Apple Pest Management Using Precision Application Timings of New Products.

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Apples are one of the most pesticide dependent agricultural commodities produced in the United States. Conservative estimates show Hudson Valley fungicide, insecticide and miticide costs to exceed $400.00 per acre in commercial orchards with expenses continuing to escalate. Entomological research points to more than 500 arthropod species that feed on apple, 40 of these being present in the Hudson Valley.

While greater limitations are being placed on pesticide utilization, traditional management tools such as the broad-spectrum organophosphates and carbamates, representing the core of fruit integrated pest management, are being lost due to regulatory restrictions. Newer technologies including pheromone disruption and bio-rational chemistries, although considered less environmentally disruptive, often come with a higher price tag. Newer materials with newer modes of action often have narrower efficacy windows that frequently compromise productivity. Some of the loss of efficacy comes with grower lack of knowledge of how these materials should be used in regards to optimum timing. With the loss of older broad spectrum and less expensive pest management tools, education based on the employment of the newer insecticides is becoming more important if producers are to remain profitable.

For any given insect pest management program to be effective an optimum application window within the vulnerable life cycle of the pest must be determined. When present, it occurs but for a relatively short period of time, given the mode of action of the insecticide. Newer chemistries, having different modes of action and timing windows than the standard insecticides used for the past 30 years, are often unfamiliar to fruit producers and a grower may utilize these insecticides the same way that older compounds were used. This may lead to insecticide failure, resulting in lower productivity and increased management costs.

Insect thresholds, developed in the mid-1980's, utilizing IPM scouting protocols, were based on the contact activity of the older classes of insecticides such as the organophosphates. Insect thresholds are the number of insects found in the field that represent a population approaching an economic damaging level, triggering the use of an insecticide application. After the application is made, the population would be evaluated to determine the efficacy of the treatment and to determine if a follow-up application was necessary. But given the nature of these newly developed insecticides, such as insect growth regulators, many pest management decisions need to begin well before economically damaging thresholds occur if these new insecticides are to be effective. The basis for these decisions will often stem from recent historical data or trap catches indicating pest presence yet the correlation of these values to actual damages is relatively speculative. They have a greater dependency on adult emergence to establish a biofix with which to calculate the period of mating, egg laying, egg hatch and larvae or nymph development.

Newly emerging insecticide technologies include modes of action such as pheromone mating disruption of adults using pheromone impregnated rubber ties or sprayed formulations, adulticides, pre-ovipositionally applied ovicides such as Esteem, post ovipositionally applied ovicides such as chemistries with miticidal activity, compounds effective at early hatch of the larval stage such as the spinosad compounds, late hatch of the larval stage, or late instar larval stage insecticides used prior to molting or pupation. Some classes of insecticides act using translaminer or locally systemic activity and are able to move into the leaf, while others incorporate only surface contact activity. Organophosphates and carbamates have long residual activity while others such as the Bt formulations breakdown quickly under U.V. light or wash off easily after rainfall requiring shorter application intervals. Pyrethroids work well under cool conditions while others are equally efficacious under warm temperatures. Some act as repellents, others act as feeding toxicants while others as contact toxicants causing rapid mortality. Insect growth regulators on the contrary are slow in reducing insect populations. Given the diversity of both new and old insecticides, understanding the placement of the insecticide within the proper stage of insect development for optimum control has become more critical if the full potential of these chemistries are to be realized by fruit producers using insect pest management.

The difficulty for farm managers comes not only in choosing the proper insecticide given its optimum timing and efficacy, but in integrating application cost, re-entry interval and pre-harvest interval, number of applications allowed per season, quantity of product per application per season, along with the determination of its longevity given environmental conditions. Just as important to producers is the potential development of insecticide resistance throughout the pest complex. Insecticide resistance is the ability for consecutive insect generations to survive exposure to repeated applications of a single class or mode of action of insecticides. Many insects and mite species have developed resistance to commonly used insecticides in New York State. One such insect, the obliquebanded leafroller, *Choristoneura rosaceana* (Harris), is now resistant to the organophosphate azinphosmethyl (Guthion). This insect continues to cause significant damage on apple throughout the Northeast and drives the mid-season pest management program in pome fruit. Another insect increasing in tolerance to pest management programs in processing blocks throughout Pennsylvania and western NY is the codling moth. More than 200 loads have been rejected in NY by processors due to this 'internal worm' in 2007. Through the rotation of insecticide classes (insecticides with differing modes of action), a pest management strategy to reduce the resistance potential can be developed on a farm-by-farm basis. Again, for this to be successful, grower understanding of insecticide classes and timing is essential.

Pest management predictive models based on insect developmental biology have been established to aid in the applications of insecticides in apple production. Many models have been developed for the lepidopteran class of insects that damage fruit. These models use trap catches of adults along with daily temperature to follow the development of the insect to predict when the optimum period for management will occur, such as the onset of egg laying or first hatch of the insect larvae.

In the past, insect modeling information was generalized to NY State, lacking specificity to the regional differences, with little or no consideration of timing of applications based on insecticide modes of action or predictions based on weather patterns or tree stress specific to the Hudson Valley region.

2007 Project: This year we purposed to educate growers on new insecticides and their modes of action for use in achieving greater insecticide resistance management, while increasing insecticide performance through application timing based on pest developmental models. We determined to establish an educational environment for regional fruit producers to enhance their knowledge base and skills with which to optimize the application of these new reduced risk insecticides. Our goal intended to provide for ample lead-time in preparation through temperature forecasts, allowing for more precise and informed insecticide decision-making processes. The key insect pests for which we have forecasting models include: **Codling Moth** targeting spray application at newly hatching larvae, predicted at 250–360 DD base 50°F after biofix using first sustained adult trap catch; **Oriental Fruit Moth** targeting spray application at 55–60% egg hatch, predicted at 350–375 DD base 45°F after biofix using first sustained adult trap catch; **Plum Curculio** requiring spray coverage until 308 DD base 50°F using McIntosh petal fall as the biofix; **San Jose Scale** 1st generation crawlers using 500 DD base 50°F and 1 March as the biofix; **Obliquebanded Leafroller** 1st summer generation targeting spray application at newly hatching larvae, predicted at 360 DD base 50°F after biofix using first sustained adult trap catch; **Codling Moth** treatment period for the 2nd generation larval hatch beginning at 1260 DD base 50°F after biofix using first sustained adult trap catch; **Oriental Fruit Moth** first treatment targeting earliest egg hatch of 2nd generation larvae between 175–200 DD base 45°F after biofix using first sustained adult trap catch; **Spotted Tentiform Leafminer** 2nd generation targeting onset of larval hatch using 690 DD base 43 after biofix using first sustained adult trap catch; **Oriental Fruit Moth** first treatment targeting earliest egg hatch of 3rd generation larvae between 175–200 DD base 45°F after biofix or 2200 from 1st gen. biofix using first sustained adult trap catch; **Spotted Tentiform Leafminer** of the 3rd generation, targeting onset of larval hatch using 690 DD base 43 after biofix using first sustained adult trap catch; **San Jose Scale** of the 2nd generation crawlers using 1451 DD base 50°F and 1 March as the biofix; **Apple Maggot** emergence of adult flies caught in red baited spheres using 5 flies per trap as trigger of first treatment.

Nine regional farms are participating directly in the study. They are representative of Hudson Valley orchards relative to their location within the region. Each site has 'ibutton' temperature sensors that collect minimum and maximum temperature data used in determining growing degree days specific to each location. In order to define key insects that drive regional pest management, we have deployed the use of pheromone and visual traps, collecting trap data from each participating farm, along with temperature data, and when appropriate, the biofix (critical life stage of insect development used in predictive models) for each relevant insect. Each farm receives daily and or weekly updates, depending on the time of year, for growing degree-days for each insect. Using 'Skybit' and NOAA weather radar, predictions on weather variables such as spray conditions, temperature and rainfall predictions, we communicate application recommendations to forecast the application window and advise growers on the potential use of each possible candidate of registered insecticide available.

The means by which this information was communicated to growers is through data summaries processed by the department of entomology and regional fruit extension agent, Mike Fargione, from Cornell's Hudson Valley Laboratory. Information communicated through digital media formats are timely to generate and familiar to the grower community accustomed to computer technology. Distribution of digitally based video and internet hosted web sites (http://hudsonvf.cce.cornell.edu/index.html) are made available to regional producers through