

SESSION SEVEN

Session Seven

Flowering, fruit set and yield

New Zealand and Australia Avocado
Grower's Conference'05
20-22 September 2005
Tauranga, New Zealand

Reproductive Biology of Avocado



Gad Ish-Am

Agricultural R & D

Western Galilee, Israel

Ohalo College, P.O.B. 222

Katzrin, 12900, Israel

Major questions concerning avocado reproductive biology

1. Why the tree bears so many flowers and only a few fruits?
2. Is self-pollination (within the flower) effective?
3. Is cross-pollination (between cultivars) needed?
4. Does pollination limit avocado productivity?
5. How can we maximize the honeybee pollination efficiency?
6. Are there better alternative pollinators for the avocado?



Avocado Flower Phases



Female Phase Flower
(‘Reed’)



Male Phase Flower
(‘Fuerte’)

Structure of the avocado flower

Stigma, style and ovary

Nectaries (3 staminodes)

Petals (6)

Stamens
(9, closed)



Female Phase

Stigma (shrunk)

Nectaries (6 true nectaries)

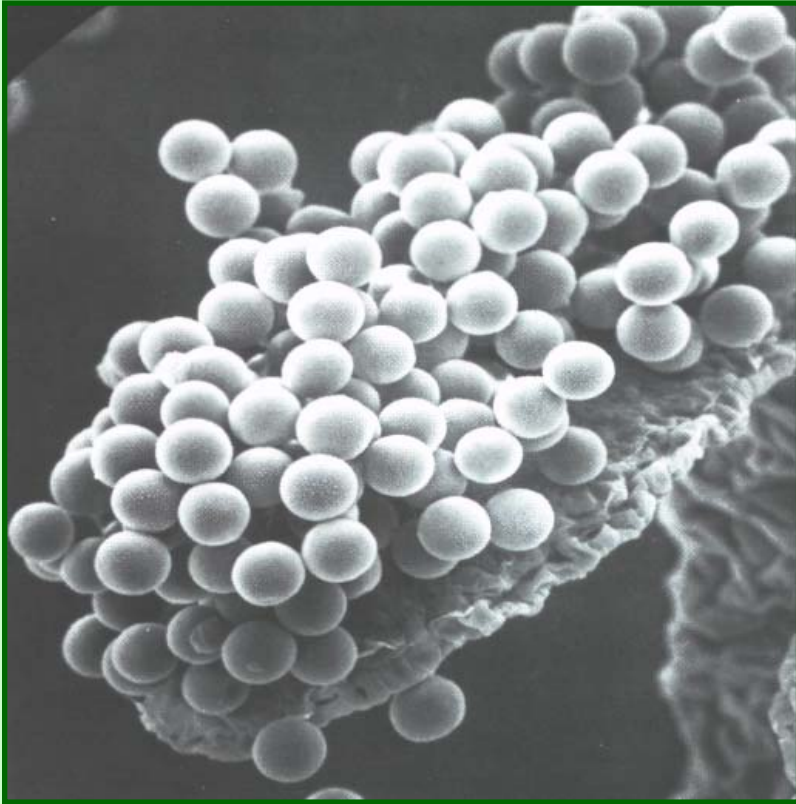
Petals (6)

Stamens
(9, opened)



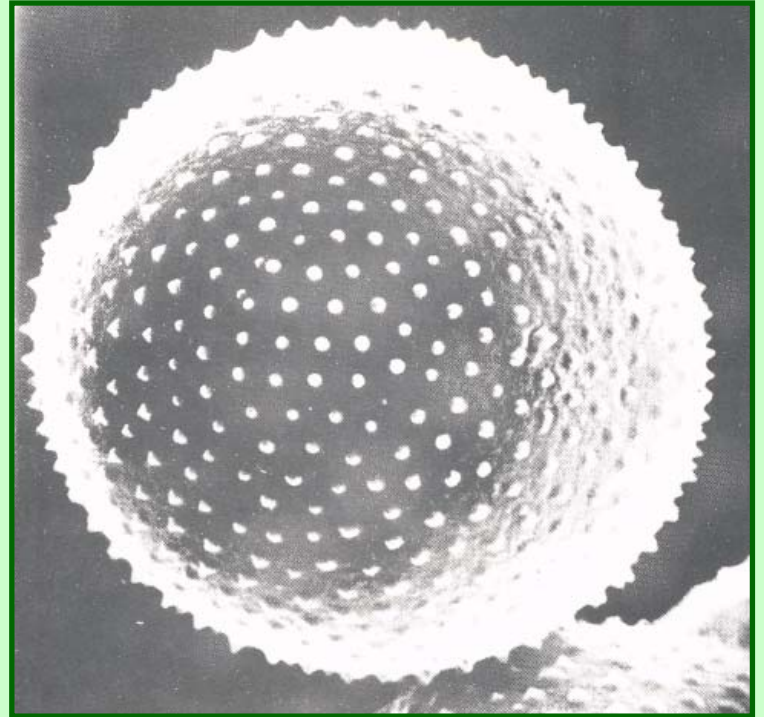
Male Phase

The avocado pollen



Ettinger pollen grains attached
To an open valve of the anther

Source: Ish-Am, 1994. PhD Thesis

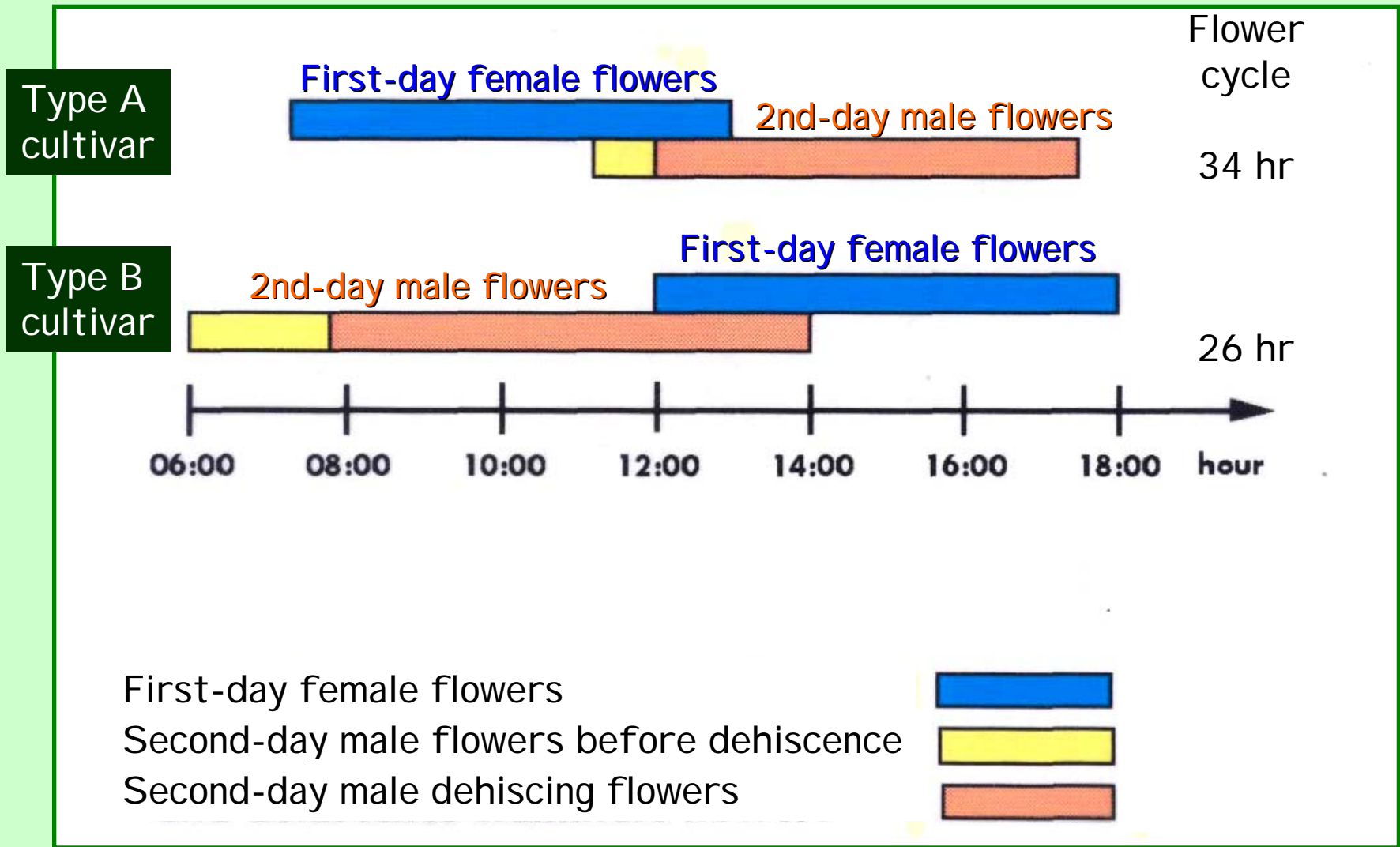


Fuerte pollen grain

Source: Gazit & Degani, 2002.

Avocado Flowering Sequence

Synchronous protogyny with intermediate closing



Overlapping of male and female flowers within the tree (‘Hass’, A type cultivar, at noon)

Female-phase flower
Open since the morning



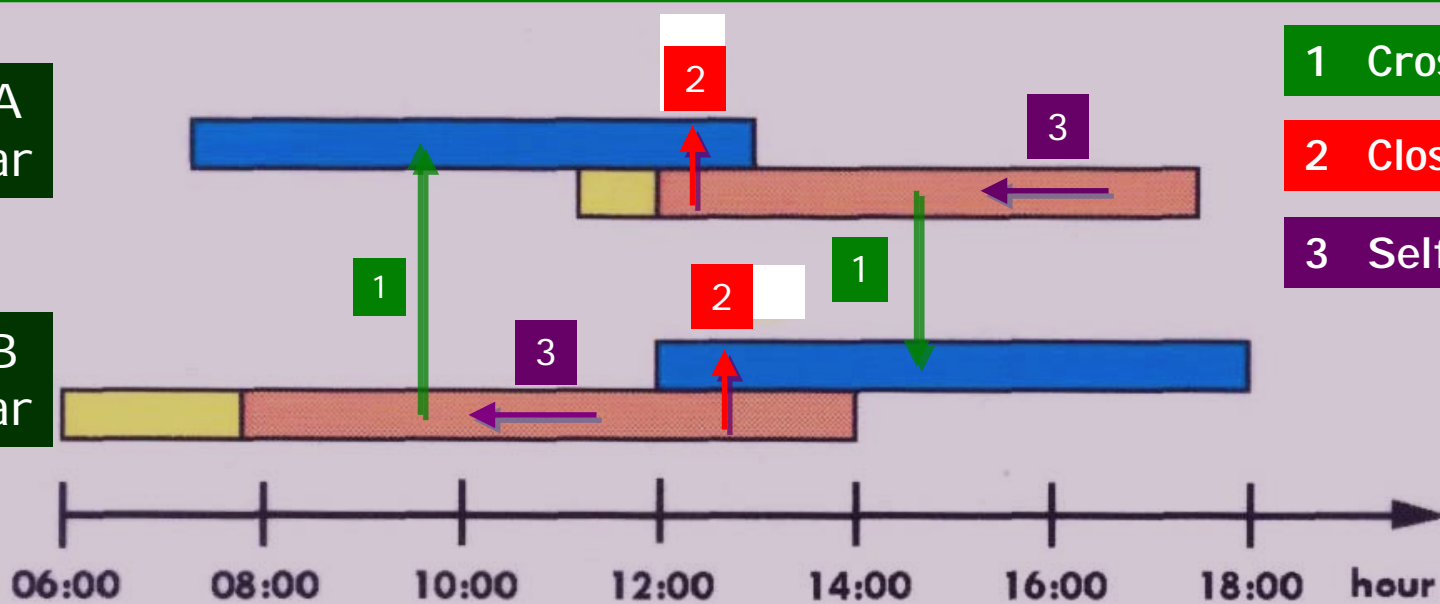
Newly opened Male-phase flower

Avocado optional pollination routes

Type A cultivar

Type B cultivar

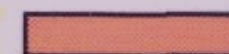
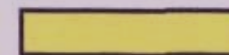
- 1 Cross pollination
- 2 Close pollination
- 3 Self pollination



First-day female flowers

Second-day male flowers before dehiscence

Second-day male dehiscing flowers



Pollination Terms (1)



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

– *Cross pollination* – the pollen deposited on the stigma is transferred from another cultivar.

– *Close pollination* – the pollen deposited on the stigma is transferred from another flower of the same tree (or the same cultivar).

– *Self pollination* – the pollen deposited on the stigma comes from the same flower's stamens.

Pollination Terms (2)



Pollinator: The agent that transfers pollen from the male to the female floral organs.

Pollinated Cultivar: The cultivar that receives the pollen. *e.g. Hass.*



Pollinizer Cultivar: The cultivar that donates the pollen.

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

Pollination Terms (3)

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.

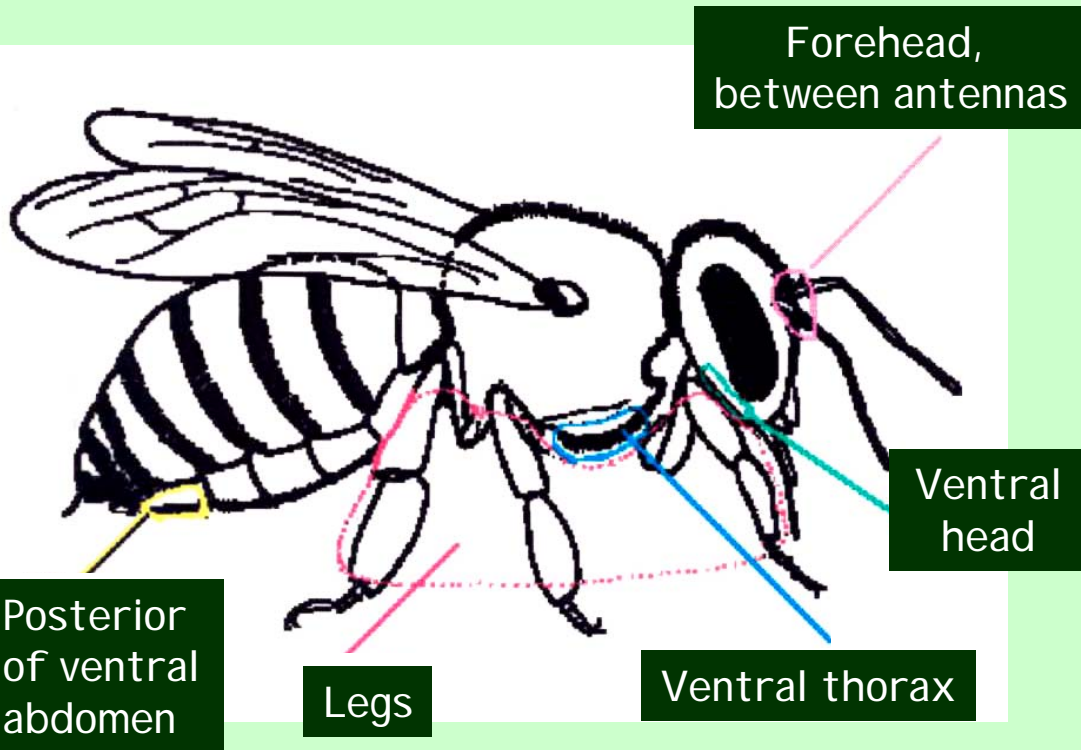
Parthenogenetic fruit – a fruit which develops without fertilization.



Transferring
the pollen
from anther
to stigma

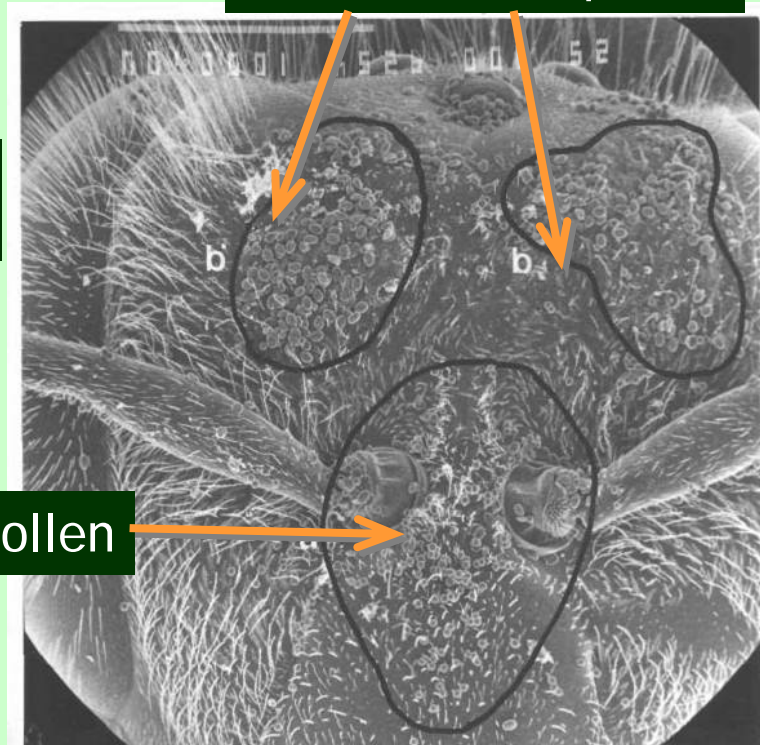


Regions of avocado pollen transfer on the honeybee body



A honeybee head (SAM picture)

Brassicaceae pollen



Efficient transfer of avocado pollen between flowers by honeybees

**Male
flower**



Forehead
transfer

**Female
flower**



Ventral-
thorax
transfer



Why does the avocado tree produce so many flowers?

Increasing attraction: the tree acts like a big inflorescence of many small flowers.

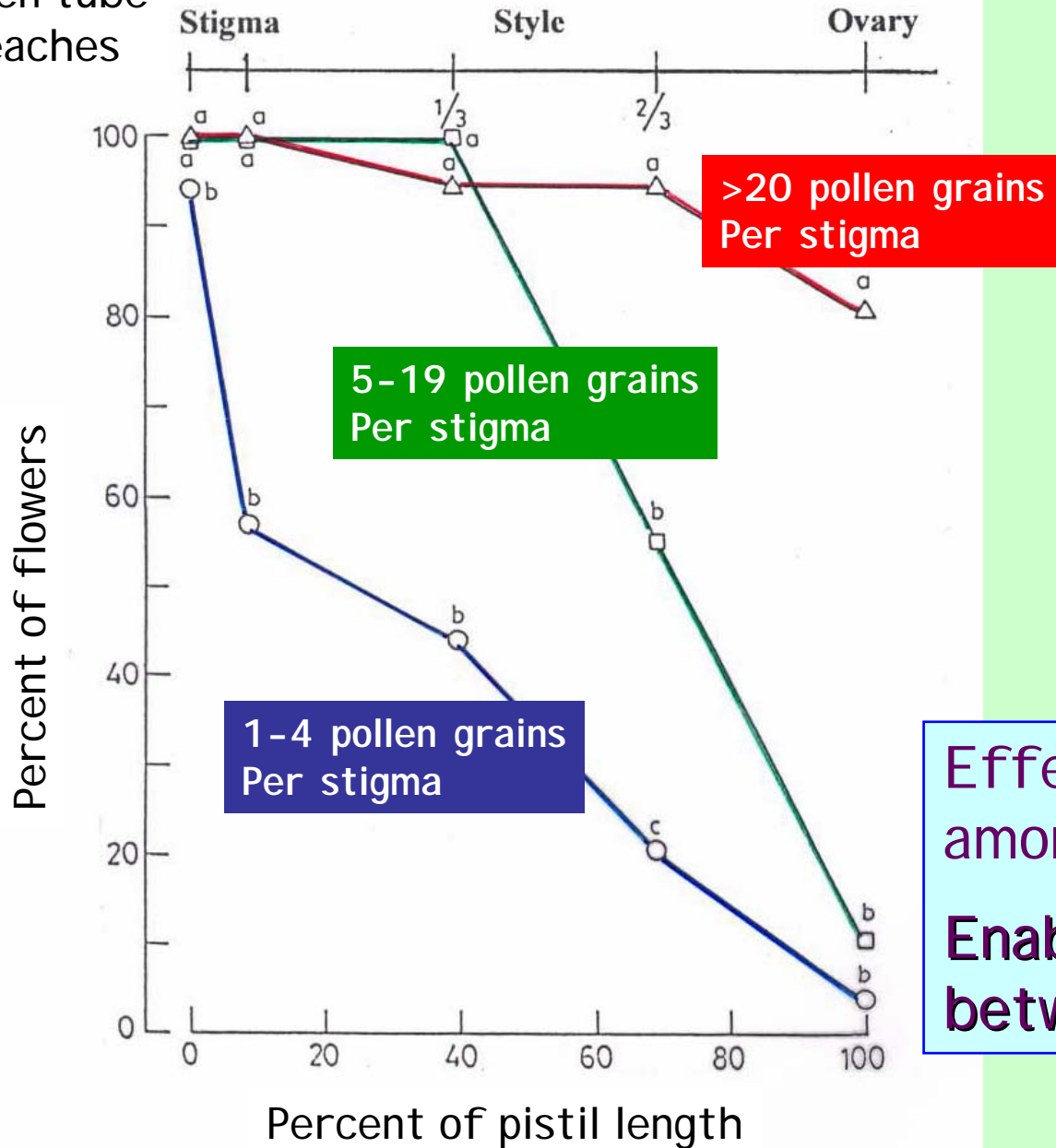
Overcoming low fertilization rates: most flowers are not fertilized and do not set fruit (parthenogenetic effect is not known).

Compensating a high rate of fruit abscission: which is an outcome of competition between fruits and growth, as well as among the fruits.



The need for many pollen grains per stigma

Pollen tube
Reaches



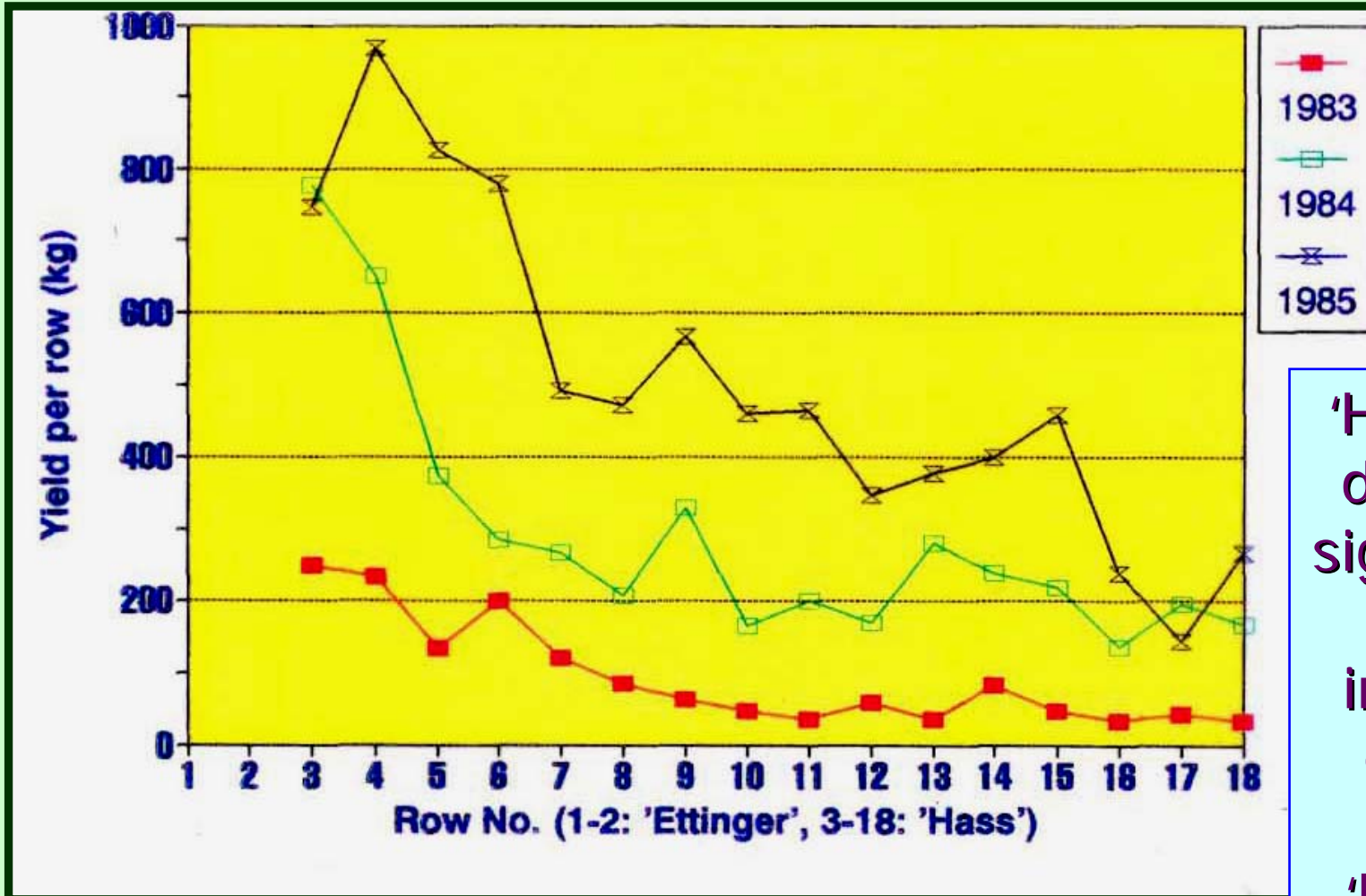
Pollen germination and pollen-tube growth, four hrs after hand pollination of 'Hass' stigmas by 'Ettinger' pollen.

Shoval, Israel 1987

Effect of cooperation among the pollen grains.

Enables also competition between the grains.

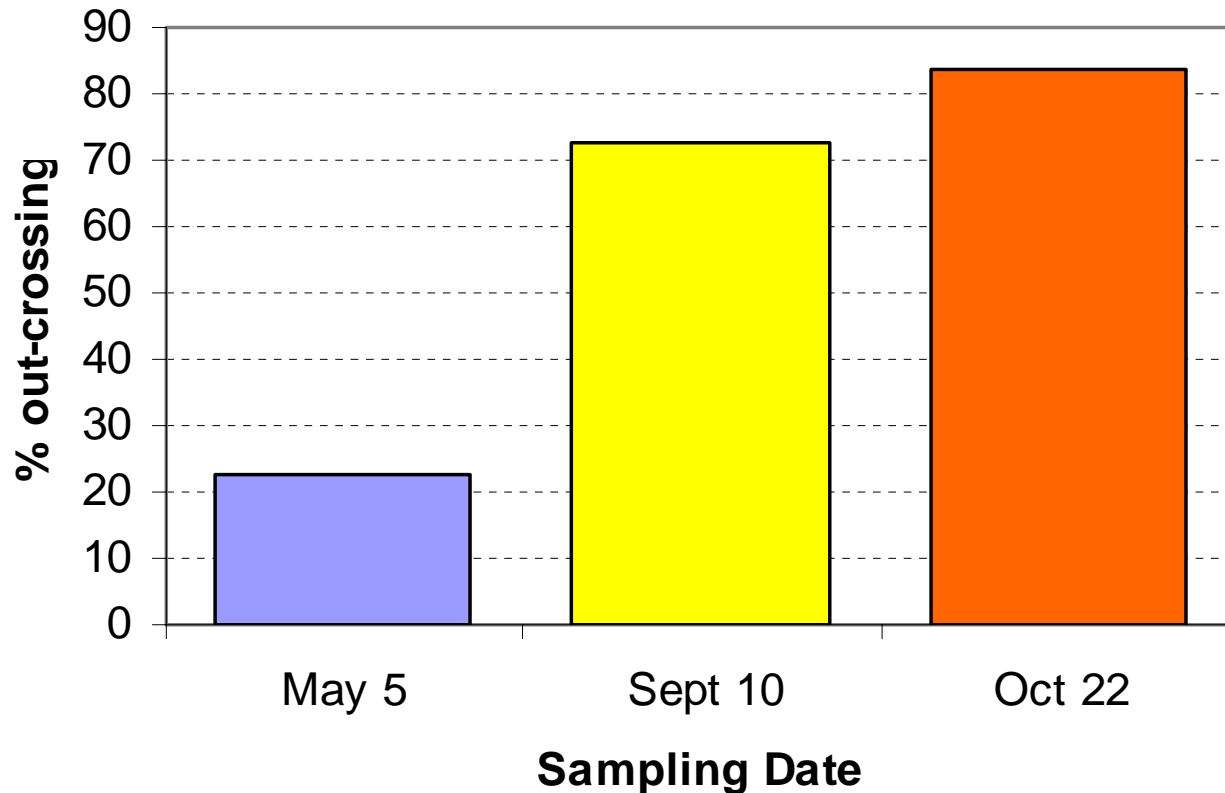
The need for cross pollination



'Hass' yield decreases significantly with increasing distance from 'Ettinger'.

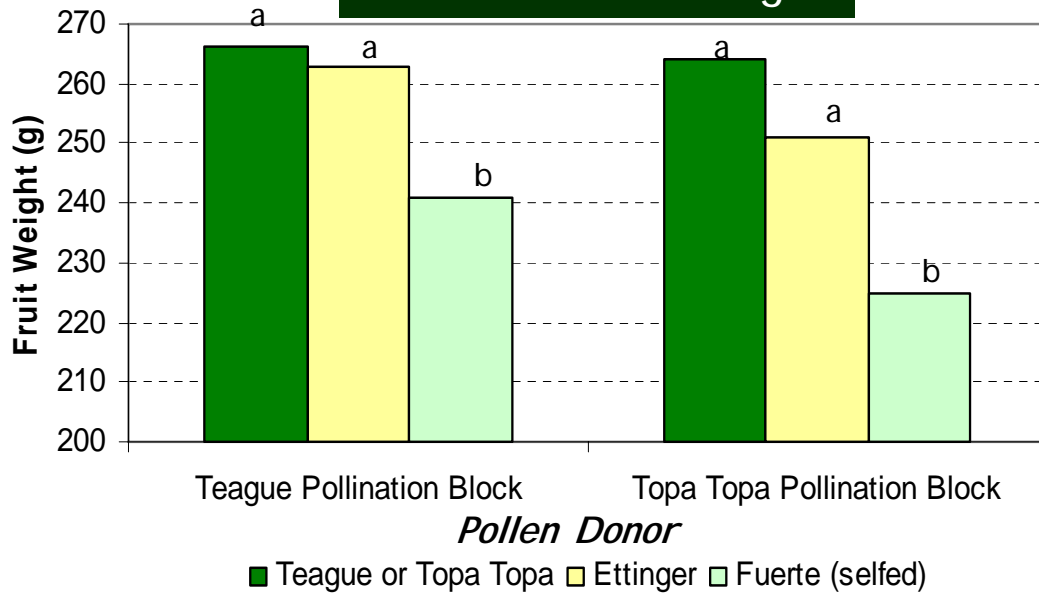
Source: Guil et al. 1986.
Alon Hanotea 40:443-455

High survival of cross fruits of male parent "potent cultivars"



Increasing percent of 'Hass' crossed fruits (by 'Ettinger' or 'Fuerte') with time after fruit set.

'Fuerte' Fruit Weight

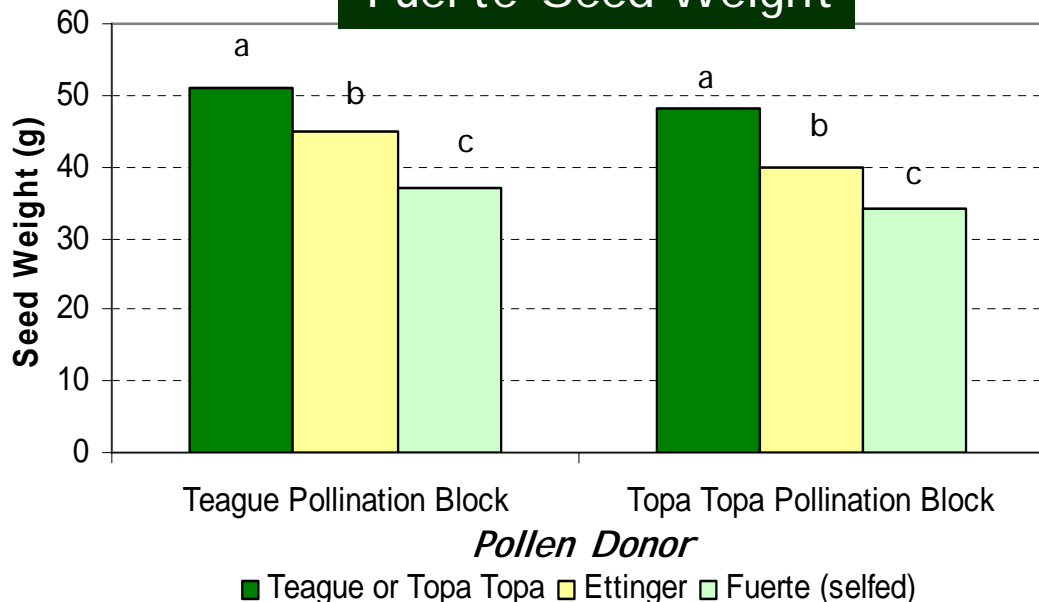


Pollen Donor Effect (metaxenia)

Higher weight of crossed 'Fuerte' fruits, as well as seeds, compared to the selves. Pollen donors are 'Teague', 'Ettinger' or 'Topa Topa'.

Data from Israel

'Fuerte' Seed Weight

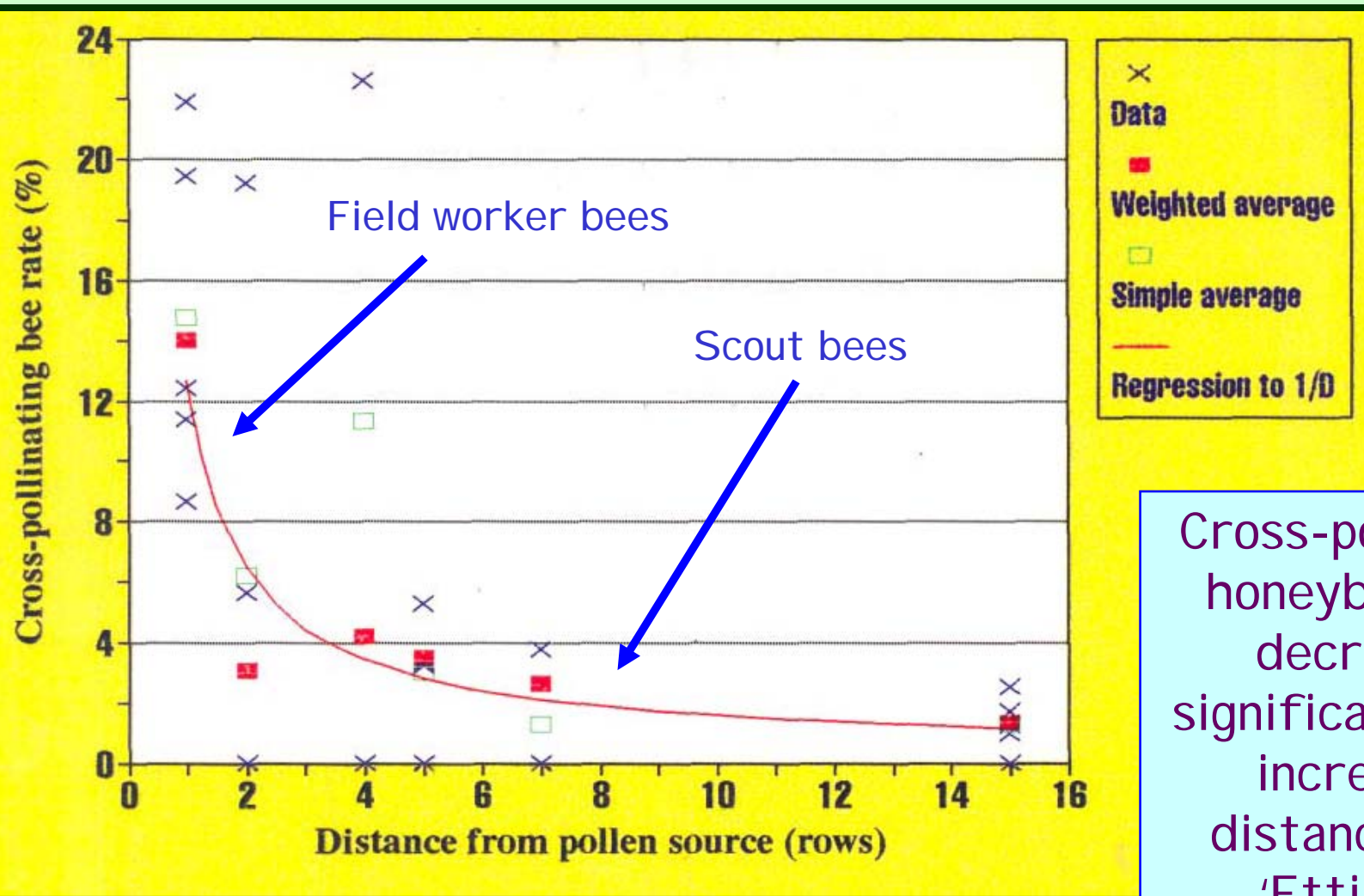


Source: Degani et al. 1990. HortScience 25(4):471-473 via www.avocadosource.com

The need for adjacent pollinizer



Percentage of cross-pollinating honeybees (on 'Hass') as a function of distance from the pollinizer ('Ettinger')



Cross-pollinating honeybee rate decreases significantly with increasing distance from 'Ettinger'.

Source: Ish-Am and Eisikowitch, 1996.

'Hass' cross-pollination rate as a function of bee density and distance from the pollinizer



'Hass' cross-pollination rate is lower with distant pollinizer ('Ettinger').

Multiple pollinizers: an effective cross pollination method



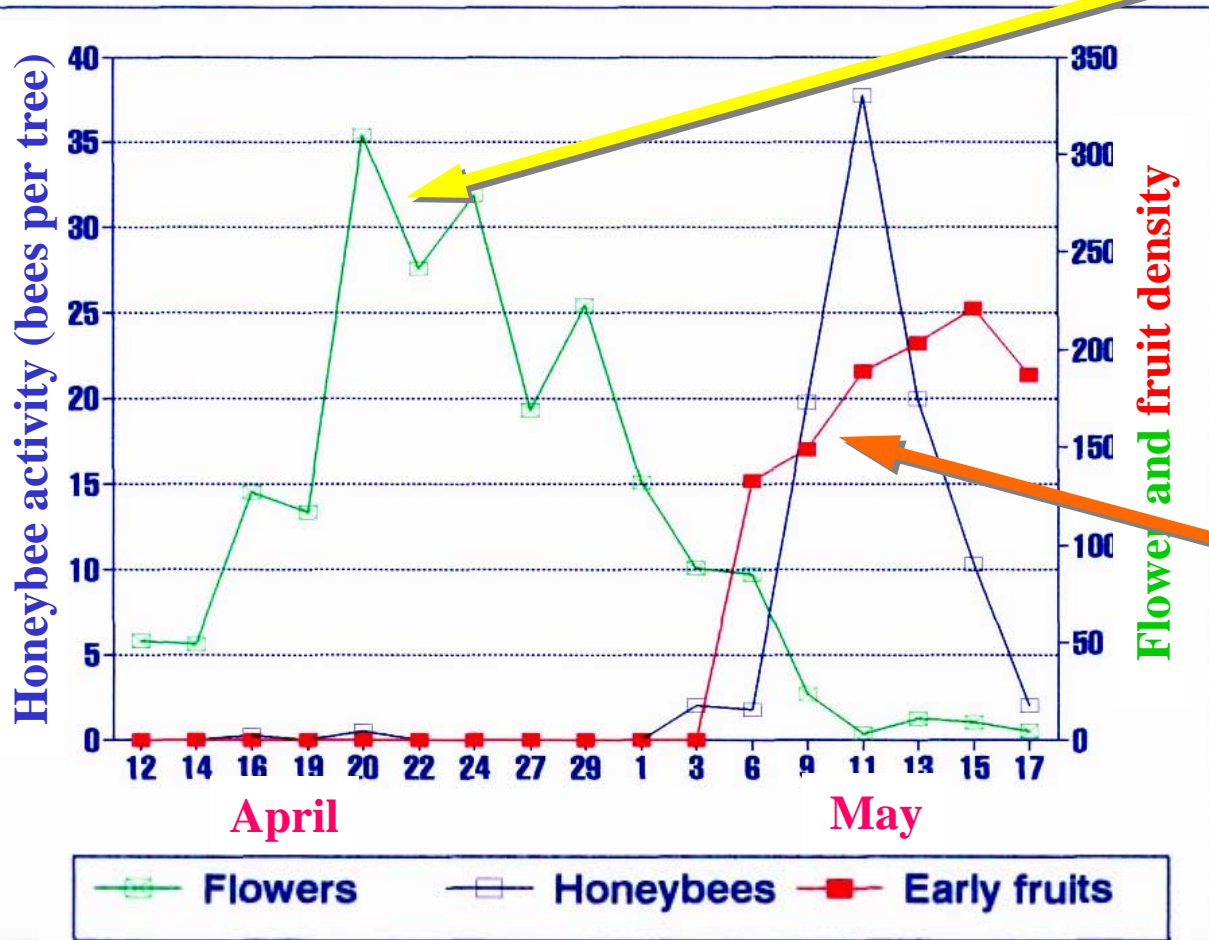
Three pollinizer
trees (Bacon,
Ettinger,
Zutano)
on one site
(R. Hofshi orchard,
California)

Attractiveness of avocado flowers to the honeybees



The honeybee was not the avocado original pollinator, and did not co-evolve with the avocado in Central America.

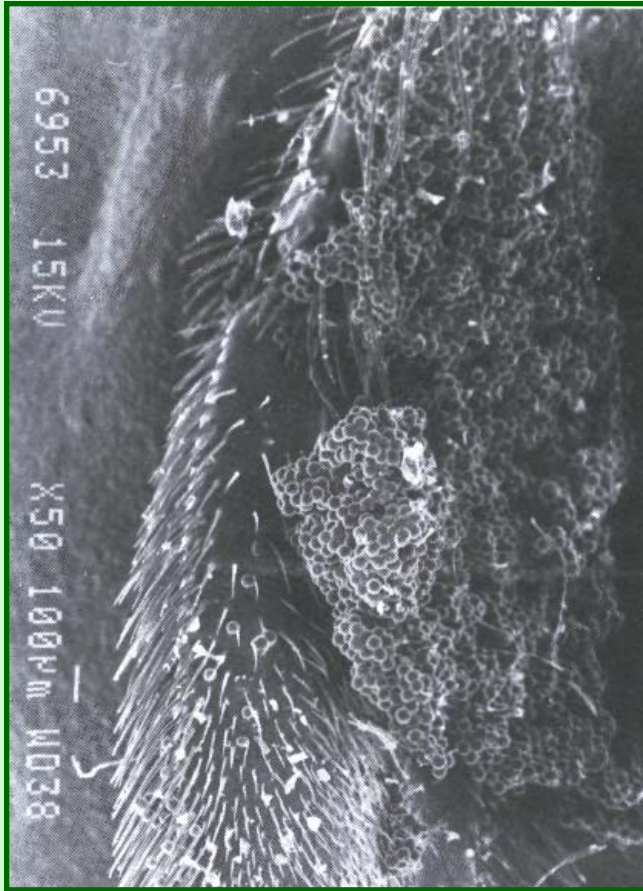
'Hass' flowering, honeybee activity and fruit set - Israel, spring 1992



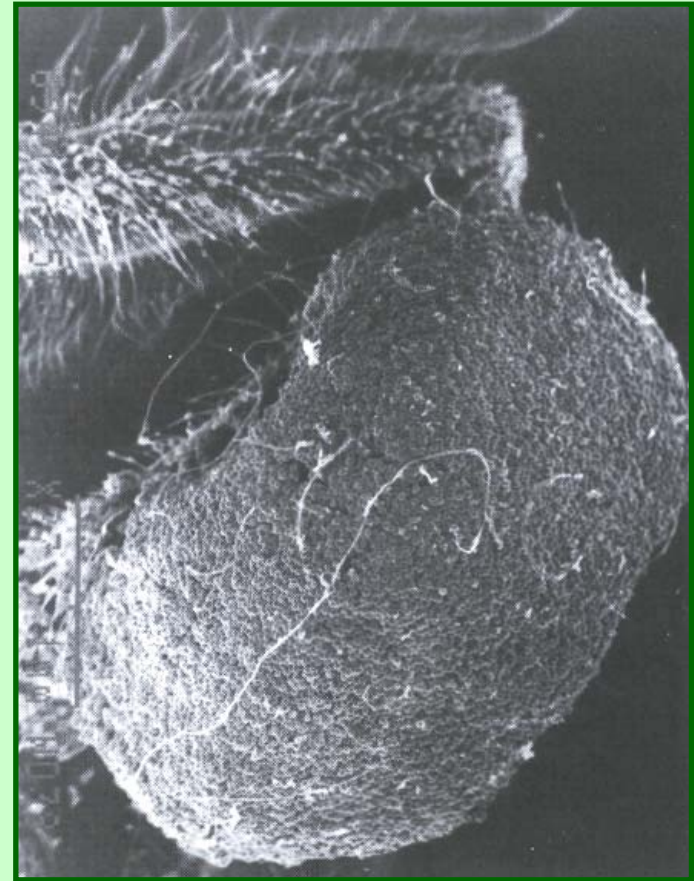
No correlation found between avocado flowering intensity and honeybee activity in the presence of competing bloom.

High correlation found between honeybee activity and fruit set.

Avocado pollen is not organized well into the honeybee's pollen-load

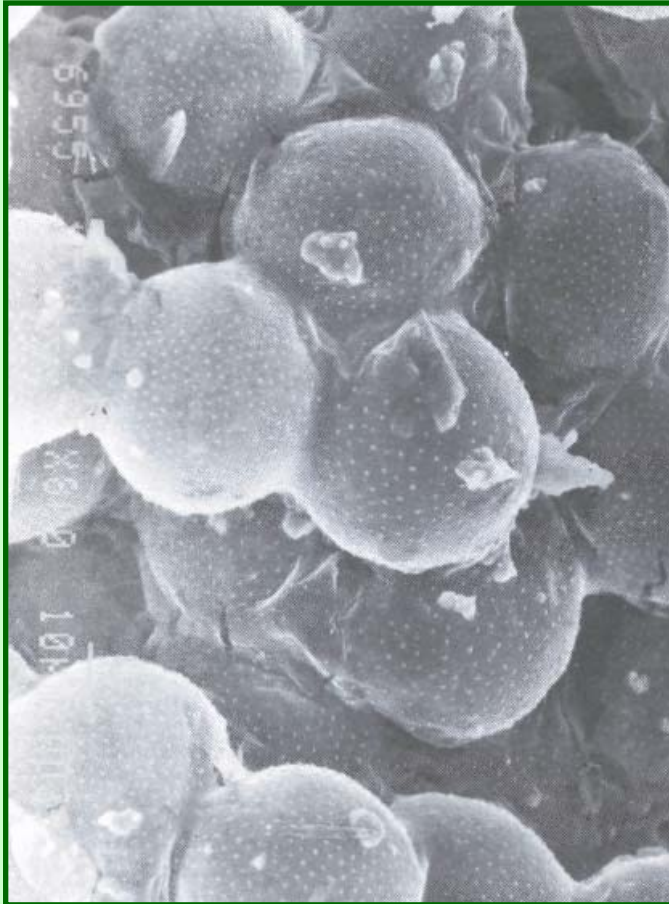


Pollen load of a honeybee containing 'Ettinger' pollen.

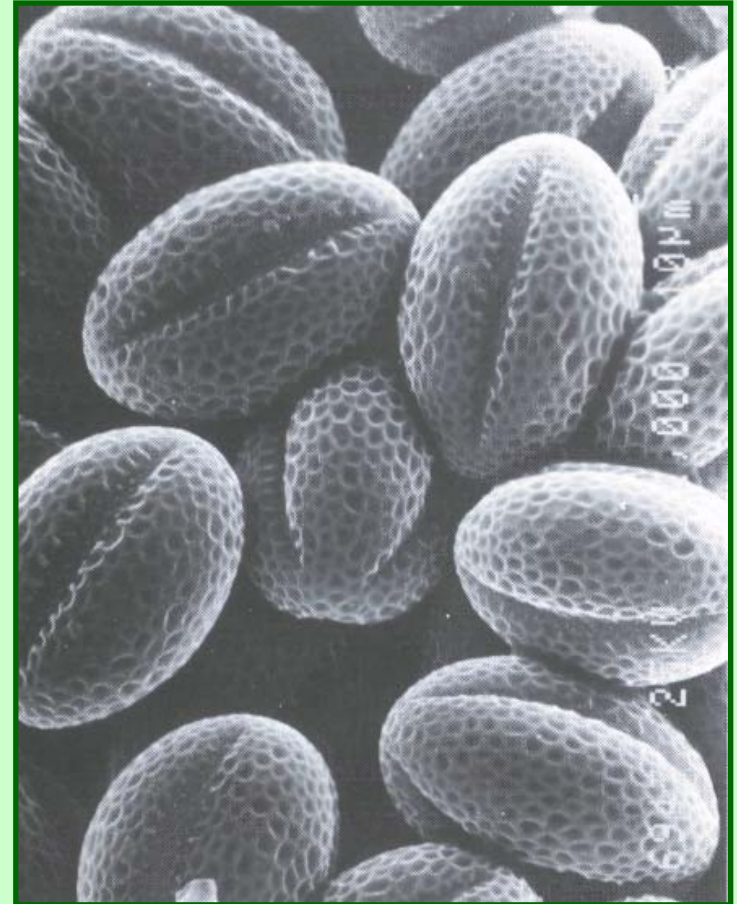


Pollen load of a honeybee containing White Mustard pollen.

Close-up of pollen in the honeybee's pollen load



Close-up of honeybee pollen load containing 'Ettinger' pollen.



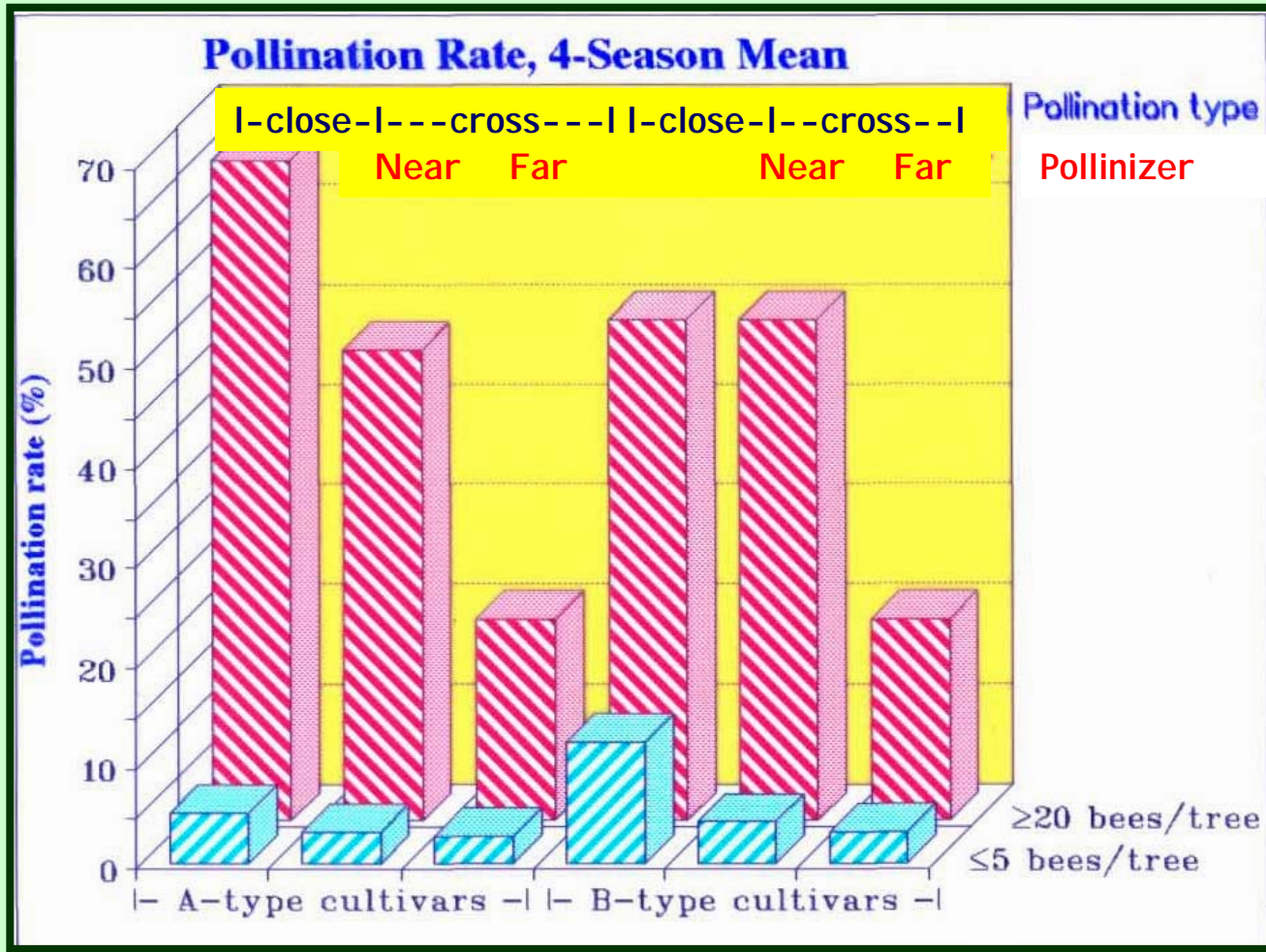
Close-up of honeybee pollen load containing White Mustard pollen.

How many
honeybees per tree
are necessary?



How many honeybee
hives per hectare
are needed?

The need for many honeybees: pollination rate



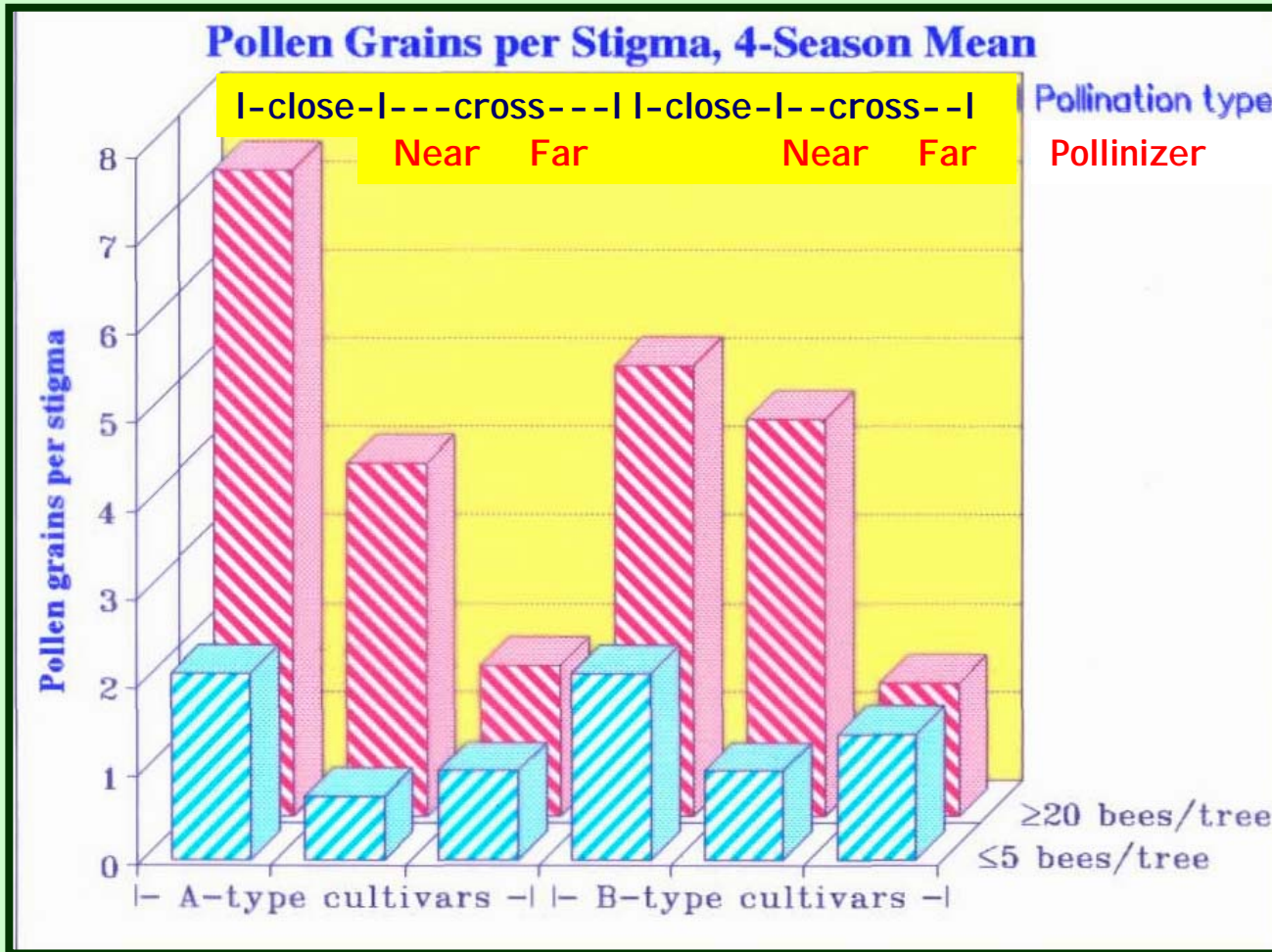
Conclusions:

- Number of bees per tree: five are not enough. Twenty may be sufficient.
- Pollinizer distance: near pollinizer induces higher cross-pollination rate.
- Pollination type: close-pollination rate is mostly higher than cross-pollination.
- Flowering type: "A" type cultivars get higher close-pollination rate.

Source: Ish-Am, 1994. PhD Thesis

The need for many honeybees: number of pollen grains per stigma

Conclusions:



- Number of bees per tree: five are not enough. Twenty may be sufficient.
- Pollinizer distance: near pollinizer donates more cross-pollen grains.
- Pollination type: close-pollination develops more pollen grains.
- Flowering type: "A" type cultivars get more close-pollen grains.

Source: Ish-Am, 1994. PhD Thesis

Monitoring honeybee activity and honeybee hive density

Bees per tree	Self-fruit set	Cross-fruit set	Adding hives
0	none	none	necessary
1-4	none	none	necessary
5-9	few	none	necessary
10-25	many	few on the 1 st row	recommended
26-55	many	on 1 st and 2 nd row	may be helpful
More than 55	many	up to the 4 th row	not needed

Source: Ish-Am, 1994. PhD Thesis

To maximize avocado yield one needs:

A. Effective pollination



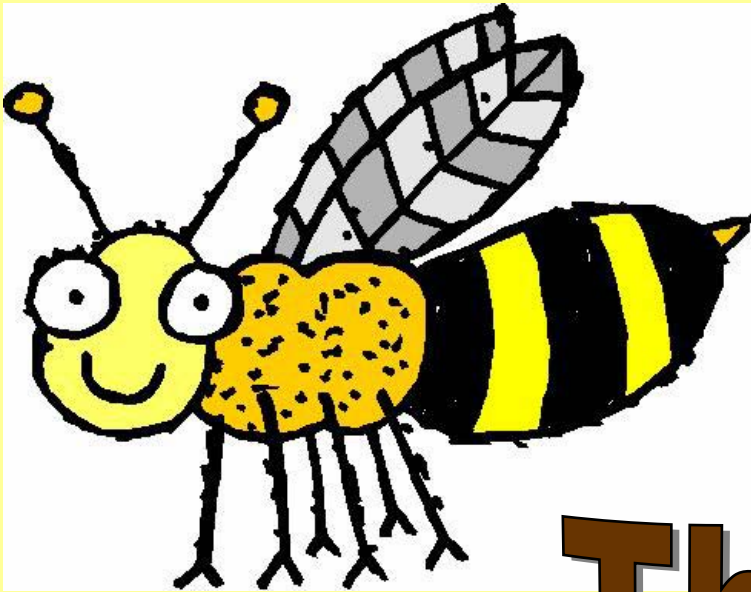
Efficient pollinator
(many honey bees)

B. Sufficient cross-pollination



Potent pollinizers
in close proximity





Thank you!!!

For more information visit
www.avocadosource.com

