Breeding and Genetics

Use of Simple Sequence Repeats (SSR) to Determine Incidence and Effectiveness of Self- and Cross-pollinated Avocado Fruit in Southern California

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SSR technology is a powerful tool to determine the pollen parents of avocado progeny of known maternal genetic background. The four SSR markers selected for use to determine pollen parents were powerfully informative for the range of cross pollinizing cultivars available in the selected orchards and were, therefore, highly capable of discerning the specific pollen parent of each sampled fruit including those that were the result of self pollination. The cultivars included in the study were Hass and its potential cross pollinizers: Bacon, Ettinger, Fuerte, Harvest, Lamb Hass, Marvel, Nobel, SirPrize, and Zutano. This, coupled with the opportunity to sample fruits in replicated experimental plots comparing cross- and self-pollinations in trees located various distances from pollinizing cultivars, and comparing retention of cross- vs. self-pollinated fruit over the development season made this endeavor one of the most comprehensive ever preformed on avocado. This report is the final installment of a four-year suite of studies. It provides California avocado growers and advisors answers to the long sought after impacts of interplanting complimentary cultivars, and how these ultimately influence the crop.

The primary objective of this research was to determine the pollen parent of each fruit sampled early in fruit development and in those sampled late in fruit development at or near maturity. Secondarily with this knowledge applied to the population of fruits sampled from trees in experimental plots described below, the objectives include:

1. Estimate the proportions of successful self-pollinations with 'Hass' and cross-pollinations with specific cultivars that occurred in the individual rows of varying proximity to cross-pollinizing cultivars.
2. Determine if the proportion of outcrossed fruit increases during maturity due to preferential abscission of self-pollinated fruit as has been found for certain pollen parents of 'Hass'.
3. Determine if there is preferential retention of cross-pollinated fruit pollinated by a specific cultivar during maturation.

Summary

In September of 2004, we began SSR analysis of near mature 'Hass' fruit embryos that were harvested on October 1, 2003 at the Debusschere orchard located on the coastal plain near Camarillo in Ventura County. The results of those samples were published in the *2004 California Avocado Research Symposium*. Details of the experimental and analytical protocols used throughout the four-year study, along with supporting literature, were included therein. Twenty-four fruits in the first two samplings (2003 near-mature fruit and 2004 marble sized fruit) and 36 fruits thereafter were sampled evenly down four 'Hass' trees of interplanted rows and six trees of purely 'Hass' rows. Each row consisted of north and south plots each having ten 'Hass' trees in 48 rows across a block of trees interplanted every 6 rows with the complimentary cultivars listed above and nearby Lamb Hass (Fig. 1). The results of subsequent samplings and pollen parent analysis of marble sized fruit collected on June, 13, 2004 and near-mature fruit collected on November 1, 2004 and November 7, 2005 were reported in the *2006 California Avocado Research Symposium*. This, the final installment, reports the completed parental analysis of the more than 4,500 fruit sampled at marble size on June 22, 2005 and June 24, 2006 and at near–mature stage on November 6, 2006. It is supplemented with further analyses summarizing the three years of pollen parent analysis results of marble sized fruits harvested in June of 2004 to 2006 and the four years of results in near-mature fruit sampled in October/November of 2003 to 2006.

Current Results and Overall Project Discussion

Results of genetic analyses of the embryos from marble sized fruit sampled on June 22, 2005 from test plots B2 and A2 at Debusschere orchard are presented in Tables 1a (western half of orchard plot) and 1b (eastern half). Similarly, the pollen parent analyses of fruit sampled from the same plots on June 24, 2006 are displayed in Tables 2a and 2b, and the same population of fruits sampled at near maturity on November 6, 2006 is presented in Tables 3a & 3b. The average number and proportion of pollinations by each pollen parent including 'Hass' (self pollinated) across the northern and southern portions of the orchard at each stage each year are listed at the end of Tables 1b, 2b, and 3b.

As has occurred each year for the last four years, self-pollination within Stage 2 (male stage) flowers was the dominant mode of reproduction. Cross-pollination was greatest in "Hass' trees interplanted in the same or adjacent rows with 'Ettinger', 'Fuerte', or 'Zutano'. The extent of cross-pollination in adjacent rows was low to very low compared to the pollinizer rows. On average, across the orchard, cross-pollination by any pollinizing cultivar was 31% or less depending upon sample year and stage of fruit development. The proportions of self-pollination ranged from 37% to 66% depending on sampling location (N or S portion of orchard), fruit stage of development, and year sampled.

The predominance of self-pollination in Stage 2 flowers was consistent for the four years of flowering as evidenced by the percent proportions of self-pollinated near-mature fruit sampled in 2003, 2004, 2005, and 2006. Self-pollination was not a result of close pollination. We have observed that floral openings in cool temperature conditions, which promote delayed and (at rare times) overlapping of floral openings in the same cultivar, are rarely sufficiently overlapped to allow pollen to be transferred from flower to flower. Moreover, temperature conditions that cause overlap are always too cold to allow sufficient pollen tube growth to reach the ovary in time to fertilize the egg. The overall average number (Table 4) and percent proportion (Table 5) of harvested fruit analyzed to be self-pollinated over the four years of study was significantly greater than those of any cross pollinizing cultivar. The overall average percent proportion of self-pollinations found in near-mature fruit was 55.5% (Table 5).

The four-year accumulated distribution of the number of near-mature fruit pollinated by the various cultivars from row to row in the North plot and South plots of the Debusschere orchard is displayed in Figures 2a and 2b, respectively. The total overall number of near-mature fruit analyzed for paternity in each row over the four seasons was around 100. The accumulated numbers and, hence, proportions

of fruit determined to be pollinated by each pollinizing cultivar in each row are displayed within each histobar. Results in the companion study examining caged and open pollinated trees, funded by BARD, over the same four-year period have consistently indicated that pollen is wind blown and that virtually no pollen is transferred by bees despite their heavy presence in the orchard. Figures 2a and 2b display the extent of pollen drift from the pollinizer rows to other rows within the North and South plots.

The extent of pollen drift for each complimentary cultivar as expressed by the outreach index over the past four years, is displayed in Table 6. The outreach index was calculated by adding the products of the proportion of fruit pollinated by a particular cultivar times the number of rows from the row in which that cultivar was planted [$\sum$ (proportion pollen parent X row # from parent)] among all the rows in the orchard for each year. Zutano was deemed the farthest reaching pollinizer with an average outreach index over the four years of 20.4, followed by Ettinger at 13.5, and the remaining potential pollinizing cultivars at 5.2 or less. The lowest outreach index in Nobel could be attributed to the small tree size of that cultivar throughout the study. They never grew more than about 4 ft high bearing few flowering stems.

The purpose for harvesting fruit for paternity analysis at the marble-sized stage and the near-mature stage was to determine if the population of cross- and self-pollinated fruit shifted in favor of any fruit pollinated by a particular superior setting cultivar. For example, it has been reported that more self-pollinated fruit abscise during development in favor of those pollinated especially by Ettinger. Analysis of differences in percent proportions of fruit pollinated by each cultivar, including self-pollinations by 'Hass', as the fruit developed to the near-mature stage revealed consistently greater retention of self-pollinated fruit over any of those pollinated by complimentary cultivars during the three observation years (Table7). The proportion of self-pollinated 'Hass' fruit retained to maturity increased by 9% to 15% whereas most of the cross-pollinated fruit had losses or little change in proportion as they developed.

Based on the average results of paternity analysis of near-mature fruit sampled in different rows at the Debusschere orchard over the past four years, we estimated the potential out crossing proportions of each complimentary cultivar at different interplanted ratios with 'Hass' if trees were growing in similar conditions as that of the Debusschere orchard (Table 8). A ratio of 1:1 represents every row interplanted with the indicated cultivar, thus having equal numbers of 'Hass' trees and trees of the pollinizing cultivar. A ratio of 1:3 would be a planting of two solid 'Hass' rows between each interplanted row and so on for the increasing proportions of 'Hass' rows in an orchard. Clearly, as one "dilutes" the orchard with more complimentary cultivars, one obtains a greater proportion of cross-pollination by that cultivar, but does it result in increased yield?.

We estimated the number of near-mature fruit on each of eight trees in each row in 2006 (Table 9). Fruit counts were made on individual trees by visually counting the fruit while holding push button counting devises to record the number of fruit observed within each tree canopy. The range in yield from tree to tree within each row without any apparent pattern was great (Table 9). Moreover the average yield from row to row displayed no discernable pattern with regard to proximity to interplanted rows (Figures 3a and 3b). Yields in the western and easternmost rows were highly influenced by shading from the poplar and eucalyptus wind break trees, but there was no indication of increased yields in the orchard rows near the interplanted rows. Yield among rows was random. Moreover, comparison of Figures 3a and 3b with Tables 3a and 3b reveal no pattern with regard to percent pollination by a particular cultivar and yield.

Finally, we measured the ratio of seed length and width and fresh seed weight before subjecting the embryos to SSR analysis (Table 10). There was a significantly greater length to width ratio in 'Fuerte'-

pollinated seeds over all the others. On average, 'SirPrize- and Harvest-pollinated seeds were significantly largest at about 21 grams compared to the smallest (12.5 g) in fruits pollinated by 'Bacon'

Conclusions

Self-pollination within Stage 2 flowers appears to be the dominant mode of avocado reproduction unless a high proportion of complimentary cultivars with high outreach indexes are interplanted in the orchard. The results reported here are consistent with the conclusions derived from caged experiments, that avocado flowers are wind pollinated. We observed liberation of pollen from Stage 2 flowers of complimentary cultivars and 'Hass' flowers each year. Each flowering tree acts as a filter to catch drifting pollen in 2 to 4% of the flowers open in Stage 1, and dispersal of 'Hass' pollen in Stage 2 makes it readily available to receptive stigmas within the same flowers.

Yield in 2006 was not related to pollen parent. Microclimates within the orchard and possible internal alternate bearing effects from the previous year's production most likely determine yield. We observed fruit set occurring only on days in which the temperatures warmed to above the high 60's at night and low 80's during the day. No cross pollinizing cultivar matched the fruit retention capabilities of self-pollinated fruit; hence the observation of superior fruit set and retention by Ettinger pollinated fruit reported in Israel is not true for conditions present in the Debusschere orchard.

How does one resolve the conflicting observations by some growers that solid 'Hass' plantings produce good yields, whereas cross-pollinizing cultivars seem to be necessary on other farms. For example, the eight cross-pollinizing cultivars with a 1:6 interplanted ratio contributed to an average of about 45% of the yield in the Debusschere orchard over the past four years. Perhaps the answer to this enigma lies in the timing of pollen arrival and the interactions of cool temperatures with flowers resulting in slowed pollen tube growth.

We observed that pollen tube growth in 'Hass 'flowers was severely inhibited when temperatures were within the lower range of those mentioned above regardless of cultivar or stage of application to the stigmas. There were no delays or overlap of floral openings; however, pollen tubes grew only to the base of the styles by three days after pollen deposition. Research in Florida has demonstrated that individual flowers begin producing large amounts of ethylene beginning on the day of Stage 2 opening, and dramatically higher proportions of flowers begin producing ethylene over the first and second days after Stage 2 opening. Once each flower begins producing ethylene it separates from the tree two days later. It is, thus, a race against time for pollen to arrive at the egg to fertilize it before the abscission event begins. Successful fertilizations prevent the onset of ethylene production in some flowers resulting in the observed initial fruit set.

Later abscission can still occur, but in California, temperature seems to dominate the success or failure of the pollination event. When temperatures are too low to allow successful fertilizations, no fruit set occurs, and flowers abscise. It is possible that, because of the one day earlier arrival of pollen from complimentary cultivars in Stage 1, this pollen has 32 more hours to grow to the egg than does the pollen arriving from within flowers in Stage 2 before the onset of the abscission event. Thus, conditions may favor successful cross-pollination during marginally cool temperature conditions, hence favoring more fruit set. Interplanting of cross-pollinizing cultivars would be advantageous in chronically cool conditions, such as Debusschere, to provide additional potential for fruit set. If temperatures are sufficiently warm during flowering, then self-pollinated flowers would have the same potential to successfully fertilize the egg and produce fruit. The need for cross pollinizing cultivars for good yields would thus be reduced as demonstrated in large, solid block plantings in warm areas.

Figure 1. Debusschere orchard plots B2 (north half) and A2 (south half) are bordered by tall windbreak rows of Poplar to the west and Eucalyptus to the east. 'Hass' (X) trees are interplanted with 'Ettinger' (ET), 'Nobel' (N), 'Fuerte' (F), and 'Zutano' (Z) in the indicated rows of the north half of the orchard and with 'Marvel' (M), 'Harvest' (HV), 'Bacon' (B), and 'SirPrize' (SP) in the indicated rows of the south half of the orchard. 'Lamb Hass' is interplanted with 'Hass' in rows 29, 35, 41, and 47 in the adjacent section immediately south of the displayed plotted section.

												NORTH ROW													
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	TREE
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1
W			ET						N						F						Z				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	2
I			ET						N						F						Z				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	3
N			ET						N						F						Z				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	4
D			ET						N						F						Z				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	5
B			ET						N						F						Z				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	6
R			ET						N						F						Z				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	7
E			ET						N						F						Z				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	8
A			ET						N						F						Z				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	9
K			ET						N						F						Z				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	10
			ET						N						F						Z				TREE
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	11
W			M						HV						B						SP				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	12
I			M						HV						B						SP				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	13
N			M						HV						B						SP				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
D			M						HV						B						SP				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
B			M						HV						B						SP				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
R			M						HV						B						SP				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
E			M						HV						B						SP				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
A			M						HV						B						SP				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	19
K			M						HV						B						SP				
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
			16						HV						B						SP				
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	

B2

A2

Table 1a. Numbers and proportions of marble sized 'Hass' fruit harvested on June 22, 2005 that were pollinated by all potential pollen donors in the western half of the Debusschere orchard plot. Table representing the eastern half of the plot is shown in Table 1b.

Pollinizer					Ettinger												Nobel							
Row	27N		28N		29N		30N		31N		32N		33N		34N		35N		36N		37N		38N	
Fruits	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Total	30	100	37	100	32	100	35	100	36	100	35	100	27	100	34	100	30	100	26	100	33	100	31	100
Zutano	10	33.3	8	21.6	0	0.0	5	14.3	3	8.3	4	11.4	5	18.5	2	5.9	5	16.7	6	23.1	3	9.1	7	22.6
Hass	2	6.7	1	2.7	0	0.0	9	25.7	14	38.9	16	45.7	15	55.6	23	67.6	16	53.3	11	42.3	19	57.6	13	41.9
Fuerte	0	0.0	0	0.0	0	0.0	1	2.9	0	0.0	0	0.0	0	0.0	1	2.9	1	3.3	0	0.0	0	0.0	3	9.7
Ettinger	17	56.7	28	75.7	30	93.8	19	54.3	18	50.0	11	31.4	7	25.9	7	20.6	6	20.0	3	11.5	9	27.3	3	9.7
Bacon	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	5.7	0	0.0	1	2.9	2	6.7	5	19.2	1	3.0	0	0.0
SirPrize	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Marvel	0	0.0	0	0.0	1	3.1	0	0.0	0	0.0	2	5.7	0	0.0	0	0.0	0	0.0	1	3.8	1	3.0	3	9.7
Harvest	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Nobel	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	6.5
LambHass	1	3.3	0	0.0	1	3.1	1	2.9	1	2.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

Pollinizer					Marvel												Harvest							
Row	27S		28S		29S		30S		31S		32S		33S		34S		35S		36S		37S		38S	
Fruits	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Total	28	100	33	100	32	100	33	100	34	100	35	100	31	100	34	100	33	100	16	100	32	100	26	100
Zutano	9	23.7	6	18.2	1	3.1	4	12.1	0	0.0	1	2.9	0	0.0	0	0.0	3	9.1	1	6.3	5	15.6	3	11.5
Hass	11	28.9	5	15.2	6	18.8	12	36.4	24	70.6	27	77.1	27	8.7	27	79.4	27	81.8	13	81.3	24	75.0	17	65.4
Fuerte	1	2.6	1	3.0	0	0.0	3	9.1	0	0.0	0	0.0	1	0.3	0	0.0	0	0.0	0	0.0	0	0.0	2	7.7
Ettinger	4	10.5	13	39.4	9	28.1	9	27.3	8	23.5	4	11.4	1	0.3	5	14.7	1	3.0	0	0.0	1	3.1	2	7.7
Bacon	0	0.0	0	0.0	0	0.0	0	0.0	1	2.9	1	2.9	0	0.0	0	0.0	1	3.0	2	12.5	2	6.3	2	7.7
SirPrize	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	2.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Marvel	3	7.9	7	21.2	16	50.0	5	15.2	1	2.9	1	2.9	1	0.3	1	2.9	0	0.0	0	0.0	0	0.0	0	0.0
Harvest	0	0.0	1	3.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.3	1	2.9	1	3.0	0	0.0	0	0.0	0	0.0
Nobel	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
LambHass	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

Table 1b. Numbers and proportions of marble sized 'Hass' fruit harvested on June 22, 2005 that were pollinated by all potential pollen donors in the eastern half of the Debusschere orchard plot. Table representing the western half of the plot is shown in Table 1a.

				Fuerte												Zutano								
39N		40N		41N		42N		43N		44N		45N		46N		47N		48N		49N		50N		Total		
#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	Fruits
36	100	33	100	36	100	33	100	33	100	33	100	29	100	32	100	36	100	32	100	33	100	27	100	779	100	Total
1	2.8	10	30.3	6	16.7	5	15.2	8	24.2	8	24.2	13	44.8	18	56.3	28	77.8	17	53.1	14	42.4	13	48.1	199	30.5	Zutano
24	66.7	12	36.4	9	25.0	20	60.6	20	60.6	19	57.6	10	34.5	10	31.3	4	11.1	8	25.0	6	18.2	5	18.5	286	43.8	Hass
4	11.1	6	18.2	16	44.4	6	18.2	3	9.1	3	9.1	2	6.9	0	0.0	1	2.8	0	0.0	1	3.0	3	11.1	51	7.8	Fuerte
3	8.3	0	0.0	5	13.9	2	6.1	2	6.1	0	0.0	4	13.8	0	0.0	3	8.3	4	12.5	9	27.3	1	3.7	191	29.2	Ettinger
0	0.0	1	3.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	6.3	0	0.0	2	6.3	1	3.0	3	11.1	20	3.1	Bacon
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	0	0.0	1	3.1	1	3.0	0	0.0	3	0.5	SirPrize
1	2.8	2	6.1	0	0.0	0	0.0	0	0.0	3	9.1	0	0.0	0	0.0	0	0.0	0	0.0	1	3.0	0	0.0	15	2.3	Marvel
0	0.0	2	6.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	0	0.0	0	0.0	0	0.0	2	7.4	5	0.8	Harvest
1	2.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.5	Nobel
2	5.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	6	0.9	L.Hass

				Bacon												SirPrize								
39S		40S		41S		42S		43S		44S		45S		46S		47S		48S		49S		50S		Total		
#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	Fruits
31	100	31	100	32	100	36	100	35	100	27	100	34	100	30	100	29	100	31	100	17	100	34	100	734	100	Total
7	22.6	12	38.7	18	56.3	7	19.4	10	28.6	5	18.5	12	35.3	4	13.3	9	31.0	10	32.3	5	29.4	10	29.4	142	21.7	Zutano
19	61.3	11	35.5	8	25.0	18	50.0	17	48.6	19	70.4	19	55.9	23	76.7	13	44.8	9	29.0	5	29.4	12	35.3	393	60.2	Hass
0	0.0	0	0.0	2	6.3	6	16.7	3	8.6	1	3.7	1	2.9	0	0.0	0	0.0	2	6.5	2	11.8	2	5.9	27	4.1	Fuerte
3	9.7	1	3.2	0	0.0	2	5.6	4	11.4	2	7.4	2	5.9	1	3.3	2	6.9	4	12.9	4	23.5	4	11.8	86	13.2	Ettinger
1	3.2	7	22.6	4	12.5	2	5.6	1	2.9	0	0.0	0	0.0	1	3.3	0	0.0	4	12.9	1	5.9	4	11.8	34	5.2	Bacon
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.3	5	17.2	0	0.0	0	0.0	0	0.0	7	1.1	SirPrize
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	5.9	37	5.7	Marvel
1	3.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	0.8	Harvest
0	0.0	0	0.0	0	0.0	1	2.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	6.5	0	0.0	0	0.0	3	0.5	Nobel
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	L.Hass

Table 2a. Numbers and proportions of marble sized 'Hass' fruit harvested on June 24, 2006 that were pollinated by all potential pollen donors in the western half of the Debusschere orchard plot. Table representing the eastern half of the plot is shown in Table 2b.

Pollinizer					Ettinger												Nobel							
Row	27N		28N		29N		30N		31N		32N		33N		34N		35N		36N		37N		38N	
Fruits	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Total	32	100	32	100	31	100	32	100	32	100	30	100	31	100	32	100	30	100	32	100	31	100	29	100
Zutano	1	3.1	0	0.0	1	3.2	0	0.0	1	3.1	0	0.0	3	9.7	3	9.4	4	13.3	1	3.1	1	3.2	5	17.2
Hass	11	34.4	5	15.6	4	12.9	10	31.3	12	37.5	22	73.3	17	54.8	23	71.9	15	50.0	21	65.6	25	80.6	12	41.4
Fuerte	0	0.0	0	0.0	1	3.2	0	0.0	4	12.5	1	3.3	0	0.0	1	3.1	6	20.0	5	15.6	2	6.5	8	27.6
Ettinger	20	62.5	27	84.4	25	80.6	22	68.8	14	43.8	6	20.0	10	32.3	3	9.4	4	13.3	4	12.5	2	6.5	2	6.9
Bacon	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.3	1	3.2	1	3.1	1	3.3	0	0.0	0	0.0	0	0.0
SirPrize	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Marvel	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	1	3.2	2	6.9
Harvest	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Nobel	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	0	0.0	0	0.0	0	0.0	0	0.0
LambHass	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

Pollinizer					Marvel												Harvest							
Row	27S		28S		29S		30S		31S		32S		33S		34S		35S		36S		37S		38S	
Fruits	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Total	18	100	28	100	29	100	31	100	32	100	32	100	28	100	32	100	29	100	31	100	32	100	32	100
Zutano	3	16.7	7	25.0	0	0.0	2	6.5	0	0.0	1	3.1	0	0.0	5	15.6	2	6.9	7	22.6	7	21.9	10	31.3
Hass	12	66.7	16	57.1	13	44.8	18	58.1	29	90.6	25	78.1	27	96.4	26	81.3	25	86.2	20	64.5	17	53.1	19	59.4
Fuerte	1	5.6	0	0.0	0	0.0	2	6.5	0	0.0	1	3.1	0	0.0	0	0.0	2	6.9	4	12.9	6	18.8	0	0.0
Ettinger	0	0.0	5	17.9	5	17.2	3	9.7	2	6.3	2	6.3	1	3.6	1	3.1	0	0.0	0	0.0	1	3.1	1	3.1
Bacon	2	11.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	6.3
SirPrize	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Marvel	0	0.0	0	0.0	11	37.9	6	19.4	1	3.1	2	6.3	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	0	0.0
Harvest	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Nobel	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
LambHass	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

Table 2b. Numbers and proportions of marble sized 'Hass' fruit harvested on June 24, 2006 that were pollinated by all potential pollen donors in the eastern half of the Debusschere orchard plot. Table representing the western half of the plot is shown in Table 2a. Fruit samples harvested from Rows 48S, 49S and 50S were not analyzed due to damage during transit to Florida .

				Fuerte												Zutano									
39N		40N		41N		42N		43N		44N		45N		46N		47N		48N		49N		50N		Total		
#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	Fruits
31	100	32	100	30	100	32	100	32	100	31	100	32	100	32	100	28	100	32	100	32	100	30	100	748	100	Total
6	19.4	0	0.0	2	6.7	7	21.9	9	28.1	17	54.8	25	78.1	31	96.9	27	96.4	17	53.1	25	78.1	3	10.0	189	25.3	Zutano
9	29.0	1	3.1	2	6.7	15	46.9	18	56.3	8	25.8	7	21.9	0	0.0	1	3.6	8	25.0	5	15.6	22	73.3	273	36.5	Hass
16	51.6	31	96.9	23	76.7	10	31.3	4	12.5	4	12.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	13.3	120	16.0	Fuerte
0	0.0	0	0.0	2	6.7	0	0.0	1	3.1	2	6.5	0	0.0	1	3.1	0	0.0	4	12.5	1	3.1	1	3.3	151	20.2	Ettinger
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	6.3	1	3.1	0	0.0	7	0.9	Bacon
0	0.0	0	0.0	1	3.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	0	0.0	0	0.0	2	0.3	SirPrize
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	0.7	Marvel
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	Harvest
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.1	Nobel
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	L.Hass

				Bacon												SirPrize									
39S		40S		41S		42S		43S		44S		45S		46S		47S		48S		49S		50S		Total		
#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	Fruits
31	100	32	100	32	100	31	100	32	100	32	100	31	100	31	100	31	100	0	####	0	#####	0	####	637	100	Total
16	51.6	23	71.9	19	59.4	13	41.9	5	15.6	14	43.8	4	12.9	17	54.8	15	48.4							170	26.7	Zutano
12	38.7	3	9.4	8	25.0	11	35.5	26	81.3	17	53.1	27	87.1	11	35.5	8	25.8							370	58.1	Hass
2	6.5	0	0.0	1	3.1	3	9.7	0	0.0	1	3.1	0	0.0	1	3.2	1	3.2							25	3.9	Fuerte
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	6.5							23	3.6	Ettinger
1	3.2	6	18.8	4	12.5	4	12.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0							19	3.0	Bacon
0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	0	0.0	0	0.0	2	6.5	4	12.9							7	1.1	SirPrize
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0							21	3.3	Marvel
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0							0	0.0	Harvest
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0							0	0.0	Nobel
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.2							2	0.3	L.Hass

Table 3a. Numbers and proportions of near-mature 'Hass' fruit harvested on November 6, 2006 that were pollinated by all potential pollen donors in the western half of the Debusschere orchard plot. Table representing the eastern half of the plot is shown in Table 3b.

Pollinizer					Ettinger												Nobel							
Row	27N		28N		29N		30N		31N		32N		33N		34N		35N		36N		37N		38N	
Fruits	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Total	30	100	32	100	30	100	28	100	32	100	31	100	31	100	31	100	26	100	27	100	28	100	24	100
Zutano	0	0.0	0	0.0	1	3.3	0	0.0	0	0.0	1	3.2	1	3.2	2	6.5	0	0.0	2	7.4	1	3.6	4	16.7
Hass	9	30.0	15	46.9	1	3.3	11	39.3	19	59.4	23	74.2	27	87.1	24	77.4	21	80.8	19	70.4	19	67.9	13	54.2
Fuerte	1	3.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.2	2	6.5	1	3.8	4	14.8	4	14.3	5	20.8
Ettinger	19	63.3	17	53.1	28	93.3	16	57.1	11	34.4	4	12.9	2	6.5	3	9.7	4	15.4	1	3.7	3	10.7	2	8.3
Bacon	1	3.3	0	0.0	0	0.0	1	3.6	1	3.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
SirPrize	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Marvel	0	0.0	0	0.0	0	0.0	0	0.0	1	3.1	1	3.2	0	0.0	0	0.0	0	0.0	0	0.0	1	3.6	0	0.0
Harvest	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.2	0	0.0	0	0.0	0	0.0	1	3.7	0	0.0	0	0.0
Nobel	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
LambHass	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

Pollinizer					Marvel												Harvest							
Row	27S		28S		29S		30S		31S		32S		33S		34S		35S		36S		37S		38S	
Fruits	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Total	31	100	32	100	32	100	23	100	26	100	30	100	32	100	29	100	27	100	32	100	31	100	30	100
Zutano	5	16.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	17.2	2	7.4	1	3.1	3	9.7	4	13.3
Hass	20	64.5	26	81.3	19	59.4	17	73.9	21	80.8	25	83.3	29	90.6	20	69.0	17	63.0	27	84.4	28	90.3	25	83.3
Fuerte	1	3.2	0	0.0	3	9.4	1	4.3	3	11.5	0	0.0	0	0.0	1	3.4	1	3.7	0	0.0	0	0.0	1	3.3
Ettinger	3	9.7	4	12.5	3	9.4	3	13.0	1	3.8	5	16.7	0	0.0	1	3.4	1	3.7	0	0.0	0	0.0	0	0.0
Bacon	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	9.4	0	0.0	1	3.7	2	6.3	0	0.0	0	0.0
SirPrize	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Marvel	2	6.5	2	6.3	7	21.9	2	8.7	1	3.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Harvest	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	6.9	5	18.5	2	6.3	0	0.0	0	0.0
Nobel	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
LambHass	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

Table 3b. Numbers and proportions of near-mature 'Hass' fruit harvested on November 6, 2006 that were pollinated by all potential pollen donors in the eastern half of the Debusschere orchard plot. Table representing the western half of the plot is shown in Table 3a.

				Fuerte										Zutano										
39N		40N		41N		42N		43N		44N		45N		46N		47N		48N		49N		50N		Total		
#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	Fruits
28	100	32	100	25	100	14	100	31	100	25	100	28	100	30	100	24	100	26	100	29	100	27	100	669	100	Total
0	0.0	7	21.9	2	8.0	1	7.1	4	12.9	6	24.0	10	35.7	26	86.7	21	87.5	15	57.7	16	55.2	6	22.2	126	18.8	Zutano
20	71.4	4	12.5	3	12.0	10	71.4	22	71.0	18	72.0	15	53.6	3	10.0	2	8.3	7	26.9	12	41.4	19	70.4	336	50.1	Hass
5	17.9	21	65.6	20	80.0	1	7.1	4	12.9	0	0.0	1	3.6	1	3.3	0	0.0	1	3.8	1	3.4	2	7.4	75	11.2	Fuerte
1	3.6	0	0.0	0	0.0	2	14.3	0	0.0	1	4.0	0	0.0	0	0.0	0	0.0	1	3.8	0	0.0	0	0.0	115	17.1	Ettinger
0	0.0	0	0.0	0	0.0	0	0.0	1	3.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4	0.6	Bacon
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	7.1	0	0.0	0	0.0	2	7.7	0	0.0	0	0.0	4	0.6	SirPrize
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	4.2	0	0.0	0	0.0	0	0.0	4	0.6	Marvel
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.3	Harvest
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	Nobel
2	7.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.4	L.Hass

				Bacon										SirPrize										
39S		40S		41S		42S		43S		44S		45S		46S		47S		48S		49S		50S		Total		
#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	Fruits
30	100	28	100	15	100	27	100	30	100	26	100	28	100	29	100	26	100	30	100	32	100	27	100	683	100	Total
13	43.3	8	28.6	9	60.0	4	14.8	10	33.3	4	15.4	11	39.3	5	17.2	5	19.2	8	26.7	9	28.1	9	33.3	115	16.8	Zutano
14	46.7	9	32.1	3	20.0	17	63.0	13	43.3	20	76.9	17	60.7	21	72.4	14	53.8	18	60.0	18	56.3	11	40.7	449	65.7	Hass
1	3.3	0	0.0	0	0.0	3	11.1	4	13.3	0	0.0	0	0.0	2	6.9	3	11.5	1	3.3	2	6.3	0	0.0	27	4.0	Fuerte
1	3.3	1	3.6	0	0.0	0	0.0	0	0.0	1	3.8	0	0.0	1	3.4	3	11.5	3	10.0	1	3.1	3	11.1	35	5.1	Ettinger
1	3.3	10	35.7	3	20.0	3	11.1	3	10.0	1	3.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.7	28	4.1	Bacon
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	6.3	3	11.1	5	0.7	SirPrize
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	14	2.0	Marvel
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.8	0	0.0	0	0.0	0	0.0	10	1.5	Harvest
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	Nobel
0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	L.Hass

Table 4. Yearly and overall average number of near-mature fruits pollinated by the indicated cultivars from 2003 to 2006. Individual row results can be found in previous reports published in the 2004, 2005, and 2006 California Avocado Research Symposium Proceedings.

Fruits	2003	2004	2005	2006	Ave.	P=0.05	P=0.01
Zutano	182	53	165	241	160.3	b	b
Hass	256	921	869	785	707.8	a	a
Fuerte	34	55	63	102	63.5	bc	b
Ettinger	154	51	209	150	141.0	bc	b
Bacon	82	12	65	32	47.8	bc	b
SirPrize	52	65	18	9	36.0	bc	b
Marvel	13	45	51	18	31.8	bc	b
Harvest	5	19	6	12	10.5	bc	b
Nobel	11	14	2	0	6.8	c	b
L.Hass	51	11	7	3	18.0	bc	b

Averages followed by different letters are significantly different at 95% and 99% confidence levels (P=0.05 column and P=0.01 columns, respectively) based on Duncan's Multiple Range Test.

Table 5. Yearly and overall average percent proportion of near-mature fruits pollinated by the indicated cultivars from 2003 to 2006. Individual row results can be found in previous reports published in the 2004, 2005, and 2006 California Avocado Research Symposium Proceedings.

Fruits	2003	2004	2005	2006	% Ave.	P=0.05	P=0.01
Zutano	21.7	4.3	11.3	17.8	13.8	b	b
Hass	30.5	73.9	59.7	58.1	55.5	a	a
Fuerte	4.0	4.4	4.3	7.5	5.1	bc	b
Ettinger	18.3	4.1	14.4	11.1	12.0	bc	b
Bacon	9.8	1.0	4.5	2.4	4.4	bc	b
SirPrize	6.2	5.2	1.2	0.7	3.3	bc	b
Marvel	1.5	3.6	3.5	1.3	2.5	bc	b
Harvest	0.6	1.5	0.4	0.9	0.9	c	b
Nobel	1.3	1.1	0.1	0.0	0.6	c	b
L.Hass	6.1	0.9	0.5	0.2	1.9	bc	b

Averages followed by different letters are significantly different at 95% and 99% confidence levels (P=0.05 column and P=0.01 columns, respectively) based on Duncan's Multiple Range Test.

Figure 2a. Accumulated distribution of the number of near-mature fruit pollinated by the indicated cultivars during the 2003, 2004, 2005 and 2006 flowering seasons by row within the North plot of the Debusschere orchard.

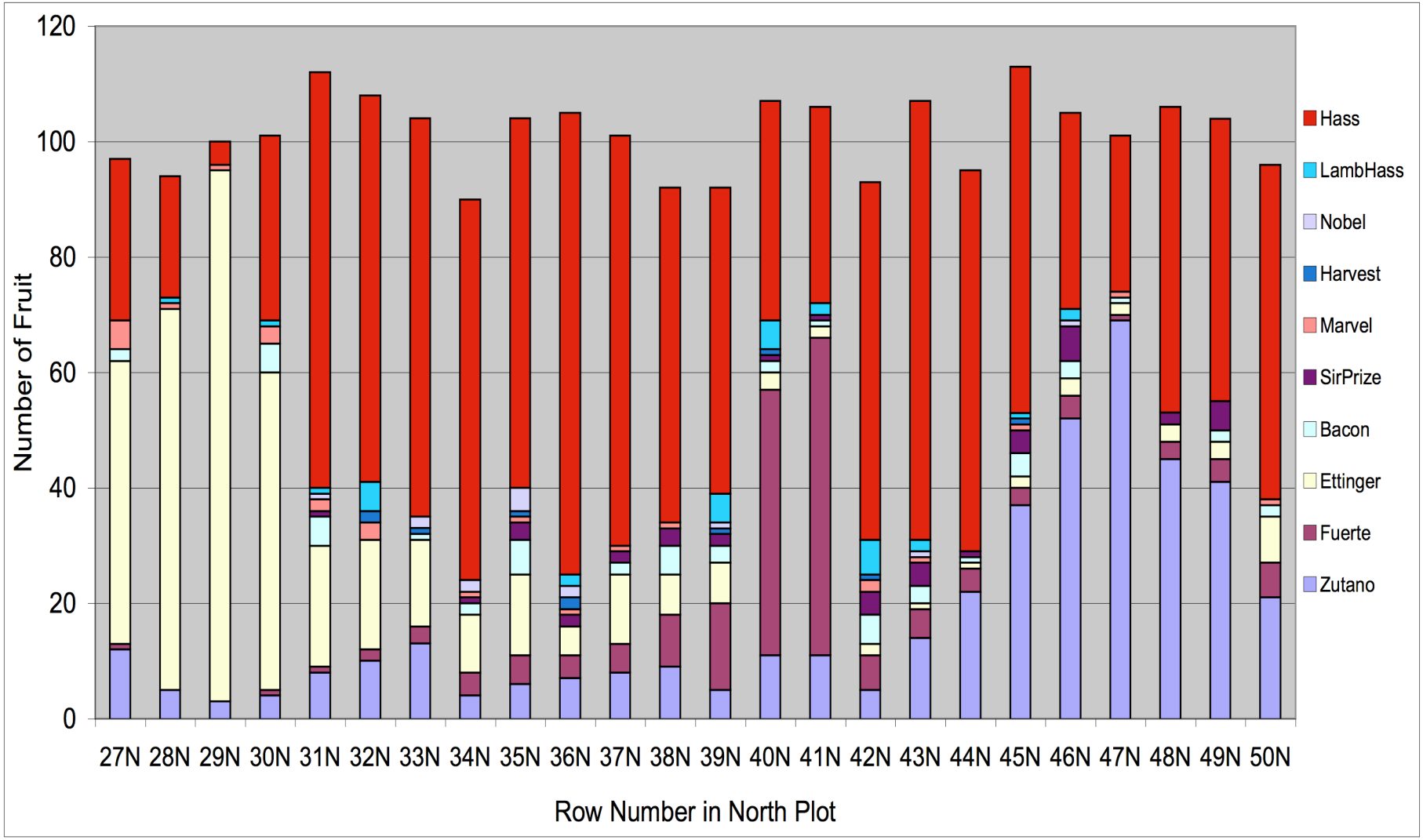

Figure 2b. Accumulated distribution of the number of near-mature fruit pollinated by the indicated cultivars during the 2003, 2004, 2005 and 2006 flowering seasons by row within the South plot of the Debusschere orchard.

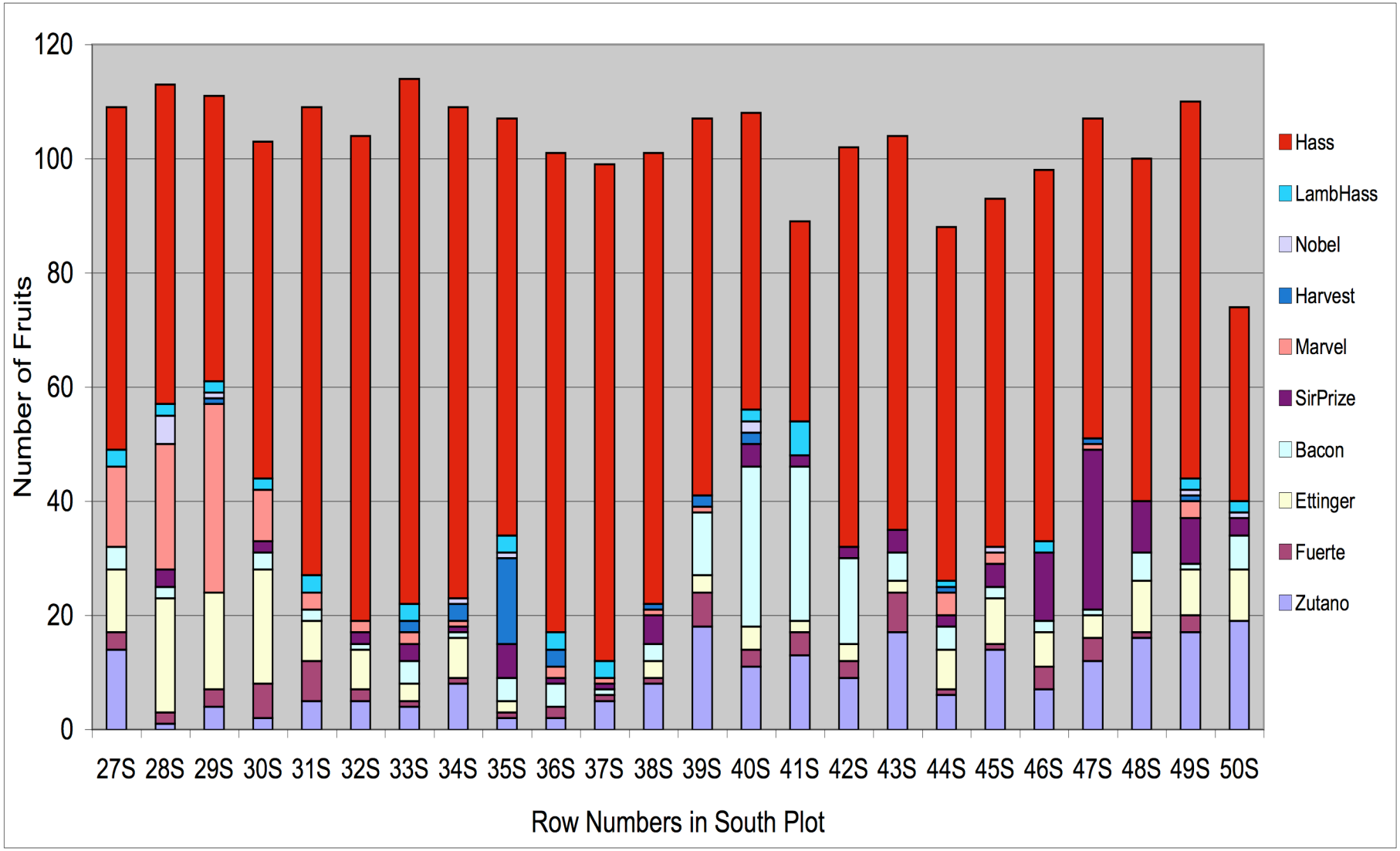

Table 6. Outreach Index calculated for each complimentary cultivar as determined from paternity results of near-mature fruit from 2003 to 2006. Outreach index was calculated by adding the products of the proportion of fruit pollinated by a particular cultivar times the number of rows from the row in which that cultivar was planted [$\sum$ (proportion pollen parent X row # from parent)] among all the rows in the orchard for each year.

Cultivar	2003	2004	2005	2006	Average	P=0.05	P=0.01
Zutano	40.0	7.4	21.5	12.7	20.4	a	a
Ettinger	21.7	4.1	17.8	10.5	13.5	b	ab
SirPrize	13.4	6.1	1.0	0.5	5.2	c	bc
Bacon	13.7	1.2	3.0	2.5	5.1	c	bc
Fuerte	2.9	3.3	4.6	6.2	4.3	c	bc
Marvel	2.5	6.9	4.0	0.4	3.4	c	c
Harvest	0.9	1.1	0.6	0.6	0.8	c	c
Nobel	1.3	0.5	0.0	0.0	0.5	c	c

Averages followed by different letters are significantly different at 95% and 99% confidence levels (P=0.05 column and P=0.01 columns, respectively) based on Duncan's Multiple Range Test.

Table 7. Average retention rate of "Hass" avocado fruit pollinated by various cultivars through all rows of the Debusschere orchard during 2004, 2005, and 2006. Fruit retention was calculated by subtracting the percent pollination proportion by each cultivar in marble–sized fruit (YO#%) from that of the same population sampled at the near-mature fruit stage (MO#%) within each row.

Year	2004 (Off-Year)			2005 (Medium-Year)			2006 (Medium-Year)		
Pollinizer	M04%	Y04%	(M04%-Y04%) ± SE	M05%	Y05%	(M05%-Y05%) ± SE	M06%	Y06%	(M06%-Y06%) ± SE
Zutano	4.3	5.8	-1.5 ± 1.3	11.3	22.5	-11.2 ± 1.9	17.8	25.9	-8.1 ± 2.2
Hass	73.7	64.5	9.1 ± 2.6	59.7	44.9	14.8 ± 2.0	58.1	46.4	11.6 ± 2.7
Fuerte	4.7	5.7	-1.0 ± 0.7	4.3	5.2	-0.8 ± 0.8	7.5	10.5	-2.9 ± 1.4
Ettinger	4.1	6.8	-2.8 ± 1.3	14.4	18.3	-3.9 ± 1.2	11.1	12.6	-1.5 ± 1.2
Bacon	1.0	0.8	0.2 ± 0.4	4.5	3.6	0.9 ± 1.1	2.4	1.9	0.5 ± 0.6
SirPrize	5.2	2.3	2.8 ± 1.0	1.2	0.7	0.6 ± 0.4	0.7	0.6	0.0 ± 0.4
Marvel	3.6	3.3	0.3 ± 0.9	3.5	3.4	0.1 ± 0.7	1.3	1.9	-0.5 ± 0.5
Harvest	1.5	1.0	0.4 ± 0.4	0.4	0.7	-0.2 ± 0.3	0.9	0.0	0.9 ± 0.5
Nobel	1.2	3.0	-1.7 ± 0.8	0.1	0.4	-0.3 ± 0.2	0.0	0.1	-0.1 ± 0.1
LambHass	0.9	6.7	-5.8 ± 1.6	0.5	0.4	0.1 ± 0.3	0.2	0.1	0.1 ± 0.2
# Fruits Tested	1246	1004		1455	1513		1352	1385	

Table 8. The estimated effect of pollinizer density in an orchard based on overall averaged pollination results of samples harvested in 2003, 2004, 2005, and 2006. It is presumed that each pollinizing cultivar would be interplanted within the row of 'Hass' trees in the pollinizing row (HP). All other rows would have only 'Hass' (H) trees.

	Percentage of Paternity (Ratio of Pollinizer to Hass)				
Pollinizer	% (1:1)	% (1:3)	% (1:5)	% (1:7)	% (1:9)
Ettinger	92.0 a	73.9 a	57.4 a	46.3 a	39.2 a
Zutano	71.0 ab	55.6 a	49.6 a	42.9 a	36.7 a
Fuerte	52.3 bc	33.2 b	24.4 b	19.6 b	16.1 b
Bacon	30.2 cd	24.8 bc	18.7 bc	15.0 bc	12.0 bc
Marvel	28.2 cd	17.9 bc	13.6 bc	10.6 bc	8.7 bc
SirPrize	25.4 cd	16.2 bc	12.1 bc	9.4 bc	8.6 bc
Harvest	12.7 d	6.2 c	4.0 c	3.2 bc	2.7 bc
Nobel	4.1 d	2.7 c	2.0 c	1.4 c	1.4 c
Hass (Self)	8.0 - 95.9	26.1 - 97.3	42.6 - 98.0	53.7 - 98.6	60.8 - 98.6

Duncan's multiple range test, p=0.05

Ratio of	Row Number														
Hass (H) to	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pollinizer (P)															
1:1	HP	HP	HP	HP	HP	HP	HP	HP	HP	HP	HP	HP	HP	HP	HP
1:3	H	HP	H	H	HP	H	H	HP	H	H	HP	H	H	HP	H
1:5	H	H	HP	H	H	H	H	HP	H	H	H	H	HP	H	H
1:7	H	H	H	HP	H	H	H	H	H	H	HP	H	H	H	H
1:9	H	H	H	H	HP	H	H	H	H	H	H	H	H	HP	H

HP=Pollinizer cultivar interplanted with 'Hass'
H='Hass' only

Table 9. Numbers of near-mature 'Hass' fruit visually counted on November 6, 2006 from each of 8 trees of every row in the North and South plots of the Debusschere orchard. Trees at the ends of each 10-tree row were not included in the counts due to potential outside influences on yield from light, wind, and/or neighboring pollinizing cultivars in the rows.

Pollinizer			Ettinger						Nobel						Fuerte						Zutano				
Row	27N	28N	29N	30N	31N	32N	33N	34N	35N	36N	37N	38N	39N	40N	41N	42N	43N	44N	45N	46N	47N	48N	49N	50N	Total
Fruits	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#
Total	531	1932	1169	2447	2178	2567	2719	2709	3457	2923	2394	2908	3341	3986	3185	3723	3689	3224	2533	3506	3273	1964	981	358	61697
Tree # 2	109	367	239	297	279	406	464	47	416	395	572	172	284	439	294	212	222	403	417	100	142	206	219	114	6815
Tree # 3	28	394	13	361	469	244	462	332	617	436	148	447	398	642	590	607	345	159	480	596	328	251	134	25	8506
Tree # 4	141	218	337	346	425	282	304	562	260	697	428	336	609	780	638	546	434	792	277	492	407	194	5	23	9533
Tree # 5	44	151	242	351	269	282	368	235	472	285	242	530	291	613	342	569	729	274	495	542	276	222	59	18	7901
Tree # 6	4	238	0	160	25	346	45	247	237	312	293	451	412	501	521	440	491	418	172	186	621	184	108	11	6423
Tree # 7	42	173	3	320	232	605	342	331	530	242	376	203	631	543	136	717	175	152	178	473	339	406	157	2	7308
Tree # 8	143	196	233	365	244	191	324	485	544	307	21	586	231	149	415	391	557	752	146	469	697	288	158	87	7979
Tree # 9	20	195	102	247	235	211	410	470	381	249	314	183	485	319	249	241	736	274	368	648	463	213	141	78	7232
Ave. fruits/tree	66	242	146	306	272	321	340	339	432	365	299	364	418	498	398	465	461	403	317	438	409	246	123	45	7712
Std. Dev.	56	90	133	71	135	134	133	166	135	150	169	164	149	197	175	178	211	248	142	194	182	73	66	42	994
Std. Err.	20	32	47	25	48	48	47	59	48	53	60	58	53	70	62	63	74	88	50	68	64	26	23	15	351

Pollinizer			Marvel						Harvest						Bacon						SirPrize				
Row	27S	28S	29S	30S	31S	32S	33S	34S	35S	36S	37S	38S	39S	40S	41S	42S*	43S	44S	45S	46S	47S	48S*	49S	50S	Total
Fruits	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#
Total	584	1464	2078	1954	2038	1790	2478	2545	1683	1806	1979	2478	2446	2655	2140	2685	3139	1983	1884	2234	1631	1222	308	728	45932
Tree # 2	18	53	594	158	377	69	219	241	170	312	315	323	398	161	320	364	515	222	318	252	230	271	13	130	6043
Tree # 3	151	97	301	626	229	167	518	464	219	128	343	244	361	457	301	175	431	283	358	363	178	200	168	96	6858
Tree # 4	45	122	241	320	419	422	336	334	76	348	368	341	320	406	339	469	431	266	284	337	262	201	22	162	6871
Tree # 5	14	157	303	68	252	202	417	244	144	118	264	309	204	470	486	305	256	188	244	201	250	38	3	19	5156
Tree # 6	39	196	185	243	197	297	111	329	334	207	97	205	266	111	1	336	223	194	147	294	242	82	1	96	4433
Tree # 7	97	90	221	212	254	152	372	246	324	443	285	475	254	340	445	336	435	173	145	428	191	153	35	76	6022
Tree # 8	151	367	144	269	42	361	247	248	233	71	113	307	284	324	207	246	428	232	239	104	75	83	51	109	5254
Tree # 9	69	382	89	58	268	120	258	439	183	179	194	274	359	386	41	454	420	425	149	255	203	194	15	40	5294
Ave. fruits/tree	73	183	260	244	255	224	310	318	210	226	247	310	306	332	268	336	392	248	236	279	204	153	39	91	5741
Std. Dev.	55	126	154	180	114	124	127	91	88	129	102	80	65	132	175	106	99	81	83	101	60	85	55	46	861
Std. Err.	19	45	54	64	40	44	45	32	31	46	36	28	23	47	62	40	35	29	29	36	21	32	19	16	304

Figure 3a. Average yield of near-mature 'Hass' fruit visually counted on November 6, 2006 from each row in the North plot of the Debusschere orchard. Compare these average row-to-row yields with the percent proportions of pollinations in 2006 by each cultivar in Table 3a & b.

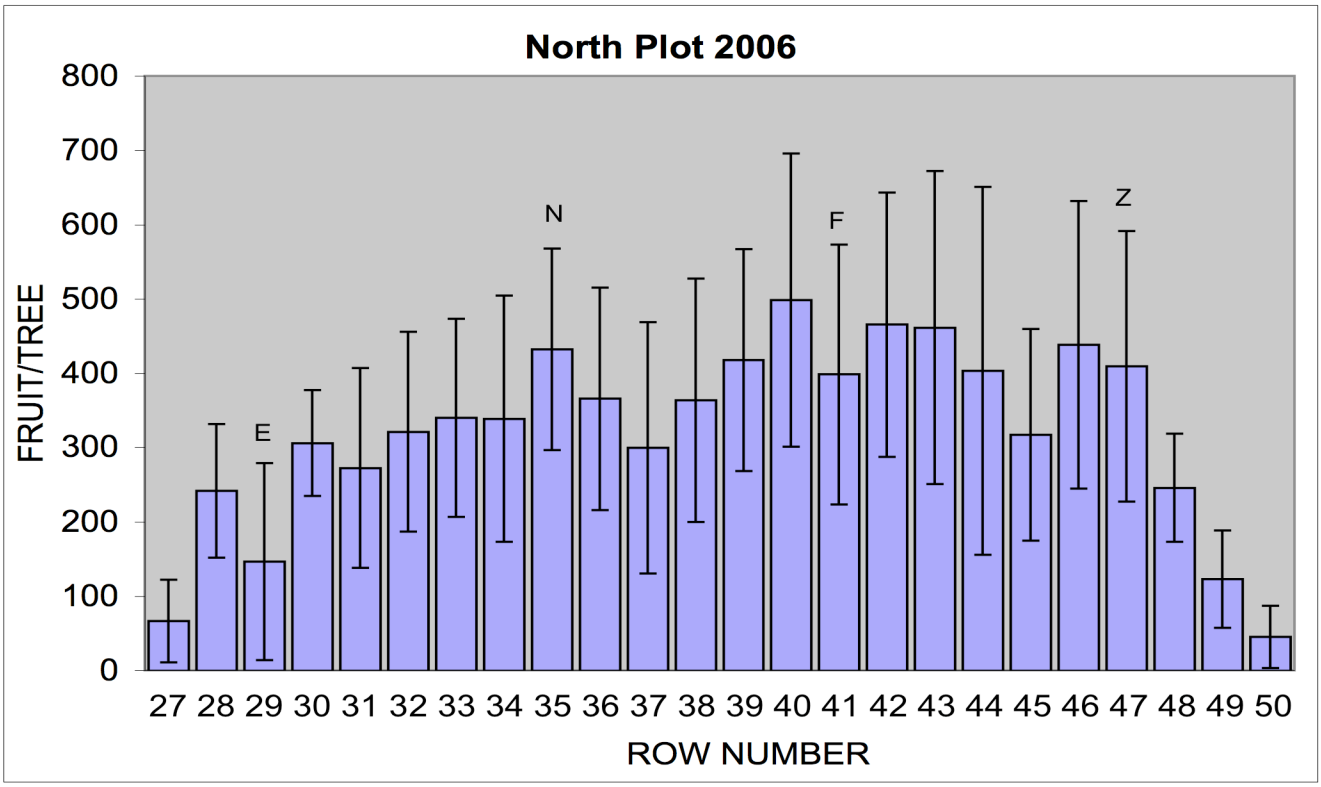

Figure 3b. Average numbers of near-mature 'Hass' fruit visually counted on November 6, 2006 from each row in the South plot of the Debusschere orchard. Compare these average row-to-row yields with the percent proportions of pollinations in 2006 by each cultivar in Table 3a & b.

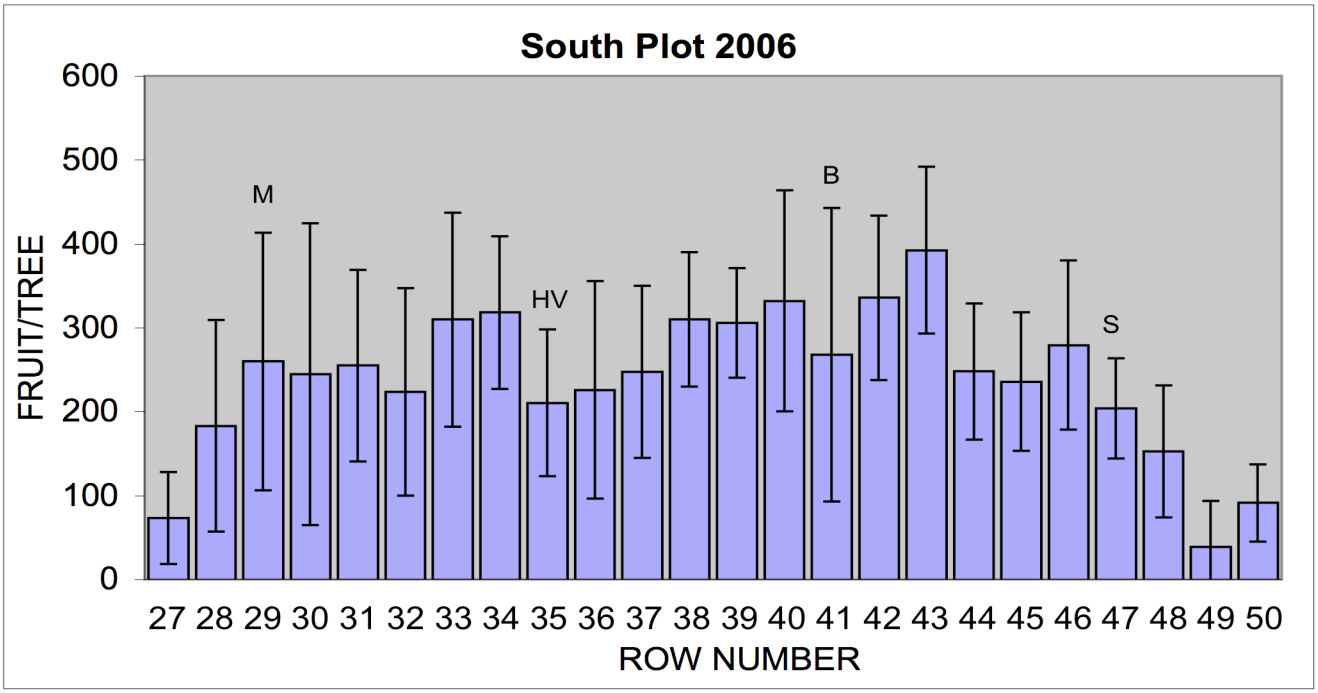

Table 10. Influence of pollen parent on near-mature 'Hass' avocado seed shape and size.

	Seed Shape		Seed Size	
	# of fruit tested	Lenth:width	# of fruit tested	Weight (g)
Zutano	175	1.20a	242	17.7c
Hass	567	1.24a	831	15.2b
Fuerte	84	1.38b	101	15.6b
Ettinger	140	1.25a	152	17.8c
Bacon	28	1.24a	33	12.5a
SirPrize	7	1.26a	9	21.3d
Marvel	15	1.27a	18	21.5d
Harvest	11	1.20a	11	14.6b
Nobel	0		0	
L.Hass	10	1.29ab	12	13.8ab

Duncan's test, P=0.01

Seeds were collected on 11/6/2006

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