Fruit Notes

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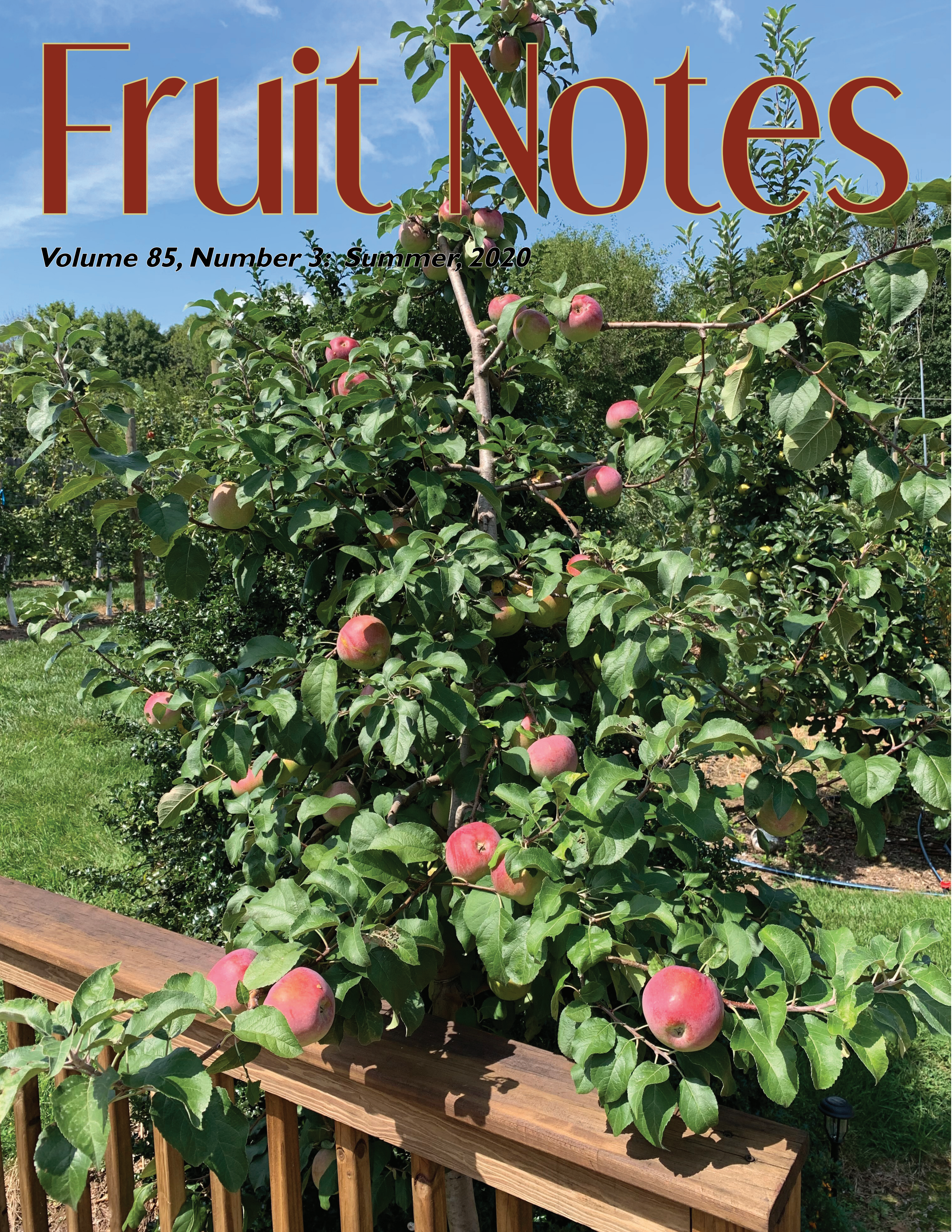

Fruit Notes

Editors: Wesley R. Autio & Winfred P. Cowgill, Jr.

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Table of Contents

Cover: A LindaMac on M.9 NAKBT337 ancors the deck at Editor Win Cowgill's orchard location in northern New Jersey, 2020. It is just about ready for Harvest! Photo: Win Cowgill.

Controlling Plum Curculio Adults and Larvae Using Odor-baited Trap Trees and Entomopathogenic Nematodes: Results from a Six-year Study

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Efforts to reduce insecticide inputs against plum curculio (PC) include perimeter-row insecticide sprays applied after the whole-orchard petal fall spray to manage dispersing adults and, more recently, post-petal fall insecticide sprays confined to odor-baited trap trees. Entomopathogenic nematodes (EPNs) can be applied to the ground underneath trap tree canopies to kill PC larvae. These two approaches may provide growers with the opportunity to reduce PC populations by killing both adults and larvae. To quantify the potential to manage this pest more sustainably in a reduced-spray environment, we conducted a 6-year study that aimed at addressing the following questions: (1) does the presence of a synergistic lure in trap trees consistently result in significant aggregation of fruit injury within these tree canopies compared to unbaited tree canopies? (2) can the orchard-wide injury by PC be maintained at economically acceptable levels under a reduced spray scenario involving the trap tree management strategy? (3) does the level of injury received by odor-baited trap trees extend to neighboring trees? and (4) are EPNs applied to the soil underneath trap trees effective at suppressing PC in multiple orchards over multiple years?

Materials & Methods

This investigation was conducted over a 6-year period (2013-2016, 2018-2019) in seven commercial orchards located in Massachusetts (Clark Brothers Orchards in Ashfield; Clarkdale Fruit Farms in Deerfield; University of Massachusetts Cold Spring Orchard in Belchertown), New Hampshire (Apple Hill Farm in Concord; Gould Hill Farm in Contoocook; Poverty Lane Orchards in Lebanon), and Vermont (Scott Farm in Dummerston). Not every orchard participated in this study on each year.

Study 1: Attract-and-kill using trap trees. For each participant orchard, we evaluated two treatments: (1) odor-baited trap tree management strategy; and (2) grower standard plots that received insecticide treatment as prescribed by the grower. Within each orchard, two experimental plots were established. One plot was randomly assigned to the trap tree treatment, and the second plot was selected for grower standard sprays. The average area of experimental plots was 3.6 and 2.8 acres for the trap tree and the grower standard plots, respectively. The same two plots within an orchard were used on each year, but the assignation of trap tree and grower standard treatments was switched on most years. All orchard plots received a full-block spray of insecticide (most commonly an organophosphate, an oxadiazine, or a neonicotinoid) by the time of petal fall. Subsequent sprays were applied to either, trap trees only in trap tree plots, or as prescribed by the growers in the grower standard plots.

During full bloom on each year, selected perimeter-row trap trees were baited with four benzaldehyde (BEN) dispensers and one PC pheromone (grandisoic acid = GA) dispenser. Each BEN dispenser was suspended inside of an inverted colored plastic drinking cup to minimize the potential negative impact of ultraviolet light on the stability of BEN. All BEN lures were left in place for the entire period of PC activity, while the GA lures were replaced once, typically 4 weeks after initial deployment. The distance between trap trees was 35 yards. On average, there were 3-4 trap trees per acre.

Treatment performance was assessed for each orchard by means of fruit injury evaluations conducted between 23 Jun and 5 July of each year. The total number of fruit with PC oviposition scars was recorded, based on a sample of 25 fruit/tree from trap trees in the trap tree plot and from unbaited (control) trap trees in the grower standard plot. To quantify the level of spillover to trees immediately adjacent to the odor-baited trap tree, 25 fruit per tree were sampled from six peripheral trees (three to the right and three to the left) next to the trap tree and the control trap tree (in the grower standard plot). To provide a measure of the efficacy of each treatment regime to protect interior-plot fruit from PC damage 20 interior trees (25 fruit/tree) were sampled within each plot. In all, 92,676 fruit were sampled across all years and orchards.

Study 2: Application of entomopathogenic nematodes (EPNs) against PC larvae in the soil. Here, we evaluated the efficacy of EPN application formulated in water targeting PC larvae in the soil. The performance of EPNs was compared against a water-only control. We used two approaches to measure the number of adult PCs emerging from the soil after EPN application. The first approach involved mini-plot cylindrical enclosures (Figure 1) made of PVC. The enclosures were buried to 7-8 inches deep. After EPN application (see below), a boll weevil trap, consisting of a green plastic cylindrical base, a molded screen cone and a collection chamber, was buried using each enclosure as a 'sleeve'. As they emerged, adult PCs were collected in the collection chamber. This type of

Figure 1. Depiction of the PVC enclosure (**left**) and pyramidal emergence cage (1 × 1 yards at the base) (**center**) used for the evaluation of entomopathogenic nematodes (EPNs) in the second study.

experimental arena was used in 2013, 2014, and 2015. The second approach consisted of pyramidal emergence cages (1 × 1 yards at the base) made of PVC and steel screen (Figure 1). One pyramidal emergence cage was placed underneath the canopy of each trap tree (the same tree used for the PVC enclosure). Emergence cages were used in 2013–2015, and 2018.

EPN treatments. We compared the performance of the EPN *Steinernema riobrave* at a rate of 100 IJs/cm^2 using one gallon of water against the same amount of water alone (control). For the 2013-2015 studies, EPNs were provided by Dr. Shapiro-Ilan (USDA-ARS) while for the 2018 study, EPNs were donated by BASF.

For the PVC enclosures, 30 fully-developed PC larvae were placed inside the enclosures 24 h prior to EPN application. For emergence pyramidal cages, approximately 75 PC-infested fruit were placed on the center of each caged area, 24 h before EPNs were applied, to allow the larvae to crawl in soil. After treatment application, the emergence cages were placed on the ground, covering the fruit, and the edges of the cages were buried in the soil to ensure the emerged adults would not escape. Each of the treatments (three nematode species) and the control were replicated five times. For both experiments, no additional water (except for natural precipitation) was added to the cages. Two weeks after EPN application, the number of adult PCs collected in the experimental arenas (PVC enclosures and emergence cages) was recorded on a weekly basis for four weeks. All insects were counted and removed from the capturing devices.

Results

Study 1: Attract-and-kill using trap trees. For the first question ("does the presence of the BEN+GA lure in trap trees consistently result in significant aggregation of fruit injury in these specific tree canopies compared with unbaited tree canopies?"), we found that the level of fruit injured by PC within the canopies of odor-baited trap trees ranged from 4.4% (in 2015) to 17.3% (in 2018) in trap tree plots. In contrast, in grower standard plots the level of injury on control (unbaited) trap trees ranged from 0.2% (in 2015) to 2.1% (in 2013). Across all six years, mean percent fruit injury was about eight times greater in trap trees (11.3%) than in control trees (1.4%) (Figure 2A).

The results generated to address question (2) ("can the orchard-wide injury by PC be maintained at economically acceptable levels under a reduced spray scenario involving the trap tree management strategy?" provided a measure of the efficacy of each treatment regime to protect interior-plot fruit. For each year, and

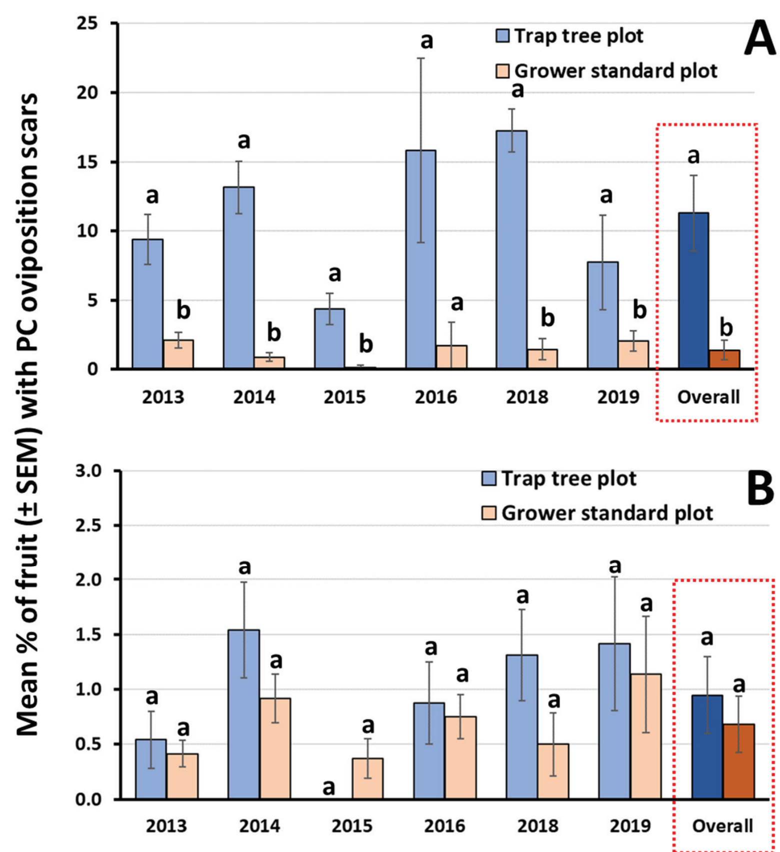

Figure 2. For each year and across all six years, level of fruit injury (mean ± standard error of the mean [= SEM], *a measure of how precise the estimate is*) caused by PC to (**A**) trap trees in trap tree plots and control (unbaited) trees in grower standard plots, and (**B**) interior trees according to treatment. Interior-tree injury is the strongest measure of treatment performance. Means within a panel and for each pair of bars capped with different letters are significantly different at odds of 19:1.

across all years, the mean percent injury in interior trees located in trap tree plots did not differ statistically from that recorded in plots subject to grower standard sprays (Figure 2B).

For the third question ("does the level of injury spill over to neighboring trees?"), across all years and orchards, the average level of injury caused by PC in odor-baited trap trees (11.3%) in trap tree plots was significantly greater than that recorded in any laterally located peripheral trees (3.7, 2.3 and 1.8%, for adjacent trees, and for trees located two away, and three away, respectively) (Figure 3). In contrast, in grower standard plots the level of injury recorded in the control tree (1.4% on average) did not differ statistically from that recorded in the most adjacent perimeter-row trees (1.2%) or in trees located further away (1.5 and 1.2% for trees located two away and three away, respectively) (Figure 3).

Study 2: EPN Application against PC larvae in the soil. The application of the EPN *S. riobrave* to the soil underneath trap trees consistently resulted in significant reductions in the number of summer-generation PC that emerged from the soil, when compared to the water control. In 2013, 2014, and 2015, significantly fewer adults were recovered from PVC enclosures that received *S. riobrave* compared to the water control (Figure 4A). For emergence cages, significantly fewer adult PCs were recovered when *S. riobrave* was applied when compared to the water control on each year, except for 2014 due to high variability among samples (Figure 4B).

Conclusions

The present study indicated that, over multiple years and locations (1) odor-baited trap trees consistently aggregated fruit injury by PC; (2) insecticide sprays confined to trap trees only after the petal fall spray resulted in similar level of fruit injury in interior trees, compared to plots that received grower-prescribed sprays; (3) small spillover effects were noted in trap tree plots involving the trees most adjacent proximal to odor-baited trap trees; and (4) the EPNs *S. riobrave* was consistently effective at killing PC larvae. The economic feasibility of using EPNs applied underneath the canopies of trap trees is very promising because, even if high rates of nematodes are applied, such applications would only need to be made to a small proportion of the acreage.

Overall, this study supports a reduced-spray IPM program that integrates the use of synergistic lures and insecticide applications to the canopies of baited trees to kill adult PCs, and one timely EPN application in the areas underneath trap trees, to kill PC larvae.

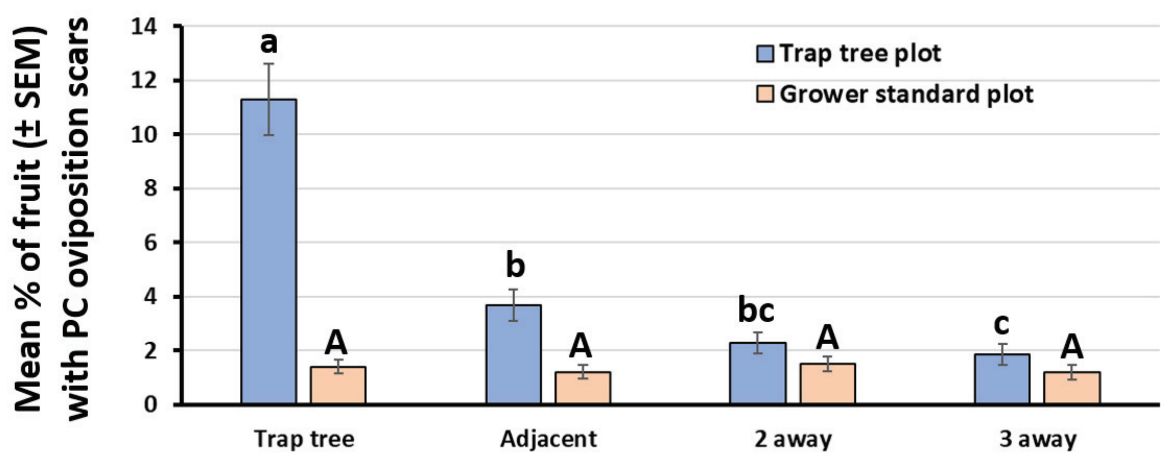

Figure 3. For the quantification of potential spillover effect, level of PC injury (mean ± standard error of the mean [= SEM], *a measure of how precise the estimate is*) to fruit sampled from odor-baited trap trees in trap tree plots, from control (unbaited) trees in grower standard plots, and from peripherally located neighboring trees. For each treatment, bars capped with different letters are significantly different at odds 19:1.

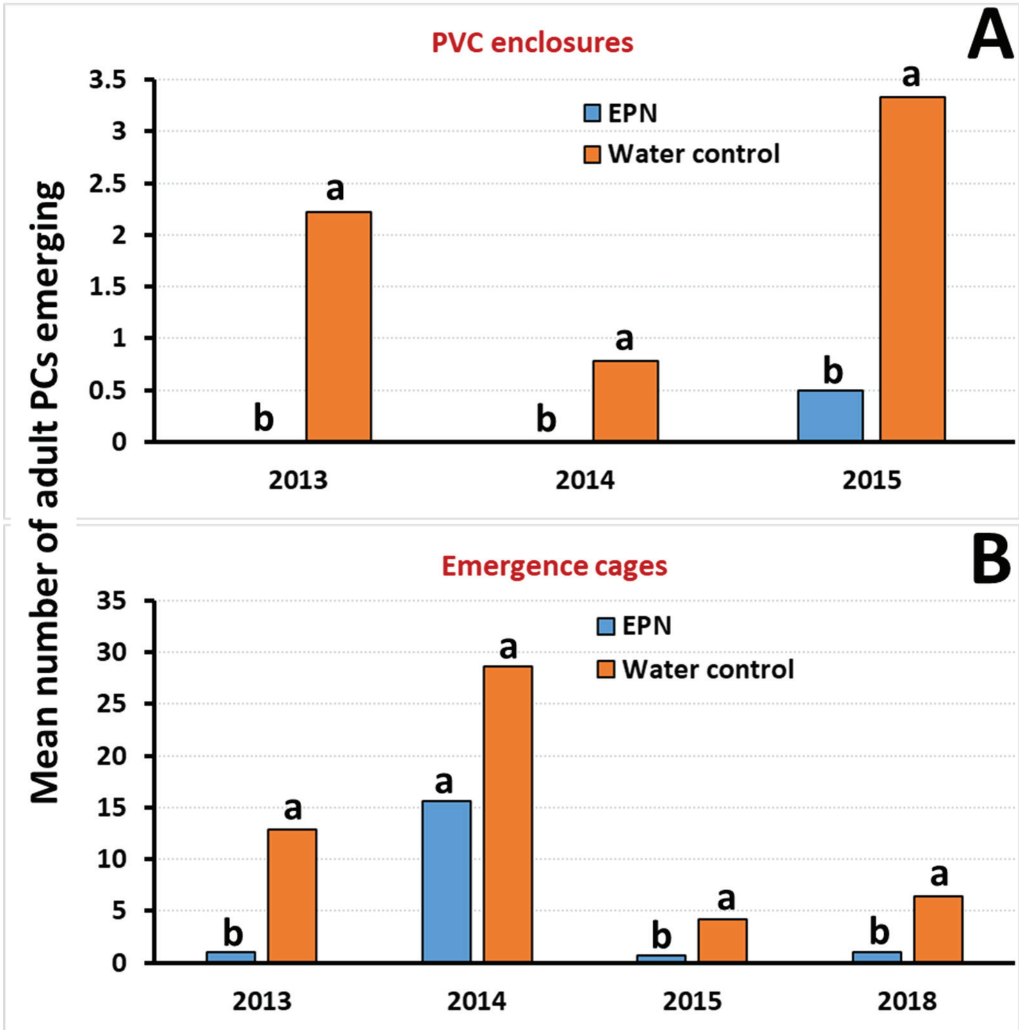

Figure 4. For each year, cumulative number of adult PCs that emerged from the soil in the trapping devices (PVC enclosures and emergence cages) according to treatment (EPN *Steinernema riobrave* versus water control). The lower the number of PCs emerging, the most effective EPNs were when compared to water control. For each year, bars capped with different letters are significantly different at odds 19:1.

Acknowledgments

We express our gratitude to the following apple growers and University orchard staff for kindly letting us use their orchard blocks: Aaron and Dana Clark, Tom and Ben Clark, Shawn McIntire (in MA), Steve Wood and Chuck Souther (in NH), and Ezekiel Goodband and Glen Schreiter (in VT). We appreciate the donation of *S. riobrave* (Nemasys® R) by BASF, Inc.

2015 Modi Organic NC-140 Apple Rootstock Trial and Drapenet Demonstration

Jon Clements, Elizabeth Garofalo, and Wesley Autio
University of Massachusetts

This NC-140 (http://nc140.org) rootstock planting in a commercial "Certified Naturally Grown" (CNG, https://www.cngfarming.org/) orchard gets more disappointing every year. In 2019, now in its fifth-leaf, more trees are dying or failing, and fruit quality and yield in 2019 was pretty abysmal. It is unclear if low fruit set and yields are a result of pollination issues or the "organic" management regimen. In 2018, there were virtually no apples, but the entire rest of the CNG orchard was light too. In 2019, the CNG orchard had a good crop, but these Modi trees had a light to moderate crop (at best) of apples. Another problem was the amount of insect damage, mostly plum curculio and internal Lepidoptera worms (codling moth or Oriental fruit moth), which made the CNG apples quite deformed and small in size. Weed control and fertilization remain organic orchard issues. Our take home to date is that G.890, because of its vigor, is a good choice for organic orchards, although G.30, G.202, and G.41 are acceptable also (maybe throw G.969 and G.214 in the ring). G.16 is not right in this planting, and M.9 has under-performed. G.935 has some issues, and we are wondering if it is a virus/rootstock/scion interaction? Liberty trees on G.935 planted between replications and as guard trees have all died. Marssonina leaf spot was confirmed in September, and has been causing early defoliation of these Modi trees. Results of tree measurement and fruit yield are presented in Table 1 and Figure 1.

In 2019 a Drapenet (https://drapenetnorthamerica.com/) was installed over replications 1-6 (and not 7-12, there are two rows), the primary objective being to see if insect damage could be reduced (there was a lot of hail around in 2019). The Drapenet was installed on May 19, 2020 during late bloom, and was secured to the bottom wire with plastic wire ties. (Figure 2) Inspection of the apples in late June showed that the Drapenet was inef-

Table 1. Tree and yield characteristics in 2019 of Modi apple trees in the 2015 NC-140 Organic Apple Rootstock Trial in a Certified Naturally Grown orchard.

Rootstock	Trunk cross-sectional area (2019, cm^2)	Tree height (m)	Canopy spread (m)	Yield per tree (2019, kg)	Cumulative yield per tree (2016-19, kg)	Yield efficiency (2019, kg/cm^2)	Cumulative yield efficiency (2016-19, kg/cm^2)	Fruit weight (2019, g)
G.11	6.3 cdef	2.7 bc	1.5 bc	0.7 abc	1.4 abc	0.11 a	0.30 ab	102 a
G.16	3.5 f	2.4 c	1.1 cd	0.4 bc	0.5 c	0.11 a	0.17 b	94 a
G.30	8.5 bc	2.9 b	1.5 bc	0.8 abc	1.9 abc	0.09 a	0.38 ab	111 a
G.41	8.0 bcd	2.7 bc	1.3 bcd	0.6 bc	1.8 abc	0.07 a	0.32 ab	115 a
G.202	9.5 b	2.7 bc	1.5 b	0.5 bc	1.7 abc	0.05 a	0.27 b	114 a
G.214	6.9 cde	2.9 b	1.4 bc	1.0 ab	1.8 abc	0.14 a	0.36 ab	97 a
G.222	4.5 ef	2.5 bc	1.1 cd	0.3 bc	1.1 abc	0.09 a	0.41 ab	102 a
G.890	14.1 a	3.3 a	2.0 a	1.3 a	2.3 ab	0.09 a	0.23 b	119 a
G.935	5.6 def	2.4 c	1.2 bcd	0.4 bc	1.9 abc	0.06 a	0.44 ab	109 a
G.969	6.4 cde	2.7 bc	1.3 bcd	0.7 abc	2.4 a	0.11 a	0.56 a	104 a
M.9 NAKBT337	4.6 ef	2.4 c	1.0 d	0.2 c	0.7 bc	0.04 a	0.22 b	101 a

Mean separation within columns by Tukey's HSD (*P=0.05*).

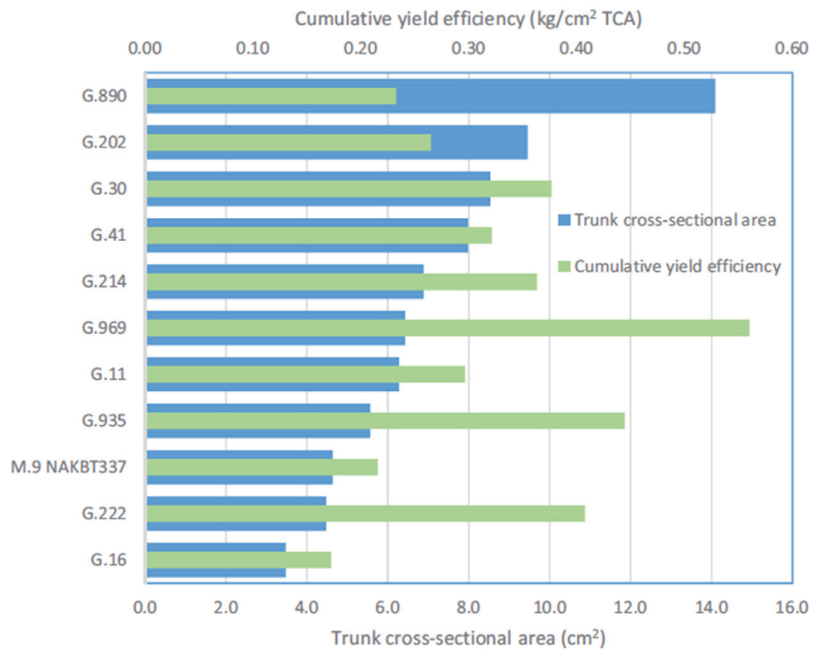

Figure 1. Trunk cross-sectional area (square centimeter trunk area)) and cumulative yield efficiency (2017-19, kg. apples per square centimeter trunk area) in 2019 of Modi apple trees in the 2015 NC-140 Organic Apple Rootstock Trial.

fective at preventing plum curculio damage; however, a more formal harvest survey of 100 fruit per treatment (covered with Drapenet vs. uncovered) for damage showed that internal worms, most likely caused by codling moth or Oriental fruit moth, were greater in the uncovered (35% damage) vs. covered (12% damage) replications. As already mentioned, plum curculio damage was greater in covered (80% damage) vs. uncovered (51% damage). See Figure 3 for an example of what the Modi apples looked like at harvest in terms of insect damage. Interestingly, the incidence of apple maggot fly injury was also greater in the covered (26%) vs. uncovered (5%) apples. Sooty blotch and flyspeck were also greater in the Drapenet apples (59% for sooty

Figure 2. Installation of Drapenet on 15-May, 2019 over Modi apple trees in the 2015 NC-140 Organic Apple Rootstock Trial in a CNG orchard.

Figure 3. Typical insect damage (and russet, September 2019) on Modi grown in a CNG orchard, including plum curculio, Oriental fruit and codling moth, and apple maggot fly.

blotch, 21% for flyspeck) than the uncovered apples (19% for sooty blotch and 12% for flyspeck). Note that at the UMass Orchard, Modi performs just fine, and in fact, was one of the most beautiful apple crops I have ever seen (Figure 4).

These results are just investigatory, as the covered vs. uncovered was not randomized and replicated for statistical analysis. But a recent article in Fruit Quarterly (http://nyshs.org/fruit-quarterly/) also showed (research conducted at Michigan State University) that Drapenet is effective at reducing/minimizing flying moth damage (codling moth, Oriental fruit moth, oblique-banded leafroller).

Note that Modi is not available to apple growers outside of a California packing house (https://modiappleusa.com/). It was bred in Italy, a cross of Gala X Liberty and is scab-resistant. It has been marketed in Europe as an enviro-friendly apple (http://www.modiapple.com/about-us).

Figure 4. Modi apple conventionally grown at the University of Massachusetts Cold Spring Orchard, Belchertown, MA, September 2019.

‘OrchardWatch’ Weather Monitoring Grid at UMass Cold Spring Orchard

Jon Clements, Jim Krupa, Paul O’Connor, Lyndsey Ware, and Daniel Cooley
University of Massachusetts

‘OrchardWatch’ is our vision to use remote sensors in an effort to gather as much environmental and visual data as possible at the UMass Orchard in Belchertown, MA. While we, and many growers, collect weather data to help manage orchards and other crops, it is usually limited to a single site on a farm. As a result, pest management and other decisions are made based on what’s happening at that weather station. Conditions around an orchard may be quite different from that one site. For example, a block surrounded by trees may have a longer wetting period than one on the top of an open hill because it takes longer to dry. This may make a difference in terms of managing apple scab and other diseases. Another scenario: degree days may vary significantly enough that insect development will also be slower or faster in different blocks. In general, we are asking the question, do environmental conditions vary enough from place to place that management decisions could be made targeting relatively small sections of an orchard, rather than the whole farm or large blocks?

This is basically what precision agriculture does, treating relatively small parts of a farm individually based on differences in things such as soil texture and fertility. However, much of the effort to develop precision ag methods has been focused on large agronomic crops and the large farms that grow them, rather than so-called “specialty crops”, including apples and other fruit, grown on smaller farms. We want to explore whether it’s feasible to use precision agriculture, particularly for pest management, in New England orchards.

In order to figure it out, we have installed a total of nine “weather stations” over the past 8 months (September 2019 through April 2020) using Onset Computer Corporation hardware and their Hobolink software to monitor “weather” conditions across 50 acres of the UMass Orchard. (Special thanks to Jim Krupa, Research Technician, for assistance with all the installations.) We are calling this our “Weather Monitoring Grid”, a major component of a larger project, OrchardWatch. OrchardWatch involves significant web-based communication and data collection which can be shared between researchers, growers

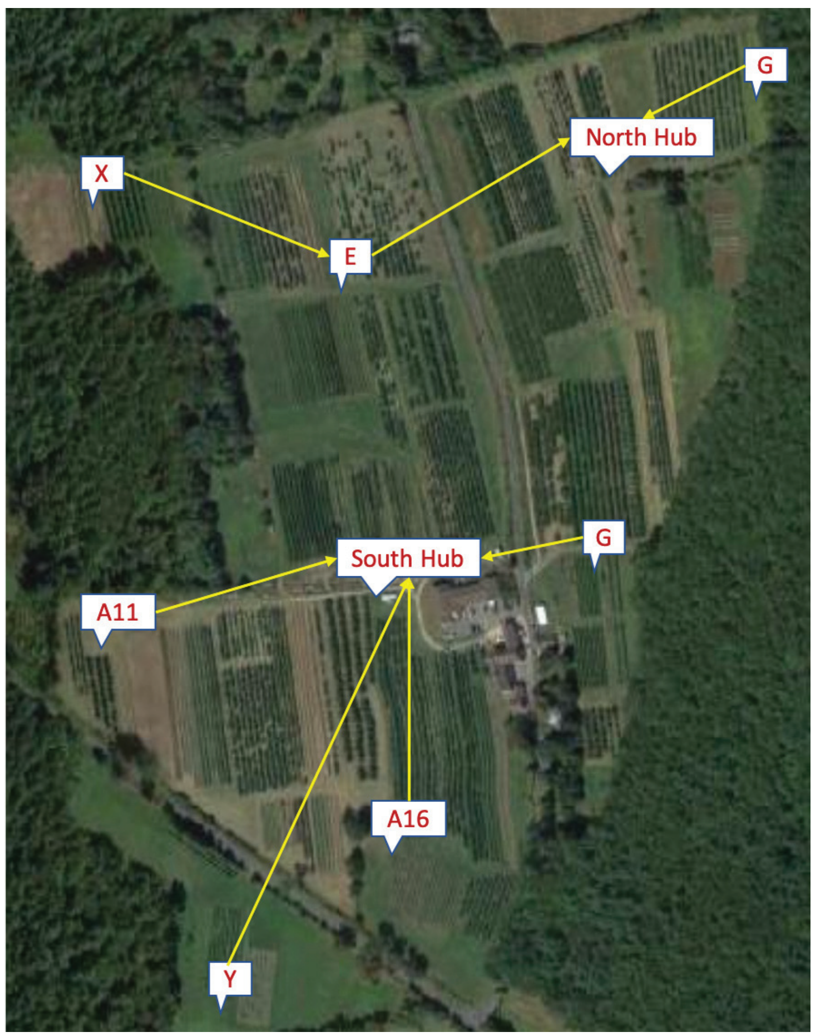

Figure 1. Orchard Watch Weather Monitoring Grid at UMass Cold Spring Orchard, Belchertown, MA.

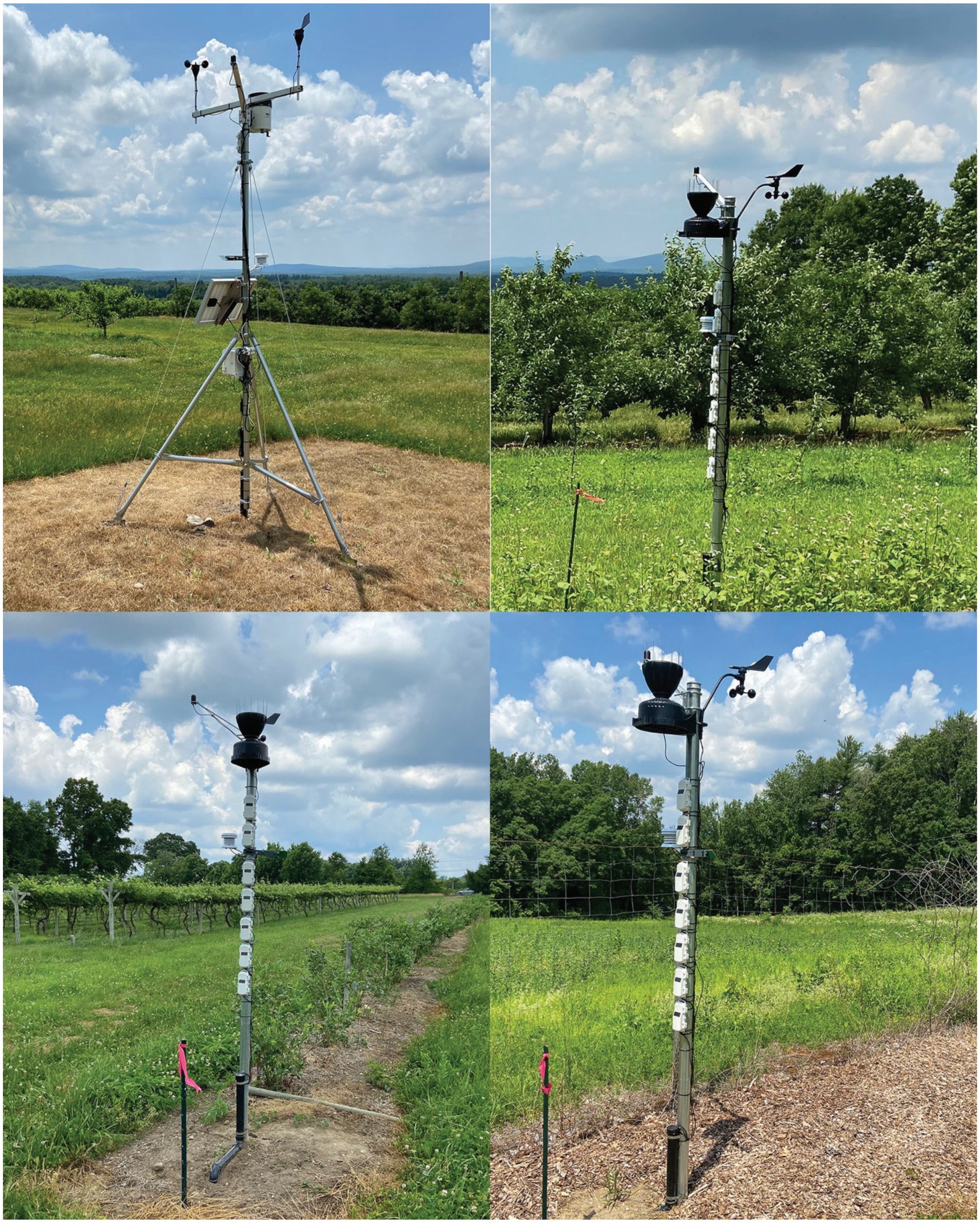

Figure 2. Four sites at the UMass Cold Spring Orchard showing the Onset RX3000 base station (North Hub, top left), and three different remote stations or "motes" (G, top right; Y, bottom left; X, bottom right).

and the public. The Weather Monitoring Grid consists of two Onset RX3000 logging base stations dubbed "OrchardWatch-North" and "OrchardWatch-South", plus seven Onset Hobonet Field Monitoring System "motes." The nine sensor locations vary in terms of elevation, surrounding terrain and the type of trees, and other crops, being grown. For example, one mote is at the highest point in the orchard surrounded by newly planted trees, and another is at one of the lowest areas with mature trees surrounded on three sides by woods.

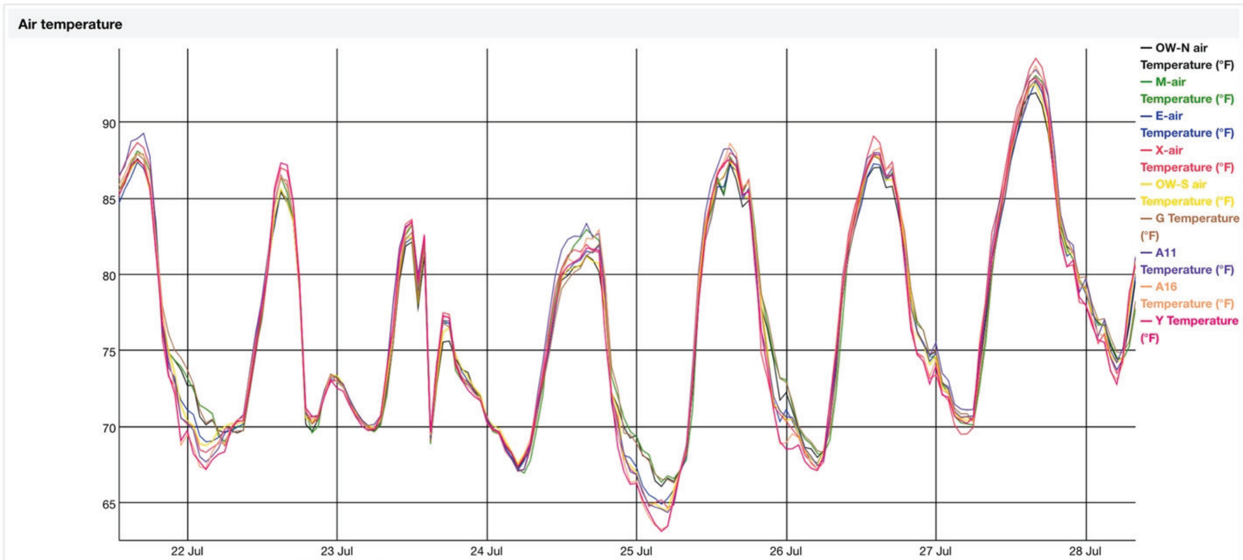

Figure 3. OrchardWatch-Air Temperature for 7 days. Note that there is not a lot of difference in air temperature over time by orchard location. The highest temperatures by site (July 27) ranged from 92.9 to 95.3 F; the lowest temperature (July 25) ranged from 62.7 to 66.2 F. Degree days base 50 F accumulated over the 7 days was very uniform, ranging from 535 to 540.

At each of the nine locations, the Weather Monitoring Grid measures the following environmental conditions:

- Air temperature, relative humidity and dew point at six feet (degrees F.)
- Rainfall (inches)
- Wetness (%)
- Solar radiation (W/m2)
- Wind speed (including gusts) and direction
- Soil temperature (degrees F.)
- Soil moisture (volumetric, m3/m3)

These weather data are logged every 5 minutes and reported to the Hobolink cloud service (hobolink.com) every 10 minutes via cellular data transmission.

We have begun to compare the measurements from the different sites. A very preliminary analysis shows that for air temperature, there isn't much variability between sites. For seven days at the end of July 2020, the average temperature was less than 1ºF, ranging from 76.4 to 77.1ºF. Accumulated degree days base 50ºF, useful for predicting insect development, had virtually no differences, ranging from 535 to 540. On the other hand, soil moisture varied significantly. One site, A11, was particularly dry, with soil moisture content usually below 20%. At the other extreme, sites E and the South Hub were above 40% for most of the week. We will continue to analyze different data with the general goal of determining whether management decisions in different parts of the orchard might differ.

The Hobolink site provides public data access: OrchardWatch-South: https://hobolink.com/p/28ce970fb2430a7eb547758bc6f4aa95 OrchardWatch-North: https://hobolink.com/p/bd2fa7ebce71003581f2f184ee0b6c12

We have also launched an OrchardWatch website at orchardwatch.wordpress.com with links to the data.

Both the North and South sites are also on NEWA, the Network for Environment & Weather Applications: http://newa.cornell.edu/index.php?page=weather-station-page&WeatherStation=ma_beow
http://newa.cornell.edu/index.php?page=weather-station-page&WeatherStation=ma_bown

Future plans include installing cameras at each location to capture real time orchard phenology and sky conditions. Cameras might even be able to see pest activity as if one were actually scouting in the orchard. We will investigate machine learning and statistical analysis tools to help develop and improve upon various models such as disease, pest pressure, tree growth and health, etc.

For more information and/or to request weather data, contact Jon Clements (jmcext@umass.edu), Daniel Cooley (dcooley@umass.edu), or Paul O'Connor (proconnor@umass.edu).

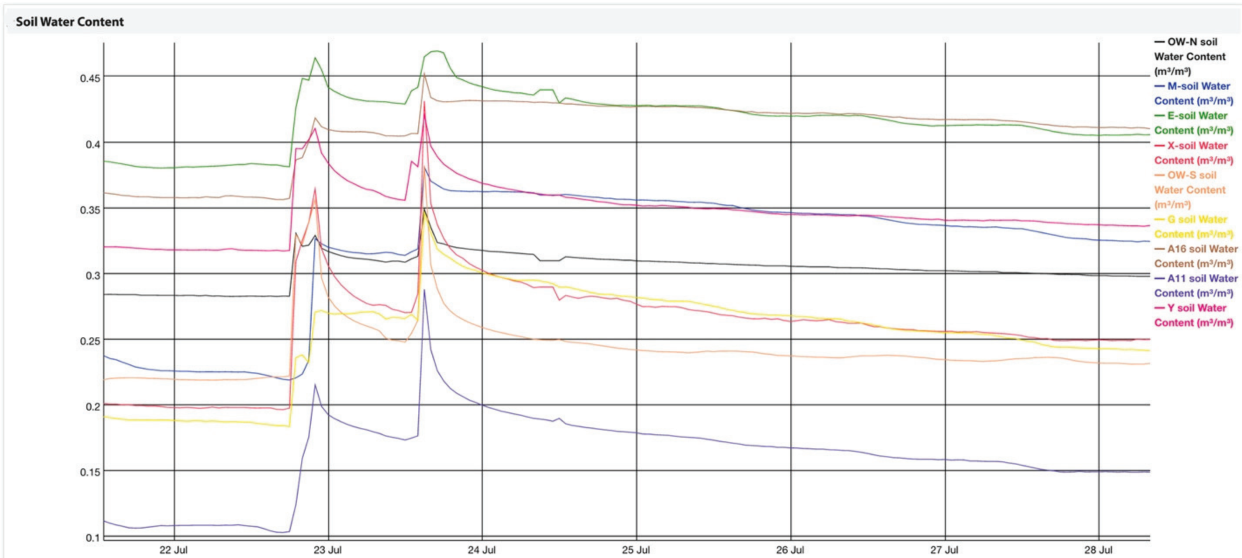

Figure 4. OrchardWatch-Soil Moisture Content for 7 days. Soil moisture (water content) varies considerably over time by orchard location. It is dry at A11, generally below 20%, and initially near 10%. At E, soil moisture is high, generally over 40%.

Acknowledgements

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Controlling Bitter Rot in Apple

Win Cowgill
Professor Emeritus Rutgers, Win Enterprises International, LLC

Bitter rot is showing up a lot this season/recently, with regular rainfall in NJ and hot temperatures across the Northeast. Bitter rot is caused by the fungi, *Colletotrichum gloeosporiodes, C. acutatum* and *Glomerella cingulata*. *Colletotrichum gloeosporioides* and *C. acutatum* are the same pathogenic fungi that cause anthracnose fruit rot on strawberry and blueberry, ripe rot on grape, and anthracnose disease on peach. Note that on apple, the skin does not need to be broken for the fungi to enter; however, it often occurs on the fruit exposed to the sun, and is linked to some level of sunburn that has occurred. Honeycrisp is the most susceptible cultivar, followed by Empire. Other varieties susceptible to sunburn are at risk as well.

The fungus *Glomerella cingulata* can also cause a leaf spot/leaf crop and canker on apple, which was an issue in some north Jersey orchards last year, particularly on cultivars with golden delicious parentage, i.e. Golden Delicious, Pink Lady, Pristine. See Horticulture News (http://www.horticulturalnews.org/99-2/a4.pdf) or Fruit Notes (http://umassfruitnotes.com/v84n2/a4.pdf), Spring, 2019.

Control. The best controls are to prevent fruit sunburn with one of the protectant sunburn materials; Raynox is best, but the calcium carbonate materials like Pure Shade can help. A regular fungicide program including a protectant like Captan or Ziram + pyraclostrobin has been the most effective. Captan 80WDG should be applied at at least 2.5 lbs./A, with 3-5 lbs./A being better. Watch out for temperatures over 85F with higher Captan rates. Combine with pyraclostrobin (Merivon or Pristine) and phosphoric acid (ProPhyte or others). In the early season, start with Mancozeb at 3lbs./A + phosphoric acid, Merivon, or Pristine. Then switch to Captan, or use Ziram closer to harvest if Captan residue is a concern. See Also: New Considerations for Controlling Bitter Rot on Apples by Dave Rosenberger (http://blogs.cornell.edu/

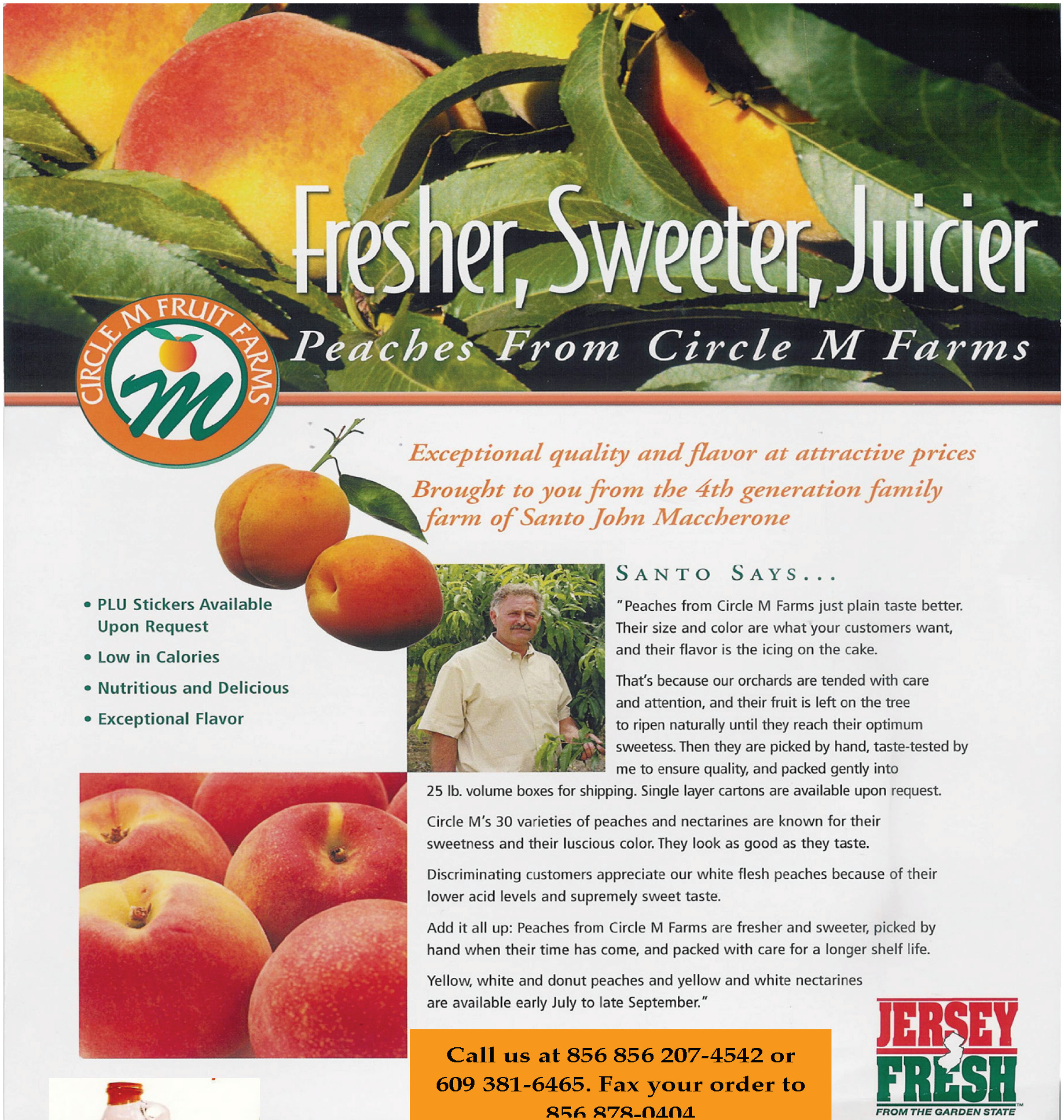
Photo 1. Bitter Rot with some bitter pit.

Photo 2. Bitter rot on apple.

Photo 3. Pruned twigs harboring decay fungi.

plantpathhvl/2017/01/20/). This article (http://blogs.cornell.edu/plantpathhvl/2020/03/29/spring-clean-up-for-orchards/) was published July 10, 2017 in Scaffolds Fruit Journal.

Post-harvest/Early-season Control of Bitter Rot. This information is from Scaffolds Fruit Journal, March 23, 2020. In blocks where bitter rot was a problem last year, remove all fallen fruit, fruit mummies, and pruned twigs from beneath trees and either dispose of them away from the orchard or flail- chop them in row middles to break them down for more rapid decay. Rotted fruit left on the orchard floor over winter have been recognized as inoculum sources since 1903 (Schrenk and Spaulding 1903; also see http://blogs.cornell.edu/plantpathhvl/apple-diseases/summer-diseases/bitter-rot/). Twigs pruned from trees last summer or this spring can be colonized by the bitter rot pathogens. Those colonized twigs may produce inoculum for fruit decay in summer.



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