

Crop Profile for Prunes in California

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General Production Information

- Over 99% of the prunes grown in the United States are grown in California (13).
- Approximately 1400 growers farm 81,000 bearing acres of prunes in California (13).
- In 1997 the crop totaled 220,000 tons valued at approximately \$210 million (13).
- California grows almost 70% of the total world production of dried prunes (13).
- The cost of producing an acre of prunes varies from \$2300.00 in the Sacramento Valley (14) to \$3817.00 in the San Joaquin Valley, (15).

Production Regions

The majority of the prunes are grown in the Sacramento Valley, with over 184,000 tons being produced in 1997. The other production areas in the San Joaquin Valley, primarily Tulare and Fresno counties produced 37,000 tons with 1,200 tons being produced in coastal areas in 1997 (6).

Cultural Practices

The prune industry has one primary variety, Improved French Prune (*Prunus domestica*, L.) which accounts for over 95% of the total prune acreage in the State. Recently some newer selections have been introduced. Selected cultivars are grafted onto rootstocks. Both varieties and rootstocks vary in susceptibility to diseases, nematodes, and other stress factors.

Prunes grow best on deep, well-drained, fine-sandy loam soils but can survive and be productive on less than ideal shallow clay type soils. Prunes will not produce adequate commercial crops without irrigation in most California growing areas. Flood, furrow and sprinkler irrigations are predominant with drip and micro-sprinkler irrigation often being used on more marginal soils.

Most prunes in California receive annual applications of nitrogen. Generally this is applied as commercial fertilizer, although manure and leguminous covercrops are used in a few cases. Potassium deficiency is common in some soils, especially in the northern Sacramento Valley and potassium nitrate or muriate of potash is applied to correct this problem. Zinc deficiency is also common and corrected by foliar applications of zinc compounds applied in the spring.

Non-cultivation of orchard soils with herbicide-treated tree rows is common and becoming more widespread as growers realize the benefits of non-tillage.

The vast majority of prunes are harvested by shaking the crop onto catching frames. They are then transported to dehydrators where they are washed, spread on drying trays and dehydrated until a desired moisture content is reached. After they are delivered to packers, they are further processed and packaged for distribution (6).

Recently, a market for fresh prunes has developed. Less than 1 percent of prunes produced in California are marketed through this channel (5).

There are few regional differences in insect pests except aphid problems are more common in the Sacramento Valley because alternate weed hosts such as cattails and plantain are more common in that area. Web spinning mites are potentially more serious in the San Joaquin Valley because of the hotter summer temperatures and trees are more likely to suffer from water stress unless moisture is monitored closely.

Overview Of Prune Pest Complex

A variety of insect, disease, nematode and weed pests attack California prunes. Severity of infestations varies from year to year and from area to area. The most serious pests, peach twig borer, *Anarsia lineatella*, leafrollers, brown rot, *Monilinia laxa* and *M. fructicola*, and prune russet scab attack the fruit directly. Others such as San Jose scale, Armillaria Root Rot, *Armillaria mellea*, Phytophthora Root and Crown rot *Phytophthora* spp., and Bacterial Canker can kill fruitwood, limbs and trees thus greatly reducing yields. These pests require control measures to be taken at low population levels to prevent economic losses. However other pests such as mites, aphids, nematodes and weeds are indirect pests. Although they do not feed on the fruit directly, they cause damage by lowering yields and fruit quality. It is possible to tolerate higher populations of indirect pests than of direct pests.

Insect Pests

Current practices. Dormant sprays using an oil and organophosphate (primarily diazinon) have been a standard cultural practice for the control of overwintering larvae and eggs of pests such as peach twig borer, San Jose scale, European red and brown mites, leafroller complex and aphids. Dormant sprays have been favored by growers because they are economical and control a wide variety of arthropod pests with a single spray with less potential for secondary pest outbreaks as compared to in-season

organophosphate sprays. Most years no other insecticide chemical treatments are needed except occasional treatments with acaricides for mites, and insecticides for aphids and leafrollers.

Major Insect Pests

Peach Twig Borer, *Anarsia linatella*

The peach twig borer (PTB) is a key pest in California. It is widely distributed throughout the state where it is a pest of a number of stone fruits. There are 3 to 4 generations per year depending on the year and location. PTB overwinters in hibernacula on the tree and are easily controlled with dormant insecticides containing selected organophosphates and synthetic pyrethroids (7).

PTB is a pest of young trees because it bores into rapidly growing shoots, causing a bushy growth, which makes infested young trees hard to train. In bearing orchards, first generation larvae feed in tender shoots and attack fruit as it matures. In addition to direct fruit loss, from dropped fruit and offgrade, fruit damaged by PTB is often attacked by brown rot which, then spreads to other fruit in the vicinity, often forming clusters of brown rot (2). Damage can amount to 10% if left untreated. **Monitoring:** Pheromone traps are widely used to monitor PTB phenology and time in season treatments. The most effective timing is 400 to 500 degree days after the beginning of the flight (7).

Controls:

Biological

Bacillus thuringiensis is an option for peach twig borer control. In 1995 *Bt* was applied to 15% of the acreage during bloom or soon after bloom at the rate of 0.15 lb. a.i. per acre (1). *Bt* will also control leafrollers and green fruitworms when properly timed (7). It has low mammalian toxicity, is selective for lepidopterous insects and is not harmful to wildlife or aquatic organisms.

Numerous natural enemies attack peach twig borer eggs and larvae. Among the most common are *Paralitomastix varicornis*, *Hyperteles lividus*, and the grain or itch mite, *Pyemotes ventricosus* which is common in some orchards feeding on larvae in the hibernacula. The California gray ant has been found to be a significant predator of PTB in San Joaquin Valley peaches. It is expected the gray ant is also a significant predator in prunes.

Mating disruption has been used for PTB control in more high value crops such as peaches. Results have been variable and the cost of this program is currently too high for it to be widely adopted in prunes. This may change as better formulations are developed and cheaper products currently being researched become available.

Chemical

- **Diazinon** - 21 day PHI. The most widely used insecticide on prunes. It is applied to 46% of the acres at the average rate of 2 lb. a.i. per acre (1). It is extensively used for ground applications mixed with petroleum oil during dormant period for control of PTB, San Jose scale, aphids, and fruit tree leafroller eggs. Diazinon can also be used in May, with or without oil for control of peach twig borer and San Jose scale crawlers and aphids. It is effective against other lepidopterous pests if properly timed. Peach twig borer and San Jose scale resistance has been documented in San Joaquin Valley peach orchards. At present there is no resistance in prunes or in the Sacramento Valley. Diazinon is selective for predaceous mites but toxic to parasitic wasps and generalist predators.
- **Esfenvalerate** – 14 day PHI. An effective peach twig borer material when applied by ground during the dormant period. It must be combined with oil to control San Jose scale. It is also effective against other lepidopterous pests. It is applied to 13% of the acreage at the rate of 0.04 lb. a.i. per acre (1). This is the most economical material available and has low mammalian toxicity. The biggest drawback is it disrupts biological control of mites, even when applied during dormancy (7).
- **Azinphos-methyl** - 15 day PHI. A very effective material for codling moth, peach twig borer, and defoliating lepidoptera when applied post-bloom. Codling moth resistance has been demonstrated in pome fruits and walnuts (10) but has not been documented in prunes. It is applied to 3% of acreage at the average rate of 0.8 lb. a.i. per acre (1). This material will also control other lepidopterous pests. It is somewhat selective for predaceous mites but highly toxic to parasitic wasps and generalist predators.
- **Phosmet** - 7 day PHI. An effective material for codling moth, peach twig borer and other lepidoptera when used during growing season. It will control aphids, and when mixed with oil, either dormant or post bloom, is effective on San Jose scale crawlers. It is applied to 2% of the acres at the rate of 1.8 lb. a.i. per acre (1). Phosmet can cause mite outbreaks but is not as disruptive as some other materials.
- **Carbaryl** – 1 day PHI. A useful material because it can be applied in an emergency situation up to 1 day prior to harvest. Effective on peach twig borer and other lepidopterous pests. It will also control San Jose scale crawlers and will kill eriophyid mites. Carbaryl is applied to <1% of the acres at the rate of 2.5 lb. a.i. per acre (1). Extremely disruptive to natural enemies and will generally cause mite outbreaks. It is highly toxic to honeybees.
- **Chlorpyrifos** – Used dormant only. Primarily applied by ground during the dormant period for control of peach twig borer, scale and aphids. If used post-bloom, this material will also control leafrollers. It was applied to 3% of the acreage at the rate of 1.5 lb. a.i. per acre (1).

- **Endosulfan** – 7 day PHI. Effective for peach twig borer and aphids when applied post-bloom. It is used on <1% of the acreage at the rate of 2 lb. a.i. per acre (1). This is a selective material for predaceous mites and parasitic hymenoptera and is moderately toxic to generalist predators. The biggest drawback is it is highly toxic to fish and other marine organisms.
- **Narrow Range Oils** – 1 day PHI. Applied dormant or post-bloom by ground to 94% of the acres at the rate of 3.5 gallons per acre (1). Oils must be used with caution because of potential phytotoxicity if trees are stressed or dry (5). Oils are selective and will suppress mites. Oil will also suppress aphids, scale insects, and fruittree leafroller when applied during the dormant or delayed dormant but follow-up treatments are often needed when populations are high. Oil, when used alone, does not control peach twig borer. A drawback with oils is they add to air pollution because of hydrocarbon volatilization

Aphids:

Mealy Plum Aphid, *Hyalopterus pruni*

Leaf Curl Plum Aphid, *Brachycaudus helichrysi*

Traditionally, aphids have not been considered serious pests of prunes because dormant or delayed sprays, containing organophosphates plus oil, destroy overwintering eggs. However, under reduced risk programs where dormant organophosphates have been eliminated, aphids are now the key pests requiring in-season pesticide intervention.

Aphids are more serious in the Sacramento Valley where alternate summer hosts are more common. Both species must feed on alternate hosts to lay overwintering eggs (7).

Both species devitalize the tree, retard growth and reduce sugar content of the fruit. Honeydew secreted by aphids dropping on the fruit can cause fruit to split. Often only one limb or a portion of a tree is infested early in the year, but spreads throughout the tree as the season progresses (2).

Controls:

Biological Control

Aphids are attacked by many natural enemies including green lacewings, brown lacewings, ladybird beetles, syrphid flies and several species of parasitic wasps. However, when pressure is severe, economic damage frequently occurs before natural enemies are able to bring the population under control.

Chemical

Organophosphates or organophosphates plus oil applied dormant or delayed dormant are highly effective. Diazinon is the organophosphate most widely used during dormant. Oil sprays alone will suppress aphids, but the addition of organophosphates provides complete control. Most organophosphates, endosulfan, and synthetic pyrethroids are effective when applied during the growing season. Endosulfan is selective for predaceous mites and somewhat selective for parasitic wasps. Synthetic pyrethroids are disruptive to biological control of mites.

Mites:

Twospotted Mite, *Tetranychus urticae*

Pacific Mite, *Tetranychus pacificus*

European Red Mite, *Panonychus ulmi*

Brown Almond Mite, *Bryobia rubiocolus*

Although European red mite can build up to high numbers, they seldom are considered to cause economic damage. However, both two-spotted and Pacific mites can cause almost complete defoliation that exposes trees and fruit to sunburn, reduces fruit size and sugar, and can interfere with harvest. Pacific mite is the dominant species in the San Joaquin Valley and two-spotted mite predominates in the Sacramento Valley (8). However, over the years Pacific mite has become more common in the Sacramento Valley, possibly due to the use of synthetic pyrethroids during the dormant period. Pacific and two-spotted mites overwinter as adult females in the trees or on the orchard floor. Both species are favored by hot, dry conditions and as the weather becomes warmer, they increase in numbers and move throughout the tree (2). Severe defoliation early in the season can cause a 25% reduction in yield. As the season progresses, the potential for direct damage decreases.

Controls:

Biological Control

Biological control plays a major role in regulating webspinning mite populations. The most dependable predator is the western orchard predator mite *Metaseiulus occidentalis*. If not disturbed by some pesticides applied for other pests, can usually keep populations below damaging levels in well managed orchards (8). *M. occidentalis* is tolerant to most organophosphates and insect growth regulators used for lepidopterous pests but extremely susceptible to synthetic pyrethroids and carbamates. Other important predators include six-spotted thrips, *Scolothrips sexmaculatus*, which can quickly bring mite populations under control after they move into a block (7). The spider mite destroyer, *Stethrus punctum* and minute pirate bugs also feed on mites but often become common after damage has occurred.

Cultural Control

Good water and fertilizer management to prevent stress is the key to suppressing mites in prunes. Well-irrigated, vigorous trees are less susceptible to mite damage because stressed trees do not tolerate mites as well. Mite fecundity is increased on stressed trees. Roads should be watered or oiled or treated with material such as Dustoff to minimize dust on the trees, which interferes with predators and parasites.

Chemical

Brown almond and European red mite are readily controlled with dormant or delayed dormant applications of oil if the rate of oil is high enough. Brown almond mite infestations are usually spotty and lend themselves to spot treatments. Predators are only partially effective on brown almond mite and it is expected that this species will increase in importance as dormant oil and organophosphate treatments are eliminated.

- **Fenbutatin-oxide** - 14 day PHI. Applied post-bloom by ground to 3% of the acres at the rate of 0.5 lb. a.i. per acre (1). Does not disrupt biological control of mites and aphids. Fits well in an IPM program. Does not work well in cool weather.
- **Formetamate Hydrochloride** - 7 day PHI. Applied post-bloom by ground to <1% of the acres at the rate of 1 lb. a.i. per acre (1). Also controls eriophyid mites. Also kills predaceous mites and may aggravate European red mite.

Scale Insects:

San Jose Scale, *Quadraspidiotus perniciosus*

Italian Pear Scale, *Edidiaspis leperii*

European Fruit Lecanium *Parthenoceanium corni*

San Jose scale is by far the most important scale insect found on prunes. San Jose scale infests branches, shoots, leaves and fruit. They can seriously weaken branches and main scaffold limbs and kill fruiting spurs, thus causing permanent injury and death to mature trees (8).

Italian pear scale usually feeds on scaffolds thus reducing tree vigor. Italian pear scale is usually associated with moss and lichens and seems to be more common on stressed trees (8).

European fruit lecanium is seldom a pest of prunes in California. The primary injury by European fruit lecanium is the production of honeydew, which in large amounts can damage leaves and fruit. Sooty mold growing in the honeydew can cause blackened areas on leaves and fruit and honeydew on fruit

can cause splitting (8).

Controls:

Biological Control

European fruit lecanium is frequently controlled by natural enemies particularly *Metaphycus* spp. parasites but has not been a major focus in prunes (8).

San Jose scale and Italian pear scale are heavily attacked by parasitic wasps *Aphytis* spp. and *Prospatella* spp. (8). In situations where broad spectrum insecticides have not been used, these parasites and predaceous beetles such as *Chilocorus orbus* and *Cybocephalus californicus* generally keep scale populations below damaging levels.

Cultural Control

Proper irrigation and nutritional management can minimize tree stress, helping prevent Italian pear scale population increase and allow trees to tolerate higher populations without damage. Minimizing dust to minimize interference with natural enemies is also important.

Chemical Control

Many prune orchards are treated routinely during the dormant or delayed dormant for scale and European red mites

- **Methidathion** – Dormant or Delayed Dormant only. The most effective material for scale. It is applied by ground to 27% of the acreage at an average rate of 1.27 lb. a.i. per acre (1). This material is toxic to beneficial insects and honeybees. Oil must be combined with this material in dormant sprays to control European red mite and brown almond mite eggs.
- Other organophosphates applied during the dormant or delayed dormant will control this pest especially if combined with oil.

Leafrollers:

Obliquebanded Leafroller, *Choristoneura rosaceana*

Fruittree Leafroller, *Archips argyrospila*

Although the biology of Obliquebanded Leafroller (OBLR) and Fruittree Leafroller (FTLR) are different, both can be managed with the same program. Larvae of both species feed on leaves, buds and the surface of fruit, causing damage and scarring of the fruit. Second generation OBLR feeding can also be a site for fruit brown rot infection. **Monitoring:** Pheromone traps are available for monitoring both

species but are of little practical value except to detect presence in the orchard and when to expect second generation OBLR larvae (7).

Controls:

Biological Control

Several parasitic wasps are important in regulating OBLR populations including *Macracentrus iridescens* and *Pteromalus* spp. In addition Hemipterian predators, *Brochymena sulcatus* and several *Phytocoris* spp. have been observed feeding on eggs and larvae (7).

Little is known about the natural enemy complex on FTLR but they are probably responsible for much mortality.

Bacillus thuringiensis sprays applied for peach twig borer or green fruitworms during bloom or shortly after bloom are effective in controlling both species.

There is also interest by prune researchers to develop mating disruption for OBLR. It is unlikely that mating disruption for this pest would be adopted in prunes because of the relatively minor status as a pest and the high cost of material.

Chemical

Currently leafrollers in prunes are managed primarily by the use of dormant oil plus organophosphate sprays. Dormant oil is somewhat effective, especially for FTLR, which overwinters in the egg stage, but is only marginally effective on OBLR. This will also control eyespotted bud moth *Spilonota ocellana* in coastal areas where it is occasionally a pest.

In-season treatments are applied when pests are present or noticeable damage has occurred. Chlorpyrifos is the most effective material for control of leafrollers post-bloom. Carbaryl, azinphos-methyl, and phosmet will also provide partial control during the growing season (7).

Minor Insect Pests

Green Fruitworm Complex:

Green Fruitworms: *Orthosia hibisci*, *Amphipyra pyrquisoides*, *Xylomyges curialis*

Prune and Plum cankerworms: *Alsophila pometaria*, *Paleacrita vernata*

Citrus Cutworm: *Xylomyges curialis*

Green fruitworms include several species of caterpillars, all of which are generally pale green or dull brown. They are well distributed throughout the state and there are regional differences in numbers of the different species. The primary concern is the potential for citrus cutworm becoming a problem in the San Joaquin Valley. They are not a major problem in prunes that have received a dormant organophosphate treatment. All of the above species have one generation per year. They cause similar damage by feeding on young leaves and fruit early in the season causing the fruit to be misshapen and scarred (8).

Controls:

Biological Control

A number of parasitic wasps attack green fruitworms. Generalist predators such as *Orius* spp., Green lacewings, and plant feeding bugs probably feed on larvae. However little is known about the impact they have on populations.

Chemical

Spring *Bt* treatments are commonly used for control of green fruitworms and are generally effective. However under heavy pest pressure growers may elect to apply single azinphos-methyl or phosmet treatments or combine organophosphates with *Bt*. Use of broad spectrum insecticides for these pests is minor.

Codling Moth, *Cydia pomonella*

Codling moth was first noted as a pest of prunes about 20 years ago. The center of the problem at that time was in District 10, north of Marysville in Yuba county. At present the problem is generally still limited to that and surrounding areas. At most, it is estimated that less than 10 percent of the acreage is treated for this pest. One treatment is sufficient where codling moth is a pest.

Codling moth larvae damage prunes by boring into fruit rendering it worthless for commercial use. Codling moth overwinters as prepupae on the tree or in the soil around the base of the tree. There are usually three generations per year in the Central Valley of California, but a partial fourth generation may develop in warmer than normal years (2). Codling moth is monitored with pheromone traps and is utilized to calculate degree days for timing treatments (3). However, no treatment thresholds have been developed and treatments are based on past history and the presence of newly hatched larvae.

Controls:

Biological Control

Although over 250 biological control organisms have been shown to attack codling moth, none have been shown to be capable of keeping populations below the economic damage level in prunes.

Codling Moth Granulosis Virus has been shown to be somewhat effective in other crops but has not been tested in prunes. It must be eaten by larvae and from 9 to 12 applications are needed each year to cover the long generation time (5). Timing these treatments is extremely difficult because irrigation scheduling prevents growers from getting into orchards in a timely matter.

Codling moth mating disruption has been well received and is successful in pears and other crops. It has received little or no attention in prunes because of the limited distribution. At present mating disruption is not economically feasible in prunes because one or possibly two insecticide applications provide adequate control.

Chemical

Management of codling moth in prunes depends almost exclusively on the use of in-season sprays at this time.

- **Azinphos-methyl** (see peach twig borer) is the most effective material in prunes. Phosmet and carbaryl are also effective when timed correctly. All these materials will surpress other lepidopterous pests if timed properly.

Lepidopterous Boring Insects:

Peachtree Borer, *Synanthedon exitosa*

American Plum Borer, *Euzophera semifuneralis*

Both species attack the trunk of healthy trees, boring into the trunk and mining in the cambium layer. Feeding by both species can weaken trees and feeding by the American plum borer can cause scaffold limbs to break. (7). Pheromone traps are available for monitoring peachtree borer (3).

Controls:

Chemical

Spot spraying with hand sprayers are effective for both species. American plum borer can be controlled by treating infested areas with a mixture of latex paint and diazinon or carbaryl.

Handgun sprays of endosulfan to the trunk of trees is effective for peachtree borer. Two treatments are necessary to span the long emergence period of this moth.

Woodboring Beetles:

Shothole Borer, *Scolytus rugulosus*

Branch and Twig Borer, *Polycaon confertus*

Pacific Flatheaded Borer, *Chrysobothris mali*

Suitable non-chemical management practices are available for managing woodboring beetles. Woodboring beetles generally limit their attacks in prunes to sunburned, unhealthy trees and can be managed by encouraging healthy trees through proper nutrition and irrigation practices. Infested trees and scaffolds can be removed and destroyed to kill beetles inside (8).

Controls:

Cultural Controls

Flatheaded borer in newly planted trees can be prevented by properly painting the trunk with latex or using trunk wraps to prevent sunburn.

Shothole beetles are managed by keeping trees healthy and removing and destroying infested trees.

Eriophyid Mites:

Plum Rust Mite, *Aculus fockeui*

Big Beaked Plum Mite, *Diptacus gigantorhynchus*

Research has shown that although large numbers of eriophyids may be present, they are seldom considered pests. In low and moderate numbers they are considered beneficial because they act as early season prey for mite predators. High eriophyid mite populations on prune leaves can cause browning of the leaf surface and upward curling of the leaves (7). They are probably more important in young orchards because feeding on newly emerging leaves results in distorted leaves causing a bushy appearance to trees and making it difficult to train. No treatment thresholds have been established but several hundred per leaf can be tolerated.

Controls:

Biological Control

Predateous mites are important in alleviating eriophyid mite populations and are capable of regulating populations at a low level in undisturbed situations. The key to biological control of these species is to avoid disruptive chemicals, especially synthetic pyrethroids, which appears to enhance population explosions.

Chemical Control

If treatments are needed, sulfur sprays are a viable option for control of these species and is the material of choice in an IPM program. All of the acaracides plus endosulfan and carbaryl will control these species (7).

- **Sulfur**-Applied to 28% of the acreage at the average rate of 9.7 lb. a.i. per acre (1). Preferred material for eriophyid mites. Will also control prune rust.

Leafrollers:

Orange Tortrix, *Argyrotaenia citrana*

The orange tortrix (OT) is found primarily in coastal areas and is not considered a major pest of prunes. It overwinters as larvae and there are two to 4 generations each year. Larvae feed on leaves, buds and the fruit surface, causing severe damage as well as contamination by feces and an entry point for fruit brown rot (8). Pheromone traps are available to monitor OT adults (3). A combination of degree days and fruit counts can be used to make treatment decisions (8).

Controls:

Biological Control

Several natural enemies attack orange tortrix. Wasp parasites include one in the family aristolidae, and *Hormius basalis* and a tachinid fly, *Nemorilla pyste*. Generalist predators including green and brown lacewings also attack this pest. Unfortunately in orchards treated with broad spectrum chemicals, natural enemies are seldom capable of bringing OT below a damaging level. Natural enemies will probably play a larger role in regulating OT populations under less disruptive programs (7).

Bacillus thuringiensis treatments will also control OT but timing is critical and multiple applications are required making it a poor choice where OT is a primary concern.

Cultural Control

Removing and disposing of mummy fruit will reduce overwintering populations but is of little practical value in prunes. Grass covercrops to eliminate overwintering broadleaf hosts will also suppress

populations of OT (7).

Chemical Control

Management of OT where it is a problem depends almost exclusively on the application of insecticides. Diazinon, carbaryl, and azinphos-methyl control OT in rare instances where treatments are necessary.

Defoliating Insects:

Redhumped Caterpillar, *Schizura concina*

Western Tussock Moth, *Orgyia vetusta*

Western Tent Caterpillar, *Malacosoma californicum*

Forest Tent Caterpillar, *Malacosoma disstria*

Fall Webworm, *Hyphantria cunea*

Although none of the above are considered serious pests, any of these species can occasionally cause severe defoliation and feed on fruit in localized sections within an orchard or in localized areas within the state.

Controls:

Biological Control

Redhumped caterpillars are frequently parasitized by parasitic wasps, the most common being *Hyposoter fugitivus* and *Apanteles comglomeratus* (7). These wasps are capable of preventing redhumped caterpillar outbreaks in many situations.

Little is known about the natural enemy complex on the other species but parasitized or diseased larvae are occasionally seen in all species.

Because all species consume large amounts of foliage, *Bacillus thuringiensis* sprays are generally effective if sufficient coverage is achieved. With tent caterpillars and fall webworms it is important to make sure sufficient water is used to wet the webs thoroughly.

Cultural Control

On young trees the tent caterpillars and webworms can be pruned out and destroyed. This is not an option in larger bearing orchards (7).

Chemical Control

Current management is based on treating with *Bt*. diazinon, phosmet, carbaryl, and azinphos-methyl are also occasionally used where good coverage with *Bt* cannot be achieved.

Post Harvest Insect Pests:

Flour mite, *Acarus siro*

*Navel orange worm, *Amyelois transitella*

Peach twig borer, *Anarsia lineatella*

Coffee bean weevil, *Araecerus fasciculatus*

*Raisin moth, *Cadra figulilella*

Dried fruit mite, *Carpoglyphus lactis*

*Dried fruit beetle, *Carpophilus spp.*

*Codling moth, *Cydia pomonella*

*Vinegar flies, *Drosophila spp.*

*Almond moth, *Ephestia cautella*

Warehouse moth/Tobacco moth, *Ephestia elutella*

Earwig, *Forficula auricularia*

Ants, Formicidae

Cigarette beetle, *Lasioderma serricorne*

Merchant grain beetle, *Oryzaephilus mercator*

*Saw-toothed grain beetle, *Oryzaphilus surinamensis*

Indian meal moth, *Plodia interpunctella

Carob moth, *Spectrobate ceratoniae*

Fruit flies, Tephritidae

Confused flour beetle, *Tribolium confusum*

Khapra beetle, *Trogoderma granarium

Hairy fungus beetle, *Typhaea stercorea*

Dried fruit moth, *Vitula edmandsea serratilinea*

*Major pest. However, the majority of insect problems in marketing channels are from Indian meal moth. Other important pests include navel orange worm, dried fruit beetle, raisin moth and vinegar flies.

Even though prunes come out of the dehydration tunnel essentially free of live insects, prunes can become quickly infested with any of more than 20 species of stored fruit insects. Stored prunes have moisture of approximately 16% thus allowing them to be stored for up to two years if necessary. Depending upon storage time, prunes may be fumigated a couple of times.

Controls:

Biological Control

A granulosis virus has been developed that is effective against Indian meal moth. Unfortunately, the virus is fairly specific and only adequately controls Indian meal moth. Even though this is the number one post harvest insect, there are numerous other storage insect pests that can also be a problem thus requiring treatment even if the granulosis virus is used. Additional insects will have to be controlled via viral organisms for it to be cost effective.

Chemical Controls

- **Methyl Bromide.** Fumigant. Applied post harvest and in storage (in 1995 there was 23,226 Lb. a. i. used for this purpose) for control of post harvest insects. Under regulations of EPA Clean Air Act, most uses of methyl bromide will be eliminated in 2005.
- **Aluminum/Magnesium Phosphide.** Fumigant. Has numerous problems thus limiting its ability to be a viable replacement to methyl bromide. Some of these problems are: fumigation time of three to twelve days, off-flavor in some commodities, not effective under 10° C in dried fruits and nuts, corrosive to copper and alloys, vacuum fumigation is not recommended because of

possible explosion hazard and has not been developed to a level approved for quarantine treatments.

Diseases

Several diseases may cause serious problems in prunes the severity depending on the local weather and soil conditions, cultural practices and the history of disease problem in and around the orchard (2).

Foliage and fruit diseases are caused by pathogens that are spread by wind, splashing water or insects and infect primarily leaves, fruit, and current season wood.

Root and crown diseases are caused by soil-inhibiting pathogens that infect roots and the crown directly through injuries directly or through injuries made during cultivation, and removal of suckers, debilitate the whole tree. Root and crown pathogens are spread in surface water, in soil contaminated equipment, and on infected planting stock.

Branch and trunk diseases are caused by pathogens that usually invade the tree through injuries to bark or wood, but in some cases may infect uninjured trees; these pathogens are spread by wind, splashing water, insects, and cultivation and harvest equipment.

Virus diseases (and other diseases are not covered in this evaluation because of the lack of chemical control options) are spread in infected budwood and by insect, mite, or nematode vectors, or in pollen.

Brown rot and *Phytophthora* root and crown rot have the potential to be damaging in most orchards while others such as oak root fungus are specific or nearly specific to certain area (7).

Fruit and Foliage Diseases

Brown Rot Blossom, *Monilinia laxa*

Twig Blight, *Monilinia fructicola*

Brown rot is one of the most serious disease problems in prunes. Brown rot causes blight of blossoms and young shoots; ripe fruit rot, and may attack very young fruit. Blossom and twig blight are most severe in years when mild, wet weather occurs during bloom and is a bigger problem in the Sacramento

Valley then in Tulare County because of this.

In prunes, both species have been reported to cause blossom blight. *M. laxa* is the dominant fungus causing blossom blight, whereas *M. fructicola* is the dominant species causing fruit rot. Conidia are spread to opening blossoms by splashing water and wind.

Controls:

Cultural Control

Orchard sanitation practices by removing and destroying mummy fruit and blighted shoots will help reduce initial inoculum.

Dense ground cover maintained during bloom favors inoculum production by fruit mummies. Mowing ground covers to destroy mummies and reduce hazards from frost will reduce the initial inoculum load.

Brown rot is managed primarily with fungicide applications. Treatment early in bloom is recommended in orchards with a history of blossom and twig blight or if unusually wet weather is expected during bloom. In most years a single application provides sufficient protection against blossom and twig blight is a systemic fungicide is made at popcorn or at full bloom with either contact or systemic fungicide. Additional treatments may be needed if weather is wet.

Chemical Control

Material listed below are currently used for control of blossom and fruit brown rot.

- **Benomyl** – 3 day PHI. Somewhat systemic material applied by ground or air to 7% of the acreage at the average rate of 0.64 lb. a.i. per acre (1). Brown rot resistance has been documented in the Sacramento Valley (7) and should not be used in orchards where resistance has been documented. Limited to one application per year and should be used in combination with a fungicide with different chemistry to delay resistance (7).
- **Captan** – 1 day PHI. Applied by ground for control of brown rot and russet scab. Captan is often combined with benomyl or thiophanate-methyl to manage brown rot resistance. This material is under review because of possible cancer risks and some processors have banned its use on dried prunes.
- **Chlorothalonil** – Cannot be applied after shuck split. Applied by ground to 21% of the acreage at the average rate of 2.1 lb. a.i. per acre (1). Will control both blossom or fruit brown rot and lacy scab if timed properly.
- **Iprodione** – 7 day PHI. Most widely used fungicide in California prunes. Applied by ground or air to 99% of the acreage at the average rate of 0.62 lb. a.i. per acre (1) for control of brown rot and rust. Addition of a narrow range oil at 1% increased the effectiveness of this material (7). Often

combined with benlate or thiophanate-methyl for resistance management.

- **Myclobutanil** – 1 day PHI. A systemic fungicide recently registered for use in California on prunes. Used to control brown rot. No use data are available from California on prunes.
- **Triforine** - Applied by air or ground to 26% of the acreage at the average rate of 0.6 lb. a.i. per acre (1). Controls brown rot. Often used in combination with benomyl and thiophanate-methyl to manage brown rot resistance. This pesticide was not reregistered during the reregistration process thus the registration was cancelled but existing stocks in grower hands may be used.
- **Thiophanate-methyl** – 1 day PHI. Somewhat systemic material applied by ground or air to 2% of the acreage at the rate of 1.2 lb. a.i. per acre for control of brown rot. Brown rot resistance has been documented in the Sacramento Valley, (7,5,) and should not be used in orchards where resistance has been documented. Limited to one application per year and should be used in combination with a fungicide with different chemistry to delay resistance.
- Strains of *M. fructicola* resistant to benzimidazole fungicides occur commonly in California. To delay resistance and increase efficacy these materials generally are used only once during the season and only in combination with products of a different chemistry. Resistance to systemic dicarboximide fungicides (iprodione and vinclozolin) has been reported in California but is not common (7).

Russet Scab

Russet Scab is a disorder that develops on the surface of prunes when heavy rains occur during bloom. Shiny areas develop on the surface of green fruit due to incomplete development of the waxy layer. The areas persist until fruit is harvested and if the spots are large they become russeted or corky patches on the surface after drying (8).

Controls:

Treatment with chlorothalonil or captan at full bloom will reduce or prevent the development of russet scab, apparently because they stimulate wax formation on the fruit surface. The popcorn timing for brown rot is not effective for russet scab.

Rust, *Tranzchelia discolor*

Rust is caused by a fungus that attacks the foliage of prunes. It rarely attacks prune fruit. Rust occurs

most frequently in Sacramento Valley orchards because it is favored by wet conditions; in the San Joaquin Valley the disease may be a problem in wet years or in orchards where cover crops or nearby rivers increase humidity. Rust is worse when rain occurs in spring and summer. Rust first appears as bright yellow, angular spots on the upper sides of leaves. Severe foliar rust can cause defoliation, which may reduce yields if defoliation occurs well before harvest (2).

Controls:

Chemical Control

In prune orchards with a history of rust, fungicides are applied early and mid-summer to control leaf infections to delay defoliation until after harvest. Iprodione and sulfur will control this disease. Two or three applications may be needed in blocks that have had severe rust problems (5).

- **Sulfur** - Applied to about 28% of the acreage at the average rate of 9.7 lb. a.i. per acre (1). Preferred material for prune rust. Will also control eriophyid mites but may cause web spinning mites to increase because of the lack of eriophyid mites as alternate prey for predaceous mites, (16).

Diseases that Attack the Crown, Roots or Trunk

Bacterial Canker, *Pseudomonas syringae*

Blast, pv. *syringae*

Bacterial canker affects scaffolds and smaller branches, and may kill buds and shoot tips. Young trees are most severely affected. Problems with bacterial canker can be reduced by carefully selecting planting sites, choosing the least susceptible rootstock and following recommended cultural practices (6).

Controls:

No control actions are available that will prevent bacterial canker, but a number of cultural practices can be used to reduce the likelihood of the disease and its severity.

Cultural Control

Avoid planting on a site that has a history of bacterial canker.

Use of rootstocks can help manage this disease. Lovell and Nemaguard peach are most resistant, and

plum most susceptible (2).

Scaffold budding or high grafting of susceptible scion wood may reduce the severity of this disease. (11).

Chemical Control

- **Methyl Bromide** fumigation to control ring nematode appears to reduce the incidence of bacterial canker (6).
- **Copper** was applied during the dormant season to 46% of the acreage at the average rate of 2.2 lb. a.i. per acre was probably for control of bacterial canker in 1995. [Can you confirm this?] Although dormant copper is effective on some fungal diseases in other stone fruits, there are no data supporting the use of copper for this in prunes in California at this time (9). However, multiple dormant copper applications are being researched and may eventually prove to be helpful.

Phytophthora Root and Crown Rot, *Phytophthora* spp.

At least 11 different *Phytophthora* species attack prune trees in California. The pathogen enters the tree either at the crown near the soil line, at the major roots or at the feeder roots, depending on the species. Trees affected with *Phytophthora* first show small leaves, sparse foliage, and lack of terminal growth. Infected trees may decline for several years or die within the same growing season in which the foliage symptoms first appear. *Phytophthora* can survive in the soil for many years and spreads and infects the trees during moist cool to moderate temperatures and some infection may occur in the summer depending on species (2). Yield losses of 50% can occur in infected orchards.

Controls:

Cultural Control

Control of *Phytophthora* and crown rot is based on rootstock selection, site selection and preparation, planting on ridges or berms, sanitation, proper irrigation management, and improvement of soil drainage.

Rootstocks vary in susceptibility to the different *Phytophthora* species; none are resistant to all species. However, Myrobalan seedlings are most resistant; Myrobalan is more resistant than Marianna 2624 is; Nemaguard and Lovell peach are highly susceptible (2). Rootstock selection for management of crown and root rots is currently practiced widely prior to planting.

Chemical Control

- **Fosetyl-al** - Which is registered for nonbearing trees only. Applied as foliar spray for control of crown and root rots. This material is not used in California as far as can be determined.
- **Metalaxyl** - Registered for use as a soil drench around the base of the trees but was not used according to pesticide use reports in 1995.

Armillaria Root Rot, *Armillaria mellea*

The severity of this fungus disease depends on the rootstock and the strain of *A. mellea*. Many strains of the fungus exist, ranging from nonviolent or weakly virulent to extremely virulent that kill trees shortly after infection occurs. The pathogen invades the roots, crown and basal trunk, eventually girdling the crown region and destroying the entire root system causing death of the tree. It can survive for many years in dead roots of many different species of trees (2).

Controls:

Management of *Armillaria* root rot primarily depends on the use of pre-plant soil fumigation, root stock selection and the selection of non-infested ground for planting (2).

Cultural Control

One of the best methods of managing *A. melleae* is careful selection of orchard ground before planting an orchard. Avoid planting where forest or oak woodland has been cleared recently or on a site with a history of *Armillaria* root rot.

Choice of rootstock is important in managing *A. mellea* in infested soils. The plum rootstock Marianna 2624 is the only tolerant understock available for *Prunus* species. Survival of Marianna 2624 in the presence of *Armillaria* depends upon the strains of the fungus present. Even though they eventually die of *Armillaria* infection, trees on Marianna are productive longer than those on other rootstocks. Myrobalan 29-C is somewhat less affected than Lovell peach rootstock (2). If the use of methyl bromide fumigation is suspended, infection of these rootstocks is expected to increase (4).

Chemical Control

- **Methyl bromide** has shown some promise for control of *A. mellea* at the rate of 300-600 lb. a.i. per acre applied by injection with tarping. In 1995 7% of the acreage was treated at an average rate of 281 lb. a.i. per acre (1). This was all used on newly planted trees or spot treated before planting replants. It is recommended that a deep-rooted covercrop be grown on the soil to dry it out completely before treating. Even under these conditions, eradication is difficult. This material will also reduce *Phytophthora*, verticillium wilt and other soil inhabiting organisms.

Crown Gall, *Agrobacterium tumefaciens*

Although crown gall can affect established orchards, the disease is most damaging to young trees. If left unchecked, crown gall may progress around the crown weakening and eventually girdling the tree. Young galls are smooth; as they age, they become rough and increase in size. Old galls are dark, brittle and cracked. The pathogen usually infects through wounds and young trees in nurseries are particularly prone to infection because of the many potential injuries during rearing and digging (7).

Controls:

Chemical Control

The primary management technique for managing this disease is using clean nursery stock, which is accomplished at present by fumigating with methyl bromide and the use of biological control agents prior to planting. Both are widely practiced already in California.

Nematodes

Lesion Nematode, *Pratylenchus vulnus*

Ring Nematode, *Criconemella xenoplax*

Southern Root Knot Nematode, *Meloidogyne incognita*

Lesion Nematode, *Pratylenchus vulnus*

Plant parasitic nematodes are microscopic roundworms that feed on plant roots of most plants including prunes. They live in soil or within the cortical tissues of the roots. The extent of the damage caused by nematodes in prunes depends largely on the density of the nematode population, soil conditions and rootstock selection. In situations where tree growth has been visibly impaired by the second year, the affected trees may never overcome the nematode problem. Symptoms of a nematode infestation include lack of vigor, small leaves, dieback of twigs and a sparse root system, particularly the lack of small feeder roots. Root galls are an indication of root knot nematode.

Ring nematodes spend their lives in soil feeding on roots. Feeding by ring nematodes stress trees and makes them more susceptible to bacterial canker (*Pseudomonas syringae*). Ring nematode is common in

sandier soils of the northern San Joaquin Valley, but also along fans of old river tributaries further south (8).

Dagger nematodes reduce tree vigor with their feeding as well as vectoring tomato ringspot viruses. It is most common in northern California soils, it also occurs frequently in other production areas (4).

Lesion nematode damage roots by moving through cortical tissues and feeding in these areas. Among first-leaf trees, damage by the lesion nematode can be severe. Stunted trees occur within irregular, circular-shaped areas across the orchard. Among older plantings damage is barely discernible. Fruit size and quantity are reduced with only slight stunting in overall tree growth. Yield and size data of plum on both peach and plum rootstocks indicate up to a 16% reduction in marketable fruit, with peach rootstocks being more adversely affected than plum (8).

Root knot nematodes take up a single feeding site within a root where they remain for their entire life. Some legumes grown for covercrop on the orchard floor provide an excellent habitat and food source for root knot nematode. Unfortunately many cover crops, including clovers do not show obvious symptoms of root galling (8).

Controls:

Biological Control

There are no known biological agents that are deliverable to soil or the surfaces of roots, which will provide relief from endoparasites such as root lesion nematode. Metabolites produced by myrothecium fungus were recently registered as nematicides under the brand name DiTera™ . Performance of this product is highly variable in small plots and there is much about this biologically derived product that is not understood. DiTera™ is now receiving commercial evaluation in plots in prunes in the Sacramento Valley (11).

Cultural Control

If possible new prune orchards should be planted on land where non-woody plants have grown for several years. However this is not a viable option for most growers (7).

To prevent the introduction of nematodes in an orchard, stocks are grown in nurseries that, up to now, were fumigated before planting with methyl bromide.

Rootstock selection is also important because rootstocks for prunes differ in response to various parasitic nematodes. Nemaguard peach rootstock and the plum rootstocks Marianna 2624 and Myrobalan 29C are resistant to root knot nematodes. Mariana 2624 and Myrobalan 29C are moderately resistant to root lesion but susceptible to ring nematode (8).

There are no effective post-plant nematicides and no rootstocks are known to be resistant to root lesion nematode so growers make a critical decision whenever they decide on a partial fumigation or to not

fumigate at all. The damage by nematodes is severe enough on prune that without methyl bromide or an effective alternative the resulting orchards will be weaker with fewer roots and any damage with above ground pests will be increased (4).

Nematode numbers are greatly reduced for as long as 6 years by fallowing 1 or 2 years and then fumigating prior to replanting. The fumigation serves the important function of killing all the remaining roots within the surface 5 feet of soil profile. Without fumigation these roots could remain alive 4 years after the old trees have been removed and the soil deep-ripped. Few growers could afford to idle their land for the 4 to 5 years necessary to achieve adequate relief from the replant problem plus root lesion nematode (4).

Work is currently underway to develop hot water treatments for preplant management of nematodes on prune rootstocks. However it is still under investigation at this point (11).

Chemical Control

- **Methyl Bromide** is used as a preplant treatment when replanting into soils previously in orchard crops. It is applied 1 to 2 feet deep by ground, usually with plastic tarpaulin stretched over the field surface. In 1995 35% (1360 acres) of newly planted prunes were treated, (1,3,4) In order to save on costs, growers in some regions may treat only the planting strips or the individual planting sites, with or without use of a tarp. These latter treatments only provide up to 2 years of nematode relief, which is adequate for the best silty loam soils. The usual treatment rate for prunes is 400 lb. a.i. per acre. An estimated 80% of soils replanted to prunes receive a treatment, although the pounds used per may be as low as 50 lb. a.i. per acre for spot treatments which could account for half of all treatments.
- **1,3 Dichloropropene (1,3-D)** is the closest replacement for methyl bromide but its use in California was suspended from 1990 to 1996 and today there are serious acreage restrictions and a limitation of 350 lb. per acre associated with its use. Use data are not available at this time. Excessive volatilization has been the key shortcoming to its recent use and the walnut industry has been searching for improved methods of application to limit in-field volatilization without jeopardizing efficacy. Prior to 1990 the normal treatment rates for 1,3-D were from 400 to 800 lb. per acre largely because prunes are grown on the finer-textured soils, compared to other tree crops. Newer methods of killing roots plus the lowered rates of 1,3-D plus the use of a water seal containing **metam sodium** biocide will soon receive field evaluation as a methyl bromide alternative, but is premature to predict the results in commercial settings (3).
- **Sodium tetrathiocarbonate** received a registration on prunes in California in the spring of 1997. This active ingredient releases carbon disulfide when in contact with soil. Several small scale field trials have shown that flood applications of sodium tetrathiocarbonate can reduce ring nematode population on prunes plus reduce the incidence of bacterial canker (11).

- Work with **ozone** as a soil fumigant is also ongoing on prunes. Preliminary data indicate the product moves at nematicidal concentrations for 6-12 inches from the point of injection. Cost projections based on trials indicate ozone could be applied at a cost comparable to other nematicides (11).

Weeds

Orchard floor management in prunes is a challenge. Depending on the weed species or covercrops either can be harmful and/or beneficial at the same time.

While all the positive and negative attributes of cover crops need to be researched more, there is sufficient scientific data from the California grape industry and literature in other parts of the U. S. and Europe to make cautious recommendations. Prune culture with the early harvest and post harvest irrigation lends itself to highly successful cover cropping systems, which can address several of the concerns of pests, biodiversity, and water quality.

Weeds can cause a multitude of problems in prune orchards by reducing the growth of young trees because they compete for water, nutrients, and space. Weeds also increase water use, increase vertebrate and invertebrate and other pest problems, and may enhance the potential for disease. The increasing use of more efficient low-volume irrigation systems has increased the need for selective preemergence herbicide use in drip, micro-sprinkler, and sprinkler irrigated orchards. Herbicides are generally used only in the tree row. This reduces the total amount of herbicides and prevents the surface roots in the tree row from being damaged by cultivation equipment. Weed species are controlled by pre-emergence, post-emergence, or a combination of pre- and post-emergent herbicides. Soil characteristics have an effect on the broad weed spectrum (often 15-30 species per orchard), the number of cultivations and irrigations required, and the residual activity of herbicides. Irrigation methods and the amount of irrigation or rainfall affects herbicide selection and the residual control achieved.

Treatment decisions and herbicide selections are based on dormant and early summer weed surveys and history of weeds in particular blocks.

Controls:

Biological Control:

Biological control can be important in regulating specific weed species such as puncturevine.

Cultural Control

Complete tillage is an option in prunes and was the only weed control technique available until the advent of herbicides. It has a number of drawbacks and is decreasing in use. Tilling requires a large expenditure for machinery, and is expensive. Machinery used for tilling depends on the use of non-

renewable fossil fuels, contributes to air pollution, destroys soil structure and causes compacted layers in the orchard, hindering water penetration. Tillage can contribute to pest buildups by causing dust on trees which increase mite and scale problems, and injuring trees allowing disease organisms to invade trees.

Hand hoeing can be used to remove weeds from around trees and sprinkler heads but is not used extensively because of the expense involved.

Chemical Control

- **Glyphosate** – 3 day PHI. Applied during the dormant, pre-and/or post-bloom by ground one or more times per season on 92% of the acreage at an average rate of 0.67 lb. a.i. per acre (1). Nonselective systemic used for a broad range of weed species. Effective anytime on emerged, irrigated, rapidly growing, non-stressed weeds, but activity is slower in lower temperatures. Not effective on some broad-leaf weeds at older stages of growth (malva and filaree). Continued use of this material leads to a shift of species and selection of tolerant species. Light activated spray technology has reduced the amount of material applied when weed cover is low by 50 to 80%.
- **Oxyfluorfen** – 0 day PHI. Applied by ground one time per season on 27% of acreage at an average rate of 0.32 lb. a.i. per acre (1). Selective broadleaf herbicide effective as a pre- and post-emergent material. Particularly useful when combined with Roundup to increase efficacy on various broadleaf weed species and to prevent broadleaf species shifts with glyphosate.
- **Paraquat** – 0 day PHI. Applied pre- or post-bloom by ground one or more times per season by ground on 12% of acreage at an average rate of 0.60 lb. a.i. per acre (1). Non-selective post-emergence material used for quick burndown of most weed species. Less effective against perennials that will regrow with vigor, e.g. bermudagrass, dallasgrass, Johnsongrass and bindweed. Most effective when used on early spring or winter growth of annual weed species in combination with pre-emergence herbicides.
- **2-4-D** – 60 day PHI. Applied as a directed spray post-bloom by ground one or two times to 25% of the acreage at the rate of 0.37 lb. a.i. per acre (1). Post-emergence systemic herbicide selective for most broadleaf annual weeds. Effective on field bindweed and useful for controlling troublesome perennials when combined with glyphosate or fuzalifop-methyl.
- **Oryzalin** - 0 days PHI. Applied pre-emergence by ground one time per season on 12% of the acreage at the rate of 1.3 lb. a.i. per season (1). Pre-emergence selective herbicide most effective on annual grass species and numerous broadleaf annuals. Very safe for young or newly planted trees and on sandy or sandy-loam soils. It is used to maintain control in strips down the row. Often used in combination with other pre-emergence herbicides.
- **Trifluralin** – 0 day PHI. Applied pre-bloom by ground one time per season on <1% of the acreage at the rate of 2.5 lb. a.i. per acre (1). Pre-emergence selective herbicide for annual

grasses. It must be combined with broadleaf herbicides and incorporated promptly for best results.

The use of "smart" sprayers to apply contact herbicides is currently being validated and demonstrated as a way to reduce the amount of herbicides being applied in tree crops.

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