

Improving the efficiency of almond pollination using fewer stronger hives

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Introduction

Founded in 2017, BeeHero is the world's largest provider of precision pollination, delivering data-driven managed pollination for commercial crops. A lot of our efforts are focused on optimizing how bees are used for almond pollination in California's Central Valley. Using electronic monitoring equipment, we can establish and optimize the ideal state of a bee colony to maximize the amount of pollination trips made by that colony. Monitoring bees leaving hives vs bees in the crop gives us valuable insights into alternative forage and post-bloom foraging opportunities. We also optimize hive placement in or around the crop, the total number of hives required and how these hives are distributed across the drops. Most recently, we have been investigating the effects hive orientation has on pollination trips. General beekeeping advice on hive placement suggests there are benefits from the entrance of the hive having a southerly (in the northern hemisphere) or easterly exposure. While amateur beekeepers tend to have a lot more flexibility with the direction in which they orientate their hives, for reasons of practicality, this is not a freedom most commercial beekeepers enjoy, especially when shipping bees for pollination services. We therefore started investigating if the strength of the colony could reduce the importance or significance of hive orientation.

Methods and Materials

The experiment was conducted at an almond orchard situated east of Fresno, in California's Central Valley. The experiment was run in collaboration with a team from the USDA ARS, Honey Bee Breeding and Genetics, Baton Rouge, LA. The team were assessing the foraging behaviour of Pol-line bees, a strain of bee specifically bred by the USDA for pollination. A comparison was made with the foraging behaviour of Russian bees. It was important that all comparisons between strains were made under the same environmental conditions so in the same orchard, two pallets of the Pol-line bees were placed next to two pallets of Russian bees. We concluded the addition of stock bees would make a valuable control. This is where working for the world's largest pollination supplier (BeeHero) proves invaluable, following a phone call late that evening, we arrived on site the following morning to find two pallets of stock bees sitting next to the pallets of Pol-line and Russians.



We monitored a total of 24 colonies, placed on six pallets, each supporting 4 hives.

Inherent to the configuration on the pallets, 12 colonies' entrances faced due east while the other 12 faced due west. Colonies were fitted with proprietary electronic equipment to track the bees' behaviour. Every five minutes, readings were taken from the sensors, and every 20 minutes this information was conveyed back to the cloud via the cellular network using a communications gateway. This allows us to remotely monitor data coming back from each colony. Flight or foraging activity is monitored using bee counters fitted across the hive's entrance. The bee counter has 26 tunnels, each with two light beams. The order in which the bee breaks the light beams signifies direction, allowing the bee counter to



log both bees leaving and bees returning to the hive. A weather pack collects wind speed and direction as well as ambient air temperature and rainfall. This meteorological information is extremely valuable as it gives context to all other monitored parameters.

Results

Figure 1 shows the start times of east facing colonies (Blue line) vs the start time of the colonies facing west (Orange line) from mid-February until mid-March 2023. Colonies facing east tend to start flying sooner than the west facing colonies. There are some exceptions, where bad weather delayed all colonies activity until later in the day, when any advantages of facing the early

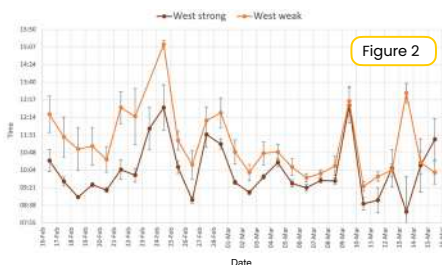


Figure 2

morning sun were lost. On average, across the whole season, we calculated colonies facing east started flying an average of 45 minutes before those facing west, which is in very close agreement with USDA (Tucson, AZ) original findings on hive orientation. We then investigated how the strength of a colony may affect its sensitivity to orientation. When grouped by strength there was little to no difference in flying start times in east facing colonies. However, we observed a much bigger difference in foraging behaviour between the strength groups in colonies facing west. We found that weaker colonies start flying as much as two hours later than their stronger counterparts facing in the same direction (Figure 2).

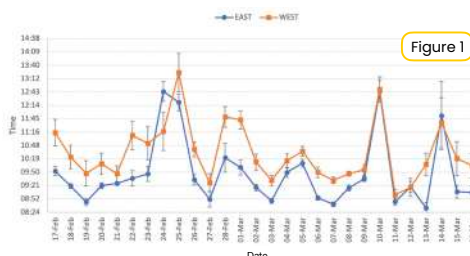


Figure 1

Discussion and Conclusion

Our results show that stronger colonies, across all three strains of bee, are far less sensitive to hive orientation. This is an important finding when seen from the perspective of a pollination service provider. Commercial beekeepers tend to keep their hives on pallets, where the hives face in opposing directions. It would be impractical to group the hives on a pallet by strength, trying to ensure all weak colonies face east. Likewise, it would not be practical to communicate a preferred pallet orientation to the person delivering the bees to site. These findings reframe how a grower pays for pollination. Traditionally, growers pay for the number of hives – most often two hives per acre, an attitude primarily driven by crop insurance companies, keen to ensure the crop received adequate pollination. However, this model fails to account for colony strength. Moving to "bee frames per acre" is a more sophisticated approach, but still neglects the fact that we can no longer compare a frame of bees with a frame of bees. A single bee frame in a weak colony facing west will start foraging later than that same frame of bees in a stronger colony facing west. As we move into the era of precision pollination, shifting to the metric of pollination trips per acre is advised. Thus, if a single twelve-frame colony, on average, provides more pollination trips than the total trips made by two six-frame colonies, in theory, the same number of pollination trips could be achieved using less than half as many bee hives. This has obvious advantages for all stakeholders involved in the pollination industry, particularly given that more than two million hives are transported annually to California's almond orchards.



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Managed honey bees are the primary pollinators of almonds in commercial agriculture, particularly in California's Central Valley, which produces 80% of the world's almonds.

Pollination accounts for up to 20% of grower's operating budgets and underpins commercial beekeeping in the USA, however beekeepers face significant challenges in maintaining an adequate supply of healthy colonies to meet this demand. Efforts to optimise almond pollination focus on maximising the efficiency of honey bee colonies to benefit both growers and beekeepers. This involves strategic management of colony health and strength, timing and configuration of hive drops and even hive orientation, all aimed at enhancing pollination efficiency and success. This study examines whether hive entrance orientation and hive strength influence the pollinating activity of honey bees in almond orchards. Working in conjunction with USDA, we assessed the various hive metrics across twenty-four colonies, half were situated with their entrances facing east, the other half facing west. Bee out counts and hive weight data were recorded continuously while colony strength was assessed on three occasions throughout the course of the study (libenfield method). East-facing hives started flight 44.2 min earlier than west-facing hives. The hive direction did not affect the timing of the cessation of foraging activity. The hive strength played a significant role: hives assessed as weak (≤ 3.0 FOB) facing east started flying up to 2 hours later than stronger hives (> 3.0 FOB). Our study showed that, during almond pollination, both hive entrance exposure and hive strength have quantifiable effects on colony foraging behaviour and that these effects combine to regulate the overall foraging activity of the pollinating colonies. As choosing hive orientation is impractical in a commercial beekeeping environment, there is a strong argument for the use of stronger colonies for pollination. Furthermore, stronger colonies help mitigate the impacts of inclement weather and with more foragers the same amount of pollination can be achieved using fewer hives. This, in turn, generates significant savings on transportation and associated environmental costs, given over two million bee hives are currently transported to California each winter. The linearity of this relationship remains a topic for future investigation.