Effects of orchard design and pollenizer density on apple pollination services

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Animal pollination dependent crops (91 of 107 leading crops)  
= 85% global crops

Klein et al., 2007 In: IPBES, 2016.

Production volume
60% of production comes from non-dependent crops
35% animal pollination dependent crops
5% not been evaluated (established)

Bees: predominant group of pollinators
70% of world crops
Self – Incompatibility:
apple needs cross-pollination between different varieties to sired seeds and set fruits

Seed number → fruit size and weight

POLLINIZER = Pollinator plant that provides compatible pollen
CROSS POLLINATION

IS THERE PERFECTION IN APPLES?
5 carpels, 10 seeds

Seed number → fruit size and weight
Pollination process: apple intensive crop

**Introduction**

**Aims**
1. Pollination limitation
2. Orchard design
3. Pollenizer density

**Conclusions**

- **Phytosanitary and Thinning products**
- **Blooming**
  - Orchard design
  - Pollenizer density
- **Pollination**
  - Diversity and abundance of pollinators
  - Foraging behavior
  - Pollination deficit
- **Fruit Set**
  - Number of fruitlets
- **Seed Set**
  - Number of seeds
  - Distribution of seeds
- **Final fruits**
  - Number, Size, Shape, Weight
- **Work in progress**
  - Hand Thinning
  - Lopsided apple
To assess the effects of two intensive agricultural conditions such as orchard design and pollenizer density on apple pollination service in three intensive apple orchards: cv. Gala (main producing) and cv. Granny Smith (pollenizer)
1. Is there optimal pollination in intensive apple orchards?
Pollination deficit

Introduction  Aims  1. Pollination limitation  2. Orchard design  3. Pollenizer density  Conclusions

Deficit di impollinazione

Hand Supplemented Pollination  Natural - Open Pollination

- Fruit Set  - Seed Set
1. Pollination limitation experiment

Hypothesis:

Intensive managed agricultural area = negative impacts on wild pollinators and insufficient honey bee contribution

== Limited pollination levels present

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Pollination limitation results

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Pollination limitation results

Although the visible differences, Fruit set was not affected by there was no effect.

Seed set is strongly dependent on cross pollination, the deficit is small (1.2 seed/apple)

Lopsided apple is affected by pollination.
11% more of lopsided apples are produced on current conditions compared with hand supplemented.

n.s.: not significant
**: p<0.01
***: p<0.001

Work in progress:

• Analyse If there are any effects on apple size and weight
2. Does tree position inside orchard affect pollination service?
2. Orchard design effects

3 Possibilities:
- Bees move sequentially from Granny to the next Gala tree on the same row:
  \[ A>M>I \]
- Bees move from Granny to the closest Gala tree on the same row or/and to the Gala in the row in front of:
  \[ A=I>M \]
- Bees move from Granny tree to another tree following a random pattern:
  \[ A=I=M \]

**Hypothesis:** shorter distance from pollenizer is translated in higher seed numbers and lesser lopsided apple.

\[ A>M>I \]
Orchard design results

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Work in progress:

• Analyse if there are any effects on apple size and weight

No differences

Position from pollenizer influence pollination efficiency. A position is more effectively pollinated

Lopsided apple is affected by position. 9% less asymmetric apples on A position

n.s : not significant
** : \( p<0.01 \)
*** : \( p<0.001 \)
3. Does pollinizer density have any influence on pollination service?
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Pollenizer density

Distance is not suitable

Density ranges

<table>
<thead>
<tr>
<th>Density</th>
<th>min</th>
<th>max</th>
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</thead>
<tbody>
<tr>
<td>low</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>medium</td>
<td>95</td>
<td>125</td>
</tr>
<tr>
<td>high</td>
<td>170</td>
<td>200</td>
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</tbody>
</table>
Pollenizer density

**Introduction**
- Aims
  - 1. Pollination limitation
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**Conclusions**
- At high density correspond with greater amount of seeds.
- Lopsided apple has lower frequency at higher density.

**Work in progress:**
- Analyse if there are any effects on apple size and weight.

**Graphs:**
- **Fruit set**:
  - high: 15%
  - medium: 13%
  - low: 12%
  - No differences

- **Seed set**:
  - high: 7
  - medium: 6
  - low: 5
  - At high density correspond with greater amount of seeds

- **Lopsided apple**:
  - high: 0%
  - medium: 2%
  - low: 4%
  - n.s: not significant

- **Significance levels**:
  - ***: p<0.001
  - **: p<0.01
  - n.s: not significant
Conclusions

• Pollination deficit present but small.
• Careful! 11% of lopsided apples are produced in the current conditions. Assessment of implications on economic level is needed.
• Intermixed design is determinant to give a uniform pollination level (maximum difference lopsided apples rate = 9 %). Pollenizer trees are fundamental, they should not be reduced.
• Low levels of Pollenizer density produce 8% di lopsided apples. To consider higher scales and surrounding orchard is important to prevent higher proportions of lopsided apples.
Thanks for your attention