



Avocado Pollination Basics



Mary Lu Arpaia
Dept of Botany and Plant Sciences,
University of California, Riverside

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The ultimate crop that one harvests is dependent upon many factors:



- On/Off status
- Overall tree health
- Conditions during flowering and fruit set
- Conditions during subsequent fruit development



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During flowering



Fully Mature



June drop



http://greenlifeinsocal.files.wordpress.com/2011/05/img_0043-avocado.jpg

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This presentation will
focus on one small
aspect of productivity

—

Pollination



Presentation Outline

- Terminology
- Avocado flower biology
- Pollinizers – do you need them?
- Pollinators – How do you get the pollen to the stigma?
- Conclusions
- Acknowledgements



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Pollination Terms:



Pollination – the transfer of pollen from the anther to the stigma.

- *Cross pollination* – the pollen deposited on the stigma is from another cultivar.
- *Close pollination* – the pollen deposited on the stigma is from another flower of the same tree or cultivar.
- *Self pollination* – the pollen deposited on the stigma is from the same flower.



Pollination Terms:

Pollinator: The agent which transfers pollen from the male to the female floral organ.

Pollinated Tree: A cultivar that receives the pollen (*i.e.* Hass).

Pollinizer: A cultivar that donates pollen to another cultivar.

Common Hass pollinizers: Bacon, Zutano, Ettinger, Edranol, Walter Hole.

Pollination Terms:

Fertilization – the fusion of the male gamete with the female gamete forming the zygote.

Effective Pollination – pollination which leads to fertilization.

Non effective pollination – pollination which does NOT lead to fertilization.



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Avocado flowering characteristics

- Attraction: the whole tree acts like a giant inflorescence with many small flowers.
- Small fertilization percent: thus most flowers do not set fruit.
- Competition: between fruits and growth, as well as among the fruits, which leads to high rate of primary fruit abscission.



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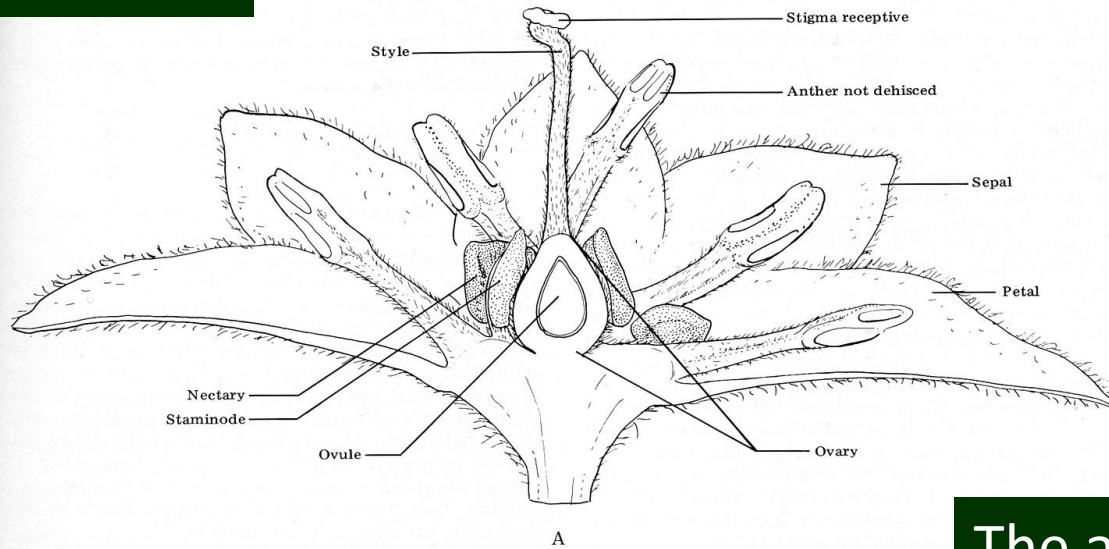
There are 2 phases to avocado flowering

This is called *Protogynous Dichogamy*

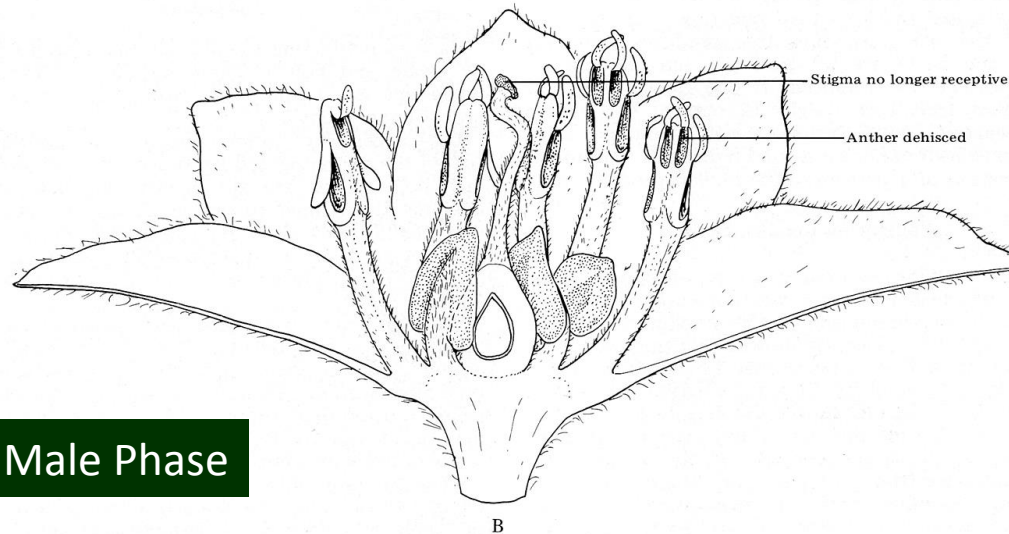


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Female Phase



The avocado flower



Male Phase

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FEMALE PHASE

Pistillate stages



B1

Opening
cup-shape



B2

Open
circular



B3

Closing
cup-shape



C

Closed

MALE PHASE

Staminate stages



D1

Before
dehiscence
circular



D2

First
dehiscence
circular



D3

Second
dehiscence
circular



D4

Closing
Oval



E

Closed

Ish Am, PhD. Thesis Fig. 1- Morphological stages of the flower

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Timing of flowering for “A” and “B” flower types.

DAY 1

DAY 2

MORNING

AFTERNOON

MORNING

AFTERNOON

Flower-type cultivar

“A”

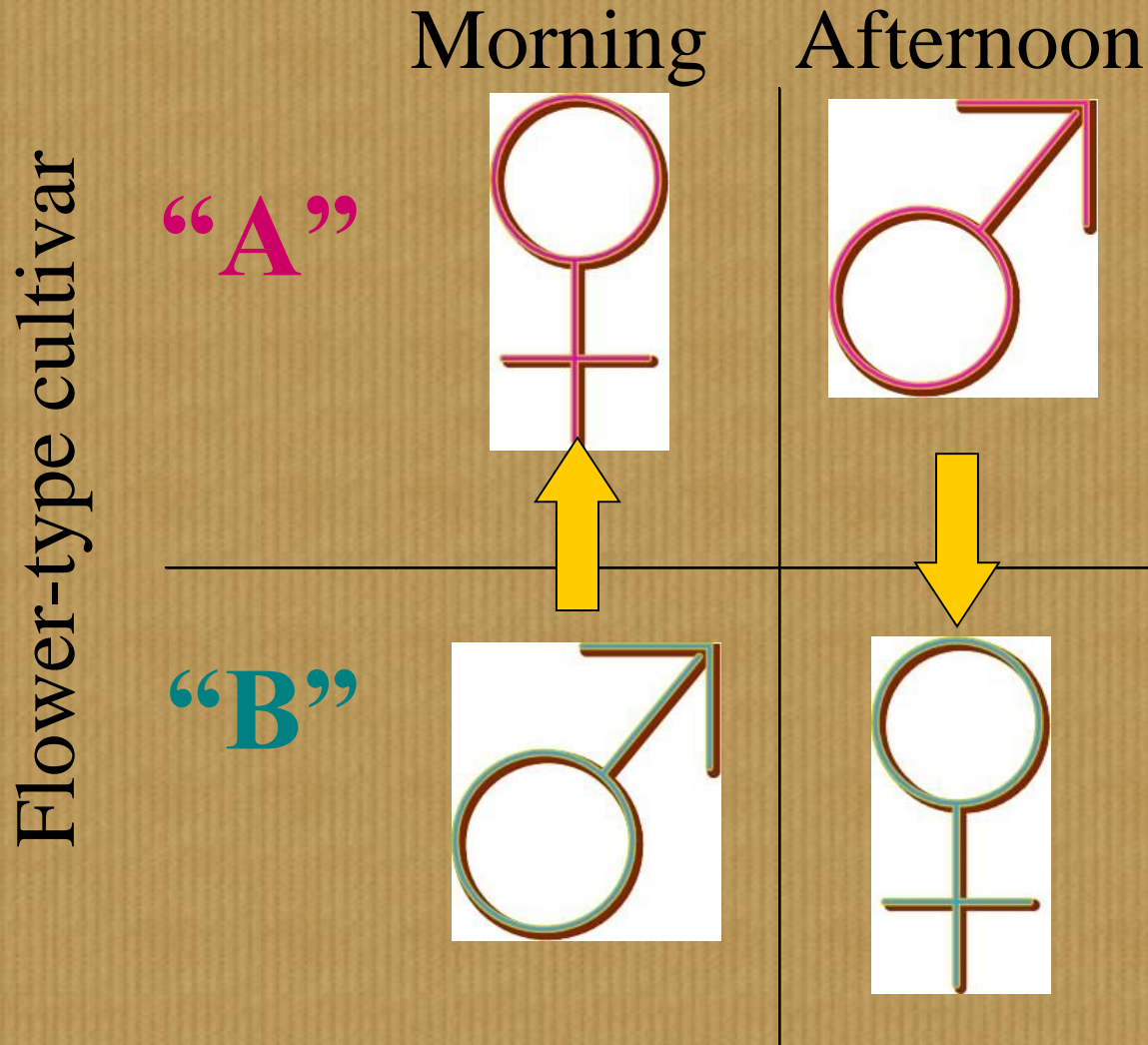


“B”



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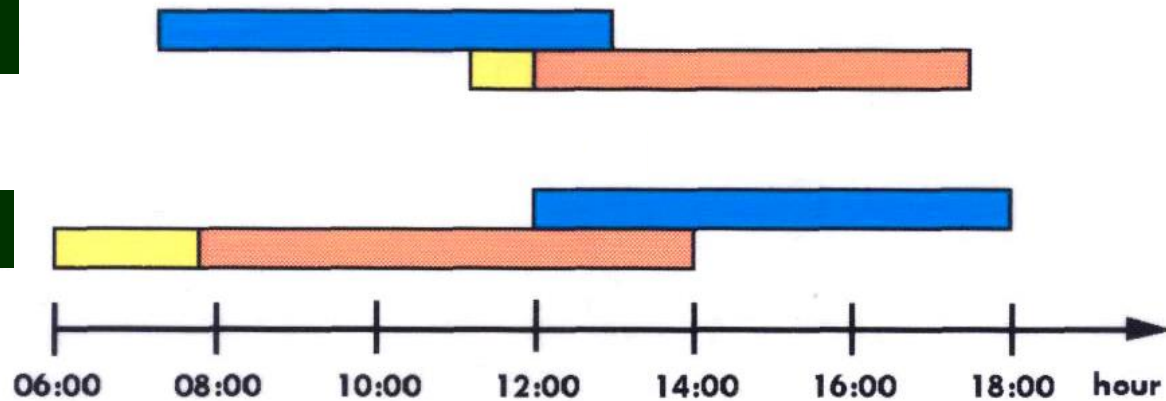
The sequence of timing for “A” and “B” flower types under field conditions.



Avocado Flowering Sequence

Type A

Type B



Female flowers

Male flowers before dehiscence

Male dehiscing flowers



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Overlap
within the
tree occurs

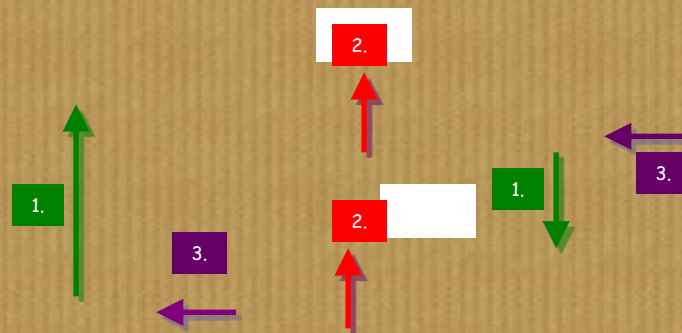


Source: I. Hormaza

Avocado flower pollination routes

Type A

Type B



1. Cross pollination

2. Close pollination

3. Self pollination

Female flowers

Male flowers before dehiscence

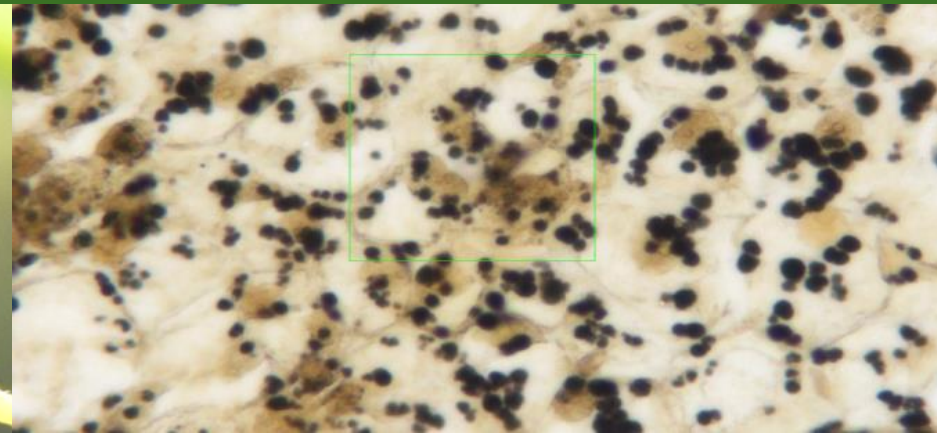
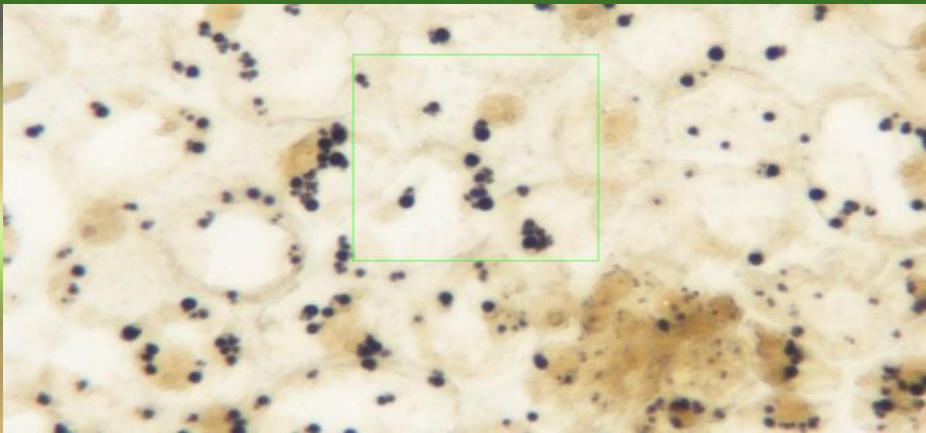
Male dehiscing flowers

Are all avocado flowers equal?

- Millions of flowers during bloom
- Long flower duration

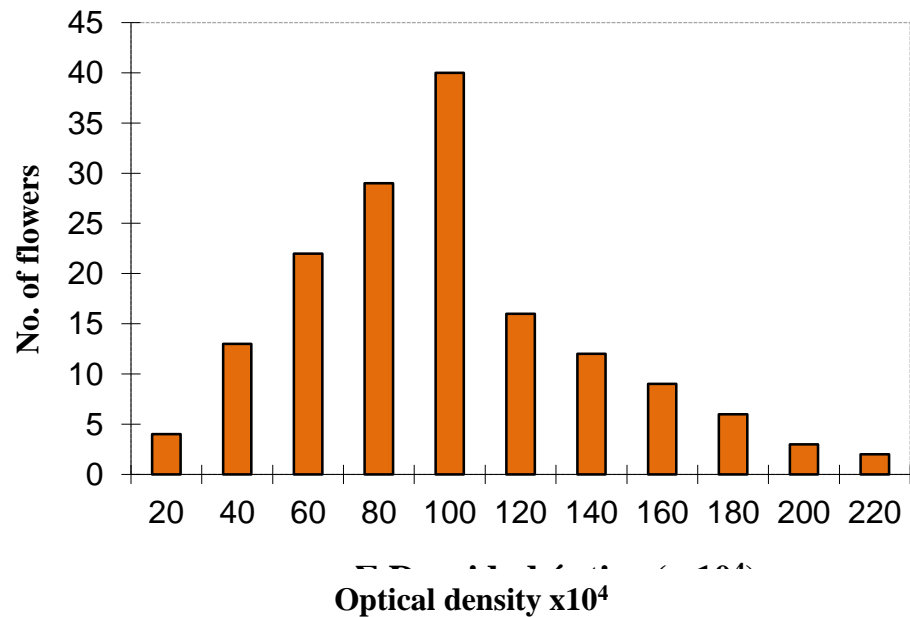


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I_2KI

- NO EXTERNAL DIFFERENCES AMONG FLOWERS
- GREAT DIFFERENCES IN STARCH CONTENT

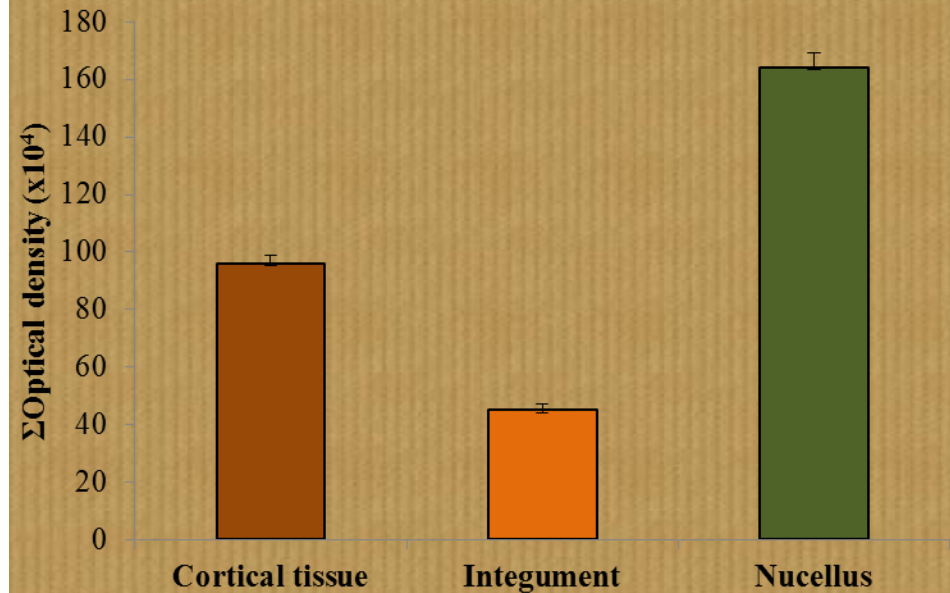
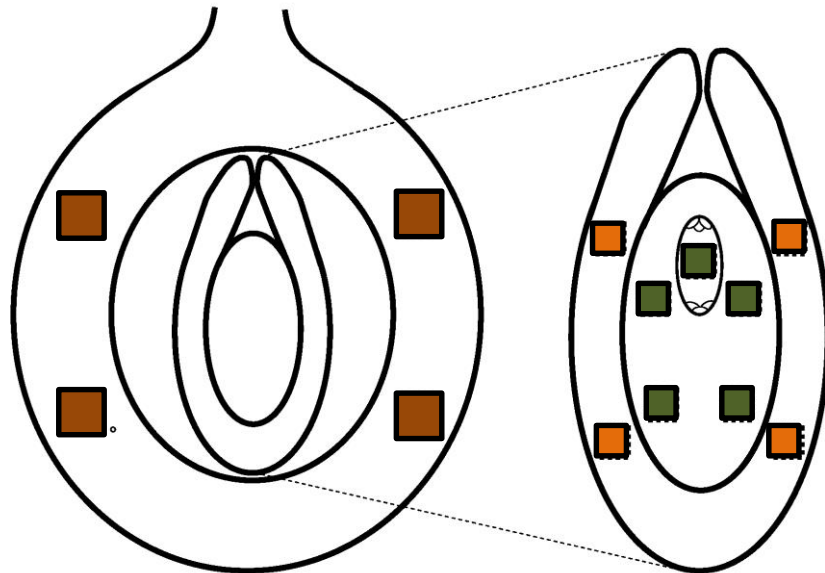


Source: I. Hormaza

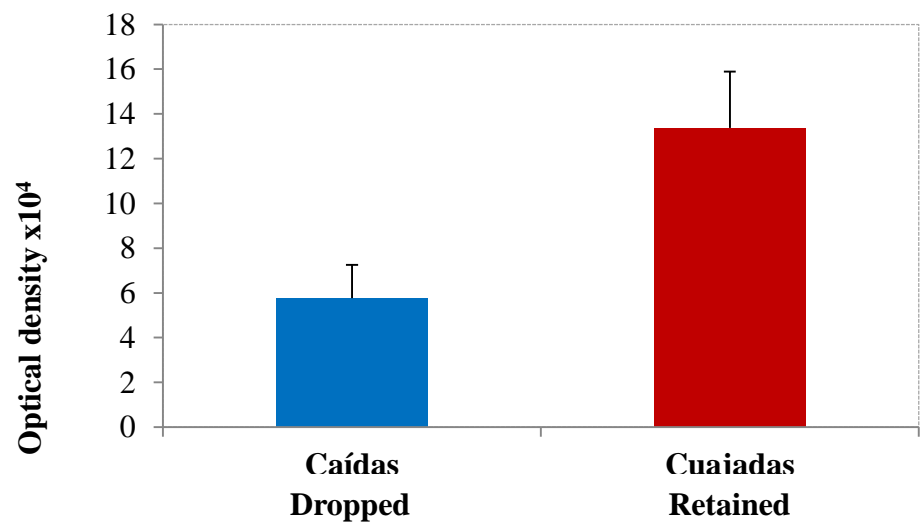
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Source: I. Hormaza

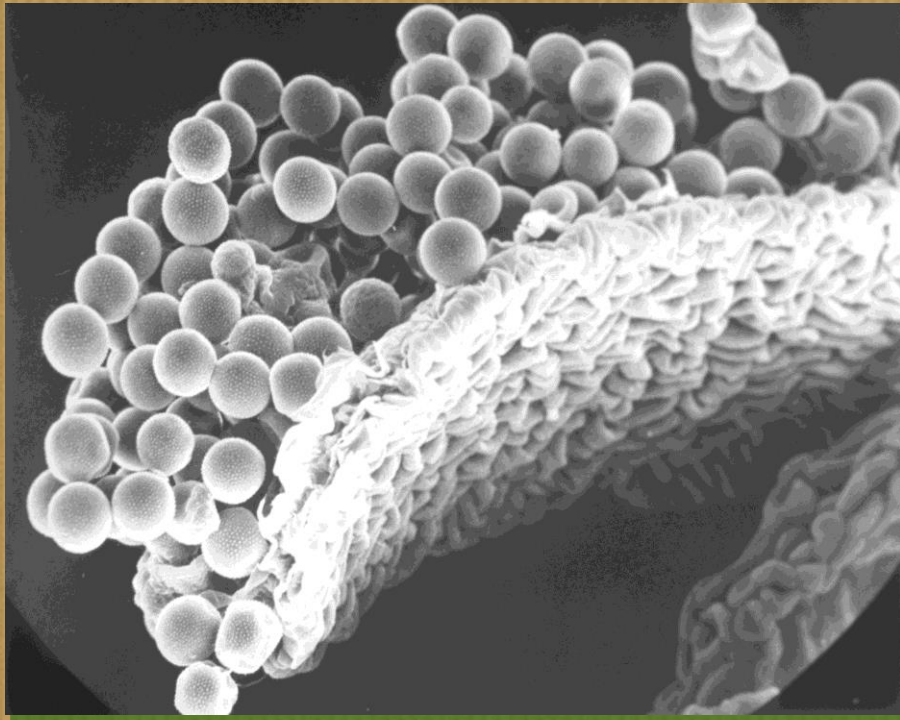


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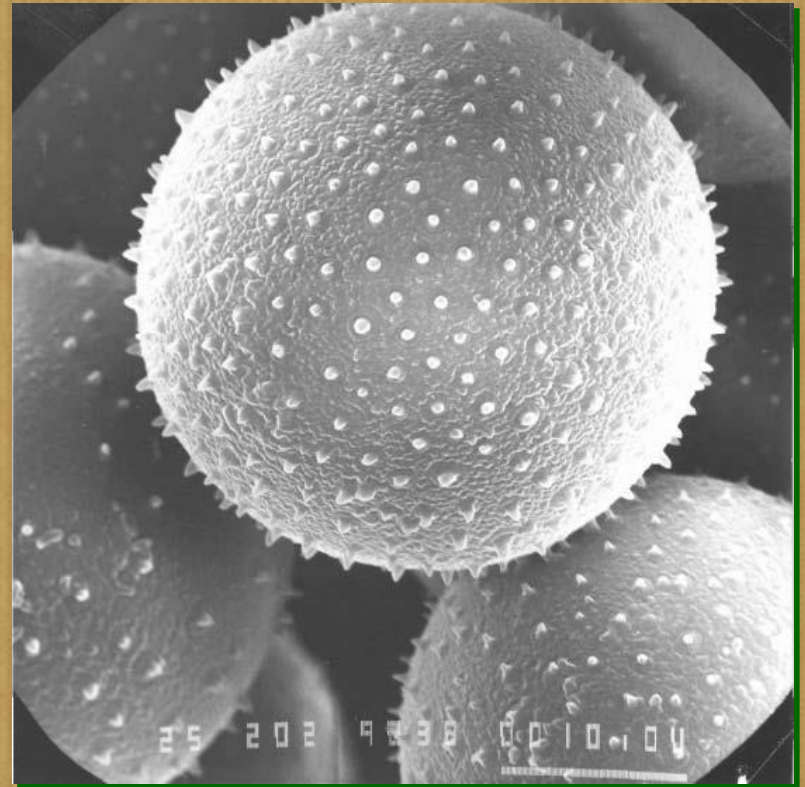


Source: I. Hormaza

The avocado pollen grain



'Fuerte' pollen on anther flap

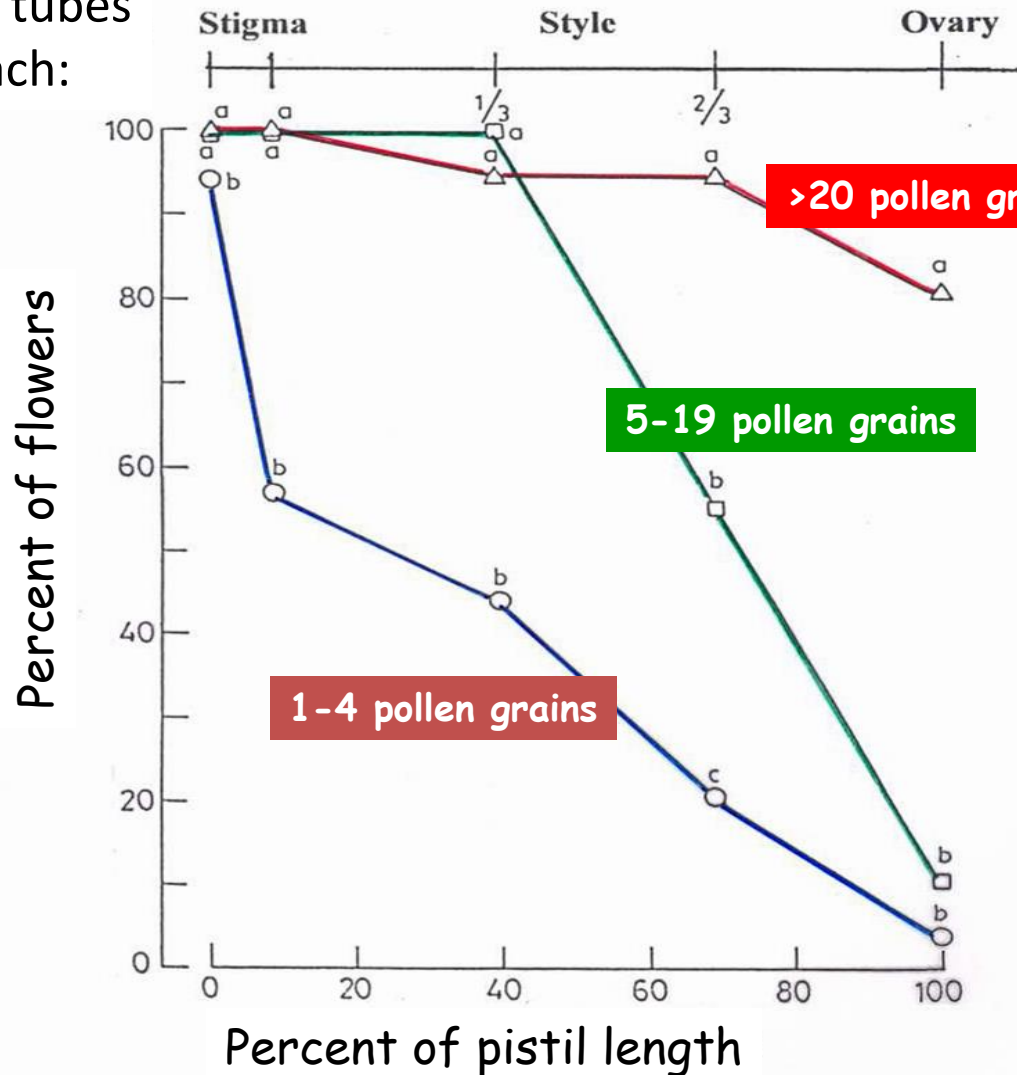


'Hass' pollen grain
(SEM x2000)

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Avocado Pollen Germination Rate

Pollen tubes
Reach:

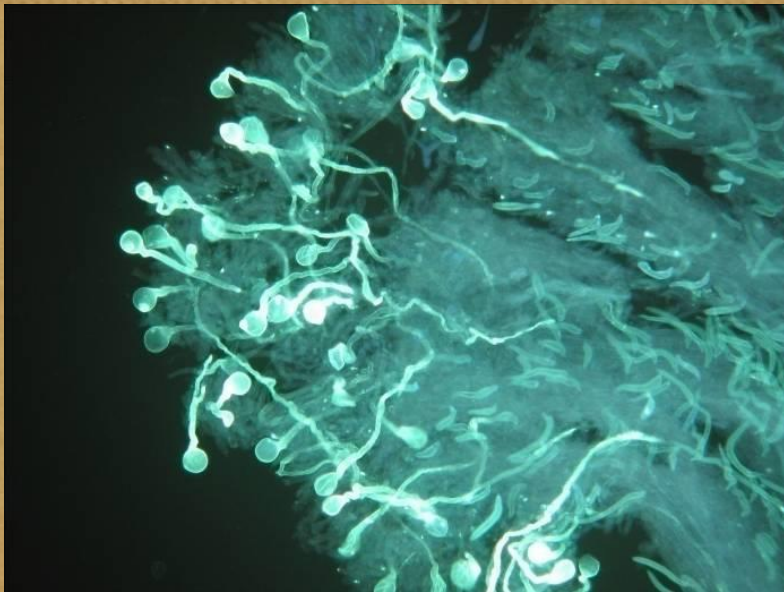


Hand pollinated
'Hass' stigmas by
'Ettinger' pollen.
Four hrs of
germination.

Shoval, 1987

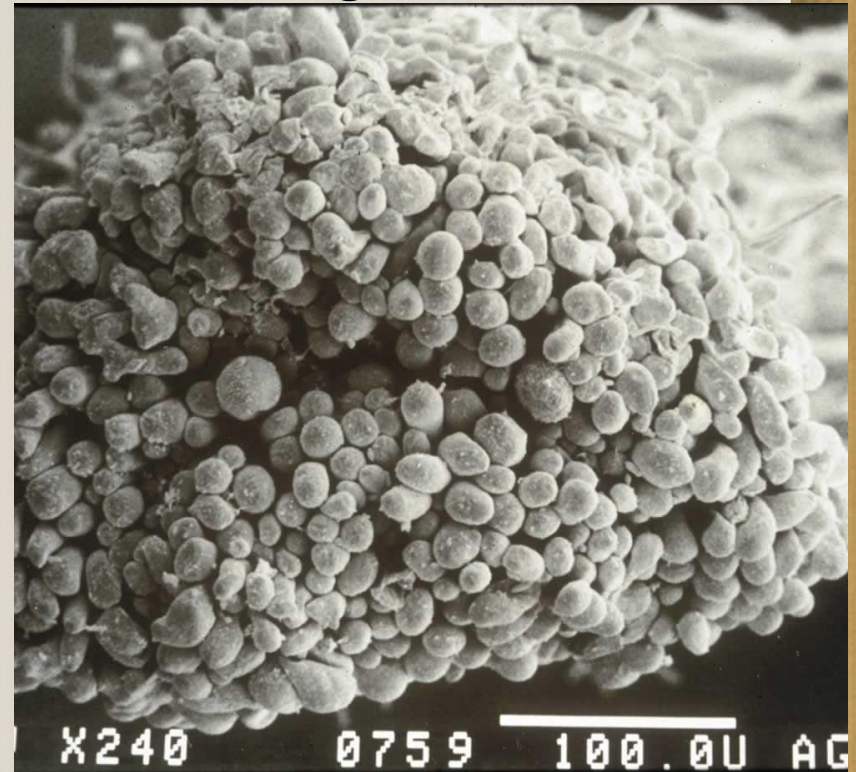
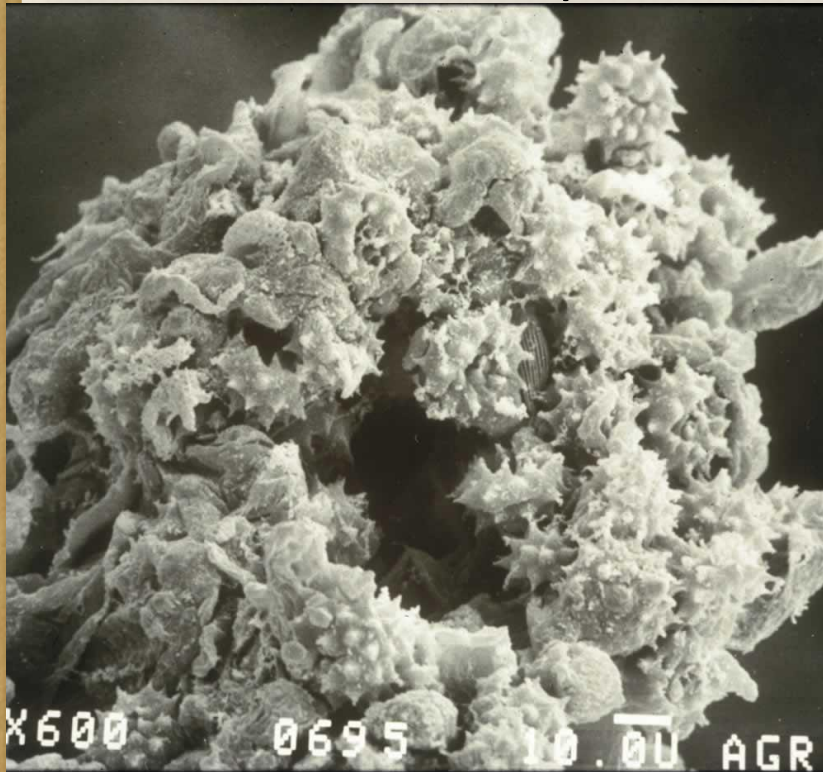
Effect of
competition
between and
cooperation
among the pollen
grains

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Does temperature and relative humidity affect amount of pollen deposited on stigmas?

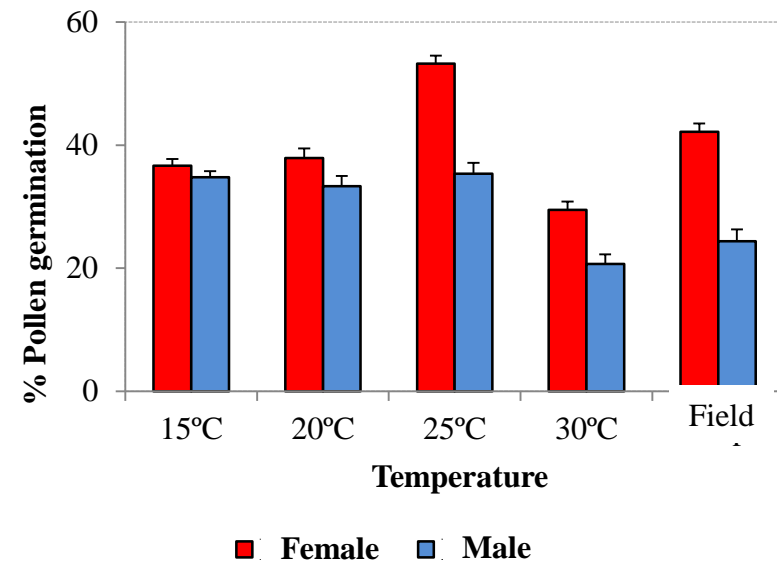
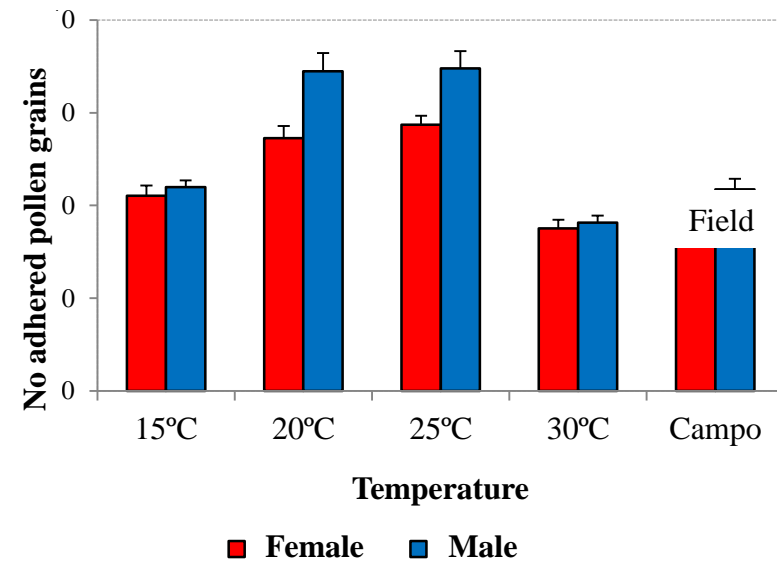


Avocado Stigma with pollen grains (SEM). <http://www.avocadosource.com>

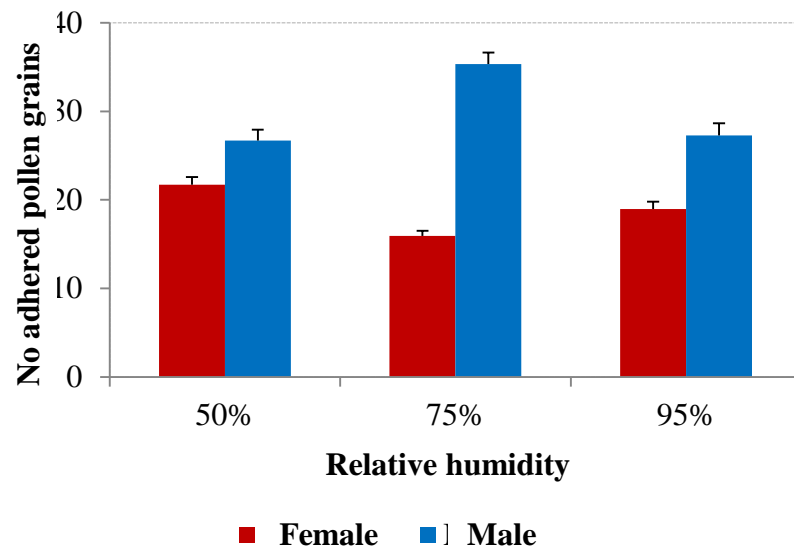
Amounts of pollen deposited on stigmas can affect rates of successful fertilization.



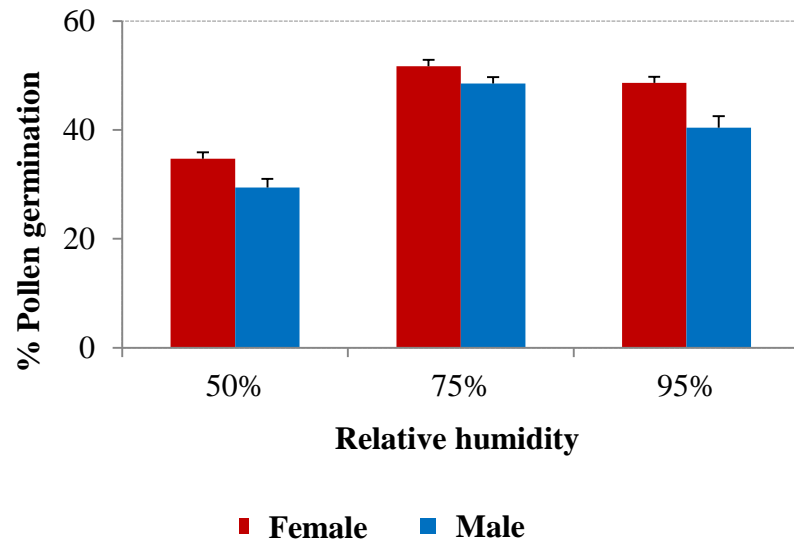
EFFECT OF TEMPERATURE ON POLLEN ADHESION AND GERMINATION



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EFFECT OF RELATIVE HUMIDITY ON POLLEN ADHESION AND GERMINATION



Sedgley and Annells, 1981

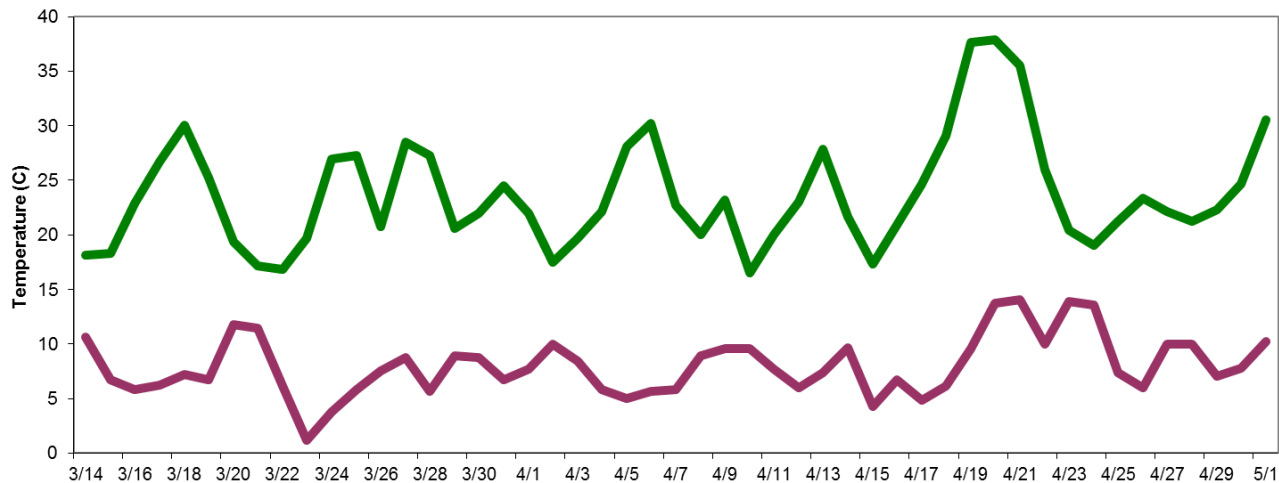
- Kept trees at 3 temperature regimes (Day/Night): 91/82; 77/68; 63/54
- Flowering cycle: At 63/54 prolonged from 36 hr to 72 hr
- Overlap: most overlap occurred at 77/68
- Fertilization: occurred at all temps but lowest at 63/54
- Embryo development: occurred at all temperatures but fruitlets abscised at high temps and growth very slow at low temp



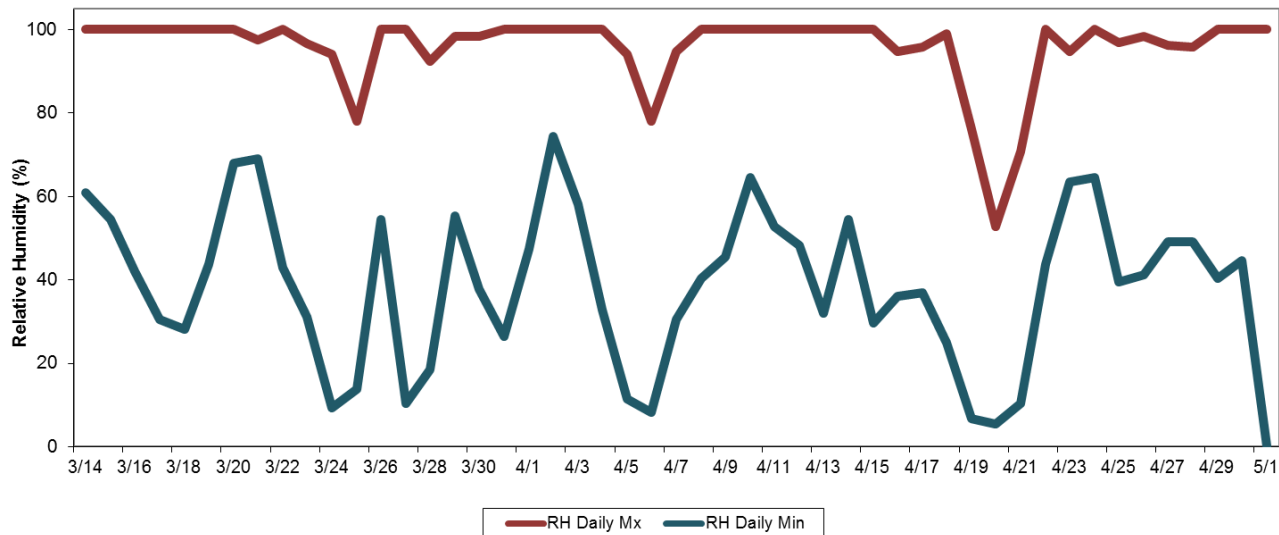
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Temperature fluctuations during flowering Irvine, CA

TEMP

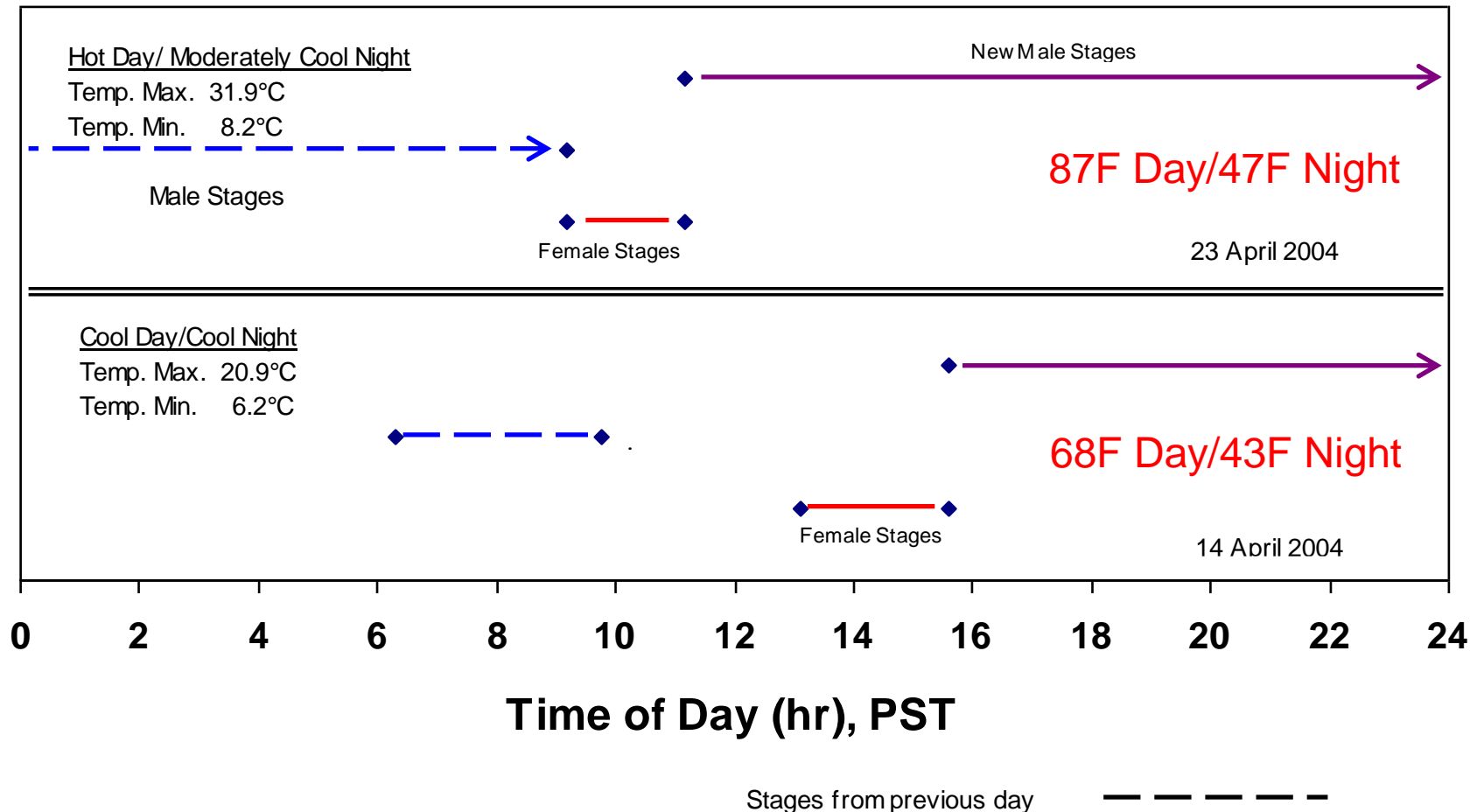


RH



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Temperature influences the timing of the female and male stages



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NetCam SC (2560 x 1920) Mon Oct 25 20:00:03 2010 298 43
Temp: 18.0°C Hum: 40% Pressure: 949.0



NetCam SC (2560 x 1920) Tue Oct 26 13:00:03 2010 299 43
Temp: 22.5°C Hum: 28% Pressure: 947.0

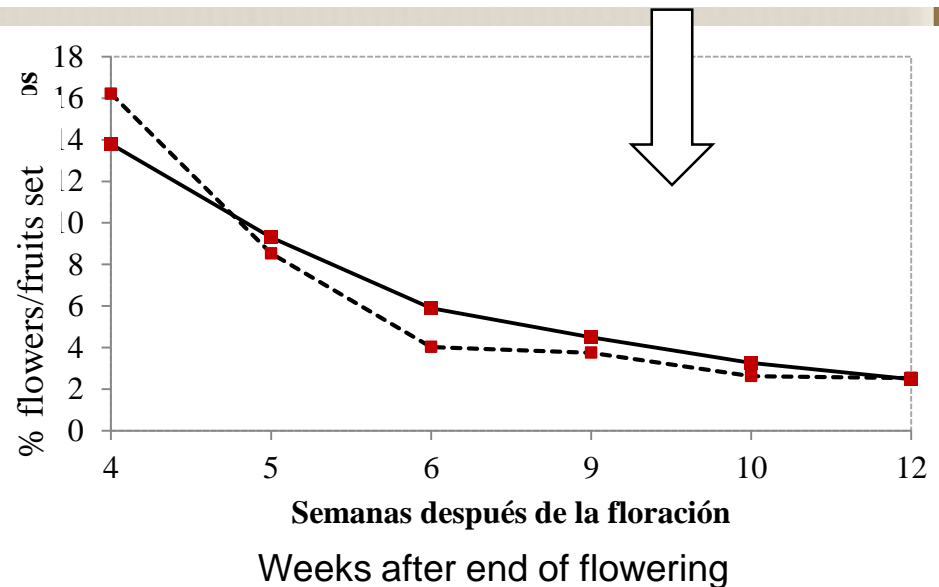
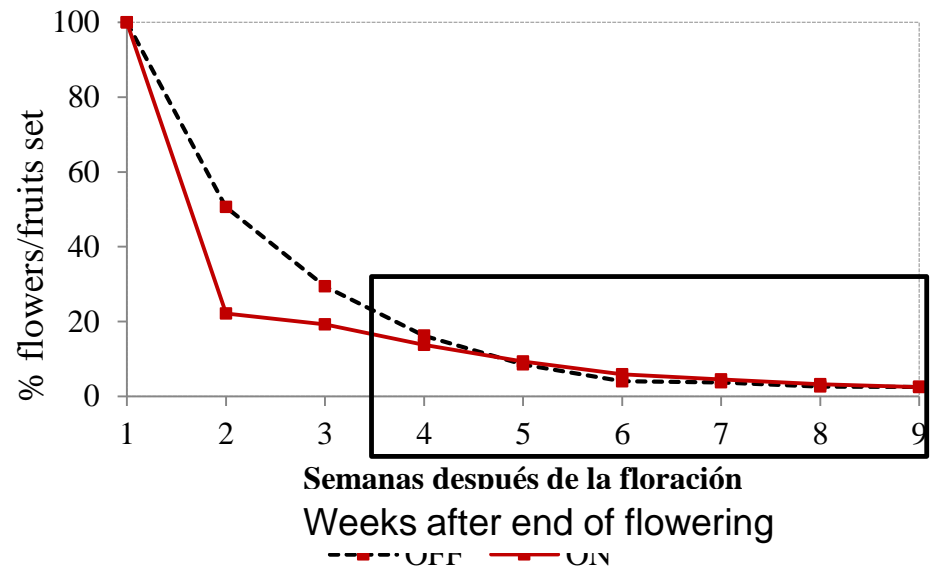


What is the impact of crop load on fruit set and starch content?



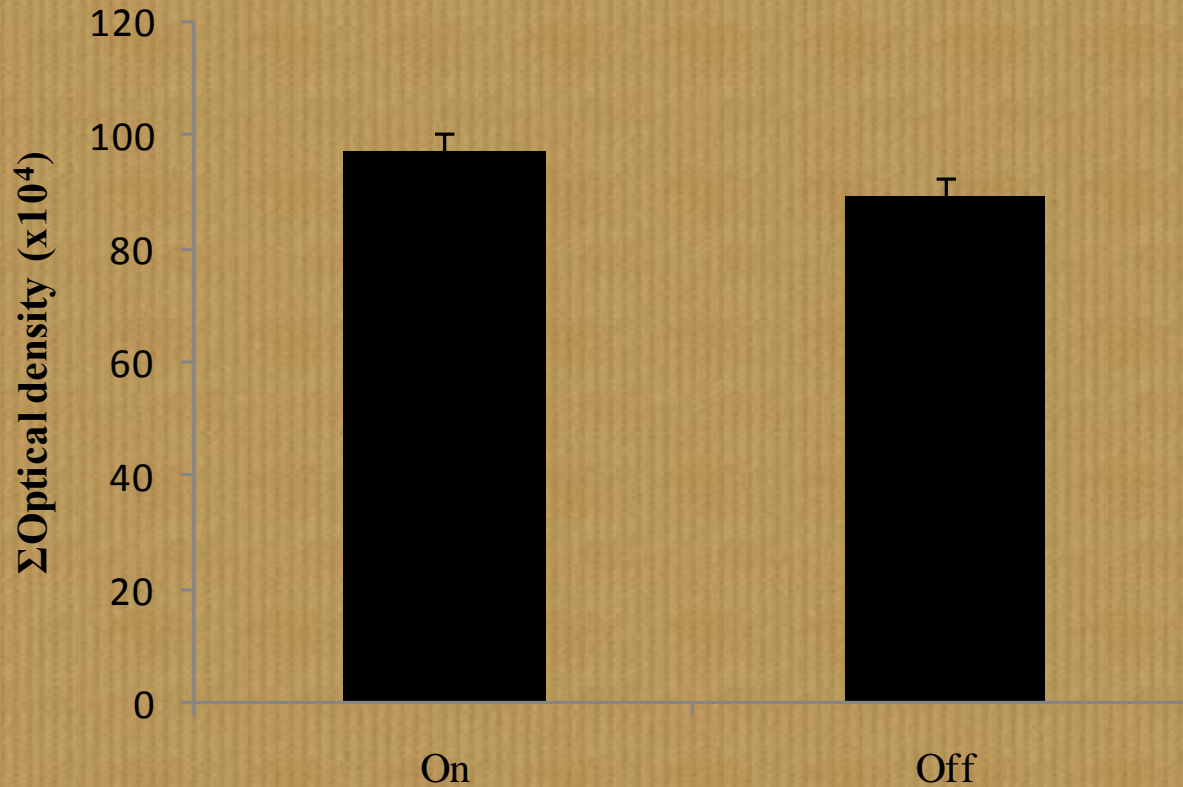
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**% fruit set
similar
between on
and off years**



Source: I. Hormaza

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Starch content in flowers collected during high bearing (On) and low bearing (Off) years.

Source: I. Hormaza

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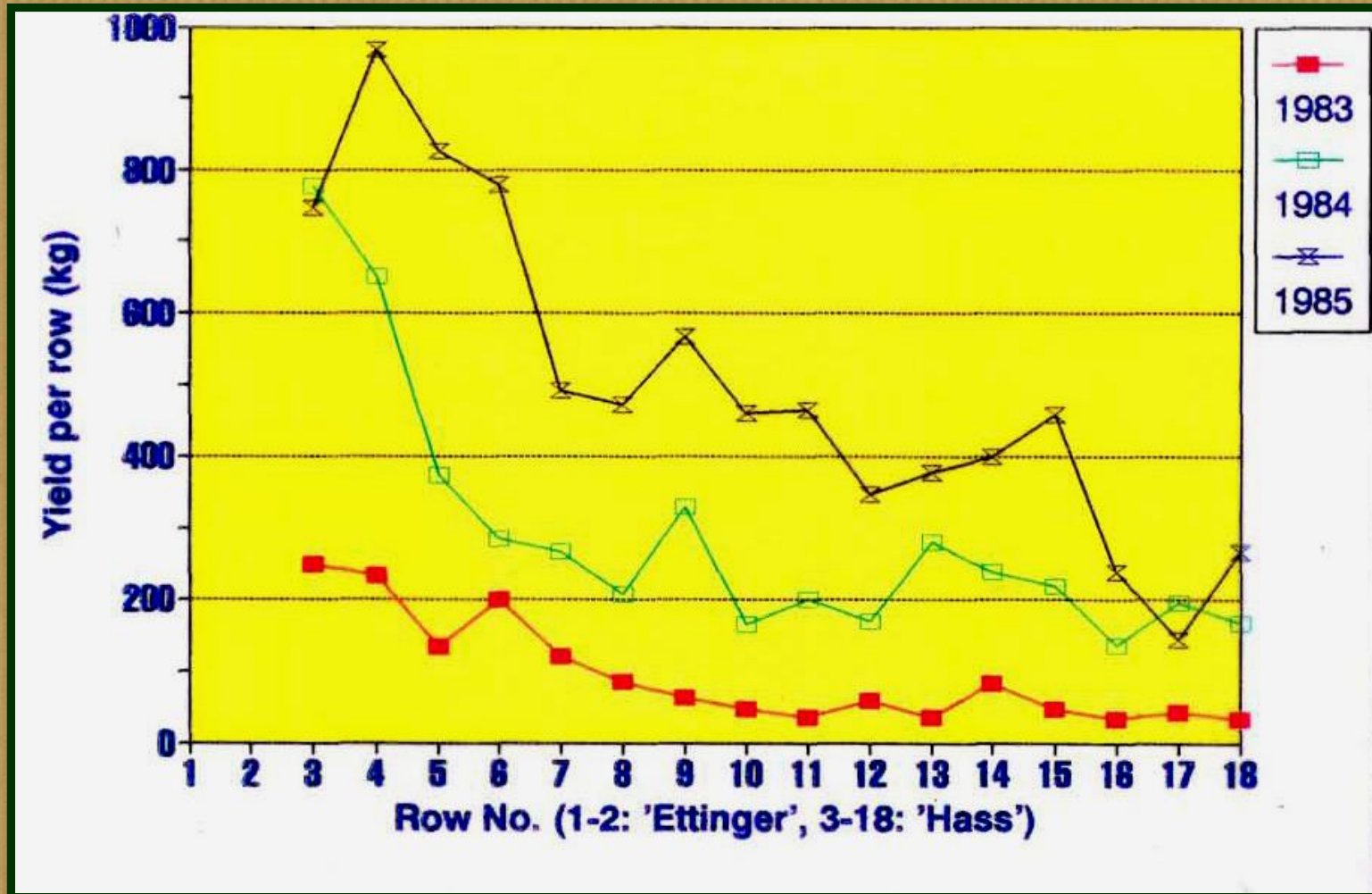


Pollinizers
Do you need them?



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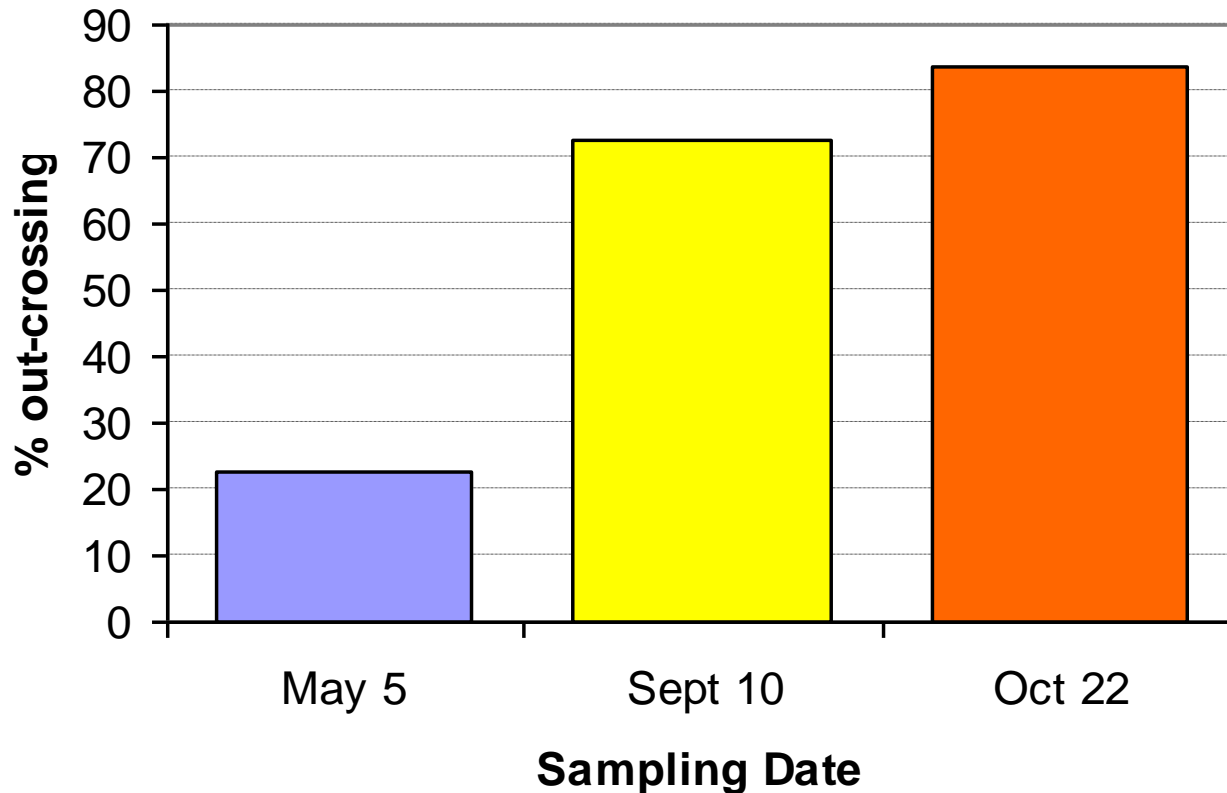
Hass yields decrease significantly with increasing distance from 'Ettinger'



Source: Guil et al. 1986. Alon Hanotea 40:443-455

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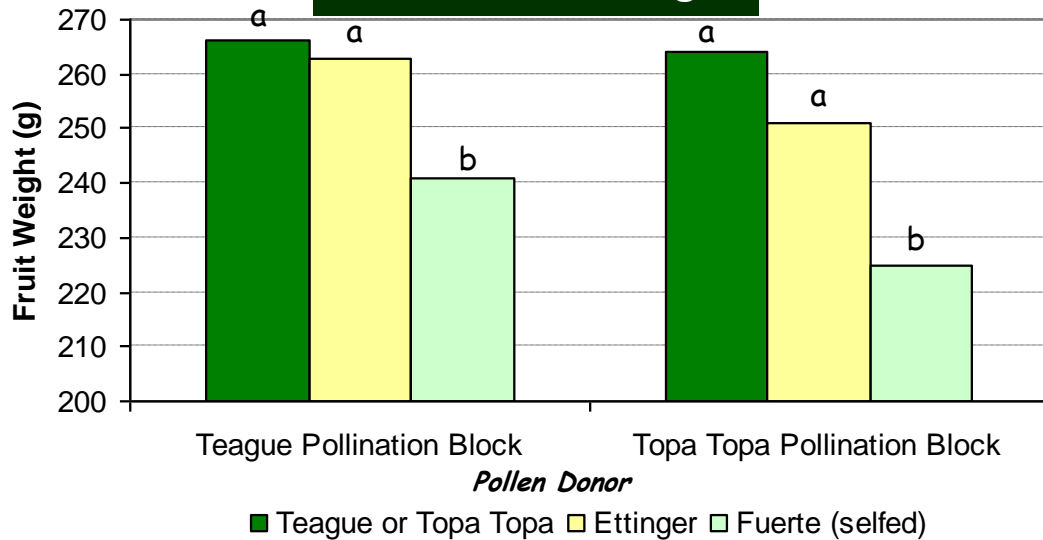
Survival of cross vs. self progenies



Percent of crossed 'Hass' fruits by both 'Ettinger' or 'Fuerte' according to time after fruit set.

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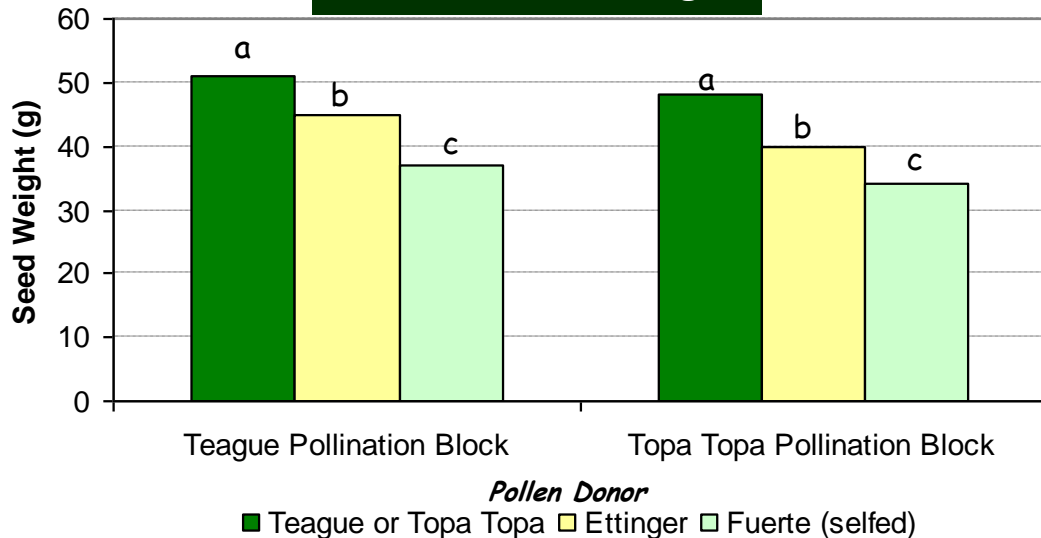
'Fuerte' Fruit Weight



Pollen Donor Effect (metaxenia)

The pollen donor cultivar impacts fruit weight and seed size.

'Fuerte' Seed Weight



Data from Israel for 'Fuerte' fruit with 'Teague', 'Ettinger' or 'Topa Topa' as pollen donors.

Source: Degani et al. 1990.
HortScience 25(4):471-473
via www.avocadosource.com

PROXIMITY



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DeBusschere Pollinizer Trial – Coastal Ventura County

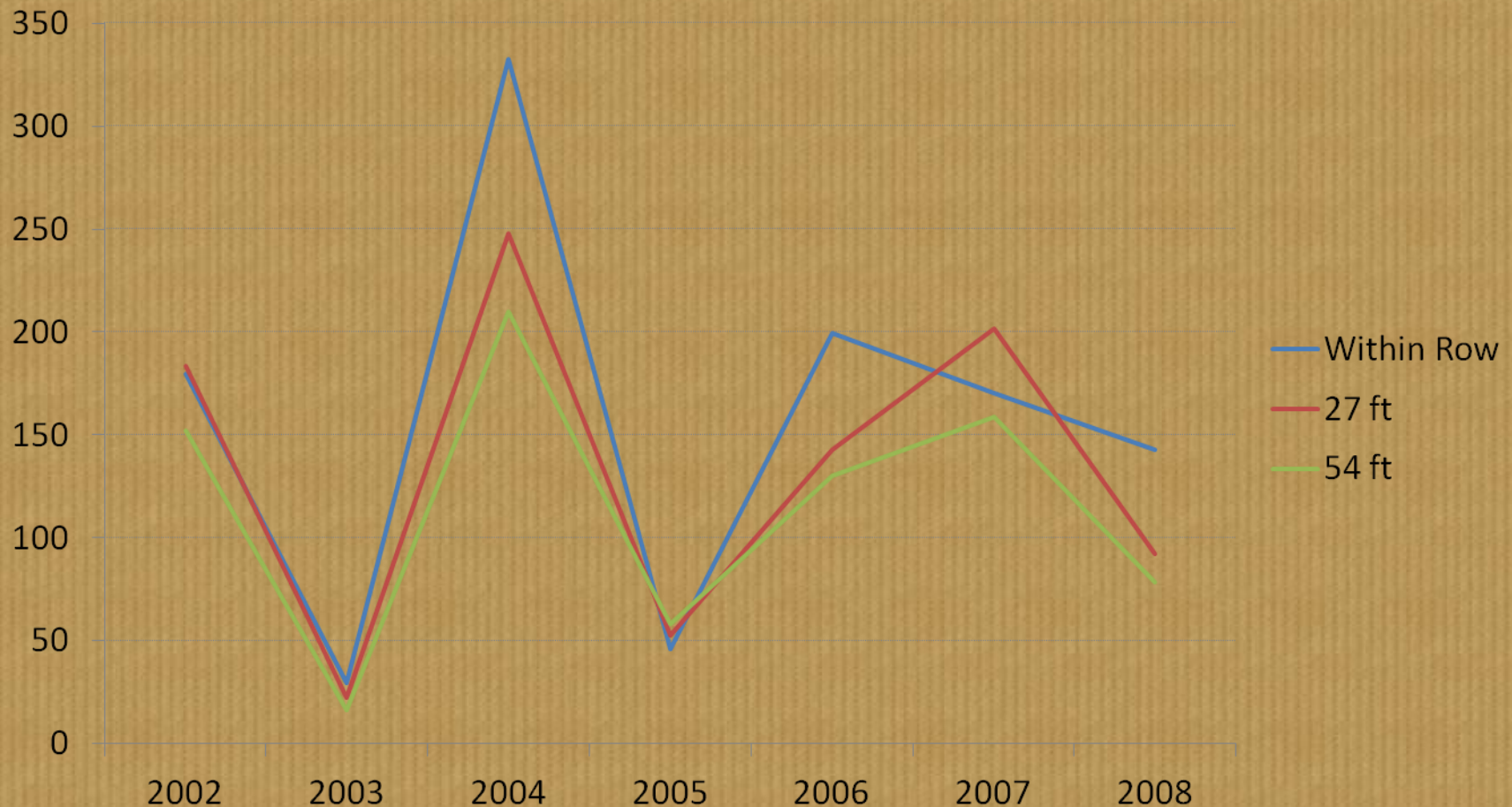
NORTH ROW																										
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50		
Poplar Windbreak	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	
	x	x	ET	x	x	x	x	x	67	x	x	x	x	x	F	x	x	x	x	x	Z	x	x	x	2	
	x	x	ET	x	x	x	x	x	67	x	x	x	x	x	F	x			x	x	Z	x	x	x	3	
	x	x	ET	x	x	x	x	x	67	x	x	x	x	x	F	x	C	C	x	x	Z	x	x	x	4	
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	O	O	x	x	x	x	x	x	5	
	x	x	ET	x	x	x	x	x	67	x	x	x	x	x	F	x	x	x	x	x	Z	x	x	x	6	
	x	x	ET	x	x	x	x	x	67	x	x	x	x	x	F	x	x	x	x	x	Z	x	x	x	7	
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	C	C	x	x	x	x	x	x	8	
	x	x	ET	x	x	x	x	x	67	x	x	x	x	x	F	x			x	x	Z	x	x	x	9	
	x	x	ET	x	x	x	x	x	67	x	x	x	x	x	F	x	x	x	x	x	Z	x	x	x	10	
	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	
	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	
	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	
	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	
	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	
	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	
	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	
	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	
	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	
	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	
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		
SOUTH																										
ET	Ettinger				16	BL 516			c	c	These are Tom Davenport's trees.															
67	BL 667				HV	Harvest					c is trees that had closed cages during Spring 2003															
F	Fuerte				B	Bacon			o	o	o is trees that were open controls during Spring 2003															
Z	Zutano				SP	SirPrize																				
Eucalyptus V																										

Eucalyptus V

Pollinizer Varieties: 8
Field trial replicates: 6
Pollinizers interset with Hass

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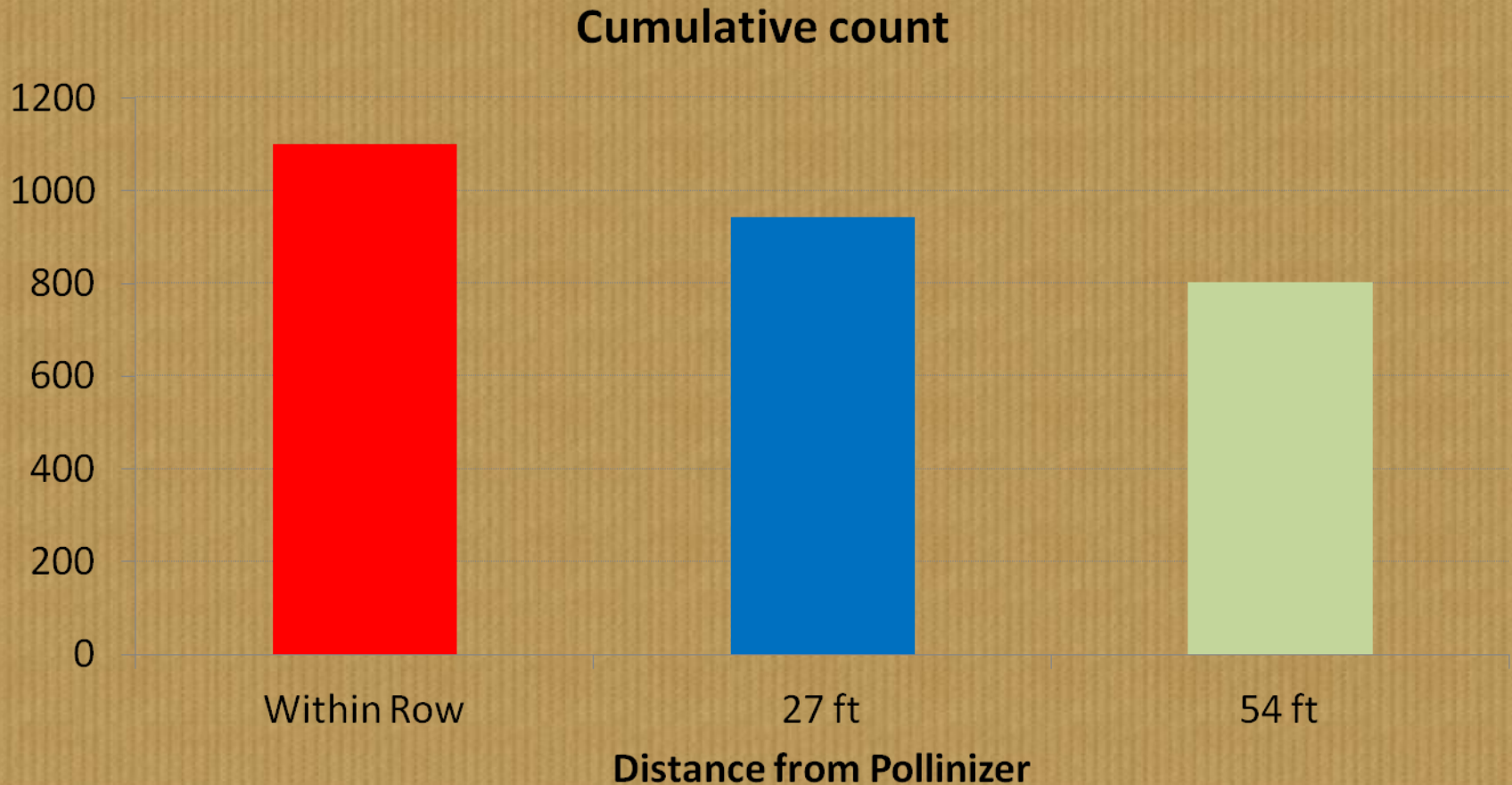
Debusschere Pollination Project – 2001 – 2008
Average fruit count across all Pollinizers by Year
Trees planted 1998



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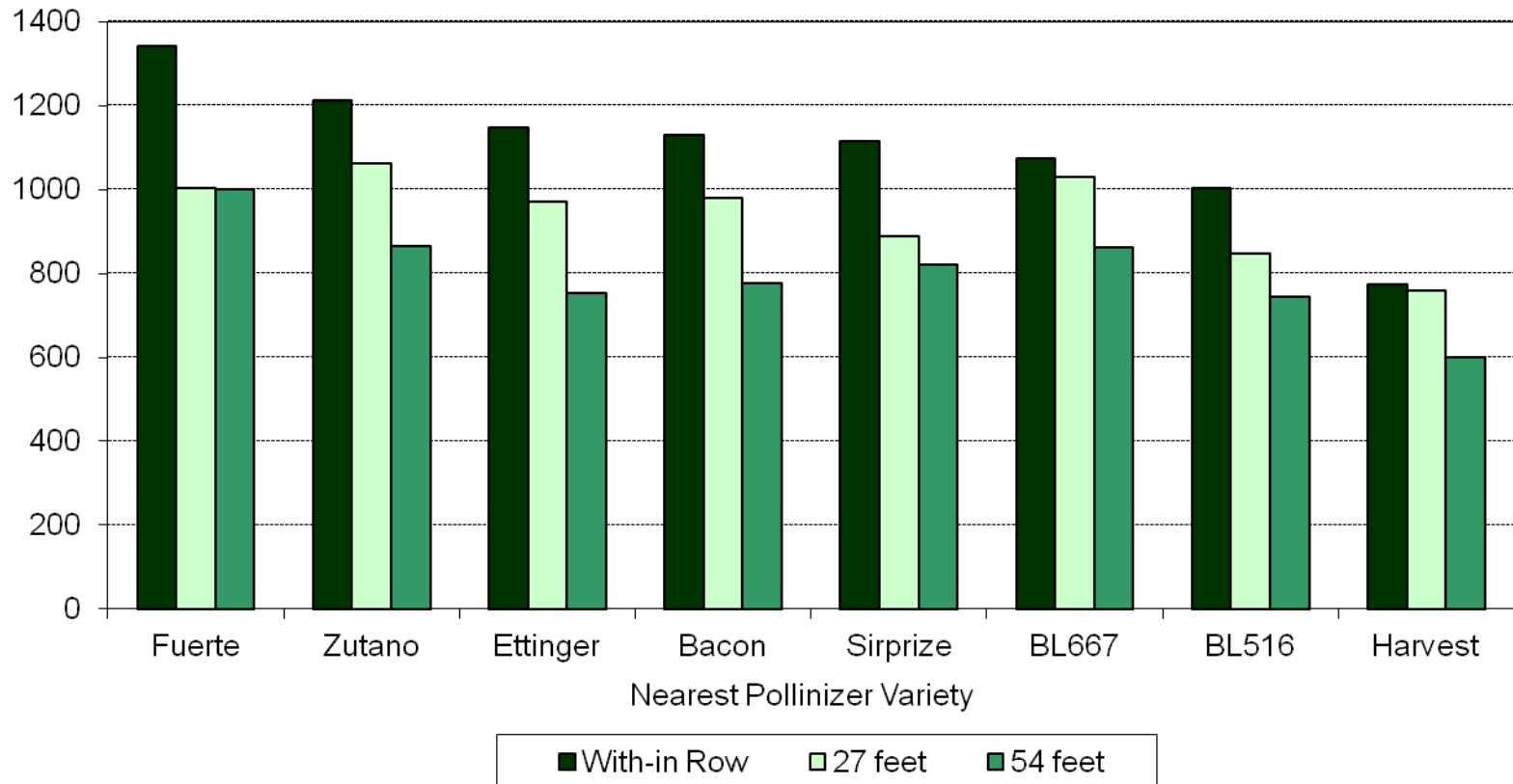
Debusschere Pollination Project – 2001 – 2008

Cumulative fruit count as a function of distance from pollinizer



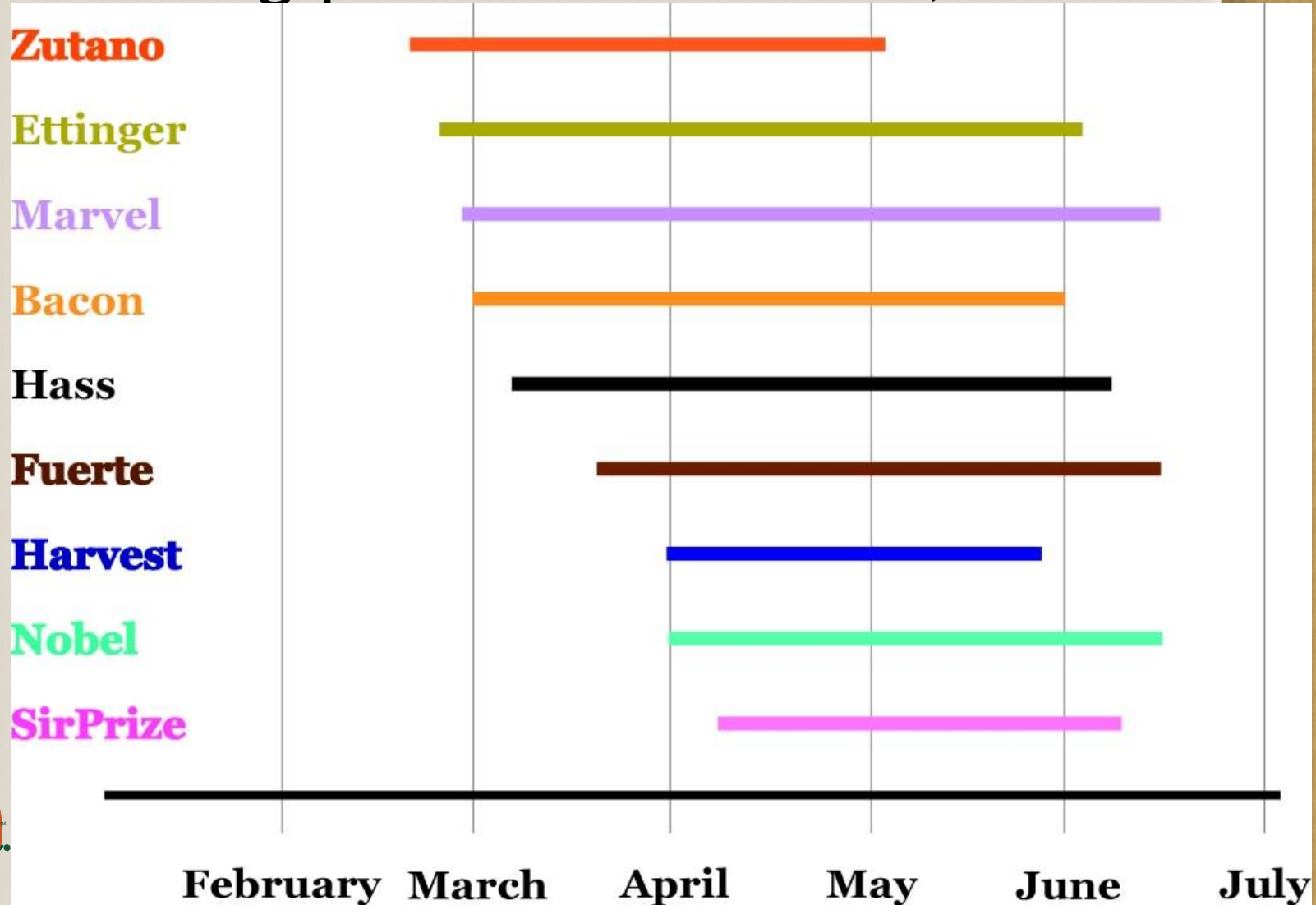
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Debusschere Pollination Project – 2001 – 2008
Cumulative fruit count as a function of pollinizer variety and distance from pollinizer

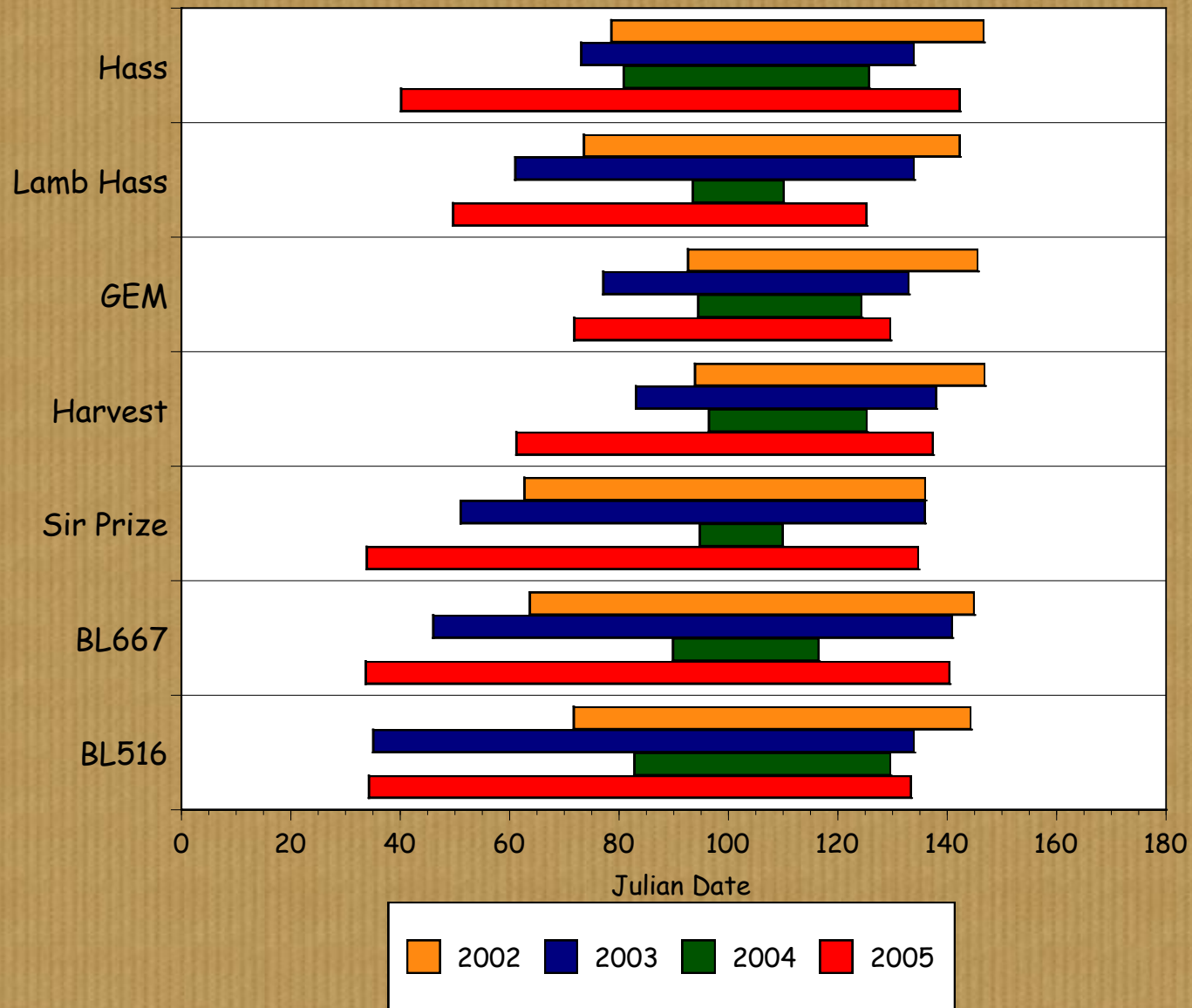


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Flowering periods – Oxnard, 2002



Duration of bloom over 4 years

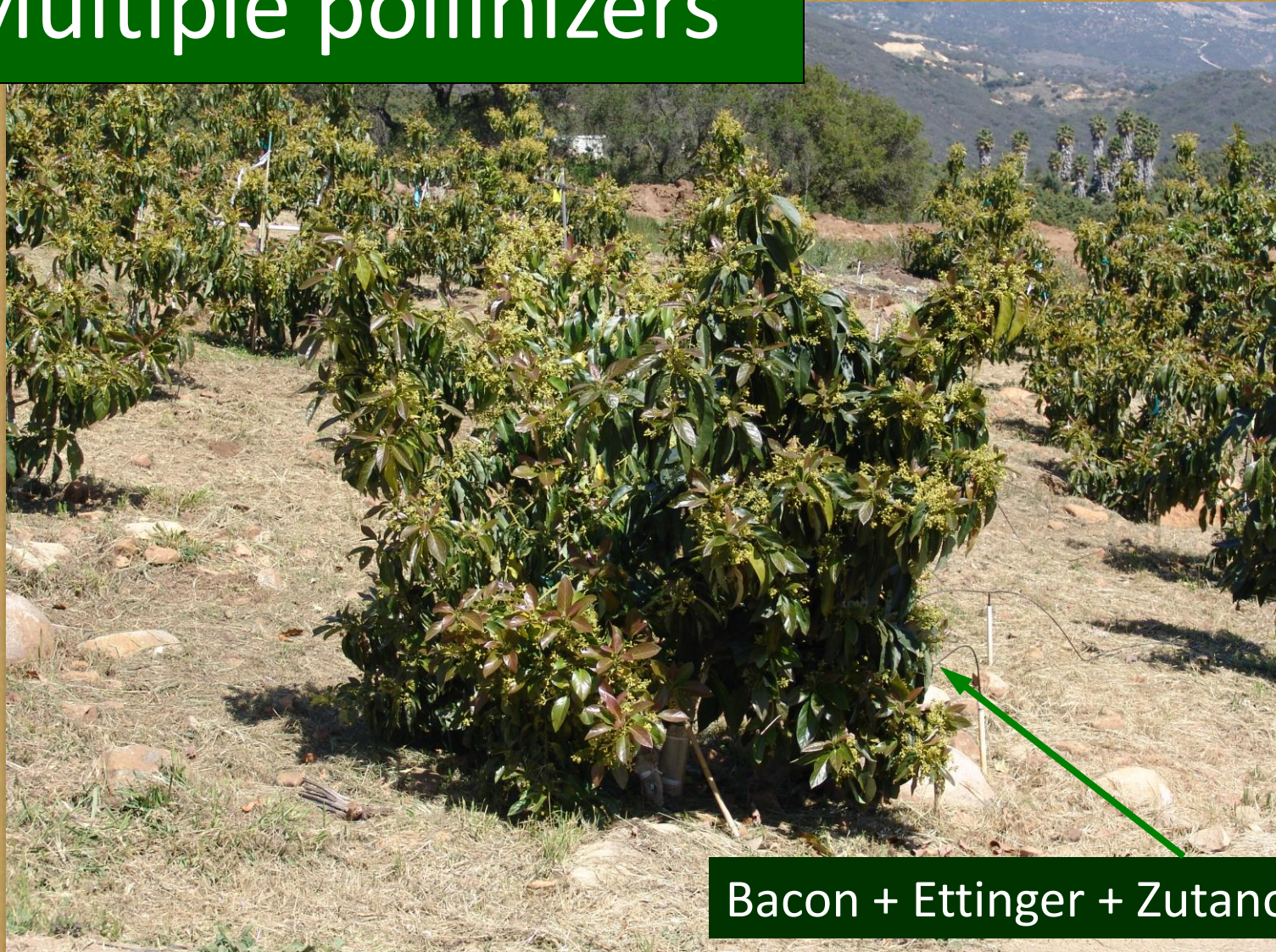


POLLINIZERS

- Careful selection of pollinizers based on overlap in sexual stages and blooming period. Different in different producing areas
- Pollen vigor: in vitro and in vivo pollen germination tests
- Do we really need pollinizers in every producing area?



Multiple pollinizers



Bacon + Ettinger + Zutano

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SEARCHING FOR THE IDEAL POLLINIZER FOR HASS

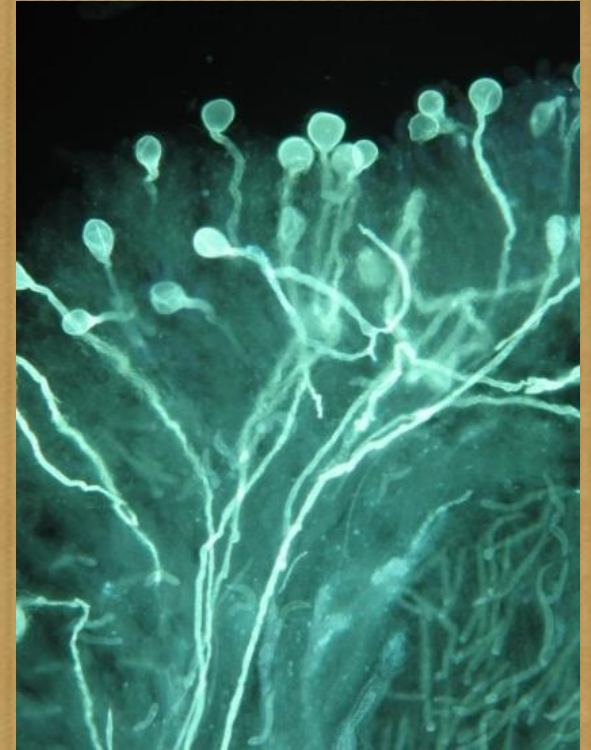
Requirements

- ➡ Type B
- ➡ Overlap in flowering time with Hass

Currently in CA a range of varieties are used but predominantly Zutano, Bacon and Ettinger

↓ For the future

- ➡ If possible: Hass-like fruits



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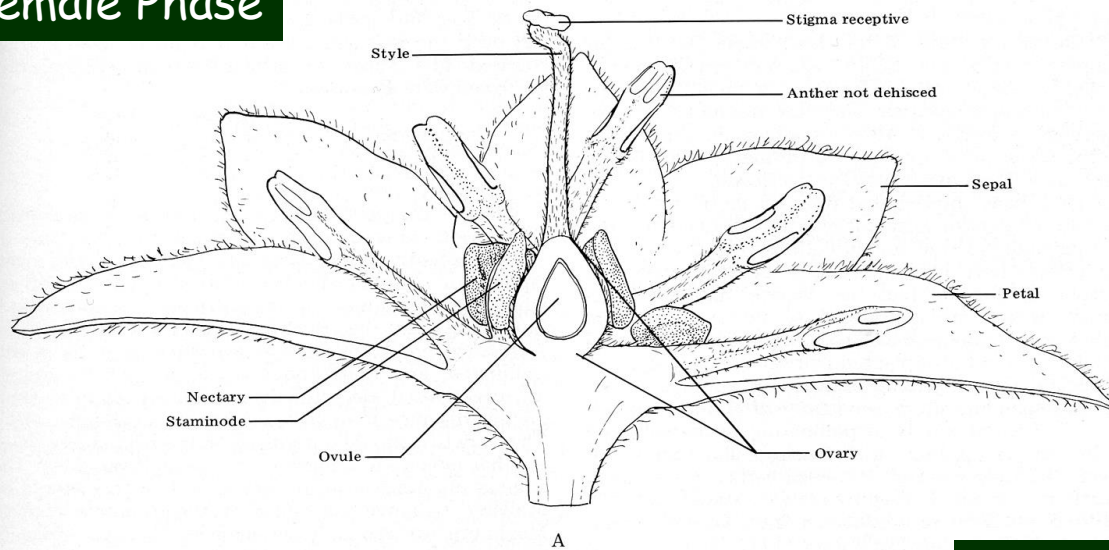


Pollinators
How do you get the
pollen to the flower?

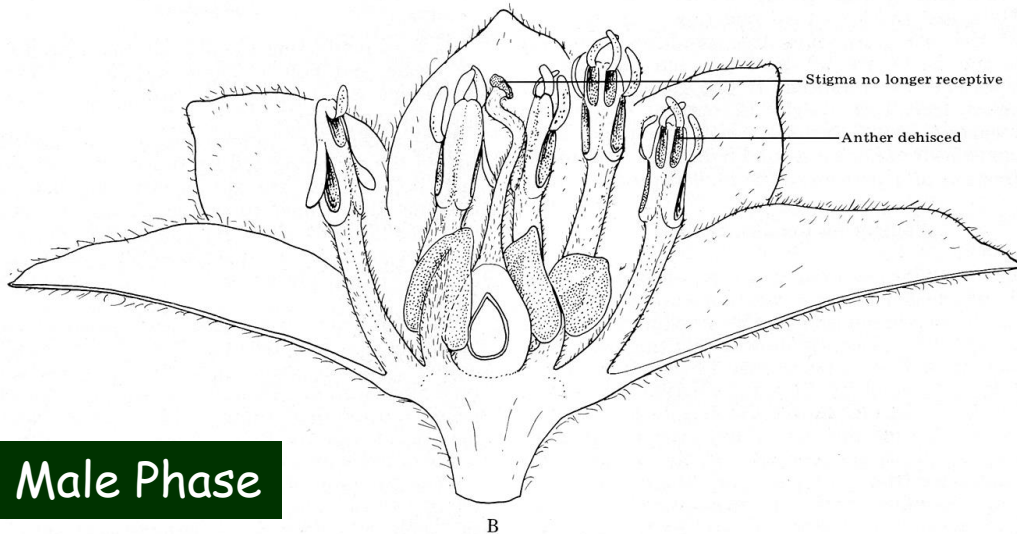


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Female Phase

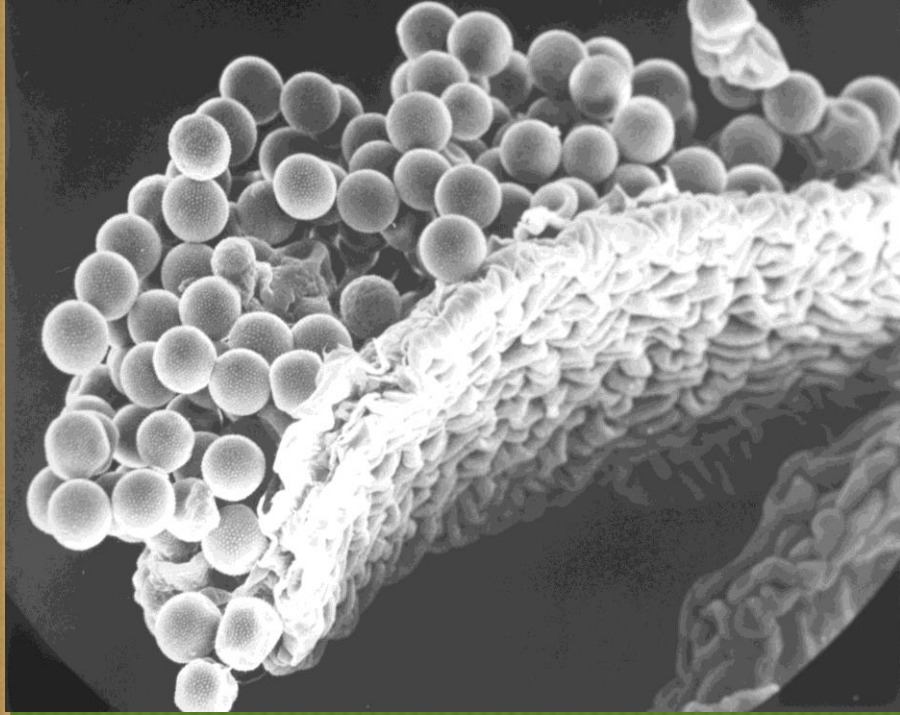


The avocado flower

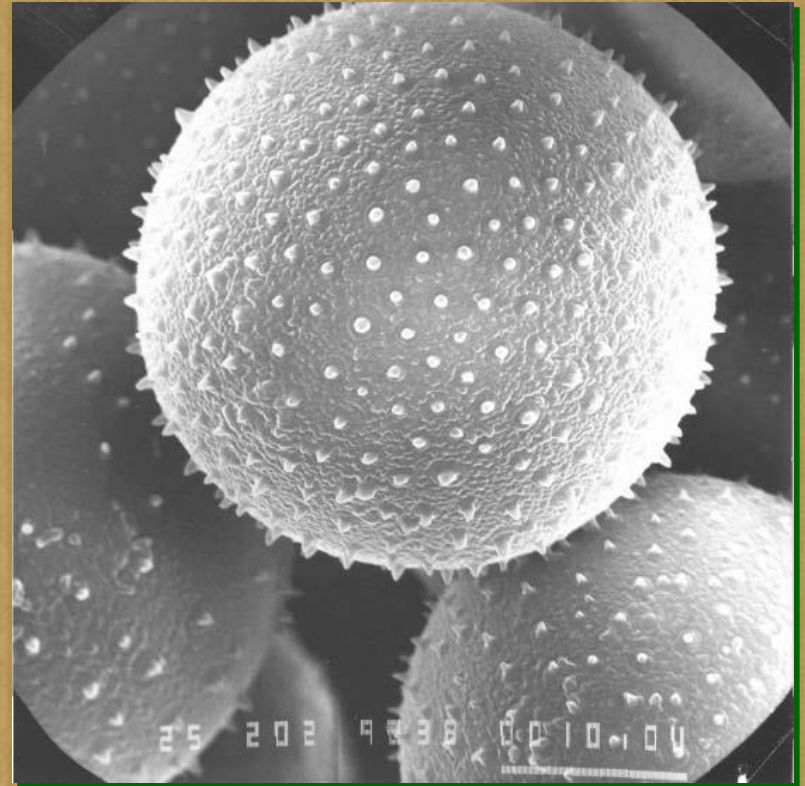


Male Phase

The avocado pollen grain



'Fuerte' pollen on anther flap



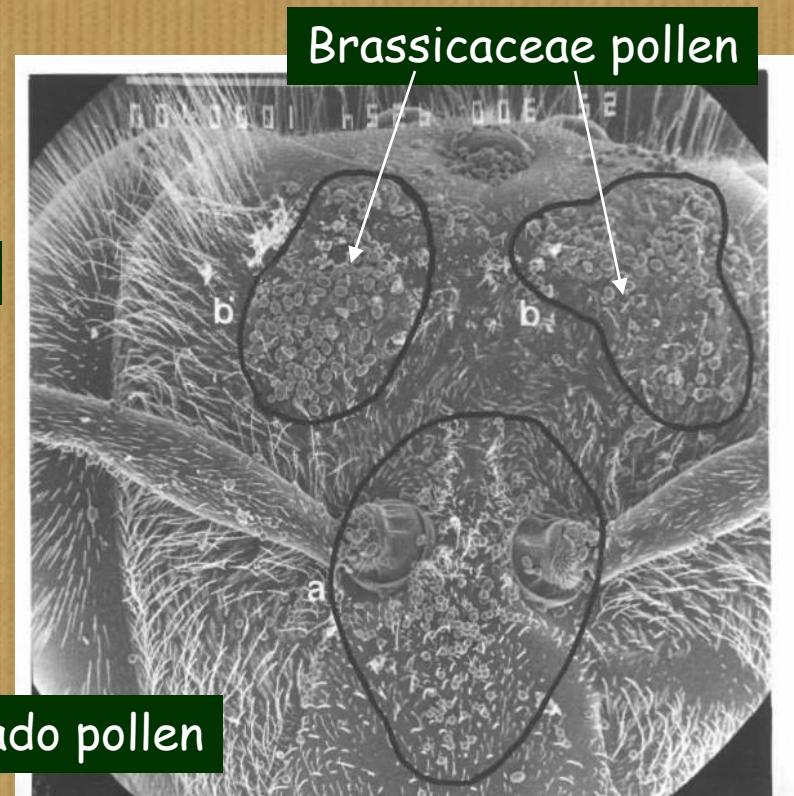
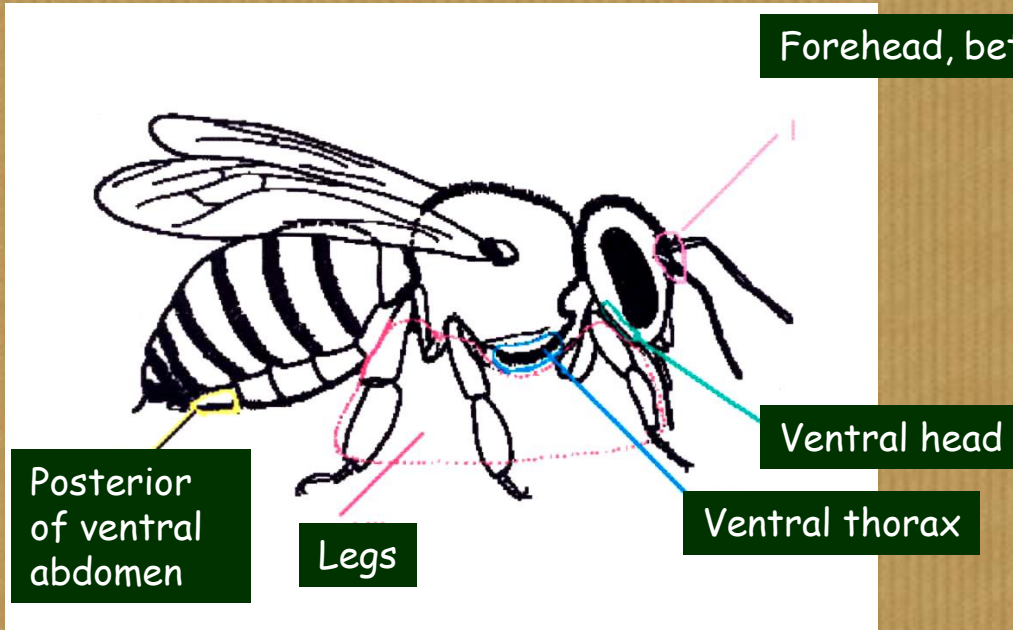
'Hass' pollen grain
(SEM x2000)

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- Two types of bees working in the field
 - Nectar collector
 - Pollen collector
- Ratio of each is dependent on needs of the hive
- The pollen in the load is not effective for pollination
- Pollen grains on bee's body is what is effective for pollination

Regions of avocado pollen transfer on the honeybee body



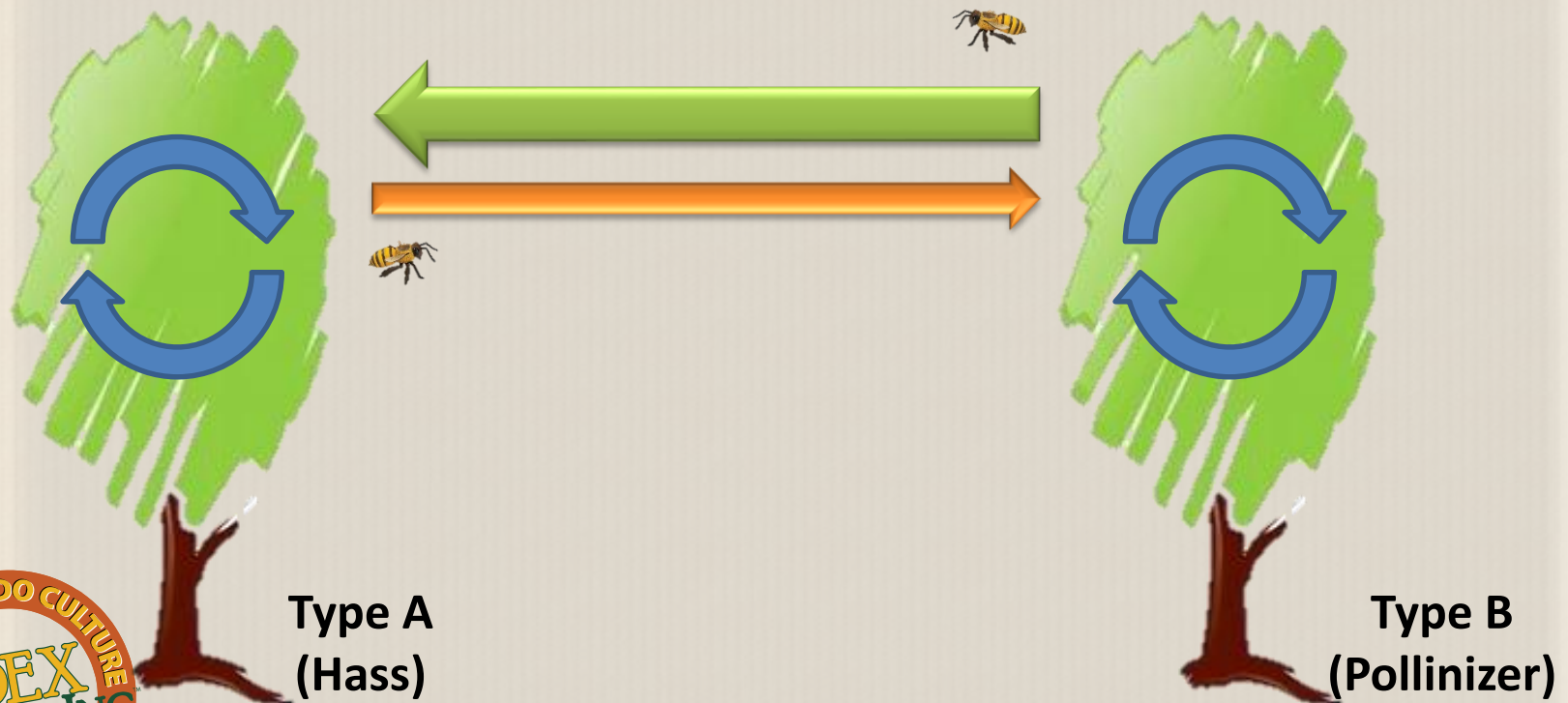
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Honey bees transferring avocado pollen between male and female flowers



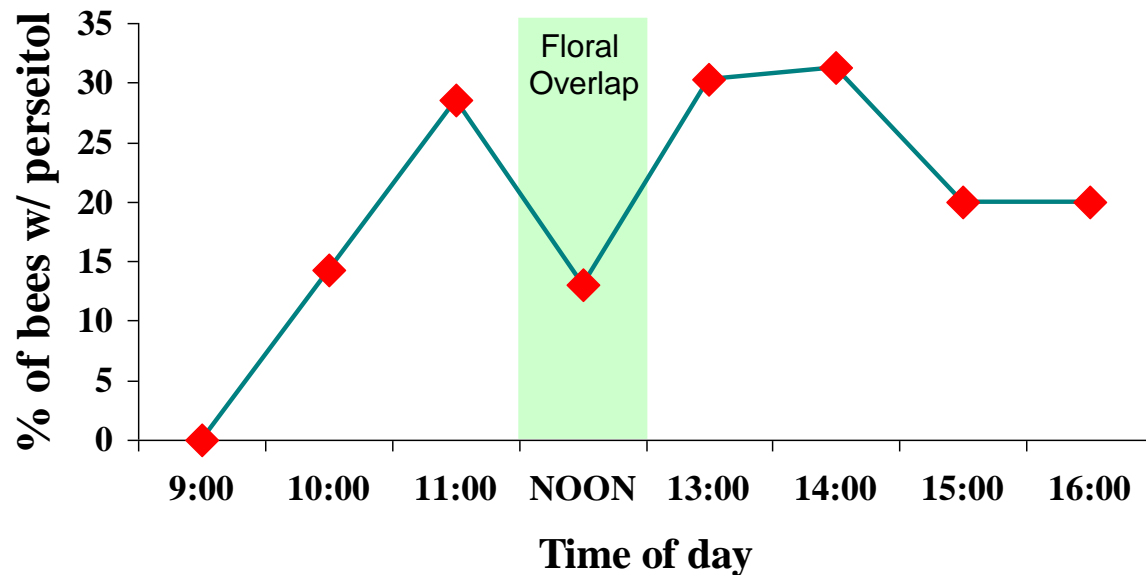
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It is crucial to get pollen moved between trees or within the tree.



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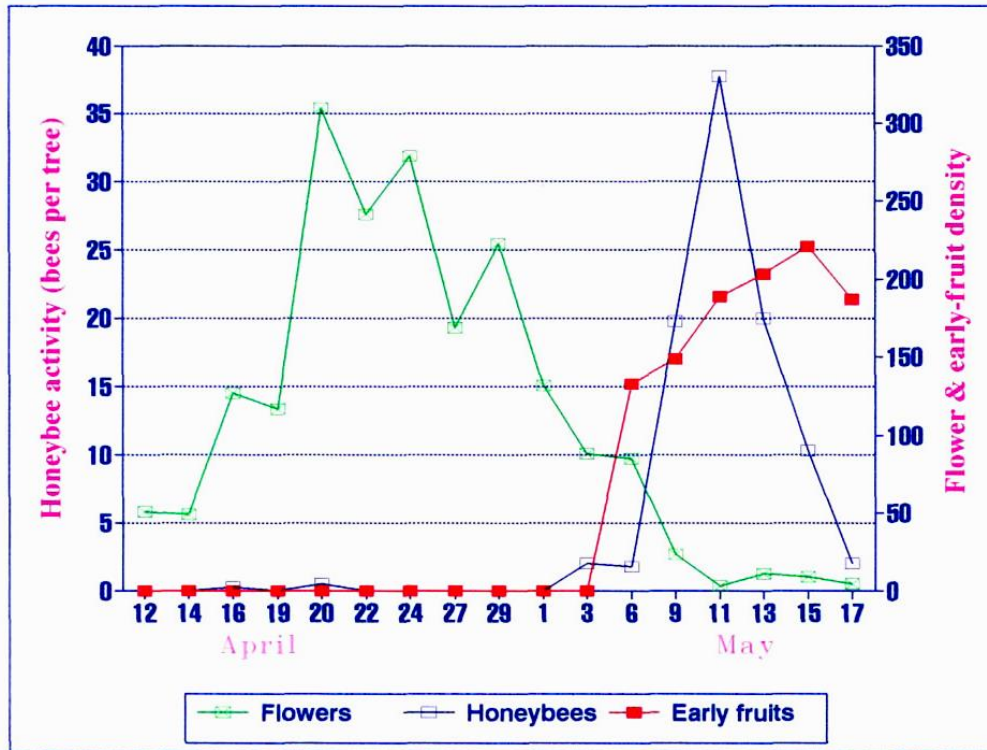
The percent of bees visiting avocado flowers



Fetscher and Arpaia, 2001

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'Hass' flowering, honeybee activity and fruit set - Israel, spring 1992



No correlation found
between avocado
flowering intensity
and honeybee activity
in the presence of
competing bloom

High correlation found
between fruit set and
honeybee activity



Source: Ish-Am, 1994. PhD Thesis

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To maximize yield one needs:

Effective pollination



Efficient pollinator
(many honey bees)

Sufficient
cross pollination



Pollinizers in
close proximity



Acknowledgements

- Gad Ish-Am, Iñaki Hormaza for sharing information in this presentation
- www.avocadosource.com
- California Avocado Commission and BARD for grant support
- The worker bees that collected the data: *L. Bates, D. Stottlemeyer, E. Focht, M. Crowley*



Summary: Factors Affecting Avocado Pollination

- Avocado trees produce millions of flowers per tree but only a few hundred will produce a marketable avocado.
- Avocado flowers open in two phases: female and male.
- Avocado flowers are classified as either “A” or “B” type depending on the time of day when they open as male or female.
- A pollinizer tree in a Hass orchard is one with a complimentary flower type to the tree that we wish to be pollinated. Some pollinizers for Hass include Bacon, Zutano and Ettinger.
- A pollinator is an animal which helps to deliver pollen to avocado flowers. Bees have been shown to help with avocado fruit set.
- Temperatures during the bloom period have a significant effect on the successful fruit set.
- Other factors that affect fruit set include the starch content of the flower and whether it is an “on” or “off” year in the alternate bearing cycle of the avocado.

