Apple Insect Targets & IPM Practices

Arthropod Pest Development
Developmental Rates & Thresholds
Degree Day Calculation
Monitoring
Methods of Measuring and Predicting Arthropod Pest Development

Apple Insect Targets & IPM Practices
• Mammals are warm-blooded, develop at constant rate regardless of environmental temperature, because they can regulate their internal temperature (biochemical processes progress normally).

• Insects are poikilothermic, do not generate body heat, therefore remain at same temperature as their environment, and depend on a favorable external temperature.

• Developmental Base or Threshold: The temperature below which an insect’s biochemical reactions cannot proceed and development therefore stops.

• Charting ambient temperature makes it possible to track insect development, which is directly proportional to the amount of time accumulated above the Developmental Base. We divide this time arbitrarily into heat units or Degree Days.
• There are different ways to determine the quantity of heat units accumulated; this is equivalent to the area under a temperature-vs.-time graph on a given day.
Degree Day Calculation Methods

**Average or Max/Min Method**

- Simplest and least precise; assumes that the daily temperature graph is linear and the area beneath it is triangular:
  \[ DD = \frac{(\text{Max temp} + \text{Min temp}^*)}{2} - \text{Developmental Threshold} \]
  
  * or Developmental Threshold, whichever is higher
• More precise; assumes the daily temp cycle takes the form of a sine wave. Area beneath the curve determined by integration (calculus). This method tends to accumulate more DDs than the Max/Min Method, particularly during the early part of the season.
Most precise method; requires multiple temperature readings hourly or more frequently throughout the day, to obtain a graph that is truly representative of the field situation. Area beneath the curve again calculated using integration; data collection most efficient if handled by a computer.
Several methods attempt to correlate a pest event or activity with another event that can be measured more precisely. Events in an insect's life cycle often occur after the same number of heat units have accumulated each year, but many years' observations must be collected to measure them precisely. Degree days can be used to predict events where weather data are available.

- **Temperature** - Monitor temp and pest activity simultaneously for many years; possible to build a database of events & their corresponding DD range.
- **Phenology** - Some pest events occur at the same time as easily observed biological field events; e.g., mite hatch from tight cluster to pink bud, sawflies lay eggs from bloom to petal fall.
- **Biofix** - A distinct, easily monitored event in an insect's life history, used to fine-tune our predictions of its activity; e.g., 1st flight, 1st egg laid, 1st mine observed.

### Table 7.1.4. Degree-day accumulations (from Jan. 1) corresponding to selected fruit phenology and arthropod pest events.

<table>
<thead>
<tr>
<th>Pest/Phenology Event</th>
<th>DD Base 43°F</th>
<th>DD Base 50°F</th>
<th>Approx. Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>std dev</td>
<td>mean</td>
</tr>
<tr>
<td>STLM Traps set out</td>
<td>1-April</td>
<td></td>
<td>4-Apr</td>
</tr>
<tr>
<td>Pear psylla – egg laying</td>
<td>84</td>
<td>44</td>
<td>33</td>
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<tr>
<td>Redbanded leafroller – 1st catch</td>
<td>145</td>
<td>32</td>
<td>62</td>
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<tr>
<td>Rosy apple aphid – 1st nymphs present</td>
<td>189</td>
<td>55</td>
<td>86</td>
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<tr>
<td>STLM – 1st adult catch</td>
<td>166</td>
<td>49</td>
<td>73</td>
</tr>
<tr>
<td>STLM – 1st egg observed</td>
<td>208</td>
<td>65</td>
<td>94</td>
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<tr>
<td>Tight cluster (McIntosh)</td>
<td>232</td>
<td>26</td>
<td>108</td>
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<tr>
<td>Tamished plant bug – 1st observed</td>
<td>222</td>
<td>105</td>
<td>105</td>
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<tr>
<td>OBLR – 1st overwintered larvae observed</td>
<td>236</td>
<td>78</td>
<td>112</td>
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<tr>
<td>European red mite – egg hatch observed</td>
<td>284</td>
<td>53</td>
<td>134</td>
</tr>
<tr>
<td>STLM Egg Sample</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OFM Traps set out</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pink (McIntosh)</td>
<td>291</td>
<td>25</td>
<td>140</td>
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<tr>
<td>Oriental fruit moth – 1st adult catch</td>
<td>273</td>
<td>51</td>
<td>129</td>
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<tr>
<td>STLM – 1st flight peak</td>
<td>338</td>
<td>70</td>
<td>168</td>
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<tr>
<td>OBLR Overwintered Gen. Sample</td>
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<tr>
<td>CM Traps set out</td>
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<tr>
<td>Full bloom (McIntosh)</td>
<td>380</td>
<td>36</td>
<td>194</td>
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<tr>
<td>Lesser appleworm – 1st catch</td>
<td>420</td>
<td>144</td>
<td>217</td>
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<tr>
<td>American plum borer – 1st catch</td>
<td>457</td>
<td>64</td>
<td>240</td>
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<tr>
<td>Oriental fruit moth – 1st flight peak</td>
<td>432</td>
<td>102</td>
<td>225</td>
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<td>Codling moth – 1st adult catch</td>
<td>481</td>
<td>85</td>
<td>254</td>
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<tr>
<td>San Jose scale – 1st adult catch</td>
<td>526</td>
<td>88</td>
<td>279</td>
</tr>
</tbody>
</table>
Use of Monitoring Techniques for Pest Management in Orchards
Monitoring Process

Physical Evidence
- Egg mass, pupal case, excrement

Plant/Fruit Damage
- Oviposition punctures, feeding damage, entrance holes, webbing

Traps
- Detection (presence)
- Establishment of biofix (e.g., 1st sustained flight)
- Determination of pest population level
- Chart developmental progress (e.g., peak flight)

Threshold Prediction
- Developmental model (start/end of egg laying; progression of hatch; development of specific stages)
- Estimation of timing (number of days until desired stage reached)
Types of Monitoring Traps

**Pheromone Traps**

- Wing
- Tent
- Delta
Types of Monitoring Traps

Visual Attractant Traps

Yellow/White Panels

Sphere

Combination ("Ladd")
Types of Monitoring Traps

Odor Attractant Traps
- plant volatiles
- food extracts (bait)

Physical Traps
- sticky tape
Components of an Integrated Crop and Pest Management System

Monitoring (Scouting) • Detecting, identifying, and determining level of pest populations on a timely basis

Forecasting • Use of weather data and crop phenological stage to predict when specific pest events will occur

Thresholds • To determine when pest populations have reached a level that could cause economic damage

Management Tactics • Cultural, biological, physical, as well as chemical control, when needed

Recordkeeping • Annual records of pest occurrence are valuable tools for avoiding pests in future
NEWA Apple Insect Models Website

- Developed to improve delivery of combined information resources to aid growers in timing and selection of pest control methods (including “reduced-risk” products).

- Crop and pest developmental stages are calculated from Degree Day accumulations at NYS IPM and National Weather Service stations throughout the state.
  - Apple maggot
  - Codling moth
  - Obliquebanded leafroller
  - Oriental fruit moth
  - Plum curculio
  - Spotted tentiform leafminer
  - San Jose scale

- DD models (supported by historical records) are used to estimate:
  - Tree Phenological Stage
  - Pest Developmental Stage
  - Pest Status (activity)
  - Pest Management Info

- When pesticide sprays are needed, a link is provided to NYS DEC label database.
Plum curculio
Pest stage
Pest status
Pest management
Pesticide information
Plum Curculio Management Assumptions

- Commercial apple orchards in NY do not harbor indigenous infestations of PC adults.
- Adults overwinter in ground debris outside of orchard.
- PC adults begin to immigrate into the edges of orchards from outside sources in spring before petal fall (55-60°F).
- Usually in the trees during bloom.
- Annual length of oviposition period depends upon seasonal temperatures after petal fall.
- Effective control requires preventive insecticide sprays from petal fall until the end of oviposition period.
• After 1-2 warm (60°F) evenings following petal fall, egg laying will start

• Model experimentally derived from modeling cumulative Plum Curculio oviposition and DD accumulation (base temp 50°F) after petal fall of McIntosh.

• Model assumes that fruit requires protection from petal fall until about 40% of the cumulative oviposition is completed (308 DD) ➔ corresponds with the end of their immigration into orchard.
EXAMPLE OF PLUM CURCULIO MODEL PREDICTIONS IN GENEVA FOR THE 2005 SEASON

0 DD

PF spray May 23

165 DD

1C June 6

June 11

308 DD, 40% oviposition; end of immigration

463 DD

June 20

End of Protection

2 Total sprays needed
EXAMPLE OF PLUM CURCULIO MODEL PREDICTIONS IN GENEVA FOR THE 2006 SEASON

0 DD  120 DD  291 DD
PF spray May 15  1C May 30  2C June 12
308 DD, 40% oviposition; end of immigration
June 14
June 26 End of Protection

3 Total sprays needed
Most Important Internal Fruit Feeding Lepidoptera

Codling moth, *Cydia pomonella*

Oriental fruit moth, *Grapholita molesta*

Lesser appleworm, *Grapholita prunivora*
Fruit Injuries by Various Internal Lepidoptera Larvae

CM

OFM

LAW
Native to Asia, in quince, apple and pear

Brought to US by first colonists

Hosts: apple, pear, quince; also hawthorn, crab apple; sporadic pest of apricot, peach, and plum (if planted adjacent to high population in apples)

May be a different strain in walnut

Larvae can overwinter in bin piles from infested crop
CM Flight Timing

Wolcott 2006

• Mean date of 1st catch in Geneva: May 18 ± 7 days
• 2019: May 29-June 3 in Wayne Co.
• Biofix generally corresponds with date of Red Delicious king bloom
CM Egg Stage

- Egg-laying starts ~100 DD$_{50\degree}$F after biofix
- Single, flat, oval, 1/20 inch; mid “red ring” and later “black head” stages
- Laid mostly on upper (apple) or lower (pear) leaf surfaces, and on fruit
- About 100 eggs/female; 90% laid in first 5 days
- Hatch in 6-14 days (starting ~250 DD$_{50\degree}$F after biofix)
CM Larval Stage

- Newly hatched: 1/10 inch; mature: 5/8 inch
- Creamy white to pinkish
- Head capsule black (young) to brown (mature)
- No anal comb (differs from OFM)
- Feeds for 3-4 weeks in fruit
Injury (internal):

- “Stings”: shallow entries, larvae killed or exited from fruit
- “Deep entries”: to core, leads to fruit rot
- Commonly feed on seeds
- May find multiple larvae in single fruit
In the early 1990s, outbreaks of codling moth occurred in commercial apple orchards throughout the world.

First outbreaks of CM occurred in apple orchards in Washington & California apple growing regions.

Within the last 15 years, outbreaks of internal Lepidoptera have occurred in commercial apple orchards in all major production areas in the USA.

Most of these outbreaks have been associated with the development of insecticide resistance, often to multiple classes of compounds.
What causes lack of effective CM/OFM control?

- Resistance to standard insecticides
- Biological factors, such as overwintering survival or changes in generation timing or duration
- Less than adequate performance of new materials – changes in spray programs
- Poor timing or stretching of spray intervals → gaps of opportunity
- Use of rates that are too low
- Inadequate spray coverage
- Rain events
Differences in Life Histories and Spray Timings

**Critical protection windows for Internal Lepidoptera**

- **Bloom**
  - May June Aug Oct
  - Egg laying → Hatch

- **Codling Moth**
  - Jul Sep
  - Egg laying → Hatch

- **Oriental fruit moth**
  - Apr May June July Aug
  - Egg laying → Hatch

Early sprays for PC
Use of pheromone traps to assist in decision-making, to tell you:

- **What?** - Detection (presence)/species ID
- **When?** - Establishment of biofix
- **How many?** - Determination of pest level
- **Significant points in life cycle** - Chart developmental progress (e.g., 1st flight, peak flight, hatch period)

Density of traps - How many to use?
- 1 trap/5 acres (idealistic)
- 1 trap/10-20 acres (realistic)
- no traps (“asking for trouble”)
CM/OFM Adult Monitoring

What type of trap to use?

- Pherocon IIB
- Pherocon VI
- Pherocon 1C
- Multipher

What type of lure to use?
- Red septum - cheap, but short field life (3-6 weeks)
- Gray septum (L2) - more expensive, but longer life
- CM-DA - pheromone + pear essence (more useful in MD blocks)
Use pheromone traps to:

1. Establish biofix (1st trap capture) for Degree Day accumulations; need to calculate, or use NEWA (CM: base 50°F; OFM: base 45°F)

2. Determine need/timing for spraying
   - CM: If >5/week, 250 DD after start of each flight; 150 DD for ovicides; e.g., Rimon (1 application/season), Intrepid OFM: If >10/week, 170 DD after start of each flight
     a) 1st broods: PF-1C sprays
     b) if have both species => use either or both trap catch thresholds
1. What specific information is needed to use degree days to chart insect development?

A) biofix; calendar date; developmental baseline

B) biofix; developmental baseline; tree phenology

C) biofix, developmental baseline, daily maximum & minimum temperatures

D) calendar date; daily maximum & minimum temperatures; tree phenology
2. Pheromone monitoring traps can help indicate whether the insect population is over threshold for treatment

A) true

B) false
3. The plum curculio model is based on the need to protect the fruit until the oviposition period is completed

A) true

B) false
4. What is probably most responsible for the increase in CM and OFM damage in NY orchards over the past 20 years?

A) immigration of CM and OFM into orchards where they weren’t previously present

B) development of insecticide resistance

C) climate change

D) development of newer apple varieties that are more susceptible to attack than the ones that used to be grown