Cornell Cooperative Extension
Eastern NY Commercial Horticulture Program

Tree Fruit News

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Recent Research on the Use of Apogee and Early Calcium Sprays to Suppress Bitter Pit in Honeycrisp

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Bitter Pit and Prohexadione-Calcium (Apogee[R], BASF)

What is Bitter Pit? Bitter pit (BP) disorder is the visual manifestation of fruit tissue desiccation under the skin, with dark, sunken spots on the fruit surface and corky tissue underneath, and not centered on a lenticel (a characteristic of lenticel breakdown). Considered the result of a localized calcium deficiency, the questions of why calcium was deficient in a particular BP afflicted apple, why a specific grouping of cells desiccates, and at what time in that fruit's development those cells became deficient are not well understood.

Calcium Distribution: Calcium is distributed throughout the tree via the xylem, transpiration is the driving force, and water is the facilitator. Once inside the plant and outside of the xylem, beyond the influence of the transpiration stream, calcium is relatively immobile. This fact helps us understand why foliar calcium applications during the growing season have such a "spotty" record (sorry for the pun!) in the suppression of bitter pit.

PHOTO: www.canr.msu.edu

What Calcium Does: Calcium is a key component in the structural integrity of cell walls where it serves to cross-link pectin chains, improving strength and reducing elasticity. Calcium

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is also essential to maintain cell membrane integrity, with cell leakage a consequence if deficient. Small amounts of calcium play an important role in hormonal signaling as well. I recall a researcher describing calcium as a "macronutrient that behaves like a micronutrient". I think this is a valuable observation, and a key point to consider when trying to understand why supplying substantial quantities of calcium to the soil, or directly to the leaves and fruit do not reliably reduce bitter pit.

Calcium Management in Plant Tissue: Once inside, the concentration of "free" calcium ions are closely managed by the plant. Calcium is "stored" within a cellular organelle called a vacuole, and studies have shown that this stored calcium can account for as much as 40% of the total calcium in a fruit. So, if cells have all this calcium stored away, how can deficiencies develop near harvest or during storage? Turns out, studies have shown that the calcium transported into the vacuole is rapidly sequestered within more complex molecules, such as chelates, and as such is no longer available to the plant. Free calcium ions in the apoplast (that is the open space in-between cells) are an important source for structural calcium, but whose concentrations are tightly regulated by the plant, possibly a consequence of the signaling role they play.

Why the Spots?: We have to start somewhere, so lets form a "working hypothesis" (WH) that offers what might be a reasonable explanation as to why Honeycrisp fruit sometimes develops BP lesions, and mostly in the calyx end of the fruit. The WH is not necessarily the answer, it is the framework upon which we develop experiments to test specific questions. As we learn more, we modify the WH to reflect our newly acquired knowledge, or maybe we just toss it out completely and start over with another explanation. Here is my current working hypothesis:

"For specific groupings of cells in the fruit, at certain times during fruit development, available calcium in the apoplast becomes temporarily deficient, resulting in localized pockets of cells with weakened wall and membrane structure. Symptoms (cell failure) may or may not express later in the growing season, and such expression may depend on factors not directly related to calcium status, such as environment, rates of cell metabolism, and the functionality of vascular tissue."

Prohexadione Calcium (Prohex) Effects: Research has demonstrated that:

Gibberellins are known to inhibit the movement of calcium ions in the xylem.

Prohexadione calcium acts to inhibit the synthesis of the inactive gibberellin GA20 to an active form, GA1.

Prohexadione calcium can thicken cell walls in leaf parenchyma tissue (McGrath et al., 2009).

In tomato, Prohex has been demonstrated to upregulate genes associated with blossom end rot (BER) inhibition, while down-regulating genes associated with BER incidence (de Freitas et al., 2018). BER is a calcium related disorder of tomato that is considered analogous to BP in apple.

In the orchard, Prohex is effective at reducing shoot extension, with the objective of reduced pruning costs and improved fruit quality due to increased light penetration through the canopy.

The practical research question is, can we find a way to utilize any of the above effects to suppress bitter pit in commercial Honeycrisp orchards?

An ARDP funded study was initiated in eastern New York in 2016 to investigate the hypothesis that competition between shoots and fruits for calcium plays a role in BP development in Honeycrisp. The hypothesis our group explored was that shoots have a natural advantage in calcium uptake due to a relatively stronger transpiration stream driven by the extensive area of leaf tissue, as well as a more complete and effective system of xylem tissue. As an example, it is thought that poor development of xylem tissue in the calyx end of the apple contributes to the explanation of why BP symptoms are more likely to be found in the calyx end. Our group was also interested in looking at the status of calcium early in fruitlet development, during the cell division (mitosis) phase. Due to its proven ability to reduce shoot extension, and its mode of action as a GA inhibitor, prohexadione-calcium was selected for testing. Several prohexadione-calcium rates and application timings were evaluated in replicated trials conducted in 2016, 2017, and 2018, along with three commercial airblast trials in 2017 and two in 2018. Data was collected on incidence and severity of BP, horticultural characteristics of the fruit, terminal and bourse shoot extension, as well as extensive peel mineral analysis. Our results over the last three years from our "detail" tall-spindle experiments are as follows:

- 2016: 45% reduction of bitter pit incidence after 45 days of regular storage
- 2017: 54% reduction of bitter pit incidence after 53 days of regular storage
- 2018: 46% reduction of bitter pit incidence after 48 days of regular storage

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- Prohexadione-calcium (Apogee) was applied at pink stage, at a rate of 9 oz./acre in 2016, 6 oz./acre in 2017 & 2018, to mature tall spindle trees at 2X concentration.
- Four out of five commercial scale trials at the 6 oz. rate and pink timing produced similar results. The one trial with no significant treatment differences had an incidence of BP in 2018 that was just too low to show significance. Good for the grower, not so great for the research!

NYS 2EE label for Apogee

Given potential uses of Apogee at pink in apples and grower requests, Dr. Kerik Cox and I worked with the DEC and BASF to establish a 2EE label specifying the use of Apogee as early as pink. Presently, Apogee is the only formulation of prohexadione-calcium labeled for use at pink in apples. The 2EE label can be found at the new NYSPAD site: http://www.dec.ny.gov/nyspad . At the site, simply type "Apogee" in the product name field and press search. The second result will take you to the new 2EE label.

Please follow the 2EE label, and you must have a copy in your possession at the time of application. Here are a few specific considerations when applying prohexadione-calcium at pink stage for bitter pit suppression:

- The 2EE label specifically states to apply at a rate of 6 oz./acre and do not adjust for tree row volume. The reason for this strict language is that 3 oz./acre at pink was not found to be effective, and 9 oz./acre resulted in a significant reduction in fruit size.
- If suppression of fire blight is NOT a concern, and BP suppression is your target, then limit Apogee to a single pink application. For both 2016 and 2017, our results demonstrated that three applications starting at petal fall increase the incidence of BP. Data from 2016 indicated that three applications starting at pink did reduce BP incidence, however this combination was not re-tested in 2017. In 2018, this negative effect was not as pronounced, as later Apogee applications did counteract the positive effect of the pink application, but ultimately BP was no worse than the control. If multiple applications of prohexadione-calcium are planned, our current recommendation is to start at pink, not petal fall.
- You should see limited vegetative growth suppression with a single application at pink.
- It is strongly recommended that you leave an untreated control somewhere within the treated block. Rating BP, either by formal counts or "eyeball" at harvest is not a reliable technique. Rating BP in the bin, or on the packing line, is also unreliable due to sampling bias. In order to effectively evaluate efficacy, 100 apple samples of both treated and untreated fruit should be stored together and evaluated after 45-60 days (or more) in refrigerated storage. Contact Dan Donahue (djd13@cornell.edu) if you'd like some assistance with this evaluation.
- Bitter pit can be a problem in other New York State grown varieties, especially Cortland and Braeburn, sometimes Golden Delicious and Red Delicious. The 2EE label for BP suppression is restricted to Honeycrisp simply because other varieties have not been tested. Will it work on other varieties? Perhaps, although some have suggested to me that Honeycrisp isn't REALLY an apple...just kidding, but as they say, your mileage may vary.

Apogee suppresses Bitter Pit, but does not increase measurable calcium in either leaves or fruit.

So how does it work? The short answer is that the mode of action is not clear. We have collected and are in the process of analyzing additional data not reported here, and work will continue in 2019.

Our results to date suggest:

- Apogee suppresses BP but does not increase measurable calcium in either leaves or fruit.
- Apogee reduces terminal shoot extension (TSE), but this effect is not related to BP reduction. Our data does not support the hypothesis that reducing TSE favors the partitioning of calcium away from the shoot and into the fruit in a manner and timing that will help reduce BP.
- While under certain conditions Apogee can either increase or decrease fruit size a small amount depending on application timing, there does not appear to be a consistent relationship of fruit sizing to BP incidence.

What else could it be then? Let's speculate:

- A group from Dr. George Sundin's lab at MSU and more recent research conducted by Dr. Kerik Cox and Ms. Anna Wallis at Cornell AgriTech (Personal Communication) have demonstrated that prohexadione calcium can thicken cell walls. Could this effect result in either

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stronger cell walls, or more efficient and longer-lasting xylem tissue?

- The ratio of auxins to gibberellins has been shown to influence the ratio of phloem and xylem development. The higher the ratio, the more emphasis on xylem development over phloem. Calcium moves in the xylem, not the phloem (very little, anyway). Possibly a reduction in gibberellins caused by the Prohex treatment, at a critical timing, encourages the development of xylem tissue. This could be an opportunity for future research. Interesting to note the abscisic acid (ABA) applications have also been shown to suppress BP, possibly producing the same result from a different direction by increasing auxin levels.
- de Freitas (et. al.) recently demonstrated that Prohex can act to either activate (up-regulate) or de-activate (down-regulate) genes in tomato that have been associated with BER, a calcium-related physiological disorder considered to be analogous to BP in apple. The genes effected are associated with oxidative stress at the cellular-level, and Prohex may act to increase cellular resistance to such stress. Again, another research direction worth pursuing.

The Value of Early Season Calcium Applications

- Our research conducted in the Hudson Valley for 2017 and 2018 has shown that POMA 6% calcium chelate when applied in five weekly applications at 2 quarts/acre starting at petal fall to mature tall-spindle trees suppressed BP 54% in 2017 and 42% in 2018.
- The objective of this research was "proof of concept", that applications of foliar calcium early, during the cell division phase of fruit development, might be an efficient timing for BP suppression. POMA was the only material evaluated, future research may include other calcium formulations, but for now I have no other recommended materials.
- To learn more about POMA foliar calcium, you can visit the manufacturer's website here: http://agro-100.ca/en/product/poma/

Practical Recommendations to Manage Bitter Pit in Honeycrisp for 2019

1. Apply Apogee at Pink for BP Suppression
2. Avoid Apogee applications at conventional (PF and later) timings in Honeycrisp for vegetative growth management unless you're battling serious fire blight or extreme vegetative growth.
3. If you're going to apply foliar calcium, start at PF with and emphasize applications during the cell division phase of fruit development, up to 45 days after full bloom.
4. Strive for even crop load from year to year.
5. To reach the goal in #4 above, your thinning program starts during the dormant pruning season. Reduce the number of fruit buds in high-density systems before bloom by pruning to a specific fruit bud count per tree. Want to finish with 100 apples per tree? Start the season with 200-250 flower buds. I'm being conservative here, gain some experience with the technique and the bud number could be a little less. Once your orchards start to bud out, the difference between floral and vegetative buds will be clearer. While pruning substantial acreage during the pre-bloom period is a management challenge, concentrate on pruning for flower bud reduction in HC blocks you expect to be "on" this season, those blocks that have a history of difficult thinning, or those blocks with historically high BP losses.
6. In the future, consider planting Honeycrisp on B.9 but adjust your spacing and intensify your horticulture to accommodate its low vigor characteristics on your site.
7. Don't over-indulge on potassium and nitrogen. Dr. Lailiang Cheng at Cornell has shown how high levels of potassium can be antagonistic to calcium. Excessive tree vigor due to high N levels results in increased biennial bearing and excessive fruit size.

Questions or comments on this topic should be directed to Daniel Donahue (djd13@cornell.edu). Thanks to Mike Basedow, Anna Wallis, Dr. Gemma Reig, Dr. Mike Rutzke, and Sarah Elone for their valuable contributions to the ENY Honeycrisp BP project. A special thanks for the financial and in-kind support of the NYS Apple Research and Development Program, Cornell Cooperative Extension – Eastern New York Commercial Horticulture Regional Program, the Hudson Valley Research Laboratory, BASF Corporation, Agro-100 Corporation and our grower cooperators Fino Farms, Crist Bros. Orchards, Yonder Farms, and Forrence Orchards.

Citations:

de Freitas, S.T., F. Martinelli, B. Feng, N.F. Reitz, and E.J. Mitcham. 2018. Transcriptome approach to understand the potential mechanisms inhibiting or triggering blossom-end rot development in tomato fruit in response to plant growth regulators. J. Plant Growth Regul. 37:183-198.

McGrath, M.J., J.M. Koczan, M.M. Kennelly, and G.W. Sundin. 2009. Evidence that prohexadione-calcium induces structural resistance to fire blight infection. Phytopathology. 99:591-596.

The Five Steps of Canopy Sprayer Calibration

Mike Basedow, CCE ENYCHP,
adapted from Dr. Andrew Landers

As we begin to gear up for the 2019 production season, now is a good time to review how to calibrate your air blast sprayers. Calibrating sprayers regularly ensures you are applying the proper amount of product at each application. Over-applying a product would be a waste of money, while under-applying a product may not provide an adequate response from the application, lowering the value of your fruit. So, let's review the five steps of calibration, get the calculators and pencils out, and make the most of your sprays this season.

STEP 1: CHECK YOUR TRACTOR'S OPERATING SPEED

Speed gauges on the tractor are likely not reliable enough for calibration purposes. To check your spraying speed, it is best to test by measuring out a set course, at least 100ft long, with a measuring tape. Lay the course out in an area that closely resembles your actual orchard conditions (don't lay the track on a paved road!).

Fill the spray tank at least half full with water to best mimic actual spraying conditions. Give yourself extra space before the start of the course to ensure the tractor is up to its usual operating speed. Then, use a stop watch to see how many seconds it takes to drive the course. Choose a fixed point on the tractor, such as the front wheels, and begin and stop the counter when that point goes into and out of the course.

It is best to run the course at least three times. Then, take the average time of the three runs. Doing this will further reduce errors in your calibration. Laying out a longer course will also help reduce errors.

To determine your miles per hour (MPH) from the course run, use the following formula:

$$\text{MPH} = \frac{\text{ft. traveled}}{\text{\# seconds}} \times \frac{60}{88}$$

STEP 2: COLLECT THE FOLLOWING INFORMATION

Here are the variables you'll need to know, along with some example numbers:

Variable	Example
Recommended application volume	100 gallons per acre (GPA)
Measured sprayer speed (from step 1)	3.0 miles per hour (MPH)
Pressure	200 psi
Row width	18ft

STEP 3: CALCULATE YOUR DESIRED NOZZLE OUTPUTS

To calculate your target nozzle outputs, use the following formula to determine gallons per minute (GPM):

$$\text{Target GPM} = \frac{\text{GPA x MPH x row width (feet)}}{495}$$

Plugging in our example values from step 2, we get:

$$\frac{\text{100 GPA x 3.0 MPH x 18ft}}{495} = \frac{5400}{495} = 10.9 \text{ GPM}$$

10.9 GPM is for the entire sprayer output. Divide this number by 2, and we get 5.45 GPM per side of the sprayer.

Divide this number by the total number of nozzles per side to get your target GPM per nozzle. In this example, let's say we have 7 nozzles per side, 14 in total for the sprayer:

$$\frac{5.45}{7} = 0.78 \text{ GPM per nozzle}$$

With this information and nozzle manufacturers' charts, we can verify we are using the correct nozzles to achieve the necessary spray rate for our desired GPA.

STEP 4: CHECK YOUR ACTUAL NOZZLE OUTPUTS

Now we will check the pressure and the nozzles on the sprayer. Remember to use clean water when checking your nozzle output. Be sure you have the proper nozzles for your desired application rate, and turn the fan gear box to neutral prior to calibration.

A. Pressure check

First, double check that you are running the correct amount of pressure. Place the pressure gauge on the nozzle fitting farthest away from the pump and turn the sprayer on. If pressure is lower at the nozzle than specified, increase pressure at the regulator.

Pressure at nozzle _____psi

Pressure at sprayer gauge _____psi

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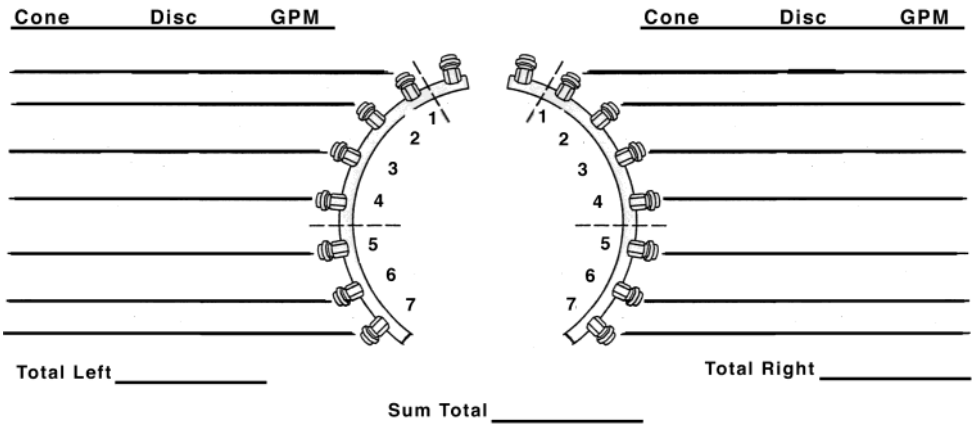
PHOTO: growingproduce.com



B. Nozzle output

Now we will check the nozzle output. This can be accomplished by:

a. Using a flow meter (obtainable from Gemplers, Spraying Systems, etc.) attached to individual nozzles **OR**

b. Connect hoses to each of the nozzles and measure the flow from each nozzle into calibrated jugs or measuring cylinders for one minute. *Remember, there are 128 fluid ounces in one gallon.

Example: If the output of one nozzle has been measured at 34.5 fl. Ounces, then output is divided by 128 = 0.27 GPM in one minute. You can use the above diagram when checking your nozzle outputs.

STEP 5: COMPARE OUTPUTS WITH THOSE YOU CALCULATED PREVIOUSLY AND MAKE ADJUSTMENTS

The nozzle output should be close to what you had calculated in step 3.

If your GPM doesn't match your target, you can use the following formula to determine your current GPA.

Formula: $\frac{\text{Total actual GPM X 495}}{\text{MPH x row spacing (ft)}}$ = Current actual GPA

If the nozzles' GPM are within 5% of your target, you can adjust your pressure or your speed to make small adjustments. Replace all nozzle tips which are more than 10% inaccurate. If more than 20% of the nozzles on the sprayer need replacing, you should replace all of them. Once replaced, recheck and recalculate to make sure you are achieving the correct GPA for your sprayer.

These steps were adapted from Dr. Andrew Lander's *Effective Orchard Spraying*, an excellent resource worth having on your bookshelf. It can be purchased online at effectivespraying.com.

CCE Harvest NY and Cornell Hard Cider Program Surveys

Cornell Cooperative Extension's Harvest NY team has partnered with the Cornell Hard Cider Program Work Team to study the production and distribution of hard cider in New York. As part of this supply chain study, the following surveys were developed to assess the demand for apples and juice by hard cider producers. This is the second hard cider supply chain study that we've undertaken. The results from the first study are available at: https://harvestny.cce.cornell.edu. Throughout this survey, we are only asking for information related to the fermented product made from apples, commonly called hard cider. **Please know that all data received through this survey will only be reported in the aggregate and that personal information about your business will not be shared with anyone outside of the core project team.** The survey should take about 20 minutes to complete. We ask that only one survey be completed for each business. The survey will remain open until March 31, 2019. If you have any questions about the survey, or the overall project, please feel free to reach out to Lindsey Pashow (lep67@cornell.edu; 518-569-3073).

Apple Grower: https://cornell.qualtrics.com/jfe/form/SV_bpcbJrtfufESoPr

Hard Cider Producer: https://cornell.qualtrics.com/jfe/form/SV_4GccxqJK4NxtO3X

Cornell University
New York State
Integrated Pest Management Program

Formidable Fruit Doyenne Earns Excellence in IPM Award

GENEVA NY, March 1, 2019: Dr. Juliet Carroll, Fruit IPM Coordinator, received an Excellence in Integrated Pest Management (IPM) Award from the New York State Integrated Pest Management Program (NYSIPM) at the Viticulture day of the B.E.V. (Business, Enology, Viticulture) conference in Rochester. NYSIPM develops sustainable ways to manage pests and helps people to use methods that minimize environmental, health and economic risks. The award honors individuals who encourage the adoption of IPM in their businesses, schools, communities, and farms, and who develop new tools and tactics for sharing these practices.

Vital. Invaluable. These are words used to describe Julie Carroll's IPM contributions by her colleagues. Carroll spearheaded the expansion of NEWA, a website and network which allows growers to understand how the weather will affect fungal and insect pests, and takes the guess work out of their pest management strategy. Carroll ran NEWA for over a decade. Timothy Weigle credits NEWA's growth in not only weather stations, but also the number of states participating, to Julie's guidance.

Under her leadership NEWA went from 45 weather stations in New York State to over 500 in 12 states. He notes further that her work on improving the user experience with the grape disease and grape berry moth models on NEWA, along with Wayne Wilcox and Greg Loeb, had an enormous impact on the implementation of grape IPM in New York.

Laura McDermott, Regional Extension Specialist in Hudson Falls, NY, noted Dr. Carroll's passion for integrating pest management strategies, and called her "a determined perfectionist."

Carroll also led the development of Trac software. Introduced in the early 2000s, the software simplified and digitized pesticide recordkeeping for large and small growers and processors alike. It allows farmers to input the information once, and generate customized reports for different processors. The software also includes reference to "IPM Elements" for grapes and other crops—a tool that helps growers assess their pest management practices. Grape processors across the state, including Constellation Brands, use TracGrape's reports for their pesticide reporting requirements. Carroll built Trac software for five fruit crops, and partnered with a colleague to create TracTurfgrass for golf, lawns, sports fields and sod farms.

Luke Haggerty, of Constellation Brands, calls Carroll's TracGrape software "a true breakthrough" in record keeping. As a Grower Relations rep for Constellation, he relies on information provided by NEWA: "Julie has always been very proactive in developing and delivering the products needed for our growers to produce grapes in an environmentally and economically sustainable way."

Tim Martinson, Cornell Cooperative Extension Viticulture specialist, noted, "IPM is built on information and decision-making tools. Juliet has built TracGrape and NEWA into useful, practical tools for growers."

Dr. Carroll also co-edited Organic Production and IPM Guides for grapes and several berry crops, and has regularly presented at Lake Erie Regional Grape Growers' conferences and Coffee Pot meetings. She has conducted research on devastating pests such as the Spotted Wing Drosophila (SWD) —investigating whether hungry hummingbirds can provide meaningful control. Dr. Carroll has also chaired the Northeast IPM SWD working groups for the last decade, bringing research scientists, growers, industry reps, and extension educators from across the region together to help find solutions.

Carroll has also helped fruit growers with bird management. Tim Weigle noted that her bird-scaring tactics have saved everyone a lot of money and are more popular than the traditional neighbor-alienating air cannon.

Learn more about Integrated Pest Management at nysipm.cornell.edu.

Upcoming Events

Preparing for a Juice HACCP Inspection

March 27, 2019 - 1:00pm-4:30pm
CCE Saratoga County, 50 West High Street, Ballston Spa, NY 12020

At this afternoon program, guest speakers Dr. Randy Worobo (Cornell Dept. of Food Science) and Dr. Omar Oyarzabal (University of Vermont Food safety Specialist) will review the key requirements of the Juice HACCP and its associated prerequisite programs. We will discuss federal and state requirements that are associated with cider line food safety in NY, a history of the programs, and will allow ample time for growers to ask questions on what to expect during their own Juice HACCP inspection.

Agenda

1:00pm - Introductions
1:10pm - Prerequisite Programs and Their History
2:10pm - Juice HACCP Regulation Requirements
2:40pm - What to Expect and How to Prepare for Your Inspection
3:15pm - Open Question and Answer Session
4:15pm - Wrap Up

Registration is $25 per farm, $15 if enrolled in ENYCHP.
Please register online by March 20th at https://bit.ly/2GtOmKK.

Cornell In-Depth Fruit School Program—'Precision Crop Load Management and Plant Growth Regulator Use in Apples'

March 26 & 27, 2019
DoubleTree by Hilton, Syracuse, NY 13057

The Cornell Fruit Team is pleased to announce an in-depth school for tree fruit growers, extension educators, and crop consultants. This meeting will be a 2-day intensive school focusing on precision crop load management and the applications of plant growth regulators in the orchard. The in-depth school will serve as a vehicle for fruit industry leaders to learn advances in precision orchard management and to catch a glimpse of the future use of computer vision and robotics to manage crop load precisely.

Participants should register for the in-depth school using the online registration form at: http://cals.cornell.edu/indepthschool2019. Deadline for registration is March 19, 2019.

An Intro to Tree Fruit IPM

April 3, 2019 - 1:00pm-3:30pm
CCE Clinton County, 6064 Route 22, Suite 5, Plattsburgh, NY 12901

Have employees that need recertification credits? We will be covering the basics of integrated pest management, including how to monitor traps, evaluate insect thresholds, and use prediction models to better manage common orchard pests of Northern New York.
We will also discuss IPM tactics for managing apple scab, fire blight, obliquebanded leafroller, apple maggot, and some common weeds in the orchard.

To register, visit: https://enych.cce.cornell.edu/event.php?id=1161

Questions? Call Mike Basedow at 518-410-6823

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