In: M. L. Arpaia and R. Hofshi (eds.), Proceedings of Avocado Brainstorming. Session 5. Pollination. Pages 101-104. October 27-28, 1999. Riverside, CA. Hofshi Foundation. http://www.avocadosource.com.

A VIEW FROM FLORIDA ON AVOCADO POLLINATION

Thomas L. Davenport
University of Florida, IFAS
Tropical Research and Education Center, Homestead, FL

The classic dogma of avocado flowering behavior has been described many times, and all avocado growers should already be familiar with the floral biology that has been accepted since Nirody first studied the phenomenon in the early twenties. Until recently, it was considered that avocados were primarily cross-pollinated (except when close-pollination occurs) as evidenced by the following characteristics:

- Flowers open two times (Stage 1 and 2) on consecutive days.
- Openings and closings are synchronous throughout the cultivar but are delayed by cool ambient temperatures.
- Close-pollination occurs when low night temperatures (in dry climates) delay the morning floral opening, causing overlap of Stages 1 and 2 within trees of the same cultivar resulting in close pollination from flowers within the same trees.
- Pollen is sticky requiring insect transfer from B to A types in the morning hours and from A to B types in the afternoon hours.
- There is a high proportion of receptive, white stigmas in Stage 1.
- Desiccation of the stigmas occurs, and pollen is made available to pollinating insects by anther dehiscence in Stage 2.
- Complementary cultivars; type A, displaying Stage 1 flowers in the morning and stage 2 flowers in the afternoon of the following day and the inverse relationship for type B cultivars, occurs in all three avocado races and their hybrids.

Observations of avocado cultivars growing in South Florida and a review of the existing dogma, however, forced me to come to a different conclusion regarding avocado pollination, especially with regard to cross vs. self pollination. Briefly, it was found that:

- Self pollination is the norm in more than 95% of the pollinated flowers.
- A substantial proportion of stigmas remains white and receptive until the close of Stage 2, perhaps governed by evaporative demand on the stigmatic surfaces.
- Pollen is not sticky as previously thought. It is, at anther dehiscence, cohesive due to wetness and, thus, appears sticky but soon dries and disperses typically within thirty minutes.
- Pollen is efficiently transferred within flowers to receptive white stigmas in Stage 2 by wind or gravity, giving rise to the high rate of self-pollination within flowers.

The high proportion of receptive white stigmas during Stage 1 opening maximizes the opportunity for successful cross-pollination by nearby complementary cultivars. Pollen deposited on the stigma in Stage 1 has a temporal advantage over that arriving in Stage 2 the following day due to earlier pollen tube growth towards the egg. Despite this potential advantage, our research efforts in South Florida found that little pollen is transferred to flowers in this stage, usually amounting to less than one percent of the available flowers. Stage 2 flowers, however, are efficiently pollinated in direct proportion to the number of white stigmas present at the time of pollen dispersal from the anther. The proportion of white stigmas in Stage 2 ranges from 10% to 80% of the open flowers, depending upon cultivar and, presumably, the drying capacity of the air. Pollen is deposited and successfully germinates in most of these.

Because of the high observed rate of self-pollination in Stage 2, we recently, investigated whether pollen from various sources could fertilize the flowers of orchard trees if deposited in that stage. Previous Australian research in controlled environment chambers indicted that pollen tubes reach the egg of the ovule by 24 hrs when pollen is deposited in Stage 1 flowers under warm temperature conditions. Pollen tubes stopped growing by 24 hrs when pollen was deposited in Stage 2 flowers under the same temperature conditions. That research, however, did not record the proportions of white stigmas available in Stage 2 flowers. Our experiments examined pollen tube growth only in flowers that still bore white stigmas in Stage 2 at the time of pollination. Pistils were observed both at 24 and 48 hrs after pollen deposition in Stage 2 in order to account for possible less-than-optimal night temperatures that may slow pollen tube growth. Some results of this study are summarized in Table 1.

Table 1. Proportion (% of total) of flowers in which the pollen tube penetrated the micropyle within 48 hr after hand cross pollination (HCP) from adjacent complementary cultivar, hand close pollination (HSP) from same cultivar, and natural self pollination (NSP) within the male phase avocado flowers.

Cultivar	Race^z	Floral Type	HCP	HSP	NSP
Booth 7	G/W	B	77.41	69.14	73.44
Brooks Late	G/W	A	82.88	50.12	57.28
Choquette	G/W	A	59.94	70.01	75.84
Monroe	G/W	B	25.00	23.58	30.16
Simmonds	W	A	63.77	58.19	64.68
Tonnage	G/W	B	39.77	57.27	56.46
Tower 2	W	B	64.91	73.68	76.76

^{z}Race: G/W is Guatemalan and West Indian race hybrid; W is West Indian race.

Twenty-four hours was insufficient time for pollen to reach the egg apparatus in the field. The only CV in which penetrated micropyles were observed within 24 hours of pollination was 'Tower 2' (HCP, 0.35). These data support the contention that a substantial portion (~25% to ~85%), regardless of pollen source, of the male phase pollinated flowers are successfully fertilized and that fertilization generally occurs between 24 and 48h after pollination. It is important to note that 24 hrs was insufficient time for pollen to reach the egg apparatus in the field. This is likely due to the lower than optimum night temperatures available for pollen tube growth. Forty-eight hours was necessary to observe pollen tube arrival to the egg apparatus. Moreover, pollen from complementary cultivars appeared to have no benefit over pollen from the same cultivar either through close or self pollination.

Selfing is clearly the primary mode of avocado pollination in Florida, but is it effective in production of a crop? Unpublished isozyme analysis results of three cultivars ('Simmonds', ‘Tonnage’, and ‘Choquette’) indicates that over 85% of the harvested fruit are derived from self pollinated flowers. Moreover, we have observed increased fruit set and retention in cheesecloth enclosed branches over open pollinated branches after shaking the enclosed branches at the time of pollen dispersal. In drier climates, however, self pollination may be reduced by desiccation of the stigma before anther dehiscence, thus reducing the opportunity for pollen deposition. One would, for example, expect higher rates of self pollination in the humid coastal areas of California than in the drier inland areas.

It was suggested by my colleagues in this conference that the West Indian, Guatemalan, and their hybrid races perform differently in Florida from the Mexican-Guatemalan hybrids favored in California and other areas of the world with regard to the importance of self pollination in Stage 2 flowers. The primary evidence presented for this difference was the observation that pollen tubes did not reach the egg apparatus within 24 hrs after Stage 2 pollination. The reader will note that we too observed no penetration of the egg apparatus by 24 hrs. It took 48 hr for pollen tubes to reach the same point under our conditions.

Mexican-Guatemalan hybrids such as ‘Fuerte’ and ‘Hass’ have generally not found favor in South Florida because of their inability to thrive in the alkaline, calcareous soils and the overwhelming competition for those cultivars in the American markets. There exist, however, numerous individual ‘Hass’ or ‘Pinkerton’ trees growing amongst our typical cultivars in commercial orchards in South Florida. Although in most years these trees finish flowering before the surrounding cultivars begin anthesis, they set and retain high numbers of fruit despite the fact that there is no available pollen from complimentary cultivars. Floral openings rarely overlap in South Florida so close pollination does not occur in these trees. Self pollination is the only explanation available. Our first preliminary pollen tube growth study was conducted a number of years ago on one of these ‘Pinkerton’ trees. In the few flowers that we observed after Stage 2 self pollination, all displayed pollen tube growth and most displayed penetration of the egg apparatus by 48 hrs. The results presented here were the larger scale version of the same experiment.

Subsequent to this meeting, I have been told that ‘Hass’, ‘Fuerte’, ‘Pinkerton’, and other Mexican x Guatemalan cultivars perform well in solid block plantings in New Zealand (Grant Thorp, personal communication) and South Africa (John Bower, personal communication) with no occurrence of overlap due to low night temperatures. It is impossible to analytically distinguish between close and self pollinated flowers. I would suggest that even though overlap of floral stages exists on certain days in dry climates, it may not be successful in fertilizing the flowers. If the night temperatures are sufficiently cool to delay floral opening, evidence suggests that it is also too cool for adequate pollen tube growth before floral abscission processes begin. Both processes are extremely sensitive to cool temperatures. We have observed no fruit set during periods when floral openings were delayed by cool temperatures. Thus, although one observes overlap of stages in a dry climate, such overlap may not result in successful pollination and fertilization of the flowers. I think these points raise interesting questions that should be addressed in future research.

Is there a conflict of ideas here? In this author’s view there is not. The key to understanding cross vs. self pollination is the proportion of receptive stigmas in Stage 2. I contend that dry, Mediterranean climates are conducive to high cross vs. self pollination ratios because of excessive desiccation of stigmas in Stage 2. More humid conditions are conducive to high self pollination due to the increased number of receptive stigmas in Stage 2. Introduction of bees in dry climates may be advantageous to yields by increasing the number of pollinated Stage 1 flowers, but their impact may be less in areas where self pollination predominates.

What does all this mean to the avocado grower? Our experience is that yield is improved in open canopies, in which air can flow freely. We also noted a shift in fruit production from the upper portion of the tree canopy to the lower sections. Thus, orchard thinning can provide a benefit. Other experiments (not reported here) have indicated that if one wets the flowers during Stage 1, the stigmas remain receptive longer resulting in greater numbers of white stigmas in Stage 2. This can be accomplished by application of water to the flowers using overhead sprinkler systems or grove sprayers during Stage 1. These approaches can be easily tested on a small scale by growers.

Finally, I would like to extend my heartfelt thanks to the organizers of this conference for the opportunity to present my ideas to the avocado growing community of California and to the California Avocado Commission for their generous contribution to my travel expenses. I sincerely hope that the growers benefit from the confluence of world expertise in growing avocados and the little part that I shared in it.

Complementary cultivars; type A, displaying Stage 1 flowers in the morning and stage 2 flowers in the afternoon of the following day and the inverse relationship for type B cultivars, occurs in all three avocado races and their hybrids.

Close-pollination occurs when low night temperatures (in dry climates) delay the morning floral opening, causing overlap of Stages 1 and 2 within trees of the same cultivar resulting in close pollination from flowers within the same trees.