 17 | 1 | 15.11 |
| 4SSW | 1411 | 1411 | 2507 | 0.8 | 0.8 | 56261 | 56774 | 25 | 1 | 22.65 |
| CALI | 2593 | 2607 | 4098 | 0.5 | 0.5 | 73677 | 73765 | 98 | 1 | 14.96 |

AI=COPPEROXYCHLORIDESULFATE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 4936 | 5691 | 10256 | 4.4 | 5.0 | 27734 | 26507 | 293 | 2 | 3.00 |
| 2CCW | 2418 | 2497 | 6513 | 2.7 | 2.8 | 17879 | 17564 | 246 | 3 | 2.94 |
| 3NSW | 16462 | 18154 | 25236 | 11.4 | 12.6 | 70344 | 73931 | 562 | 1 | 3.00 |
| 4SSW | 16112 | 16435 | 22344 | 9.6 | 9.8 | 54421 | 54693 | 275 | 1 | 3.00 |
| CALI | 41886 | 44735 | 67006 | 8.0 | 8.5 | 177687 | 180017 | 1405 | 1 | 3.00 |

AI=COPPERSALTSOFFATTYANDROSINACIDS

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 1659 | 2021 | 2640 | 1.5 | 1.8 | 2563 | 2553 | 172 | 1 | 0.91 |
| 3NSW | 7041 | 7459 | 8085 | 4.9 | 5.2 | 10905 | 10928 | 133 | 1 | 1.22 |
| 4SSW | 53 | 56 | 78 | 0.0 | 0.0 | 179 | 179 | 6 | 2 | 2.43 |
| CALI | 8753 | 9536 | 10802 | 1.7 | 1.8 | 13647 | 13660 | 311 | 1 | 1.22 |

AI=COPPERSULFATE(BASIC)

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 194 | 200 | 537 | 0.2 | 0.2 | 618 | 621 | 19 | 1 | 2.70 |
| 2CCW | 579 | 579 | 616 | 0.6 | 0.6 | 1498 | 1426 | 40 | 1 | 2.84 |
| 3NSW | 473 | 480 | 504 | 0.3 | 0.3 | 1255 | 1244 | 18 | 1 | 2.81 |
| 4SSW | 1427 | 1427 | 2523 | 0.9 | 0.9 | 10697 | 10794 | 27 | 1 | 4.30 |
| CALI | 3209 | 3223 | 4716 | 0.6 | 0.6 | 15120 | 15136 | 107 | 1 | 2.84 |

AI=CRYOLITE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 129 | 170 | 170 | 0.1 | 0.2 | 1112 | 1112 | 5 | 1 | 5.76 |
| 2CCW | 4131 | 4275 | 5396 | 4.6 | 4.7 | 31214 | 31020 | 60 | 1 | 5.76 |
| 3NSW | 30030 | 32080 | 33288 | 20.9 | 22.3 | 198969 | 199039 | 534 | 1 | 5.76 |
| 4SSW | 77090 | 78818 | 82125 | 46.1 | 47.1 | 451619 | 451864 | 1403 | 1 | 5.76 |
| CALI | 113195 | 117326 | 123074 | 21.5 | 22.3 | 692298 | 692403 | 2031 | 1 | 5.76 |

AI=CYPRODINIL

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 15929 | 19010 | 22736 | 14.1 | 16.8 | 9537 | 11798 | 848 | 1 | 0.47 |
| 2CCW | 12770 | 15357 | 18850 | 14.1 | 17.0 | 8781 | 8679 | 443 | 1 | 0.47 |
| 3NSW | 13063 | 13755 | 18577 | 9.1 | 9.6 | 6869 | 7732 | 294 | 1 | 0.42 |
| 4SSW | 10207 | 10362 | 13284 | 6.1 | 6.2 | 4281 | 4376 | 125 | 1 | 0.47 |
| CALI | 53964 | 60527 | 77020 | 10.3 | 11.5 | 31170 | 34836 | 1831 | 1 | 0.47 |

AI=DIAZINON

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 860 | 1015 | 1127 | 0.8 | 0.9 | 784 | 1092 | 61 | 1 | 0.75 |
| 2CCW | 912 | 1477 | 1665 | 1.0 | 1.6 | 1659 | 2154 | 36 | 1 | 1.00 |
| 3NSW | 414 | 415 | 428 | 0.3 | 0.3 | 144 | 144 | 8 | 1 | 0.46 |
| 4SSW | 681 | 681 | 873 | 0.4 | 0.4 | 1424 | 1334 | 23 | 1 | 1.00 |
| CALI | 2875 | 3595 | 4101 | 0.5 | 0.7 | 4013 | 4725 | 130 | 1 | 0.99 |

AI=DICLORAN

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 1809 | 1980 | 2296 | 1.6 | 1.7 | 4379 | 5006 | 91 | 1 | 1.80 |
| 2CCW | 5821 | 6856 | 10520 | 6.4 | 7.6 | 16970 | 16977 | 115 | 1 | 1.80 |
| 3NSW | 4985 | 5189 | 5588 | 3.5 | 3.6 | 9084 | 9095 | 132 | 1 | 1.80 |
| 4SSW | 5403 | 5884 | 7253 | 3.2 | 3.5 | 11686 | 12009 | 130 | 1 | 1.50 |
| CALI | 18758 | 20664 | 26649 | 3.6 | 3.9 | 45395 | 46356 | 501 | 1 | 1.80 |

AI=DICOFOL

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 4495 | 5189 | 5366 | 4.0 | 4.6 | 9012 | 8875 | 280 | 1 | 1.20 |
| 2CCW | 1539 | 1791 | 2208 | 1.7 | 2.0 | 2406 | 2403 | 67 | 1 | 1.08 |
| 3NSW | 4607 | 4707 | 4857 | 3.2 | 3.3 | 4921 | 4945 | 118 | 1 | 1.05 |
| 4SSW | 6396 | 6732 | 6732 | 3.8 | 4.0 | 5712 | 5711 | 63 | 1 | 1.05 |
| CALI | 17712 | 19138 | 19897 | 3.4 | 3.6 | 22766 | 22659 | 553 | 1 | 1.12 |

AI=DIMETHOATE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 3197 | 3551 | 3958 | 2.8 | 3.1 | 1964 | 2003 | 246 | 1 | 0.37 |
| 2CCW | 217 | 218 | 220 | 0.2 | 0.2 | 163 | 161 | 4 | 1 | 0.98 |
| 3NSW | 410 | 410 | 410 | 0.3 | 0.3 | 137 | 137 | 10 | 1 | 0.12 |
| 4SSW | 1742 | 1917 | 1922 | 1.0 | 1.1 | 2871 | 2875 | 18 | 1 | 1.60 |
| CALI | 5615 | 6158 | 6572 | 1.1 | 1.2 | 5171 | 5211 | 286 | 1 | 0.46 |

AI=DIURON

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 1503 | 1706 | 1767 | 1.3 | 1.5 | 2443 | 2372 | 111 | 1 | 1.47 |
| 2CCW | 107 | 107 | 107 | 0.1 | 0.1 | 167 | 167 | 7 | 1 | 1.60 |
| 3NSW | 26052 | 27476 | 30904 | 18.1 | 19.1 | 23391 | 24250 | 643 | 1 | 0.64 |
| 4SSW | 13602 | 14698 | 15040 | 8.1 | 8.8 | 20736 | 22622 | 342 | 1 | 0.80 |
| CALI | 41346 | 44163 | 47996 | 7.9 | 8.4 | 46895 | 49569 | 1114 | 1 | 0.73 |

AI=ENDOSULFAN

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 25 | 25 | 44 | 0.0 | 0.0 | 38 | 38 | 4 | 2 | 0.79 |
| 2CCW | 11 | 11 | 11 | 0.0 | 0.0 | 16 | 16 | 2 | 1 | 1.51 |
| 4SSW | 698 | 698 | 698 | 0.4 | 0.4 | 671 | 671 | 14 | 1 | 0.38 |
| CALI | 737 | 742 | 760 | 0.1 | 0.1 | 731 | 731 | 22 | 1 | 0.79 |

AI=FENAMIPHOS

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 1392 | 1577 | 1721 | 1.2 | 1.4 | 5679 | 5662 | 55 | 1 | 2.92 |
| 2CCW | 2687 | 3857 | 4590 | 3.0 | 4.3 | 8563 | 8698 | 69 | 2 | 0.96 |
| 3NSW | 2078 | 2414 | 3366 | 1.4 | 1.7 | 6630 | 6709 | 75 | 1 | 1.46 |
| 4SSW | 8097 | 8303 | 14194 | 4.8 | 5.0 | 19275 | 17828 | 129 | 1 | 1.00 |
| CALI | 14277 | 16174 | 23894 | 2.7 | 3.1 | 40191 | 38941 | 330 | 1 | 1.46 |

AI=FENARIMOL

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 14408 | 17537 | 29853 | 12.7 | 15.5 | 1014 | 1101 | 1654 | 2 | 0.03 |
| 2CCW | 25873 | 33293 | 59173 | 28.6 | 36.8 | 2018 | 2082 | 1259 | 2 | 0.03 |
| 3NSW | 17095 | 18713 | 26349 | 11.9 | 13.0 | 1017 | 1200 | 593 | 1 | 0.03 |
| 4SSW | 49677 | 51329 | 75680 | 29.7 | 30.7 | 2995 | 3125 | 1256 | 1 | 0.04 |
| CALI | 109949 | 123936 | 195796 | 20.9 | 23.6 | 7196 | 7701 | 4951 | 2 | 0.03 |

AI=FENBUTATINOXIDE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 1364 | 1529 | 1551 | 1.2 | 1.4 | 5503 | 5399 | 89 | 1 | 1.00 |
| 2CCW | 327 | 410 | 457 | 0.4 | 0.5 | 399 | 366 | 14 | 1 | 0.86 |
| 3NSW | 5926 | 6093 | 6127 | 4.1 | 4.2 | 5204 | 5234 | 60 | 1 | 0.50 |
| 4SSW | 3508 | 3508 | 3508 | 2.1 | 2.1 | 3142 | 3142 | 39 | 1 | 0.88 |
| CALI | 11124 | 11539 | 11642 | 2.1 | 2.2 | 14248 | 14140 | 202 | 1 | 0.88 |

AI=FLUAZIFOPBUTYL

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 2CCW | 48 | 48 | 48 | 0.1 | 0.1 | 3 | 4 | 7 | 1 | 0.07 |
| 3NSW | 190 | 190 | 190 | 0.1 | 0.1 | 41 | 42 | 3 | 1 | 0.20 |
| 4SSW | 1771 | 1896 | 2129 | 1.1 | 1.1 | 681 | 701 | 35 | 1 | 0.38 |
| CALI | 2008 | 2134 | 2367 | 0.4 | 0.4 | 725 | 747 | 45 | 1 | 0.30 |

AI=GLYPHOSATEISOPROPYLAMINESALT

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 40668 | 59579 | 77557 | 35.3 | 51.8 | 85345 | 80473 | 5204 | 2 | 1.00 |
| 2CCW | 35538 | 55110 | 92585 | 38.6 | 59.9 | 86839 | 82457 | 2559 | 2 | 0.90 |
| 3NSW | 58504 | 67468 | 96975 | 40.4 | 46.6 | 85397 | 89615 | 2042 | 1 | 0.74 |
| 4SSW | 78884 | 85055 | 129091 | 47.1 | 50.7 | 115028 | 117408 | 2060 | 1 | 0.67 |
| CALI | 217986 | 272383 | 402876 | 41.0 | 51.3 | 378120 | 375618 | 12171 | 1 | 1.00 |

AI=IMIDACLOPRID

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 10782 | 12986 | 14563 | 9.5 | 11.5 | 524 | 552 | 742 | 1 | 0.04 |
| 2CCW | 9191 | 11887 | 12514 | 10.1 | 13.1 | 392 | 383 | 287 | 1 | 0.04 |
| 3NSW | 30410 | 33750 | 34582 | 21.1 | 23.5 | 34732 | 35197 | 629 | 1 | 0.04 |
| 4SSW | 34562 | 36004 | 37621 | 20.7 | 21.5 | 1227 | 1246 | 539 | 1 | 0.03 |
| CALI | 85089 | 94810 | 99476 | 16.2 | 18.0 | 36883 | 37385 | 2221 | 1 | 0.04 |

AI=IPRODIONE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 15471 | 18643 | 25008 | 13.7 | 16.5 | 18644 | 18717 | 1153 | 1 | 0.75 |
| 2CCW | 11773 | 15364 | 19762 | 13.0 | 17.0 | 13991 | 15137 | 415 | 1 | 0.69 |
| 3NSW | 35005 | 37822 | 45203 | 24.3 | 26.3 | 29697 | 30066 | 887 | 1 | 0.50 |
| 4SSW | 31638 | 32150 | 34699 | 18.9 | 19.2 | 19299 | 19154 | 409 | 1 | 0.50 |
| CALI | 96315 | 106620 | 128569 | 18.3 | 20.3 | 84138 | 85596 | 2995 | 1 | 0.64 |

AI=LIMESULFUR

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 1631 | 1989 | 2383 | 1.4 | 1.8 | 19389 | 19559 | 163 | 1 | 4.60 |
| 2CCW | 371 | 390 | 491 | 0.4 | 0.4 | 5862 | 5870 | 30 | 1 | 3.96 |
| 3NSW | 12808 | 14154 | 26855 | 8.9 | 9.8 | 31299 | 63382 | 327 | 2 | 0.36 |
| 4SSW | 1987 | 1987 | 2227 | 1.2 | 1.2 | 7747 | 7747 | 24 | 1 | 1.66 |
| CALI | 17001 | 18725 | 32170 | 3.2 | 3.6 | 65724 | 97986 | 556 | 1 | 0.72 |

AI=MALATHION

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 45 | 53 | 53 | 0.0 | 0.0 | 77 | 76 | 5 | 1 | 1.96 |
| 2CCW | 1101 | 1195 | 1269 | 1.2 | 1.3 | 1413 | 1425 | 45 | 1 | 1.10 |
| 3NSW | 68 | 68 | 68 | 0.0 | 0.0 | 1965 | 1965 | 3 | 1 | 2.50 |
| 4SSW | 75 | 115 | 115 | 0.0 | 0.1 | 191 | 191 | 3 | 2 | 2.00 |
| CALI | 1289 | 1432 | 1505 | 0.2 | 0.3 | 3646 | 3658 | 56 | 1 | 1.12 |

AI=MANCOZEB

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 22882 | 28564 | 41452 | 20.2 | 25.2 | 54739 | 54800 | 1764 | 2 | 1.39 |
| 2CCW | 9845 | 11030 | 14641 | 10.9 | 12.2 | 24094 | 24602 | 197 | 2 | 1.58 |
| 3NSW | 17041 | 17998 | 20761 | 11.8 | 12.5 | 29876 | 32475 | 353 | 1 | 1.48 |
| 4SSW | 8555 | 8708 | 9102 | 5.1 | 5.2 | 13981 | 13638 | 101 | 1 | 1.50 |
| CALI | 58938 | 66984 | 86854 | 11.2 | 12.7 | 124150 | 127049 | 2462 | 1 | 1.48 |

AI=MANEB

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 861 | 1121 | 1915 | 0.8 | 1.0 | 2878 | 2900 | 23 | 1 | 2.00 |
| 2CCW | 315 | 315 | 315 | 0.3 | 0.3 | 1366 | 1366 | 2 | 1 | 3.16 |
| 3NSW | 720 | 1088 | 1354 | 0.5 | 0.8 | 4367 | 4280 | 17 | 2 | 2.87 |
| 4SSW | 90 | 130 | 130 | 0.1 | 0.1 | 259 | 259 | 3 | 2 | 2.00 |
| CALI | 2394 | 3061 | 4121 | 0.5 | 0.6 | 9685 | 9619 | 53 | 1 | 2.00 |

AI=MEFENOXAM

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 4SSW | 70 | 70 | 70 | 0.0 | 0.0 | 17 | 17 | 4 | 1 | 0.12 |
| CALI | 70 | 70 | 70 | 0.0 | 0.0 | 17 | 17 | 4 | 1 | 0.12 |

AI=METAMSODIUM

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 114 | 118 | 220 | 0.1 | 0.1 | 3539 | 3537 | 15 | 1 | 12.58 |
| 2CCW | 16 | 16 | 16 | 0.0 | 0.0 | 7 | 7 | 1 | 1 | 0.45 |
| 4SSW | 10 | 10 | 10 | 0.0 | 0.0 | 2390 | 2390 | 1 | 1 | 239.02 |
| CALI | 140 | 144 | 246 | 0.0 | 0.0 | 5937 | 5934 | 17 | 1 | 12.58 |

AI=METHOMYL

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 2CCW | 7488 | 11366 | 12613 | 8.3 | 12.5 | 5163 | 5429 | 138 | 2 | 0.24 |
| 3NSW | 2589 | 2750 | 3057 | 1.8 | 1.9 | 1293 | 1298 | 31 | 1 | 0.45 |
| 4SSW | 5629 | 5737 | 5877 | 3.4 | 3.4 | 5290 | 5290 | 77 | 1 | 0.90 |
| CALI | 15788 | 19935 | 21628 | 3.0 | 3.8 | 11796 | 12066 | 248 | 1 | 0.55 |

AI=METHYLBROMIDE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 571 | 596 | 596 | 0.5 | 0.5 | 231370 | 231352 | 68 | 1 | 398.00 |
| 2CCW | 343 | 523 | 525 | 0.4 | 0.6 | 206512 | 205762 | 29 | 2 | 398.00 |
| 3NSW | 414 | 426 | 426 | 0.3 | 0.3 | 113793 | 113874 | 31 | 1 | 396.52 |
| 4SSW | 26 | 26 | 26 | 0.0 | 0.0 | 6786 | 6786 | 2 | 1 | 213.93 |
| CALI | 1369 | 1585 | 1587 | 0.3 | 0.3 | 563839 | 563153 | 132 | 1 | 398.00 |

AI=MYCLOBUTANIL

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 43183 | 54925 | 111698 | 38.1 | 48.5 | 10185 | 10924 | 4186 | 2 | 0.10 |
| 2CCW | 32701 | 42856 | 95568 | 36.1 | 47.3 | 9567 | 14969 | 1991 | 3 | 0.10 |
| 3NSW | 60653 | 67199 | 134882 | 42.2 | 46.7 | 19189 | 19117 | 2416 | 2 | 0.10 |
| 4SSW | 66629 | 68567 | 120688 | 39.8 | 41.0 | 15448 | 18031 | 1772 | 1 | 0.10 |
| CALI | 206349 | 236882 | 468122 | 39.2 | 45.0 | 54910 | 63617 | 10711 | 2 | 0.10 |

AI=MYROTHECIUMVERRUCARIADRIEDFERMENTATIONSOLIDS

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 14 | 25 | 25 | 0.0 | 0.0 | 271 | 273 | 2 | 2 | 10.92 |
| CALI | 14 | 25 | 25 | 0.0 | 0.0 | 271 | 273 | 2 | 2 | 10.92 |

AI=NALED

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 109 | 109 | 109 | 0.1 | 0.1 | 85 | 85 | 8 | 1 | 0.86 |
| 2CCW | 54 | 62 | 62 | 0.1 | 0.1 | 41 | 41 | 4 | 2 | 0.66 |
| 3NSW | 905 | 925 | 972 | 0.6 | 0.6 | 645 | 643 | 36 | 1 | 0.50 |
| 4SSW | 455 | 455 | 475 | 0.3 | 0.3 | 438 | 438 | 22 | 1 | 1.01 |
| CALI | 1527 | 1555 | 1622 | 0.3 | 0.3 | 1211 | 1209 | 71 | 1 | 0.68 |

AI=NAPROPAMIDE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 448 | 565 | 572 | 0.4 | 0.5 | 1312 | 1319 | 80 | 1 | 2.62 |
| 2CCW | 860 | 900 | 920 | 0.9 | 1.0 | 1884 | 1812 | 41 | 1 | 1.37 |
| 3NSW | 1959 | 2215 | 2221 | 1.4 | 1.5 | 3518 | 3384 | 73 | 1 | 1.33 |
| 4SSW | 234 | 241 | 241 | 0.1 | 0.1 | 181 | 181 | 6 | 1 | 0.75 |
| CALI | 3516 | 3937 | 3970 | 0.7 | 0.7 | 6942 | 6741 | 208 | 1 | 1.60 |

AI=NORFLURAZON

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 640 | 820 | 820 | 0.6 | 0.7 | 1321 | 1342 | 93 | 1 | 2.36 |
| 2CCW | 1595 | 2048 | 2107 | 1.8 | 2.3 | 1655 | 1522 | 61 | 1 | 0.67 |
| 3NSW | 8179 | 8552 | 8831 | 5.7 | 5.9 | 7449 | 7312 | 249 | 1 | 0.63 |
| 4SSW | 15074 | 15246 | 18432 | 9.0 | 9.1 | 14445 | 14341 | 242 | 1 | 0.64 |
| CALI | 25584 | 26762 | 30285 | 4.9 | 5.1 | 24967 | 24614 | 649 | 1 | 0.71 |

AI=ORYZALIN

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 8454 | 10513 | 11304 | 7.5 | 9.3 | 25426 | 24583 | 936 | 1 | 2.14 |
| 2CCW | 15873 | 24049 | 25430 | 17.5 | 26.5 | 40166 | 37257 | 760 | 1 | 1.60 |
| 3NSW | 29905 | 33099 | 35658 | 20.8 | 23.0 | 59408 | 58892 | 719 | 1 | 1.45 |
| 4SSW | 24246 | 27382 | 28967 | 14.5 | 16.4 | 62478 | 338813 | 531 | 1 | 1.94 |
| CALI | 79102 | 95743 | 102069 | 15.0 | 18.2 | 188756 | 460811 | 2998 | 1 | 1.92 |

AI=OXYFLUORFEN

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 22874 | 29918 | 31816 | 20.2 | 26.4 | 24276 | 23764 | 2054 | 1 | 0.75 |
| 2CCW | 27212 | 42642 | 55868 | 30.0 | 47.1 | 27778 | 28782 | 1633 | 1 | 0.51 |
| 3NSW | 62456 | 69295 | 85552 | 43.4 | 48.2 | 33093 | 34820 | 1638 | 1 | 0.30 |
| 4SSW | 44994 | 47654 | 51221 | 26.9 | 28.5 | 27210 | 27545 | 847 | 1 | 0.40 |
| CALI | 160122 | 192295 | 228001 | 30.4 | 36.5 | 113713 | 116266 | 6268 | 1 | 0.49 |

AI=PARAQUATDICHLORIDE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 4150 | 5426 | 6061 | 3.7 | 4.8 | 5317 | 5359 | 362 | 1 | 0.87 |
| 2CCW | 12833 | 18829 | 24534 | 14.2 | 20.8 | 16808 | 16290 | 700 | 2 | 0.81 |
| 3NSW | 62147 | 68779 | 103999 | 43.2 | 47.8 | 60171 | 63287 | 2176 | 1 | 0.44 |
| 4SSW | 40417 | 42225 | 57832 | 24.2 | 25.2 | 36853 | 36984 | 982 | 1 | 0.63 |
| CALI | 121854 | 137703 | 195565 | 23.2 | 26.2 | 120735 | 123535 | 4290 | 1 | 0.58 |

AI=PENDIMETHALIN

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 1028 | 1240 | 1275 | 0.9 | 1.1 | 4220 | 4028 | 91 | 1 | 3.33 |
| 2CCW | 1696 | 2196 | 2296 | 1.9 | 2.4 | 4608 | 4368 | 143 | 1 | 2.50 |
| 3NSW | 5476 | 6013 | 6061 | 3.8 | 4.2 | 9716 | 9751 | 102 | 1 | 1.50 |
| 4SSW | 1892 | 1969 | 1969 | 1.1 | 1.2 | 1496 | 1486 | 23 | 1 | 0.84 |
| CALI | 10207 | 11533 | 11716 | 1.9 | 2.2 | 20271 | 19867 | 364 | 1 | 1.92 |

AI=PHOSMET

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 169 | 207 | 236 | 0.1 | 0.2 | 168 | 169 | 11 | 1 | 0.25 |
| 2CCW | 543 | 572 | 572 | 0.6 | 0.6 | 465 | 465 | 29 | 1 | 0.70 |
| 3NSW | 633 | 676 | 738 | 0.4 | 0.5 | 1069 | 1066 | 21 | 1 | 1.00 |
| 4SSW | 4073 | 4107 | 4180 | 2.4 | 2.5 | 4199 | 4199 | 76 | 1 | 0.93 |
| CALI | 5449 | 5595 | 5766 | 1.0 | 1.1 | 5969 | 5975 | 144 | 1 | 0.93 |

AI=POTASHSOAP

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 789 | 949 | 982 | 0.7 | 0.8 | 7000 | 7297 | 72 | 1 | 7.85 |
| 2CCW | 2178 | 2451 | 2940 | 2.4 | 2.7 | 42093 | 40665 | 87 | 1 | 12.13 |
| 3NSW | 1836 | 1879 | 2470 | 1.3 | 1.3 | 14331 | 13575 | 41 | 1 | 4.37 |
| 4SSW | 458 | 458 | 458 | 0.3 | 0.3 | 904 | 904 | 6 | 1 | 2.73 |
| CALI | 5483 | 5971 | 7104 | 1.0 | 1.1 | 65904 | 64024 | 231 | 1 | 8.73 |

AI=POTASSIUMBICARBONATE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 2078 | 2645 | 3284 | 1.8 | 2.3 | 6028 | 5998 | 179 | 1 | 2.05 |
| 2CCW | 4259 | 5919 | 9824 | 4.7 | 6.5 | 19953 | 19882 | 173 | 2 | 2.05 |
| 3NSW | 2336 | 2620 | 3340 | 1.6 | 1.8 | 6286 | 6190 | 83 | 1 | 2.05 |
| 4SSW | 6708 | 6949 | 7524 | 4.0 | 4.2 | 13876 | 13847 | 83 | 1 | 2.02 |
| CALI | 15523 | 18320 | 24380 | 3.0 | 3.5 | 46614 | 46401 | 527 | 1 | 2.05 |

AI=PROPARGITE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 2575 | 2966 | 3006 | 2.3 | 2.6 | 4406 | 4622 | 159 | 1 | 1.60 |
| 2CCW | 2170 | 2564 | 2715 | 2.4 | 2.8 | 4559 | 4402 | 68 | 1 | 1.60 |
| 3NSW | 17912 | 18993 | 19436 | 12.4 | 13.2 | 31927 | 31627 | 373 | 1 | 1.60 |
| 4SSW | 22097 | 22639 | 24547 | 13.2 | 13.5 | 47953 | 48009 | 343 | 1 | 1.80 |
| CALI | 45788 | 48195 | 50769 | 8.7 | 9.2 | 90368 | 90178 | 975 | 1 | 1.60 |

AI=PYRETHRINS

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 549 | 601 | 601 | 0.5 | 0.5 | 13 | 13 | 42 | 1 | 0.01 |
| 2CCW | 38 | 63 | 63 | 0.0 | 0.1 | 3 | 3 | 3 | 2 | 0.04 |
| 3NSW | 110 | 110 | 190 | 0.1 | 0.1 | 30 | 30 | 4 | 1 | 0.01 |
| 4SSW | 340 | 397 | 397 | 0.2 | 0.2 | 10 | 10 | 6 | 1 | 0.03 |
| CALI | 1037 | 1171 | 1251 | 0.2 | 0.2 | 56 | 56 | 55 | 1 | 0.02 |

AI=ROTENONE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 59 | 68 | 68 | 0.1 | 0.1 | 1 | 1 | 5 | 1 | 0.00 |
| CALI | 59 | 68 | 68 | 0.0 | 0.0 | 1 | 1 | 5 | 1 | 0.00 |

AI=SETHOXYDIM

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 1047 | 1237 | 1432 | 0.9 | 1.1 | 217 | 198 | 130 | 1 | 0.13 |
| 2CCW | 858 | 1174 | 1205 | 0.9 | 1.3 | 866 | 774 | 34 | 1 | 0.18 |
| 3NSW | 2378 | 2699 | 2905 | 1.7 | 1.9 | 594 | 537 | 80 | 1 | 0.18 |
| 4SSW | 3989 | 4860 | 8681 | 2.4 | 2.9 | 1476 | 1470 | 124 | 1 | 0.16 |
| CALI | 8380 | 10077 | 14331 | 1.6 | 1.9 | 3173 | 2999 | 372 | 1 | 0.17 |

AI=SIMAZINE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 15207 | 18818 | 19467 | 13.4 | 16.6 | 37744 | 35475 | 1232 | 1 | 2.00 |
| 2CCW | 12297 | 17436 | 18114 | 13.6 | 19.2 | 20637 | 17345 | 500 | 1 | 0.90 |
| 3NSW | 46640 | 50500 | 55987 | 32.4 | 35.1 | 58517 | 68845 | 1258 | 1 | 0.90 |
| 4SSW | 50132 | 52348 | 56971 | 30.0 | 31.3 | 57926 | 56902 | 1113 | 1 | 0.90 |
| CALI | 125962 | 140911 | 152580 | 23.9 | 26.8 | 176588 | 180318 | 4182 | 1 | 0.99 |

AI=SODIUMTETRATHIOCARBONATE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 535 | 677 | 881 | 0.5 | 0.6 | 18242 | 18554 | 54 | 1 | 19.25 |
| 2CCW | 4752 | 7922 | 10632 | 5.2 | 8.7 | 253562 | 259056 | 154 | 2 | 25.34 |
| 3NSW | 2539 | 2729 | 4345 | 1.8 | 1.9 | 112573 | 112589 | 46 | 1 | 26.57 |
| 4SSW | 5090 | 6189 | 8988 | 3.0 | 3.7 | 201602 | 197403 | 113 | 2 | 19.07 |
| CALI | 12916 | 17516 | 24847 | 2.5 | 3.3 | 585979 | 587602 | 367 | 2 | 22.25 |

AI=SULFURDUST

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 71831 | 84927 | 410884 | 63.4 | 75.0 | 4702995 | 4474279 | 13133 | 5 | 11.36 |
| 2CCW | 55926 | 65300 | 505317 | 61.7 | 72.1 | 3902191 | 4222587 | 7899 | 8 | 5.16 |
| 3NSW | 113442 | 121085 | 988524 | 78.8 | 84.2 | 12591421 | 11924251 | 17440 | 8 | 14.70 |
| 4SSW | 142108 | 145770 | 1025307 | 85.0 | 87.1 | 10212507 | 9836702 | 13911 | 7 | 9.80 |
| CALI | 390617 | 424523 | 2984042 | 74.2 | 80.7 | 32085626 | 31104073 | 53648 | 7 | 9.80 |

AI=SULFURWETT

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 63473 | 75847 | 261913 | 56.1 | 67.0 | 1378168 | 1830005 | 9495 | 4 | 3.23 |
| 2CCW | 31470 | 37078 | 115285 | 34.7 | 40.9 | 730820 | 792746 | 2982 | 3 | 3.44 |
| 3NSW | 36606 | 38885 | 123044 | 25.4 | 27.0 | 1311148 | 1362952 | 2392 | 2 | 8.98 |
| 4SSW | 60312 | 61907 | 192308 | 36.1 | 37.0 | 1525347 | 1574104 | 2852 | 3 | 7.24 |
| CALI | 198909 | 221254 | 712651 | 37.8 | 42.0 | 5081820 | 5710164 | 18592 | 3 | 4.00 |

AI=TRIADIMEFON

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 1346 | 1492 | 2211 | 1.2 | 1.3 | 328 | 330 | 114 | 1 | 0.13 |
| 2CCW | 1786 | 1787 | 3231 | 2.0 | 2.0 | 455 | 39116 | 208 | 2 | 0.16 |
| 3NSW | 128 | 128 | 129 | 0.1 | 0.1 | 10 | 10 | 4 | 1 | 0.06 |
| 4SSW | 3106 | 3840 | 10270 | 1.9 | 2.3 | 1416 | 1469 | 77 | 4 | 0.13 |
| CALI | 6516 | 7452 | 16106 | 1.2 | 1.4 | 2253 | 40968 | 420 | 2 | 0.13 |

AI=TRIFLUMIZOLE

| | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|
| 1NCW | 14032 | 17515 | 28539 | 12.4 | 15.5 | 4935 | 7747 | 1318 | 1 | 0.16 |
| 2CCW | 15983 | 18394 | 27868 | 17.6 | 20.3 | 6727 | 6950 | 321 | 1 | 0.16 |
| 3NSW | 16601 | 18640 | 37720 | 11.5 | 13.0 | 6613 | 6515 | 449 | 2 | 0.16 |
| 4SSW | 33717 | 34514 | 54978 | 20.2 | 20.6 | 9462 | 9316 | 701 | 1 | 0.15 |
| CALI | 80973 | 89711 | 150333 | 15.4 | 17.0 | 27961 | 30725 | 2822 | 1 | 0.16 |

AI=TRIFLURALIN

| | | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1NCW | 18 | 27 | 35 | 0.0 | 0.0 | 67 | 65 | 6 | 3 | 1.62 |
| | 2CCW | 112 | 112 | 112 | 0.1 | 0.1 | 169 | 169 | 7 | 1 | 1.97 |
| | 3NSW | 4092 | 4366 | 4366 | 2.8 | 3.0 | 6258 | 6300 | 49 | 1 | 1.27 |
| | 4SSW | 10945 | 11050 | 13762 | 6.5 | 6.6 | 6939 | 8209 | 106 | 1 | 0.95 |
| | CALI | 15564 | 15952 | 18672 | 3.0 | 3.0 | 13837 | 15147 | 183 | 1 | 1.00 |

AI=ZIRAM

| | | MIN TRT | MAX TRT | CUM TRT | MIN% | MAX% | COMP LBSAI | SUM LBSAI | N APPS | MED | MEDAPPR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1NCW | 52 | 52 | 70 | 0.0 | 0.0 | 146 | 146 | 4 | 1 | 2.28 |
| | 3NSW | 5399 | 5403 | 5570 | 3.8 | 3.8 | 16532 | 16533 | 43 | 1 | 3.04 |
| | 4SSW | 10388 | 10519 | 11474 | 6.2 | 6.3 | 29851 | 29929 | 167 | 1 | 2.28 |
| | CALI | 15839 | 15974 | 17114 | 3.0 | 3.0 | 46529 | 46608 | 214 | 1 | 2.28 |