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Pollen Deposition on Avocado Stigmas in Southern Florida

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Abstract. **The percentage of stigmas bearing pollen were determined in flowers of avocado *(Persea americana* Mill.). Stigmas were harvested at the end of the first and second floral openings (functionally female and male, respectively) in several cultivars located at several locations in southern Florida. Generally, < 2% of the flowers were pollinated during the first opening of all observed cultivars. Due to the synchronously dichogamous flowering behavior of avocado, the source of this pollen was likely from interplanted complimentary cultivars (cross-pollination). Up to 15 times as many flowers received pollen during the second opening in some cultivars. The most likely source of this pollen was from within the same flowers. These preliminary observations suggest that self-pollination within avocado flowers during the second opening may be an important mechanism of avocado reproduction in the humid tropics.**

Nirody (1922) and Stout (1923) were first to note that avocado flowers, bearing both pistils and stamens, exhibit a synchronously dichogamous behavior with two floral openings (dianthesis). The flowering behavior of avocadoes has recently been reviewed in detail (Davenport, 1986). The first opening, occurring daily in groups of flowers distributed throughout the trees, lasts about one half day. This opening (Stage I) has been classified as functionally female, since no pollen is released and the small stigmatic surface appears white and receptive to pollination. The second opening (Stage II), which also lasts about one-half day, occurs the following day in the same flowers. It has been classified as functionally male because pollen is released during this opening and be cause pistils have been thought to be non receptive to pollen during this opening. This opinion was based exclusively on the observation that the stigmas in some cultivars appeared brown and desiccated during this opening (Nirody, 1922; Stout, 1923). Pollen does not adhere to desiccated stigmas. More over, Sedgely (1977)

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reported that pollen germination and tube growth through the styles of 'Fuerte' flowers was inhibited when pollen was deposited during Stage II, as op posed to Stage I.

Because of the dichogamous habit of avocado flowers and the observed nonreceptive stigmas in the second opening, it has been thought that pollen is deposited on stigmas only during the first opening of each flower by flying insects that carry pollen from nearby complimentary cultivars, resulting in cross pollination. Complimentary cultivars are those showing opposing floral stages during the same time, i.e., A types show Stage I in the morning and Stage II in the afternoon hours, while B types show Stages II and I during the same respective time periods. It has been observed, however, that pollen could occasionally be transferred from flowers borne on the same tree or cultivar during conditions that favored overlapping of flower openings, such as during cool or overcast days (Davenport, 1986; Robinson and Savage, 1926; Sedgley and Grant, 1983). During these periods, inflorescences may show both Stage I and II flowers at the same time, thus facilitating self-pollination by insect transfer of pollen from Stage II to Stage I flowers.

The protocol described here was originally designed to investigate another research question involving the amount of pollen deposition occurring in various commercial cultivars as related to two fruit-setting habits defined by Davenport (1982). The current report describes the unexpected pollination behavior observed during this separate study.

A field experiment was conducted, based on the above described dogma, whereby stigmas were initially harvested at the end of Stage I in several commercial cultivars. Using fine forceps immediately before closing of Stage I flowers (about solar noon for A types and at dusk for the B types), 50 styles with intact stigmas were harvested from flowers borne on mature, bearing, avocado trees. Five replicate trees from each of seven cultivars from seven orchards located within 17 km of each other were sampled weekly (see Table 1 for cultivar names). The stigma/styles were placed on microscope slides that were coated with a gel prepared according to H. Melamud (personal communication) by combining aqueous glycerol (20 ml of glycerol in 70 ml of H_2O) with a solution of 2.5 g of carboxymethyl cellulose and 0.1 g of aniline blue in 10 ml of 95% ethanol. A cover slip was applied for protection, and samples were stored at room temperature until they could be observed using light microscopy. The percentage of harvested stigmas bearing any number of pollen grains per tree per day and the number of pollen grains per pollinated stigma were noted.

Each cultivar was sampled weekly throughout its flowering period, beginning with those earliest to flower ('Simmonds' and 'Lula'). The data presented are the mean of all weekly samples taken during the season. Flowering behavior and weather conditions, as well as the type and number of flying insects visiting the flowers, were also noted throughout each day of the study. Weather conditions during the period of observation, which lasted throughout the flowering season from early March to late April, were moderate. There were no days during this period when flower openings overlapped; thus, there was no opportunity for pollen to be transferred from an open male to an open female within the same branch or cultivar. Moreover, few flying insects were observed visiting the flowers. The most prevalent of these were *Polistes* spp. wasps, in agreement with the observations of Stout and Savage (1925). Bees were infrequent visitors.

Prompt examination of stigmas harvested early in the flowering season revealed surprisingly few pollinated flowers (1% to 2%) in any cultivar, even though ample initial fruit set was occurring in some cultivars, such as 'Simmonds'. The inconsistency in the observed high rates of initial fruit set with low frequency of pollen deposition prompted me to begin sampling flowers at the end of the Stage II opening, as well as at the end of Stage I. The results of observations of both Stage I and II flower stigmas harvested throughout the flowering period are presented in Table 1, reflecting the mean, seasonal percentage of stigmas that received pollen. The mean number of pollinated Stage I flowers in all of the cultivars and locations observed was consistently < 4% of the total, with an overall average of =1.5%. The surprising result of the Stage II observations, however, was the remarkably frequent occurrence of pollinated stigmas. The mean number of pollinated Stage II flowers ranged from nearly 35% ('Booth 8') down to values of those found for Stage I flowers. Where clearly visible, all pollen grains on the stigmas appeared to be germinated. The mean number of pollen grains counted on individual pollinated stigmas during this study appeared to be similar (one to two pollen grains per pollinated stigma) in flowers collected in both Stage I and Stage II.

Table 1. Seasonal mean percentage of avocado flower stigmas bearing pollen. Flowers were collected weekly (50 flowers per tree for five trees) at the end of Stage I or II (functionally female or male openings, respectively) in various cultivars located in different orchards of southern Florida.

Stage	Cultivar x pollenizer (Flowering type)[z]	Orchard	Pollination (% ± SE)
I	Booth 7 (B) x Lula (A)	1 and 6	0.0
II	Booth 7 (B) x Lula (A)	1 and 6	0.0
I	Tonnage (B) x Peterson (A)	2	2.5 ± 0.8
II	Tonnage (B) x Peterson (A)	2	30.2 ± 6.0
I	Peterson (A) x Tonnage (B)	2	3.9 ± 1.3
I	Peterson (A) x Hardee (B)	5	0.3 ± 0.3
I	Booth 8 (B) x Walden (A)	3	2.1 ± 1.1
II	Booth 8 (B) x Walden (A)	3	34.7 ± 7.0
I	Booth 8 (B) x Walden & Nadir (A)	6	1.4 ± 0.8
II	Booth 8 (B) x Walden & Nadir (A)	6	9.3 ± 3.0
I	Simmonds (A) x Tonnage (B)	2	2.4 ± 1.0
I	Simmonds (A) x Ruehle (B)	4	2.0 ± 0.7
I	Simmonds (A) x Hardee (B)	5	0.8 ± 0.3
I	Pollock (B) x Nadir (A)	7	1.2 ± 1.0
I	Lula (A) x Booth 8 (B)	7	0.2 ± 0.2
I	Lula (A) x mixed cvs.	8	1.0 ± 0.5
II	Lula (A) x mixed cvs.	8	0.7 ± 0.7

[z]A: Stage I in morning, II in afternoon; B: Stage II in morning, I in afternoon.

The amount of pollen deposition on flowers varied substantially from day to day (data not presented), as indicated by the relatively high SE of the means. No pollen deposition occurred in either stage on several occasions in all cultivars examined. I was unable to discern a correlation between the occurrence of large, flying insects and pollen deposition in either Stage I or II. I did, however, notice a possible correlation between pollen deposition and weather conditions, especially with regard to the drying capacity of the air. Although quantitative weather data were not collected in the experimental orchards at the time, I observed that the stigmatic surface in all cultivars observed in the study tended to remain white throughout the first and second flower openings whenever the relative humidity was high (80% to 95%) and winds light (<4 $m \cdot s^{-1}$). The stigmas would readily dry out during the second flower opening when cold fronts brought several dry (40% to 75% RH) and/or windy (>7 $m \cdot s^{-1}$) days. During extreme conditions, stigmas dried out even during the first opening. Periods of desiccating weather conditions generally resulted in poor pollination. I observed no pollen sticking to desiccated stigmas.

The results presented here are preliminary and based on only one season's work. They do, however, suggest new possibilities to consider in our understanding of avocado pollination. The surprisingly low incidence of pollen deposition occurring in Stage I flower openings in all of the cultivars in which I made the comparison and the observation that ≈90% of the pollen arrived during Stage II in three of the five cultivars observed, is counter to the general thinking that has evolved regarding avocado pollination, i.e., all pollen must arrive at the stigma during Stage I. Thus, in the humid conditions found in southern Florida, self-pollination, a phenomenon known to be occurring, especially in solid-block plantings, may not require the transfer of pollen from Stage II to Stage I flowers. It may be occurring during Stage II within the same flower.

The impact of pollen arriving during Stage II depends on the fecundity of the pistil at the time of and following pollen deposition. It is recognized that a white stigmatic surface does not necessarily guarantee receptivity to pollen or subsequent fertilization. The observation that 'Simmonds' was initially setting more fruitlets than the Stage I pollination rates indicated suggests that at least one cultivar is receptive. Furthermore, it offers a plausible explanation for high productivity of solid-block avocado plantings during periods when floral openings do not overlap.

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