

Pollen Transfer in Two ‘Hass’ Orchards is Mediated by Wind

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The objectives of the research project were to:

1. Determine the relative proportion of cross vs. self pollination of ‘Hass’ avocado flowers by recording the amount of pollen deposition in Stage 1 (indicating cross pollination by local complementary cultivars) and in Stage 2 (indicating self pollination within ‘Hass’ flowers).
2. Determine if a humid or dry Mediterranean-like climate has an influence on pollen transfer and deposition.
3. Determine the importance of wind in the transfer of pollen from Stage 2 complimentary cultivar flowers to Stage 1 ‘Hass’ flowers and in transfer of pollen within Stage 2 ‘Hass’ flowers.

Three sites in Ventura County, CA were chosen for the studies:

Humid Site: Debusschere orchard located on the coastal plain adjacent to the Point Mugu Navel Air Station near Oxnard/Camarillo. It is characterized by chronically cool temperatures, high humidity, and often foggy or overcast weather.

Dry Site1: Orchard Rancho Sympatico located in the dry hills near Fillmore. This site was used in the 2001 study only.

Dry Site 2: Hardison orchard located in the dry hills between Fillmore and Santa Paula. This site was used in the 2003, 2005, and 2006 pollination studies. Both sites are characterized by drier air that tends to have warmer day temperatures as compared to the humid site.

Nearly all experiments involved the use of trees enclosed in Baylor brand 40% saran shade cloth of sufficient opening size to facilitate wind penetration through the cage while preventing entry of pollinating insects, notably bees and adjacent open-pollinated trees. Photos depicting the four caged and open tree pairs at Debusschere and each of the two dry sites are displayed.

Flowers were collected from each of the four replicate caged and open trees at each site at the end of Stage 1 and Stage 2 floral openings and preserved in labeled vials for later observation of pollen on stigmas under a microscope. As many days (up to a week) as weather permitted were used to collect flowers as soon as temperatures were warm enough to permit normal or near normal floral opening behavior. The strategy allowed us to determine the amount of pollen deposition in both stages in flowers that were

protected from bee visitation and those in which bees were freely allowed to visit the flowers.

Results reporting the amounts of pollen deposition among flowers in stages 1 and 2 obtained over several days of the 2001, 2003, 2005, and 2006 flowering seasons are summarized in the following tables.

Also reported are results of SSR analyses determining the pollen parents of fruit collected from caged and open pollinated trees in the Hardison orchard in 2003.

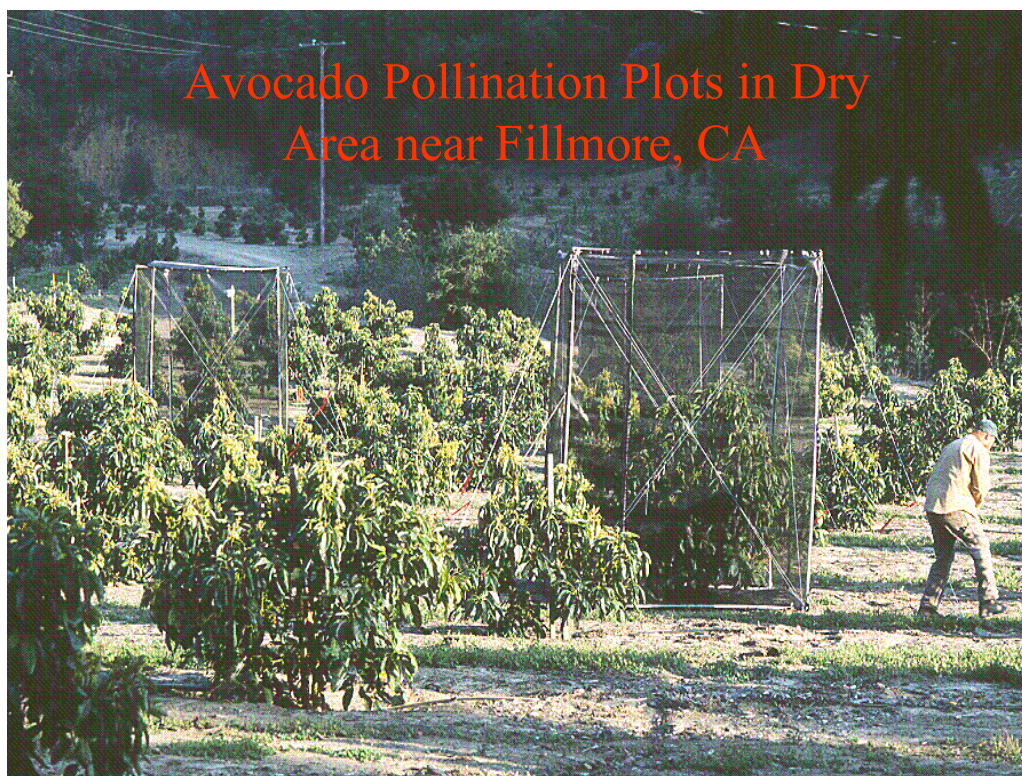
We also include results of another experiment demonstrating the maximum pollen tube growth distance in avocado floral pistils during the period of pollen depositions studies at Debusschere Orchard in 2006. Temperatures recorded at the nearby Oxnard CIMIS weather station during the study week are also included.

Finally, results of experiments, in which inserts carrying ‘Zutano’ pollen were placed in the entrance of beehives placed in several orchards, are displayed. The amount of pollination of ‘Hass’ flowers by bees carrying ‘Zutano’ pollen from the inserts was determined by sampling fruit during various stages of development in ‘Hass’ orchards containing no ‘Zutano’ trees.

Caged and Open Pollinated Trees at Debusschere Orchard, 2001



Caged and Open Pollinated Trees at Ranch Sympatica, 2001



Caged and Open Pollinated Trees at Debusschere Orchard, 2006



Caged and Open Pollinated Trees at Hardison Orchard, 2006



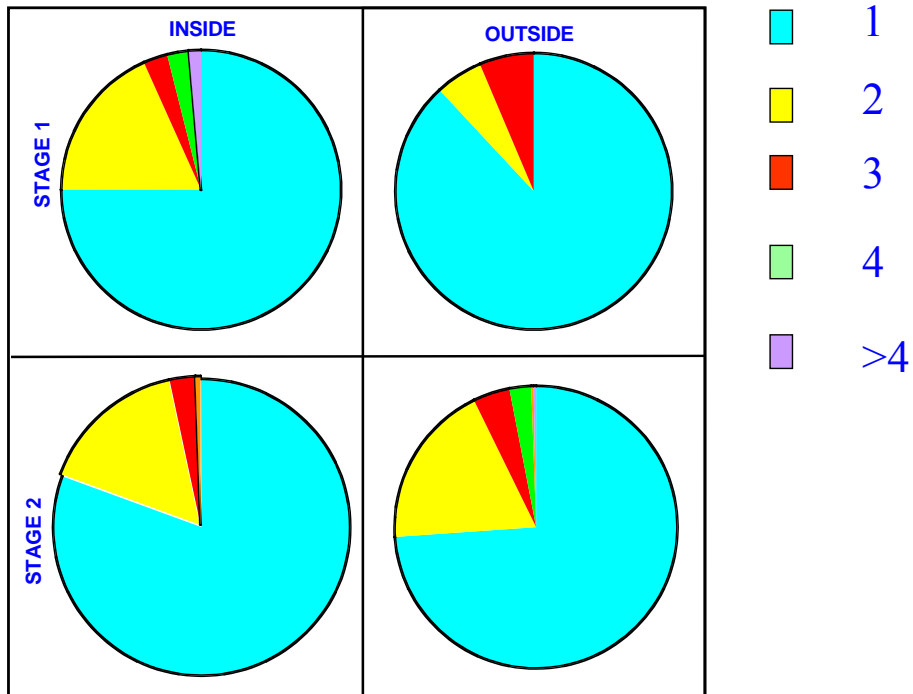
Pollen Deposition at Debusschere Orchard, 2001

POLLINATION SUMMARY AT DEBUSSCHERE (2001)				
DAILY AVERAGE PERCENTAGE (%)				
DATE	INSIDE		OUTSIDE	
	STAGE 1	STAGE 2	STAGE 1	STAGE 2
4/18	4.98		3.41	
4/26	2.10	30.28	3.91	33.61
4/27		21.40		18.36
4/30	3.00	37.01	2.92	36.28
5/1	2.14		3.95	
5/2		13.77	1.85	15.18
5/3		17.68		14.76
5/4	4.79	11.77	6.30	17.00
AVERAGE	3.40	21.98	3.72	22.53
CORRECTED	3.40	18.58	3.72	18.81

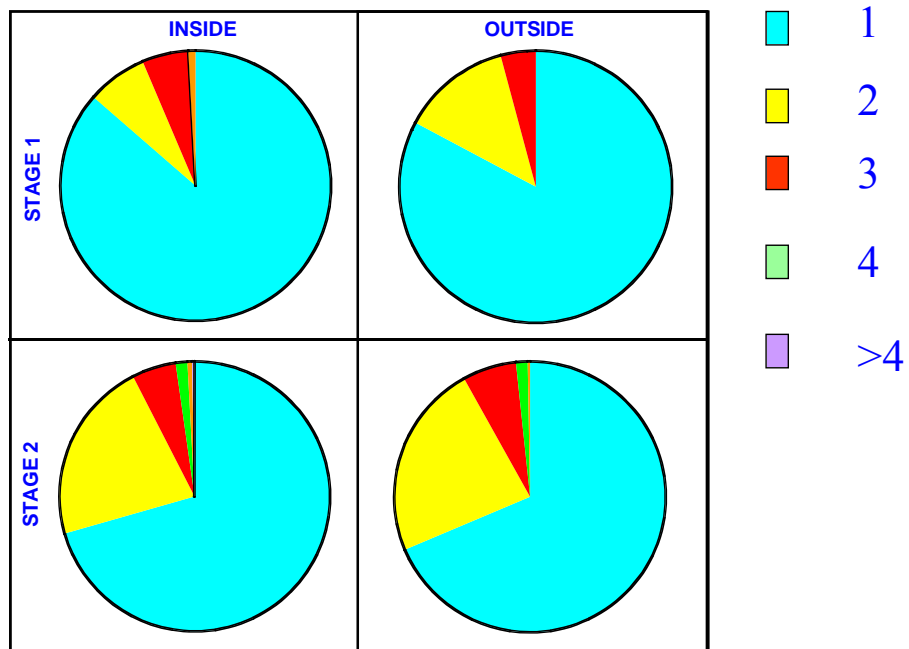
Pollen Deposition at Rancho Sympatica, 2001

POLLINATION SUMMARY AT RANCHO SYMPATICA (2001)				
DAILY AVERAGE PERCENTAGE (%)				
DATE	INSIDE		OUTSIDE	
	STAGE 1	STAGE 2	STAGE 1	STAGE 2
5/7	1.14		6.01	20.00
5/8	8.42	25.61	20.54	29.28
5/9	10.07	28.79	9.38	26.73
5/10	4.59	20.90	5.21	26.80
5/11	3.56	26.62	10.69	43.64
5/14	3.16	20.58	5.53	29.53
5/22	4.35	23.58	5.73	18.79
5/24	1.24	29.49	7.29	21.33
5/25		16.11		15.10
6/1	7.41	22.21	4.17	18.61
AVERAGE	4.88	23.77	8.28	24.98
CORRECTED	4.48	18.76	7.39	17.59

Number of Pollen Grains Observed per Pollinated Stigma, Debusschere Orchard, 2001



Number of Pollen Grains Observed per Pollinated Stigma, Rancho Simpatuca, 2001



Pollen Deposition at Debusschere Orchard, 2003

POLLINATION SUMMARY AT DEBUSSCHERE (2003)				
DAILY AVERAGE PERCENTAGE (%)				
	INSIDE		OUTSIDE	
DATE	STAGE 1	STAGE 2	STAGE 1	STAGE 2
21-Apr		44.2		35.6
23-Apr	0.0	34.0	1.1	44.2
24-Apr		32.7		34.3
25-Apr	0.0	49.6	0.3	43.6
AVERAGE	0.0	40.1	0.7	39.4

Pollen Deposition at Hardison Orchard, 2003

POLLINATION SUMMARY AT HARDISSON (2003)				
DAILY AVERAGE PERCENTAGE (%)				
	INSIDE		OUTSIDE	
DATE	STAGE 1	STAGE 2	STAGE 1	STAGE 2
6-May	0.0		0.0	
7-May		20.1		16.8
AVERAGE	0.0	20.1	0.0	16.8

SSR Analyses Determining Pollen Parents at Hardison, 2003

Table 4. Marble-sized Hass fruit harvested on May 27, 2003 from caged and open-pollinated trees in the Hardison orchard near Santa Paula.

Paternity	Tree Locations															Summary				
	Tree #2		Tree #3		Tree #4		Tree #5		Tree #6		Tree #7		Tree #8		Tree #9		All Caged		All Open	
	Caged #5	Open #5	Caged #6	Open #6	Caged #7	Open #7	Caged #8	Open #8	Caged #9	Open #9	Caged #10	Open #10	Caged #11	Open #11	#	%	#	%		
Fruits	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Zutano	5	35.7	11	52.4	10	62.5	9	40.9	9	39.1	10	62.5	9	45.0	13	65.0	33	45.2	43	54.4
Hass	0	0.0	0	0.0	2	12.5	0	0.0	0	0.0	2	12.5	1	5.0	2	10.0	3	4.1	4	5.1
Fuente	0	0.0	0	0.0	0	0.0	3	13.6	3	13.0	1	6.3	1	5.0	1	5.0	4	5.5	5	6.3
Ettinger	5	35.7	4	19.0	3	18.8	2	9.1	2	8.7	1	6.3	5	25.0	1	5.0	15	20.5	8	10.1
Bacon	1	7.1	0	0.0	0	0.0	0	0.0	1	4.3	1	6.3	0	0.0	2	10.0	2	2.7	3	3.8
M/N/L	3	21.4	6	28.6	1	6.3	8	36.4	8	34.8	1	6.3	4	20.0	1	5.0	16	21.9	16	20.3
Total	14	100.0	21	100.0	16	100.0	22	100.0	23	100.0	16	100.0	20	100.0	20	100.0	73	100.0	79	100.0
Selfing %		0.0		0.0		12.5		0.0		0.0		12.5		5.0		10.0		4.1		5.1
Crossing%		100.0		100.0		87.5		100.0		100.0		87.5		95.0		90.0		95.9		94.9

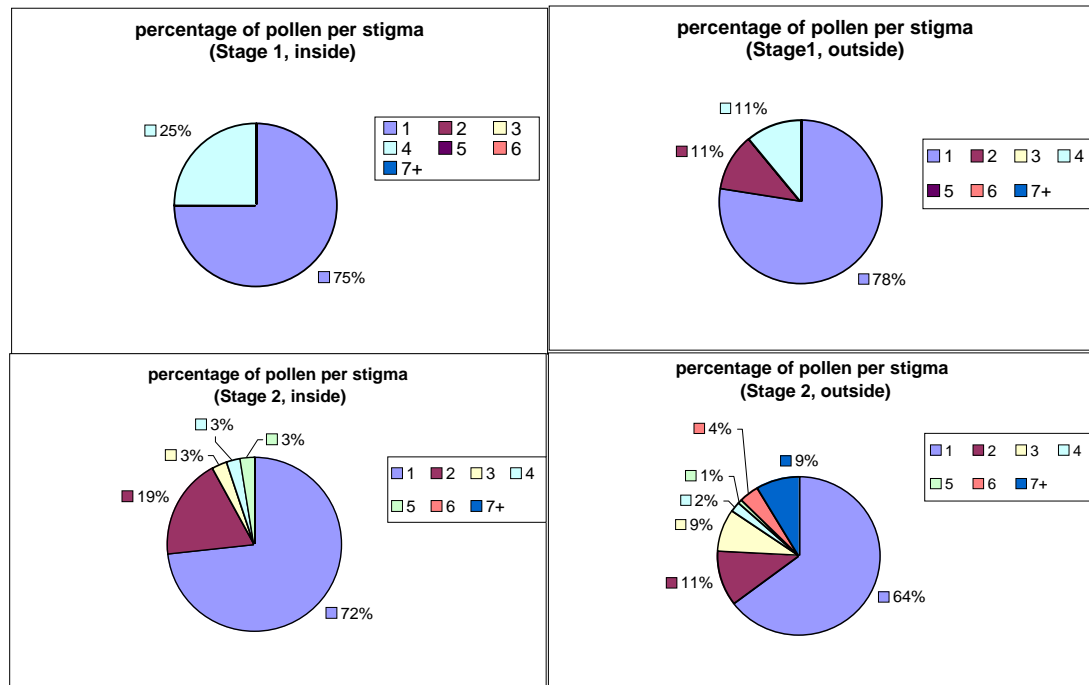
Pollen Deposition at Debusschere Orchard, 2005

DATE	INSIDE						OUTSIDE					
	STAGE 1			STAGE 2			STAGE 1			STAGE 2		
	TS	SP	%	TS	SP	%	TS	SP	%	TS	SP	%
4-Apr	132	1	0.8	178	3	1.6	221	2	0.9	208	8	3.8
6-Apr	366	0	0	303	21	6.5	383	0	0	452	53	11.7
11-Apr	183	2	1.09	49	3	6.25	195	0	0	133	22	16.5
12-Apr	425	0	0	184	3	1.6	186	0	0	175	9	5.14
14-Apr	193	0	0	198	4	2	193	0	0	194	16	8.2
15-Apr	192	0	0	200	3	1.5	195	0	0	197	12	6
TOTAL	1491	3	1.84	1112	37	19.5	1373	2	0.9	1359	120	51.3
AVE	248.5	0.5	0.31	185	6.17	3.24	228.8	0.33	0.2	226.5	20	8.56

Pollen Deposition at Hardison Orchard, 2005

DATE	INSIDE						OUTSIDE					
	STAGE 1			STAGE 2			STAGE 1			STAGE 2		
	TS	SP	%	TS	SP	%	TS	SP	%	TS	SP	%
5-Apr	164	0	0	285	14	4.91	159	6	3.7	321	31	9.65
6-Apr	179	16	8.9	394	19	4.82	200	15	7.5	419	91	21.7
11-Apr	450	11	2.45	439	85	19.3	428	3	0.7	388	121	31.1
15-Apr	523	3	0.57	557	74	13.3	789	9	1.1	549	181	32
25-Apr	176	0	0	ND	ND	ND	250	5	2	ND	ND	ND
TOTALS	1492	30	11.9	1675	192	42.3	1826	38	15	1677	424	94.5
AVE	298	6	2.38	418.8	48	10.6	365.2	38	3	419.3	106	23.6

Number of Pollen Grains Observed per Pollinated Stigma, Debusschere Orchard, 2005



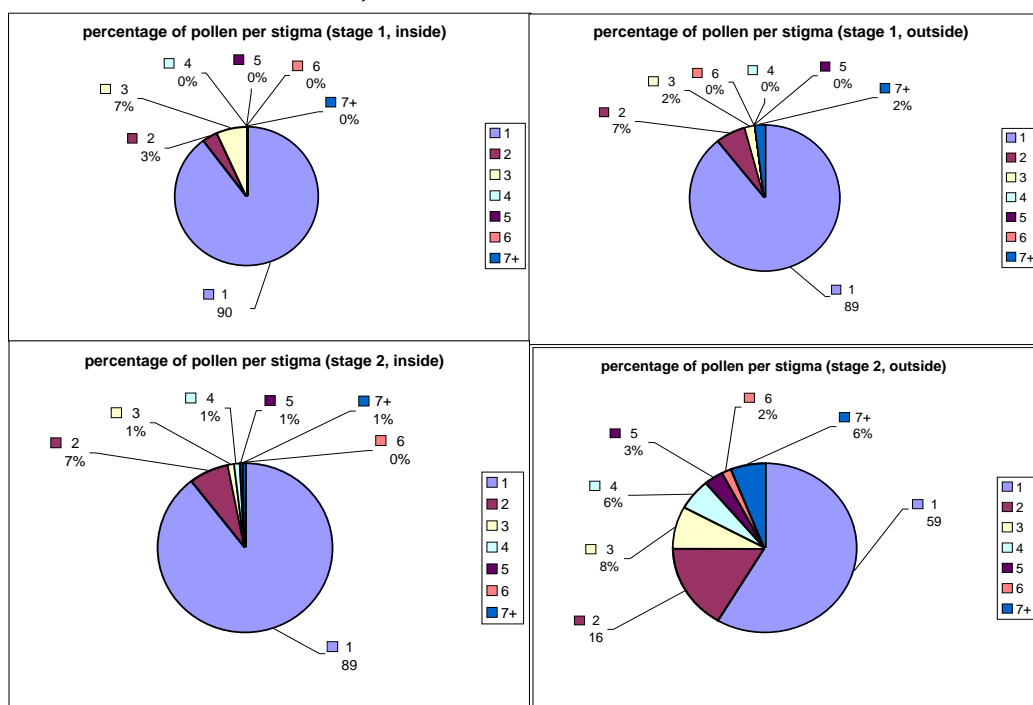
Number of Pollen Grains Observed per Pollinated Stigma, Hardison Orchard, 2005

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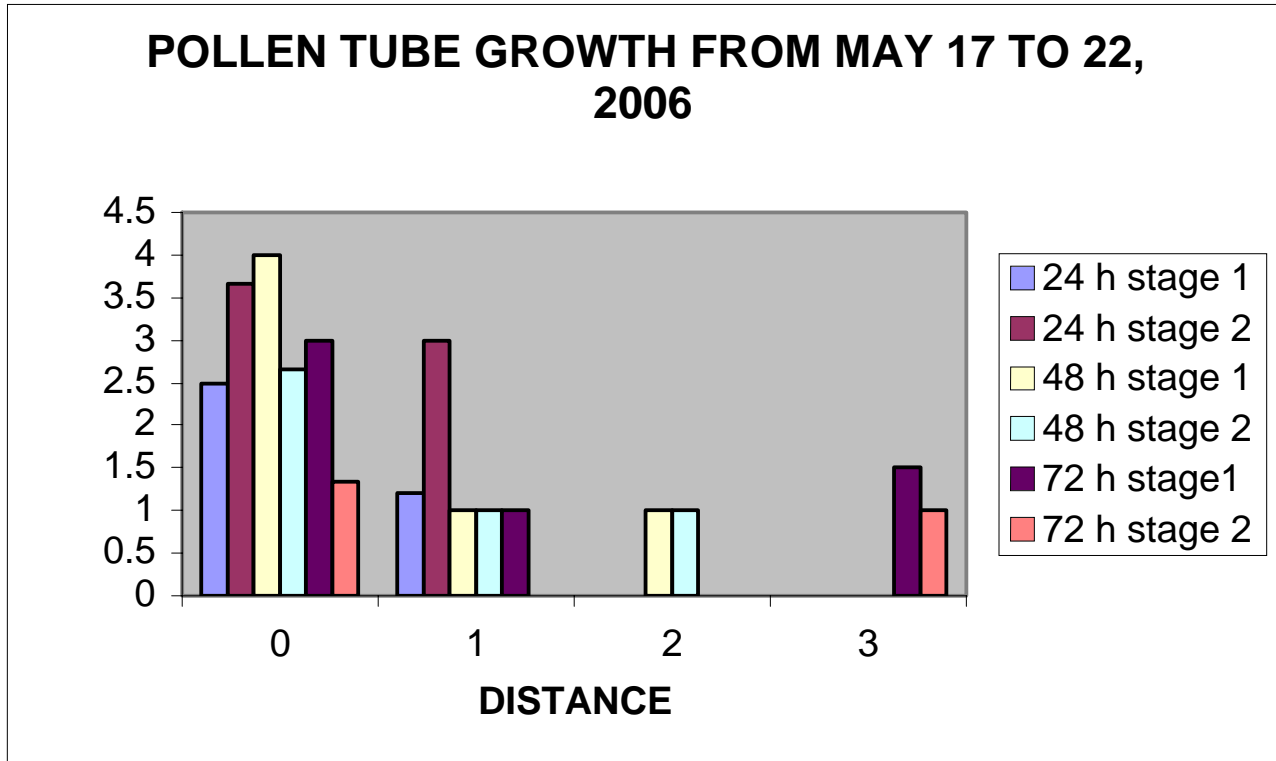
Pollen Deposition, Debusschere Orchard, 2006

DATE	STAGE 1		STAGE 2	
	INSIDE	OUTSIDE	INSIDE	INSIDE
16-MAY	1.15	2.62	14.75	40.63
17-MAY	0.74	2.37	16.14	34.57
18-MAY	0.84	2.68	11.90	20.67
19-MAY	3.09	4.08	9.14	20.12
20-MAY	0.63	3.49	7.54	20.41
21-MAY	0.89	3.81		
22-MAY	0.52	4.47	6.59	20.45
23-MAY	1.28	3.91	2.59	29.31
Average	1.14	3.43	9.81	26.60

Number of Pollen Grains Observed per Pollinated Stigma, Debusschere Orchard, 2006



Maximum Pollen Tube Travel Distance in Avocado Floral Pistils



- D0 = No germination
- D1 = Just germinated but no travel
- D2 = Half way down style
- D3 = Between 1/2 and base of style
- D4 = In ovary
- D5 = Base of ovary
- D6 = In egg apparatus

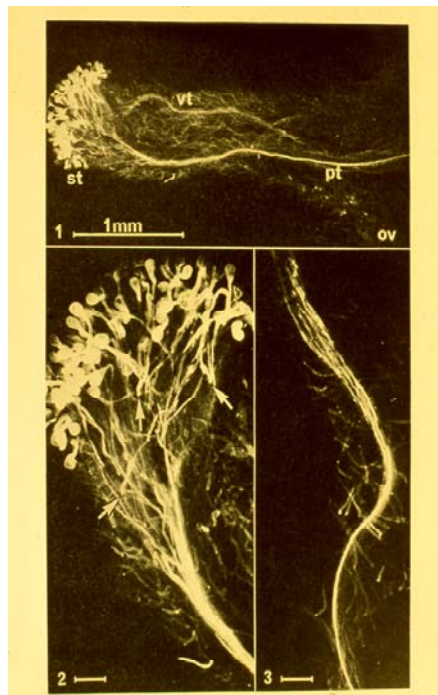


Table 3 Effects of Hass pollination by honey bees with or without Zutano pollen supplements in 2004

Zutano Pollen Supplemented	Total Tested	Percentage (%)		
		Zutano	Selfing	Others
Yes	390	2.1a	72.0b	25.9a
No	400	0.5a	86.0a	13.5b

Number separation within each column by Student's t-test, P<0.05.

Orchard A--LambHass interplanted and Bacon 1000' away

Orchard AC--No other pollinizers within one mile

Orchard F--Bacon/Leavens Hass?/Nobal/LambHass

Orchard L--Nothing

Orchard OF--LambHass

Orchard T--Bacon 1000' away and some Bacons interplanted

Orchard W--Nothing

Orchard LO--Nothing

Orchard OS--Bacon paralleled at 60' away

Orchard ON--Bacon paralleled at 60' away

Table 4 Paternity analysis of Hass fruits at 5 different distances from bee hives with Zutano pollen across all 5 orchards

Row #	Total Tested	Percentage (%)		
		Zutano	Selfing	Others
1	81	2.5a	80.2a	17.3a
2	77	0.0a	75.3a	24.7a
3	77	2.6a	63.6a	33.8a
5	78	2.6a	71.8a	25.6a
10	77	2.6a	68.8a	28.6a

Number separation within each column by Duncan's multiple range test, P<0.01.

Table 5 Paternity analysis of Hass fruits at 5 different distances from bee hives without Zutano pollen across all 5 orchards

Row #	Total Tested	Percentage (%)		
		Zutano	Selfing	Others
1	79	0.0a	81.0a	19.0a
2	80	0.0a	86.3a	13.8a
3	78	1.3a	85.4a	12.8a
5	86	0.0a	90.7a	9.3a
10	77	1.3a	85.7a	13.0a

Number separation within each column by Duncan's multiple range test, P<0.01.

Table 6 Paternity analysis of Hass fruits from three different stages across all 10 orchards in 2004

Fruit stage	Total Tested	Percentage (%)		
		Zutano	Selfing	Others
Marble	271	0.0a	76.0a	24.0a
Intermediate	269	1.1a	86.6a	12.3a
Near Mature	250	2.8a	74.4a	22.8a

Number separation within each column by Duncan's multiple range test, P<0.01.

Table 7 Paternity analysis of Hass fruits from selfing vs. crossing from three different stages across all 10 orchards in 2004

Selfing vs. Crossing	Total Tested	Fruit Stage (Fruit size)		
		Marble	Intermediate	Near Mature
Hass-Selfing	625	76.0%a	86.6%a	74.4%a
Hass-Crossing	165	24.0%b	13.4%b	25.6%b

Conclusions

There is a higher proportion of pollen deposition in Stage 2 (*self-pollination*) than in Stage 1 (*cross pollination*) ‘Hass’ flowers.

Proportions of self- and cross-pollination were not affected by relative humidity (humid vs. dry climates).

Pollination is mediated virtually exclusively by wind.

Bees do not pollinate avocado flowers despite excessive numbers of hives in the orchard.

Max/Min air temperatures of 67/58° F are sufficiently high to allow near normal floral opening behavior of ‘Hass’ but too low to allow sufficient pollen tube growth to the egg in the ovary.

Cool temperature, not lack of pollinizers or bees, is the dominant factor limiting avocado productivity in California.

Cross pollination of ‘Hass’ by complimentary “B” type cultivars may provide a benefit in marginally cool flowering conditions due to the earlier arrival of pollen on the stigmas in Stage 1 vs. Stage 2.