



Department of Pesticide Regulation



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MEMORANDUM

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HSM-16001

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SUBJECT: CRITICAL USES OF CARBARYL WITHIN CALIFORNIA

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1. Summary

During 2015-2016, the Department of Pesticide Regulation (DPR) conducted fact-finding about why and how the insecticide carbaryl is used within California. The goal of the fact-finding was to learn about stakeholders' needs regarding critical uses of carbaryl, to help DPR select among several mitigation options that would all be equally protective. This document uses the term "critical use" as meaning a current legal use of carbaryl that addresses an important need and for which there are few or no feasible alternatives to the use of carbaryl.

To make most efficient use of its resources, DPR intentionally limited its fact-finding to seven crops or use categories in which carbaryl use is relatively high. Fact-finding indicated carbaryl critical uses in five use categories:

- **Apple production:** chemical fruit thinning (liquid formulations of carbaryl);
- **Melon production:** control of soil-dwelling insect pests (granular formulations);
- **Non-production plantings of ornamental plants:** eradication of incipient infestations of glassy-winged sharpshooter (GWSS), under the direction of quarantine officials of the California Department of Food and Agriculture (CDFA) (liquid formulations);
- **Ornamental-plant production:** prophylactic control of GWSS on shipments from GWSS-infested counties in southern California to uninfested California counties, as required by quarantine regulations (liquid formulations); and
- **Tomato production:** control of soil-dwelling insect pests shortly after planting (granular formulations).

Though not meeting this document's definition of "critical", the following carbaryl uses are valued by industry or CDFA quarantine officials and should be carefully considered when selecting among mitigation options:

- **Citrus production:** no critical uses per se, though carbaryl is a valuable tool for late-season control of red scale, for helping prevent resistance, and for control of multiple insect species with a single application, and is one of several pesticides effective against Asian citrus psyllid (liquid formulations); and
- **Olive production:** no critical uses per se, though carbaryl is a useful rotation insecticide for scale control to help prevent resistance (liquid formulations).

Critical uses that involve granular formulations, namely those within melon and tomato production, produce lower foliar residues and thus may be simpler to mitigate than those involving liquid formulations.

2. Purpose

This memorandum summarizes fact-finding by DPR about carbaryl use within California. Carbaryl is a broad-spectrum carbamate insecticide used in production of fruits, nuts, field crops, and ornamental plants. In addition, carbaryl is used on non-production plantings including turf, landscaping, and home gardens. As of April 2016, there are 21 carbaryl products with active California registrations. Summaries of those products are included in [Zeiss \(2015\)](#).

In June 2014, DPR completed an assessment of human health risks associated with carbaryl use ([Rubin 2014](#)). The resulting Risk Characterization Document (RCD) concluded that estimated risks include Margins of Exposure (MOEs) less than 100 or cancer risks greater than 10^{-6} for many of the carbaryl exposure scenarios that involve:

- occupational handlers;
- occupational re-entry by workers, *primarily of concern for planted areas treated with liquid formulations (not granular bait formulations)*;
- residential handlers and residential re-entry; and
- bystanders ([Rubin 2014](#)).

Risk managers within DPR currently are evaluating the RCD to determine whether any of the estimated risks will require mitigation.

To help prepare for the possibility of mitigation action, during 2015-2016 DPR conducted fact-finding about why and how carbaryl is used within California. The goal of the fact-finding was to learn about stakeholders' needs regarding critical uses of carbaryl, to help DPR select among several mitigation options that would all be equally protective. DPR's mission is, "to protect human health and the environment by regulating pesticide sales and use, and by fostering reduced-risk pest management" ([DPR 2013b](#)). In cases when any one of several mitigation options would serve to achieve this mission, DPR considers stakeholders' needs when selecting among equally-protective mitigation options. This memorandum summarizes the findings of DPR's fact-finding.

3. Definition of "critical use"

During fact-finding about carbaryl uses, DPR scientists seldom used the phrase "critical use". Instead, DPR scientists asked open-ended questions about which carbaryl uses were important, and what non-carbaryl alternatives (if any) were available.

Nonetheless, for convenience, this document will use the term "critical use" as meaning *a current legal use of carbaryl that addresses an important need and for which there are few or no feasible alternatives to the use of carbaryl*. For carbaryl, "important need" can include controlling economically-important insect pests, or achieving economically-important fruit characteristics via carbaryl's direct effect on fruit-tree growth patterns. In previous assessments of other pesticides, some experts have recommended also including longer-term needs such as managing the evolution of pests' resistance to alternative pesticides ([UCIPM 2014a](#)). In this document, needs such as resistance management are considered and discussed, but are not included within "critical use".

For additional perspectives on the "critical use" concept, see the 2014 report on critical uses of chlorpyrifos ([UCIPM 2014a](#)), and the 1997 decision on critical-use exemptions for methyl bromide ([UNEP 1997](#)).

4. Scope of DPR's carbaryl fact-finding

4.1 Use categories

Carbaryl insecticide products are registered in California for use on more than 45 distinct crops or use categories ([Zeiss 2015](#)). To make most efficient use of its resources, DPR intentionally limited its fact-finding to the following seven use categories:

- apple production;
- citrus production;
- melon production;
- non-production plantings of turf or other ornamental plants (distinct from production of ornamental plants);
- olive production;
- ornamental-plant production; and
- tomato production (both processing and fresh-market).

DPR selected those use categories because they had the highest total quantity of reported carbaryl use (pounds of active ingredient), or had the highest number¹ of reported carbaryl applications, within California during recent years ([Zeiss 2015](#)). Though this was a logical decision, it might inadvertently have excluded certain use categories with small but critical carbaryl uses. If DPR receives information about carbaryl critical uses within additional use categories, DPR will consider those additional uses when selecting mitigation options.

4.2 Information sources

During fact-finding, DPR scientists contacted selected University of California staff, County Agricultural Commissioner staff, and private-sector companies and organizations associated with the selected use categories (for example, the California Landscape Contractors Association and California Citrus Mutual). Information collection included telephone discussions, email correspondence, written questionnaires, in-person meetings, and field visits to observe selected crop-production practices. Representative examples of the questionnaires are shown in Appendix 1 and 2.

For each of the selected use categories, DPR has received information from at least four independent sources. Names and affiliations of individual experts are intentionally excluded from this memorandum. Experts' views and opinions summarized in this memorandum are solely those of the experts contacted, and do not necessarily represent the views of DPR.

¹ California regulations define production agriculture as the production for sale of agricultural commodities as defined in 3 CCR 6000. For production-agriculture use categories, California regulations require that pesticide use reporting be location-specific and time-specific. Thus for production-agriculture use categories, it is straightforward to count the actual number of unique applications such that each application has a unique combination of location and date. In contrast, for non-production and non-agricultural use categories, pesticide use reporting is via a monthly summary of total quantity used of each pesticide. Therefore, it is not possible to count the number of unique applications. Instead, for non-production and non-agricultural use categories, DPR estimated the number of applications by counting the number of monthly-summary reports submitted per use category.

Mention of commercial products is not to be construed as either an actual or implied endorsement, nor as an indication that DPR considers one product to be more efficacious than another.

Independent of DPR's fact-finding, a team managed by CDFA's Office of Pesticide Consultation and Analysis (OPCA) also has been assessing carbaryl critical uses. DPR scientists have communicated and shared information with OPCA, and DPR will consider any findings reported by the OPCA team.

5. Findings: critical uses of carbaryl within California

In summary, fact-finding indicated carbaryl critical uses in five use categories:

- **Apple production:** chemical fruit thinning (liquid formulations of carbaryl);
- **Melon production:** control of soil-dwelling insect pests (granular formulations);
- **Non-production plantings of ornamental plants:** eradication of incipient infestations of glassy-winged sharpshooter (GWSS), under the direction of CDFA quarantine officials (liquid formulations);
- **Ornamental-plant production:** prophylactic control of GWSS on shipments from GWSS-infested counties in southern California to uninfested California counties, as required by quarantine regulations (liquid formulations); and
- **Tomato production:** control of soil-dwelling insect pests shortly after planting (granular formulations).

Though not meeting this document's definition of "critical", the following carbaryl uses are valued by industry or CDFA quarantine officials and should be carefully considered when selecting among mitigation options:

- **Citrus production:** no critical uses per se, though carbaryl is a valuable tool for late-season control of red scale, for helping prevent resistance, and for control of multiple insect species with a single application, and is one of several pesticides effective against Asian citrus psyllid (liquid formulations); and
- **Olive production:** no critical uses per se, though carbaryl is a useful rotation insecticide for scale control to help prevent resistance (liquid formulations).

Detailed findings are presented below, in alphabetical order by use category.

5.1 Apple production

Includes a critical use of carbaryl: **fruit thinning**. Certain liquid-formulation carbaryl products are labeled for fruit thinning on apple. Chemical fruit thinning intentionally removes a portion of the immature fruits from the tree. Fruit thinning can help improve fruit yield and quality for the current year, and improve bloom for the following year ([Grant et al. 2006](#)).

For fruit thinning, liquid carbaryl formulations are applied via airblast sprayer, usually one or two applications in April (Figure 1). Exact timing varies with apple variety and annual weather

patterns. All experts contacted agreed that chemical thinning would become more difficult if carbaryl mitigation required changes to application method (airblast), timing, or application rate for carbaryl. The following are representative examples of experts' comments:

“Good coverage is extremely important, very difficult to penetrate tree canopy without air[blast].” “Thorough and uniform coverage of all flowers/fruitlets is important. The thinning effect is very localized.”

“The timing of carbaryl applications for thinning is very time sensitive. Applications outside the optimal window for each variety are ineffective and the results are very difficult to predict.”

“The rate of carbaryl is dependent on variety, tree condition and weather dependent. Using a rate lower than those dictated by the specific conditions would result in sub-optimal effects (less thinning).”

Regarding alternatives, several other plant growth regulators commonly are used for apple thinning, but all are typically used *in combination with carbaryl*. As one expert put it:

“Other products are usually based around the use of [carbaryl] as the main thinning agent. NAA [1-naphthaleneacetic acid] and NAD [1-naphthaleneacetamide] both can cause pigmy fruit in California; Ethrel [ethephon] can over thin, MaxCel [6-benzyladenine] needs [carbaryl] to thin properly.”

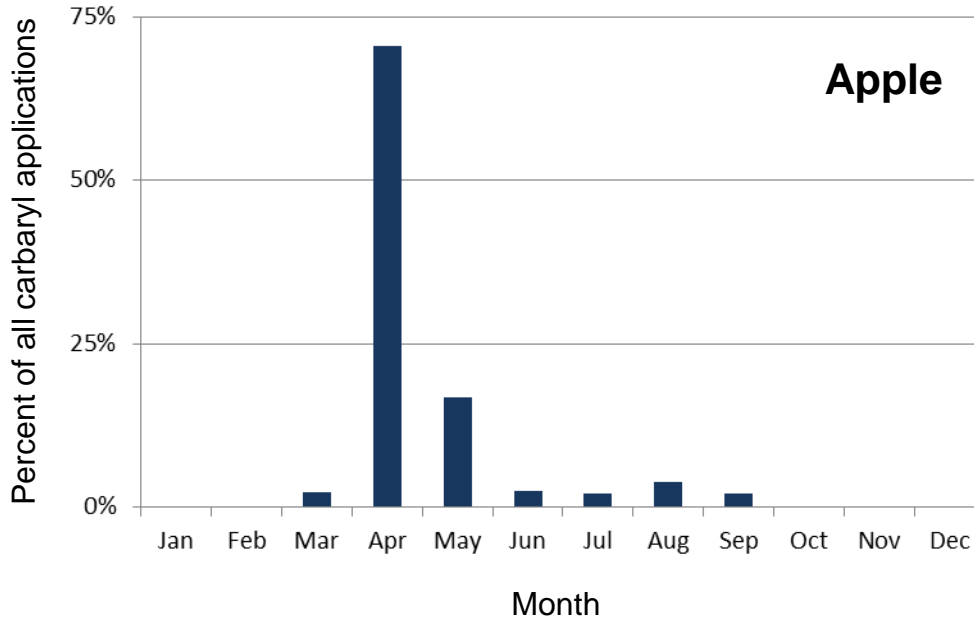
This is consistent with UCIPM guidelines, which specify carbaryl as part of the tank mix for each of the apple varieties mentioned ([Grant et al. 2006](#)).

A second expert added:

“Carbaryl has at least one especially desirable thinning capability that I have not found on other tested PGRs [plant growth regulators]. It has the ability to ‘singulate’ fruitlet clusters. All the other thinners I have trialed reduce fruit load by removing the entire flower or fruitlet clusters. The ideal effect, more or less unique to Sevin, is the removal [of] the lateral fruitlets, leaving the ‘king’ fruitlet which has greater sizing potential than the lateral ones.”

Figure 1. Timing of carbaryl applications to California apple fields, 2009 – 2013

Source of data: DPR Pesticide Use Report database (DPR 2015b).



5.2 Citrus production

Citrus does not include any carbaryl critical uses, per se. However, it does include several uses that are valued by industry or CDFA quarantine officials and that should be carefully considered when selecting mitigation options. These are listed below, in approximate order of importance. All uses described below use liquid formulations.

5.2.1 Asian citrus psyllid (ACP)

This sucking insect vectors the bacterium that causes the devastating citrus disease huanglongbing, also known as citrus greening ([UCIPM 2016a](#)). The Plant Health and Pest Prevention Services of the California Department of Food and Agriculture (CDFA) administers California's ACP quarantine. ACP quarantine regulations do not restrict movement of citrus fruits, but do require pesticide treatments of regulated citrus nursery stock² ([CDFA 2015a](#)). However, carbaryl is merely one of four active ingredients approved by CDFA for foliar treatment of nursery stock moving within an ACP quarantine area. In contrast, for nursery stock that will be moved interstate, CDFA does not approve carbaryl, and instead approves five other foliar active ingredients ([CDFA 2015a](#)).

² For the list of plant species regulated under the State Interior Quarantine for Asian Citrus Psyllid, see California Code of Regulations, title 3, section 3435(c), available at: <http://pi.cdfa.ca.gov/pqm/manual/htm/420.htm>

In areas where ACP has become established, citrus growers must manage ACP populations in their production orchards. However, in UCIPM guidelines for citrus, carbaryl is merely one of eight broad-spectrum foliar insecticides recommended for ACP control. Of the eight, carbaryl is listed last, whereas “pesticides having the greatest IPM value [are] listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top” ([UCIPM 2016a](#)).

There is no question that ACP and the pathogen it vectors have the potential to cause severe economic damage to the California citrus industry ([UCIPM 2016a](#)). Nonetheless, given the availability of alternative pesticides and their formal approval by CDFA, the use of carbaryl for ACP management does not meet this document’s definition of “critical use”. However, I recommend that DPR consider ACP management in citrus when designing any future mitigation.

5.2.2 *Fuller rose beetle*

This flightless beetle causes only minor direct damage to California citrus, but nonetheless is important because of quarantine prohibitions against its eggs by key citrus-fruit importing countries such as Korea ([UCIPM 2015b](#)). Some citrus experts stated that Fuller rose beetle is not adequately controlled by alternative insecticides. In addition, some fruit-importing countries reportedly have not established Maximum Residue Limits (MRL’s) for some alternative insecticides, but do have MRL’s in place for carbaryl.

However, at a 2016 meeting of citrus experts, consensus was that several other active ingredients have good efficacy against Fuller rose beetle. This is consistent with UCIPM guidelines, which list seven active ingredients *other than carbaryl* ([UCIPM 2015b](#)). Most countries that are substantial importers of California citrus ([CDFA 2014](#)) have MRLs for three or more of those seven active ingredients; the main exception is cryolite ([Bryant Christie, Inc. 2016](#)).

5.2.3 *California red scale*

This armored scale is a key pest of California citrus. Reasons why carbaryl can be important for managing red scale include:

- ***Few alternatives for mature scales.*** Several citrus experts stated carbaryl is the only effective option during mid to late season (July-August), when scales are too mature for insect growth regulators (IGRs). As one expert put it, “Once scale survives a May application, it explodes in July and August.” This may be exacerbated by changing weather patterns. Since first California registration in 1998, insect growth regulators (IGRs) typically have provided good control if applied in June-July, when crawlers (immature scales) had emerged from nearly all red scales ([UCIPM 2015c](#)). However, a 2016 meeting of citrus experts reported that in recent years, unusually warm weather has enabled red scale populations to continue development even during the winter. This reportedly has resulted in overlapping generations, which reduces IGR effectiveness because less-susceptible life stages are now present throughout the year. Systemics such as spirotetramat are active against all scale stages ([UCIPM 2015c](#)), but the 2016 meeting of citrus experts stated systemics did not give adequate control of populations on older woody branches. As one

expert put it, “What worries me about systemics is, they leave an untreated hole in the center of the tree that’s like a mini-insectary.” Chlorpyrifos has good efficacy against most scale stages on most plant parts, but has an inconveniently long restricted entry interval (REI) of 5 days ([UCIPM 2015c](#)) and is being considered by U.S. EPA for regulatory action ([USEPA 2015](#)). Carbaryl avoids all these limitations: it is effective against a wide range of scale life stages, even on mature wood, and has an REI of only 3 days even if used at the highest rate (12 lbs carbaryl / acre) that labels allow for red scale.

- **Resistance management.** Several citrus experts mentioned the importance of including carbaryl in a rotation of insecticides to help prevent red scale from developing resistance to IGRs and systemics.

These management challenges are real, but do not meet this document’s definition of “critical uses”. The availability of narrow-range oil, IGRs, systemics, and chlorpyrifos ([UCIPM 2015c](#)) provides alternatives for managing both mature scales and resistance. Nonetheless, I recommend that DPR consider the need to manage red scale on citrus when designing any future mitigation.

5.2.4 Secondary or occasional pests, especially simultaneous control of multiple species

“Secondary” or occasional pests of citrus include soft scales such as black scale, brown soft scale, and cottony cushion scale, as well as some of the pest species previously discussed. Although these are occasional pests, they do require control in some orchards and some years. Reasons why carbaryl can be important for managing these pests include:

- **Efficacy.** Some experts stated that these pests are not adequately controlled by alternative insecticides. However, UC IPM guidelines for soft scales list several alternative insecticides, many of which are classified as having greater IPM value³ than carbaryl ([UCIPM 2015a](#)). Further, several citrus growers reported they have not used carbaryl for any purpose during the past 10 years.
- **MRLs.** Some experts stated that fruit-importing countries have not established MRLs for some alternative insecticides, but do have MRL’s in place for carbaryl. It is true that some of the pesticides recommended by UCIPM for soft scales ([UCIPM 2015a](#); E. Grafton-Cardwell, UCIPM, unpublished data) have no MRLs established on some or all citrus commodities ([Bryant Christie 2016](#)) within some countries that are major importers of California citrus ([CDFA 2014](#)). To mention just one example, Canada is a major importer of several California citrus commodities ([CDFA 2014](#)), yet has no MRLs established on those commodities for the soft-scale insecticides buprofezin or malathion ([Bryant Christie 2016](#)). However, for most such combinations of a citrus commodity and an importing country ([CDFA 2014](#)), there are two or more synthetic insecticides *other than carbaryl* that are recommended by UCIPM for soft-scale control ([UCIPM 2015a](#); E. Grafton-Cardwell, UCIPM, unpublished data) and for which the importing country currently has an MRL ([Bryant Christie 2016](#)). In addition to synthetic pesticides, narrow-range oil helps control most scale species ([UCIPM 2015a](#); E. Grafton-Cardwell, UCIPM, unpublished data) and is exempt from the requirement for an MRL and thus acceptable for most importing countries.

³ IPM value is described as follows: “pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table” ([UCIPM 2016a](#)).

In summary, the availability of non-carbaryl alternatives is comparable to the situation for Fuller rose beetle, already discussed in section 5.2.2 above.

It is a genuine challenge for producers of any export commodity, when selecting a pesticide, to anticipate the disparate MRL requirements of various importing countries. Nonetheless, selecting carbaryl is not the only solution to this challenge. Indeed, California producers who sell oranges and lemons to China, a substantial customer for those commodities ([CDFA 2014](#)), already cope with the MRL challenge without using carbaryl. The reason is, China currently has no MRLs for carbaryl on oranges or lemons ([Bryant Christie 2016](#)). Looking to the future, Korea MRLs may become more problematic for the citrus industry in 2019, when Korea will switch to using only Korean national MRLs for commodities including citrus ([Lantz 2016](#)). However, the California citrus industry already is working with U.S. trade representatives to prepare for this transition (J. Cranney, California Citrus Quality Council, personal communication).

- **Multiple pests.** Carbaryl can control multiple species of insect pests that can all be present within a single orchard. A 2016 meeting of citrus experts pointed out that controlling multiple pests with a single application, “minimizes costs, compaction, fruit damage, VOCs [from machinery engines], and risks for workers”. It can also reduce water used as a carrier. While real, these benefits also are true for any broad-spectrum insecticide.

In summary, citrus has several carbaryl uses that are valued by the citrus industry or CDFA quarantine officials and that should be carefully considered when selecting mitigation options. Carbaryl can be a valuable tool for late-season control of red scale, for helping prevent resistance, for control of multiple insect species with a single application, and is one of several pesticides useful for controlling ACP. However, none of the citrus uses meet this document’s definition of “critical use”.

5.3 *Melon production*

Includes a critical use of carbaryl: use of granular bait formulations to control soil-dwelling insects, both at planting and during fruit development (Figure 2). In contrast, use of liquid carbaryl formulations to control cucumber beetles is not a critical use because there are more alternatives.

5.3.1 *Baits for soil-dwelling insects*

Every melon expert contacted (10 of 10) reported that insecticidal-bait application was a common and important pest management intervention to control soil-dwelling insect pests. The pests mentioned most often were cutworms⁴ and darkling beetles, but also included wireworms⁵, crickets and earwigs. This group of pests can cause three types of damage in melons:

- 1) Chewing the stems of young plants shortly after planting, when even a small amount of feeding can kill a plant;

⁴ Cutworms refers to a group of caterpillar pests within the Order Lepidoptera.

⁵ Wireworms are a group of beetle larvae pests within Order Coleoptera.

- 2) Chewing into drip-irrigation tape, causing leaks that disrupt irrigation; and
- 3) Later in the season when fruits are maturing, chewing into fruits from below, directly damaging fruits and indirectly enabling microbes to rot the fruits. ([UCIPM 2012a](#), [2012b](#)). Even a small area of damage makes a fruit unmarketable ([UC Davis 2016](#)). A separate type of insect, cucumber beetles, also damage fruits in the same way (discussed in section 4.3.2 below).

Experts explained that bait is the most effective formulation for soil-dwelling insects because soil shields these insects from most contact insecticides. For early-season application, bait can be banded along the row of plants, or applied in a band over the top of drip tape to protect the tape. For later applications to protect fruit, bait is broadcast either via ground equipment or air.

Carbaryl is the only bait recommended by UCIPM to control either darkling beetle ([UCIPM 2012a](#)) or cutworms ([UCIPM 2012b](#)). Carbaryl is not the only bait formulation labeled for melons. There are at least two alternative active ingredients, permethrin and spinosad⁶, that are available in bait formulations labeled for outdoor production-agriculture use on melon. None of the melon experts contacted mentioned the spinosad bait, which was first registered in California in 2010. For a separate crop, tomato, one expert's experience with spinosad bait is summarized in section 5.7 of this memo. A search of DPR's Pesticide Data Index (DPR 2016) indicated that DPR has received three studies on spinosad efficacy against cutworms in field crops including cucurbits, and one study of efficacy against darkling beetles in poultry-rearing facilities. Review of those studies is beyond the scope of this memo, but may be appropriate before DPR selects mitigation options.

Regarding the second bait alternative, permethrin, one melon expert stated that permethrin bait actually provided better control than did carbaryl bait, and that there was no substantial cost difference. However, the majority of melon experts (7 of 10) stated that carbaryl bait provides better control, and is cheaper. As one expert put it:

“the [carbaryl] bait is more effective than the [permethrin] bait we have replaced it with. We band these materials over the plant row when the melons begin to emerge. Because it's in a small area (10-15% of the area) to use less material, it needs to be active longer for the pests to find it. I think the carbaryl is active longer than the permethrin.”

The small number of alternatives, and reports that they are less effective than carbaryl, justifies classifying bait applications for soil insect control in melon as a critical use of carbaryl.

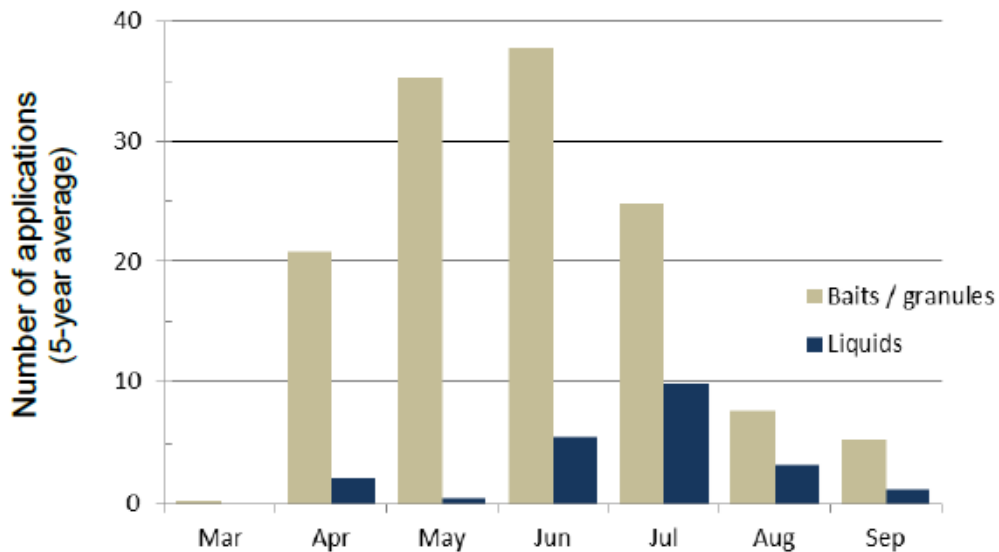
⁶ The insecticidal bacterium *Bacillus thuringiensis* f. sp. *kurstaki* also is available in bait formulation, but has efficacy only against caterpillars in the Order Lepidoptera, and thus would not be expected to control darkling beetles, wireworms, crickets, or earwigs.

5.3.2 Liquid formulations for cucumber beetle

Developing melon fruits are susceptible to damage by both soil-dwelling insects (discussed above) and adult cucumber beetles. In the upper San Joaquin Valley and lower Sacramento Valley areas, cucumber beetle damage to melon fruits has increased in recent years, perhaps because of changes to agronomic practices including reduced tillage ([UC Davis 2016](#)). Several experts stated that carbaryl was an important tool for controlling cucumber beetle, including both bait and liquid formulations. The timing of reported use (Figure 2) suggests that most liquid is applied for late-season cucumber beetles. However, carbaryl is merely one of four active ingredients recommended for cucumber beetle ([UCIPM 2012c](#)). Therefore, the use of liquid⁷ carbaryl formulations to control cucumber beetle in melons is not a critical carbaryl use. Likewise, use of liquid carbaryl formulations to control other melon pests such as flea beetles is not a critical use because several alternative pesticides are available ([UCIPM 2012d](#)).

Figure 2. Timing of carbaryl applications to California melon fields, 2009 – 2013

Source of data: DPR Pesticide Use Report database (DPR 2015b).



⁷ The conclusion about cucumber beetles has more significance for mitigation of liquid carbaryl formulations. It's a moot point for baits. Section 5.3.1 already concluded that late-season bait applications *to control soil insects* is a critical use, and such bait applications would simultaneously control cucumber beetles.

5.4 *Non-production plantings of turf and ornamental plants*

Non-production plantings include:

- turf or other ornamental plants planted for the purpose of landscaping, recreation, or other uses outside the definition of production agriculture⁸; and
- food plants in home gardens or other locations from which the harvest is not sold ([DPR 2014](#)).

Thus, this use category is distinct from ornamental-plant production (section 5.6, below), in which a commercial enterprise produces plants for sale.

Most experts reported that carbaryl was seldom needed in non-production plantings. For example, in a survey conducted by California Landscape Contractors Association, 78% of respondents reported that they did not use any carbaryl in their businesses; and of those who did use carbaryl, 56% rated it as only “slightly important”. Similarly, UC Advisors whom we contacted all stated there were effective alternatives to carbaryl. However, non-production plantings do include one carbaryl critical use: eradication of incipient GWSS infestations. In addition, use of carbaryl to control ACP is valued by CDFCA quarantine officials and should be considered when selecting mitigation options. All major quarantine uses are listed below, in approximate order of importance. All use liquid formulations of carbaryl.

5.4.1 *Glassy-winged sharpshooter (GWSS)*

GWSS is economically important primarily as a vector of the bacterium that causes Pierce’s disease, which can cause scorching, wilting, and death in various ornamental plants as well as grape ([Varela et al. 2007](#)). In recent years, CDFCA and the County Agricultural Commissioners have used ground applications of carbaryl, cyfluthrin, and especially imidacloprid to control GWSS in several counties ([DPR 2013a](#)). Current guidance from UCIPM states:

“The main material used to protect [GWSS]-susceptible plants in both commercial agriculture and urban landscapes is imidacloprid, which is registered for home and professional landscape use on nonfood crops. Imidacloprid is sold in two formulations: one for soil application and one for foliar application” ([Varela et al. 2007](#)).

Similarly, CDFCA’s Pierce’s Disease Control Program (PDCP) stated the following in its 2015 report to the California legislature (the report did not mention carbaryl):

“Imidacloprid has proven very effective against the GWSS. It is used in treatment programs in urban and residential settings and can be used for both foliar and soil treatment applications” ([CDFCA 2015c](#)).

Although imidacloprid has proven to be an effective alternative to carbaryl, imidacloprid is currently under reevaluation in California and registration review at the Federal level ([DPR](#)

⁸ California regulations define production agriculture as the production for sale of agricultural commodities as defined in 3 CCR 6000.

[2015a](#)). In addition, in response to DPR’s request for input about carbaryl critical uses, CDFA’s Plant Health and Pest Prevention Services informed DPR:

“We’d like to keep the ACP and GWSS uses. . . . For the Urban/Residential side of the PDCP, including right-of-ways, carbaryl was a key product used that has helped us eradicate GWSS in multiple incipient infestations within the program”

Both because of the small number of proven alternatives, and because of the specific request from CDFA, I consider carbaryl use under the direction of CDFA quarantine officials to eradicate incipient infestations of GWSS on non-production plantings to be a critical use of carbaryl.

5.4.2 *Asian citrus psyllid (ACP)*

Carbaryl is one of several insecticides recommended by UCIPM for managing ACP in landscapes and home gardens ([Grafton-Cardwell and Daugherty 2013](#)). In contrast, the Residential Treatment Program for ACP control that is carried out by CDFA does not rely on carbaryl. Instead:

“When a psyllid is found in these areas, all citrus and other known ACP host plants on a property and nearby properties receive a combination of two insecticides. These are a foliar pyrethroid insecticide to quickly kill adults and immature psyllids it comes in direct contact with, followed by a systemic (ground drench application) insecticide to provide sustained control of nymphs tucked inside young leaves” ([Grafton-Cardwell and Daugherty 2013](#))

Another indication of the availability of alternative pesticides is CDFA’s approval of several pesticides other than carbaryl for treatment of nursery stock within the ACP quarantine program ([CDFA 2015a](#)), as previously discussed in section 5.2.1. Nonetheless, CDFA’s Plant Health and Pest Prevention Services informed DPR, “we’d like to keep the ACP and GWSS uses.”

There is no question that ACP and the pathogen it vectors have the potential to cause severe economic damage to the California citrus industry ([UCIPM 2016a](#)). Nonetheless, given the availability of alternative pesticides and their formal approval by CDFA, the use of carbaryl for ACP management does not meet this document’s definition of “critical use”. However, I recommend that DPR consider ACP management in non-production plantings when selecting mitigation options.

5.4.3 *Japanese beetle (JB)*

Though common in the eastern U.S., this polyphagous pest is not established in California ([CDFA 2016](#)). CDFA and CAC staff conduct annual detection trapping, and when JB adults are detected, CDFA implements pesticide applications to eradicate the infestation ([CDFA 2016](#)). In recent years, CDFA eradication programs sometimes used carbaryl to kill adult JB on fruiting plants (e.g., CDFA 2015b). However, CDFA’s Plant Health and Pest Prevention Services

informed me, “We are moving away from it [carbaryl] on JB” (S. Brown, CDFA Plant Health and Pest Prevention Services, personal communication).

5.5 Olive production

Olive production does not include any carbaryl critical uses, per se. Black scale is one of the key pests of olive in California. Most olive experts contacted stated that liquid carbaryl formulations are an inexpensive and effective control for black scale. However, carbaryl is merely one of several pesticides recommended by UCIPM for black scale control on olive ([UCIPM 2014b](#)). Recommended alternatives include narrow range oil⁹, methidathion, and pyriproxyfen, an insect growth regulator (IGR). The UCIPM recommendations are supported by comments from several olive experts such as the following:

“for scale control there are potential alternatives, at least one alternative would be the IGRs, that have worked for scale pests and there are a number of systemics – such as neonicotinoids and lipid biosynthesis inhibitors that should also be investigated.”

Because alternative pesticides are available and widely recognized as effective, scale control on olive is not a critical carbaryl use. Nonetheless, the number of proven alternatives is relatively small, and several olive experts stated that carbaryl was a useful rotation insecticide to help prevent resistance. As one expert put it:

“Resistance management: although IGRs work well against scales, growers should avoid using IGRs year after year, to avoid the risk of resistance to IGRs. Crop oil, by itself, does not adequately control scales in olive.”

An additional limitation of the alternatives is that they are primarily for application after olive harvest (dormant or delayed dormant applications). Although pyriproxyfen product labels do allow “in-season cover spray” on olive, UCIPM recommends pyriproxyfen and methidathion only postharvest ([UCIPM 2014b](#)). This is supported by comments from several olive experts, including the following:

“Only options for scale control in olives in season (July – harvest) are narrow range oil, or narrow range oil + carbaryl. Post-harvest, there are different options ([methidathion]).”

“Growth regulators usually take time to control the scale and are most effective applied in the Fall.”

Therefore, although it is not a critical carbaryl use, I recommend that DPR consider the need to manage resistance for olive scales when selecting mitigation options.

⁹ Narrow range oil is highly-refined petroleum oil that kills certain pests primarily by smothering. Synonyms include crop oil and horticultural oil ([UCIPM 2016b](#)).

5.6 Ornamental-plant production

Includes a critical use of carbaryl: prophylactic control of GWSS on shipments of nursery stock from GWSS-infested counties in southern California to uninfested California counties, as required by quarantine regulations. CDFA's Nursery Stock Approved Treatment Program requires the originating nursery to treat such shipments with an approved insecticide prior to shipment. Only two insecticides are approved: carbaryl and fenprothrin ([CDFA 2011](#)). In response to DPR's request for input about carbaryl critical uses, CDFA's Plant Health and Pest Prevention Services informed DPR:

“fenprothrin also plays a critical role in the Approved Treatment Program, but its more restrictive label (i.e. on food crops, open flowers) often makes carbaryl the only option for these nurseries. In addition, fenprothrin has a 24 hour REI, while carbaryl has a 12 hour REI. This additional 12 hours can have an impact on a rush sale or the ability to deliver the shipment to its destination prior to the expiration of the treatment (5 days). Due to these main factors, over 90% of the shipments in the Approved Treatment Program are treated with carbaryl. Researchers have tested multiple chemicals over the years for consideration as candidate replacement compounds in the Approved Treatment Program and none have provided adequate levels of control.”

Most nursery experts contacted emphasized the importance of carbaryl's 12-hour REI. The following is one example:

“With the 12 REI it allows us to be more competitive with other nurseries shipping into GWSS non-infested counties. If the REI is increased we would lose days that we will be able to ship into GWSS-non-infested counties and lose our customer base in these counties. [Our nursery] fully understands DPR's concern about [carbaryl] having a higher risk than thought. We want our employees to have a safe environment to work in. We would like to have DPR increase PPE for applicators (which we are doing now as you saw) and maybe have some type of increase of PPE for [re-entry] workers (like Long sleeved shirts Etc...) But keep the REI the same.”

Given that treatment is mandatory under quarantine regulations, and that there is only one approved alternative, prophylactic GWSS control on shipments of nursery stock from GWSS-infested counties is a critical carbaryl use.

5.7 Tomato production

Includes a critical use of carbaryl: use of granular bait formulations to control soil-dwelling insects. This group of pests, and the usefulness of baits to control them, were already discussed for melons in section 5.3.1.

In tomato production, soil-dwelling insects chew the stems of young plants shortly after planting, when even a small amount of feeding can kill a tomato plant. Several experts reported darkling beetle damage to young tomato plants has increased in recent years, due to a reduction in tillage.

Nearly every tomato expert contacted stated that early-season application of carbaryl bait was common and essential. For example:

“Immediately following transplanting, the only effective tool on the market is carbaryl. The pests live in the soil surface, at night they chew the stems in half. 10 – 50% losses have occurred if not applied immediately. . . . We have tried many different products. Some have bee restrictions and some are just not effective on the pests.”

“Carbaryl is the only means of control for the pest spectrum listed above. There are no other registered effective alternative means of control for the target pest spectrum. All of the pests [for which we use carbaryl bait] are either soil dwelling or highly mobile. This makes it nearly impossible to control the listed pests with conventional spray applications of other insecticides. In processing tomatoes, carbaryl is applied as bait to the soils surface. Target insects will feed on the bait instead of transplanted tomato seedlings.”

Carbaryl is the only bait recommended by UCIPM to control cutworms in tomato ([UCIPM 2013](#)). UCIPM lists darkling beetles as a tomato pest during seedling growth, but does not present control recommendations ([UCIPM 2014c](#)). As in melon, there are at least two alternative active ingredients, permethrin and spinosad¹⁰, that are available in bait formulations labeled for outdoor production-agriculture use on tomato. One tomato expert provided this assessment of the alternative baits:

“Spinosad bait is more effective on earwigs but is a lot more expensive. . . . [and] less effective on ground beetles. . . . Permethrin bait [provides] fair control on ground beetles – but not as effective as [carbaryl] – weaker on cutworms. Have not seen control on earwigs.”

The small number of alternatives, and reports that they are less effective than carbaryl, justifies classifying bait applications for soil insect control in tomato as a critical use of carbaryl.

¹⁰ The insecticidal bacterium *Bacillus thuringiensis* f. sp. *kurstaki* also is available in bait formulation, but has efficacy only against caterpillars in the Order Lepidoptera, and thus would not be expected to control darkling beetles, wireworms, crickets, or earwigs.

6. Implications for risk management

Risk managers within DPR currently are evaluating the carbaryl RCD ([Rubin 2014](#)) to determine whether any of the estimated risks will require mitigation. For an overview of DPR’s risk management process, see [DPR \(2011\)](#).

Carbaryl critical uses that involve granular formulations, namely those within melon and tomato production, produce lower foliar residues than those involving liquid formulations. Thus, if mitigation is determined to be necessary, it may be simpler to mitigate the critical uses that involve granular formulations. Table 1 shows the relationship between carbaryl critical uses identified in this memorandum, and scenarios with MOEs less than 100 or cancer risks greater than 10^{-6} , as reported in the RCD ([Rubin 2014](#)).

Table 1. Overlap between carbaryl critical uses and estimated risks reported in the RCD

X = Scenarios with MOEs less than 100 or cancer risks greater than 10^{-6} are expected to occur within this critical use

? = Scenarios with MOEs less than 100 or cancer risks greater than 10^{-6} might occur within this critical use

| Critical uses identified in this memorandum | Scenarios for which RCD risk estimates include MOEs less than 100 or cancer risks greater than 10^{-6} (Rubin 2014): | | | |
|---|--|---|---|---|
| | Occupational handler ^a (RCD Table IV-7a) | Occupational re-entry ^b (RCD Table IV-7b) | Residential handler & re-entry ^c (RCD Table IV-8) | Bystander ^d (RCD Table IV-11) |
| Apple (liquids for fruit thinning) | X | X | | |
| Melon (baits for soil insects) | X | ? | | |
| Non-production plantings (liquids for GWSS) | X | X | ? | |
| Ornamental production (liquids for GWSS) | X | X | | |
| Tomato (baits for soil insects) | X | | | |

Notes for Table 1:

- a* For occupational handlers, RCD risk estimates include MOEs less than 100 or cancer risks greater than 10^{-6} for most carbaryl formulations and most application methods.
- b* Regarding occupational re-entry, fieldworkers entering **tomato** fields previously treated with carbaryl granules are not expected to have substantial contact with soil or baits. In contrast, scouts entering **melon** fields treated late in the season reportedly would have high contact with soil (and thus potentially with carbaryl bait) when evaluating fruit maturity. Scouting for melon fruit maturity reportedly involves crawling along a row to cut open fruits. For **ornamental production**, retail workers who unload trucks of ornamental plants treated for GWSS with liquid carbaryl formulations would be expected to have high contact with foliar residues, comparable to the scenario “Ornamental plant hand harvesting” in the RCD (Eric. Kwok, DPR Human Health Assessment Branch, personal communication).
- c* Residential re-entry might be an issue if GWSS control requires CDFR quarantine officials to treat ornamental plantings around residences.
- d* Bystander risks are not expected to be unacceptably high for any carbaryl critical uses, because carbaryl critical uses do not involve aerial applications. RCD bystander risk estimates include MOEs less than 100 or cancer risks greater than 10^{-6} only for aerial applications.

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Questions about carbaryl use and fieldworker activities in apple
to help CDPR understand how and why growers use carbaryl,
and what activities fieldworkers do within fields previously treated with carbaryl

October 28, 2015

Contact:

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Background: carbaryl use and products

Carbaryl is a broad-spectrum insecticide used in production of fruits, nuts, field crops, and ornamental plants. In addition, carbaryl is used on non-production plantings including lawns, landscaping, and home gardens. For production agriculture, carbaryl products¹¹ registered in California include both liquid and bait formulations:

- Carbaryl 4L
- Carbaryl Cutworm Bait
- Drexel Carbaryl 4L
- Drexel Carbaryl 5% Bait
- First Choice Carbaryl Cutworm Bait
- Sevin 5 Bait
- Sevin Brand 4F Carbaryl Insecticide
- Sevin Brand XLR Plus Carbaryl Insecticide
- Sevin SL Carbaryl Insecticide
- The Andersons Professional Turf Products 8% Granular Insecticide With Carbaryl

Questions (total of 15):

1. In apple, what are the main uses for carbaryl? In other words, to control which insect pests, or for which horticultural reason such as chemical fruit thinning?
2. Why do growers choose carbaryl products over other pesticide alternatives, or other chemicals such as plant-growth regulators? Possible answers might include less effective, higher cost, insect pests are resistant to other insecticides, etc.
3. Are there any uses for which carbaryl is the **only** suitable tool (in other words, for which there is no suitable alternative to carbaryl)? If so, which use or uses, and why?

(continued next page)

¹¹ Mention of commercial products is not to be construed as either an actual or implied endorsement.

Appendix 1: Representative technical questionnaire

4. The timing of carbaryl applications is shown in Figure 1 (following the questions). Why is carbaryl applied at that particular time (that particular month or growth stage)? Would it be practical to move the application date:
 - 3 to 4 weeks earlier? Or
 - 3 to 4 weeks later?Why or why not?

5. When carbaryl is applied, what type of application equipment is usually used?
 - /___/ Aircraft (fixed-wing or helicopter)
 - /___/ Airblast (a large motorized fan that usually is pulled behind a tractor)
 - /___/ Motorized ground sprayers other than airblast (e.g., boom sprayers)
 - /___/ Motorized ground equipment for applying granule or bait formulations
 - /___/ Hand-held equipment such as wands, hose-end “guns”, or hand-held equipment for applying granule or bait formulations

6. If carbaryl is usually applied via aircraft or airblast, would it be practical to apply it via motorized ground sprayers (e.g., boom sprayers)? Why or why not?

7. The range of carbaryl application rates is shown in Figure 2 (following the questions). Are there situations where using a lower rate of carbaryl would be practical? If so, which situations and why? If not, why not?

8. How many times during each cropping cycle is carbaryl usually applied? If more than once, would it be practical to reduce the number of applications per cropping cycle? Why or why not?

9. During the months when carbaryl is usually applied (Figure 1), what crop management activities do fieldworkers usually carry out in apple fields? Possible answers might include manipulating irrigation equipment, pruning branches, manual thinning of fruit, harvesting, etc.

10. Why do fieldworkers carry out those crop management activities at that particular time (that particular month)? Would it be practical for fieldworkers to do that activity:
 - 3 to 4 weeks earlier? Or
 - 3 to 4 weeks later?Why or why not?

(continued next page)

Appendix 1: Representative technical questionnaire

11. When carrying out those crop management activities, which of the following apparel do fieldworkers usually wear? Check all that are worn by most fieldworkers:

Clothes:

- Long pants
 Long-sleeved shirt
 One-piece coveralls with long sleeves and long pants legs
 Jacket or coat that is not waterproof (for example, made of cotton or wool)
 Jacket or coat that is waterproof (for example, a raincoat or nylon poncho)

Head covering:

- Head covering that is not waterproof (bandana, hat, or hood of a jacket that is not waterproof)
 Head covering that is waterproof (bandana, hat, or hood of a jacket that is waterproof)

Shoes:

- Open-toed shoes such as sandals
 Closed-toe shoes or boots that are not waterproof (for example, made of leather)
 Closed-toe shoes or boots that are waterproof (for example, made of rubber)

Gloves:

- Gloves that are not waterproof (for example, made of leather or cloth)
 Gloves that are waterproof

12. Is there ever a need for fieldworkers to enter a carbaryl-treated field while the Restricted Entry Interval is still in effect (called “early-entry fieldworkers”)? If so, what crop management activities are those early-entry fieldworkers usually doing? Would it be practical to postpone those activities until after the Restricted Entry Interval has expired? Why or why not?
13. Is there anything else that would be helpful for us to know about carbaryl use or fieldworker activities?
14. If there were any questions for which you were unsure about the answer, could you recommend a person or organization that might be able to provide the answer?
15. Would you have preferred to answer these questions via some other method (for example, via an in-person interview, or via an online survey such as SurveyMonkey)? If so, please tell us what method you would have preferred.

Thank you for your help! Learning how growers manage pests and crops helps DPR plan its pesticide guidelines to fit growers’ needs as much as possible.

Figure 1. Timing of carbaryl applications to California apple fields, 2009 – 2013

Source of data: CDPR Pesticide Use Report database, queried via Cal-PIP

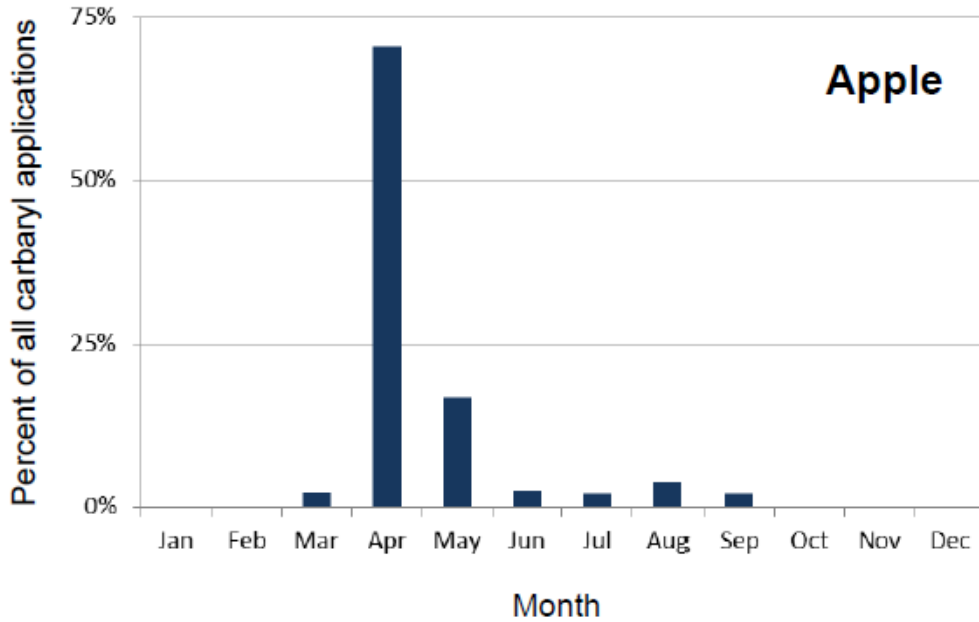
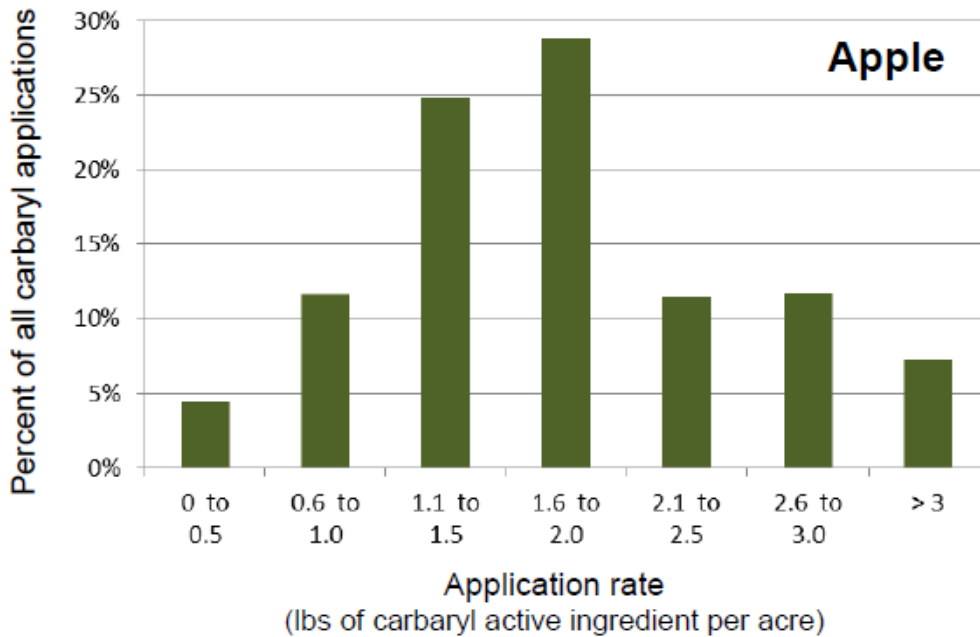


Figure 2. Rate of carbaryl applied to California apple fields, 2009 – 2013

Source of data: CDPR Pesticide Use Report database, queried via Cal-PIP



Carbaryl factfinding: Short questionnaire for apple growers

WHS Branch, California Department of Pesticide Regulation (DPR)
December 29, 2015

- 1) Do you use carbaryl? (Most carbaryl products have “Carbaryl” or “Sevin” in their name. For your convenience, the names of some carbaryl products are listed on the back of this questionnaire.)

- 2) If you use carbaryl, for what purpose do you use it? In other words, to control which insect pests, or for which horticultural reason such as changing the growth pattern of the plant?

- 3) If you use carbaryl, how important is it for your production:
/___/ Slightly important (I have alternatives that are as good or better)
/___/ Important (carbaryl is one of my go-to tools)
/___/ Very important (it would be difficult for me to produce without carbaryl)

- 4) Would you or your PCA be willing to discuss how and why you use carbaryl with DPR? If so, please provide contact information so DPR could send you some additional questions, or meet with you in person if you prefer:

Background: carbaryl use and products

The California Department of Pesticide Regulation (DPR) is gathering information about how the apple industry uses carbaryl, because recent analyses by DPR indicate that health risks for some carbaryl uses appear to be higher than DPR’s usual risk targets. Therefore, DPR is evaluating what steps we need to take, if any. Learning how apple growers manage pests and workers helps DPR plan its pesticide guidelines to fit growers’ needs as much as possible.

(continued on next page)

Appendix 2: Representative short questionnaire

Carbaryl is a broad-spectrum insecticide used in production of fruits, nuts, field crops, and ornamental plants. In addition, carbaryl is used on non-production plantings including lawns, landscaping, and home gardens. For production agriculture, carbaryl products¹² registered in California include both liquid and bait formulations:

- Carbaryl 4L
- Carbaryl Cutworm Bait
- Drexel Carbaryl 4L
- Drexel Carbaryl 5% Bait
- First Choice Carbaryl Cutworm Bait
- Sevin 5 Bait
- Sevin Brand 4F Carbaryl Insecticide
- Sevin Brand XLR Plus Carbaryl Insecticide
- Sevin SL Carbaryl Insecticide
- The Andersons Professional Turf Products 8% Granular Insecticide With Carbaryl

Contact:

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¹² Mention of commercial products is not to be construed as either an actual or implied endorsement. Some products may not be approved for apple production. Read and follow label instructions and restrictions.