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Introduction to irrigation of small fruits using sensor technologies under humid conditions

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Inherent to the southeastern United States, rainfall in hot-humid climates is highly variable in both frequency and duration. In Louisiana, historical rainfall averages 1,350 – 1,700 mm (53 – 67 inches) annually with most dry periods expected during the summer months (Sohoulande et al., 2021). However, historical patterns may not fit actual conditions in any given year (Figure 1). This unpredictability can impact the growth and quality of small fruits due to either abundant or elusive availability of soil water during critical portions of the crop season. For example, blueberries generally require water during berry swell, fruit set, and through harvest (Lamont, Jr. et al., 2001), which typically occurs throughout May and June, depending on variety (Cambre and Sharpe, 2018). Complicating this issue, high quality freshwater resources typically used for agricultural irrigation have become increasingly difficult to access economically. Thus, we must work toward monitoring the soil water status during critical growth stages and only apply irrigation when necessary.

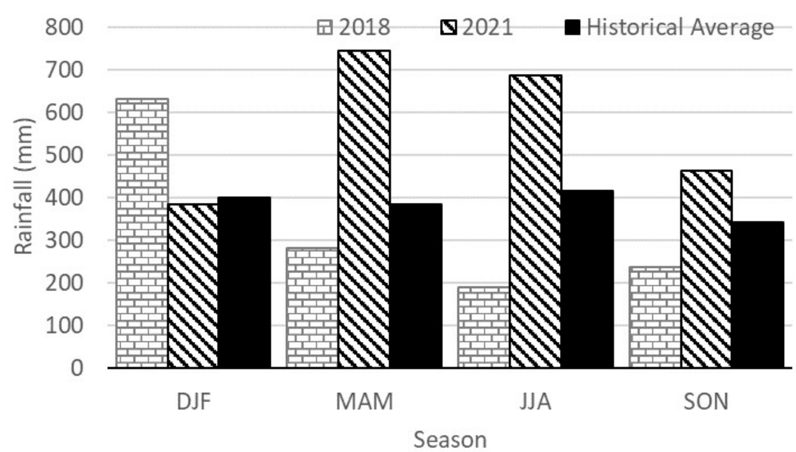

Figure 1. Seasonal precipitation totals for a dry year (2018), wet year (2021), and the historical average for Alexandria, LA. DJF = December, January, February; MAM = March, April, May; JJA = June, July, August; SON = September, October, November

Over the years, the irrigation industry has embraced technological advancements including products that aid in making irrigation decisions. Soil moisture sensors are one such technology that can provide real time feedback on soil water status in the root zone. Further, sensor data can act as the irrigator's eyes below the soil surface and provide insight into root growth, soil structural conditions, and overall plant health. This data is especially advantageous when physiological damage can occur before visual cues of water stress emerge in the above-ground plant material. Water stress can lead to various consequences including reductions in vegetative growth, flowering, fruit size, yield, and quality of yield (El-Farhan and Pritts, 1997). Sensors can estimate soil moisture differently, but most research has utilized soil water potential (SWP) sensors in production systems for small fruits.

The SWP represents the energy that must be exerted by the plant to overcome the forces that hold the water in the soil profile and is measured in units of pressure (e.g., kPa, cb). Though not a sensor, the original product used to measure SWP for irrigation is the tensiometer (Figure 2). These devices consist of a water-filled tube under vacuum, clay porous tip buried to the appropriate root zone depth, and a pressure gage maintained above the soil surface. As the soil dries over time, water is pulled from the tube through the clay tip resulting in an increase in negative pressure. The critical water levels for irrigation are saturation, field capacity, and permanent wilting point, which measure 0 kPa, -10 kPa, and -1,500 kPa, respectively. However, the irrigation threshold is specific to the plant material and dependent on criticality. In California, optimal irrigation occurred at an irrigation threshold of −10 kPa in open-field strawberry production systems (Gendron et al., 2018). Similarly, maximum yield was obtained at a threshold of -10 kPa, but fruits per plant and fresh weight per fruit were reduced when irrigating at thresholds of -30 kPa, -50 kPa, and -70 kPa in Spain (Serrano et al., 1992). Comparatively, blueberries can tolerate longer drought periods than strawberries, but should be irrigated well before reaching the critical water potential, which is achieved at full stomatal closure and varies based on variety (Davies and Johnson, 1982). The sensor version of the tensiometer is called a granular matrix sensor, soil water potential sensor, or soil matric potential sensor depending on the manufacturer; sensors are advantageous to tensiometers due to reduced maintenance needs during the growing season and automatic sub-daily data collection that reduces the burden of frequent manual data collection during critical growth stages.

Proper placement within the field and within the bed are critical to collecting good information for making irrigation decisions. All sensors should be installed in a representative portion of the field, away from edge effects, and easily accessible for recording or downloading data. Loggers equipped with telecommunication capability should be considered in situations where access during the growing season may be difficult. At least one sensor should be placed near the root ball of the plant, where most of the water is accessed, when irrigation decisions are the only purpose. If tracking water movement within the soil, multiple sensors can be installed at different depths and portions of the plant bed for a more dynamic perspective. For example, adding an additional sensor below the root ball can indicate when to cease an irrigation application to minimize overwatering. If soils have high sand content, a volumetric water content (VWC) sensor may be more appropriate, but can increase the complexity, applicability, and cost.

Irrigation decisions made using soil moisture sensors can result in higher yields, better quality fruit, and lowered production costs due to more informed water management practices. In some cases, the investment costs associated with purchasing sensors are returned within one season due to yield representing the largest driver of cost effectiveness (Gendron et al., 2018). Although many studies have been conducted on irrigation water requirements of various small fruits, there are still many varietal and environmental factors affecting irrigation strategies that should be explored. Additionally, future research should focus on addressing possible adoption barriers such as gaining confidence in trying new technologies, building trust in the sensor data, and developing strategies for adjusting management styles.

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Different Types of High Tunnel Plastic Covers Affect Raspberry Performance and Pests in a Containerized System

Kathy Demchak, Matt Cooper, and Rich Marini (Penn State University); Maria Cramer (Univ. of Maryland, formerly Penn State)

High tunnels are widely used for raspberry production in much of the world, and it is easy to understand why. The longer growing season, increased yields and improved quality, and the ability to schedule tasks without concerns, for example, the occurrence of rain changing plans make tunnel production appealing. Growers also often cite improved fruit appearance as a reason for growing raspberries in high tunnels (Figure 1).

Figure 1. 'Polka' red raspberry in a high tunnel.

From 2015 to 2019, a trial was conducted at Penn State as part of a large SCRI project "Optimizing the Protected Culture Environment for Berry Crops", led by Eric Hanson at MSU. This part of the project looked at high tunnel production of raspberries and strawberries with the goal of determining whether plastic-type affected yield and pest complexes (Figure 2).

Figure 2. Tunnels used for this part of the project were research-sized single-bay ones (17' x 36').

How Do Plastic Covers Differ? Plastic films used on high tunnels are typically 6-mil thick, and are categorized as "clear" or "diffuse". Clear plastics scatter light less, and diffusing plastics scatter light more. In specification sheets for plastics, this is often referred to as "clarity" vs. "haze". With a diffusing plastic film, light should be spread more evenly throughout the tunnel and the plant canopy, theoretically making better use of available sunlight and decreasing sunburn (Figure 3). You also may see references to "light transmission", or "light transmissivity". This describes how much visible light (which also covers the range of wavelengths that plants use for photosynthesis) passes through the plastic film. With a new plastic cover, 85-90% transmission is common for the majority of clear and diffusing plastics. You'll also see references made to the plastic films being either "UV-blocking", or "UV-stabilized". UV light breaks plastic down without additives to protect it. If a UV-blocker is used, UV light is prevented from passing through the plastic, much like a UV-blocking sunscreen would work. If the plastic is UV-stabilized, the plastic contains an additive that prevents the plastic's chemical bonds from being broken down, but most of the UV light still passes through. This is what allows a high tunnel film to typically have a 4-year life, rather than becoming brittle and falling apart. Then there are "IR" films, which partially prevent the wavelengths that we feel as heat from entering the tunnel during the day and being emitted at night. And finally, there are AD (anti-drip), and AC (anti-condensate) film additives or coatings, which keep water droplets from condensing and coalescing on the plastic in large droplets and falling onto your plants. With most films, there is no "inside" or "outside" to the film, so it doesn't matter if it gets flipped, but sometimes it does make a difference if there is a coating. This will be marked on the plastic itself. Plastics can vary in their pricing, though we found that there were bigger price differences between different suppliers of the same plastic type rather than between different plastics. Shipping costs can easily add another 50% to the cost of a plastic.

Figure 3. The plastic cover on the left is KoolLite Plus, which is a diffusing plastic that blocks some wavelengths from entering the tunnel, and the one on the right is Tufflite IV, a clear plastic with high light transmission. Note the differences in how light is reflected and what you can see through the plastic.

Plastics Trialed. We first screened over 50 plastics available to growers in North America for their light transmittance characteristics and picked three commercially available ones that were different from each other in visible, IR, and UV light transmission and two experimental films. Commercially-available films chosen were Berry Plastics Tufflite IVTM (TIV), RKW-Klerks KoolLite Plus (KLP), and Ginegar Sunsaver (GSS). The two experimental films, (UV-T and UV-O) differed only in UV transmission and were included in a study on Japanese beetle. Of these films, all were highly diffusing except for TIV. All transmitted about 85-90% of the visible light, except for

KLP which transmitted about 70%. KLP also blocked some IR light, keeping tunnels cooler during the day compared to other plastics and warmer at night. TIV and UVT transmitted about 80% of UV-A and UV-B light, KLP blocked UV-B light but allowed most of the UV-A through, and GSS blocked some of both. UV-O blocked nearly all UV light. Three tunnels were covered with each plastic, plus three were left uncovered. Cover treatments were arranged in a randomized complete block design.

'Josephine' and 'Polka' raspberry plants (12 per plot) were grown in soilless media in growbags to avoid confusing differences from plastics with differences from variation in soil nutrients in each tunnel. Bags were 3-gallon at first, but plants were repotted into 5-gallon bags after the first winter. The media was an unamended 2:1 peat:perlite mix and plants were grown in a constant-feed system using 20-7-20 soluble fertilizer for high bicarbonate waters at 100 ppm N. This worked well for our climate and our water source, but other systems may work better in other locations. Plants remained in the tunnels for the winter of 2016-17 and were overwintered by being laid down and covered with row covers, but started growing too early in the spring. Thus, they were moved into the lower level of an unheated bank barn for the following winter. This impacted differences in first date of harvest in the subsequent years. In 2017, harvest began on May 26 in all tunnels except for those covered with KLP for 'Josephine', where harvest began on May 30, while harvest for plants with no cover began nearly a month later on June 23. Harvest ended on Nov. 8 for all treatments in 2017, even for plants with no cover. In 2018, harvest started on June 13 for 'Polka' in tunnels covered with any type of plastic, but for 'Josephine' started June 13 under TIV, June 15 under GSS, and June 20 under KLP. Harvest of plants under no cover started June 15 for 'Polka' and June 20 for 'Josephine'. Harvest ended on Oct. 25 for plants with no cover, and Nov. 19 for plants in tunnels in 2018. In both years, plants were harvested 3 times per week through the first week of September and twice per week thereafter.

What did we think would happen? Raspberries prefer cool to moderate temperatures and since tunnels can get quite hot during the summer, our theory was that plants in tunnels covered with KLP might perform best. Though visible light levels were lower under KLP, raspberry plants reach "light saturation" at fairly low light levels, so we thought this might make little difference. We also thought that TIV-covered tunnels might be too hot and plants in them would yield less.

What actually happened? In a nutshell, the opposite of what we thought. Total yields were highest in tunnels that were the warmest during the day (covered by Tufflite IV), and lowest in those that were the coolest (covered by KoolLite Plus). 'Josephine' produced total yields 23% higher, and Polka, yields that were 11% higher in tunnels covered with TIV than with KLP. Yields in tunnels covered with Ginegar Sunsaver were intermediate. On two dates in early Sept. 2018 when it was very hot though, there was a larger proportion of 'Polka' fruit showing symptoms of sunscald under TIV plastic, a non-diffusing highly transmissive plastic, than under the other films, though the amount of sunscald in all of the tunnels was much less than for plants with no cover at all. When marketable yield was considered, the same overall trends still held as with total yield. Berry size was larger under all plastics than no plastic for both cultivars. There were some differences in the percentages of marketable fruit between plastic types, but they were minimal.

To put things in perspective, plants in tunnels covered with any kind of plastic greatly outyielded plants that were not covered, and these differences somewhat dwarfed the differences between plastics. For 'Josephine', total yields in tunnels were 2.5 to 3 times as high as outside yields, and for 'Polka', yields were 4 to 5 times greater, depending on the plastic type. It is likely that differences in nutrition accounted for some of the difference between indoor and outdoor yield, since the potting media for outside plants was subjected to some leaching from rain.

Differences between covered tunnels, however, were due entirely to plastic type and its range of effects. Varieties responded slightly differently in the different years, but when yield was averaged over years, trends on how they responded to plastics were the same for both.

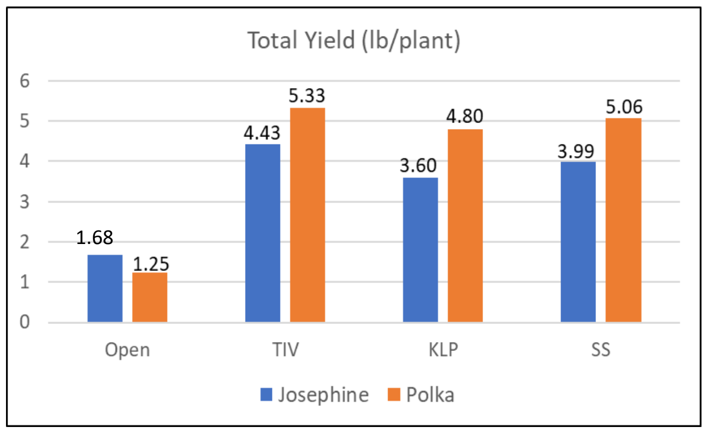
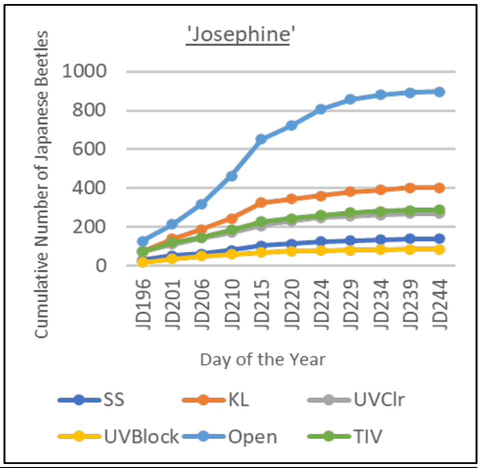


Figure 4. Total yield obtained per plant for 'Josephine' and 'Polka' raspberry plants. Average of yields from 2017 and 2018 is presented.

So, why would yields have been higher under TIV where temperatures were higher than under KLP where temperatures were lower? We think that the yield increases were really driven by conditions in the spring and the fall, when warmer temperatures are spurring growth and prolonging higher yields, rather than effects in the summer when the tunnels are fully vented. Thus, some of the negative effects that could have occurred from high temperatures might have been moderated in the summer due to the tunnel sides being up (Figure 4).

Regarding pest complexes, the biggest differences were in Japanese beetle populations. Japanese beetles were counted and removed from each 12-plant plot from mid-July through the end of August. All plastics decreased their numbers, but the plastic that diffused light and blocked UV resulted in the largest decreases (Figure 5). This could have large implications for future pest management tactics.



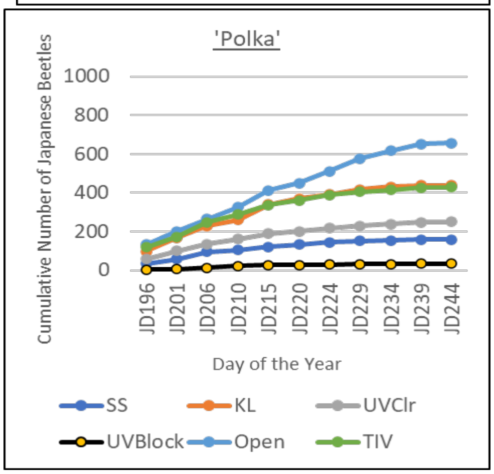


Figure 5. Cumulative numbers of Japanese beetles counted and removed from raspberry plants in 2017. Effects were the same in 2016 and 2018, but not all plastics were included in

The bottom line. Effects and the best plastics to use would likely be different in different environments, and results could have been entirely different in a warmer location. However, for our location in central PA: 1) Any plastic was better than no plastic. 2) The 6-mil plastic that was the least expensive and the easiest to obtain in PA (TIV) resulted in higher yields than any other plastic. So there appeared to be no yield-related reason to pay for a more expensive plastic, and durability was similar for all of the plastics tested. 3) If you are trying to manage plants as pesticide-free or organically, at least for Japanese beetle control, you may want a film that blocks UV light possibly in combination with diffusing light. However, while not discussed above, tunnels that transmitted more UV light had fewer adult spotted wing drosophila caught in traps and lower levels of fruit infestation than those that didn't transmit much – but this was not enough to make a difference in other practices needed for controlling the fly. 4) If you own more than one tunnel, you might want to try different plastics on your tunnels in the same year to be able to make a comparison on your own farm. 5) If you live in an area warmer than central PA, consider the results cautiously, since factors like sunscald will probably become more important to you if using a non-diffusing plastic. But if you live in a similar or cooler area, you probably don't want to choose a plastic that reduces temperatures.

More information on this project can be found at https://blogs.cornell.edu/berries/productions/tunnel-production/

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UV light as a non-chemical alternative for control of plant pathogens

By David Gadoury (Cornell University) and Natalia Peres (University of Florida)

Fig 1. Interior of a reflectorized hemicylindrical array of germicidal UV-C lamps.

Microbial pathogens that attack the above-ground parts of plants live in a world that is bathed in sunlight and have done so for nearly 300 million years. In that time, these simple one-celled microbes have evolved to sense, use, and interpret light to direct their development. One component of natural sunlight is in the shortwave ultraviolet part of the spectrum. The shortest of these wavelengths that reach the Earth are harmful to cells of many organisms, and if you are one-celled, well then you just don't have a lot of cells to waste. Shortwave UV from the sun causes subunits of the pathogen's DNA to bind together so that instead of a genetic code, it is genetic babble.

This presents a challenge to microbial pathogens; one to which they evolved an ingenious solution: a photolyase enzyme that can undo the damage caused by UV to their DNA as fast as it occurs. The "photo" part of photolyase refers to its requirement for light to drive the biochemical repair process. The repair process requires another part of the solar spectrum: blue light. Because there is neither UV nor blue light at night, the repair mechanism does not operate in the dark.

And that last fact is the key to using ultraviolet light as a means to suppress plant pathogens. When used at night, we bypass the pathogen's ability to repair damage to its DNA, and we can kill a pathogen (and even some insect and mite pests) with a relatively low dose of UV that is harmless to a multicellular organism like a plant. Our work on UV for control of plant pathogens has been developed by an international, multi-disciplinary, and multi-institutional group that collaborates to bring this technology to bear for several food crops.

Strawberries were one of the first crops where the nighttime UV technology was delivered in a manner that was practical for field production. We chose the powdery mildew pathogen (Podosphaera aphanis) as the target. Powdery mildew is primarily an external parasite, so it occupies an exposed niche. There were certain requirements for a device to deliver the required UV dose in an effective manner. It would need to be powerful enough to deliver the UV to the plant at a speed sufficient to cover significant acreage in a single evening. It would also have to do so uniformly on a target that was architecturally complex: all of the exposed surfaces of a multi-layered canopy of a strawberry plant. We settled on a hemicylindrical array of low-pressure discharge UV-C lamps backed by polished aluminum reflectors (Fig. 1). This array could be configured to diverse plant canopies by altering its height, width, and length, and it could be moved as a tractor-drawn device or by a fully autonomous robotic carriage.

Trials in commercial strawberry fields in Florida began during the 2016-17 growing season. UV applications of up to 200 Joules per square meter were applied 1- to 2-times per week to a highly-susceptible variety that received no other fungicides for suppression of powdery mildew. UV treatments in general produced excellent suppression of powdery mildew. In fact, usually better than that provided by the best-available fungicide (Fig. 2). Trials in multiple locations in the US and Europe have duplicated these results.

Some of the most intense interest in UV technology comes from strawberry nursery operations, where UV presents a promising method to suppress powdery mildew on transplants without exposing the surviving isolates to selection for resistance to fungicides used in the fruit production fields. This has always been a conundrum of commercial strawberry production. There are relatively few modern fungicides that do not present a risk of resistance. The more you use them, the greater the risk. So, how does one preserve them for the greatest good? UV offers a non-chemical means to effectively suppress powdery mildew in nursery operations without risk of resistance. UV technology has been used for over 75 years in various microbiological applications, including hospitals, water purification, and food processing, with no reported examples of practical resistance. At least one commercial nursery in Nova Scotia has applied the UV technology on a grand scale, building the largest UV array developed to date (Fig. 3) and using it.

Nighttime UV technology has now shown activity against several powdery mildews of other crops, including grapevine, cucurbits, rose, basil, and rosemary; as well as suppressing plant-feeding mites. Most recently, it has shown surprising activity against a bacterial disease of apple (fire blight), a severe leaf blight of beets (Cercospora leaf spot), as well as sour rot on grapes, and some mild suppression of gray mold (Botrytis cinerea) on strawberries. Detailed examinations of the physiology of UV-exposed plants have not detected any harmful effects at the doses used to protect them from harmful pathogens or pests. Likewise, populations of harmless microbes on the surfaces of UV-treated plants seem to rebound rapidly after treatment, perhaps because the UV treatments leave no suppressive residue to prevent recolonization.

The nighttime UV technology is flexible, adaptable, and scalable. Plans to build towable arrays are available and could be constructed by anyone with appropriate skills in fabrication. In addition, there are companies that produce autonomous robotic arrays that can either be purchased or contracted as a service. As we gain experience in multiple crops, we are also training the scientists and end-users to develop the human capital that will hopefully sustain the technology as it develops.

Acknowledgments This research was primarily supported by the USDA Organic Research and Extension Initiative award number 2015-51300-24135, with additional support from the Florida Strawberry Growers, Wish Farm Strawberries, Fancy Farm Strawberries, Driscoll's Berries, the New York Wine and Grape Foundation, John Martini at Anthony Road Wine Company, and Greg and Lillian Taylor at Bully Hill Vineyards, and Saga Robotics LLC, Drs. Collaborators included Mark Rea and Mariana Figueiro of Mount Sinai Research Hospital, Drs. Arne Stensvand and Aruppillai Suthaparan of the Norwegian University of Life Sciences, Dr. Jan Nyrop at Cornell University, Dr. Lance Cadle-Davidson of the USDA Grape Genetics Research Unit, Dr. Rodrigo Onofre of Kansas State University, Dr. Michelle Moyer at Washington State University, and Dr. Walt Mahaffee, USDA-ARS, and finally to the late Alfred J. Michaloski, who first approached us with a crazy idea that germicidal lamps might control grape powdery mildew in 1991 (see US Patent Number 5,040,329).

Plum curculio: Not just for tree fruits

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Fig. 1a. Plum curculio larvae in host fruit – note the head capsule and lack of legs. 1b. Adult plum curculio – note the mottled brown color with bumps on the back

Usually thought of as apple, peach, cherry and plum pest but plum curculio also will attack blueberry, huckleberry, grape, and persimmon (Milholland & Meyer 1984). Plum curculio is one of the most potentially damaging pests on various hosts during the petal fall period. The biology of PC is similar for most deciduous fruits, although the timing may be slightly different. The adults overwinter in the top few inches of leaf litter in nearby hedgerows, trashy fields and woods (especially on the south edge of a fruit planting). The adults initially appear in orchards during bloom. Most beetle activity occurs during the first warm period after petal fall, when the maximum temperature is 70°F or higher. Periods of cool, rainy weather with maximum temperatures below 70°F are not suitable for adult activity. Adults can be found in orchards for 5 to 7 weeks.

Egg laying activity starts once the fruit begins to form, with egg hatch occurring after 7 days. In successfully attacked hosts, the hatching larva burrows into the fruit's center, where it makes large irregular cavities. Fruit that are successfully attacked by larvae are prone to drop prematurely. After 14-16 days within the fruit the larvae exit and enter the soil where they form a pupation chamber for an additional 10-12 days before transforming into adults. New adults can appear in the orchards in mid- to late- July with emergence continuing until early September. In September and October adults begin seeking overwintering quarters. There is only one generation per year in the mid-Atlantic region. There is a second generation in eastern Virginia and southward.

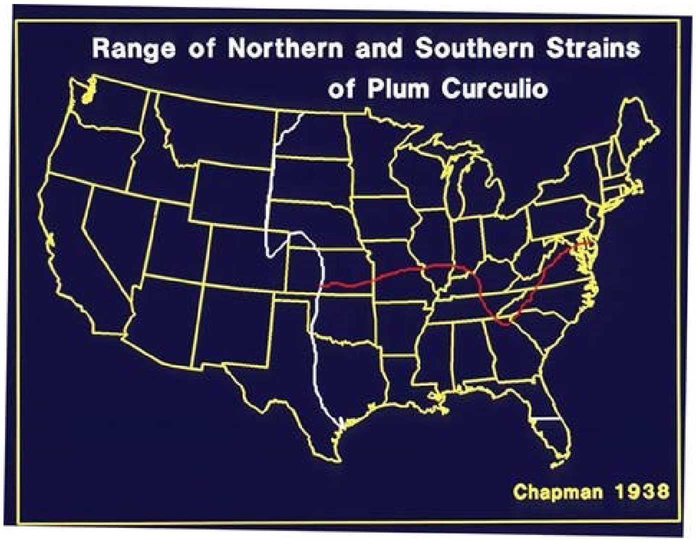

Fig. 3. Distribution of geographic strains of plum curculio

Adults become active when average daily temperatures near 10-15°C (50-60°F) for 2 or more consecutive days and high temperatures are 24°C (75°F) for 2 or more consecutive days (Milholland & Meyer 1984). Plum curculio is often active when early blueberry varieties are beginning to bloom (Marucci 1966). Females oviposit in fruit, leaving crescent-shaped scars. Larvae develop in fruit, over about a 2-week period. Infested berries turn blue prematurely, often dropping to ground before uninfested berries turn blue. A few late-maturing larvae may reach market (Marucci 1966). Most of the adults produced enter diapause, but a few mate and produce a second generation in the south (Mampe & Neunzig 1967). Reissig et al. (1998) reported that injury progressed faster and ended earlier in smaller apple trees than larger trees, probably because of differences in tree architecture; this may relate also to a relatively small host plant as blueberry.

A note on plum curculio strains. There are two strains of plum curculio. The northern strain has an obligatory chilling requirement. Therefore, there is a single generation per season. The southern strain lacks this chilling requirement and can develop two generations seasonally. A rough map showing the distribution of the northern (single-brooded) and southern (double-brooded) strains was developed by Chapman (1938). There are genetic differences among geographic strains of PC (Zhang et al. 2008). Furthermore, there are *Wolbachia* symbionts in PC, also with geographical differences in their genetics (Zhang et al. 2010). These differences in *Wobachia* infections likely result in observed differences to mate within and among PC strains (Zhang and Pfeiffer 2008).

Plum curculio may be monitored by shaking branches over a sheet. Examine fruit for fresh injury, especially on borders adjacent to woodlands. Two applications of a contact insecticide are usually necessary (Milholland & Meyer 1984); first when adults begin to return to field; second timed to end of migration period, when max. temps. reach 32°C (90°F) (Milholland & Meyer 1984). Imidan is very effective; check the Southern Region blueberry bulletin (https://smallfruits.org/ipm-production-guides/) or state recommendations for additional alternatives.

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Before Launching into Drones, Do your Research

Dr. Amanda McWhirt

Increasingly researchers and growers are investigating the use of drones for small fruit production. In North Carolina a strawberry grower used a drone to monitor a strawberry field that had flooded or there have been instances of using drones to spray strawberry plug plants. The applications of drones are endless, including: spraying, scouting, crop nutrient status monitoring, and more.

Before growers jump into buying a drone, they need to be aware of the laws that govern drone use and the advantages and disadvantages of different types of drones.

Some great information on these topics was developed by Dr. Jim Robbins, University of Arkansas (retired).

Dr. Jim Robbins with a Spray Drone (Amanda McWhirt)

Pilot Certification and Aircraft Registration for Non-Hobby Users of Small Un-

manned Aircraft Systems (sUAS) https://www.uaex.uada.edu/publications/pdf/FSA-6150.pdf

Features to Consider When Purchasing a Small Unmanned Aircraft System (sUAS) https://www.uaex.uada.edu/publications/pdf/FSA-6151.pdf

Growing Long-cane Raspberries in the Southeast

Lisa Rayburn, NCSU, Josh Mays, TriEst Ag Group, Inc., James Hewitt, Lewis Nursery and Farms, Gina Fernandez, NCSU

In 2021, NC State University started an on-farm research project with Lewis Nursery and Farms to investigate the feasibility of long-cane raspberry production in the state. Until now, commercial production of this high value crop has been limited to the western part of the state where the temperatures are cooler. In the coastal plain, heat and humidity take their toll on fruit quality and plantings are short-lived with low yields. But raspberry long canes present a possible alternative.

In a long-cane system, raspberry primocanes are grown in containers in a nursery before being shipped to the farm for fruiting. The nursery is traditionally in a cooler climate that is better suited for strong primocane growth. The plants are grown in soilless substrate and trained to produce 1 or 2 tall primocanes which are topped out at 160 cm (about 5 feet). These are the "long canes" that the system is named after.

The grower receives the chilled canes from the nursery in late fall and stores them in a cooler until the desired pullout date. The grower pulls the canes out of the cooler, pots them up if necessary, and lines them out in a high tunnel in late winter. The long-cane raspberry plants are grown in containers, supported by a trellis and fertigated through a drip system.

Close attention has to be paid to venting the high tunnels to make sure they are warm in the winter and cool in the spring and summer. In addition, close attention is needed to manage moisture and nutrient levels in the substrate.

Dormant raspberry long canes. Photo credit: Lisa Rayburn

In our trials, the canes take approximately 90 days to reach the beginning of harvest although this can vary based on variety and pullout date. Early pullouts will take longer while later pullouts benefit from warmer temperatures and mature faster. Timing of pullout is chosen to coincide with the optimum harvest window for the market and to get the berries out of the tunnel before high temperatures result in fruit quality and retention issues. In southeastern NC, mid-January to mid-February looks to be the optimum pullout window for spring resulting in harvest from mid-April through early June.

Long-cane raspberries showing early season growth. Photo credit: Lisa Rayburn

In hot climates like the coastal plain, the plants will likely be disposed of after the harvest is complete. In this scenario, the long-cane system becomes annualized, in much the same way that strawberry production was annualized when the industry moved from a matted row system to an annual plasticulture system. In more temperate areas, growers may choose to grow two new primocanes through to chill and then harvest in the following season.

The pH and EC of the nutrient solution is checked on a daily basis. Photo credit: Gina Fernandez.

Beyond allowing raspberries to be grown in otherwise inhospitable areas, the long-cane production system offers several other advantages to caneberry growers. Since this system relies on soilless substrate, growers can bring into use land that otherwise doesn't have suitable soil for field production whether due to soil type or disease issues. Due to the intensive management, much higher yields per acre can be achieved in this system compared to in the field. The grower can also produce a crop that is not normally available to consumers, especially in local markets.

Raspberries ready to harvest. Photo credit: Lisa Rayburn

The system is not without its challenges. Higher yields are needed as this system require a large upfront investment. The costs of grading and land preparation, high tunnels, irrigation system, pots, fertilizer, substrate and plants add up quickly.

Utilizing the long-cane system, growers can put raspberries on the table alongside blackberries, blueberries and strawberries. Photo courtesy of Lewis Nursery.

Careful attention needs to be paid to fertility and water management during the growing season. The small size of the containers and limited buffering capacity can result in pH and nutrient problems developing and resulting in lost yield much more quickly than in a soil system. The grower needs to monitor the irrigation system on a daily basis including the pH and EC of the fertilizer solution entering and exiting the containers and the total amount of drainage.

Finally, fluctuating spring weather also poses a risk. Unseasonably warm weather can result in poor berry quality and dropped fruit. Likewise, strong storms and heavy winds pose a risk to high tunnel structures.

Coco coir is the industry standard substrate for long-cane raspberry production in Europe and Canada but our on-farm research is currently being conducted in southeastern NC to determine if a locally produced pine bark substrate can be used instead. This research is ongoing but early trends are promising. Pine bark substrate would not only provide a sustainable, local alternative to coco coir, but at a substantially cheaper price point.

Research is ongoing but raspberry long canes production may provide growers in the southeast with a sweet, new berry to offer their local costumers.

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James Hewitt with Lewis Nursery inspects the root growth of a raspberry long-cane plant. Photo credit: Lisa Rayburn

Ripe raspberries ready to be enjoyed. Photo credit: Lisa Rayburn

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