Crop Profile for Nectarines in California

Prepared: May, 1999
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General Production Information

- California ranks first in the U.S. in the production of nectarines (13).
- California produces 96% of the total U.S. nectarine crop (13).
- California produces 96% of the U.S. fresh market nectarines (13).
- 214,000 tons of fresh market nectarines valued in excess of $100 million were produced during the 1998 crop year on approximately 36,500 acres (3).
- Production cost nectarines (1992) averaged $5,816/acre (16).
- Fresh market nectarines comprise approximately 98% of the annual tonnage of nectarines produced in California (12,13).
- Processing nectarines comprise approximately 2% of the annual tonnage of nectarines produced in California. (12,13). There are no production differences between fresh market and processing nectarines.

Production Regions

There are two major growing regions in California. The San Joaquin Valley (Fresno, Kings, Merced, Tulare, Kern, Madera, Stanislaus, San Joaquin) and Los Angeles County (Scattaglia). The fresh market stone fruit growing area is approximately 95% concentrated in Fresno, Kings, Tulare and Kern Counties. As a result of the geographic, timing of harvest and post-harvest handling differences, there are slight variations in cultural and system operations between the regions in their production of nectarines. (8,12)

Cultural Practices

Deep, fine-sandy loam soils with good internal drainage and freedom from alkali or salinity are best for optimum nectarine growth and production. Nectarine trees will not produce commercially acceptable crops under arid California conditions without supplemental irrigation water. Many nectarine orchards are furrow or flood-irrigated. No-till cultivation is widely used in California in mature nectarine

orchards. This entails a herbicide-treated berm in the tree row with weeds in the row middles being controlled by mowing. Fruit thinning is an annual practice and hand labor is preferred over mechanical or chemical options. Nectarines follow a similar pattern to freestone peaches with a harvest season extending from late April through late September. (8,12)

Nitrogen and zinc fertilizers are traditionally applied in the summer and fall following harvest. In some instances nitrogen fertilizer may need to be applied in both spring and late summer. Generally, it is applied at a rate of 50 to 75 pounds of nitrogen per acre in the form of manure. Zinc sulfate is applied in the autumn at leaf fall at a rate of 10 pounds per acre.

Insect Pests

San Jose Scale (SJS):
A serious pest of nectarines that causes economic losses every year. The adults, which feed on limbs, twigs, and fruit, are small, circular, and gray. If the shell-like cover is removed, a bright yellow female body is exposed. Young scale crawlers emerge from beneath the shell and move to the fruit where they cause spotting and pitting. The fruit develops a characteristic red spot discoloration around the insect and may be unsightly enough to cause the fruit to be culled. High populations may seriously weaken or kill fruiting branches and main limbs, thus causing permanent injury to mature trees. (6,7,12)

Controls:

Chemical:

- **Narrow Range Oils**, Applied to 74% of the acres at a rate of 1-6 gallons per acre. Application during the dormant season provides partial control. Oils are most frequently applied in combination with other pesticides, particularly dormant applications. (4,7,8)

- **Chlorpyrifos**, applied to 2% of the acres by ground at an median rate of 2.0 lbs. a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 4 days. Chlorpyrifos can only be applied during dormant or delayed dormant period. Labeling does not allow meat or dairy animals to graze in treated orchards. (4,7,14)

- **Diazinon,** generally a dormant spray but sometimes is applied post-bloom. Applied to 36% of the acres by ground at an median rate of 2.0 lbs. active ingredient (a.i.) with a typical PHI of 90+

days and a labeled PHI of 21 days. There have been documented cases of San Jose Scale resistance. Also, this product may induce other pest problems. (2,5,6,7,9,11,14)

- **Carbaryl,** generally a dormant spray but sometimes is applied post-bloom. Applied to 7% of the acres by ground application at a median rate of 4.0 lbs. a.i. per acre and has a 1-day PHI. It will generally cause mite outbreaks. Use of this chemical has decreased because of signs of resistance. (4,6,7,9)

- **Methidathion,** applied to 17% of the acres by ground application at an median rate of 2.0 lbs. a.i. per acre. This chemical is widely used but will probably decrease in use due to signs of resistance in San Jose Scale. (4,11,14)

- **Methyl Parathion,** applied to 20% of the acres with an median rate of 1.41 lbs. a.i. per acre. Use of this chemical has increased because it is inexpensive and there are resistance problems with other alternatives. (4,14)

- **Phosmet,** is applied to 19% of the acres by ground at an median of 2.8 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI. Timing is critical. (4,7,9,14)

Oriental Fruit Moth:
This is a serious pest in California. There are usually 4 to 5 generations per year in California, although a sixth generation has been observed in years with warm weather in early spring. They overwinter as mature, diapausing larvae inside tightly woven cocoons in protected places on the tree or in the slash and debris near the base of the tree. In early spring, pupation takes place inside the cocoon and adults begin emerging in February or early March. Eggs are deposited on newly emerged shoots and the larvae feed in terminals where they complete their development. Larvae cause damage by feeding on developing shoots and fruits. The most severe damage occurs where larvae feed on fruit, causing it to be rated off grade. Larvae burrow deep into the flesh often moving to the stone. Feeding damage may increase the incidence of fruit decay. (7,9)

Controls:

Biological:
Mating Disruptants, effective Oriental Fruit Moth control can be achieved with pheromone dispensers. However, this is the least popular control method mainly due to costs. Disruptants are applied just before or at first moth emergence in spring, or roughly around March 1. Replace baits on product recommendation, usually 3 months. Two current products are **Isomate M-100** applied at a rate of 150 dispensers per acre. **Checkmate SF Dual OFM + PTB** applied at 150 dispensers per acre. These are applied by hand labor (6,7,9). Growers and PCAs are reluctant to use pheromone mating disruption due to the potential for secondary pest outbreaks of Oblique Banded Leafroller (OBLR), the increased cost

of pheromone application and the difficulties some growers have experienced with mating disruption failure to suppress reproduction of the target pest.

Chemical:

- **Azinphos-methyl,** is applied to 1% of the acres by ground at an median rate of 1.5 lbs. a.i. per acre with a typical 21 day PHI which is the labeled PHI. However, current California regulations limit application rate to 1.0 lb. a.i. per acre with a reentry interval of 45 days. Resistance has occurred in some orchards in the Sacramento Valley and in the northern San Joaquin Valley. (4,7,9,14)

- **Methomyl,** is applied to 23% of the acres by ground at an median rate of 0.90 lb. a.i. per acre with a typical PHI of 4 days which is the labeled PHI. It kills beneficials and/or non target organisms and is not compatible with an IPM program. It was used in the past as a clean-up material, but the reentry interval has been changed to 4 days, so it no longer is used for this purpose. (6,7,4,11,14)

- **Phosmet,** is applied to 19% of the acres by ground at an median of 2.8 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI. Timing is critical. (4,7,9,14)

- **Methyl Parathion,** applied to 20% of the acres with an median rate of 1.41 lbs. a.i. per acre. Use of this chemical has increased because it is inexpensive and there are resistance problems with other treatment alternatives. Used only early in the season. (4,14)

- **Esfenvalerate**, is applied to 36% of the acres by ground or air at an median rate of 0.04 lb. a.i. per acre with a labeled PHI of 14 days.

- **Diazinon,** is applied to 36% of the acres most of which is a dormant application. It is applied by ground at an median rate of 2.0 a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 21 days. Timing is critical. Resistance is suspected but has not been documented. (4,6,7,9,14)

- **Carbaryl,** applied to 7% of the acres by ground at an median rate of 4.0 lbs. a.i. per acre with a 1-day PHI. Use of this product will cause mite outbreaks. Not recommended for routine use and does not fit within an IPM program. It is the only chemical that can be used under certain emergency conditions because of the 1-day PHI. (4,7,11,12)

Peach Twig Borer (PTB):

Peach Twig Borer is a severe pest to nectarines and annually causes severe losses. Adult peach twig borer moths are 0.3 to 0.4 inch long with steel gray, mottled forewings. The bluntly oval eggs are yellow white to orange and are laid on twigs, leaves, or on the fruit surface. They overwinter on the tree as a

first or second instar larva within a tiny cell, called a hibernaculum, usually in crotches of 1 to 3-year old wood, in pruning wounds, or in deep cracks in bark. Larvae emerge in early spring, usually during the bloom, and migrate up twigs and branches where they attack newly emerged leaves and shoots. First generation larvae usually develop in twigs during May and June and give rise to the next flight of moths in late June or early July. Larvae from this and subsequent generations may attack either twigs or fruit. Shoot damage is most severe on young developing trees because feeding kills the terminal growth. As fruit matures, it becomes highly susceptible to attack; damage is most likely to occur from color break to harvest. PTB burrows into the flesh but does not reach the pit. Feeding damage, however, can increase the incidence of fruit decay. (4,7,12)

Controls:

Biological:
PTB has about 30 species of natural enemies. Among those commonly found in California are the chalcid wasps, *Paralitomastix varicornis* and *Hyperteles lividus*, the native gray ant *Formica aerata*, and the grain or itch mite, *Pyemotes ventricosus*. In some years these natural enemies destroy a significant portion of larvae, but by themselves they generally do not reduce PTB populations below economically damaging levels. (7)

Bacillus thuringiensis, applied to over 35% of the nectarine acres by ground during bloom and prior to harvest. The first spray is applied at pinkbud or first bloom and the second 7-10 days later, but no later than petal fall. Good coverage is essential. Precede this treatment with an oil spray during the dormant season to control SJS and European red mite eggs.

Chemical:

- **Diazinon or Methidathion + Oil,** are often applied during the dormant season. (6,7)

- **Chlorpyrifos**, applied to 20% of the acres by ground at an median rate of 2.0 lbs. a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 4 days. Chlorpyrifos can only be applied during dormant or delayed dormant period. Labeling does not allow meat or dairy animals to graze in treated orchards. (4,7,14)

- **Azinphos methyl,** applied to 1% of the acres by ground at an median rate of 1.5 lbs. a.i. per acre with a typical PHI of 21 days which is the labeled PHI. This is a post-bloom application. (4,7,14)

- **Diazinon,** is applied to 36% of the nectarine acres for various different pests. It is applied after the dormant season by ground at an median rate of 2.0 lbs. of a.i. per acre with a typical PHI of 90 + days and a labeled PHI of 21 days. May induce other pest problems. (4,6,7,11,14)

- **Carbaryl,** applied to 7% of the acres by ground at an median rate of 4.0 lbs. a.i. per acre with a 1-day PHI. Use of this product will cause mite outbreaks. Not recommended for routine use and

does not fit within an IPM program. It is the only chemical that can be used under certain emergency conditions because of the 1-day PHI. (4,7,11,12)

- **Phosmet,** applied to 19% of the acres by ground at an median rate of 2.8 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI. This is a post-bloom application. (4,7,14)

Omnivorous Leafroller (OLR):
The Omnivorous Leafroller has increased in importance as a pest of nectarines. The larvae feed on both the foliage and fruit. Damage caused by leaf feeding is usually minor. Feeding on fruit is typically shallow, often around the stem end. In addition, feeding wounds are also sites for the invasion for fungi, and is often seen in a complex with brown rot which can destroy the fruit completely. Injury can occur spring through fall as the Omnivorous Leafroller can complete 3 to 5 generations from March through October. (4,7,12)

Controls:

Biological:
Bacillus thuringiensis, applied to over 35% of the nectarine acres by ground during bloom and prior to harvest. The first spray is applied at pinkbud or first bloom and the second 7-10 days later, but no later than petal fall. Good coverage is essential. Precede this treatment with an oil spray during the dormant season to control SJS and European red mite eggs.

Chemical:

- **Diazinon or Methidathion + Oil,** are often applied during the dormant season. (6,7)

- **Chlorpyrifos**, applied to 20% of the acres by ground at an median rate of 2.0 lbs. a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 4 days. Chlorpyrifos can only be applied during dormant or delayed dormant period. Labeling does not allow meat or dairy animals to graze in treated orchards. (4,7,14)

- **Azinphos methyl,** applied to 1% of the acres by ground at an median rate of 1.5 lbs. a.i. per acre with a typical PHI of 21 days which is the labeled PHI. This is a post-bloom application. (4,7,14)

- **Diazinon,** is applied to 36% of the nectarine acres for various pests. It is applied after the dormant season by ground at an median rate of 2.0 lbs. of a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 21 days. May induce other pest problems. (4,6,7,11,14)

- **Carbaryl,** applied to 7% of the acres by ground at an median rate of 4.0 lbs. a.i. per acre with a 1-day PHI. Use of this product will cause mite outbreaks. Not recommended for routine use and

does not fit within an IPM program. It is the only chemical that can be used under certain emergency conditions because of the 1-day PHI. (4,7,11,12)

- **Phosmet,** applied to 19% of the acres by ground at an median rate of 2.8 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI. This is a post-bloom application. (4,7,14)

Codling Moth:
has a 0.5 to 0.75 inch wingspan. The tip of each forewing has a coppery tinged, dark brown band that distinguishes codling moth from other moths. Females lay eggs singly on leaves. Newly hatched larvae are white with black heads. Mature larvae are 0.5 to 0.75 inch long, pinkish white, with mottled brown heads. Codling moth is not a problem in nectarines and tends to occasionally occur in plums and prunes.

Controls:

Cultural:
Remove abandoned host trees in nearby orchards. Also remove unharvested fruit from nearby host trees. Following harvest remove unpicked fruit to prevent a large overwintering population.

Biological:
Bacillus thuringiensis, applied to over 35% of the nectarine acres by ground during bloom and prior to harvest. The first spray is applied at pinkbud or first bloom and the second 7-10 days later, but no later than petal fall. Good coverage is essential. Precede this treatment with an oil spray during the dormant season to control SJS and European red mite eggs.

Chemical:

- **Methidathion,** applied to 17% of the acres by ground application at an median rate of 2.0 lbs. a.i. per acre. This chemical is widely used but will probably decrease in use due to signs of resistance in San Jose Scale. (4,11,14)

- **Phosmet,** applied to 19% of the acres by ground at an median rate of 2.8 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI. This is a post-bloom application. (4,7,14)

- **Esfenvalerate**, is applied to 36% of the acres by ground or air at an median rate of 0.04 lb. a.i. per acre with a labeled PHI of 14 days.

- **Methyl Parathion,** applied to 20% of the acres with an median rate of 1.41 lbs. a.i. per acre. Use of this chemical has increased because it is inexpensive and there are resistance problems with other chemical alternatives. Used only early in the season. (4,14)

Western Flower Thrips:
Western Flower Thrips are attracted to the blooms of nectarines. In early spring, the nymphs hatch and feed in numbers on tiny fruit, often under the drying calyx or flower parts. Damage is more pronounced in cool seasons when shedding of the calyx is slow. Injury consists of several types including holes or depressions, punctures and scarring in large or small blotches. (4,7,12)

Controls:

Chemical:

- **Formetanate HCl,** applied to 59% of the acres by ground at an median rate of 0.75 lb. a.i. per acre with a typical PHI of 14 days which is the labeled PHI. The label requires a 48 hr REI. (4,6,7,11,14)

- **Methomyl**, applied to 23% of the acres by ground at an median rate of 0.9 lb. a.i. per acre with a typical PHI of 4 days which is the labeled PHI. It kills beneficials and/or nontarget organisms. May induce other pest problems. It was used in the past as a clean-up material, but the reentry interval has been changed to 4 days, so it no longer is used for this purpose. (4,6,7,11,14)

Spider mites:
If uncontrolled can be a serious pest problem in California. Pacific and two-spotted spider mites overwinter as adult females in protected places on the tree or in the litter, trash and weeds on the orchard floor. Mites become active in early spring and begin feeding on weeds or in the lower part of the trees. Both species are favored by hot, dry conditions, and as the weather becomes warmer, they increase in numbers and move up the center of the tree until the entire tree is infested. Nectarines can tolerate some mite damage, particularly on water sprouts in the center of trees. Feeding by both species causes a mottling of the leaves, and under severe conditions can cause heavy leaf drop. If defoliation happens early in the season, fruit fails to size properly and limbs and fruit may be exposed to sunburn. (6,7,9)

Controls:

Cultural:
Keeping orchards well irrigated and treating orchard roads, if necessary, to keep dust to a minimum helps to manage mite buildups. Choice of insecticides for other pest problems can influence mite buildup (e.g. carbaryl and pyrethroids). (7)

Biological:
Predators are very important in regulating pest mite populations in orchards. The three major predators

are the western predatory mite, six-spotted thrips and the spider mite destroyer, *Stethorus picipes*. All of these predators are adversely affected by certain materials applied for control of other pests, such as Oriental Fruit Moth. (6,7)

Chemical:

- **Insecticidal Soap,** applied at various application rates depending on the product. May pose problems with plant phytotoxicity. (7)

- **Narrow Range Oil,** applied to 76% of the acres at various application rates depending on the product. (4,6,7)

- **Clofentezine,** applied to 10% of the acres by ground at an median rate of 0.13 lb. a.i. per acre with a minimum 21-day PHI. This material is more effective in the early part of the year. It kills eggs and young larval stages most effectively. To delay development of resistance, use only once per season. (4,7)

- **Dicofol,** has just been registered for use on nectarines in California. In 1997, 12% of the nectarine acres were treated. It is applied at a median rate of 1.4 lbs. a.i. per acre with a typical PHI of 7 days, which is the labeled PHI.

- **Fenbutatin oxide**, applied to 11% of the acres at a median rate of 0.75 lb. a.i. per acre.

- **Propargite**, applied to 35% of the acres at a median rate of 2.1 lbs. a.i. per acre. The labeled PHI is 14 days and the REI is 7 days.

Secondary Pests

Secondary pests such as true bugs, aphids and katydid are generally not significant problems as they are controlled with existing control systems. However, the loss of organophosphates and the shift to softer chemical programs will likely see an increase in these secondary pests.

True Bugs:
These pests are not usually considered major problems but they can be if neighboring fields contain crops which are hosts. In general, the true bugs of greatest economic interest to the nectarine industry are the Lygus and the Consperse stink bugs. Adult true bugs are about 0.20 to 0.25 inch long.
Lygus hesperus adults vary from yellowish to reddish brown and the adults of *L. allises* are pale or yellowish green. True bugs overwinter as adults in plant debris, in the crown of plants on the orchard

floor, and in uncultivated areas outside the orchard. As temperature rises, true bug adults migrate to irrigated areas where mating occurs. It is believed adults are chiefly responsible for damage to fruit orchards. There may be as many as 6 to 10 overlapping generations per year. Damage by true bugs can be either to the growing shoot tips which can cause them to die or to the fruit which can cause them to be misshapen. Fruit damage is sporadic and does not occur every year; however, in some years severe economic losses can occur. In general, true bug populations are highest in years where there is loss of lush vegetation growing in and around the orchard. (6,7)

Controls:

Cultural:
Cover crop manipulation is important in lygus and stink bug management. Clean cultivation or a weed free orchard floor in lieu of a cover crop will aid in suppressing lygus. Legumes are major hosts for both species. (7)

Chemical:

- **Methomyl**, applied to 23% of the acres by ground at an median rate of 0.90 lb. a.i. per acre with a typical PHI of 4 days which is the labeled PHI. It kills beneficials and/or nontarget organisms. May induce other pest problems. It was used in the past as a clean-up material, but the reentry interval has been changed to 4 days, so it is no longer used for this purpose. (4,6,7,11,14)

Aphids:
Aphids can be seen on the underside of leaves in the early spring. In particular, the green peach aphid is a secondary pest of nectarines. Honeydew secreted by the aphids can cause cracking of the fruit. The wounds may become secondarily infected with fungi and render the fruit unfit for consumption.

Aphids are best controlled through the use of an insecticide in the dormant spray to kill overwintering eggs. This is a common grower practice for controlling San Jose Scale as well.

Diseases

Brown rot, green fruit rot, shot hole, rust, and powdery mildew are the most common and devastating fungal diseases of nectarines. Other fungal diseases such as anthracnose and scab occur in California nectarine growing regions, however, they have not caused economic damage. Root diseases such as

Phytophthora root rot and *Armillaria* root rot can be a problem in wet years when flooding occurs or in specific regions, respectively. Bacterial diseases such as crown gall and bacterial blast or canker are also perennial problems in California. Peach leaf spot does not occur in California.

Fresh market nectarines: The most commonly applied fungicides in fresh shipping nectarines are benomyl, thiophanate-methyl, captan, iprodione, sulfur, myclobutanil, propiconazole and tebuconazole. (14)

Brown Rot:
A major perennial problem for nectarines in California that is dependent on wind, wetness and warm temperature. Brown rot infections are caused by two airborne fungi, *Monilina fructicola* or *M. laxa.* The disease is favored by high relative humidity and develops very well in moderate to warm temperatures.

Monilina spp. overwinter as mycelium in twigs, peduncles and mummified fruit. The most important sources of inoculum are remaining infected flower parts and fruit mummies on which the fungi produce masses of asexual spores beginning in late winter. *M. fructicola* also produces a sexual stage on fallen mummified fruit that functions in producing primary inoculum in the spring. *M. laxa* usually blights blossoms and twigs, and occasionally rots ripening fruit. *M. fructicola* is the organism most commonly found in nectarine orchards, and is generally responsible for blossom and twig blight, as well as fruit brown rot outbreaks. Aerial applications are generally not as effective as properly applied ground sprays, but may be necessary when the orchard floor is wet. (7,8,12)

Controls:

Cultural:
Removal of unharvested fruit and mummies from trees and cultivation of orchard floor (to bury mummies) before bloom will help reduce inoculum. Pruning infected twigs also helps reduce the spread of this disease. (8,11)

Chemical:

- **Iprodione,** applied to 34% of the acres by ground or air at an median rate of 0.75 lb. a.i. per acre with a typical 7 day PHI which is the labeled PHI. Addition of a narrow range oil at 1-2% increases the effectiveness of this material. Label changes made in 1998 do not allow preharvest applications on nectarines. Thus, the fungicide is restricted to only blossom and petal fall applications. (4,8,14)

- **Captan,** applied to 7% of the acres by ground or air at an median rate of 2.9 lbs. a.i. per acre with a typical 30+ days PHI with a labeled PHI of 0 days. This is mostly used during bloom. Do not apply in combination with, immediately before, or closely following oil sprays. (4,8,14)

- **Thiophanate-methyl,** applied to 1% of the acres by ground or air at an median rate of 1.0 lb. a.i. per acre with a typical PHI of 90+ days which has a labeled PHI of 1 day. Mostly used during bloom. Resistance has been documented in the Sacramento and northern San Joaquin Valleys. (4,8,11,14)

- **Vinclozolin,** applied to >1% of the acres by ground or air at an median rate of 0.38 lb. a.i. per acre with a typical PHI of 30+ day and the labeled PHI is 7 days. Mostly used during bloom. Do not use with or closely following oil sprays. Label changes made in 1998 do not allow preharvest applications on nectarine. Thus, the fungicide is restricted to only blossom and petal fall applications. (4,8,14)

- **Chlorothalonil,** applied to 11% of the acres by ground or air at an median rate of 3.0 lbs. a.i. per acre with a typical PHI of 30+ days and the labeled PHI is 0 days. Mostly used during bloom. Do not apply after shuck split nor preharvest. Do not use with or closely following oil sprays. (4,8,14)

- **Myclobutanil,** applied to 27% of the acres by ground or air at an median rate of 0.15 lb. a.i. per acre with a minimum 7-day PHI. (4,8)

- **Benomyl,** applied to 3% of the acres by ground or air at an median rate of 0.75 lb. a.i. per acre with a typical PHI of 90+ day and a labeled PHI of 3 days. Mostly used during bloom. Apply at pink bud only and use a companion fungicide of different chemistry. Resistance has been documented in the Sacramento and northern San Joaquin Valleys. (4,8)

There have been several new registered products in California for control of Brown Rot. These products include propiconazole (Break EC), and tebuconazole (Elite). Use information is not available on these products yet.

<u>Jacket Rot/Green Fruit Rot</u>:
These diseases are caused by a complex of fungi namely *Monilinia* species, *Botrytis cinerea,* and *Sclerotinia sclerotiorum*. Senescent and dead flower parts are colonized by any one or a combination of these fungi during wet weather. The flower parts usually dry out and drop off quickly in dry weather as the immature fruit develops. In wet weather the flower tissues remain attached and provide a substrate for these fungi to colonize the developing fruit. Symptoms usually develop one to three weeks after petal fall. Green fruit rot, however, can also occur in years of wet weather and heavy fruit set when non-thinned fruit are in contact with each other.

Controls:

Chemical:

In the past, full bloom and petal fall applications of fungicides such as benomyl or iprodione have provided effective control. Recently, with the introduction of newer compounds, such as the strobilurins and DMI fungicides, management of this disease is more difficult because these compounds are less effective against *B. cinerea*.

- **Benomyl,** applied to 3% of the acres by ground or air at an median rate of 0.75 lb. a.i. per acre with a typical PHI of 90+ day and a labeled PHI of 3 days. Mostly used during bloom. Apply at pink bud only and use a companion fungicide of different chemistry. Resistance has been documented in the Sacramento and northern San Joaquin Valleys. (4,8)

- **Thiophanate-methyl,** applied to 1% of the acres by ground or air at an median rate of 1.0 lb. a.i. per acre with a typical PHI of 90+ days which has a labeled PHI of 1 day. Mostly used during bloom. Resistance has been documented in the Sacramento and northern San Joaquin Valleys. (4,8,11,14)

- **Iprodione,** applied to 34% of the acres by ground or air at an median rate of 0.75 lb. a.i. per acre with a typical 7 day PHI which is the labeled PHI. Addition of a narrow range oil at 1-2% increases the effectiveness of this material. Label changes made in 1998 do not allow preharvest applications on nectarines. Thus, the fungicide is restricted to only blossom and petal fall applications. (4,8,14)

- **Chlorothalonil,** applied to 11% of the acres by ground or air at an median rate of 3.0 lbs. a.i. per acre with a typical PHI of 30+ days and the labeled PHI is 0 days. Mostly used during bloom. Do not apply after shuck split nor preharvest. Do not use with or closely following oil sprays. (4,8,14)

- **Captan,** applied to 7% of the acres by ground or air at an median rate of 2.9 lbs. a.i. per acre with a typical 30+ days PHI with a labeled PHI of 0 days. This is mostly used during bloom. Do not apply in combination with, immediately before, or closely following oil sprays. (4,8,14)

Peach Leaf Curl:

Peach Leaf Curl is caused by *Taphrina deformans*, an airborne fungus. About 90% of the nectarine acres are treated for this disease. Leaves produced in the spring are deformed, thickened, curled, and red or yellow colored instead of normal green. Severely affected shoots die. Irregular reddish lesions are sometimes seen on the fruit where touched by infected leaves. Badly diseased leaves fall by early summer, and repeated infections debilitate trees and kill branches. Dormant applications are necessary in all nectarine growing districts. One application in late winter before budswell is sufficient, except in areas of high rainfall or where leaf curl has become an increasing problem. (4,7)

Controls:

- **Chlorothalonil,** applied to 11% of the acres by ground at an median rate of 3.0 lbs. a.i. per acre. Do not use with or closely following oil sprays. (4,7)

- **Copper,** applied to 66% of the acres by ground at various application rates depending on the product. (4)

- **Ziram,** applied to 22% of the acres mostly by ground at an median rate of 6 lbs. a.i. per acre with a minimum 30-day PHI. (4)

Powdery Mildew (*Sphaerotheca pannosa*):
Terminal leaves of shoots are covered in powdery, white fungal growth. Leaves become misshapen and puckered and fruits develop powdery white spots. *S. pannosa* survives as mycelium in bud scales and other Roseaceous hosts. The climate in the San Joaquin Valley is suitable for powdery mildew, particularly during spring when the disease causes the most damage. Growth of the pathogen is favored by cool, moist nights and warm days. (7,12)

Controls:

Cultural:
Cultural control of powdery mildew can be accomplished through the judicious use of nitrogen fertilizers and heavy pruning during the growing season. Both practices cause excessive succulent growth which is ideal habitat for powdery mildew. Removal of alternate hosts adjacent to nectarine orchards is suggested as a method to reduce inoculum.

Chemical:

- **Benomyl,** applied to 3% of the acres by ground at an median rate of 0.75 lb. a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 3 days. Mostly used during bloom. Resistance to benomyl may develop if this material is used repeatedly. It is important to alternate benomyl with materials of a different chemistry. (4,7)

- **Sulfur,** is a preventative treatment and applied at various application rates, depending on the product, mostly by ground. It is applied to about 32% of the nectarine acres. Do not apply within 3 weeks of an oil application. (4,6,7,9)

- **Myclobutanil,** applied to 27% of the acres by ground at an median rate of 0.15 lb. per acre with a minimum 1-day PHI. (4,7,9)

- **Thiophanate-methyl,** applied to 1% of the acres by ground or air at an median rate of 1.0 lb. a.i. per acre with a typical 90+ day PHI and a labeled 1-day PHI. Mostly used during blossom. Apply

at pink bud only. Resistance has been documented in the Sacramento and northern San Joaquin Valleys. (4,8,11,12)

Phytophthora Root and Crown Rot:
Generally, crown rots advance rapidly and trees collapse and die soon after the first warm weather of spring. Leaves of such trees wilt, dry, and remain attached to the trees. Phytophthora infections typically kill young trees because their root systems and crown areas are small compared to those of mature trees. Can also kill mature trees. Periods of 24 hours or more of saturated soil favor Phytophthora infections. Conversely, good soil drainage and more frequent but shorter irrigations reduce the risk of root and crown rot. Also planting trees on a berm reduces the chances of this disease.

Controls:

Chemical:

- **Fosetyl-al,** applied to less than 1% of the acres by ground at a rate of 0.2 lbs. a.i. per acre. It is used as a post-plant treatment for nonbearing trees only. It can be applied as both a foliar and soil spray at 60-day intervals. (4,6,7)

Peach rust:
Leaves and fruit of nectarines are infected. In recent years, the disease is most severe on nectarines in Sutter/Yuba Co. of the Sacramento Valley, but also occurs in counties of the San Joaquin Valley. The fungus overwinters as a mycelium in one-year old twigs. In the spring the fungus forms lens-shaped twig cankers filled with rusty-brown spores. On leaves the disease develops as bright yellow, angular lesions. Rusty-brown sporulation pustules of the fungus develops on the lower leaf surface. Severe infections result in early season defoliation. Direct crop loss can occur from fruit infections that develop as sunken, greenish lesions as fruit ripen. Twig cankers form regardless of weather in the spring, however, growing season epidemics are dependent on high rainfall in the spring.

Controls:

Cultural control:
practices have not been developed, however, the disease is most severe in lowland areas and high density orchards with poor air-circulation and long periods of wetness from dew or rain.

Chemical:

- **Sulfur,** applied in a wettable formulation, is a preventative treatment. Various application rates

are used but 20 lb. per acre is commonly used for rust management. Do not apply within 3 weeks of an oil application (4,6,7,9).

- **Tebuconazole, Propiconazole** and **Myclobutanil** have also been shown to be effective.

Shot hole:
Lesions on twigs develop as purplish spots that expand and turn brown with a tannish center. Spores develop in the center of the lesion. Infected buds are dark brown to black and sometimes covered with gummy exudate. Leaf and fruit infections are circular. On leaves the lesions are chlorotic and commonly abscise. On fruit, lesions are corky and raised.

Controls:

Chemical:

- **Copper,** applied to 66% of the acres by ground at various application rates depending on the product. Copper is applied as a dormant application in late November and early December. (4)

- **Chlorothalonil,** applied to 11% of the acres by ground at an median rate of 3.0 lbs. a.i. per acre. Chlorothalonil is applied as a dormant spray in late November or early December. It is also effective in protecting leaves and immature fruit with spring applications.

- **Captan,** applied to 7% of the acres by ground or air at an median rate of 2.9 lbs. a.i. per acre with a typical 30+ days PHI with a labeled PHI of 0 days. This is mostly used during bloom. Do not apply in combination with, immediately before, or closely following oil sprays. It is also effective in protecting leaves and immature fruit with spring applications. (4,8,14)

- **Iprodione,** applied to 34% of the acres by ground or air at an median rate of 0.75 lb. a.i. per acre with a typical 7 day PHI which is the labeled PHI. Addition of a narrow range oil at 1-2% increases the effectiveness of this material. Label changes made in 1998 do not allow preharvest applications on nectarine. Thus, the fungicide is restricted to only blossom and petal fall applications. It is also effective in protecting leaves and immature fruit with spring applications. (4,8,14)

- **Propiconazole**, applied to 50% of the acres at a median rate of 0.11 lb. a.i. per acre.

- **Ziram,** applied to 22% of the acres mostly by ground at an median rate of 6 lbs. a.i. per acre with a minimum 30-day PHI. It is effective in protecting leaves and immature fruit with spring applications. (4)

Crown gall:
This is caused by the bacterial pathogen *Agrobacterium tumefaciens*. Galls commonly occur on roots, crowns, and stems. Smooth, young galls enlarge to become woody tumors with irregular surfaces. The disease can occur on nursery, young, or mature trees. Soil temperature of 22 degrees C and moisture of 60% is most favorable for disease development. Management techniques that reduce populations of the bacterial pathogen include soil fumigation and disinfestation of equipment with sodium hypochlorite. Biological control has been used successfully with the use of a nonpathogenic strain, *A. radiobacter*.

Soil fumigants are used in nursery operations but are not completely effective in managing the disease. Sodium hypochlorite is used to disinfect equipment used during planting by nursery and orchard operations.

Biological control:
using a strain of *A. radiobacter* (e.g. Galltrol), is used during planting of trees at orchard sites.

Bacterial Canker (*Pseudomonas syringae*):
An median of 2-5% of the nectarine acres are treated for this disease. There are higher incidences of bacterial canker in sandy fields and during cold wet winters. The colder the temperature the higher the incidence of this disease. Symptoms are most obvious in spring and include limb dieback, with rough cankers and amber colored gum. There may also be leaf spot and blast of young flowers and shoots. Frequently, trees sucker from near ground level; cankers do not extend below ground. *P. syringae* survives on plant surfaces, is spread by splashing rain, and is favored by high moisture and low temperatures in spring. Vigorous trees are less susceptible to bacterial canker, while young trees, 2 to 8 years old, are more affected. This disease, if left uncontrolled, will kill young trees. (6,7)

Controls:

Cultural:
Delayed pruning may help. Lovell rootstock is usually more tolerant than others. In light, sandy soils and in some heavy soils, control has been achieved with preplant fumigation for nematodes. There is no known reliable chemical control for bacterial canker. Therefore, good practices that promote tree health and vigor may help deter bacterial canker. In addition, planting of trees in sandy soils is avoided due to the link between this soil type, high ring nematode populations and increased incidence of the disease. (8,12)

Chemical:

- **Fenamiphos,** Applied to 1% of the acres as a post-plant application at an median rate of 1.5 lbs.

a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 45 days. Make initial application in fall. All applications should include low volume irrigation to move the material into the root zone. Low use due to costs and efficacy. (4,8,12,14)

Nematodes

Nematodes are microscopic roundworms that live in diverse habitats. Plant parasitic nematodes live in soil and plant tissues and feed on plants by puncturing and sucking the cell contents with a mouthpart called a stylet. Of the several genera of plant parasitic nematodes detected in California orchard soils, root knot, ring, lesion, and dagger nematodes are considered to be the most important.

Root knot nematode: This nematode is not a problem if Nemaguard rootstock is used. Feeding by root knot nematodes can impair root functions such as uptake of nutrients and water. Root knot nematodes have been implicated in nectarine disease complexes with fungi and bacteria; for example, *Meloidogyne javanica* has been reported to increase the incidence of crown gall on nectarine roots. Symptoms of root knot infestation are reduced vigor and yield, patches of unevenly sized trees, and characteristic galls on roots. (6,7,9)

Ring nematode: Infestation impairs development and function of nectarine roots which reduces tree vigor and predisposes trees to bacterial canker. (7)

Root Lesion nematodes: Penetrates roots and causes damage by feeding and migrating through the root tissues. Lesion nematode infestation reduce overall root presence and may cause reddish to dark lesions occur occasionally. (7)

Dagger nematodes: Feed from outside the roots, but can reach the vascular tissues with their long stylet and are capable of reducing vigor and yield of trees. The main damage caused by the dagger nematode is that it vectors a strain of tomato ringspot virus that causes peach yellow bud mosaic which debilitates and can kill trees. Symptoms of dagger infestation include reduced growth and vigor. (6,7)

Controls:

Cultural:
Before fumigating, remove old trunks and large roots brought to the surface by ripping and fallow or plant green manure cover crops for 1-2 years. Use certified nematode-free rootstocks or seedlings to establish new orchards. (6,7)

Chemical:

- **Methyl Bromide,** preplant application by ground at a rate of 300-600 lbs. a.i. per acre. Use the higher rates for fine textured soils. Methyl bromide fumigation kills 99% of all nematode species, but populations will gradually begin to rebuild over a two year period. This period allows the tree time to develop a healthy root system that can ultimately withstand or tolerate some nematode damage when populations rebound. (7,12)

- **Fenamiphos,** Applied to 1% of the acres as a post-plant application at an median rate of 1.5 lbs. a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 45 days. Make initial application in fall. All applications should include irrigation to move the material into the root zone. Low use due to cost and efficacy. Efficacy is increased under drip irrigation or low volume sprayer to move material deep into soil. (4,8,12,14)

Weeds

Weeds are a typical problem especially during the first two years after planting an orchard. When the canopy closes and shades out the middles, weed growth is usually reduced. Generally, there is one preemergent application made on the berm surrounding the trees. The preemergence herbicide is usually applied in the fall following harvest, or is applied in the winter or spring. Weeds in the row middles are generally controlled with repeated post emergent applications, alone or in combination with cultivation. The spectrum of weeds within an orchard changes so much that loss of the broad spectrum herbicides (glysophate and paraquat) would cause the loss of post emergent weed control in orchards. It would also cause the loss of effective control of perennial weeds. (10,12)

Controls:

Cultural control:
frequent discing or harrowing, helps eliminate perennial and broadleaf weeds. (12)

Chemical:

- **Glysophate,** applied to 62% of the nectarine acres at a median rate of 0.5 lb. a.i. per acre by ground application. (4,10)

- **Simazine,** A dormant application applied to 38% of the acres with an median rate of 0.45 lb. a.i. per acre by ground application. Potential groundwater contaminate. (4,10,11,14)

- **Paraquat,** applied to 29% of the nectarine acres at an median rate of 0.52 lb. a.i. per acre by ground application. Restricted use material. (4,11)

- **Norflurazon**, applied to 11% of the acres at a median rate of 0.65 lb. a.i. per acre by ground application.

- **Oryzalin**, applied to 18% of the acres at a median rate of 0.98 lb. a.i. per acre by ground application.

- **Oxyfluorfen,** applied to 43% of the nectarine acres at an median rate of 0.20 lb. a.i. per acre by ground application. Must be used in conjunction with another substance or tactic. (4,11)

Post Harvest

Post-harvest management of brown rot, gray mold, and *Rhizopus* rot is dependent on integrated pest management programs. Rapid cooling and cold temperature management during packing and shipping of fruit is a critical practice for shipping fruit to fresh markets. Sanitation practices are also an integral part of post-harvest handling of fruit. Fruit washes with neutral cleaners, chlorine or other sanitizing agents remove fungal spores from fruit surfaces and reduce the potential for contamination of other fruit. Sterilants are also used to clean equipment after fruit are processed to again reduce inoculum levels on the equipment and to prevent re-contamination of fruit. Sorting lines that remove injured or bruised fruit also reduce the potential of decay spreading from damaged fruit to fruit in packed boxes. Fungicides for management of brown rot, gray mold, Rhizopus rot, and other decays are also effectively used by packers who use mechanical post-harvest packing equipment (e.g., a washer/waxer). Currently, dicloran (Allisan) is the only fungicide fully registered on fresh market nectarines for management of decays caused by *Rhizopus stolonifer* and *Botrytis cinerea*. There are no current efficacious post-harvest fungicides for brown rot registered for use in fresh market nectarines. Iprodione use is allowed in packing sheds which may still have inventory from before the voluntary in-activation of the registration of this material by the manufacturer. In 1997, a Section 24 C was obtained for thiophanate-methyl (Topsin-M) for management of brown rot and gray mold. Due to resistant populations of Monilinia species to benzimidazole fungicides, a Section 18 emergency registration was obtained for fludioxonil (Medallion 50WP) in the 1998 season and will be applied for in 1999. This is a broad spectrum, reduced risk fungicide that is very effective at low rates (8 oz product/100 gal of water) in managing all the major post-harvest decay fungi of fresh market nectarines. It is important to note early harvested varieties of fresh shipping nectarines are less likely to develop post-harvest brown rot infections than varieties that are harvested later in the season due to lower inoculum levels . (12)

IPM

There is increasing grower implementation of reduced risk management strategies for the control of pathogens and pests in the fresh shipping nectarine industry. Increasing costs, secondary pest outbreaks and potential loss of traditional chemicals for control has prompted growers to try alternative methods. Specifically, pheromone mating disruption to suppress lepidopteran larval populations has gained general acceptance and is used by growers. The installation of monitoring traps for San Jose scale and lepidopteran species has maximized the effectiveness of those sprays that are necessary and decreased the incidence of unnecessary "routine calendar" insecticide sprays. In addition, the nearly universal use of nematode resistant rootstock, such as Nemaguard and Nemared, has curtailed the need for methyl bromide fumigation. Growers are also sampling for nematode species complexes to determine if the need for pre-plant fumigation actually exists. Each of these common practices reduces pesticide risk by initiating an overall system change from habitual to minimal insecticide use. (12)

Current Research Efforts

Research is continuing to be done which examines alternatives to the use of methyl bromide as a preplant fumigant for controlling nematodes. Currently, a metam sodium plus aldicarb drench has been identified as an economic and suitable nematode control replacement for methyl bromide. However, this treatment is currently not registered for use and commercial field trials have yet to be completed. Also, a long term project to screen new rootstocks for resistance to Bacterial Canker and nematodes is ongoing. Reduced risk fungicides and biological control in the orchard continue to be a priority for the industry. Residue work was completed for fludioxinil and this reduced risk fungicide is currently being evaluated by the EPA. (12)

Due to barriers in attaining a more widespread acceptance and adoption of pheromone mating disruption, research to examine refining the commercial application rates for pheromone mating disruption continues. The goal of the research is to increase the soundness of the mating disruption system and restore grower confidence, thus increasing routine use of this reduced risk pest management alternative. Moreover, research has begun which will evaluate and implement sustainable pest management practices for San Jose Scale, Peach Twig Borer and Oriental Fruit Moth. The project seeks to test the efficacy of new reduced risk insecticides, including oils, and survey and identify endemic/ commercial parasite strains to develop a biological control augmentation program for controlling San Jose Scale. (12)

Current research efforts include:

1. Development and Evaluation of Brown Rot Resistant Cultivars of Cling Peach (T. Gradziel, R. Bostock, and J. E. Adaskaveg)

2. Development of a Cling Peach Rust Forecasting Model Based on Inoculum Levels and Micro-

Environmental Conditions to Effectively Time Fungicide Applications. (J. E. Adaskaveg)

3. Management and Epidemology of Pre- and Postharvest Brown Rot. (J. E. Adaskaveg)

4. Development of Effective Post-Harvest Biocontrols for Management of Brown Rot and Other Peach Diseases. (Themis Michailides)

5. Improved Rootstock of Peach and Nectarine (T.M. DeJong)

6. Attempts to Make a "Compatible Virgin Soil as a Potential Replacement for Methyl Bromide. (Michael McKenry)

7. San Jose Scale Management with Petroleum Oils. (Walt Bentley)

8. Thrips Control on Fresh Shipping Fruit. (Richard Coviello).

9. San Jose Scale Natural Enemies: Investigating the Potential for Natural or Augmented Control. (Kent Daane)

10. Development of a Biochemical Assay for San Jose Scale Resistance to Insecticides. (Beth Grafton-Cardwell)

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