On-Farm Evaluation of Apple IPM Protocols in the Champlain Valley

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Pest management is one of the most expensive and time-consuming responsibilities of operating an orchard. Unfortunately, it is also a moving target. Over the past two decades, changes in the landscape of Northeastern NY orchards have made it increasingly challenging for growers in the region to manage economically significant pests. Such changes have included changing to new rootstocks, implementation of new tree training systems, restrictions on chemical controls, changing climate, and introduction of pests from other areas (Agnello and Reissig 2010; Robinson et al. 2013, 2014; Bebber 2013).

According to observations by growers, consultants, and other industry members, insects have become increasingly difficult to control in Northeastern NY. Reports have included increasing populations and occurrence of later generations, resulting in more frequent fruit damage and bin rejections. For example, obliquebanded leafroller (OBLR), which historically required little or no targeted control, became a serious pest in the 1990s and wreaked havoc on the majority of operations in the Champlain Valley (J. Eve, personal communication, Aug 2014) (Figure 1). Over the course of only a few years, OBLR-specific scouting and pesticides became the norm, and the insect continues to be the driving force behind most summer insect management programs. Codling moth and oriental fruit moth are other insects that have previously required less intensive control measures in the Champlain Valley as compared with other apple production regions in the Northeast. However, increasing trap captures and fruit damage in both NY and VT, and observations of later generations have forced growers and consultants to track these pests more closely and alter programs accordingly (J. Eve, personal communication, August 2014).

The cause of these changes is complicated and doubtless the result of multiple factors. A warming climate is likely expanding insect ranges and facilitating their overwintering farther north (Bebber 2013; Acimovic 2017). Considerable changes have been made in rootstocks, varieties, and training systems (Robinson 2013, 2014), which may be favoring insect populations and making new plantings more susceptible to damage.

Movement of plant material, bins, and fruit to and from the region has the potential to introduce or increase insect populations (APHIS 2010; Acimovic 2017). Also, changes in chemical controls have complicated management. Movement away from traditional broad-spectrum materials with long residual and high mammalian toxicity (e.g., organophosphates, carbamates) to more pest-specific, less persistent chemistries limits the tools available for insect control, and requires growers to spend more time learning these new products and making more informed, targeted pesticide applications (Agnello and Reissig 2010; Jen tsch 2017).

Fortunately, there is a plethora of information available to aid growers in insect pest management decisions. These resources include fact sheets and trapping protocols developed by Cornell, web-based monitoring systems such as the Network for Environment and Weather Applications (NEWA), and advising by private consultants. In addition, a thorough insect IPM (integrated pest management) protocol was developed in the early 2000s using web-based resources (Agnello and Reissig, 2010).

However, there has been a gap in knowledge in Northeastern NY about insect pest pressure and management. Lack of resources allocated to the region, distance from main agricultural experiment stations, and a gap in extension personnel in the area resulted in missing or poor documentation of pest pressure and implementation of sustainable pest management strategies. Often, orchardists lack extensive knowledge of the biology of these pests and expertise in using these resources, often relying...
heavily on private industry consultants with limited resources. Furthermore, technology barriers and training time required have prevented many farmers from adopting the system.

The goal of this work was to fill in these gaps by documenting insect pest populations and pressures in Northeastern NY, testing an IPM protocol in on-farm situations, and providing grower training to support IPM implementation on farms in the region.

Methods

Blocks were established at 5–12 sites in 2015, 2016, and 2017 on commercial orchards in Northeastern NY (Figure 2) to trap and scout for economically significant insects: codling moth (CM), oriental fruit moth (OFM), oblique banded leafroller (OBLR), apple maggot (AM), leafhoppers, mites, aphids, and scales. Traps were monitored and sites were scouted weekly throughout the growing season, beginning in mid-April until harvest in early September (Figure 3).

At five sites in 2015, paired “IPM” and “Control” blocks were established, approximately 1–5 acres in size, of the same or very similar variety, rootstock, age, training system, etc. Blocks were selected that were planted with Honeycrisp and McIntosh, the most commercially important varieties produced in this region, and modern high-density plantings of mature bearing age. Recommendations were given to growers weekly for IPM blocks. A summary of pests, target life stages, and management thresholds is summarized in Table 1. Control blocks were to be managed at the growers’ discretion, according to their normal program, to represent a grower standard. They were asked not to intentionally replicate the IPM management program if possible.

Overarching goals of the IPM program included:

- **Thresholds**: Pesticide applications were only recommended once pests or damage were detected above a pre-determined economic threshold (i.e., trap numbers or leaf/fruit damage).

<table>
<thead>
<tr>
<th>Insect</th>
<th>Target life stage</th>
<th>Threshold or Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERM</td>
<td>Eggs</td>
<td>Dormant oil</td>
</tr>
<tr>
<td>PC</td>
<td>Adults moving into orchard until 40% oviposition</td>
<td>PF spray</td>
</tr>
<tr>
<td></td>
<td></td>
<td>More sprays until 308 DD50</td>
</tr>
<tr>
<td>OFM</td>
<td>1st gen larvae</td>
<td>350-375 DD45 from biofix</td>
</tr>
<tr>
<td></td>
<td>2nd gen larvae</td>
<td>175-200 DD45 from 2nd flight</td>
</tr>
<tr>
<td>CM</td>
<td>1st gen larvae</td>
<td>250-360 DD50 from biofix</td>
</tr>
<tr>
<td></td>
<td>2nd gen larvae</td>
<td>250-350 DD50 from 2nd flight</td>
</tr>
<tr>
<td>OBLR</td>
<td>Overwintered brood</td>
<td>3% infestation of bud clusters</td>
</tr>
<tr>
<td></td>
<td>Summer brood</td>
<td>Rate fruit at 600 DD43 from biofix, 1 damaged fruit</td>
</tr>
<tr>
<td>AM</td>
<td>First migrating flies</td>
<td>5 flies per trap (average of 3 traps)</td>
</tr>
<tr>
<td></td>
<td>Subsequent sprays</td>
<td>5 flies per trap or 10-14 days</td>
</tr>
</tbody>
</table>

**Figure 2. Insect monitoring sites in Northeastern NY.**

**Figure 3. Insect traps used for monitoring. (A) Delta traps with pheromone lures deployed for codling moth, oriental fruit moth, and oblique banded leafroller. (B) Sticky card with pheromone lure, oblique banded leafroller trap. (C) Apple maggot sticky red sphere trap with volatile apple essence lure, in an orchard in Clinton County. Lures are deployed at the beginning of July near the orchard edge, near other host trees (e.g., hawthorn), if present. (Photos: A. Wallis)**
Timing: Pesticide applications were made based on insect activity to target the most susceptible life stage.

Materials: Pesticides used were considered more “IPM-friendly”: more pest-specific, lower mammalian toxicity, shorter persistence in the environment.

To evaluate efficacy of the IPM protocol compared with the grower standard, insect damage was evaluated at harvest. A sample of 600 fruits from each site (200 from the center of the orchard block, 100 from each side of the block) was evaluated for type of insect damage, and packing-line grade (clean, fancy, #1, or cull). Insect damage was compared against pesticide records and pest activity to determine which pests were effectively or insufficiently managed.

We attempted to replicate the work done in 2015 evaluating the efficacy of the insect IPM protocol. Due to the following circumstances, we were unable to follow it through the 2016 and 2017 seasons:

- Grower collaborators were often already using the IPM protocol in some capacity, so spray timings and materials were the same for IPM and Control treatments. We observed that pest management decisions were based heavily on recommendations provided by extension publications, web-based models, and/or private consultants’ recommendations, which were informed by models and extension protocols.
- Grower collaborators used the recommendations given for “IPM treatment” blocks to make decisions about the “Control” blocks. Therefore, paired blocks received the same treatments.
- Growers in the Champlain Valley experienced extraordinary weather and disease challenges during the 2016 season. Therefore, they were unable to provide labor, time, and/or more expensive materials necessary to implement the IPM treatments.

To determine if treatments applied in 2015 had a carryover effect for the 2016 crop, insect damage was evaluated 1) in late spring and 2) at harvest. In late May, 600 terminals were sampled for OBLR infestation (200 from the center of the block, 100 from each side). At harvest, a sample of 600 fruits was again taken from each site (200 from the center of the orchard block, 100 from each side of the block) and was evaluated for type of insect damage, and packing-line grade. Insect damage was compared against pesticide records and pest activity to determine which pests growers effectively managed, and which were not effectively controlled.

Results & Discussion

Insect flight patterns

Flight patterns of oriental fruit moth (OFM), codling moth (CM), and obliquebanded leafroller (OBLR) were variable between years and sites, as illustrated in Figure 4, showing trap captures at sites in the Champlain Valley where we monitored in each year.

OFM biofix occurred in mid- to late May in all three seasons (18–23 May), at approximately 400–465 DD43. This is later than the average biofix observed in Geneva over the past 33 years, (223–324 DD43), corresponding to an average calendar date of 2 May (Agnello 2017a). The discrepancy may be due to low insect populations in Northeastern NY and therefore low detection. Trap catches throughout the season indicate approximately three generations. Timing of these generations varied considerably by year and are likely related to seasonal conditions. While moth activity appeared to cease after mid-summer in 2017, we continued to detect insects into September during 2015 and 2016. This indicates the need for continued scouting and possible management closer to the harvest date.

CM biofix occurred in late May (25–30 May), at approximately 560–590 DD43. This is slightly later than average Geneva observations over the past 35 years: first catch 396–566 DD43 and average calendar date of 18 May (Agnello 2017b). The patterns of CM catch generally followed the same pattern observed in other regions of NY (Breth 2010). Trap captures indicated an “A” and “B” peak for the first generation flight and a second generation flight. The considerable variability in moth number and flight pattern (relative size of A and B peaks, for example) between sites is not unusual, and justifies site-specific monitoring and management.

OBLR biofix ranged from 1–20 June, at approximately 730–1003 DD43, consistent with the Geneva average first catch: 795–980 DD43 (Agnello 2017c). A clear 1st peak flight was observed in late June to early July each year at most sites. A slight increase in trap captures was observed early in September. This may be related to reduced insecticide applications approaching harvest. Alternatively, it may indicate the presence of later generations, as the result of longer, warmer growing seasons. Therefore, monitoring insects through the beginning of September is advised in order to detect insect pressure close to harvest.

In 2017, we included an abandoned, unmanaged orchard site. CM trap captures at the abandoned site were much higher than at commercial sites. This could indicate that managed orchard sites are “clean” (i.e., growers have excluded or effectively managed these insects). We did not observe this discrepancy for the other moths we monitored.

For all three insects (OFM, CM, and OBLR), we expected that we might observe lower trap captures, fewer generations, and lower pressure as compared with other regions of NY, due to geographic isolation, colder winters, and shorter growing season. However, we observed very similar patterns and generation numbers, with slight (expected) delays in emergence in the spring. We observed great variability among sites for all insects. This and the foreseeable change in orchard landscape factors (climate, introduction of pests, management tools) substantiate the need for continued monitoring of multiple sites in Northeastern NY, to detect changes in regional patterns, and to provide site-specific management recommendations.

IPM Protocol: Fruit Damage

In both 2015 and 2016, we found very little difference in the percent damaged fruit between the IPM and Control blocks (Table 2). In 2015, the total number of damaged fruit in both IPM and Control blocks averaged less than 3%. In 2016, insect damage in fruit evaluated at harvest at all sites and in both treatments was less than 2% for any particular insect. This is well below the 5% damage typically tolerated in the packing line.

With respect to fruit grade, we also observed very little difference between treatments (Table 3). In 2015 an average of 96.3% of fruit from Control blocks and 96.0% of fruit in IPM blocks were clean (no insect damage at all). In 2016, nearly all fruit were again classified as clean in both the grower standard, with an average of 100%, and 96.4% clean in Control and IPM blocks, respectively. Both treatments during both seasons exhibited...
less than 5% damage, which is considered acceptable damage levels for commercial packing standards. These data show that the IPM treatments were just as effective in controlling insect damage as the growers’ standard treatments. Only about 2% of fruit did not meet the standard for “fancy” for both the grower standard and IPM treatments.

The most significant damage observed in 2015 was caused by tarnished plant bug (TPB), an early season insect that feeds on developing fruitlets, leaving a deep dimple in mature fruit. The number of fruit with TPB damage was not different for grower standard (2.4%) or IPM (2.3%) treatments. In both years, growers reported increasing pressure from TPB and other early season insects (in particular European apple sawfly and plum curculio).
Table 2. Average insect damage at harvest for 5 commercial sites in northeastern NY (% of 600 fruit sampled)

<table>
<thead>
<tr>
<th>Damage Type</th>
<th>2015 Control (%)</th>
<th>2015 IPM (%)</th>
<th>2016 Control (%)</th>
<th>2016 IPM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early OBLR</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Late OBLR</td>
<td>0.1</td>
<td>0.4</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>AM</td>
<td>0.0</td>
<td>0.0</td>
<td>0.4</td>
<td>0.8</td>
</tr>
<tr>
<td>PC</td>
<td>0.5</td>
<td>0.7</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>TPB</td>
<td>2.4</td>
<td>2.3</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>RAA</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>SJ5</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>EAS</td>
<td>0.0</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>SB</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Scab</td>
<td>0.2</td>
<td>0.2</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

*OBLR=obliquebanded leafroller, AM=apple maggot, PC=plum curculio, TPB=tarnished plant bug, RAA=rosy apple aphid, SJ5=San Jose scale, EAS=European apple sawfly, SB=stink bug

Table 3. Average fruit grade at harvest at 5 commercial sites in northeastern NY (% of 600 fruit sampled)

<table>
<thead>
<tr>
<th>Packing Grade</th>
<th>Control 2015 (%)</th>
<th>IPM 2015 (%)</th>
<th>Control 2016 (%)</th>
<th>IPM 2016 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td>96.3</td>
<td>96.0</td>
<td>100</td>
<td>96.4</td>
</tr>
<tr>
<td>Fancy</td>
<td>1.9</td>
<td>1.8</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>#1</td>
<td>1.6</td>
<td>1.9</td>
<td>1.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Cull</td>
<td>0.3</td>
<td>0.4</td>
<td>1.4</td>
<td>1.1</td>
</tr>
</tbody>
</table>

*Note: values percentages do not add up to 100 for each column because they are an average of the percent damage in individual blocks

Considerable discussion was held with individual growers and industry members about the need for a “pink” spray, depending on individual years.

One major difference between our IPM recommendations and some growers’ standard treatments is that our IPM program omitted the traditional “pink insecticide spray.” Our results showed that the omission of the pink spray did not result in more early season fruit damage, but additional studies should be done in the future to validate these results. One grower reported more OBLR damage in the IPM fruit at harvest due to a delayed summer insecticide application, but this was not reflected in our fruit evaluation. This suggests that there may be different tolerance levels for summer worm injury among growers.

Another topic of considerable controversy in discussions with growers regarded waiting for the OBLR threshold (1 damaged fruit) to apply an insecticide for this insect. This is despite the fact that our results showed that no increased fruit damage resulted from following this IPM practice. This suggests that growers are uncomfortable about using traditional IPM practices of sampling and a treatment threshold for a pest such as OBLR that directly damages fruit. Fruit sampling programs do require some extra time and labor, and in larger scale operations, waiting for this threshold may not leave a large enough management window for effective control, especially where there are insufficient resources to manage each block individually. In the future, more studies should be done to determine if sampling for fruit damage is feasible and if growers will accept this concept.

IPM Protocol: Carryover effect to 2016

In 3 of 5 sites, OBLR pressure (% terminals infested out of 600 rated) was higher in the Control than in the IPM block (Table 4). In only two locations was damage greater than 5%. On average, OBLR-infested terminals was at 2.4% in IPM blocks and 2.7% in Control blocks. These low infestation rates indicate that overwintering and early season OBLR activity was not impacted differently by treatments.

Table 4. Overwintering OBLR (Infested terminals) for 5 commercial sites in northeastern NY, evaluated May 2016. (% of 600)

<table>
<thead>
<tr>
<th>Location</th>
<th>IPM</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.17</td>
<td>0.33</td>
</tr>
<tr>
<td>2</td>
<td>1.00</td>
<td>2.50</td>
</tr>
<tr>
<td>3</td>
<td>2.67</td>
<td>10.67</td>
</tr>
<tr>
<td>4</td>
<td>6.83</td>
<td>4.17</td>
</tr>
<tr>
<td>5</td>
<td>0.17</td>
<td>0.67</td>
</tr>
<tr>
<td>Average</td>
<td>2.37</td>
<td>3.67</td>
</tr>
</tbody>
</table>

IPM Protocol: Targeted Insecticide Applications

Pesticide applications were much more targeted in the IPM blocks than in the Controls. In the IPM blocks, insecticides were only applied following model recommendations and when a pest population reached an action threshold, determined as the threshold at which economically significant damage would occur. In addition, applications targeted specific insects and life stages. However, pesticide applications in Control blocks were generally related to weather (covering after a rain) or calendar intervals (10–14-day periods). However, this is a gross over-generalization. Control blocks were managed very differently, due to variation between farms in pest management philosophy, comfort with the web-based tools, familiarity with newer chemistries, and the consultants and industry members supplying information to them.

Despite this variation, overall, growers made between 1 and 5 fewer insecticide applications in the IPM blocks than the grower standard blocks during the 2015 season. Typically this was because the IPM protocol eliminated an insecticide application at “pink” and reduced the number of mid-summer insecticide applications targeting OBLR and AM. Because of this, despite increased resources required to train workers in the IPM protocol, and time spent checking traps and scouting, growers likely saved a significant amount of money by using the IPM protocol.

An example of the spray program at a representative site in the Champlain Valley is shown in Figure 5, juxtaposing the IPM protocol and the Control. Key differences of note in the IPM blocks were: 1) dormant oil application at bud swell, 2) the “pink” spray was omitted, 3) summer insecticide applications were made exclusively when models recommended them, and 4) mite control was unnecessary in the summer, despite historically heavy mite pressure in both the Control and IPM blocks.

Outreach efforts

1) Weekly scouting of orchards informed grower alerts. In addition to informing the research project reported above, weekly scouting performed at the 5 study sites was used
in grower outreach. Apple “e-alerts” are short emails developed in 2014 by the Eastern New York Commercial Horticulture Program Fruit Team (Dan Donahue, Anna Wallis) and produced approximately twice per week during the growing season, with the goal of providing an easy-to-digest, timely report on regional trends, management recommendations, and industry events. Weekly insect trap captures, field observations, and accompanying IPM recommendations were reported in these e-alerts in 2015, 2016, and 2017.

2) Grower workshops provided hands-on training. Several workshops were held in Northeastern NY to provide growers training on the apple IPM protocols and the resources available to assist in orchard pest management (Figure 6). Two Apple IPM Workshops were held in Peru and Ballston Spa in April 2015, attended by a total of 30 participants. Workshops were 5-hour, classroom-style programs, providing information on IPM theory, insect and disease pest biology and control, NEWA “Real Time IPM,” tree-row volume, and an example IPM plan. Presentations were given by Dr. Art Agnello, Dr. Julie Carroll, Dr. Kerik Cox, Dan Donahue, and Dr. Harvey Reissig. In March 2017, a one-day IPM training session focused on web-based pest management programs was held in Chazy, NY, attended by 21 participants from NY and VT.

3) Response to fire blight epidemic in 2016. A “perfect storm” of weather events in the spring of 2016 caused an epidemic of fire blight, an extremely destructive disease of apples, in the Champlain Valley. While it has previously been reported in this region, in most seasons conditions are not conducive to infection, and growers have extremely limited experience managing it. Because we were regularly visiting the 5 study sites in this work, we were well equipped to assist growers with management by:
- Identifying the infections shortly after they occurred,
- Tracking when, where, and how the disease was progressing in each of the locations and across the region,
- Providing disease biology, activity, and management recommendations in e-alerts, and
- Providing immediate, site-specific management recommendations

In addition, an emergency fire blight workshop was held in Peru during August 2016 following the epidemic in the Champlain Valley. Dr. Srdjan Ćimović, Plant Pathologist at the Hudson Valley Research Lab, presented information on cause of the epidemic, fire blight life history, and management strategies (Figure 7).
Figure 6. Cornell entomologist Dr. Art Agnello presents information on IPM theory and insect pest biology to growers at an Apple IPM Workshop in April 2015. The workshop also included presentations on disease management, NEWA, tree row volume, and a sample IPM plan, given by Dr. Kerik Cox, Dr. Julie Carroll, Dan Donahue, and Dr. Harvey Reissig. [Photo: A. Wallis]

Figure 7. Growers at an emergency fire blight workshop held in August 2016 following the epidemic in the Champlain Valley. Dr. Srdjan Aćimović, Plant Pathologist at the Hudson Valley Research Lab, presents information or cause of the epidemic, fire blight life history, and management strategies. [Photo: A. Wallis]

Conclusions
In general, insect populations and patterns in Northeastern NY followed patterns similar to other apple production regions in NY. This was somewhat surprising, as we expected lower populations and pressure due to the colder climate, shorter growing season, and geographic isolation of the region. In both 2015 and 2016, in the five sites included in this study, the IPM protocol we tested was found to be as effective as the grower standard in terms of fruit quality at harvest. The IPM protocol typically reduced the total number of sprays in the season and included more targeted pesticide applications, likely saving the growers time and money. However, the ‘grower standard’ is variable, and we found that many farmers were already following IPM recommendations in some capacity, if not entirely. There was great variability in insect pressure and flight patterns among sites. Continued monitoring will be necessary to detect regional and site-specific changes. Grower outreach was well received and should continue as it will provide growers with information on seasonal trends, regional variation, and recommendations for appropriate IPM management.

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References


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