

# **Enhancement of Avocado Pollination and Fruit Yield**

## **New Project; Year 1 of 2**

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## **Benefits to the Industry**

Pollination is a factor limiting yield in commercially grown avocados (Ish Am and Eisikowitch, 1991, 1993; Vithanage, 1986). Italian honey bees are typically brought into orchards to carry out pollination. However, their low attraction to avocado bloom means that alternative forage, such as citrus and wildflowers (Stout, 1923; Ish Am and Eisikowitch, 1992), competes strongly for honey bees' pollination services. In an attempt to identify a pollinator that is more strongly attracted to avocado than the commonly used Italian honey bee, we have been evaluating honey bees of the New World Carniolan (NWC) race. Also of great concern to the California avocado industry is cross pollination. The synchronously dichogamous flowering behavior characteristic of avocado discourages selfing. For this reason, growers often include pollinizer cultivars in their orchards, in order to promote outcrossing between trees of different flower types. However, the most popular pollinizer cultivars used at this time produce fruits that are generally considered inferior to 'Hass'. B-flower type cultivars that both served as effective pollen donors and produced more marketable fruit than existing pollinizers would be of great benefit to the California avocado industry. We have embarked on a study evaluating the siring success of newly generated pollinizers, from the University of California, Riverside breeding program, which produce 'Hass'-like fruits.

## **Objectives**

The object of this project is to enhance the avocado industry through the improvement of avocado pollination and fruit yield. Our efforts have focused on two factors that potentially influence pollination and fruit set: 1.) pollinator type, and 2.) pollinizers. The pollinator component of this project examines the comparative efficacy of avocado pollination by the commonly used Italian honey bee, and an alternative agent, the New World Carniolan (NWC) honey bee. Previous observations by Reuben Hofshi have suggested that NWC bees may be more avid visitors to avocado than Italian bees. Our goal is to determine whether NWC honey bees are superior to Italians for avocado pollination. We are also conducting an intensive evaluation of newly generated pollinizers from the UCR breeding program, and comparing their siring ability with the standard cultivars that are commonly used in California. Results of our

pollination projects will provide a basis for recommendations to growers regarding the use of pollinators and pollinizer cultivars.

## Summary

### 1. Alternative pollinators for avocado (NWC honey bees):

Results from the first year of this study indicate some differences between Italian and NWC honey bees that could relate to their quality as pollinators of avocado.

#### a. Effect of perseitol on feeding behavior

Dr. David Roubik of the Smithsonian Tropical Research Institute collaborated with us in a feeding study that demonstrated a significant difference between the races in their reactions to the presence of perseitol in nectar. Perseitol is a unique, 7-carbon sugar produced by avocado. It has been found in the nectar of all cultivars that have been tested (Liu *et al.*, 1995), but is not found in the nectar of the main competitors of avocado bloom, including citrus and wild mustard flowers (Ish Am, 1994). Bees of each race were provided a 20  $\mu$ L drop of sucrose solution, either with or without 2% perseitol, and the amount of time the bees took to finish the solution was recorded. The presence of perseitol in a 60% sucrose solution affected imbibing time differentially, depending on race (there was a significant perseitol\*race interaction for imbibing time,  $P < 0.016$ ). Whereas the presence of perseitol reduced the time spent imbibing by Italians, it increased the time for NWC bees. This finding indicates that perseitol can affect feeding behavior differentially for the two races, and suggests that such a behavioral difference may influence quality of the honey bees as pollinators of avocado. More elaborate studies on the race-specific influence of perseitol on feeding behavior have been proposed for future work (see Future Directions).

#### b. Honey bee visitation rates to avocado

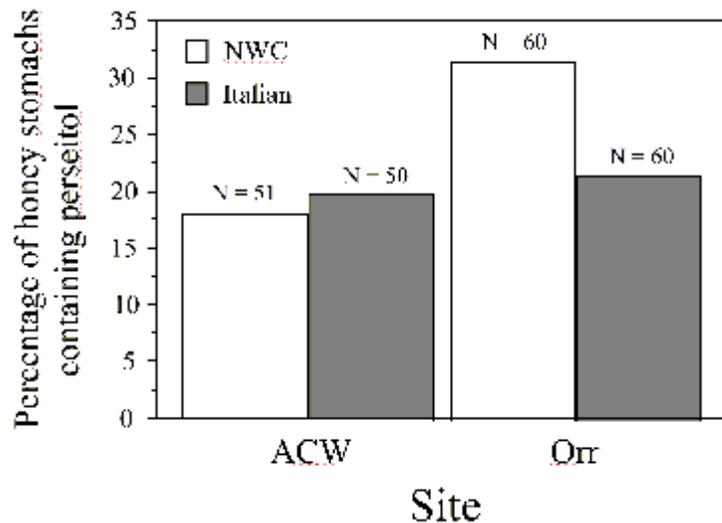
In order to estimate the frequencies of visitation to avocado by Italian vs. NWC bees when alternative forage was present, we set up apiaries in two locations: the ACW Farm in Fallbrook (late March through late May 2000) and the Orr Farm in Somis (late May through June 2000). Both locations have abundant citrus and wildflowers nearby, although they differ markedly in type, quantity, and layout. Study plots in each site contained equal numbers of NWC and Italian hives at a density of 4 hives/acre. We have found that the most effective method for measuring visitation of honey bees to avocado (information which can then be used to compare the pollination efficacy of the two races) is by means of looking at the pollen loads and honey-stomach contents of bees returning to their hives.

*Avocado-pollen foraging frequencies:* Pollen traps were installed in a subset of hives of both races at various times throughout the season. Pollen was collected from traps, and the quantity of avocado pollen (in terms of number of pollen-basket loads, as well as total weight) was assessed for each, in order to determine the percentage of gathered pollen that was avocado. The mean number of pollen-basket loads/day collected in traps was 53.3 (SD = 48.9), which corresponds to

approximately 27 pollen-foraging trips to avocado flowers/hive/day. The mean percentage (by weight) of total pollen that was avocado was 8.1%, with a range of 0 to 84.7%. However, all but one of 29 hives sampled had < 25% avocado pollen. Therefore, in general, only a small fraction of the pollen-collecting effort of any given hive was devoted to avocado. All in all, more avocado pollen was collected/day at Orr than at ACW, however, this difference was non-significant. There was also a non-significant tendency for NWC bees to collect a higher percentage of avocado pollen than Italians, at the Orr ranch, but the reverse was true at ACW.

*Avocado-nectar foraging frequencies:* Field bees returning from foraging trips were caught at hive entrances and the contents of their honey stomachs were expelled, measured, and collected for HPLC analysis for detection of perseitol. Dr. Monica Madore carried out the analyses. The presence of perseitol in honey-stomach samples was used to infer whether individual bees had visited avocado flowers. Over 90% of the samples have now been analyzed, and of the 221 samples for which we have results, 21.6% contain perseitol, meaning that an average of 22% of nectar-foraging trips from a given hive are to avocado, overall. There was a non-significant trend toward more visitation to avocado by NWC bees than Italians at the Orr Farm, however, the reverse was true, although to a much lesser extent, at ACW (Fig. 1). Our collaborators in Israel, Dr. Sharoni Shafir and Dr. Arnon Dag, were also unable to detect a significant difference between the two honey bee races with regard to honey-stomach perseitol content. However, they harvested honey from the hives at the end of the season and found not only that NWC bees produced almost twice as much honey as Italian bees, they also produced a significantly higher percentage of avocado honey than Italians, in one of their study sites (an orchard in which avocado is in competition with citrus bloom). In their other site, one in which wildflowers are the main competitors for pollinator visitation, there was no difference in avocado honey production between the two races. These results suggest that NWC honey bees may be more attracted to avocado than Italian bees in a site-dependent manner. Competing forage may be a major factor determining the degree to which the two honey bee races differ in terms of their propensity to visit avocado.

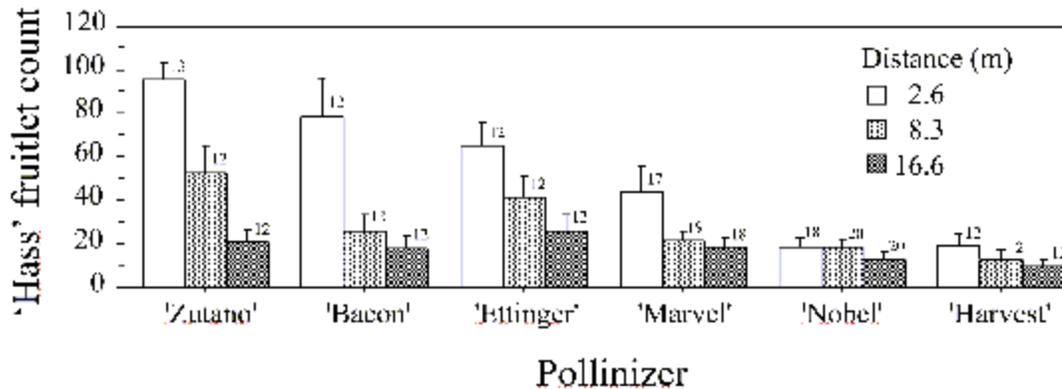
**Figure 1.** The percentage of honey bees, returning to their hives, whose honey-stomach contents contained perseitol, indicating that they had been foraging at avocado flowers. Differences between the races are non-significant at both sites, and difference between sites in the percentage of avocado foragers is also non-significant ( $P > 0.15$  in all cases).



## 2. Siring ability of pollinizer cultivars

A pollinizer trial was set up in Oxnard, CA by Dr. Mary Lu Arpaia and Dr. Ben Faber in 1998. The goal of the trial was to test 'Hass'-fruit siring ability of newly generated pollinizers from the UC Riverside Avocado Breeding Program. The pollinizers to be tested had been selected by virtue of their B-flower type and their production of dark, 'Hass'-like fruits, which are potentially more marketable than fruits of existing pollinizer cultivars. The trial grove contains 6 blocks of 'Hass' with rows of a different pollinizer interplanted with every 6th row of 'Hass'. The following pollinizers are included: 'Bacon', 'Ettinger', 'Zutano', 'Fuerte', 'Marvel', 'Nobel', 'SirPrize' and 'Harvest' (an "A" flower type). The latter four cultivars were recently generated by the Breeding Program whereas the remaining 4 cultivars are long-used "standards". Fruitlet-count data were collected from a subset of 'Hass' and pollinizers in three experimental blocks during late-July, early-August of 2000 (Fig. 2). The focal 'Hass' trees whose fruitlets were counted were spaced at varying distances (rows) from their nearest pollinizers. These preliminary data show that the cultivar of the nearest pollinizer and the distance of that pollinizer row from the focal 'Hass' tree were both highly significant determinants of 'Hass' fruitlet count. There was also a significant interaction between pollinizer and distance. The data demonstrate that a substantial variance in siring ability exists among the cultivars and that at least one of the new B-flower cultivars with 'Hass'-like fruit ('Marvel') is also an apt pollinizer, as 'Hass' fruitlet count in its vicinity was significantly higher than background levels (as estimated using values for 'Harvest', an "A"-flower type that served as a control in this study;  $P < 0.04$ ).

**Figure 2.** The influence of pollinizer cultivar on 'Hass' fruit set approximately 4 months after anthesis. Data were collected from 'Hass' trees located at varying distances from rows interplanted with pollinizers in a grove containing honey bees at a density of 6.25 hives/Ha. Numbers above each histogram are sample sizes. The effects of pollinizer, distance, and pollinizer\*distance were significant:  $P < 0.0001$ ,  $P < 0.0001$ , and  $P < 0.025$ , respectively, using log-transformed fruitlet counts. 'Hass' fruitlet data are shown only for trees in the vicinity of pollinizer cultivars that had flowered in the past year, as evidenced by fruit set on the pollinizers.



### Future Directions

Research in the coming year will include a continuation of work comparing the efficacy of Italian and NWC honey bees in avocado pollination, with an emphasis on the relative production of avocado honey by the two races in environments with different compositions of competing forage. We will also be collaborating with Dr. Thomas Davenport and Dr. Thomas Chao in a study that seeks to determine the extent to which intrafloral self-pollination occurs in avocado in California. We will launch a detailed examination of phenological and floral biology characteristics of a variety of pollinizer cultivars (including new ones from the breeding program) in an effort to determine what factors are most important in influencing siring success. Such knowledge will aid in making decisions about which new B-flower type cultivars should be released in the future.

Drs. Arpaia, Shafir, Davenport, Dag, and Fetscher have cowritten a BARD proposal for funding of a comprehensive avocado pollination project which will allow us to gather the kinds of data mentioned in this report, over a span of three years. In addition to this, we have proposed to conduct feeding-preference experiments (Shafir *et al.*, 1999) that will elucidate the aspects of avocado nectar (concentration, composition, presence of perseitol, etc.) which influence any differences in feeding behavior between the two honey bee races. These data, in conjunction with colony-specific data on avocado-nectar collection in the field, will be used as the basis for a honey bee breeding program whose aim is to generate lines of bees that are more highly attracted to avocado.

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