The Road to Productivity

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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
This presentation will focus on one small aspect of productivity - Pollination
Terminology
The avocado flower

- **Stigma**
- **Ovule - Seed**
- **Ovary - Fruit**
- **Flesh and Peel**
- **Style**
- **Anther/Filament - Source of Pollen**
- **Sepal**
- **Petal**
- **Nectary**
- **Staminode**
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.
Avocado Flower Behavior
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.
There are 2 phases to avocado flowering

This is called *Synchronous Dichogamy*

Source: I. Hormaza
The avocado flower

Female Phase

Male Phase
Fig. 1 - Morphological stages of the flower

Ish Am, PhD. Thesis
Timing of flowering for “A” and “B” flower types.

<table>
<thead>
<tr>
<th>Flower-type cultivar</th>
<th>DAY 1</th>
<th>DAY 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MORNING</td>
<td>AFTERNOON</td>
</tr>
<tr>
<td>“A”</td>
<td>♂️♀️♀️♀️</td>
<td></td>
</tr>
<tr>
<td>“B”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The sequence of timing for “A” and “B” flower types under field conditions.

**Flower-type cultivar**

<table>
<thead>
<tr>
<th></th>
<th>Morning</th>
<th>Afternoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>“A”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“B”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Avocado Flowering Sequence

**Type A**
- Female flowers
- Male flowers before dehiscence
- Male dehiscing flowers

**Type B**
Overlap within the tree occurs

Source: I. Hormaza
Fruit Set
• Millions of flowers during bloom
• Long flower duration
Are all flowers created equal?
- NO EXTERNAL DIFFERENCES AMONG FLOWERS
- GREAT DIFFERENCES IN STARCH CONTENT

Source: I. Hormaza
Caídas Cuajadas

Optical density x10^4

Dropped

Retained

Source: I. Hormaza
The avocado pollen grain

'Fuerte' pollen on anther flap

'Hass' pollen grain (SEM x2000)

From: G. Ish Am
Hand pollinated 'Hass' stigmas by 'Ettinger' pollen. Four hrs of germination.

Shoval, 1987

Effect of competition between and cooperation among the pollen grains.
Hass Flowers/Fuerte Pollen germination does not appear to be limiting.
NUMBER OF POLLEN GRAINS ON STIGMA AND FLOWER FATE

Early drop

Initial retention

Final fruit set
Temperature and Humidity
Temperature and Relative Humidity Impacts Pollen Germination

Source: I. Hormaza
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
Temperature fluctuations during flowering
Irvine, CA

TEMP

RH
Temperature influences the timing of the female and male stages.
Do You Need Pollinizers?
Survival of cross vs. self progenies

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

Via www.avocadosource.com
### MATERIALES Y MÉTODOS

<table>
<thead>
<tr>
<th>TMTO</th>
<th>Descripción</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Control, No Net House, 5,5% Edranol</td>
</tr>
<tr>
<td>1</td>
<td>Net House, 12 Hass + 0 Edranol</td>
</tr>
<tr>
<td>2</td>
<td>Net House, 11 Hass + 1 Edranol</td>
</tr>
<tr>
<td>3</td>
<td>Net House, 10 Hass + 2 Edranol</td>
</tr>
</tbody>
</table>

5 Replicated Blocks  
Each Net House had Honey Bees

<table>
<thead>
<tr>
<th>TMTO</th>
<th>Frutos 2012</th>
<th>Frutos 2013</th>
<th>Frutos 2014</th>
<th>∑ 2012-2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50,51 ± 57,88 a</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1</td>
<td>19,30 ± 43,97 c</td>
<td>138,90 ± 67,62 ab</td>
<td>49,25 ± 59,70 b</td>
<td>207,45 ± 85,58 b</td>
</tr>
<tr>
<td>2</td>
<td>22,89 ± 42,21 bc</td>
<td>151,98 ± 70,06 a</td>
<td>79,25 ± 62,82 a</td>
<td>254,13 ± 89,35 a</td>
</tr>
<tr>
<td>3</td>
<td>41,48 ± 50,30 ab</td>
<td>121,52 ± 67,28 b</td>
<td>74,70 ± 77,96 ab</td>
<td>237,70 ± 106,05 ab</td>
</tr>
</tbody>
</table>

Letras distintas indican que existen diferencias significativas. (Test de Tukey, P ≤ 0,10).
Hass yields decrease significantly with increasing distance from 'Ettinger'.

Source: Guil et al. 1986. Alon Hanotea 40:443-455
Does distance play a role?

| Pollinizer Varieties: 8 |
| Field trial replicates: 6 |
| Pollinizers interset with Hass |
Debusschere Pollination Project – 2001 – 2008
Cumulative fruit count as a function of distance from pollinizer

![Cumulative count graph]

- Within Row: 1100
- 27 ft: 900
- 54 ft: 800

Distance from Pollinizer

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

Bacon + Ettinger + Zutano
Flowering periods – Oxnard, 2002

- Zutano
- Ettinger
- Marvel
- Bacon
- Hass
- Fuerte
- Harvest
- Nobel
- SirPrize

February | March | April | May | June | July
Duration of bloom over 4 years

Irvine, CA
How do you get the pollen to the flower?
4 Treatments:
1) Outside control
2) Net House with Bees
3) Net House Small insects
4) Net House where all trees sprayed to eliminate insects
Encon Trial – 2011

R. Hofshi, J. Schmidt, F. Mena, F. Gardiazabal, M. L. Arpaia

4 Treatments:
1) Outside control
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3) Net House Small insects
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5 Field Replications
14 trees per net house
To maximize yield one needs:

- **Effective pollination**
- **Efficient pollinator**
  - (many honey bees)
- **Sufficient cross pollination**
- **Pollinizers in close proximity**