Bumble bee colony decline in greenhouses with supplementary lighting

T. Blacquière  tjeerd.blacquiere@wur.nl
B. Cornelissen & J. Donders
Applied Plant Research, Bee Unit
Supplementary light and pollinators

- introduction
  - pollinators and crops
  - lighting
- Changes as consequence of lighting
- Bee problems
  - literature
  - field experiences
- Solutions
Pollinators in greenhouses

- Honey bees
- Bumble bees
Which pollinators for which crops

- **Tomato** (bumblebees)
- **Sweet & spicy peppers** (honeybees, bumblebees)
- Aubergine (egg plant) (honeybees, bumblebees)
- Courgette/zucchini (honeybees)
- Melon (honeybees)
- **Strawberry** (honeybees, bumblebees)
- Cymbidium (honeybees)
- Seed production (various pollinators)
- Raspberry (honeybees)
- Blackberry (honeybees)
- Cherry (bumblebees, honeybees)
Tomato cultivation + lighting

- **Normal cultivation:**
  - flowering February-October
  - bumblebees pollinate
  - colonies four through six weeks active

- **Lighted cultivation:**
  - flowering year round
  - bumblebees pollinate
  - colonies last shorter
  - more colonies needed

- **Problems with lighting:**
  - shorter life time colonies
  - reduced radius of action
  - if introduced during dark weather: very fast decline of colonies

- **Possible causes:**
  - light spectrum
  - photoperiod
  - many light sources
  - indirect effects
Supplemental light and pollinators

- **Light for plant growth**
  - Source of energy: photosynthesis; temperature
    - Wavelength ~400-700 nm; 800-3500 nm
  - Provides information: direction, colour, day length, intensity
    - Wavelength ~300-800 nm
    - UB-blue photoreceptor: (280-) 300-450 nm
    - Phytochrome (red and far-red): 660 nm and 730 nm

- **Light for bees**
  - Source of energy: temperature
    - Wavelength ~ 800-3500 nm
  - Provides information: direction, colour, day/night, top/down, orientation, balance
    - 5 eyes; rhodopsins, 280-600 nm
Changes as a consequence of supplemental light

Direct changes
- Light intensity
- Light colour:
  - Much orange/red
  - No blue, UV
- Perception of day length
  - plants: Red/far-red
  - fungi: blue, UV
  - bees: UV
- Direction of the light
- From 1 → 3000 ‘suns’
- Sunlight is continuous, discharge lamps ‘flash’ with frequency 50 Hz, 150 Hz or 120,000 (modern high frequency installations)
- Bee eyes can observe flashing < 300 Hz (humans perceive 50 Hz already as continuous light)
Bee senses: seeing

- Two types of eyes:
  - Composed eye (2):
    - To see, recognize the environment, flowers and polarization of light
  - Ocelli (3):
    - For perception of day/night, top/down, horizon
Bee senses: vision

- Human perception of colours (top graph)
  - Three ranges of pigments
    - violet/blue
    - green
    - Yellow/red
  - Overlap of ranges

- Bee perception of colours (bottom graph)
  - Three pigments
    - ultraviolet
    - blue/green
    - yellow

- Both have relative colour discrimination
Bee senses: vision

- Recognition of flowers
  - Peaks in susceptibility
  - Steep slopes in flower reflectance spectra
  - UV patterns
Bees see no red, humans see no ultra-violet: Both see ‘black’
Research questions to address:

- when and why do colonies decline?
- how fast decline?
- do all ages disappear?
  - learning
  - circadian rhythms
- orientation problems?
  - starvation, lack of fuel (nectar)
Experiment set up

- **Experiment 1**
  - tomato
    - only pollen
  - sweet bell pepper
    - pollen and nectar
  - lighted greenhouse
  - Jan 24 - Feb 20, 2006
  - Age cohorts marked:
    - wk 1 - wk 4
  - Colony code
    - colony 1 - 10

- **Experiment 2**
  - tomato and sweet pepper
  - lighted and unlighted greenhouses
  - Feb 22 - Mar 20, 2006
  - Age cohorts marked:
    - wk 6 & wk 8
  - Colony code
    - colony 1 - 20
Observations

- **Flight activity**
  - Result: too low to do observations

- **Recovery of lost workers**
  - Result:
  - tomato, Jan 30:
    - missing: 325, recovered: 10
  - pepper, Jan 30:
    - missing: 225, recovered: 18
    - most recovered close to main path (= close to nests)

- **Age cohorts:**
Fate of the ages, exp. 1

- **Sweet pepper**
  - lighted

---

**Graph Details:**
- **Y-axis:** unmarked, drifters, wk 4, wk 3, wk 2, wk 1
- **X-axis:** 24-Jan, 30-Jan, 06-Feb, 13-Feb, 20-Feb

---

**Legend:**
- Red: unmarked
- Purple: drifters
- Light blue: wk 4
- Beige: wk 3
- Maroon: wk 2
- Light purple: wk 1
Fate of the ages, exp. 1

Tomato
- lighted
Fate of the ages, exp. 2: tomato

tomato + lighting

<table>
<thead>
<tr>
<th>Date</th>
<th>Drifters</th>
<th>Unmarked</th>
<th>wk 6</th>
<th>wk 7+8</th>
</tr>
</thead>
<tbody>
<tr>
<td>22-Feb-06</td>
<td>41</td>
<td>42.4</td>
<td>14</td>
<td>6.6</td>
</tr>
<tr>
<td>24-Feb-06</td>
<td>43.4</td>
<td>15</td>
<td>14</td>
<td>5.6</td>
</tr>
<tr>
<td>28-Feb-06</td>
<td>48.4</td>
<td>14</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>6-Mar-06</td>
<td>47.6</td>
<td>34</td>
<td>0.8</td>
<td>1.8</td>
</tr>
<tr>
<td>13-Mar-06</td>
<td>0.8</td>
<td>30</td>
<td>0</td>
<td>0.8</td>
</tr>
<tr>
<td>20-Mar-06</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Drifters</th>
<th>Unmarked</th>
<th>wk 6</th>
<th>wk 7+8</th>
</tr>
</thead>
<tbody>
<tr>
<td>22-Feb-06</td>
<td>41</td>
<td>42.4</td>
<td>14</td>
<td>6.6</td>
</tr>
<tr>
<td>24-Feb-06</td>
<td>43.4</td>
<td>15</td>
<td>14</td>
<td>5.6</td>
</tr>
<tr>
<td>28-Feb-06</td>
<td>48.4</td>
<td>14</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>6-Mar-06</td>
<td>47.6</td>
<td>34</td>
<td>0.8</td>
<td>1.8</td>
</tr>
<tr>
<td>13-Mar-06</td>
<td>0.8</td>
<td>30</td>
<td>0</td>
<td>0.8</td>
</tr>
<tr>
<td>20-Mar-06</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0.8</td>
</tr>
</tbody>
</table>
Fate of the ages, exp. 2: sweet pepper

**sweet pepper + lighting**

- 22-feb-06: 33
- 24-feb-06: 54.6
- 28-feb-06: 60.6
- 6-mrt-06: 72
- 13-mrt-06: 71.6
- 20-mrt-06: 79.8

**sweet pepper - lighting**

- 22-feb-06: 36.6
- 24-feb-06: 10.6
- 28-feb-06: 6.8
- 6-mrt-06: 4.4
- 13-mrt-06: 106.6
- 20-mrt-06: 140.6

Categories:
- drifters
- unmarked
- wk 7+8
- wk 6
Conclusions

- colonies decline very fast
  - upon introduction
  - pepper and tomato
  - lighted & unlighted
  - youngest cohort slower loss

- newly hatched workers:
  - better survival (?)
  - tomato worse than pepper
  - lighted worse than unlighted

- growth colonies
  - in greenhouses impaired
  - field: 70 → 500 in few wks
Thanks for your attention!

Thanks to Syngenta Bioline Bees, Koppert BV, Biobest BV, Hortilux \ Schréder BV, Philips Nederland for support, and Vereijken tomato growers and Van der Boomen Sweet Pepper Growers for permission to study in their facilities.

© Wageningen UR