Avocado Pollination – by Honeybees or by Wind?

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A major question remains re avocado pollination:

What is the relative contribution of wind vs. honeybees (and other insects)?
Or: is it necessary to introduce honeybee hives into avocado orchards to ensure pollination?

Davenport (2003 and more): Wind is the major avocado pollination agent in Florida.

Ying, Davenport *et al.* (2009): Wind, and not honeybees, is the main avocado pollinator also in California.
The purpose of this study was:

to determine the relative importance of honeybee activity and wind in the pollination of avocado trees under a Mediterranean climate.
**Methods (1)**

**Location**
Avocado orchard, Western Galilee, Israel

**Cultivars and trees**
Five cultivars: Hass, Reed (flower group A)
Ettinger, Fuerte, Nabal (flower group B)
Five trees in full bloom (next to a pollenizer tree) for each cultivar, per season.

**Observation seasons and days**
Seven seasons: 1982 - 1984, 1989 - 1992,
Nine days per season.

**Meteorology data**
Two stations: inside the orchard, and in an open field next to the orchard.
Methods (2)

**Temperatures**
Daily max, min and average.

**Wind velocity**
Measuring every 30 min, from 08:00 to 18:00. Recording daily max and average.

**Honeybee density**
Number of bees per tree, counts every 30 min during the day, for each tree. Recording daily “Max bee density” for each cv.

**Flower stages**
Recording open flower stages every 30 min for each tree.

**Rates of pollination**
Sampling 50 styles per cultivar every 60 min. Checking “Percent pollination” under a light microscope. Recording daily “max percent pollination” per cv.
Methods (3)

**Simulation of wind effect**

‘Hass’ & ‘Fuerte’ male flowers were subjected to changing wind velocities under lab condition. Pollen drift was recorded using a stereoscope.

**Statistical analysis**

1. Data from the 7 years were pooled.
2. Daily “Max percent pollination” of the 5 cultivars was pooled and analyzed vs:
   - Daily “max bee density”
   - Wind velocity (daily max or average)
   - Temperature (daily max or average)
   - Cultivar
3. “Max percent pollination” of each cultivar was also analyzed against “Max bee density” and wind velocity.
Wind velocity in the field
Maximum wind velocity (61 observation days):
Open field - 9.7 m/sec; Inside the orchard - 4.5 m/sec.

Simulation of wind effect
Wind velocity of up to 10 m/sec
No pollen dispersal from the male flowers.

Wind velocity of 10 to 14 m/sec
Few pollen dispersed from the male flowers.

Wind velocity of 14 to 16 m/sec
Pollen dispersal from all male flowers.

High wind velocities caused pollen dispersal mainly in clusters.

Anther of ‘Hass’ male flower
Results (2)

Effects on “Percent pollination” of the 5 cultivars
“Honeybee density” – high significant positive effect ($P < 0.0001$).
“Wind velocity” – no effect, neither of max, nor of average velocity.
“Average daily temperature” – positive effect ($P = 0.020$).
“Cultivar” – significant effect ($P = 0.012$).

Effects on “Percent pollination” of each cultivar

Honeybee density: significant positive effects.

Wind velocity: neither daily max, nor average wind velocities had any effect.

‘Hass’ female flower pollinated stigma
Results (3)

“Percent pollination” of ‘Hass’ is affected by:

“Honeybee density” – a high significant positive effect ($P < 0.0001$).
“Wind velocity” – no effect ($P = 0.10$).

‘Hass’ percent pollination vs. honeybee density and wind velocity
Discussion

the avocado flower - a typical insect pollinated flower
- Nectar secretion by both gender flowers.
- Small stigma and small amount of pollen.
- Flowers are colorful and have scent.
- Large, sticky pollen grains.
The avocado pollen grains are large and sticky.
Experiments of pollination under net

**Flowering tree under net, with no bees:** no fruits, or very few fruits (1-3% of un-caged trees).

**Flowering tree + pollenizer tree under net, with no bees:** few additional fruits (4-6% of un-caged trees).

**Flowering tree under net, with bees:** numerous fruits.

**Sources:** numerous works from California, Israel, South Africa, and Yucatán.

**Flowering tree under net, with bees + pollenizer next to net:** numerous fruits, of which only 7% (3-14%) are cross.

**Source:** Degani et al., 2003
Measurements of avocado air-borne pollen

Very low quantities, mostly as clusters. 'Ettinger' pollen floats up to 25 m.

Source: Katz, 1995

No correlation between wind velocity and air-borne avocado pollen amounts.

Air-borne pollination rates in caged trees:
- 2.5%-4.7% in trees next to a pollenizer tree.
- 0.6% pollination in a secluded 'Ettinger' tree.
‘Hass’ flowering, honeybee activity and fruit set – Israel, spring 1992

No fruit-set during ‘Hass’ peak bloom, while honeybee activity was very low.

High fruit-set began when the bees visited the trees, at the end of bloom.

Source: Ish-Am and Eisikowitch, 1998
Honeybees transfer the pollen

Avocado pollen carried on a honeybee’s body

Head of a honeybee

Avocado pollen

Brassicaceae pollen

Source: Ish-Am and Eisikowitch, 1993
Pollen and stigma touch same locations

Male flower

Forehead transfer

Female flower

Ventral-thorax transfer
Honeybees are efficient pollinators, but...

Vithanage (South-West Australia, 1990):
Honeybees are the most available efficient avocado pollinator. Two beehives/hectare increased yield (3.5-fold), comparing to no hives. Three beehives/hectare further increased productivity by 20% to 38%.

Ish Am et al. (Israel, 2000):
Adding bumblebee hives increased yield, and mainly increased cross-yield in trees that are distant from pollenizer.

Ish Am & Gazit (Mexico, 2002):
Eight local Meliponinae species are more efficient pollinators than honeybees.
**Conclusion:** the need for numerous honeybees. Average pollination rates are affected by:

- **Number of bees per tree:** Twenty may be sufficient.
- **Pollenizer distance:** Near pollenizer induces better cross-pollination.
- **Pollination type:** Close-pollination rate is mostly higher than cross-pollination.
- **Flowering group:** "Group A" cultivars get higher close-pollination rate.

**Source:** Ish-Am and Eisikowitch, 1998
Conclusion: our work, plus other works, invalidate the claims of Davenport and his colleagues.

Recommendation: monitoring honeybee activity, and adjusting honeybee-hive density accordingly:

<table>
<thead>
<tr>
<th>Bees per tree</th>
<th>Close-fruit set</th>
<th>Cross-fruit set</th>
<th>Adding hives</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>none</td>
<td>none</td>
<td>necessary</td>
</tr>
<tr>
<td>1-4</td>
<td>Very few</td>
<td>none</td>
<td>necessary</td>
</tr>
<tr>
<td>5-9</td>
<td>few</td>
<td>none</td>
<td>necessary</td>
</tr>
<tr>
<td>10-25</td>
<td>many</td>
<td>few on the 1st row</td>
<td>recommended</td>
</tr>
<tr>
<td>26-55</td>
<td>many</td>
<td>on 1st and 2nd rows</td>
<td>may be helpful</td>
</tr>
<tr>
<td>More than 55</td>
<td>many</td>
<td>up to the 4th row</td>
<td>not needed</td>
</tr>
</tbody>
</table>

Source: Ish-Am, 2005
Thank you...