Cross- vs. Self-Pollination of Avocados Growing in Coastal and Inland Orchards of Southern California

Funded Project Year 1 of 2

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Benefit to the Industry

Despite many years of academic study and grower experience, the California avocado industry still lacks sufficient scientific information on this crop's flowering biology to determine whether it is more advantageous to plant the industry standard cultivar, Hass, in solid blocks or interplant with complementary cultivars and provide bees to facilitate pollination. The latter options both dilute the profitability of orchards by displacing the desired cultivar with inferior quality complimentary cultivars and create an added cost to growers with the installation of beehives. In contrast, increased pollination of Stage 1 (female) 'Hass' flowers because of available pollen from the complimentary, interplanted cultivar and transfer by the honeybees may increase productivity to levels beyond the capability of solid planted orchards. The overall purpose of the research project conducted during the 2001 avocado flowering season was to determine the incidence and effectiveness of cross- and self-pollination occurring in orchards located in either distinctly humid or dry climates of southern California. The results can provide growers with the basic information needed to decide whether the cost of interplanting cultivars and provision of honeybees is necessary to produce a high-profit crop of avocados under the environmental conditions present in southern California.

Objectives

1. Estimate proportion of cross- vs. self-pollination of 'Hass' flowers during cool and warm periods through examination of pollen deposition times.
2. Estimate pollen tube growth in cross and self-pollinated 'Hass' flowers during cool and warm periods
3. Determine the impact of climate on longevity of white stigmas in "Hass' avocado
4. Examine possible mobility of pollen in air as related to wind-mediated, abiotic cross- & self-pollination

Summary

Protocols
The two locations chosen in Ventura County to represent humid and dry conditions respectively were Debusschere Farm, located on the coastal plain near Oxnard, and Rancho Simpatica, situated in the hills near Fillmore. The two times of observations at each site were designed to investigate floral behaviors during the early-season cool period and later during periods of warmer temperatures. Mr. Brad Meiners was hired to conduct the pollination research in my absence. This research was conducted in collaboration with Dr. Betty Fetscher who's separately funded project investigated honeybee activity in the avocado orchards used in the described research. Beehives were placed in the orchard near the trees described (about 100 yds). Details of her activities will be discussed in a separate report.

The primary experiment was designed to investigate the amount of cross-pollination and self-pollination occurring daily. We determined the proportion of flowers having pollen deposited on 'Hass' (A type) stigmas during Stage 1 (female phase) and during Stage 2 (male phase). Four caged 'Hass' trees standing about 8 ft high and their in-row partners were tagged for this experiment at each location. All trees were located adjacent to the complimentary cultivar, 'Zutano', a "B" type cultivar. Cages (10 ft^3) were constructed of 40 % LENO/LOCK shade cloth (Style #10419, TC Baycor) supported by ¾ inch PVC pipe frames in order to completely cover the caged trees without touching the inflorescences. The size of the openings in the cloth matrix was 2x4 mm, which was sufficient to prevent honeybee penetration but also allow passage of wind and pollen if present. Open seams in the corners of the cages were tightly sealed with duct tape and closely monitored for any possible entry of bees. None were ever found inside any cage at any time during the course of observations.

Flower collections in the 'Hass' trees were done at the end of each opening stage on the days of observation to determine the amount of pollen deposition in each stage. On days in which the morning (Stage 1) opening of 'Hass' was delayed and the afternoon (Stage 2) opening of 'Hass' was not delayed, there was the potential for female flowers to be present in the early afternoon along with the male flowers in the same panicles. If the female Stage 1 flowers were still open after anther dehiscence, pollen could potentially be transferred from the male Stage 2 'Hass' flowers to the open female Stage 1 'Hass' flowers in the same panicles or trees (called close pollination) either by bees or potentially by wind. We recorded the times of flower openings and closings as well as dehiscence times and pollen release times in 'Zutano' in order to determine the probability of close pollination. Self-pollination takes place only in Stage 2 flowers that still have white stigmas at the time of pollen dispersal. The numbers of white stigmas at the end of Stage 2 were, thus, also monitored.

Results

There was a prolonged period of cool temperatures during a substantial part of the flowering season this year, which made it difficult to make collections in a meaningful way. This is because few flowers opened on any one day and floral behavior was severely modified such that the few flowers that opened stayed open for more than a day, usually in groups of the same stage either female (Stage 1) or male (Stage 2). As a result, only a third of the planned samplings were accomplished.

About 60% of the samples, consisting of more than 20,000 harvested flowers collected at the ends of Stages 1 and 2 inside and outside the cages, have been observed for presence or absence of pollen. The data collected so far across the span of the flowering season have been averaged and reported here as the percent of observed flowers that bore pollen in each floral stage of inflorescences inside and outside of the cages:

Farm	Average % Pollinated Flowers			
	Inside		Outside	
	Stage 1	Stage 2	Stage 1	Stage 2
Debusschere	3.8	18.7	4.6	21.5
Simpatica	6.1	25.6	8.2	29.1

Straightforward averages of the data were employed for the purpose of this preliminary report. Other mathematical analyses will later be tested once all of the samples are analyzed for better expression of the observations; however, several points can be made about these preliminary results that will not likely change as we complete the analyses for this year. First, there appears to about the same amounts of pollen deposition occurring in Stage 2 as we have observed in cultivars grown in south Florida. The amount of self-pollination occurring inside and outside the cages in the two orchards can be estimated by subtracting the average pollination rates in Stage 1 from those in Stage 2 in the appropriate columns. The range of Stage 2 flowers being self-pollinated, thus, appears to be about 15 to 20 % for this season.

In contrast to my experience in Florida, the proportion of white stigmas present for self-pollination in Stage 2 was far greater than the proportion of self-pollination occurring in Stage 2. Ten triplicate observations of proportion of white stigmas were made at Debusschere Farm from April 17 to May 4, 2001. Similarly, ten triplicate observations were made at Rancho Simpatica from May 7 to June 1. Observations were made at the close of Stages 1 and 2 and

also at the close of Stage 2 in flowers that were sprayed with water before closing of Stage 1. The overall average proportion of stigmas at the end of each stage were:

Farm	Stage 1 %	Stage 2 %	Sprayed Stage 2
Debusscher	99	96	88
Simpatica	97	53	87

The improvement in the proportion of white stigmas in the flowers that were sprayed during Stage 1 at the dry location of Rancho Simpatica justifies further tests next season to see if yield is improved by sprinkler irrigation of inflorescences in the dry climate.

The proportion of flower stigmas receiving pollen in Stage 1 ranged from about 4 to 8 % depending on location. There was no consistent or significant difference in the amount of pollination in Stage 1 inside or outside the bee-proof cages. It is not clear from our present data what was the source of pollen deposited in Stage 1.

Clearly, bees did not contribute to Stage 1 pollination inside the cages. The amount of Stage 1 pollination outside the cages was generally higher but not always. Thus, it is unclear from these few data what the contribution of bees was to pollination in the open.

Other sources of Stage 1 pollination could come from overlap of floral openings within inflorescences allowing abiotic pollen transfer from Stage 2 to Stage 1 flowers. We observed some days of floral overlap, but it was not consistent throughout the collection period whereas pollen deposition in Stage 1 was consistent in samples until the Zutano flowering finished. Thereafter, we observed little to no pollen deposition in Stage 1 flowers both outside and inside cages.

The possibility that pollen may be transported in the wind from complimentary Stage 2 'Zutano' flowers to the Stage 1 'Hass' would fit the observed pollination patterns. Pollen traps were constructed to measure the density of avocado pollen flying in the air. They consisted of a 6-inch diameter Plexiglas entry tube and a battery-powered box fan pulling air across a 20µ nylon filter. One each was place inside and outside the cages at each location throughout the observation period. Examination of the contents caught by the filters revealed no avocado pollen grains captured in any sample taken throughout the observation periods. This can mean there was no pollen carried on the wind, or it may mean our traps were faulty. It is possible that the Plexiglas entry tube was charged with static electricity that could attract the pollen before it could be trapped by the filter. Scotch Guard antistatic product was sprayed onto the inside plastic surfaces of the entry tubes before the start of the experiments, but no tests were conducted on the attraction of pollen to the plastic surfaces before beginning our observations. Further tests at the beginning of next season are needed to confirm that pollen can reach the filters if present in the air and corrections made if necessary.

Conclusion

Overall, the preliminary results, based on samples thus far analyzed, are provocative if not conclusive. They indicate the strong probability that self-pollination is a major component of fruit set in both environments and that pollen can be transferred to Stage 1 flowers without honeybees. This is not to discount the importance of honeybees in pollination of avocado flowers; however, other factors clearly impact yield in California. It is hoped that further funding of this work will bring definitive answers to the questions such that growers can make logical choices in their effort to maximize yields of 'Hass' avocado.

As described earlier, far fewer observations were made than originally planned. Moreover, due to the daily delays in floral activity, many operations that require precise timing were unable to be done. If funding is continued, I will plan to be at the site longer in the beginning to assist the technician in solving problems and return at least two times during the collection period to insure that the experiments are progressing at the appropriate pace.