Honey Bee Pollination Affects Onion Seed Set in California’s Central Valley

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Collaborators:
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• Pollinators provide ecosystem services in both natural and agro-ecosystems

• Yields of 1/3 of world’s crops increased by pollination

• Essential for production of hybrid seed – a high value agricultural product

http://www.tc.umn.edu/~reute001/
• Considerable effort directed towards maintaining pollinator populations
  - Native pollinator conservation
  - Honeybee health

• But, healthy pollinator populations will do little for agriculture if management regimes reduce visitation to crops
• Hybrid onion seed is an important specialty, small acreage crop of California

• Pollinators move pollen between male fertile “male” pollen donors and male sterile “female” pollen recipients

• Primary pollinator is the honeybee
• Hybrid onion seed yields have drastically declined since 2003

• Yield declines coincided with increase in insecticide use to control onion thrips

• Onion thrips vector Iris Yellow Spot Virus (IYSV) – emergent disease

• Could efforts to control this pest be reducing honeybee pollination of onion?
In order for pollination to be successful, pollen must germinate and grow through the flower’s stigma.

Physiological characteristics of the stigma can help or hinder this process.

Could pesticides have a negative impact on this process in onion?
• Our project examines how insecticide use can reduce seed yields in hybrid onion via indirect effects on pollination

1. Field surveys of insecticide use and pollination service

2. Replicated experiment testing role of specific insecticides in changing pollination service
Field Surveys:

- In 2010 we surveyed pollinator visitation at 13 commercial fields in Yolo and Colusa counties throughout peak bloom.

- We also quantified seed set at the umbel level.

- Insecticide use per field taken from state records.
• Low honey bee visitation was correlated with low seed set

![Graph showing the correlation between mean number of honey bee visits and mean seeds/umbel](https://example.com/graph.png)

Long and Morandin, Cal Ag, 2010
• High numbers of insecticide applications correlated with reduced honeybee visitation.

Long and Morandin, Cal Ag, 2010
Summary: Field Surveys:

- Yields increased with increasing honey bee visitation
  - pollination could be limiting factor

- High insecticide use lead to reduced visitation

- Lack of pollen transfer due to insecticide use may be the cause of poor seed set
Our project examines how insecticide use can reduce seed yields in hybrid onion via indirect effects on pollination.

1. Field surveys of insecticide use and pollination service

2. Replicated experiment testing role of specific insecticides in changing pollination service
   - Pollinator visitation
   - Pollen viability
   - Seed set
### Treatments: 8 different insecticide products

<table>
<thead>
<tr>
<th>Product name</th>
<th>Active ingredient</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>None</td>
<td>n/a</td>
</tr>
<tr>
<td>Bioforge</td>
<td>Plant growth regulator</td>
<td>n/a</td>
</tr>
<tr>
<td>Pest Out</td>
<td>Essential Oils</td>
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</tr>
<tr>
<td>Lannate</td>
<td>methomyl</td>
<td>translaminar movement</td>
</tr>
<tr>
<td>Radiant</td>
<td>Spinetoram</td>
<td>local systemic, translaminar</td>
</tr>
<tr>
<td>Assail</td>
<td>Acetamiprid</td>
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</tr>
<tr>
<td>Warrior</td>
<td>Lambda-Cyhalothrin</td>
<td>Primarily contact insecticide</td>
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Applied 2-3 times pre-bloom according to label instructions
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| Warrior      | Lambda-Cyhalothrin                     | Primarily contact insecticide        | **3x, 4x, 6x**
In each replicate plot, we measured:

• **Pollinator activity**
  
  – Counted visitors to males and females in 1.5 x 1 m quadrat for 5 minute periods throughout bloom
In each replicate plot, we measured:

• **Pollen tube growth**
  - Mediated by females – impacts on stigmatic surface
  - Mediated by males – impacts on pollen

• 5 crosses per sex per plot = 25 stigmas per treatment
Analysis:

• Pollinator visitation
  - Honeybee or total visitors/observation analyzed with negative binomial models
  - Visitation = Number flowers + Date + time of day + block + treatments

• Pollen tubes
  - Zero inflated negative binomial models
  - Germination/base tubes = Treatment
Main treatments did not reduce pollinator visitation
Warrior reduced visitation when applied 6x
Field surveys showed negative effect of spray on visitation in 2009
However, in 2010, when growers sprayed less, this relationship disappeared.
Insecticides reduced pollen germination on treated stigmas
• Insecticide use, even pre-bloom appears to reduce pollen germination success

• This effect is mediated by impacts on the stigma, not the pollen

• Chemicals with significant impacts:
  - All have some kind of translaminar movement or systemic activity
  - May penetrate tissue of developing flowers
• Few studies have examined pesticide impacts on stigmatic surface

• Yi et al (2003): certain fungicides applied to stigmas reduce pollen tube growth in apple, but not almond

• Chemical impacts on pollen tubes may vary between products and plant species

• This effect of pesticides merits further investigation
Summary

- Reductions in honeybee visitation at highest spray intensity, matching field data
  - spray rates above 4 may reduce honeybee visitation

- Insecticides also have potential to change plant physiology, reducing pollen tube growth and ovule fertilization
Implications

• Results highlight the importance of considering the indirect effects of pesticides on the pollination process.

• Careful timing of spray application may minimize impacts on pollinator health, over-use may still lead to yield reductions

• In hybrid onion, moderation in insecticide use is advised
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Seed companies: Sakata Seeds, Nunhems Inc, Seminis
Questions?