

Crop Profile for Caneberries in California

Prepared: February, 2000

General Production Information

- Caneberries is the general term for *Rubus* spp., which are commonly called raspberries and blackberries. When picked, raspberries leave the receptacle behind resulting in a cup-shaped fruit. On the other hand, blackberries retain the receptacle within the fruit and the fruit are not cup-shaped. Raspberries are in *Rubus* subgenus *Idaeobatus* and blackberries are in the subgenus *Eubatus*. There are also hybrids between raspberries and blackberries such as loganberry, boysenberry, and ollalieberry (5). In this profile raspberries, blackberries, and hybrids are considered together except where noted. Where they are separated, raspberries are one group and blackberries and hybrids are another group.
- In 1997, 19,400,000 pounds of raspberries were produced on 1,900 acres in California. The average yield was 10,200 pounds per acre. The average price was \$1.41 per pound and the total crop value was \$27,330,000 (2).
- Blackberries were produced on 714 acres in California in 1997 (1).
- In 1997, 2,500,000 pounds of boysenberries were produced on 270 acres in California. The average yield was 9,100 pounds per acre. The average price was \$0.67 per pound and the total crop value was \$1,639,000. The 1997 crop value was down from a high in 1988 of \$3,814,000 when the price per pound was \$1.82. In 1988, 2,100,000 pounds of boysenberries were produced on 400 acres and yield was 5,300 pounds per acre (2).
- In 1996, California ranked third in raspberry production, producing 26% of the nation's raspberries. Raspberries ranked 64th in value of all of California's agricultural commodities (3).
- In 1996, California ranked second in boysenberry production, producing 32% of the nation's boysenberries. Boysenberries ranked 74th in value of all of California's agricultural commodities with a total value of \$2,248,000 (4).

Production Regions

- In California the leading production regions for raspberry are Santa Cruz and Monterey Counties and the harvest season is June 1 - October 31 (3).
- The leading production area for boysenberries is the northern San Joaquin Valley. Boysenberries are typically harvested from June 1 to July 15 (4).

Production Practices

- Caneberries have perennial crown and root systems and biennial shoots. The first year of shoot growth is entirely vegetative and termed the primocane. Primocanes are dormant through the winter. The second year the shoots produce lateral branches bearing flowers and are termed floricanes. The floricanes die at the end of the growing season and must be removed by pruning (5).
- Caneberries are trained on trellising and routinely pruned. Specific, pruning and trellising practices vary by variety (7,9).
- The majority of California's caneberries are produced for fresh market and are picked by hand and drip irrigated (7, 9).
- The top raspberry varieties are Heritage, Willamette, and Autumn Bliss (7). The top variety of boysenberry is an Oregon State University selection, OSU 43 (9).
- Raspberries are typically planted either in the fall or early spring (7).
- The useful life of a caneberry crown is variable. Raspberries are replanted every 18 months to 5 years, whereas, blackberries may not be replanted for as many as 15 years (7,9).

Pesticide Data

Label rates, re-entry intervals and pre-harvest intervals for all chemicals listed in this document are from labels. Many of the labels are contained in the Crop Protection Reference (6) or at <http://www.cdms.net/manuf/manufac.asp>. Percent of acres treated, average number of applications, median application rate, and total lb a.i. applied are from the California Department of Pesticide Regulation (1).

Insect Pests

Leafrollers - Apple pandemis (*Pandemis pyrsuana*), Omnivorous leafroller (*Platynota sultana*), and Orange tortrix (*Argyrotaenia citrana*)

Leafrollers belong to the Tortricidae family. Apple pandemis and orange tortrix occur in coastal areas whereas omnivorous leafroller is a pest in the Central Valley. Apple pandemis has two generations a year, orange tortrix has three and while the omnivorous leafroller has four to five. Leafroller larvae feed on fruit and foliage. Foliar injury is minor. Larvae may web leaf surfaces together and live between them or may fold leaves and live in folds. Larvae also feed within berries. Significant economic damage can

occur if larvae contaminate the harvested fruit (5,10).

Control:

Non-chemical:

Many naturally occurring parasites attack leafrollers. Since overwintering larvae survive in weeds or in debris beneath the vines, good sanitation practices during the dormant season help prevent a buildup of the leafroller population (10).

Chemical:

Monitor by examining plants for leafroller activity. Pheromone traps are also used.

- ***Bacillus thuringiensis*** - Label has a rate of 0.033-0.088 lb a.i./acre and 0 day PHI¹. In 1997, *Bacillus thuringiensis* was applied to 71.5% of California's raspberry acreage 1-3 times (variable by formulation). A total of 130 lbs *Bacillus thuringiensis* was applied to California raspberries at a median application rate of 0.06 lbs a.i./acre in 1997. On blackberries, 32% of the acreage was treated 1-3 times. A total of 34 lbs *Bacillus thuringiensis* was applied at a median application rate of 0.07 lbs a.i./acre in 1997 (1). *Bacillus thuringiensis* is an organically acceptable means of control (10).
- **Azinphos-methyl** - Label has a rate of 0.22 lb a.i./acre and 14 day PHI. The maximum number of sprays allowed per season is 2. In 1997, azinphos-methyl was applied to 3.5% of California's raspberry acreage 1 time. A total of 29 lbs azinphos-methyl was applied to raspberries at a median application rate of 0.49 lbs a.i./acre in 1997. Azinphos-methyl was not used on blackberries in 1997 (1).
- **Carbaryl** – Label has a rate of 1-2 lb a.i./acre and a 7 day PHI. In 1997, 19.5% of California's blackberry acreage was treated with carbaryl 1 time. A total of 243 lbs a.i. was used at a median application rate of 1.8 lbs a.i./acre. Carbaryl was not used on raspberries in 1997 (1).

Redberry mite - *Acalitus essigi*

Redberry mite is a pest of cultivated and wild blackberries, but not raspberries. It is a microscopic mite with two pairs of legs and is worm-like and translucent white. It can be seen with a 10-14x hand lens. Overwinters in bud scales or deep in buds. Mites move into the shoots as they develop in the spring. They infest unfolding buds, flowers, and developing drupelets of the berries. Infested fruit remain hard and green or bright red and is unmarketable. The mite can spread from small isolated infestations to large portions of a planting the next season. High populations result in significant losses. Late maturing blackberry cultivars are most susceptible to damage (5,10).

Control:

Non-chemical:

There is no effective non-chemical control (10).

Chemical:

Treatment is best at the delayed dormant stage. A second spray at first bloom may be necessary for high populations.

- **Lime sulfur** - Label has a rate of 12.3 lb a.i./acre. In 1997, 22,347 lbs lime sulfur were used to treat 41.5% of the acreage 1 time at a median application rate of 15.34 lbs a.i./acre. On blackberries, 58% of the acreage was treated with lime sulfur 1.4 times. A total of 17,025 lbs lime sulfur was applied to California blackberries at a median application rate of 18.04 lbs a.i./acre in 1997 (1). Lime sulfur is an acceptable method of organic control (10).

Leafhoppers - White apple leafhopper (*Typhlocyba pomaria*) and Rose leafhopper (*Edwardsiana rosae*)

Rose leafhoppers lay their eggs in young stems of rosaceous plants and apple leafhoppers lay their eggs in 3-4 year old apple twigs. The bark swells where the eggs are laid. Hatching occurs in mid-April. Nymphs develop on their overwintering hosts and disperse to raspberries and blackberries as adults in early June. As adults, both leafhoppers are white and about 1/8 in. long. Apple leafhoppers have two generations per year and rose leafhoppers have three generations per year. Caneberry leaves are damaged by leafhoppers sucking on leaf tissue and reducing photosynthetic area. Leaves may be speckled with white markings and black droppings if infestation is severe (10).

Control:**Non-chemical:**

Predators include green lacewings and minute pirate bugs. Parasitization of eggs may keep population levels down (10).

Chemical:

- **Potash Soap** – Label has a rate of 1-2% v/v solution. In 1997, potash soap was applied to 0.4% of California's raspberry acreage 3 times. A total of 29 lbs potash soap was applied to raspberries at a median application rate of 4.37 lbs a.i./acre in 1997. First generation nymphs are targeted. Provides only temporary population reduction. Potash soap was not used on blackberries in 1997 (1). Potash soap is an organically acceptable means of control (10).
- **Diazinon** - Label has a rate of 1 lb a.i./acre in a minimum of 100 gallons water and 7 day PHI. In 1997, diazinon was applied to 4% of California's raspberry acreage 1 time. A total of 103 lbs

diazinon was applied to California raspberries at a median application rate of 1 lb a.i./acre in 1997. On blackberries, 24.5% of the acreage was treated 2 times. A total of 403 lbs diazinon was used on blackberries at a median rate of 1.5 lbs a.i./acre in 1997 (1).

- **Azinphos-methyl** - Label has a rate of 0.22 lb a.i./acre and 14 day PHI. The maximum number of sprays allowed per season is 2. In 1997, azinphos-methyl was applied to 3.6% of California's raspberry acreage 1 time. A total of 29 lbs azinphos-methyl was applied to raspberries at a median application rate of 0.49 lbs a.i./acre in 1997. Azinphos-methyl was not used on blackberries in 1997 (1).
- **Malathion** - Label has a rate of 0.937 lb a.i./acre and 1 day PHI. In 1997, malathion was applied to 13.9% of California's raspberry acreage 1 time. A total of 353 lbs malathion was applied to raspberries at a median application rate of 1 lb a.i./acre in 1997. On blackberries, 11.6% of the acreage was treated 1 time. A total of 37 lbs malathion was applied to blackberries in 1997 (1).
- **Carbaryl** – Label has a rate of 1-2 lb a.i./acre and a 7 day PHI. In 1997, 19.5% of California's blackberry acreage was treated with carbaryl 1 time. A total of 243 lbs a.i. was used at a median application rate of 1.8 lbs a.i./acre. Carbaryl was not used on raspberries in 1997 (1).

Diseases

Verticillium wilt - *Verticillium dahliae*

Leaves on infected canes turn yellow, wither, and drop beginning from the bottom of the cane and progressively moving upward. The leaf symptoms may appear asymmetrically on the cane. Eventually the canes wilt and die. The fungus is soilborne and may be present before planting if the previous crop was a host (good hosts include solanaceous plants, strawberries, cotton, and cucurbits). The disease is favored by cool, wet weather. Susceptibility to Verticillium wilt is variable: boysenberries are highly susceptible, loganberries are highly resistant, red raspberries are less susceptible than blackberries (5,10).

Control:

Non-chemical:

Growers use clean planting stock and avoid planting in fields known to be infected. Soil solarization can reduce inoculum levels in some Central Valley locations (10).

Chemical:

Pre-plant fumigation reduces inoculum levels in the soil.

- **Methyl bromide/Chloropicrin** - Label has a rate of 180-240 lbs methyl bromide/acre. In 1997, methyl bromide was applied to 2.7% of California's raspberry acreage 1 time. A total of 8,059 lbs methyl bromide and 4,739 lbs chloropicrin was applied to California raspberries in 1997. The median application rates were: 165.73 lbs a.i./acre methyl bromide and 85.84 lbs a.i./acre chloropicrin. In 1997, 131 lbs methyl bromide and 44 lbs chloropicrin were applied to less than 1 acre for California blackberries (1).
- **Metam Sodium** – Label has a rate of 160-320 lbs a.i./acre. In 1997, metam sodium was applied to 4.9% of the blackberry acreage 1 time. A total of 8,467 lbs a.i. was used at a median application rate of 241.9 lbs a.i./acre. Metam sodium was not used on raspberries in 1997 (1).

Phytophthora root rot - *Phytophthora spp.*

On caneberries infected with *Phytophthora* root rot the primocanes wilt and their shoot tips dieback. Floricanes of infected plants have weak lateral shoots. The leaves turn yellow or scorch beginning at the margins. Plants undergo severe wilting during hot weather. The roots and crown of infected plants are dark colored. The fungus survives in soil as thick-walled oospores. Prolonged saturation of the soil causes the release of motile spores that swim to and infect the roots and crowns (5,10).

Control:

Non-chemical:

Growers avoid planting in fields that are infested or have poor drainage. In some cases raised beds can help improve drainage. Clean planting stock is used (10).

Chemical:

Pre-plant fumigation reduces inoculum levels in the soil.

- **Methyl bromide/Chloropicrin** - Label has a rate of 180-240 lbs methyl bromide/acre. In 1997, methyl bromide was applied to 2.7% of California's raspberry acreage 1 time. A total of 8,059 lbs methyl bromide and 4,739 lbs chloropicrin was applied to California raspberries in 1997. The median application rates were: 165.73 lbs a.i./acre methyl bromide and 85.84 lbs a.i./acre chloropicrin. In 1997, 131 lbs methyl bromide and 44 lbs chloropicrin were applied to less than 1 acre for California blackberries (1).
- **Metam Sodium** – Label has a rate of 160-320 lbs a.i./acre. In 1997, metam sodium was applied to 4.9% of the blackberry acreage 1 time. A total of 8,467 lbs a.i. was used at a median application rate of 241.9 lbs a.i./acre. Metam sodium was not used on raspberries in 1997 (1).

The following chemicals are applied post-plant and typically after harvest but before the fall rains.

- **Metalaxyl** - Label has a rate of 0.125 lb a.i./1,000 row feet (5.4 lb a.i./acre for an 8 ft row spacing) and 45 day PHI. In 1997, metalaxyl was applied to 2.7% of California's raspberry acreage 1 time. A total of 24 lbs metalaxyl was applied to raspberries at a median application rate of 0.46 lbs a.i./acre in 1997. Metalaxyl is not labeled for use on California blackberries (1).
- **Mefenoxam** (formerly metalaxyl) – In 1997, mefenoxam was applied to 12.4% of California's raspberry acreage 1 time. A total of 108 lbs a.i. was applied at a rate of 0.5 lbs a.i./acre. Mefenoxam was not applied to blackberries (1).
- **Fosetyl-Al** - Label has a rate of 4 lb a.i./acre and 60 day PHI. Fosetyl-al was not applied to raspberries in 1997. On blackberries, fosetyl-al was applied to 12% of California's blackberry acreage 1.2 times. A total of 158 lbs fosetyl-al was applied to blackberries at a median application rate of 4 lbs a.i./acre in 1997 (1). Fosetyl-al cannot be tank mixed with copper compounds, surfactants, or foliar fertilizer.

Armillaria root rot - *Armillaria spp.*

Above ground symptoms of *Armillaria* root rot are cane wilting and dieback. Examination of the crown and main roots reveals white to cream mycelia just under the bark. The mycelia are typically fan-shaped and have characteristic mushroom odor. *Armillaria* root rot spreads from plant to plant by rhizomorphs. The rhizomorphs are root-like in appearance but are actually white fungal mycelium encased in dark red to black rind. Occasionally mushrooms are produced around the base of infected plants. The mushrooms have a yellowish-brown cap and a ring around the stem just below the cap. Initial inoculum is infected woody roots in soil, often remaining after land is cleared of infected trees. *Armillaria spp.* attack a wide range of woody orchard and forest plants. Other common names include honey fungus, oak root fungus, and shoestring fungus (5,10).

Control:

Non-chemical:

Although difficult to remove all roots, infected roots and stumps are removed and destroyed before planting a new field. If a field is planted adjacent to an infected area, barriers are installed in soil to prevent growth of rhizomorphs from infected areas into the field (10).

Chemical:

Pre-plant fumigation.

- **Methyl bromide/Chloropicrin** - Label has a rate of 180-240 lbs methyl bromide/acre. In 1997,

methyl bromide was applied to 2.7% of California's raspberry acreage 1 time. A total of 8,059 lbs methyl bromide and 4,739 lbs chloropicrin was applied to California raspberries in 1997. The median application rates were: 165.73 lbs a.i./acre methyl bromide and 85.84 lbs a.i./acre chloropicrin. In 1997, 131 lbs methyl bromide and 44 lbs chloropicrin were applied to less than 1 acre for California blackberries (1).

- **Metam Sodium** – Label has a rate of 160-320 lbs a.i./acre. In 1997, metam sodium was applied to 4.9% of the blackberry acreage 1 time. A total of 8,467 lbs a.i. was used at a median application rate of 241.9 lbs a.i./acre. Metam sodium was not used on raspberries in 1997 (1).

Botrytis fruit rot - *Botrytis cinerea*

Botrytis fruit rot is also called gray mold fruit rot for the color of the spores produced on infected fruit. The disease cycle begins from flattened, black masses of fungal sclerotia found on canes in winter. In the spring spores are produced from the sclerotia and they infect flowers. The spores are grayish-brown and are evident along with hyphae on infected tissues. Hyphae in infected flowers generally remain dormant until the fruit approaches ripeness. Then the fungus becomes active as host tissue senesces resulting in late season or post-harvest rot. The fungal spores are dispersed by wind, rain, and overhead irrigation. Botrytis needs free water for spore germination and infection. The disease is most common in cool, wet weather. *Botrytis cinerea* is a facultative parasite of many plants and prefers senescent tissues (5,10).

Control:

Non-chemical:

Growers promote rapid drying of plant tissue by pruning and trellising to open the canopy and promote good air circulation. Nitrogen fertilizer applications are minimized. Fresh market berries are picked before full maturity at red ripe stage directly into containers to go to consumer. Picking and storage procedures are designed to minimize exposure of senescent tissue to conditions appropriate for fruit rot development. Partial resistance to Botrytis fruit rot is available for some red raspberry cultivars (10).

Chemical:

Fungicides are applied as protective sprays at 7- to 14-day intervals from early bloom to harvest. Chemicals are alternated to avoid development of resistance.

- **Benomyl** - Label has a rate of 0.375 lb a.i. and 3 day PHI. The maximum application of benomyl is 5 applications per crop per season or 1.875 lb a.i./acre per year. In 1997, benomyl was applied to 0.7% of California's raspberry acreage 1 time. A total of 1 lb benomyl was applied to California raspberries at a median application rate of 0.12 lb a.i./acre in 1997. No benomyl was applied to California blackberries in 1997 (1).

- **Iprodione** - Label has a rate of 0.5-1.0 lb a.i./acre in a minimum of 100 gallons of water and 0 day PHI. The maximum number of applications allowed per year is 4. In 1997, iprodione was applied to 15.9 % of California's raspberry acreage 1.5 times. A total of 213 lbs iprodione was applied to California raspberries at a median application rate of 0.29 lb a.i./acre. On blackberries, 10% of the acreage was treated 1 time. A total of 72 lbs a.i. was applied to California blackberries at a median application rate of 0.75 lb a.i./acre in 1997 (1).

Leaf spot - *Mycosphaerella rubi* (anamorph *Septoria rubi*)

Mycosphaerella rubi infects blackberries and does not infect raspberries. Symptoms on the leaves are "frog-eye" lesions: roughly circular, 3-4mm diameter lesions with a brown or purplish margin and a white center. Lesions also occur on the canes but are more elongate in shape. Small, black pycnidia develop in the center of mature leaf and stem lesions. The pycnidia produce spores which are disseminated by wind and splashed water. The spores require free-water for germination and infection. The fungus overwinters in dead leaves and stems (5,10).

Raspberry leaf spot, caused by *Cylindrosporium rubi* (anamorph *Sphaerulina rubi*), is not common in California (5).

Control:

Non-chemical:

Growers promote rapid drying of plant tissue by pruning and trellising to open the canopy and promote good air circulation. Old floricanes are pruned out and damaged canes and leaf debris are removed to reduce sources of inoculum (10).

Chemical:

- **Lime sulfur** - Label has a rate of 12.3 lb a.i./acre. In 1997, lime sulfur was applied to 41.5% of California's raspberry acreage 1 time. A total of 22,347 lbs lime sulfur was applied to raspberries at a median application rate of 15.34 lbs a.i./acre in 1997. On blackberries, 58% of the acreage was treated with lime sulfur 1.4 times. A total of 17,025 lbs lime sulfur was applied to California blackberries at a median application rate of 18.04 lbs a.i./acre in 1997 (1). Lime sulfur is an acceptable method of organic control (10).
- **Copper formulations:**
 - Copper hydroxide** - Label has a rate of 3.08 lb a.i./acre. In 1997, copper hydroxide was applied to 0.3% of California's raspberry acreage 1 time. Less than 1 lb a.i. was applied to raspberries at a median application rate of 0.92 lb a.i./acre. On blackberries, 31% of the acreage was treated with copper hydroxide 1 time in 1997. A total of 631 lbs copper hydroxide was applied to California blackberries at a median application rate of 2.2 lbs a.i./acre (1).

-Copper oxychloride - Label has a rate of 3.7 - 4.6 lb a.i./acre. In 1997, copper oxychloride was applied to 13.3% of California's raspberry acreage 1 time. A total of 1,265 lbs copper oxychloride was applied to raspberries at a median application rate of 3.41 lbs a.i./acre. On blackberries, 0.06% of the acreage was treated with copper oxychloride 2.5 times in 1997. A total of 122 lbs copper oxychloride was applied to California blackberries at a median application rate of 14.96 lbs a.i./acre (1).

-Copper oxychloride sulfate - Label has a rate of 1.75-3.75 lb a.i./acre. In 1997, copper oxychloride sulfate was applied to 34.6% of California's raspberry acreage 2 times. A total of 2,171 lbs copper oxychloride sulfate was applied to raspberries at a median application rate of 1.5 lbs a.i./acre. Copper oxychloride sulfate was not applied to California blackberries in 1997 (1).

-Copper sulfate (basic) - Label has a rate of 1.98 lb a.i./acre. In 1997, copper sulfate (basic) was applied to 13.3% of California's raspberry acreage 1 time. A total of 240 lbs copper sulfate (basic) was applied to raspberries at a median application rate of 0.65 lbs a.i./acre. On blackberries, 0.6% of the acreage was treated with copper sulfate (basic) 2 times in 1997. A total of 23 lbs copper sulfate (basic) was applied to California blackberries at a median application rate of 2.84 lbs a.i./acre (1).

-Copper salts of fatty and rosin acids - Label has a rate of 2.3 - 3.5 lb a.i./acre. In 1997, copper salts of fatty and rosin acids was applied to 38% of California's raspberry acreage 2 times. A total of 3,127 lbs copper was applied to raspberries at a median application rate of 2.43 lbs a.i./acre. On blackberries, 7.6% of the acreage was treated with copper 3 times in 1997. A total of 339 lbs copper was applied to California blackberries at a median application rate of 2.43 lbs a.i./acre (1).

Powdery mildew - *Sphaerotheca macularis*

Sphaerotheca macularis is an obligate parasite and cannot grow without living host tissue. It infects raspberries but not blackberries or hybrids. The fungus overwinters as mycelium in infected buds or on primocanes. The symptoms in the spring begin as light green spots on the upper surface of leaves. White mycelial growth can be seen on the corresponding underside of leaf. The spots may become water-soaked. Infected shoot tips and fruit may be covered with white mycelium. Severely infected shoots may become long and spindly (rat-tailed) with dwarfed leaves. Spores are produced on the surface of infected tissues. The spores are airborne and disease development is favored by warm, dry weather. Free-water is not necessary for spore germination or infection (5,10).

Control:

Non-chemical:

Highly susceptible varieties are not planted in areas where powdery mildew is a serious problem annually. The varieties Chief, Marcy, and Malling Orion are resistant and Logan are immune to powdery mildew. Late-forming suckers with powdery mildew symptoms are removed and floricanes are pruned to horticulturally desired height to reduce inoculum (10).

Chemical:

- **Benomyl** - Label has a rate of 0.375 lb a.i./acre and 3 day PHI. The maximum application of benomyl is 5 applications per crop per season or 1.875 lb a.i./acre per year. In 1997, benomyl was applied to 0.7% of California's raspberry acreage 1 time. A total of 1 lb benomyl was applied to California raspberries at a median application rate of 0.12 lb a.i./acre in 1997. No benomyl was applied to California blackberries in 1997 (1). Benomyl gives some measure of disease suppression but may not provide enough control under high disease pressure (10).
- **Sulfur** - Label has a rate of 4.8-9.6 lb a.i./acre and 0 day PHI. In 1997, sulfur was applied to 20.3% of California's raspberry acreage 2 times. A total of 1,147 lbs sulfur was applied to California raspberries at a median application rate of 1.6 lbs a.i./acre. On blackberries, sulfur was applied to 15% of the acreage 1.65 times in 1997. A total of 886 lbs sulfur was used at a median application rate of 4.88 lbs a.i./acre (1). Sulfur is phytotoxic to some varieties especially if the temperatures are greater than 90°F (10).

Downy mildew - *Peronospora sparsa*

Peronospora sparsa is an obligate parasite and cannot grow without living host tissue. The initial symptom on leaves is a yellow discoloration of the upper surface that progresses to red or purple. Lesions are restricted by veins and therefore are angular in shape. The lower surface of leaves turn light pink to tan in areas that are directly below lesions on upper surfaces. Additionally, white to light gray sporulation on lower surface of leaves is evident. If the disease is systemic, the unfolding leaves have yellow and red angular lesions and severe distortion. Severely infected leaves die and fall from plant. Primocanes from systemically infected plants are often stunted and have red streaks on the side facing the sun and the terminal leaves are reddish. Infected fruit appear dull and may turn red and dry out. Downy mildew is prevalent during wet weather at temperatures around 65° F. The fungus overwinters as mycelium inside roots crowns and canes. Airborne spores are produced during cool wet nights and disseminated by wind (5,10).

Control:

Non-chemical:

Pathogen-free planting material is used. Alternate hosts such as roses and wild blackberries are destroyed. Suckers and weeds are removed from the base of the plant to reduce humidity. Old fruiting canes are removed and destroyed (10).

Chemical:

Copper compounds are acceptable means of organic control.

- **Fosetyl-Al** - Label has a rate of 4 lb a.i./acre and 60 day PHI. Fosetyl-al was not applied to

raspberries in 1997. On blackberries, fosetyl-al was applied to 12% of California's blackberry acreage 1.2 times. A total of 158 lbs fosetyl-al was applied to blackberries at a median application rate of 4 lbs a.i./acre in 1997 (1). Fosetyl-al cannot be tank mixed with copper compounds, surfactants, or foliar fertilizer.

- **Copper formulations:**

- Copper hydroxide - Label has a rate of 3.08 lb a.i./acre. In 1997, copper hydroxide was applied to 0.3% of California's raspberry acreage 1 time. Less than 1 lb a.i. was applied to raspberries at a median application rate of 0.92 lb a.i./acre. On blackberries, 31% of the acreage was treated with copper hydroxide 1 time in 1997. A total of 631 lbs copper hydroxide was applied to California blackberries at a median application rate of 2.2 lbs a.i./acre (1).

- Copper oxychloride - Label has a rate of 3.7 - 4.6 lb a.i./acre. In 1997, copper oxychloride was applied to 13.3% of California's raspberry acreage 1 time. A total of 1,265 lbs copper oxychloride was applied to raspberries at a median application rate of 3.41 lbs a.i./acre. On blackberries, 0.06% of the acreage was treated with copper oxychloride 2.5 times in 1997. A total of 122 lbs copper oxychloride was applied to California blackberries at a median application rate of 14.96 lbs a.i./acre (1).

- Copper oxychloride sulfate - Label has a rate of 1.75-3.75 lb a.i./acre. In 1997, copper oxychloride sulfate was applied to 34.6% of California's raspberry acreage 2 times. A total of 2,171 lbs copper oxychloride sulfate was applied to raspberries at a median application rate of 1.5 lbs a.i./acre. Copper oxychloride sulfate was not applied to California blackberries in 1997 (1).

- Copper sulfate (basic) - Label has a rate of 1.98 lb a.i./acre. In 1997, copper sulfate (basic) was applied to 13.3% of California's raspberry acreage 1 time. A total of 240 lbs copper sulfate (basic) was applied to raspberries at a median application rate of 0.65 lbs a.i./acre. On blackberries, 0.6% of the acreage was treated with copper sulfate (basic) 2 times in 1997. A total of 23 lbs copper sulfate (basic) was applied to California blackberries at a median application rate of 2.84 lbs a.i./acre (1).

- Copper salts of fatty and rosin acids - Label has a rate of 2.3 - 3.5 lb a.i./acre. In 1997, copper salts of fatty and rosin acids was applied to 38% of California's raspberry acreage 2 times. A total of 3,127 lbs copper was applied to raspberries at a median application rate of 2.43 lbs a.i./acre. On blackberries, 7.6% of the acreage was treated with copper 3 times in 1997. A total of 339 lbs copper was applied to California blackberries at a median application rate of 2.43 lbs a.i./acre (1).

Cladosporium fruit rot - *Cladosporium herbarum* and *C. cladosporoides*

Cladosporium fruit rot is primarily a post-harvest disease. Damaged or over-ripe berries have velvety, olive-green mycelial growth and are unmarketable. The fungi can be isolated from the surfaces of all parts of the plants and from healthy berries but will cause disease on damaged or over-ripe fruit. The optimum temperatures for growth are 68-77°F (20-25°C) but may occur at lower temperatures during normal fruit storage (5,10).

Control:

Non-chemical:

Fruit is harvested regularly to reduce numbers of over-ripe fruit. Damaged and infected fruit is removed. Berries are cooled as rapidly as possible (10).

Chemical:

Treatments are used if weather conditions are favorable for the development of Botrytis and Cladosporium post-harvest rots.

- **Iprodione** - Label has a rate of 0.5-1.0 lb a.i./acre in a minimum of 100 gallons of water and 0 day PHI. The maximum number of applications allowed per year is 4. In 1997, iprodione was applied to 15.9 % of California's raspberry acreage 1.5 times. A total of 213 lbs iprodione was applied to California raspberries at a median application rate of 0.29 lb a.i./acre. On blackberries, 10% of the acreage was treated 1 time. A total of 72 lbs a.i. was applied to California blackberries at a median application rate of 0.75 lb a.i./acre in 1997 (1).

Orange rust - *Gymnoconia nitens* and *Arthuriomyces peckianus*

Gymnoconia nitens is predominate on erect and trailing blackberries and does not produce teliospores (short-cycle rust). *Arthuriomyces peckianus* is predominate on black raspberries and does produce teliospores in brownish-black pustules on the undersides of leaves. Neither has an alternate host as is common for many rust diseases. Red raspberries are not susceptible to either fungus. Systemically infected plants produce shoots that are spindly, stunted, and bushy (witch's broom). Unfolding leaves are stunted, misshapen, and pale green to yellow. Blister-like pustules form on the undersides of the leaves, rupture, and release masses of powdery orange spores (aeciospores). Aeciospores are wind disseminated and infect new plants. Later in the season, *A. peckianus* will produce dark colored spores (teliospores) in pustules on the lower surface of leaves. Wild blackberries may be a source of inoculum (5,10).

Control:**Non-chemical:**

Control is dependent on elimination of sources of new infections. Disease-free nursery stock is used for new plantings. Planting should be inspected during the first weeks of each growing season. Infected plants should be removed, including the roots, before spores develop (10).

Chemical:

There is no effective chemical control.

Yellow rust - *Phragmidium rubi-idaei*

Yellow rust is a disease of raspberries only. The first symptom is the development of orange-yellow pustules (aecia) on the upper surfaces of leaves. Severely infected leaves turn yellow and drop.

Aeciospores initiate new infections on raspberry leaves. In early summer orange to pale yellow pustules (uredinia) develop on undersides of leaves. Urediniospores germinate only in water between 10.8°C and 25°C and infect the youngest green plant tissue in the presence of free-water. In fall, black pustules (telia) develop on the undersides of leaves. Teliospores overwinter in the soil and in the surface of the bark on the floricanes. Teliospores require several months of winter weather to overcome dormancy and produce new infective spores (basidiospores) in the spring (5,10).

Control:

Non-chemical:

Cultivation in late fall or early spring to cover fallen leaves and other plant refuse can eliminate some inoculum sources. Some raspberry cultivars have reduced susceptibility to yellow rust (10).

Chemical:

Highly susceptible varieties with a history of yellow rust receive applications of protective fungicides before the onset of symptoms in the spring. Lime sulfur and fixed coppers are organically acceptable means of control.

- **Lime sulfur** - Label has a rate of 12.3 lb a.i./acre. In 1997, lime sulfur was applied to 41.5% of California's raspberry acreage 1 time. A total of 22,347 lbs lime sulfur was applied to raspberries at a median application rate of 15.34 lbs a.i./acre in 1997. On blackberries, 58% of the acreage was treated with lime sulfur 1.4 times. A total of 17,025 lbs lime sulfur was applied to California blackberries at a median application rate of 18.04 lbs a.i./acre in 1997 (1). Lime sulfur is an acceptable method of organic control (10).
- **Copper formulations:**
 - Copper hydroxide** - Label has a rate of 3.08 lb a.i./acre. In 1997, copper hydroxide was applied to 0.3% of California's raspberry acreage 1 time. Less than 1 lb a.i. was applied to raspberries at a median application rate of 0.92 lb a.i./acre. On blackberries, 31% of the acreage was treated with copper hydroxide 1 time in 1997. A total of 631 lbs copper hydroxide was applied to California blackberries at a median application rate of 2.2 lbs a.i./acre (1).
 - Copper oxychloride** - Label has a rate of 3.7 - 4.6 lb a.i./acre. In 1997, copper oxychloride was applied to 13.3% of California's raspberry acreage 1 time. A total of 1,265 lbs copper oxychloride was applied to raspberries at a median application rate of 3.41 lbs a.i./acre. On blackberries, 0.06% of the acreage was treated with copper oxychloride 2.5 times in 1997. A total of 122 lbs copper oxychloride was applied to California blackberries at a median application rate of 14.96 lbs a.i./acre (1).
 - Copper oxychloride sulfate** - Label has a rate of 1.75-3.75 lb a.i./acre. In 1997, copper oxychloride sulfate was applied to 34.6% of California's raspberry acreage 2 times. A total of

2,171 lbs copper oxychloride sulfate was applied to raspberries at a median application rate of 1.5 lbs a.i./acre. Copper oxychloride sulfate was not applied to California blackberries in 1997 (1).

-Copper sulfate (basic) - Label has a rate of 1.98 lb a.i./acre. In 1997, copper sulfate (basic) was applied to 13.3% of California's raspberry acreage 1 time. A total of 240 lbs copper sulfate (basic) was applied to raspberries at a median application rate of 0.65 lbs a.i./acre. On blackberries, 0.6% of the acreage was treated with copper sulfate (basic) 2 times in 1997. A total of 23 lbs copper sulfate (basic) was applied to California blackberries at a median application rate of 2.84 lbs a.i./acre (1).

-Copper salts of fatty and rosin acids - Label has a rate of 2.3 - 3.5 lb a.i./acre. In 1997, copper salts of fatty and rosin acids was applied to 38% of California's raspberry acreage 2 times. A total of 3,127 lbs copper was applied to raspberries at a median application rate of 2.43 lbs a.i./acre. On blackberries, 7.6% of the acreage was treated with copper 3 times in 1997. A total of 339 lbs copper was applied to California blackberries at a median application rate of 2.43 lbs a.i./acre (1).

Cane and leaf rust - *Kuehneola uredinis*

Cane and leaf rust is a disease of susceptible blackberry cultivars. It rarely occurs on raspberry. Wet spring conditions favor disease. Lemon-yellow pustules (uredinia) split bark on the fruiting canes and small yellow pustules develop on the underside of leaves. If infection is severe, defoliation can occur. The disease is not systemic. The urediniospores from bark pustules infect the leaves during the growing season. The disease can be distinguished from orange rust by the presence of uredinia on both leaves and canes. Orange rust has uredinia on leaves only (5,10).

Control:

Non-chemical:

Diseased fruiting canes are removed and disposed of soon after harvest (10).

Chemical:

- **Lime sulfur** - Label has a rate of 12.3 lb a.i./acre. In 1997, lime sulfur was applied to 41.5% of California's raspberry acreage 1 time. A total of 22,347 lbs lime sulfur was applied to raspberries at a median application rate of 15.34 lbs a.i./acre in 1997. On blackberries, 58% of the acreage was treated with lime sulfur 1.4 times. A total of 17,025 lbs lime sulfur was applied to California blackberries at a median application rate of 18.04 lbs a.i./acre in 1997 (1). Lime sulfur is an acceptable method of organic control (10).
- **Copper formulations:**
 - Copper hydroxide - Label has a rate of 3.08 lb a.i./acre. In 1997, copper hydroxide was applied to 0.3% of California's raspberry acreage 1 time. Less than 1 lb a.i. was applied to raspberries at a median application rate of 0.92 lb a.i./acre. On blackberries, 31% of the acreage was treated

with copper hydroxide 1 time in 1997. A total of 631 lbs copper hydroxide was applied to California blackberries at a median application rate of 2.2 lbs a.i./acre (1).

-Copper oxychloride - Label has a rate of 3.7 - 4.6 lb a.i./acre. In 1997, copper oxychloride was applied to 13.3% of California's raspberry acreage 1 time. A total of 1,265 lbs copper oxychloride was applied to raspberries at a median application rate of 3.41 lbs a.i./acre. On blackberries, 0.06% of the acreage was treated with copper oxychloride 2.5 times in 1997. A total of 122 lbs copper oxychloride was applied to California blackberries at a median application rate of 14.96 lbs a.i./acre (1).

-Copper oxychloride sulfate - Label has a rate of 1.75-3.75 lb a.i./acre. In 1997, copper oxychloride sulfate was applied to 34.6% of California's raspberry acreage 2 times. A total of 2,171 lbs copper oxychloride sulfate was applied to raspberries at a median application rate of 1.5 lbs a.i./acre. Copper oxychloride sulfate was not applied to California blackberries in 1997 (1).

-Copper sulfate (basic) - Label has a rate of 1.98 lb a.i./acre. In 1997, copper sulfate (basic) was applied to 13.3% of California's raspberry acreage 1 time. A total of 240 lbs copper sulfate (basic) was applied to raspberries at a median application rate of 0.65 lbs a.i./acre. On blackberries, 0.6% of the acreage was treated with copper sulfate (basic) 2 times in 1997. A total of 23 lbs copper sulfate (basic) was applied to California blackberries at a median application rate of 2.84 lbs a.i./acre (1).

-Copper salts of fatty and rosin acids - Label has a rate of 2.3 - 3.5 lb a.i./acre. In 1997, copper salts of fatty and rosin acids was applied to 38% of California's raspberry acreage 2 times. A total of 3,127 lbs copper was applied to raspberries at a median application rate of 2.43 lbs a.i./acre. On blackberries, 7.6% of the acreage was treated with copper 3 times in 1997. A total of 339 lbs copper was applied to California blackberries at a median application rate of 2.43 lbs a.i./acre (1).

Nematodes

Root-lesion nematode is a concern in caneberry production areas. *Pratylenchus penetrans* causes initial below ground symptoms of small lesions on new roots. As an infestation becomes more severe, feeder roots die, stimulating growth of fine roots resulting in witches' brooming. Eventually all feeder roots die leaving only the large roots which cannot support the water and nutrient uptake requirements of the plant. Above ground stunting occurs along with reduced vigor, reduced number of canes and reduced cane diameter. Plant decline is usually slow. All life stages of *P. penetrans* are capable of causing root damage. Root lesion nematodes are controlled by planting nematode-free stock in uninfested fields (5).

Several species of dagger and root knot nematodes can attack raspberries and blackberries. *X. americanum* causes the greatest impact by vectoring tomato ringspot virus and alfalfa mosaic/strawberry latent ringspot nepovirus (5).

Control:**Non-chemical:**

There is no effective non-chemical control.

Chemical:

- **Methyl bromide/chloropicrin** - Label has a rate of 180-240 lbs methyl bromide/acre. In 1997, methyl bromide was applied to 2.7% of California's raspberry acreage 1 time. A total of 8,059 lbs methyl bromide and 4,739 lbs chloropicrin was applied to California raspberries in 1997. The median application rates were: 165.73 lbs a.i./acre methyl bromide and 85.84 lbs a.i./acre chloropicrin. In 1997, 131 lbs methyl bromide and 44 lbs chloropicrin were applied to less than 1 acre for California blackberries (1).
- **Metam Sodium** – Label has a rate of 160-320 lbs a.i./acre. In 1997, metam sodium was applied to 4.9% of the blackberry acreage 1 time. A total of 8,467 lbs a.i. was used at a median application rate of 241.9 lbs a.i./acre. Metam sodium was not used on raspberries in 1997 (1).

Weeds

Weeds compete with the caneberry crop for water, light and essential nutrients. They are also detrimental by harboring insects and diseases (5). The primary weed pests of caneberries are purslane and nettle during the winter and bindweed and malva during the summer (8). Mare's tail and groundsel can also occasionally be weeds of caneberries.

Control:**Non-Chemical:**

Weeds are not generally a large problem in California caneberries. They can usually be managed by a combination of close cultivation between the rows, hand roguing, and use of drip irrigation. Drip irrigation prevents the germination and growth of weeds during the summer months when natural rain is atypical.

Chemical:

Herbicides are used to control both annual and perennial broadleaved weeds. Pre- and post-emergent herbicides are used in addition to contact herbicides. Precautions (shielded spray heads, dormant season applications, etc.) must be taken when applying herbicides to avoid damage to caneberry plants.

- **Glyphosate** - Label has a rate of 0.25-0.5 lb a.i./acre and 14 day PHI. Glyphosate must not contact green foliage or canes and is used to control annual and perennial weeds. In 1997, glyphosate was applied to 0.12% of California's raspberry acreage 1 time. A total of 3 lbs a.i. was applied to raspberries at a median application rate of 1.65 lbs a.i./acre. On blackberries, 4.2% of the acreage was treated 1 time in 1997. A total of 13 lbs a.i. was applied to California blackberries at a median application rate of 0.48 lbs a.i./acre (1).
- **Napropamide** - Label has a rate of 4 lbs a.i./acre. In 1997, napropamide was applied to 0.04% of California's raspberry acreage 1 time. Less than 1 lb a.i. was applied to raspberries at a median application rate of 0.47 lb a.i./acre. On blackberries, 6.2% of the acreage was treated 1 time in 1997. A total of 57 lbs a.i. was applied to California blackberries at a median application rate of 1.33 lbs a.i./acre (1).
- **Norflurazon** – Label has a maximum application rate of 1.96-3.93 lbs a.i./acre/year. In 1997, 31 lbs a.i. were applied to 4.5% of the blackberry acreage 1 time at a median application rate of 0.98 lb a.i./acre. Norflurazon was not applied to raspberries in 1997 (1).
- **Oryzalin** - Label has a rate of 2-6 lbs a.i./acre. Oryzalin is used pre-emergence to control annual weeds. In 1997, oryzalin was applied to 3% of California's blackberry acreage 1 time. A total of 28 lbs a.i. was applied to blackberries at a median application rate of 1.63 lbs a.i./acre. No oryzalin was applied to California raspberries in 1997 (1).
- **Paraquat** - Label has a rate of 0.625-0.937 lb a.i./acre and is applied before the emergence of new canes. Paraquat is used to control grasses. In 1997, paraquat was applied to 31% of California's raspberry acreage 3 times. A total of 1,715 lbs a.i. was applied to raspberries at a median application rate of 1.3 lbs a.i./acre. On blackberries, 24% of the acreage was treated 1 time in 1997. A total of 213 lbs a.i. was applied to California blackberries at a median application rate of 0.8 lb a.i./acre (1).
- **Sethoxydim** - Label has a rate of 0.47 lb a.i./acre. Sethoxydim is labeled for non-bearing blackberries only with 1 year PHI. The PHI for raspberries is 45 days. Maximum applications per year are 0.94 lb a.i. for raspberries and 1.41 lb a.i. for blackberries. Sethoxydim is used to control annual and perennial grasses. Sethoxydim was applied to less than 1% of California's raspberry acreage in 1996. It was not used on raspberries or blackberries in 1997 (1).
- **Simazine** - Label has a rate of 1-2 lb a.i./acre and is only allowed when fruit are not present. Simazine is used to control annual weeds. In 1997, 6.3% of the blackberry acreage was treated 1 time. A total of 53 lbs a.i. was applied to California blackberries at a median application rate of 1.2 lbs a.i./acre. Simazine was not used on raspberries in 1997 (1).

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