

Crop Profile for Peaches in California

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General Production Information



- California ranks first in the U.S. in the production of peaches.(13)
- California produces 71% of the total U.S. crop. (13)
- California produces 100% of the U.S. processed peaches. (13)
- California produces 49% of the U.S. fresh market peaches. (13)
- 943,500 tons of peaches valued in excess of \$317 million were produced during the 1997 crop year on approximately 68,000 acres (3).
- Production cost Clingstone peaches (1998) averaged \$3,910/acre (15).
- Production cost Fresh Market peaches (1992) averaged \$6,554/acre (16).
- Clingstone peaches comprise approximately 70% of the total crop in California and are exclusively utilized for processing which includes canning (including baby food), juice and frozen. (13)
- The California fresh shipping freestone peach production represents 30% of the annual tonnage. (12,13)

Production Regions

There are two major growing regions in California. The San Joaquin Valley (Fresno, Kings, Merced, Tulare, Kern, Madera, Stanislaus, San Joaquin) and the Northern Region (Solano, Sutter, Yuba, Placer, Butte and El Dorado Counties). The fresh market stone fruit growing area is approximately 90% 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 processing and fresh shipping production of peaches.(8,12)

Cultural Practices

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

a herbicide-treated berm in the tree row with weeds in the row middles being controlled by cultivation. Fruit thinning is an annual practice and hand labor is preferred over mechanical or chemical options. Clingstone canning peaches are harvested beginning in July through mid September. Shipping of fresh freestone peaches begins with early season harvests in late April and continues through late October. (8,12)

Insect Pests

San Jose Scale (SJS): A serious pest of peaches which 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 obtains 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

- **Narrow Range Oils**, Applied to 97%⁽¹⁾ 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 4%⁽²⁾ of the acres by ground at an average rate of 1.9 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 is sometimes applied post-bloom. Applied to 38%⁽³⁾ of the acres by ground at an average rate of 2.5 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 is sometimes applied post-bloom. Applied to 7%⁽⁴⁾ of the acres by ground application at a average rate of 3.5 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 and pressure from processors of baby food. (4,6,7,9)
- **Methidathion**, applied to 21%⁽⁵⁾ of the acres by ground application at an average rate of 1.5 lbs.

a.i. per acre. This chemical is widely used but will probably decrease in use due to signs of resistance of San Jose Scale. (4,11,14)

- **Methyl Parathion**, applied to 21%⁽⁶⁾ of the acres with an average rate of 1.42 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)

Oriental Fruit Moth: This is a serious pest in California. There are usually 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 trash 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 causing decay. (7,9)

Controls

Biological Control -

- **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. Replace baits on product recommendation, usually in 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)
- **Azinphos-methyl**, is applied to 5%⁽⁷⁾ of the acres by ground at an average rate of 1.75 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 1%⁽⁸⁾ of the acres by ground at an average rate of 0.80 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 good for 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 11%⁽⁹⁾ of the acres by ground at an average of 2.5 lbs. a.i. per acre with a

typical PHI of 14 days which is the labeled PHI. Timing is critical; may not control heavy populations. (4,7,9,14)

- **Methyl Parathion**, applied to 21% of the acres with an average rate of 1.42 lbs. a.i. per acre. Use of this chemical has increased because it is inexpensive and there are resistance problems with other alternatives. Used only early in season. Some processors do not allow use. (4,14)
- **Permethrin**, is applied to 28%⁽¹⁰⁾ of the acres by ground at an average rate of 0.05 lb. a.i. per acre with a typical PHI of 5 days (Ambush) and 7 days (Pounce) with are the labeled PHIs. There should be caution when using permethrin because of potential secondary pest problems. (4,7,9,14)
- **Esfenvalerate**, is applied to 28%⁽¹¹⁾ of the acres by ground or air at an average rate of 0.05 lb. a.i. per acre with a labeled PHI of 14 days.
- **Diazinon**, is applied to 38% of the acres most of which is a dormant application. It is applied by ground at an average rate of 2.5 a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 21 days. Timing is critical; may not control heavy populations. Resistance is suspected but has not been documented. (4,6,7,9,14)
- **Carbaryl**, applied to 7%⁽¹²⁾ of the acres by ground at an average rate of 3.5 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. Use of this chemical has decreased because of signs of resistance and pressure from processors of baby food. It is the only chemical that can be used under certain conditions because of the 1-day PHI. (4,7,11,12)

True Bugs: These pests are not usually considered major problems but they can be if neighboring fields contain crops which are hosts. In general adult lygus bugs are about .20 to .25 inch long. *Lygus hesperus* adults vary from yellowish to reddish brown and the adults of *L. ellises* are pale or yellowish green. Lygus 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, lygus 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 lygus 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 misshaped. Fruit damage is sporadic and does not occur every year; however, in some years severe economic losses can occur. In general, lygus bug populations are highest in years where there is loss of lush vegetation growing in and around the orchard. (6,7)

Controls

- **Cultural control**, 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)
- **Formetanate HCl**, applied to 3% (13) of the acres by ground at an average rate of 0.75 lb. a.i. per acre with a typical PHI of 21 days which is the labeled PHI. (4,6,7,11,14)
- **Methomyl**, applied to 1% of the acres by ground at an average rate of 0.80 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)

Peach Twig Borer (PTB): Peach Twig Borer is a severe pest to peaches 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 however it can decay. (4,7,12)

Controls

- **Biological control** - PTB has about 30 species of natural enemies. Among those commonly found in California are the chalcid wasps, *Paralitomastix varicornis* and *Hyperteles lividus*, 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 50% of the peach acres by ground only during bloom; the first at popcorn or early 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.
- Dormant sprays are an effective way to control PTB in peaches. All of the organophosphate and oil treatments listed for the SJS are effective for PTB plus the following additions. (6,7)

- **Diazinon or Methidathion + Oil**, are often applied during the dormant season. (6,7)
- **Chlorpyrifos**, applied to 4% (14) of the acres by ground at an average rate of 1.9 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 5% of the acres by ground at an average rate of 1.75 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 38% of the peach acres for various different pest. It is applied after the dormant season by ground at an average rate of 2.5 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 average rate of 3.5 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. Use of this chemical has decreased because of signs of resistance and pressure from processors of baby food. It is the only chemical that can be used under certain conditions because of the 1-day PHI. (4,7,11,12)
- **Phosmet**, applied to 11% of the acres by ground at an average rate of 2.5 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)

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. Peaches 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 control**, keeping orchards well irrigated and treating orchard roads, if necessary, to keep dust to a minimum helps to manage mite buildups. Proper pruning and adequate amounts of fertilizer to maintain tree vigor will also discourage two-spotted and Pacific mites. Choice of

insecticides for other pest problems can influence mite buildup (e.g. carbaryl and pyrethroids). (7)

- **Biological control**, 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)
- **Fenbutatin Oxide**, applied to 21% of the acres by ground at an average rate of 0.58 lb. a.i. per acre with a minimum 14-day PHI. This material appears to be most effective when applied early in the season. (4,7)
- **Narrow Range Oil**, Applied to 97% of the acres at various application rates depending on the product. (4,6,7)
- **Clofentezine**, applied to 8% of the acres by ground at an average rate of 0.10 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 peaches in California. No use data are available. It is applied at 1.3 lbs. a.i. per acre with a typical PHI of 7 days which is the labeled PHI.

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 and on fruit. Newly hatched larvae are white with black heads. Mature larvae are 0.5 to 0.75 inch long, pinkish white, with mottled brown heads.

Controls

- **Cultural Control**, 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.
- **Esfenvalerate**, is applied to 28% of the acres by ground or air at an average rate of .05 lb. a.i. per acre with a labeled PHI of 14 days.
- **Permethrin**, is applied to 28% of the acres by ground at an average rate of 0.05 lb. a.i. per acre with a typical PHI of 5 days (Ambush) and 7 days (Pounce) with are the labeled PHIs. There should be caution when using permethrin because of potential secondary pest problems. (4,7,9,14)

- **Methyl Parathion**, applied to 21% of the acres with an average rate of 1.42 lbs. a.i. per acre. Use of this chemical has increased because it is inexpensive and there are resistance problems with other alternatives. Used only early in season. Some processors do not allow use. (4,14)

Secondary Pests

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

Diseases

Brown rot, green fruit rot, shot hole, rust, and powdery mildew are the most common and devastating fungal diseases of peaches. Other fungal diseases such as anthracnose and scab occur in California peach growing regions, however, they have not caused economic damage. Root diseases such as *Phytophthora* root rot and *Armillaria* root rot can be problems in wet years when flooding occurs or 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.

Processing peaches: Benomyl and captan are not used much anymore. Growers rely on sulfur, iprodione, propiconazole, tebuconazole and myclobutanil. (14)

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

Brown Rot: A major perennial problem for peaches 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 source 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 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 peach 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 control**, 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)
- **Iprodione**, applied to 59%⁽¹⁵⁾ of the acres by ground or air at an average 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 peach. Thus, the fungicide is restricted to only blossom and petal fall applications. (4,8,14)
- **Captan**, applied to 9%⁽¹⁶⁾ of the acres by ground or air at an average 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 7%⁽¹⁷⁾ of the acres by ground or air at an average rate of 0.70 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 4% of the acres by ground or air at an average rate of 0.75 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 peach. Thus, the fungicide is restricted to only blossom and petal fall applications. (4,8,14)
- **Chlorothalonil**, applied to 32%⁽¹⁸⁾ of the acres by ground or air at an average rate of 2.4 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 and before harvest. Do not use with or closely following oil sprays. (4,8,14)
- **Myclobutanil**, applied to 25%⁽¹⁹⁾ of the acres by ground or air at an average rate of 0.13 lb. a.i. per acre with a minimum 7-day PHI. (4,8)
- **Benomyl**, applied to 17%⁽²⁰⁾ of the acres by ground or air at an average 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 azoxystrobin (Abound), propiconazole (Break EC), and tebuconazole (Elite). Use information is not available on these products yet.*

Jacket Rot/Green Fruit Rot: 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 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

- 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 17% of the acres by ground or air at an average 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 7% of the acres by ground or air at an average rate of 0.70 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 59% of the acres by ground or air at an average 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 peach. Thus, the fungicide is restricted to only blossom and petal fall applications. (4,8,14)
- **Chlorothalonil**, applied to 32% of the acres by ground or air at an average rate of 2.4 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 and before harvest. Do not use with or closely following oil sprays. (4,8,14)

- **Captan**, applied to 9% of the acres by ground or air at an average 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 peach acres are treated for this disease. Leaves produced in the spring are deformed, thickened, curled, and colored red or yellow 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 peach 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 32% (21) of the acres by ground at an average rate of 2.5 lbs. a.i. per acre. Do not use with or closely following oil sprays. (4,7)
- **Copper**, applied to 89% (22) of the acres by ground at various application rates depending on the product. (4)
- **Ziram**, applied to 49% (23) of the acres mostly by ground at an average rate of 6 lbs. a.i. per acre with a minimum 30-day PHI. (4)

Bacterial Canker (*Pseudomonas syringae*): An average of 2-5% of the peach acres are treated for this disease. There are higher incidence of bacterial canker in sandy field 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. Dormant copper is used with some success. (6,7)

Controls

- **Cultural control**, delayed pruning may help. Lovel peach 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 know 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)

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 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 peach orchards is suggested as a method to reduce inoculum.
- **Benomyl**, applied to 17% of the acres by ground at an average 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 40% of the peach acres. Do not apply within 3 weeks of an oil application. (4,6,7,9)
- **Myclobutanil**, applied to 25% of the acres by ground at an average rate of 0.12 lb. per acre with a minimum 1-day PHI. (4,7,9)
- **Thiophanate-methyl**, applied to 7% of the acres by ground or air at an average rate of .70 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 diseases.

Controls

- **Fosetyl-al**, applied to less than 1% of the acres by ground at a rate of 5.0 lbs. a.i. per acre. It is used as a post-plant treatment for nonbearing trees only. It is a foliar spray, 60-day intervals. (4,6,7)
- **Metalaxyl**, applied to less than 1% of the acres. The fungicide is applied as a soil drench (6 fl oz/1,000 sq ft.) under the tree canopy. The application rate varies with the method of application and size of trees. This is a post-plant application on nonbearing and bearing trees. Up to three applications are made from early spring to fall. (4)

Peach rust: Leaves and fruit of peach are infected. In recent years, the disease is most severe on cling peach 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, disease is most severe in lowland areas and high density orchards with poor air-circulation and long wetness periods from dew or rain.
- **Sulfur**, applied in a wettable formulation, is a preventative treatment. Various application rates are used but 20 lb/A is commonly used for rust management. Do not apply within 3 weeks of an oil application (4,6,7,9).

- Tebuconazole, Propiconazole, Myclobutanil, and Abound have 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

- **Copper**, applied to 89% 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 32%⁽²⁴⁾ of the acres by ground at an average rate of 2.5 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 in Spring applications.
- **Captan**, applied to 9% of the acres by ground or air at an average 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 in Spring applications. (4,8,14)
- **Iprodione**, applied to 59% of the acres by ground or air at an average 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 peach. Thus, the fungicide is restricted to only blossom and petal fall applications. It is also effective in protecting leaves and immature fruit in Spring applications. (4,8,14)
- **Ziram**, applied to 49% of the acres mostly by ground at an average rate of 6 lbs. a.i. per acre with a minimum 30-day PHI. It is effective in protecting leaves and immature fruit in Spring applications. (4)

Crown gall: 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 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 disinfest 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.

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 peach disease complexes with fungi and bacteria; for example, *Meloidogyne javanica* has been reported to increase the incidence of crown gall on peach 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 peach roots which reduces tree vigor and predisposes trees to bacterial canker. (7)

Lesion nematodes: Penetrate roots and cause damage by feeding and migrating through the root tissues. Lesion nematode infestation reduce overall root presence and may cause reddish brown lesions on roots that later turn dark and ultimately black. (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 control**, 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)
- **Methyl Bromide**, preplant application by ground and tarped 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 and 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)
- **Metam Sodium**, preplant application. Applied to less than 1% of the acres at 300 lbs. per acre. Metam sodium can reduce populations of nematodes if applied properly, but it does not penetrate plant roots very well and it is very difficult to get 4-5 feet down from the surface. Before applying this material, thoroughly cultivate the area to be treated. After cultivation and about one week before treatment, pre-irrigate the field with 6-8 acre--inches of water. After treatment, do not plant for 30 days, or 60 days if soil is high in organic matter or cold (below 50F). (4,7)
- **Fenamiphos**, Applied to 2% of the acres as a post-plant application at an average rate of 2.75 (3.6)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 costs and efficacy. (4,8,12,14)
- **Sodium Tetrathiocarbonate**, is a new registration and use patterns are not available at this time.

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 (glyphosate 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)
- **Glysofphate**, applied to 71% of the peach acres at a average rate of .5 lb. a.i. per acre by ground application. (4,10)
- **Simazine**, applied to 30% of the peach acres as a dormant spray with an average rate of 1.0 lb. a. i. per acre by ground application. Potential groundwater contamination. Virtually not used in Northern California due to phytotoxicity. (4,10,11,14)
- **Paraquat**, applied to 34% of the peach acres at an average rate of .70 lb. a.i. per acre by ground application. Restricted use material. (4,11)
- **Oxyfluorfen**, applied to 21% of the peach acres at an average rate of .21 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 agent (ozone, chlorine dioxide, etc) 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 from spreading 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 stone fruit crops 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 peaches. Iprodione is still being used in packing sheds which may still have inventory from before the voluntary inactivation 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. This 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 peaches. It is important to note early harvested varieties of fresh shipping peaches 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 awareness of reduced risk management strategies for the control of pathogens and pests in the cling peach and fresh shipping peach 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 with expanded regularity by growers each season. The installation of population monitoring traps for San Jose scale and lepidopteran species has maximized the effectiveness of those sprays which are necessary and decreased the incidence of unnecessary "routine calendar" insecticide sprays. In addition, the increased frequency of growers fallowing pre-plant sites for 1 year or longer and the nearly universal use of nematode resistant rootstock, such as Nemaguard and Nemared, has significantly curtailed the need for methyl bromide fumigation. Growers are taking advantage of laboratory services to closely monitor the need for nitrogen fertilizer to diminish succulent new tree growth thus, limiting habitat for overwintering fungal pathogens. 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. 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 and has a renewed Section 18 for the 1999 season. (12)

Current plant pathology 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. Development of effective pre-harvest fungicides with reduced risk classification by EPA for management of brown rot and other peach diseases. (J. E. Adaskaveg and B. Teviotdale)
4. Development of effective post-harvest fungicides with reduced risk classification by EPA for management of brown rot and other peach diseases. (J. E. Adaskaveg)
5. Development of effective post-harvest biocontrols for management of brown rot and other peach diseases. (T.J. Michailides)
6. Development of a brown rot forecasting model for peach (T. J. Michailides and J. E. Adaskaveg)
7. Evaluation of cultural practices such as mummy removal for brown rot management of peach (T.J. Michailides)
8. Evaluation of post-harvest fumigation of fruit with organic acids for brown rot control (T.J. Michailides)

Contacts

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- (3) Personal communication with Rich Hudgins, November 14, 1997.
- (4) 1995 CDPR Use Report.
- (5) Kearney Tree Fruit Review, Vol. 2. Based on Dr. Richard Rice field trials.
- (6) Personal communication with Harry Andris, November 18, 1997.

- (7) University of California Integrated Pest Management Pest Guidelines.
- (8) Growing Shipping Peaches & Nectarines in California U.C. Cooperative Extension Leaflet 2851, August, 1983.
- (9) Personal communication with Bill Olsen, November 21, 1997.
- (10) Personal communication with Kurt Hembree, February 13, 1998.
- (11) Alternatives Survey, 1997. Conducted by CDPR and IPM.
- (12) Pest Management Evaluation for Clingstone Canning and Fresh Shipping Peaches, Plum and Nectarines, May, 1998. (California Tree Fruit Agreement)
- (13) National Agricultural Statistics Service Data, 1998
- (14) California League of Food Processors FQPA Phase 1 Report, 1998
- (15) University of California - Cooperative Extension "Sample Cost" (1998)
- (16) University of California - Cooperative Extension "Sample Cost" (1992)

1. This refers to the percent of peach acres treated with narrow range oils per year. Narrow range oils are used to control several different pests.

2. This refers to the percent of peach acres treated with Chlorpyrifos per year. Chlorpyrifos is used to control San Jose Scale, Oriental Fruit Moth, Peach Twig Borer and Leaf Roller.

3. This refers to the peach acres treated with diazinon per year. Diazinon is used to control San Jose Scale, Oriental Fruit Moth, Peach Twig Borer and Leaf Roller.

4. This refers to the percent of peach acres treated with carbaryl per year. Carbaryl is used to control San Jose Scale, Peach Twig Borer and Oriental Fruit Moth.

5. This refers to the percent of peach acres treated with methidathion per year. Methidathion is used to control San Jose Scale and Peach Twig Borer.

6. This refers to the percent of peach acres treated with methyl parathion per year. Methyl Parathion is used to control San Jose Scale, Oriental Fruit Moth and Codling Moth.

7. This refers to the percent of peach acres treated with azinphosmethyl per year. Azinphosmethyl is used to control Oriental Fruit Moth, Peach Twig Borer and Leaf Roller.
8. This refers to the percent of peach acres treated with methomyl per year. Methomyl is used to control Oriental Fruit Moth, Peach Twig Borer and Lygus bugs.
9. This refers to the percent of peach acres treated with phosmet per year. Phosmet is used to control San Jose Scale, Oriental Fruit Moth, Peach Twig Borer and Leaf Roller.
10. This refers to the percent of peach acres treated with permethrin per year. Permethrin is used to control Oriental Fruit Moth, Peach Twig Borer, Leaf Roller and Codling Moth.
11. This refers to the percent of peach acres treated with esfenvalerate per year. Esfenvalerate is used to control Oriental Fruit Moth and Codling Moth.
12. This refers to the percent of peach acres treated with carbaryl per year. Carbaryl is used to control Oriental Fruit Moth and Peach Twig Borer.
13. This refers to the percent of peach acres treated with Formetanate HCl per year. Formetanate HCl is used to control Oriental Fruit Moth and Peach Twig Borer.
14. This refers to the percent of peach acres treated with Chlorpyrifos per year. Chlorpyrifos is used to control Oriental Fruit Moth, Peach Twig Borer and Leaf Roller.
15. This refers to the percent of peach acres treated with Iprodione per year. Iprodione is used to control Shot hole, Scab, Blossom rot, Jacket Rot/Green Fruit Rot and Shot hole.
16. This refers to the percent of peach acres treated with Captan per year. Captan is used to control Brown Rot, Jacket Rot/Green Fruit Rot and Shot hole.
17. This refers to the percent of peach acres treated with thiophanate-methyl per year. Thiophanate-methyl is used to control Powdery Mildew, Blossom blight, Scab and Jacket Rot/Green Fruit Rot.
18. This refers to the percent of peach acres treated with chlorothalonil per year. Chlorothalonil is used to control Brown rot, Peach Leaf Curl, Scab and Jacket Rot/Green Fruit Rot.
19. This refers to the percent of peach acres treated with myclobutanil per year. Myclobutanil is used to control Brown rot and Powdery mildew.
20. This refers to the percent of peach acres treated with benomyl per year. Benomyl is used to control Brown rot, Powdery mildew and Jacket Rot/Green Fruit Rot.

21. This refers to the percent of peach acres treated with chlorothalonil per year. Chlorothalonil is used to control Peach Leaf Curl and Shot hole.
22. This refers to the percent of peach acres treated with copper per year. Copper is used to control Peach Leaf Curl and Shot hole.
23. This refers to the percent of peach acres treated with ziram year. Ziram is used to control Peach Leaf Curl and Shot hole.
24. This refers to the percent of peach acres treated with chlorothalonil per year. Chlorothalonil is used to control Peach Leaf Curl and Shot hole.

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