



HONEY BEE BEST MANAGEMENT PRACTICES FOR CALIFORNIA ALMONDS

A GUIDE FOR POLLINATION STAKEHOLDERS



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KEEPING HONEY BEES HEALTHY

Honey bees are essential for successful pollination of almonds and the long-term health of the California almond industry. Why should almond growers — and all parties involved in almond pollination — care about healthy, strong bees?



BEES ARE A VALUABLE RESOURCE and almond production input, and the time they spend in almonds impacts hive health throughout the year, from the time they leave almond orchards until they return the next season.



ALMONDS ARE ONLY ONE OF MORE THAN 90 FOODS THAT RELY ON POLLINATION BY BEES, due to the industry's size and number of bees needed, the public is increasingly watching the California almond community on matters related to the health and stability of honey bee populations.

Of concern is how to manage the use of pest control materials in ways that minimize their potential impact on honey bees and other pollinators. It is important that growers of all crops implement best management practices to support bee health, and for those whose crops rely on honey bee pollination to consider honey bee health not only during the pollination season but throughout the entire year.

The Almond Board of California (ABC) and partners continue to support bee health research in a variety of areas. The following pages outline the best management practices that this bee health research determined will promote the health of honey bees and protect them from environmental factors that could be detrimental to their health in the orchard. While many of these practices are generally applicable across all crops, some are almond specific.

This guide covers precautions to follow to protect honey bees during the almond pollination season. Four key precautions are:

- Maintain clear communication among all parties involved, particularly on the specifics of pesticide application.
- If it is necessary to spray the orchard (with fungicides, for instance), do so in the late afternoon or evening when bees and pollen are not present.
- Avoid tank-mixing products (i.e., combining more than one formulated product) during bloom until more is known in this area.
- Avoid applying insecticides during bloom until more is known about the applications' effects on honey bees, particularly to young, developing bees in the hive. Fortunately, there are several insecticide application timing options available beyond bloom-time treatments.

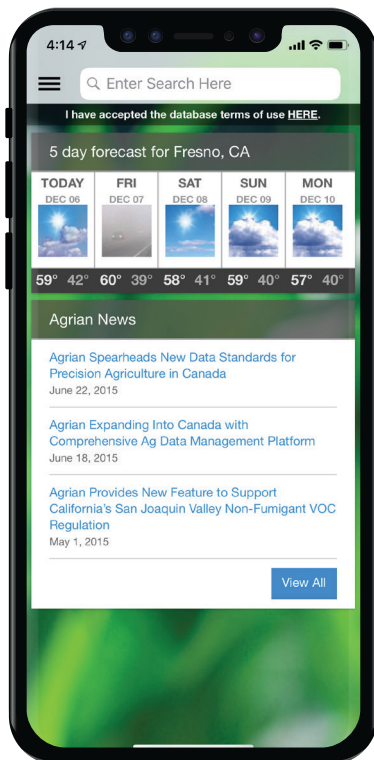
California almond growers and others involved in the almond pollination process should follow these important best management practices to preserve the health of honey bees in California almond orchards.

THE COMMUNICATION CHAIN

Establish a clear communication chain among all parties involved in pollination and pest management to help ensure that responsibilities are met and information is effectively conveyed.

The acting parties may simply be a beekeeper and a grower, but depending on the scale and organization of the operation, those involved in the almond pollination process may also include a bee broker, pest control adviser (PCA) and certified pesticide applicator (CPA).

California county agricultural commissioners are also a vital link in the communication chain as each year they require beekeepers in California to register their hive locations and update their locations within 72 hours after they move. Hive registration offers county agricultural commissioners and staff visibility of all registered hive locations in a certain area.



As the Bee Where program evolves, electronic crop management systems will provide advisories on hive locations.

One option for hive registration is the Bee Where program, which offers beekeepers a dynamic, real-time geographic information system (GIS) where they can mark hives with a simple pin drop in the orchard via a mobile app. Hives may be electronically registered using the Bee Where program's registration portal located at BeeWhereCalifornia.com, where hive locations will be visible on a GIS grid.

On the Bee Where program's website, applicators who intend to apply products that may be toxic to bees can see hive locations within a 1-mile radius of orchards where sprays are planned and access beekeepers' information and contact them. Applicators can also receive this information from their local county agricultural commissioner. Knowing where sprays are planned and where hives are located allows beekeepers to be notified 48 hours ahead of intended sprays, which is particularly important when insecticides are being applied and even outside the almond bloom season. Regardless of these precautions, all pollination stakeholders should note that a 1-mile buffer will not protect honey bee colonies under all conditions, as bees may forage up to 4 miles away from their hives to collect food and find water when resources are scarce.^{1,2}

¹ Eckert, J.E. 1933. The flight range of the honey-bee. J. of Agri. Res. 47(8):257-285.

² Beekman, M. and F.L.W. Ratnieks. 2001. Long-range foraging by the honey-bee, *Apis mellifera* L. <https://besjournals.onlinelibrary.wiley.com/doi/full/10.1046/j.1365-2435.2000.00443.x>

**BEEKEEPER
&
BEE BROKER**

**ALMOND
GROWER**

**PEST CONTROL
ADVISER (PCA)**

APPLICATOR

**COUNTY
AGRICULTURAL
COMMISSIONER**

BEEKEEPER & BEE BROKER

- **ENGAGE IN AGREEMENTS** with growers.
- **REGISTER HIVES** through the Bee Where program at BeeWhereCalifornia.com by Jan. 1 each year or upon hive arrival in California.
- **CHECK HIVE LOCATIONS** and update locations with any hive movement using the Bee Where app.
- **CLEARLY MARK EACH COLONY** with beekeeper contact information.
- **IMMEDIATELY REPORT** suspected pesticide-related bee incidents to a grower or county agricultural commissioner at almond bloom and throughout the year.

ALMOND GROWER

- **ENGAGE IN AGREEMENTS** with beekeepers/bee brokers.
- **COMMUNICATE DETAILS** and specifications of agreements, including pesticide applications, to beekeepers and other stakeholders down the chain (i.e., PCA, applicator).
- **FOLLOW PRACTICES** in the Honey Bee Best Management Practices Quick Guide and, if applying pesticides, follow the Honey Bee BMP Quick Guide for Applicators.
- **CONTACT BEEKEEPERS** 48 hours before a pesticide application. This includes beekeepers pollinating the orchard and beekeepers within 1 mile of the orchard. Ensure the appropriate individual (i.e., applicator) visits BeeWhereCalifornia.com to locate hives or contacts a county agricultural commissioner directly to locate hives within a 1-mile radius of the application site.
 - **AN ADVANCED WARNING** is mandatory for pesticide products with the statement “toxic to bees” on the Environmental Hazard section of the label and is recommended for all other applications, particularly during almond bloom.
- **IMMEDIATELY REPORT** suspected pesticide-related bee incidents to a beekeeper or county agricultural commissioner at almond bloom and throughout the year.

PEST CONTROL ADVISER (PCA)

- **COMMUNICATE DETAILS** and specifications of pesticide application agreements made with the beekeeper, including specific application recommendations, to the applicator.
- **CONTACT BEEKEEPERS** 48 hours before a pesticide application. This includes beekeepers located within 1 mile of the orchard. Ensure the appropriate individual (i.e., applicator) visits BeeWhereCalifornia.com or contacts a county agricultural commissioner directly to locate hives within a 1-mile radius of the application site.
- **FOLLOW PRACTICES** in the Honey Bee Best Management Practices Quick Guide.
 - **AN ADVANCED WARNING** is mandatory for pesticide products with the statement “toxic to bees” on the Environmental Hazard section of the label and is recommended for all other applications, particularly during almond bloom.
- **IMMEDIATELY REPORT** suspected pesticide-related bee incidents to the grower, beekeeper or county agricultural commissioner at almond bloom and throughout the year.

APPLICATOR

- **FOLLOW PRACTICES** in the Honey Bee Best Management Quick Guide for Applicators and relay messages to the spray-rig driver.
- **CONTACT BEEKEEPERS** 48 hours before a pesticide application. This includes beekeepers pollinating the orchard and beekeepers within 1 mile of the orchard. Visit BeeWhereCalifornia.com or contact a county agricultural commissioner directly to locate hives within a 1-mile radius of the application site.
 - **AN ADVANCED WARNING** is mandatory for pesticide products with the statement “toxic to bees” on the Environmental Hazard section of the label and is recommended for all other applications, particularly during almond bloom.
- **IMMEDIATELY REPORT** suspected pesticide-related bee incidents to the grower, beekeeper or county agricultural commissioner.

COUNTY AGRICULTURAL COMMISSIONER

- **OVERSEE HIVE REGISTRATION** and map via CalAgPermits and the Bee Where program.
- **PROVIDE PESTICIDE APPLICATORS** with contact information for beekeepers with hives registered within a 1-mile radius of the application site.
- **INVESTIGATE REPORTS** of suspected pesticide-related bee incidents.



GROWER-BEEKEEPER COMMUNICATION PRIOR TO ALMOND BLOOM

Communication is the first step toward a successful almond pollination season as it ensures expectations between the beekeeper and grower are fully understood. Growers should contact beekeepers as early as possible before the pollination season to discuss their requirements and expectations. Growers who do not have an established relationship with a beekeeper can refer to ABC’s pollination directory at Almonds.com/PollinationDirectory for a database that includes both beekeepers and bee brokers.

Growers and beekeepers should outline and mutually agree on their expectations for each other to avoid misunderstandings. Communication on pesticide use during bloom, for instance, should be a fundamental conversation, and could involve outlining a pesticide plan that specifies which pest control materials might be used. The grower and beekeeper should agree on which products can be applied if a treatment is deemed necessary. Before bloom, when applications are imminent, it’s important to establish a line of open communication between all who are involved in pollinating almonds and/or applying pesticides to



For successful pollination and safeguarding of honey bees, growers should contact beekeepers early and create an agreement that outlines the expectations of both parties.

orchards so that each party in the communication chain is informed in advance of this busy season.

By registering hives and providing their locations electronically with the county agricultural commissioner through the Bee Where program, found at BeeWhereCalifornia.com, beekeepers can request an advance notice of pesticide applications labeled as "toxic to bees" within a 1-mile radius of the colonies. This advance warning is mandatory for pesticide products with "toxic to bees" label statements and recommended for all other applications, particularly during almond bloom.

Beyond pesticide applications, growers and beekeepers should agree upon each other’s responsibilities in these areas prior to bloom:

Growers and beekeepers can access a sample template of an almond pollination agreement at ProjectApism.org under the Resources tab in the section titled, “Best Management Practices for Almond Growers.”



THE NUMBER OF FRAMES of honey bees, including an average and minimum frame count.



DATE AND LOCATION of hive placement in the orchard.



AMBIENT TEMPERATURE and time of day at the inspection site in the field.



PAYMENT TERMS, including the deposit, progress payment and final payment.



ACCESSIBILITY of colonies to beekeeper.



WHEN BEES ARE REMOVED from the orchard.

PREPARING FOR ARRIVAL

For pollination in mature almond orchards, it is common practice to place an average of two hives per acre and to have an average of eight frames of bees with a six-frame minimum hive strength.³ However, there are a number of variables involved in any local situation, and pollination requirements will vary.

HIVES SHOULD BE PLACED:



Where they are accessible and convenient at all hours for servicing and removal.



With eastern and southern exposures for hive openings to encourage honey bee flight.



Near flowering forage before and after bloom if possible.



Away from areas prone to shade or flooding.

GROWERS + BEEKEEPERS SHOULD:

PROVIDE A CLEAR AREA for bee drop-off and keep access roads maintained and free of obstructions at all times.

CHOOSE LOCATIONS that have appropriate buffers between pesticide-treated areas and colonies.

PROVIDE ABUNDANT POTABLE WATER that is free from contamination for bees to drink, and the grower and beekeeper should determine who will be responsible for providing and maintaining water. This will ensure that bees spend more time pollinating the crop than searching for water and safeguards against bees using water that is contaminated with pesticides. Water should be checked and replenished throughout the bees' time in the orchard. Landings such as burlap or screens over containers make water accessible and prevent bee drowning. The responsible party should also either cover or remove water sources before a pest control treatment, or supply clean water after a treatment is made.

Provide bees with clean, potable water sources with landings, like this cloth. Water sources should also be covered or removed before a pest control treatment, or clean water should be supplied after a treatment is made.



³ Mueller, Shannon. 2012. "Colony Strength Evaluation." Presented at The Almond Conference.

ASSESSING HIVE QUALITY AND STRENGTH

Hives should be inspected as they arrive in the orchard, either by the beekeeper or an objective third-party apiary inspector, and the grower should observe the inspection. Hives should be inspected for colony strength (see Preparing for Arrival, Page 7) and for other parameters as agreed upon between the grower and beekeeper.

An inspection will determine if the terms stated in the grower/beekeeper agreement are being met. Typically, only a representative sample of hives will be inspected. If the beekeeper is not conducting the inspection, growers should be sure to notify the beekeeper of the inspection so they can assist in handling the hives. It is best to let the hives acclimate to the orchard landscape before conducting the inspection.

Colony strength evaluations not only help ensure growers get what they pay for, they also help ensure that beekeepers are compensated for additional expenses in providing quality hives.

Comprehensive guidelines for all parties can be found in the learning course “Honey Bees and Colony Strength Evaluation,” which can be accessed at Class.UCANR.edu in the Agriculture folder. This online education and training course provides protocols for assessing the strength of honey bees and colonies, and can also help growers become better informed when renting hives from beekeepers and hiring apiary inspectors. The course covers basic bee biology and colony organization, different inspection procedures and standards, and how to recognize some parasites, diseases and other potential problems.

Growers can further monitor colony strength by walking orchards daily during bee flight hours to observe activity levels. In addition, growers should record hives that appear weak (i.e., relatively few bees coming and going at the hive entrance) or inactive, and then report those hives to the beekeeper.



Hives should be inspected by an apiary inspector or the beekeeper as soon as bees arrive in the orchard.



A hive inspection includes an evaluation of colony strength. (Photo courtesy Project Apis m.)



When walking orchards during bee flight hours, look for bees carrying pollen on their legs, which confirms that pollination is taking place. (Photo courtesy Project Apis m.)

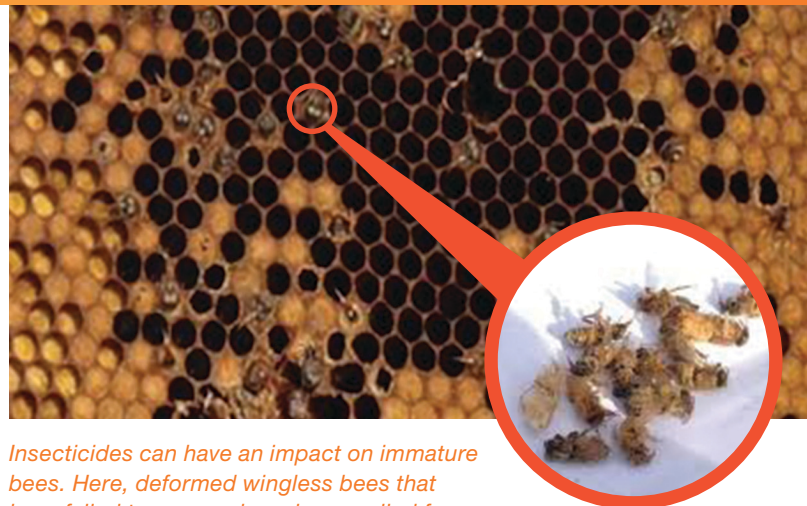
PROTECTING HONEY BEES AT BLOOM

Due to a combination of factors, including Varroa mite, loss of natural forage, disease and the effects of some pesticides, beekeepers are losing a large number of colonies.⁴ Researchers continue to study the causes of these losses and how to prevent them; this is an ongoing effort.

Honey bees are vulnerable to many of the pesticides used to control insects, disease and weeds. As such, pesticides that are used within the hive for mites and disease control, as well as those applied on crops, are currently under investigation. Their methods of application are also under investigation. California almond growers must maintain a delicate balance between protecting their crop from disease, insects and weeds, while at the same time protecting honey bees from potentially harmful pest control materials.

HONEY BEES AND INSECTICIDES

Insecticides — a term that includes insect growth regulators, also known as IGRs — should not be applied during bloom. The only exception is *Bacillus thuringiensis* (Bt), which can be applied safely because it is documented to be safe for both adult and immature bees. Some bee losses in almonds also have been associated with tank-mixing insecticides and bloom-time fungicides. While these losses could have other causes, tank-mixing warrants a scientific basis for concern that is based on a combination of field experience and controlled studies.^{5,6} Currently, most bee label warnings are only based on adult acute toxicity studies; however, recent information indicates some pesticides, insecticides included, may be harmful to developing eggs, larvae or pupae (collectively referred to as “bee brood”) in the hive. Because the length of a brood’s lifecycle is about 21 days, problems like deformed wingless bees that fail to emerge from the hive may not appear until after almond bloom. Specifically, deformed wingless bees are pulled from their comb cells by other bees and then are commonly found in front of the



Insecticides can have an impact on immature bees. Here, deformed wingless bees that have failed to emerge have been pulled from their comb cells by other bees, leaving those comb cells empty.

hive entrance, leaving those comb cells empty. The Environmental Protection Agency (EPA) now requires data for possible pesticide effects on bee brood. Insecticide residues, specifically, have been detected in the pollen that foragers bring back to the hive, which is fed to the bee brood.

Furthermore, controlled studies⁶ demonstrate that some insecticides are known to interact with some fungicides, such that when they are tank-mixed they can have greater cumulative toxicity to bees than either chemical used alone. This synergy is being documented in ongoing studies,⁶ so until more is known, avoid tank-mixing an insecticide — except for Bt — with a fungicide during almond pollination.

It is important to note that tank-mixing of a number of these insecticides and fungicides is not specifically prohibited by the label. The EPA and the California Department of Pesticide Regulation (DPR) are looking to include warnings on product labels to outline which specific tank-mixing combinations should not be made.

⁴ Kulhanek, Kelly et al. 2017. A national survey of managed honey bee 2015-2016 annual colony losses in the USA. Journal of Apicultural Research. 56 (4): 328-340. <https://www.tandfonline.com/doi/abs/10.1080/00218839.2017.1344496>

⁵ Mussen, Eric. 2013. Problems with almond bloom sprays. UC Apiaries newsletter, Jan./Feb. 2013.

⁶ Johnson, Reed. 2017. Effects of Insecticide-Fungicide-Adjuvant Combinations Commonly applied during bloom on Honey Bee Development and Survival. Almond Board of California 2017 Research Update, p. 47.

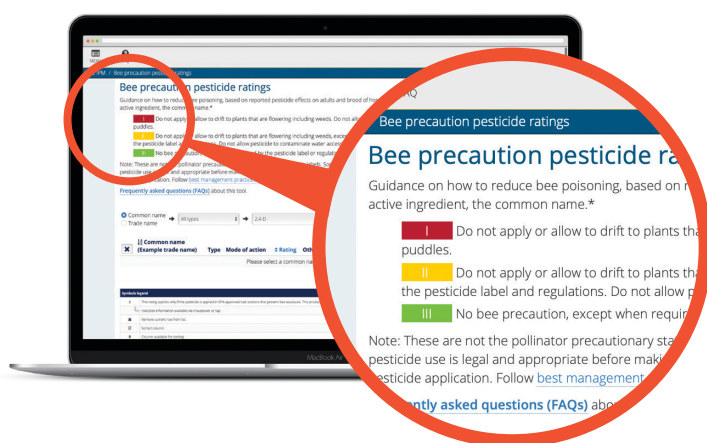


Label language will continue to evolve as more information becomes available on the effects of pesticides on bee brood. However, until more is known about the effect of insecticides on bee brood, growers and their applicators should avoid applying any insecticide, except Bt, during almond bloom in order to protect bee brood, and instead should consider other effective timing options for applications outside of the bloom period.

Before making insecticide applications during the delayed-dormant, bloom or post bloom periods, the appropriate individual (i.e., applicator) should visit BeeWhereCalifornia.com or contact their county agricultural commissioner to locate hives within a 1-mile radius of the spray site. They should also notify the beekeeper of the upcoming spray.

The University of California Statewide Integrated Pest Management Guidelines for almonds provide insecticide application and timing options at IPM.UCDavis.edu under the Agricultural Pests section. The UC Statewide IPM site also has an interactive tool for determining bee precaution pesticide ratings.

Another valuable resource is “How to Reduce Bee Poisoning from Pesticides,” a Pacific Northwest Extension publication, PNW 591. Toxicity ratings in this publication focus on acute contact toxicity to adult foraging bees, and new information on additional risks to bee brood in the hive are included when available. A free downloadable version is available at Almonds.com/BeeBMPs and a free app is available at Almonds.com/OSUBeeApp.



The University of California Statewide Integrated Pest Management Program provides guidance on bee precaution pesticide ratings at IPM.UCANR.edu/BeePrecaution.

HONEY BEES AND FUNGICIDES

All parties involved in almond pollination or pesticide applications should only apply fungicide(s) deemed necessary and, during bloom, should only apply those fungicides in the late afternoon or evening when bees and pollen are not present. Fungicide applications are needed in many situations as disease protection during almond bloom is key. However, fungicides may negatively impact pollination. For example, spraying while bees are foraging weakens the floral-scented chemicals that draw the bees to the blossom. In fact, there is also research that shows some fungicides, while fairly safe for use around adult honey bees, may contribute to brood losses in larval and pupal stages.⁷

Delayed dormancy is the period of time from the resumption of growth after dormancy — indicated by bud swell, up until green tip — which occurs around Feb. 1, depending on region, variety and weather. This period is followed by bloom. Post bloom begins after petal fall, which is typically in late March but may vary based on region, variety and weather. As shown in this image, bloom sprays made at night will minimize the exposure of bees and pollen to spray chemicals.



⁷ Mussen, E.C., J.E. Lopez, C.Y.S. Peng. 2004. *Effects of selected fungicides on growth and development of larval honey bees, Apis mellifera L.* Environ. Entomol. 33(5):1151-1154.

The University of California recommends avoiding the use of fungicides containing iprodione, captan or ziram during almond bloom, and research performed in response to field observations of brood effects confirms that these fungicides can affect brood development. These compounds, however, do provide effective fungal control outside of bloom.

As previously noted, controlled studies⁸ demonstrate that some insecticides are known to result in greater than additive toxicity when combined with certain fungicides such that when the insecticide and fungicide are tank-mixed, the combination can be more toxic to bees than either chemical used alone. Until more is known, avoid tank-mixing insecticides with fungicides during the almond pollination season, the only exception being mixing Bt with a fungicide.

USE INTEGRATED PEST MANAGEMENT TO MINIMIZE SPRAYS

Following a monitoring-based integrated pest management (IPM) program in every season enhances pest control, protects water and air quality, and minimizes exposure of bees and pollen to pesticide sprays. Sources of information on developing and implementing an IPM program in almonds include the "UC Statewide IPM Pest Management Guidelines" and "Year-Round IPM Program for Almonds," which are available at IPM.UCANR.edu under Agricultural Pests and Almond.

HONEY BEES AND SELF-COMPATIBLE ALMOND VARIETIES

Self-compatible (or self-fertile) varieties do require bees for pollination, although the number of bees required to pollinate the blossoms is reduced. A number of factors — genetic, environmental and even the individual flowers — determine self-pollination and set. Even with self-compatible varieties, honey bees can ensure maximum set because bees consistently transfer pollen within the same flower from the anthers to the stigma of the pistil, where fertilization is initiated (see Fig. 1, Page 18). However, with self-compatible varieties, because pollen no longer needs to be transferred between different varieties, the number of hives needed is reduced.



UC IPM online provides many resources to almond growers.



BE CAUTIOUS ABOUT ADJUVANTS

The University of California recommends adjuvants should not be used with fungicides during bloom, unless specified otherwise on the label. Most fungicides are already formulated with adjuvants, including wetting agents, spreaders and stickers. With few exceptions, additional adjuvants do not statistically improve the efficacy of fungicides for managing diseases. Although there is limited information on the interaction of adjuvants and fungicides with honey bees, it is best to take a precautionary approach because adjuvants may increase the wettability of bees and subsequently the potential toxicity of fungicides to bees. For more detail, see "Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut, Strawberry, and Vine Crops," available at Almonds.com/UCPollination.

⁸ Johnson, Reed. 2017. Effects of Insecticide-Fungicide-Adjuvant Combinations Commonly applied during bloom on Honey Bee Development and Survival. Almond Board of California 2017 Research Update, p. 47.

BEST MANAGEMENT PRACTICES FOR PEST CONTROL DURING BLOOM

Follow these precautions to help protect honey bees from pesticide applications:

- Read labels carefully and follow directions.
- Do not use pesticides with cautions on the label that read “highly toxic to bees,” “toxic to bees,” “residual times” or “extended residual toxicity.” Residual toxicity to bees varies significantly between pesticides and pesticide products, and their impact can last anywhere from hours to a week, or more.
- Avoid applying insecticides — except Bt — during bloom until more is known about their potential risk to bees. If treatment is necessary, only apply fungicides and avoid tank-mixing insecticides with fungicides (unless mixing with Bt).
- Apply fungicides in the late afternoon or evening, when bees and pollen are not present, as bees collecting pollen often leave the almond blossoms by mid-afternoon. This later application will help avoid contaminating pollen with spray materials. However, do not spray so late that the fungicide does not have time to dry before bees begin foraging the next day.

See the sections "Evaluating the Pollination Process" and "Removing Honey Bees from the Orchard" for guidelines on how to determine whether exposed pollen is present in flowers.

- Adjuvants should not be used with fungicides during bloom, unless stated otherwise on the label. Most fungicides are formulated with adjuvants including wetting agents, spreaders and stickers.
- Cover or remove water sources before spraying or supply clean water for bees after a treatment is made.
- Do not directly spray hives with any pesticide. Ensure that the spray-rig driver turns off nozzles when near hives.
- Do not hit flying bees with spray applications. Bees that come in contact with agricultural sprays will not be able to fly because of the weight of spray droplets on their wings. Be sure to avoid pesticide application or spray drift to blooming weeds in or adjacent to the orchard when honey bees are present.
- Before bloom, avoid applying a pesticide with a long residual (extended residual toxicity or systemic pesticides).

More information on residue toxicity is available in “EPA Information on Residue Toxicity Times for Growers and Beekeepers,” which is located at Almonds.com/BeeBMPs.

Remember to keep all parties informed of agricultural sprays according to the communication chain agreed upon so that beekeepers are always aware of impending applications and applicators are fully informed of the parameters regarding materials, timing, location and method of application.



ADDRESSING SUSPECTED PESTICIDE-RELATED HONEY BEE LOSSES

It is in the best interest of beekeepers and growers to immediately report suspected pesticide-related bee incidents to the local county agricultural commissioner's office.

POSSIBLE SIGNS OF A PESTICIDE-RELATED INCIDENT INCLUDE:

- Excessive numbers of dead and dying adult honey bees in front of hives.
- Dead brood at the hive entrance and dead newly emerged workers (they appear fuzzy).
- Lack of foraging bees on a normally attractive blooming crop.
- Bees that are lethargic (i.e., dazed, unconscious) or immobile, and are unable to leave flowers.
- Bees that are demonstrating jerky, wobbly or rapid movements; spinning on their backs; or are excessively grooming.
- Disorientation and reduced efficiency of foraging bees.
- Bees that are unable to fly and are crawling slowly, as if chilled.



WHAT SHOULD YOU DO?

In reporting a suspected incident to the local county agricultural commissioner's office, include notes describing the previous health of the colony, prevailing wind, EPA registration number from the suspected pesticide label, name of the suspected pesticide and how the bees may have been exposed to the pesticide. Photos or videos of the incident can also be included.



Beekeepers should also report pesticide treatments applied to the hives and pertinent details related to the health of the bees leading up to the incident.



Immediately freezing at least two ounces of adult bees, brood, pollen, honey, nectar or wax in labeled, clean containers will preserve the evidence of an incident and may be helpful if the incident warrants lab analysis.



Do not disturb the hives or site when an investigation is pending.



EVALUATING THE POLLINATION PROCESS

Pollen is released when anthers split open, or dehisce, once temperatures reach above 55°F. After blossoms open, they release pollen for about four days. This process happens in progression; the anthers do not open all at once.

On a typical day in bloom, the bees have collected the pollen that was released by mid-afternoon. The blossom's pollen-receiving structure, the stigma surface, is receptive to fertilization for about five days after the flower opens. However, fertilization is most successful when pollination occurs during the first few days that a flower is open. Bees, both pollen and nectar collectors, concentrate on newly opened blossoms. One study found about 90% of all bee visitations were confined to flowers that have pollen. With adequate weather and bee activity, essentially all pollen will be collected from individual flowers within about four days after they have opened. In fact, past studies show that during favorable pollination weather, blossoms remain receptive to cross-pollination up to four-to-five days after opening. Cooler weather — below 60°F — will lengthen the period of pollen collection and flower receptivity, and will delay petal fall.

Petals normally remain on flowers past the receptive period for cross-pollination, but once the pollen is depleted bee visitation to flowers drops off substantially and the remaining few visitors concentrate on collecting nectar. Nectar collectors



are not efficient pollinators. These bees typically descend on the petals, probe for nectar at the base of flowers, and rarely pick up or transfer pollen. In contrast, pollen-collecting bees descend on the top of anthers and transfer pollen to the stigma surface, which is necessary for fertilization.

Determining if flowers have pollen and are receptive to cross-pollination is fairly simple. In newly opened flowers, most, if not all, anthers have not yet opened and are plump; yellow, but not fuzzy. Anthers with pollen appear yellow and fuzzy, and for about four days there will be a mixture of opened (dehisced) and unopened anthers. Older anthers without pollen are dry and light brown, and in older flowers when none of the anthers have pollen, the style (the tube below the stigma surface) turns from green to brown, and the stigma and style are no longer receptive to pollination.

It is best to check for pollen in the morning before honey bees finish foraging for all the pollen available that day.



WHAT TO EXPECT IN AN INVESTIGATION

States have primacy in enforcing labels and investigating suspected pesticide-related incidents, including those associated with adverse effects on honey bees. In California, suspected honey bee pesticide-related incidents are investigated by the local county agricultural commissioner, aided at times by California DPR.

AN INVESTIGATION WILL INCLUDE THE FOLLOWING:

- County agricultural commissioners will gather pesticide use information to determine which pesticides were used in the vicinity where the hives were placed.
- The surrounding area will be surveyed to consider how pesticides may have been applied to blooming crops, orchards or weeds where the bees may have been foraging.
- The beekeeper will be asked about any pesticide treatments made to the hives to protect against various hive pests. Samples from the bees and from the surfaces of the identified hives may be collected for analysis of pesticide residues.
- If specific pesticides are suspect, the analysis may be limited to those compounds; however, if specific products are not identified, then the samples may be subject to a broad spectrum (multi-residue) analysis.

If a beekeeper expresses concern that their bees may have been affected by pesticides, a report needs to be submitted by the beekeeper, grower or other involved parties listed on the Honey Bee BMP Communication Chain (on Page 5) to the county agricultural commissioner's office. Accurate information and real data can only be obtained if suspected bee incidences are properly investigated, as without an investigation it becomes a matter of opinion and supposition. These reports should be submitted as soon as possible after an incident occurs to help ensure the details are documented as accurately as possible.



In cases of suspected honey bee pesticide-related incidents the area surrounding affected hives will be inspected.





CONSIDER PLANTING SUPPLEMENTAL FORAGE

Ongoing Almond Board-funded research shows that planting forage provides honey bees with better nutrition — and healthy honey bees means better pollination.⁹

FORAGE BENEFITS FOR BEES AND ALMOND POLLINATION

Research shows that forage does not compete with almond blooms and indicates a trend toward increased colony strength with supplemental forage, in particular with the brassicas.¹⁰ In general, orchards with supplemental forage plantings tend to have higher nut set than those without plantings.¹¹

Plantings consistently extend flower resources for bees after orchard bloom. Supplemental forage in particular provides bees with natural nutrition before and after bloom, when there is a dearth of pollen. Honey bees respond positively to forage plantings and collect pollen and forage from them.¹¹ Plantings can also be managed to flower before the almond blossoms and can provide supplemental nutrition for bees ahead of bloom.

In light of researchers' discovery of forage's benefits for bees, emerging agreements include a discount on hive rental prices if forage is planted.

HORTICULTURAL CONSIDERATIONS

Bee forage can be planted within the orchard as a cover crop or adjacent to orchards, i.e., along margins or in open fields nearby.

In addition to providing robust food resources for honey bees, growers who plant bee forage cover crops within orchards may benefit from multiple other improvements, including:

-  Improved soil fertility
-  Improved water infiltration
-  Improved soil moisture conservation
-  Fixed nitrogen
-  Increased organic material
-  Soil stabilization and erosion control

The Almond Board of California is funding research to better understand the benefits and trade-offs of in-orchard plantings. Some of the key items of study include:¹²



Impact on soil health.



Water use (both for the cover crop and tree water status).



Potential for frost damage (impact on soil and air temperature).



Soil-borne pests and weed suppression.



Navel orangeworm: How do cover crops impact populations in grounded mummy nuts?



Cover crop management: What are the best mixes for different situations and what is the best date to terminate?

⁹ DeGrandi-Hoffman, G.; Chen, J.; Carroll, M., 2013. Comparing the Effects of Protein Supplements vs. Natural Forage on Colony Health, 2013-2014 Almond Board of California Annual Research Reports.

¹⁰ Nino, Elina, 2016 and 2017. Longitudinal Evaluation of Honey Bee Colonies on Different Forage Regimes. Almond Board of California Annual Research Reports.

¹¹ Williams, N.M., 2017. Evaluating Alternative Bee Forage Plantings to Support Honey Bees in Almond Orchards—Assessing Bloom Time, Bee Use and Orchard Pollination. Almond Board of California Annual Research Reports.

¹² Gaudin, Amelie, et al. 2018. Management and Benefits of Cover Crops in Almond Orchards. Almond Board of California 2018 Research Update.

PESTICIDE BEE SAFETY AND FORAGE

Growers should note that planting forage will require attention to pesticide use and consideration of bees if they are visiting the forage. If forage is planted in or adjacent to orchards, it is important to carefully read and follow pesticide label directions. For forage inside the orchard, growers can reference these Honey Bee Best Management Practices as a guide on how to protect bees. As for forage outside orchards, many pesticides can be used safely near bees as long as label directions are followed.

FORAGE WATER REQUIREMENTS

When forage seeds are sowed in the fall, they should germinate with normal precipitation in fall and early winter, providing forage blossoms in time for honey bee colonies when they arrive for almond bloom. However, seedling growth should be monitored to determine if irrigation will be needed to supplement rainfall. Planting bee forage in early-to-mid October ensures the maximum rainfall-use efficiency, though some available seed mixtures have a low moisture requirement.



PROJECT APIS M. SEEDS FOR BEES PROGRAM:

Visit ProjectApism.org and click on the Forage tab to learn more about the Seeds for Bees Program. Growers will find a wealth of knowledge, including a guide to planting cover crops, a forage resource guide to seed mixes, and information on how Seeds for Bees provides subsidized seed mixtures and seeds to support honey bee health in California.



REMOVING HIVES FROM THE ORCHARD

The University of California recommends bee removal in traditional multi-self compatible variety orchards when 90% of the flowers on the latest blooming variety are at petal fall.¹³ Pollination does not take place beyond that point, and when bees forage for alternate food sources and water outside the orchard — bees can fly up to 4 miles beyond the orchard — they will be at a higher risk of coming in contact with insecticide or fungicide-treated crops.

Another option is to provide supplemental forage for bees, particularly before and after bloom, as covered on Pages 16 and 17. Unfortunately, though, even if bee removal timing may be included in the pollination agreement between the

grower and beekeeper, both parties should keep in mind that beekeepers can't always be available, or don't have an alternative location to move the bees.

Once the hives have been removed, it is still recommended to check the locations of the hives within a 1-mile radius of a spray site. Applicators can use programs like Bee Where, found at BeeWhereCalifornia.com, or contact a county agricultural commissioner directly to check hive locations. Bees may still be foraging in neighboring orchards or in other crops nearby, so it's important to check these sources prior to the use of any insecticide or fungicide.

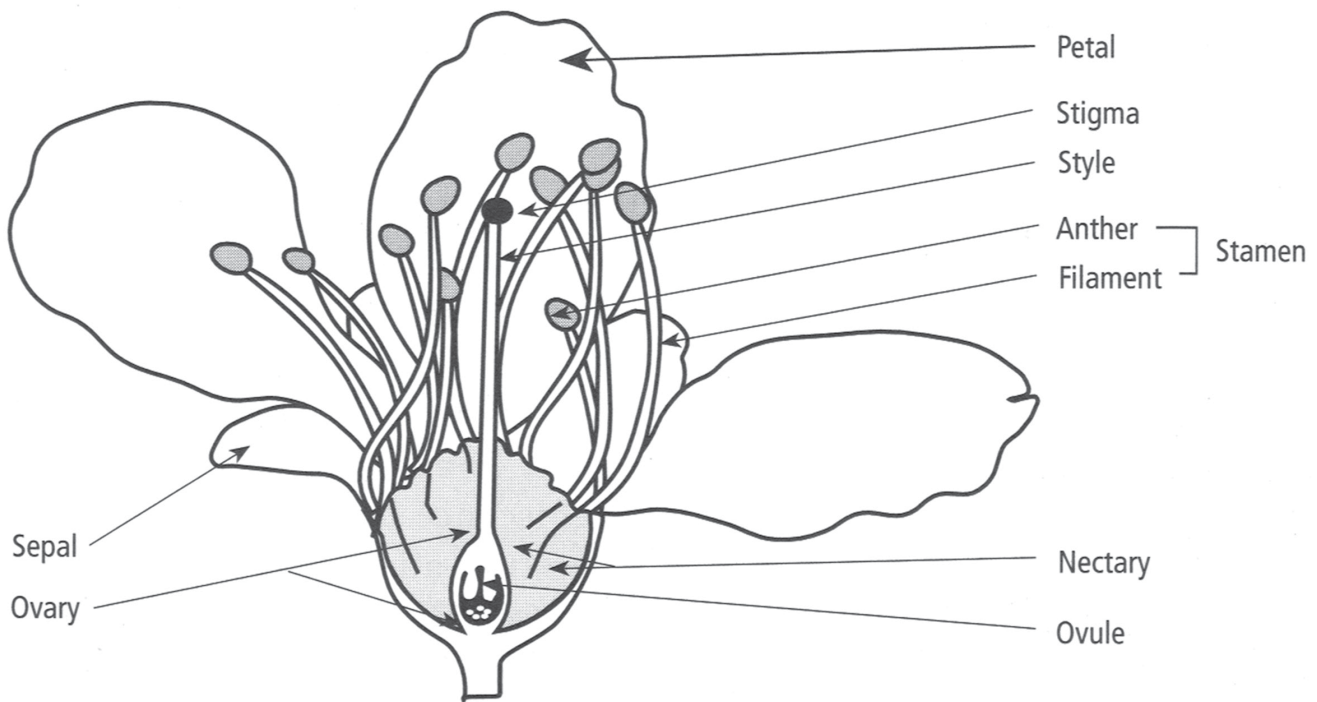


Fig. 1. Diagram of a Mission variety almond flower. For fertilization to be initiated, pollen from the anthers must be transferred to the stigma surface. When no anthers have pollen, the style turns from green to brown and the stigma and style are no longer receptive to pollination, and thus fertilization.

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