

Economic Considerations of Growing Bee-Friendly Cover Crops in Almond Orchards: Grower and Beekeeper Perspectives

Marieke Fenton and Brittney Goodrich

Planting bee-friendly cover crops in almond orchards can improve honey bee colony health and lower beekeepers' costs of feeding, while also providing soil health benefits. However, for the full bee-health benefits to be realized, growers must plant in the fall and receive timely rains or have access to irrigation between orchard rows. We review benefits and considerations for both growers and beekeepers of this potentially mutually beneficial practice.

Every February, beekeepers from across the United States trek to California to pollinate the state's almond orchards. Currently, California's 1.3 million bearing acres of almonds require nearly 90% of all U.S. colonies for pollination.

Almond bloom typically begins around February 15th, so almonds are the first major crop to bloom in the spring. At this time, honey bee colonies are at their smallest size from overwintering. Abundant pollen and nectar naturally signal honey bees to increase their numbers in the spring. Because almond growers want colonies with high numbers of bees to ensure adequate pollination, beekeepers simulate this natural process by feeding pollen substitutes and sugar syrup.

Some almond growers now plant bee-friendly cover crops in their orchards, which can help stimulate the colony expansion process and improve the overall health of the colony. Cover crops are grasses, small grains, legumes, brassicas, or a mixture of these, planted between the rows of

almond trees for soil protection and improvement. When growers plant cover crops that provide abundant nectar or pollen, such as vetch, clover, and mustards, cover crops can benefit beekeepers and their colonies as well as growers.

Benefits for Almond Growers

Cover crops are known to provide agronomic benefits, though these benefits will vary by geography, management system, and crop. Benefits include protection against erosion, increased soil organic matter, improved nutrient cycling, weed control, and natural tillage. These agronomic benefits can translate to economic benefits through increased or less variable yields, or fewer inputs, such as fewer fertilizer or pesticide applications.

In the case of almonds, beekeepers may also be willing to reduce pollination fees when bee-friendly cover crops are provided due to the nutritional benefits for their colonies. Such a discount would provide a direct and immediate monetary incentive for establishing cover crops. This would likely be welcome to almond growers who, according to the California State Beekeeper's Association (CSBA) in 2021, paid pollination fees of \$200 per colony on average, whereas growers of later-blooming crops often paid \$35–\$40 per colony.

Some benefits, such as weed control and pollination discounts, are immediate, while others, such as increased soil organic matter, accrue over years of cover crop use. In general, though, cover cropping is best viewed as a long-term endeavor. A recent study by DeVicentis and coauthors (2020)

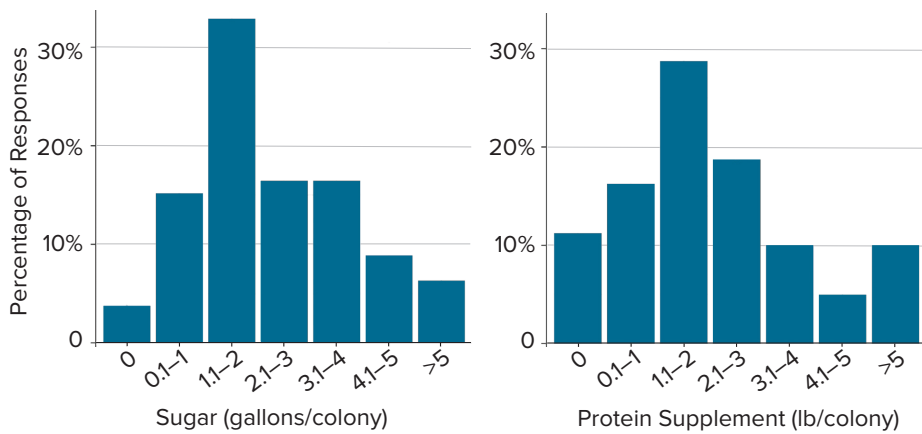
finds that implementing cover crops in almond orchards over 30 years is profitable for a typical grower. They estimate a benefit-cost ratio of 1.2, where any value over 1.0 means that implementing the practice leads to better economic outcomes than not doing so. The authors conducted a sensitivity analysis, and while the range of predicted cost-benefit ratios is large for almonds, most scenarios show an economic benefit to cover crop use in this system.

Considerations for Almond Growers

While bee-friendly cover crops can be economically beneficial, there are important considerations. All general cover crop considerations apply and include, but are not limited to, material costs, labor costs, and management decisions. Any new agronomic practice has a learning curve, and cover crops are no exception. For example, determining the ideal timing and method of termination of the cover crop is key for a successful cover cropping experience. Growers can use the "Cover Crop Best Management Practices" referenced at the end of this article to develop their cover cropping plans.

Honey bees are only in almond orchards for a short window each year, so timing cover crop bloom correctly is essential for colonies to benefit from the increased forage. Bee-friendly mixes should be planted in early- to mid-October so that they will bloom while bees are in or near almond orchards for pollination. Careful planning is required, since this planting date comes directly after almond harvest and can be a busy time

Figure 1. Amount of Food Supplements Provided Per Colony Before Almond Bloom



Note: Sample size (N) = 79 for sugar syrup, N = 80 for protein supplement. Amounts fed between January 1st and beginning of almond bloom 2021.

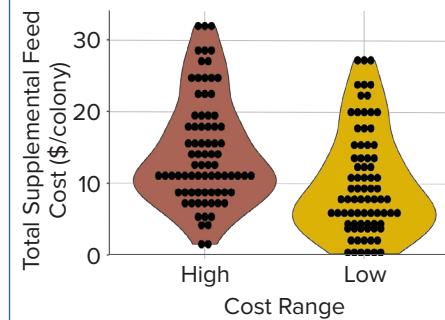
for growers. In dry years, cover crops may need water for establishment, and possibly for maintenance throughout the season. Many growers use water-saving irrigation methods that do not reach the center of orchard rows, so successful cover crop establishment and bloom timing will be dependent on rainfall. Additionally, many growers are concerned that providing additional forage in the form of bee-friendly cover crops will detract from pollination. However, studies have shown that this is not the case.

Benefits for Beekeepers

We conducted an online survey of beekeepers participating in the market for almond pollination services during the 2021 almond pollination season. Their responses reveal common beekeeper preferences and perceptions toward the use of cover crops in almond orchards. We received 105 responses, though not all respondents answered all questions.

During the 2021 almond pollination season, 20% of beekeepers (sample size N = 93) stated that at least one almond grower who they contracted with had provided pollinator habitat. A bee-friendly cover crop planted between almond rows—provided to 14% of respondents—was the most common habitat type. Eight percent of

Figure 2. Ranges for the Total Cost of Feeding Per Colony Before Almond Bloom



Note: Each dot represents total calculated feed costs using the lower (low-cost range) and upper bounds (high-cost range) of the sugar and pollen ranges fed by each beekeeper between January 1st and the beginning of almond bloom 2021. Sample size (N) = 79.

respondents indicated a grower had planted temporary bee forage nearby the almond orchard or bee yard, and 5% of respondents indicated a grower had planted permanent pollinator habitat in or near the orchard or bee yard.

A primary benefit to beekeepers of bee-friendly cover crops in almond orchards is increased forage availability and diversity. During almond bloom, colonies have recently emerged from overwintering and need food sources to quickly build up their populations. These sources include supplemental food provided by beekeepers, such as sugar syrup and protein supplements, and foraged nectar and

pollen from flowering plants, including bee-friendly cover crops.

Cover crops can provide diverse pollen sources during the otherwise monofloral almond bloom, leading to improved bee nutrition. This improved bee nutrition improves the overall health of colonies, making them more resilient to pests, diseases, detrimental climate effects, and pesticide exposure.

Beekeepers transport most colonies into almond orchards prior to bloom, so this potential reduction in feed costs is another reason they favor bee-friendly cover crops. Figure 1 shows the amount of sugar syrup and protein supplements fed between January 1st and the beginning of almond bloom 2021. Around 30% of beekeepers supplemented with 1.1 to 2 gallons of sugar syrup and 1.1 to 2 pounds of protein supplement per colony between January 1st and the beginning of almond bloom.

Figure 2 shows ranges for the total cost of feeding by respondent, calculated using the lower and upper bounds of the sugar and pollen ranges selected. We used prices of \$3.82 per gallon for sugar syrup and \$1.50 per pound for pollen patties. Most commonly, beekeepers were spending between \$5 to \$11 per colony on supplemental feed, though this ranged from \$0 to over \$30 per colony. Bee-friendly cover crop forage could replace some or all of these costs.

Not all cover crops are equal when it comes to providing bee-friendly benefits, primarily due to the short time colonies are in almond orchards and the lack of forage prior to almond bloom. We asked beekeepers which cover crop mix they would prefer, using common mixes provided by Project Apis m.'s Seeds for Bees program. Table 1 shows the results of this question, along with the bloom timing of the cover crops and potential benefits to the almond orchard. Overall, beekeepers showed a clear preference

for cover crops, with only one respondent indicating that they would prefer their grower not plant cover crops. Nearly a third of beekeepers stated that any of the seed mixes would be welcome. The largest portion of beekeepers preferred a brassica mix, followed by the soil builder mix, both of which are the earliest blooming mixes, displaying beekeepers' desire for the supplemental feed at a key time.

The beekeeper survey also revealed positive beliefs about some aspects of bee-friendly cover crops in almond orchards. Of 81 commercial beekeepers who answered these questions, 93% agreed that planting bee-friendly cover crops in almond orchards would improve colony health by enhancing pollen and nectar variety, while 70% agreed that it would reduce feeding costs. Only 9% thought that the cover crops would provide too little forage to benefit their colonies, and only 11% thought the use of cover crops would increase pesticide exposure.

Considerations for Beekeepers

Bee-friendly cover crops only provide beneficial forage if they bloom while colonies are in or near the orchard. As bee-friendly cover crops in almond orchards are not yet a common practice, beekeepers may need to work with growers to ensure that planting occurs at the correct time. Beekeepers could consider offering discounts on their pollination fee for the provision of bee-friendly cover crops. In our sample, three beekeepers reported accepting a discount in their pollination fee of \$5 to \$10 per colony in exchange for this provision of cover crops (approximately 3–5% of the 2021 CSBA average pollination fee). Clauses about cover crop planting dates or bloom could be included to ensure that beekeepers receive a benefit for providing the discount.

Pesticide exposure is a concern for beekeepers. Growers commonly work

Table 1. Beekeeper Preferences for Cover Crop Mix

Beekeepers Preferred Cover Crop Mix	Bloom Timing	Potential Benefits to Almond Orchard	Percentage of Responses
Any of the following bee-friendly cover crops are welcome	—	—	32%
Brassica mix (mustards, canola, etc.)	January–March	Increased soil organic matter, water infiltration	36%
Clover mix	March–June	Erosion control, nitrogen fixation	11%
Soil builder mix (Combination brassicas, legumes, and grains)	January–May	Combination of brassica and clover mix benefits	15%
Wild flowers (California poppy, black-eyed susan, etc.)	February–June	Aesthetically pleasing, not ideal for planting within orchards	2%
I would prefer my grower not plant a bee-friendly cover crop	—	—	1%
Other	—	—	2%

Source: Bloom timing and potential benefits taken from PAm Seeds for Bees site: <https://bit.ly/3H0juAr> and CNPS California Wildflowers guide: <https://bit.ly/3CHM7jl>.

Note: Sample size (N) = 81.

with beekeepers to prevent pesticide exposure, including reducing or ceasing pesticide applications while colonies are in the orchard, or limiting the time bees spend in orchards. Minimizing the time that colonies are in an almond orchard might limit the benefits those colonies receive from blooming cover crops. Beekeepers, in collaboration with growers, should therefore consider whether their colonies can safely benefit from additional forage in the orchard directly before and after almond bloom, and how much they value additional forage if it is only accessible during almond bloom. With careful implementation and forethought, the practice of bee-friendly cover crops shows promise for both beekeepers and growers.

Suggested Citation:

Fenton, Marieke and Brittney Goodrich. 2023. "Economic Considerations of Growing Bee-Friendly Cover Crops in Almond Orchards: Grower and Beekeeper Perspectives." *ARE Update* 26(3): 9–11. University of California Giannini Foundation of Agricultural Economics.

Authors' Bios

Marieke Fenton is a Ph.D. candidate and Brittney Goodrich is an assistant professor of Cooperative Extension, both in the ARE department at UC Davis. They can be reached at mcfenton@ucdavis.edu and bkgoodrich@ucdavis.edu, respectively.

For additional information, the authors recommend:

DeVincentis, Alyssa J., Samuel Sandoval Solis, Ellen M. Bruno, Amber Leavitt, Anna Gomes, Sloane Rice, and Daniele Zaccaria. 2020. "Using Cost-Benefit Analysis to Understand Adoption of Winter Cover Cropping in California's Specialty Crop Systems." *Journal of Environmental Management* 261, Article 110205. Available at: <https://bit.ly/3kaEpYx>.

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