University of Maryland

Wye Research and Education Center

2020 Strawberry Booklet

(No onsite tour due to COVID-19)

COLLEGE OF AGRICULTURE & NATURAL RESOURCES

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Thanks to all the people that make the Strawberry Program at WyeREC work and to the contributors to this publication

Book contributors:

Mengjun Hu, Assistant Professor, UMD-PSLA Fruit Pathologist

Anita Schoeneberg, UMD-PSLA Technician

Kelly Hamby, Assistant Professor, UMD Department of Entomology

Dave Myers, Anne Arundel County, UME Principle Agent.

Kim Lewers, Research Geneticist/Plant Breeder, USDA, Beltsville, MD

Fumiomi Takeda, Research Horticulturist/Lead Scientist, USDA, KEARNEYSVILLE, WV

Angela Marie C. Ferelli, UMD-PSLA, Agent Associate in Food Safety

Support from:

University of Maryland Extension

Maryland Agricultural Experiment Station

Maryland State Horticultural Society

Special thanks to:

Kate Everts WyeREC Director

Dan Poet

Raymond Harrison

Michael Hitchings

Barbara South

Taylor Garrett

Elizabeth Friedel

Taylor Robinson

Extra Thanks to:

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Greetings to Strawberry growers everywhere.

I hope everybody is safe and is able to make the best out of a bad situation. Everybody within the agricultural community that I have met over these many years have proven to be a resilient group and I will forever feel privileged to have been able to serve this group.

This is the first time in my tenure here that we have had to cancel the annual Strawberry Twilight Meeting here at WyeREC and I did not want the information presented in this book to go unseen.

I hope you take the time to read what is presented here and I hope that you will be able to glean some things that will be helpful in making your operation better and more profitable.

I've always tried to include information that is pertinent to the strawberry industry, both research conducted at WyeREC and information on cutting edge research conducted at institutions near-by.

In this year's book:

*Information from the 2018/19 Strawberry variety trial

*Disease management

*Observations of what's going on under th row covers

*Insect pest on strawberries

* Spray guide for Multi-small fruit plantings

*Latest information on using robotics/UV-C for pest control

*MDA information for growers and sellers during COVID-19

*Food Safety Webinars

*USDA-Beltsville fruit lab updates

This book will also be posted on The WyeREC website (https://agnr.umd.edu/research/research-and-education-centers-locations/wye-research-education-center) where you can access previous Books and presentations for this meeting and the annual Winter Bay Area Fruit Meeting.

Sincerely,

Michael Newell

2019 Evaluation of 15 Strawberry Cultivars in the Annual Plasticulture System at WyeREC

Michael Newell

Maryland Agricultural Experiment Station

Wye Research and Education Center

Queenstown, MD 21658

mnewell@umd.edu

Several cultural systems are available to growers who produce strawberries for commercial harvest. This trial utilized the annual plasticulture system of production which has been used in Maryland for over 20 years. It is a system that requires high input cost, but has the potential to produce high yields of high-quality fruit. There are specific management requirements to achieve success with this system and much information about the system has been published and presented at annual growers meetings in the mid-Atlantic region. Like most agricultural enterprises, local weather conditions can have a profound impact on success or failure. Growers need to be able to adjust to these ever-changeable conditions to ensure success. Cultivar selection and plant type, planting date, row cover management and the use of tunnels for rain protection and/or growth enhancement are all important things to consider.

The 15 cultivars trialed were;

AC Valley Sunset Allstar Camarosa Chandler Darselect FlavorFest

Galetta Jewel Malwina Mayflower Record Ruby June Rutgers Scarlet

Strawberry Festival Yambu

In September 2018, pre-plant fertilizers were applied to provide 60 lbs of nitrogen plus phosphorous, potassium and sulfur based on soil test results. An additional 30 lbs of nitrogen was applied through the drip in the Spring. The field was prepared with raised-shaped beds (2.5ft x 8inch), with a centered single drip line (12 inch emitter spacing @ 0.4 gpm) covered with black embossed plastic. Pre-emergent herbicides were applied between the rows with a shielded sprayer and plugs were planted on September 21st on a 12 in x 12 in staggered double row spacing. Plant-plugs were produced at WyeREC utilizing harvested runner tips from a nursery of Spring-planted bare-rooted dormant plants purchased from Nourse Farms, Whately, MA and Lassen Canyon Nursery, Redding, CA. Fall temperatures allowed for good growing conditions and over-wintering row covers (1.2 oz) were deployed on January 9, 2019 and removed on March 15. Frost events on April 1st and 2nd necessitated row cover deployment to protect the earliest blooms. The lowest temperature observed was on February 1st of 8 f.

As an aside demonstration, we deployed a low tunnel on one row on April 5th. This tunnel was purchased from **Dubois Agrinovation** (https://www.duboisag.com/). This tunnel was deployed as a rain shield, not as a growth enhancement method. No fungicides were applied to this row. Fungicides were

applied to the other rows using a back-pack air assisted sprayer based on recommendations by the Strawberry Advisory System (SAS) weather station located at WyeREC. In general, fruit rot disease (*Botrytis* and Anthracnose) incidents were low in 2019 with the recommended spray program. We did observe fewer Anthracnose spots on some cultivars under the low tunnel, but again rot incidents overall were minimal, despite over 6 inches of rain in May. If you want to learn more about low tunnel for strawberry production, I encourage you to visit Dr. Kim Lewers USDA website. https://www.ars.usda.gov/northeast-area/beltsville-md-barc/beltsville-agricultural-research-center/genetic-improvement-for-fruits-vegetables-laboratory/docs/low-tunnel-strawberry-production-2013/

Observations:

Fall runner production:

We do not want fall runnering. These will Winter kill contributing to dead plant material which may be infected with disease inoculum. Removal of dead plant material in late Winter before new leaf growth occurs is recommended to reduce inoculum. The alternative is a regular spray program to reduce the inoculum levels (no research to support this). We can sometimes plant late enough in the Fall to reduce runner production, but if we plant to late, crown development may suffer.

From greatest to least number of runners produced, counted on December 7 2018.

Chandler>Galetta>Ruby June>Record>Rutgers Scarlet>Strawberry Festival.

The remaining selections had less than 1 runner per plant.

Fall flowering:

Unless we want to produce fruit in the Fall, we do not want Fall flowering. These flowers will freeze leaving dead plant material with possible disease inoculum. We will usually see Fall flowering on cultivars that flower earlier in the Spring.

From greatest to least number of Fall flowers produced, counted on January 3, 2019

Jewel>Strawberry Festival>Allstar>Galetta

The remaining selections had none or less than 1 flower per plant.

Fall branch crown growth:

We would like to see at least 1 or 2 branch crowns produced in the Fall. If we plant too early we could see too many branch crowns form which may lead to smaller fruit size in the Spring. If we plant too late, Fall applied row covers may help by increasing heat units which may help in increased Spring flowering. All cultivars with the exception of Ruby June produced less than 1 branch crown per plant in the Fall.

From greatest to least number of branch crowns produced, counted on December 19, 2018

Ruby June>Flavorfest>AC ValleySunset>Yambu>Camarosa>Mayflower>Daraselect=Allstar>Malwina=

Jewel=Galetta>Record>Strawberry Festival=Rutgers Scarlet.

Spring growth status:

We should always be looking to see what growth stage the plants are as they begin to resume growth in the late Winter/early Spring. We use these indices to help us manage fertility applications, pesticide applications and needed frost/freeze protections. These observations were made on March 19th.

All cultivars had resumed vegetative growth (new leaf push) by this date. This initial growth is usually the time we apply the first Spring nitrogen application.

With the exception of AC Valley Sunset, FlavorFest and Malwina, all others began showing tight flower buds at the top of the crown (no elongated stems yet).

Allstar was the only cultivar to show tight flower buds at the top of crown in all plants.

First open flowers:

With the first flowers open, this begins the most sensitive time for frost damage. Although we can have cold damage to buds earlier, the flowers are most sensitive to frost.

Observations on April 2, and April 11, 2019

With the exception of FlavorFest, AC Valley Sunset and Malwina, all other cultivars had begun flowering by April 2. By April 11, AC Valley Sunset and Malwina still had not flowered.

Brix:

%Brix or soluble solid content is a measure of sweetness. It is one component of the over-all flavor. Brix levels can change during the harvest season depending on soil water content, how much sunshine we have and how warm it is leading up to each harvest. If we have cloudy, rainy weather, we usually expect lower brix levels.

The average brix ranged from 5.7 to 7.4 across 14 cultivars. AC Valley Sunset had the highest brix levels, followed by FlavorFest and Jewel. The lowest brix levels were with Strawberry festival, Camarosa and Yambu.

Harvest:

The 2019 harvest season started on May 8 and ended on May 31 (except for Malwina) for a total of 8 harvest dates. The percentage of fruit harvested during the first 2 weeks of the season are as follows: Strawberry Festival 75%, Galetta 68%, Ruby June 64%, Chandler 61%, Camarosa 55%, Rutgers Scarlet 43%, Allstar 38%, Yambu 36%, Flavorfest 35%, Darselect 32%, Jewel 25%, Mayflower 22%, Record <2%, AC Valley Sunset < 1%. Malwina 0% (harvest for Malwina was June 7th-June 18th).

2019 Spring Harvest yields:

Cultivar	Per Plant Yields Marketable yields (lbs) *	Marketable number	Culled fruit (lbs)**	Culled number	Average fruit size (oz)
Yambu	1.74 a	38	0.11	7	0.75
AC Valley Sunset	1.65 a	28	0.03	1	0.96
Darselect	1.50 a	34	0.12	6	0.73
Flavorfest	1.38 ab	31	0.15	9	0.73
RubyJune	1.33 ab	29	0.06	3	0.76
Mayflower	1.26 b	30	0.13	8	0.68
Record	1.25 b	23	0.01	1	0.88
Chandler	1.16 bc	28	0.11	6	0.67
Jewel	1.13 bc	31	0.16	11	0.59
Camarosa	1.12 bc	25	0.06	4	0.73
Rutgers Scarlet	1.11 bc	25	0.11	6	0.71
Strawberry Festival	1.10 bc	24	0.07	4	0.75
Allstar	1.03 c	30	0.22	15	0.56
Galetta	0.75 d	14	0.05	3	0.86
Malwina	0.32 e	10	0.03	2	0.51

* Similar letters within this column are not significantly different

** Culled fruit are any fruit < 0.35 oz or deformed fruit due to pollination issues

Summary and Comments about this variety trial:

Historically, strawberry production has one of the highest profit potential of all the small fruits. To be on the high side of these profits, many factors need to come together. Some we can control (when we plant, what system we use, varieties and markets). Some we cannot control ie. the weather! Information from local and region Universities are a growers best source for evidence based recommendations.

New strawberry varieties are being released regularly around the world. Local and/or regional variety trials (or your own on-farm trials) are the best source of information on how strawberry varieties will perform at your location. Depending on your markets (direct sales, PYO, shipping), you may want to choose varieties based on specific characteristics, i.e. firmness of fruit for shipping. We all want fruit that has great flavor and size, low disease incidence and resist rain damage, but the reality is we are still looking for that magic variety. We need to use other tools in our toolbox to get where we want to go!

Many of the varieties in this trial are not commonly available as plug plants or even as runner tips. We purchased bare-rooted dormant plants in the Spring 2018 and produced our own plugs. Producing plugs is not difficult, you'll need a source of clean (disease free) strawberry runner tips, space to set up a timer-controlled micro-sprinkling system to mist the newly set runner tips, 50 cell trays and labor to collect the runner tips (if you grow your own) and set the tips. It will require about 4 weeks to produce a suitable plug ready for field transplanting. Here is a link to the plug production procedure.

https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1293&context=extension_curall

2018 Fall field preparations were interrupted by rain events during late August and into September, but we managed to get the trial planted on September 21st. We do not as a practice soil fumigate here at WyeREC. Instead, we rely on long rotations between fields. Wet weather in late summer when fumigation is used can further delay Fall planting because of the plant-back restrictions of many of the fumigants. September 21st is within the generally accepted window of planting for the annual plasticulture system in our area. Fall growing conditions were good and we deployed the over-wintering floating row cover on January 9th 2019, which is the latest we have ever covered.

Maintaining timely Spring fungicide applications prevented serious fruit quality issues in the open field. Tunnels can help reduce the need for fungicide applications and also reduce damage caused by too much rain during harvest.

Historically, the Chandler variety has been the "standard" in the annual plasticulture in our region.

It's not always the highest yielding variety as seen in this data, but it has been the workhorse here in the east for several decades. I'm excited to see new selections out of North Carolina and USDA-Beltsville and hope to trial some of those in the near future.

If you have any questions about this trial or anything strawberries, don't hesitate to contact me.

2018/19 Variety Descriptions

These descriptions of the fruit in this variety trial are from the Register of Fruits and Nuts. Additional notes and comments provided by the Breeder and where noted, Mike Newell, WyeREC.

1) 'Galletta'
Short-day strawberry adapted to North Carolina. **Origin:** North Carolina State University, by J.R. Ballington. NCH 87-22 × Earliglow; selected 1993; tested as NCS 93-05; USPP 19,763; 24 Feb. 2009. **Fruit:** dark purple-red and red blend skin; as large as Camarosa, 32 g primaries, 20 g secondaries, 10 g tertiaries; long conic to conic; orange-red flesh, firmer and tougher than Bish and Chandler, less firm and tough than Camarosa; achenes slightly below surface; ripens very early, first ripe fruit 7 Apr., before Bish, Camarosa, and Chandler. **Plant:** medium vigor; yields greater than or equal to Chandler and Camarosa; medium canopy density; crown and fruit resistant to anthracnose, but fruit susceptible when artificially inoculated with C. acutatum. Named in memory of long-time North Carolina State University and USDA-ARS strawberry breeder Gene J. Galletta. **Notes:** Galetta's flavor is variable and sometimes great. King fruits in 2019 at WyeREC over 3 ounces!

2) 'Yambu'
Short-day strawberry adapted to plastic tunnels in the Netherlands. **Origin:** Fresh Forward Holding, Zetten, the Netherlands, by E.J. Meulenbroek. E1991-023 · Honeoye; crossed 2001; selected 2003 in a controlled environment, Elst, Gelderland, the Netherlands. USPP 28,048; 23 May 2017. **Fruit:** size medium, 18-19 g; uniformly conic; glossy red-orange (RHS 34A); flesh red-orange (RHS 34B and RHS 33A); firm; flavor pleasant; calyx medium-large, surface, reflexed; achenes at surface; ripens early with long season; shelf life excellent, 8 d. **Plant:** vigor medium; yield medium high, 900 g/plant; growth habit compact, semi-upright, medium density; flowers at canopy, fruiting trusses prostrate; resistant to botrytis fruit rot and *Phytophthora* crown rot; somewhat resistant to powdery mildew. Average fruit size in 2019 at WyeREC was 0.75 oz.

3) 'Allstar' .
Short-day strawberry with wide adaptation, mid-Atlantic, Northeast, and Midwest, USA. Origin. USDA-ARS, Beltsville, MD, and the University of Maryland by G.J. Galletta, A.D. Draper, H.J. Swartz. US4419 x MDUS3184; selected 1971 at Wye, MD; tested as MDUS4429; introduced 1981. Fruit: glossy orange-red; average size; symmetric, shapely; firm light orange-red flesh; mild sweet flavor; freezes very well without turning color and retains texture with thawing. Plant. Vigorous, runner freely to form a dense matted row; also performs well in plasticulture with medium density plants and consistently high yields. Resistant to five races of red stele, local anthrancose fruit rot, crown rot; moderately resistant to field botrytis fruit rot, postharvest botrytis fruit rot, leaf blight, leaf scorch; moderately susceptible to powdery mildew. **Notes:** without fungicides, can have fruit rot, can have fruit cracking in rainy seasons, usually low botrytis levels but can have botrytis on the calyx, can have orange-red skin color much less orange than Portola or Record. It has been noted that the fruit is more red when grown on black plastic.

4) 'Darselect'
A fresh-market, short-day strawberry that is similar to 'Elsanta' but is more erect, has longer petioles, larger fruit, and more uniform skin color. **Origin:** in France by R.C Hureau, Society Civile Darbonne. 'Elsanta' × 'Parker'; introduced in 1998. USPP 10402. **Fruit:** large; conical; red, glossy and bright exterior; white interior; tough skin, juicy with good flavor; firm; large calyx. **Plant:** short-day type; very vigorous; large plant; lower chilling requirement than 'Elsanta'; abundant runners. Tolerant of *Phytophthora cactorum*. Good winter hardiness and frost resistance; has tolerated -25 °C. **Notes:** Darselect is terribly susceptible to scorch.

5) 'Jewel'

Short-day strawberry adapted to the Northeastern, Great Lakes, and Midwestern regions of the United States. It is a hardy and consistent cropping cultivar with large, attractive, high quality fruit. Origin: 'Jewel' was selected in 1971 from the progeny of a NY 1221 x 'Holiday' cross made in 1969 (Fig. 2). It was tested as NY 1324. 'Jewel' was tested for many years in un-replicated plots at Geneva, New York. 'Jewel' was included in replicated trials in 1981 and 1982 at Geneva, and was widely distributed to cooperative testers in the Eastern United States in 1983 and 1984. Description: Plants are moderate runner producers. Foliage is not excessive, relatively compact, and dark green. Fruit mature in the mid-to-late part of the strawberry season. Fruit are very large and are wedge-conic in shape with bright red color, high gloss and uniform development. Fruit are moderately firm with firm skin, have uniform internal color, and have a pleasant flavor and a mild 'Holiday' aroma. Performance. 'Jewel' is exceptional in all-around performance. It is hardy, widely adapted, and consistently produces good yields. The fruit combine size, beauty, ease of picking, moderate firmness, good skin, good internal color, high fresh fruit quality and good frozen fruit quality. In addition, the fruit appear to have a significant degree of post-harvest fruit rot resistance**. Notes:** late season, good taste, can have fruit rot without fungicides, foliage often has severe scorch.

6) 'Flavorfest'

Short-day strawberry adapted to the Mid-Atlantic, USA. Origin: USDA-ARS, Beltsville, MD, by K.S. Lewers, J.M. Enns, S.C. Hokanson, J.L. Maas, G.J. Galletta. B759 x B786, crossed 1996; selected in Beltsville, MD, 1998; tested as B1033; introduced 2013. Fruit:bright red; large/average from 49/25 g to 28/14 g; variable plump round-conic; firm, light red flesh, excellent flavor (6.4-9.8 °Brix, pH 3.3-4.0); small-medium spreading surface calyx; inset-surface achenes; long mid-season. Plant: vigorous, medium stolon number; moderate to high yield, 690 g/plant 9-yr av. (341-1,114 g/plant); large, upright, medium density, light at base; flowers at or below canopy, prostrate fruiting trusses, resistant to local anthrancnose fruit rot, crown rot (C. accutatum, C. fragariae CF63), red stele (Race A-3, Rpf1); moderately resistant to field botrytis fruit rot, leaf blight, leaf scorch; moderately susceptible to powdery mildew, red stele (Race A-5); susceptible to anthracnose crown rot (C. fragariae CG163, C. gloeosporoidesCG162), postharvest botrytis fruit rot. **Notes:** without fungicides can have short postharvest life in some years, can have cordate ridges on fruit. At WyeREC blooms a little later than Chandler.

7) 'Mayflower'

Short-day cultivar adapted to United Kingdom. **Origin:** East Mailing Research, Kent, UK by D.W. Simpson. EM-639 · ITA 80-52-1; crossed 1996; selected in Kent, UK, 1997; tested as EM-995; USPP 24,394; 22 Apr. 2014. **Fruit:** moderately glossy, bright red (RHS 44A) and bright red-orange (RHS 34A); broad conical; flesh firm, bright red (RHS 44A), bright red-orange (RHS 34A), and strong pink (RHS 37A); flavor balanced, with moderate sweetness and acidity; calyx small, raised, reflexed; achenes slightly below surface; mid-late season. **Plant:** vigor good; yield medium, upright globose; flowers below canopy; tolerant to *Phytophthora* crown rot and rain.

8) Rutgers Scarlet™

Short-day strawberry adapted to mid-Atlantic. Origin: Rutgers University, New Brunswick, NJ, by G. Jelenkovic, L. Lutz, P. Nitzsche, and W. Hlubik. NJ96-12-1 × Camarosa; selected 1999, New Brunswick; tested as NJ99-204-1. USPP 27,587; 24 Jan. 2017. **Fruit:** large, 24 g; variable, necked wedge-conic to conic; glossy dark red (RHS 45A-53A); flesh strong red (RHS 46A, 46C); firm; flavor excellent, 8 °Brix; calyx medium, raised, clasping to reflexed; achenes at surface; midseason. **Plant:** vigor medium; marketable yield good, 607 g/plant; growth habit upright, medium density; flowers at canopy, fruiting

trusses prostrate. **Notes:** Yields at WyeREC have consistently been as good or better than Chandler. Has had some issues with Bacterial angular leaf spot.

9) 'AC Valley Sunset'
Short-day strawberry adapted to eastern Canada. **Origin:** Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, Kentville, Nova Scotia by A.R. Jamieson. K94-15 × K95-24; crossed 1998; selected 1999; tested as K99-28; introduced 2009. Canadian PBR certificate no. 3484, 14 May 2009. **Fruit:** orange-red; large, 24 g; wedged to cordate; broader than long, flesh medium firm, light orange-red; fresh flavor good, medium sweetness and acidity; achenes level with fruit surface; late season, ripens with or just before 'Ovation'. **Plant:** medium vigor; moderate runner numbers; productive in matted rows; susceptible to red stele root rot (Phytophthora fragariae), powdery mildew, and botrytis fruit rot. **Notes:** Large fruit, at WyeREC preformed well as a 2nd year carry-over variety in plasticulture.

10) 'Malwina'
Short-day strawberry adapted to central European climates. **Origin:** P. Stoppel, Kressbronn, Germany. Unnamed seedling × Sophie, crossed 1999; selected in Kressbronn, Germany, 1999; tested as PS.01-S4; PP23,246, 11 Dec. 2012. **Fruit:** glossy red (RHS 45A, RHS 53A); large; conic; moderately firm flesh, very good flavor; small, raised spreading to reflexed calyx; surface achenes; very late season. **Plant:** vigorous; globose; flowers below foliage, fruiting trusses; resistant to rain cracking, sunburn, Verticilium wilt, local root diseases; moderately resistant to Botrytis fruit rot, powdery mildew; susceptible to flower thrips (Frankliniella spp.), common leaf spot. **Notes:** Malwina is the latest imaginable; I liked it, until it fell apart from the heat! AT WyeREC in 2019, as of May 10th, this variety had not yet bloomed! First harvest was June 17th.

11) 'Chandler'
Short-day strawberry adapted to California, but grown widely in diverse environments. Origin: University of California by V. Voth, R. S. Bringhurst. `Douglas` (US PP4487) × Cal 72.361-105 = C55 (US PP4481); crossed 1977; selected near Davis, CA, 1979; tested as Cal 77.32-103 and later as C24; US PP5262, 24 Jul. 1984. Fruit: glossyred (5R4/12), highly variable medium-large, long conic to long flat wedgy; flesh color similar to skin color, solid to slightly hollow, fairly firm. Bright yellow achenes flush to slightly embedded; mid-season, good flavor. Medium to small reflexed calyx on distinct neck. Plant: semi-erect, with high runner production, moderate fruit yield; susceptible to anthracnose fruit and crown rot. **Notes:** Needs more nitrogen fertilizer than most, foliage turns yellow, often is damaged in winter with straw cover, postharvest shelf-life very short with fruit loosing texture, flavor and color characteristics overnight in refrigeration after harvest. Average yield at WyeREC over the past 20 years is 1.2 lbs/plant. With 2 lbs per plant as a high point and 0.6 lb a low point. Average fruit yield year in 2019.

12) 'Record'
A late season, short-day cultivar adapted to the northern Italy. **Origin**: in Cesena, Italy, from the public breeding activity of the Italian National Project "Frutticoltura", mainly financed by the Ministry of Agriculture; developed by W. Faedi and G. Baruzzi (CRA-Istituto Sperimentale per la Frutticoltura–Forlì Section), M. Baudino and R. Giordano (Consorzio di Ricerca Sperimentazione e Divulgazione per l'Ortofrutticoltura Piemontese – Cuneo), P. Lucchi (Centro Ricerche Produzioni Vegetali - Cesena). Idea × Marmolada; cross made in 1992 in Cesena; selected in Cesena in 1994; tested as 92.340.3; issued in 2005; assigned to CRPV in Europe. **Fruit:** large, symmetric conic shape; medium-firm skin, very bright orange-red color; medium firm flesh, medium good organoleptic characteristics, high ascorbic acid contents. **Plant:** vigorous, good yield, well adapted to organic culture, un-fumigated soils, and poor soils; tolerant to anthracnose crown rot, powdery mildew; susceptible to leaf scorch and angular leaf spot. **Notes:** Record tends to be soft, tart, and orange, but late.

13) 'Camarosa'

Short-day strawberry adapted to California and similar climates. Origin: at Univ. of California, South Coast Research and Extension Center, near Irvine, by V. Voth and R.S. Bringhurst. Douglas × Cal 85.218-605; cross made in 1988; selected in 1989; tested as Cal 88.24-603; introduced. in 1992. U.S. plant patent pending. Fruit: larger and firmer than Chandler; very flat conic; external color similar to Chandler, glossy; internal color darker than Chandler; achenes light to dark red, even with surface or slightly indented; very good flavor, less aromatic than Chandler; fresh-market, processing, and home-garden uses. Plant: producing fruit over an extended period in arid, subtropical climates; production pattern similar to Chandler, but produces more early season fruit; high yielding; more vigorous than Chandler. Moderately susceptible to common leaf spot: relatively resistant to powdery mildew; equal or greater tolerance to two-spotted mite than Chandler; tolerant to viruses occurring in California. **Notes:** Very firm, flavor and color when ripe, varies with growing environment, susceptible to anthracnose fruit rot. Need to train pickers to leave it on the vine until fully ripe. Some tolerance to rain damage. Many plant this variety for shipping.

14) 'Strawberry Festival'

Short-day strawberry adapted to Florida's winter production. **Origin:** University of Florida, Dover, Florida, by C.K. Chandler. 'Rosa Linda' × 'Oso Grande'; selected 1995-1996 winter, Dover, Florida; tested as FL 95-41. USPP 14,739; 27 Apr. 2004. **Fruit:** large, 17.6 g; variable wedge-shaped to conic; glossy, deep red (Pantone® 188); flesh bright red (Pantone 179); very firm; moderately juicy; excellent flavor 7.4 °Brix and 0.79% titratable acidity; calyx large and showy; achenes at surface; early season. **Plant:** very vigorous; high yield (700 g/plant); growth habit upright, flower at or below canopy; numerous stolons (runners); susceptible to *Botrytis* fruit rot, anthracnose fruit rot (*Colletotrichum acutatum*) and crown rot (*Colletotrichum gloeosporodies*), powdery mildew (*Sphaerotheca macularis*), and angular leaf spot (*Xanthomonas fragariae*). In the field at WyeREC, the flavor quality never impressed, but growing in high tunnels, the flavor was hard to beat!

15) 'Ruby June'

Short-day strawberry with dayneutral tendencies, adapted to coastal Central California. **Origin:** Lassen Canyon Nursery, Redding, CA, by J. Bagdasarian. 2G16 · 10B131; crossed 2008; selected 2010, Watsonville, CA; tested as 33K46. USPP 27,190; 27 Sept. 2016. Fruit: medium to large, 30 g; conic with few tips and creases; glossy red (Pantone 1797C); flesh variable light orange-red; firm; sweet; flavor very good; calyx small to medium, surface, spreading to reflexed; achenes inset to surface; ripens early. **Plant:** vigor medium to strong, stolon number adequate; yield medium high, 919 g/plant; growth habit semi-upright, foliage dense; flowers at or above canopy, fruiting trusses prostrate; resistant to *fusarium* wilt. **Notes:** Has performed well in Virginia and North Carolina. First time grown at WyeREC. It didn't knock our socks off!

UPDATES ON MANAGMENT OF STRAWBERRY ANTHRACNOSE AND BOTRYTIS GRAY MOLD

Mengjun Hu, mjhu@umd.edu
Department of Plant Science and Landscape Architecture
University of Maryland, College Park

Both anthracnose and *Botrytis* gray mold are important diseases on strawberries, which typically drive fungicide sprays throughout the season. In this article, we will provide some insights into the infection behaviors of the pathogens and their fungicide resistance issues. A list of recommended fungicides for each disease is also provided at the bottom.

Gray mold (aka Botrytis)

Botrytis gray mold can occur in the crown (syn. *Botrytis* crown rot), flower, and fruit. In general, Botrytis crown rot is of less concern than Botrytis fruit rot which can be a result of flower infections. To date, there are two main Botrytis species found affecting strawberries in the Eastern United States, including *Botrytis cinerea* and *Botrytis fragariae* (a recently discovered species). While *B. cinerea* is often isolated from both flowers and fruit, *B. fragariae* is often isolated from flowers only. It has been shown that *B. fragariae* infection was much more aggressive on strawberry flowers than fruit. Both species have great capability of developing resistance to multiple chemical classes of fungicides. *B. fragariae* seemed to be more tolerant to fludioxonil (product name: Switch) and polyoxin D zinc salt (Ph-D or OSO). However, frequency of *B. cinerea* resistant population to boscalid (Pristine), penthiopyrad (Fontelis), cyprodinil (another component in Switch), iprodione (Rovral), or fenhexamid (Elevate) is higher than *B. fragariae*. Overall, frequency of resistance to fludioxonil and newer SDHIs (such as Kenja, Luna Sensation, and Merivon) in *Botrytis* spp. is much less than other chemical classes (see findings presented in figure 1).

Last year, we determined fungicide resistance in 249 *B. cinerea* isolates collected from strawberries and other small fruits. Overall frequencies of resistance were found to be: 92% to pyraclostrobin (one component in Pristine), 86% to cyprodinil (one component in Switch), 71% to thiophanate-methyl (Topsin M), 48% to fenhexamid (Elevate), 47% to iprodione (Rovral), 26% to boscalid (one component in Pristine), 11% to fludioxonil (one component in Switch), 8% to penthiopyrad (Fontelis), 7% to benzovindiflupyr (Aprovia), 4% to adepidyn (Miravis Prime), and 4% to isofetamid (Kenja). The fungicides used for the resistance detection represented seven distinct chemical classes according to their FRAC codes. As mentioned in the paragraph above, fludioxonil (FRAC 12) and newer SDHI fungicides (FRAC 7) had less resistance issues than other fungicides.

Recommendations:

- Avoid using fungicides that are at risk. Based on our finding, FRAC 7 (newer SDHI fungicides) and FRAC 12 (Switch) are probably the only chemical groups are still effective against Botrytis.

- Base resistance management with multi-site fungicides such as Captan that does not select for resistance.
- Due to resistance concerns, do NOT use single-site fungicides alone if possible.
- Only use single-site fungicides and tank-mix with Captan when disease pressure is high.

The key to managing resistance is spraying less single-site fungicides. When weather conditions are less favorable for disease infection, consider extending spray intervals. The best fungicides are not as good as good weather.

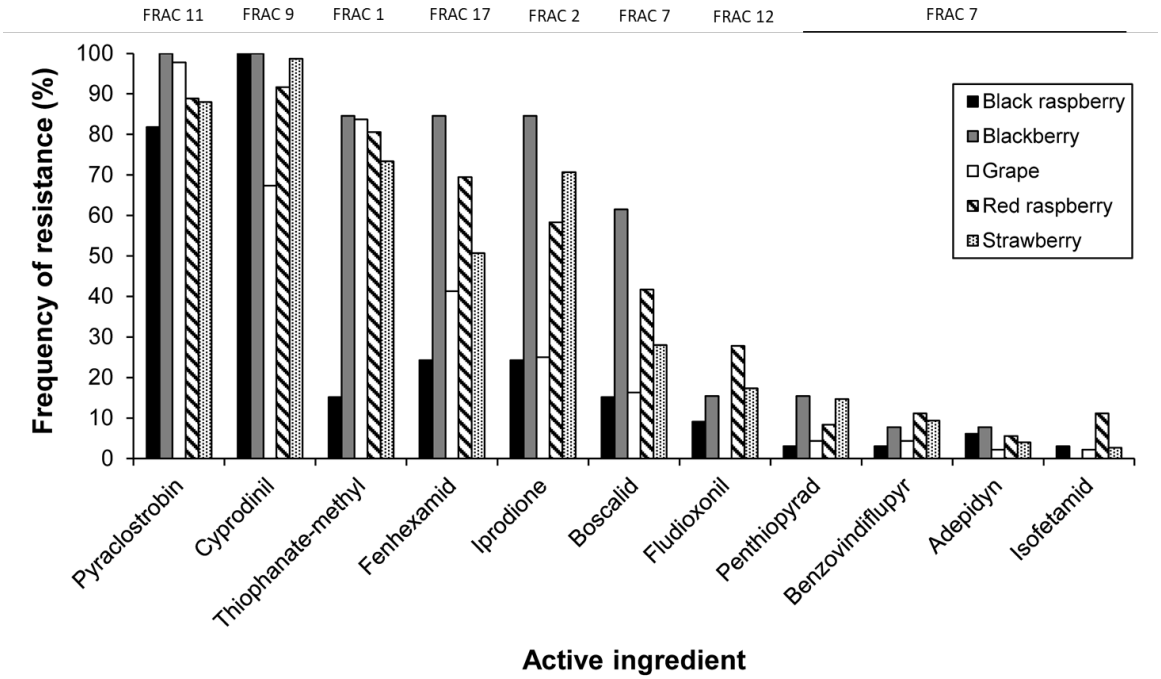


Fig. 1. Frequencies of resistance to eleven active ingredients in *Botrytis cinerea* isolates collected from black raspberry (n=33), blackberry (n=13), grape (n=92), red raspberry (n=36), and strawberry (n=75).

Strawberry Anthracnose

Compared to *Botrytis* gray mold, anthracnose (caused by *Colletotrichum* spp.) is arguably more difficult to control. The control of anthracnose is complicated by 1) limited fungicide choices: strobilurins (QoIs) are probably the only fungicides that have good efficacy; 2) Widespread resistance in *Colletotrichum* isolates from strawberries to QoI fungicides; and 3) potential latent infections in transplants from nurseries. Three different *Colletotrichum* species, including *C. acutatum*, *C. gloeosporioides*, and *C. fragariae*, have been found to cause anthracnose disease on strawberries. *C. acutatum* and *C. gloeosporioides* are species complexes, and *C. fragariae* is considered to be a part of *C. gloeosporioides* complex. *C. acutatum* is primarily known to cause a destructive fruit rot with some runner and petiole lesions. Though it is capable of sometimes causing crown rot, it almost always is limited to fruit rot. Plants can recover and produce symptom-

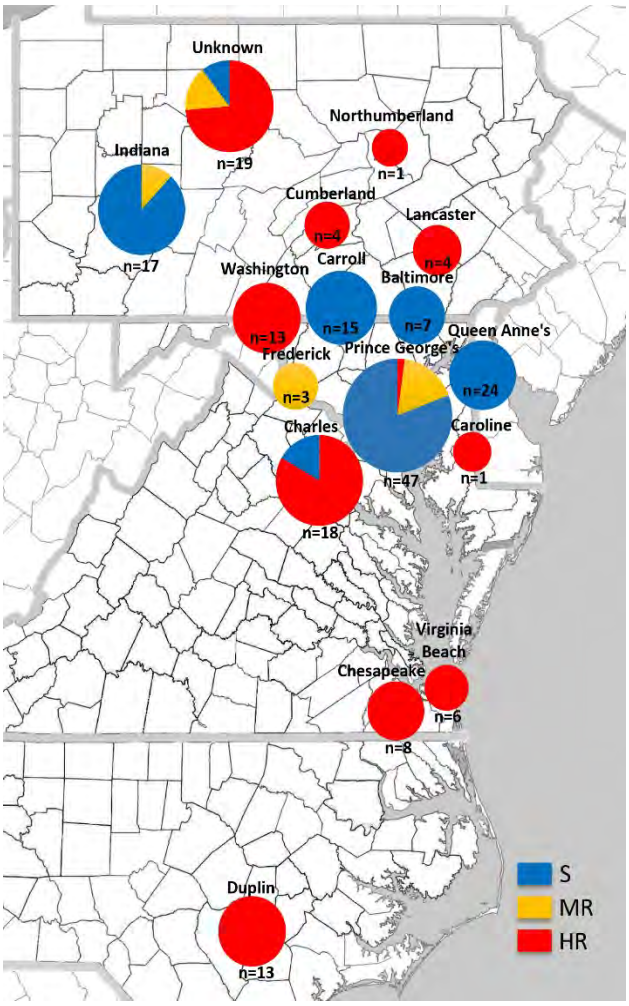


Fig. 2. Frequency of *Colletotrichum* spp. isolates sensitive (**S**), moderately resistant (**MR**), and highly resistant (**HR**) to QoI fungicide azoxystrobin (unpublished data).

free fruit again after having produced diseased fruit. *C. gloeosporioides* and *C. fragariae* infections often result in crown necrosis that leads to plant wilting or death, although they sometimes can infect the strawberry fruit. A recent study showed *C. nymphaeae* (one member within *C. acutatum* complex) is predominate in a pool of 271 isolates collected from six states over 23 years.

Cultural methods of anthracnose management in open-field production do not provide sufficient control alone. Thus, fungicide sprays have been a major pillar in the integrated management of strawberry anthracnose. Quinone-outside inhibitors (QoI; FRAC mode of action group 11) are the primary fungicide class used for strawberry anthracnose caused by both *C. acutatum* and *C. gloeosporioides* complex species. Methyl benzimidazole carbamates (MBC; FRAC mode of action group 1) fungicides are typically effective against *C. gloeosporioides* but not *C. acutatum* complex species. However, resistance has been of increasing concern. Bioassays were performed to test for resistance to azoxystrobin (QoIs) in all the 200 isolates we collected from mid-Atlantic region strawberries. Overall frequency of resistance to azoxystrobin (QoIs) was 41.9 % (**Fig. 2**). Moreover, all *C. gloeosporioides* complex isolates were additionally screened for resistance to thiophanate-methyl (MBCs), and the overall frequency of resistance was 63.6 %. Interestingly, a few QoI-resistant isolates were collected from an organic farm in Pennsylvania that never sprayed fungicides, indicating these isolates may have originated from nursery plants.

These results indicate that QoI or MBC fungicides may no longer be effective against *Colletotrichum* spp. Use of these fungicides should be avoided or minimized. Other fungicides including Captan and Switch both have decent efficacy for anthracnose control. In addition, the FRAC 3 products, difenoconazole and propiconazole have shown good efficacy against anthracnose based on lab testing. Inspire Super contains difenoconazole with cyprodinil (one of the active ingredients in Switch, so watch rotations if also using Switch). Various products such Tilt, Protocol and Bumper contain propiconazole. Note that other FRAC 3 fungicides are ineffective for anthracnose based on lab testing. Most FRAC 7 fungicides are not effective

against anthracnose, so it is advisable to NOT use mixtures containing group 11 + 7 in particular, such as Pristine and Merivon.

Table 1. Fungicide products recommended for strawberry Botrytis management.

Group	Product Name	Product Rate	Active Ingredient(s) (*=Restricted Use)	PHI (d)	REI (h)	Bee TR
Apply Captan or Thiram solely when disease pressure is low to moderate. Captan is a much better choice if anthracnose is a concern or present.						
M3	Thiram 480 DP	4.4 lb/A	Thiram	3	24	N
M3	Thiram Granuflo	4.4 lb/A	Thiram	3	24	N
M3	Thiram 24/7	2.6 qt/A	Thiram	1	24	N
M3	Thiram SC	2.6 qt/A	Thiram	1	24	N
M4	Captan 50W	6.0 lb/A	Captan	0	24	N
M4	Captan 80WDG	3.7 lb/A	Captan	0	24	N
M4	Captec 4L	3.0 qt/A	Captan	0	24	N
M4 + 17	Captevate 68WDG[1]	3.5 to 5.25 lb/A	captan + fenhexamid	0	24	N
Tank mix Captan or Thiram with one of the following fungicides ONLY when disease pressure is high. NEVER apply the following fungicides solely during critical periods (*i.e.*, blooming and maturing) due to high resistance risk. Do not apply the same FRAC code more than twice in a row or in a season.						
2	Meteor[2]	1.5 to 2.0 pt/A	iprodione	n/a	24	N
2	Nevado 4F[2]	1.5 to 2.0 pt/A	iprodione	n/a	24	N
2	Rovral 4F[2]	1.5 to 2.0 pt/A	iprodione	n/a	24	N
7	Fontelis	16 to 24 fl oz/A	penthiopyrad	0	12	L
7	Kenja	13.5 to 15.5 fl oz/A	isofetamid	0	12	--
7	Luna Privilege	6.8 fl oz/A	fluopyram	0	12	N
7 + 9	Luna Tranquility	16 to 27 fl oz/A	fluopyram + pyrimethanil	1	12	N
7 + 11	Luna Sensation	6 to 7.6 fl oz/A	fluopyram + trifloxystrobin	0	12	N
7 + 11	Merivon	8 to 11 fl oz/A	fluxapyroxad + pyraclostrobin	0	12	--
9 + 12	Switch 62.5WG	11 to 14 oz/A	cyprodinil + fludioxonil	0	12	N
17	Elevate 50 WDG	1.5 lb/A	fenhexamid	0	4	N

[1]Do not tank mix Captevate with Elevate. [2]Do not make more than 1 application per season. Do not apply it after first fruiting flower.

Table 2. Fungicide products recommended for strawberry anthracnose management.

Group	Product Name	Product Rate	Active Ingredient(s) (*=Restricted Use)	PHI (d)	REI (h)	Bee TR
Maintain continuous coverage of Captan.						
M4	Captan 50W	6.0 lb/A	captan	0	24	N
M4	Captan 80WDG	3.7 lb/A	captan	0	24	N
M4	Captec 4L	3.0 qt/A	captan	0	24	N
M4 + 17	Captevate 68WDG[1]	3.5 to 5.25 lb/A	captan + fenhexamid	0	24	N
Use of the following fungicides ONLY when disease pressure is high. NEVER apply them solely during critical periods (*i.e.*, blooming and maturing) due to high resistance risk. Do not apply the same FRAC code more than twice in a row or in a season (Cabrio and Pristine are considered the same FRAC code).						
9 + 12	Switch 62.5WG	11 to 14 oz/A	cyprodinil + fludioxonil	0	12	N
3 + 9	Inspire Super[2]	16-20 fl oz/A	difenoconazole + cyprodinil	0	12	N
3	Tilt[2]	4 fl oz/A	propiconazole	0	12	N

[1]Do not tank mix Captevate with Elevate. [2]Other fungicides containing propiconazole or difenoconazole are not listed.

Note: Resistance to FRAC 11 and FRAC 1 is common. **Avoid using these fungicide classes if previous control with the same class has failed.** FRAC 3 fungicides other than propiconazole and difenoconazole are not effective against *Colletotrichum* species.

What's going on under the cover? A glimpse into weather variables and disease infection risk at strawberry canopy

Anita Schoeneberg[1], Mengjun Hu[1], John Lea-Cox[1], and Michael Newell[2]

[1]Department of Plant Science and Landscape Architecture, University of Maryland, College Park, MD
[2] University of Maryland Extension, Wye Research and Education Center, Queenstown, MD

Background: The use of floating row covers (FRC, Fig. 1) is essential for growing strawberries in plasticulture systems in open-fields in many production areas such as the coastal plain or piedmont areas of the eastern U.S. FRC are deployed primarily during winter to increase ambient temperatures within the strawberry canopy and in the root zone, to help mitigate cold and frost damage during winter and early spring. The use of FRC during establishment in fall also promotes crown development and flower initiation, by increasing degree-day accumulation. However, it is not well understood how the deployment of FRC alters canopy-level microclimatic conditions, and whether these possible changes could increase the risk for disease development. Even without a row cover, the microclimatic conditions at canopy-level could be different from parameters measured by a weather station. Shading between plants, moisture retention in the canopy, or heat absorption by the black plastic are just a few factors which can influence the plant microclimate.

Figure 1: Deployment of row covers in a strawberry plasticulture field at the Wye REC.

The three main goals of our study are to 1) address the potential difference in environmental variables between canopy-level sensors and an on-site weather station, with or without deployment of row covers; 2) whether these differences could lead to differences in prediction of disease infection risk; and 3) evaluate the efficacy of a canopy-level sensor-based disease prediction system for disease control. Our central hypothesis is that monitoring canopy-level environmental variables will significantly improve disease prediction precision while maintaining or even increasing marketable yield, compared to data inputs from a weather station spatially removed from the crop.

Trials to monitor microclimatic conditions. Three field trials, two in Maryland and one in Virginia, are currently in progress to understand the difference in environmental variable measurements between canopy-level sensors and on-farm weather stations. The trials are funded by a Northeastern IPM partnership grant (2019-2021) and will be repeated next year. We are using commercially-available sensors (Meter Group, Inc., Pullman, WA) (Fig. 2) and monitoring software to calculate infection risks and to visualize the data (Ag-Zoom, Verdu, Spain).

Figure 2: Canopy-level weather variable sensor (right) with leaf wetness sensor (left) mimicking a strawberry leaf.

The spray program, disease and yield evaluation are ongoing during spring, 2020. Yet, preliminary environmental and infection risk data during the row cover period already reveal some interesting results.

The temperature was markedly higher underneath the FRC compared with the temperature measured at the weather station for all three sites (data not shown). Figure 3 shows an example for temperature and leaf wetness for one week in March. On March 9, the last day where the FRC was on, the temperature under the FRC reached about 85 °F, compared to the ambient air temperature of 70 °F. But even without FRC, the temperature measured by sensors installed in the strawberry canopy differed from that measured by the weather station, also seen in the example in Figure 3.

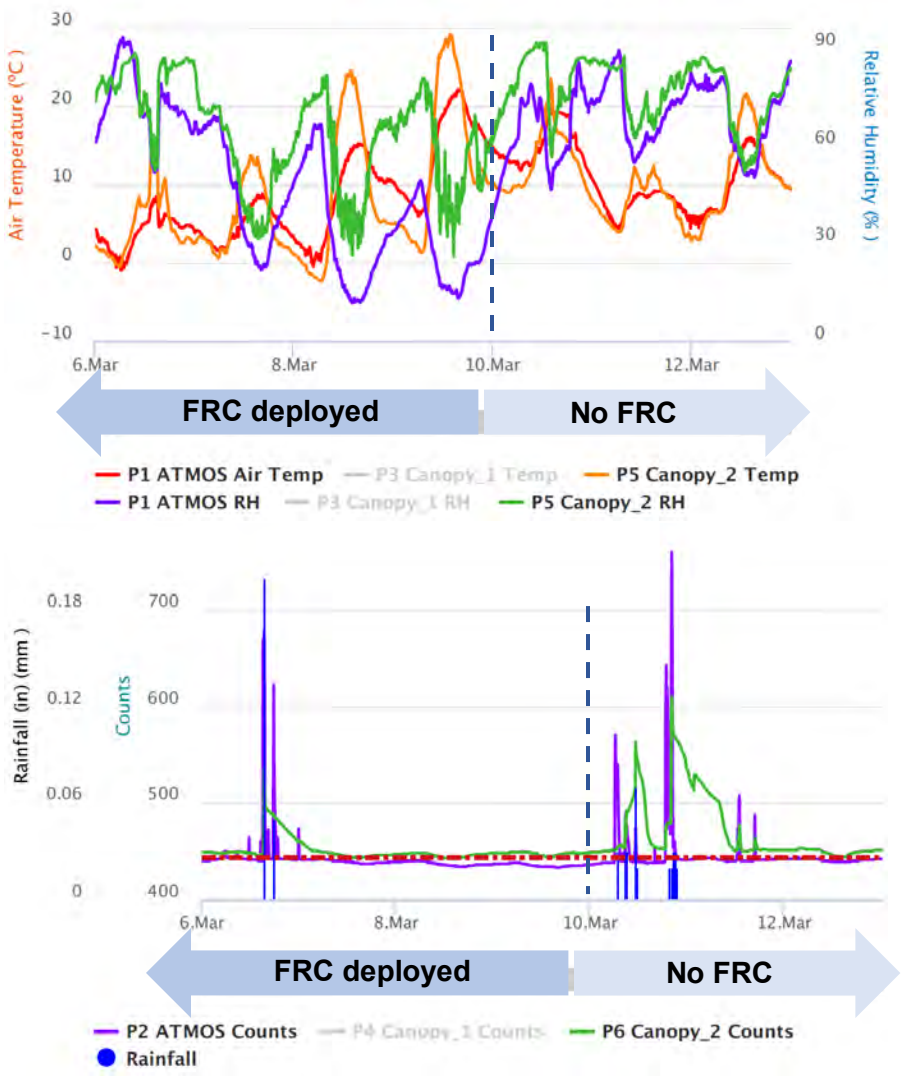


Figure 3: Air temperature and relative humidity (RH) (upper chart), and leaf wetness duration and rainfall (lower chart) displayed on the platform Ag-Zoom. Notice the larger difference in temperature and RH between weather station (ATMOS) and the microclimate sensors (Canopy_1 and Canopy_2) before March 10, when FRC was still deployed, compared to after March 10 without FRC. However, leaf wetness duration was increased in the canopy independently of RFC use.

In the two commercial sites in MD and VA, leaf wetness duration (LWD) was increased in the canopy, but appeared to not be affected much by row covers (see example in Figure 3). In the trial at Wye Research and Education Center (Wye REC, Queenstown, MD) we have two replicate plots

to study the variability in fall FRC on microclimate and disease infection risk. In contrast to the two commercial sites, LWD was found to be decreased in one of the plots (plot 1) on the prevailing wind side. A fall cover was deployed as early as November 1 on plot 1. On December 9, the neighboring plot 2 was also covered for frost protection. The fall cover is used to promote plant growth before winter, and allows for a direct comparison of canopy-level weather variables between covered and uncovered plots at the same time. While the temperature under the fall FRC on plot 1 was higher compared with the uncovered plot 2 as expected (data not shown), the LWD was lower in the fall FRC plot 1. During winter, when both plots were covered, plot 1 continued to have a lower LWD than plot 2 and the weather station, while LWD in plot 2 was slightly higher compared with the weather station (Fig. 4). Differences in exposure of the plots to wind, or to sun and shade from a nearby woodside or weeds are possible explanations for the discrepancy that need to be investigated further. Interestingly, we did notice over-growing weeds in the row middles at the commercial site in MD in early March, which could have formed a wind barrier, retaining the moisture at the canopy level.

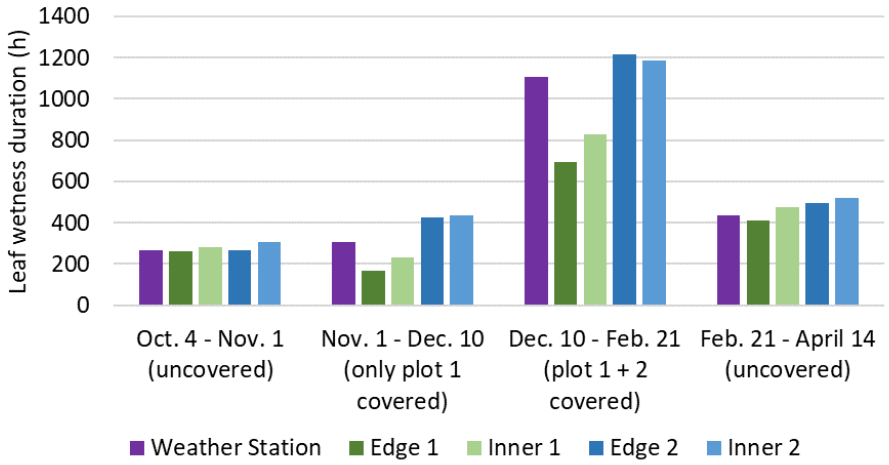


Figure 4: Leaf wetness duration (in hours) for the weather station, edge and inner rows of the fall- and winter-covered plot 1 and the winter-covered plot 2, respectively, at the Wye REC during covered and uncovered periods.

Importantly, leaf wetness duration and air temperature are the primary input variables used in the models that calculate the infection risk for botrytis (BFR) and anthracnose fruit rot (AFR). Notably, the number of days with moderate or high infection risk for AFR and BFR was higher with canopy-level data compared to the on-site weather station data for the two commercial sites in MD and VA (Fig. 5), as LWD and temperatures were increased in the canopy. Although the effect was more pronounced during the row-covered period, the number of days with infection risk calculated from canopy-level sensor data was also increased during uncovered periods (data not shown). This shows that measuring temperature and LWD at canopy-level could lead to differences in disease prediction compared with measurements taken by an on-farm weather station. In contrast, the number of infection risk days at the Wye was lower in the fall FRC plot 1 than in the uncovered plot 2, and comparable with the weather station (Fig. 5). This trend is also true for the period from December 10 to February 21, where FRC was deployed on both plots, and is again in line with the observations made for LWD in these plots. The Wye trial shows that more factors besides the FRC can alter the microclimate within the strawberry canopy and stresses the importance of further

investigation of canopy-level weather variables. We will be deploying wind sensors at the canopy level at the Wye during the 2020/21 season.

Variability between canopy level sensors in the same field was observed at all three sites, showing how microclimatic conditions can differ even within a field. More days with infection risk and an increased leaf wetness duration were calculated for the respective inner rows compared with the edge rows in both MD trials (Fig. 5). The inner rows are less exposed to wind and might retain higher humidity and temperatures.

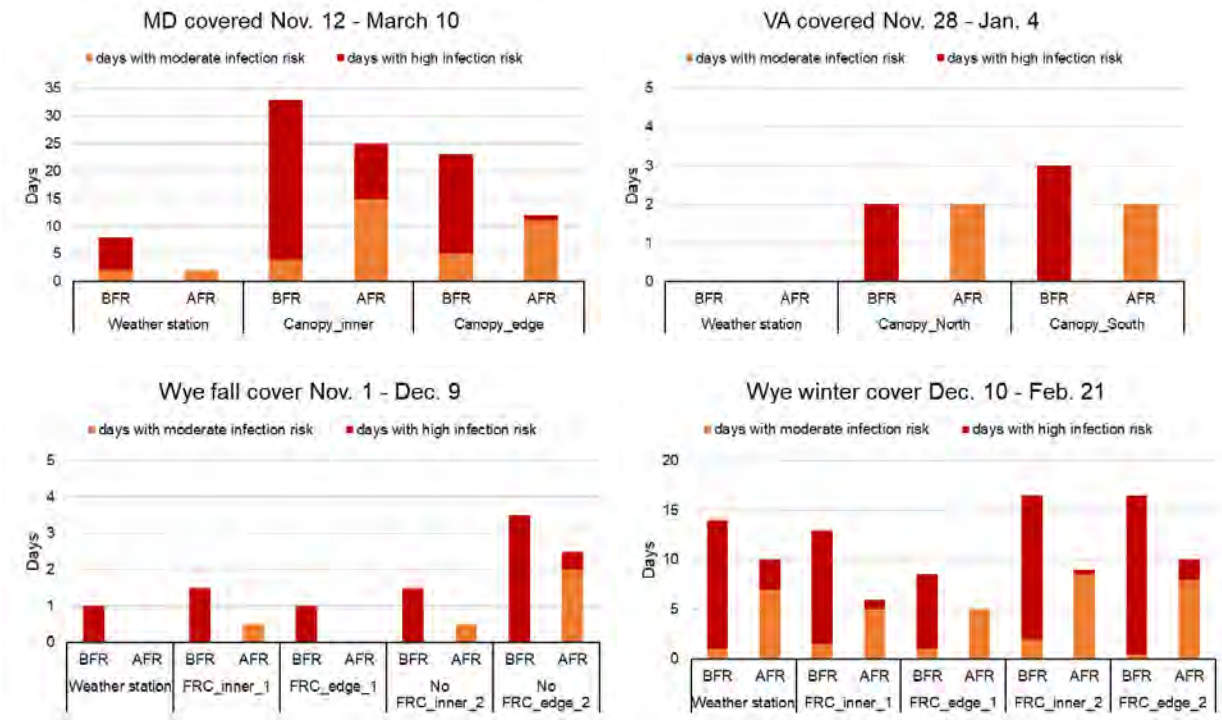


Figure 5: Predicted number of days with moderate (orange) or high (red) infection risk for botrytis (BFR) and anthracnose (AFR) at the commercial farm in MD (top left), the commercial farm in VA (top right) and at the Wye (bottom) for row-covered periods.

Conclusions. The preliminary data shows that FRC alters canopy microclimatic conditions. While temperature was increased by FRC in all three trials, the effect on leaf wetness duration and on infection risk for Botrytis and anthracnose was not consistent between trials. It is still unclear, whether infections occurring during fall and winter under FRC have an impact on disease development in spring. Notably, canopy-level conditions differed from those recorded with the on-site weather station, even without row covers. It therefore seems important to consider micro-climatic conditions for disease prediction and accurate fungicide spray timing. This will not only enable more targeted and more efficient sprays but could also reduce the number of fungicide sprays compared to weekly "calendar-based" applications. Fewer sprays also means less selection pressure on fungal communities, reducing the risk of resistance development. Degree day accumulation and frost monitoring, a component missing from current existing technologies and practices, are added benefits of canopy-level sensors for farmers. We are excited to see the results of this year's harvest, and how the microclimate conditions developed over the growing season. Stay tuned for more insights into the secret life inside the strawberry canopy!

Strawberry Insect Pests

Maria Cramer, Research Assistant
Department of Entomology, University of Maryland
mec@umd.edu

Kelly Hamby, Assistant Professor/Extension Specialist
Department of Entomology, University of Maryland
kahamby@umd.edu

Strawberry clipper weevil

- Enters fields in spring as strawberry plants begin to bud
- Lays an egg in a strawberry bud then girdles it. Larva feeds on pollen as it develops protected in the fallen bud
- Adults feed on the pollen in closed buds, causing a shot-hole appearance when flowers open
- Bud and flower damage most obvious signs of clippers
- Only one generation per year

Fig. 1. (Left) Strawberry clipper weevil, (right) a clipped bud (M. Cramer).

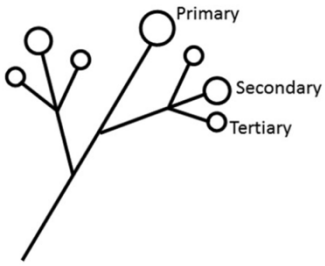


Fig. 2. Bud emergence of typical Strawberry inflorescence (McPhie and Burrack, 2017).

Strawberry plants compensate for bud clipping with additional fruit

- Tolerance for clipper is high because plants produce extra fruit when buds are clipped
- The largest berry, from the primary bud, usually survives because it opens before clippers become active
- Open flowers aren't good places to lay eggs, so they aren't susceptible to clippers
- Day-neutral cultivars blossom after clippers have left, escaping damage
- The threshold is 1 clipped bud per linear foot, sampling 5 separate 10-foot sections
- Early season sprays for clippers can cause outbreaks of two-spotted spider mites
- More info at https://content.ces.ncsu.edu/strawberry-clipper-weevils-in-strawberry

Sap beetle or slug?

- Feeding holes tend to look similar and are often the only sign of the pest
- Sap beetles feed in ripe and overripe fruit. They usually make a circular hole, and the surrounding fruit will become soft and sunken (Fig. 3.)
- Slug damage looks similar, but slugs also feed on unripe fruit. Damage is often more irregular in shape, but with clean edges, and slugs may leave behind slime where they feed (Fig. 4.)

Fig. 3. Sap beetle feeding damage (LSU extension).

Fig. 4. Slug feeding damage with slime (M. Cramer).

What can you do?

- Feeding ID is key— you need different approaches depending on the pest
- Sap beetles are best managed through sanitation—always cleanly pick all ripe strawberries and alternative host crops like sweet corn and other berries. Promptly renovate fields after harvest. Insect growth regulators (e.g., Rimon®) may be useful as part of a management plan with sanitation as the first line of defense.
- Slugs are not susceptible to insecticides, and because they can feed on unripe fruit, simply practicing good harvest sanitation may not prevent slug damage. Remove overwintering sites like compost piles in the field and use practices that dry and warm the field (tillage and plastic mulch). In the case of heavy slug feeding and losses, slug baits should be used, according to manufacturer instructions.

Also keep a look out for:

Fig. 5. (Top) TPB nymph (University of New Hampshire), (bottom) feeding damage to berries (University of Maine).

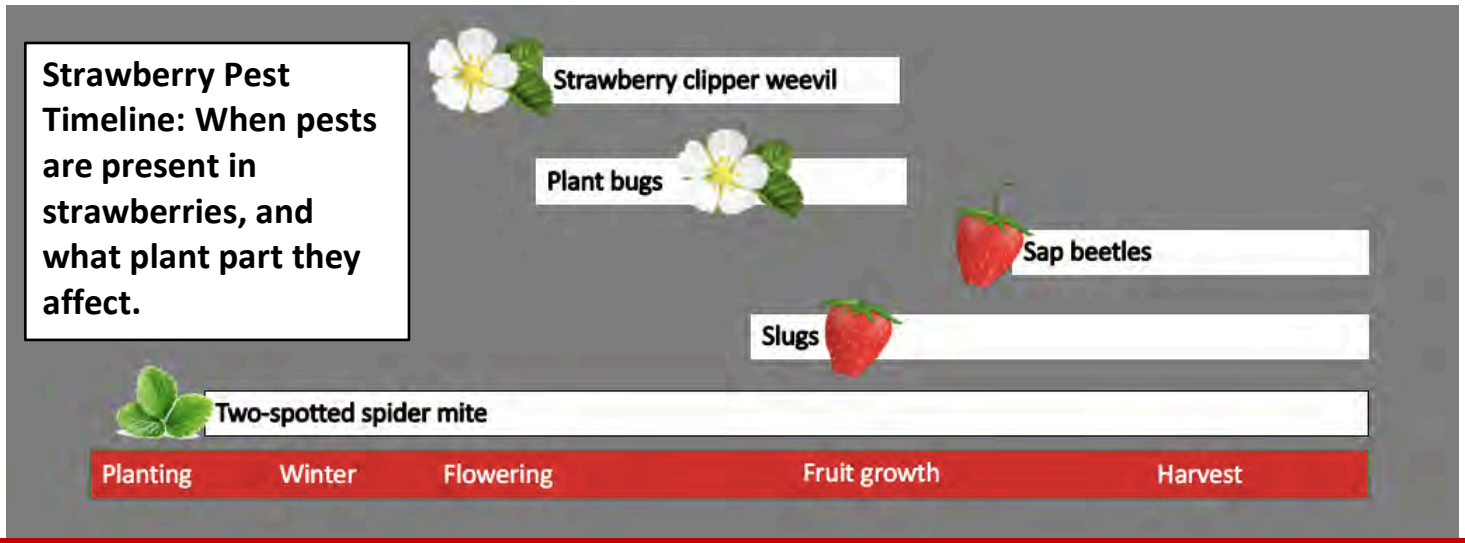
Plant bugs

- Different bugs in the *Lygus* family, but tarnished plant bug (TPB) is the most common culprit.
- Shiny green-brown bug with piercing-sucking mouth parts
- TPB feeds at the tip of the berry right after pollination-- Damaged areas develop abnormally and are puckered with dense, unpalatable flesh (Fig. 5. bottom)
- Day-neutral cultivars are more susceptible to TPB because they bloom later when TPB is in high numbers
- Early June-bearing cultivars may totally escape damage by blooming before TPB arrives
- Right before bloom, sample 30-50 trusses. Shake them over paper and count nymphs that fall out. Threshold: 1 nymph per 4 trusses

Spider mites

- Feed on leaves causing stippling, dusty-looking foliage, and yield reductions
- Complete development in two weeks, have 10-15 generations in a year
- Often controlled by natural enemies, unless insecticide sprays wipe out these enemies
- Monitor by examining the undersides of 10 leaflets per acre in early spring
- Overwintering mites will be reddish-orange while later generations will be light green as in Fig. 6.
- Before harvest, the threshold is more than 5 mites per leaflet
- Plants tolerate high mite levels after strawberry harvest begins
- For more information: https://entomology.ces.ncsu.edu/2017/02/its-time-to-scout-and-manage-spider-mites-in-strawberries/

Fig. 6. Two-spotted spider mite adults, nymphs, and spherical eggs. Monitor with a hand lens or magnification on your phone—these were just visible to the naked eye (M. Cramer).



Further Resources:

Identification, monitoring, and pesticide info: The Mid-Atlantic Berry Guide https://extension.psu.edu/the-mid-atlantic-berry-guide-for-commercial-growers

More from UMD Extension: https://extension.umd.edu

UNIVERSITY OF MARYLAND EXTENSION

Spray Program for Multi-Small Fruit Plantings

Many local farms are composed of multi-small fruit combinations producing for fresh market blackberries, raspberries, blueberries, strawberries and grapes. Aggressive fruit spray programs are required to achieve high quality fruit. These multi-small fruit plantings create many spray management challenges for the achievement of good pest control in accordance to label guidelines.

Therefore, the following multi-small fruit spray program for the control of major small fruit pests and diseases may offer some assistance:
Labeled as noted in 2020 for All Small Fruit – Strawberries, Brambles: Blackberries, Raspberries, Blueberries, and Grapes.

FUNGICIDES: [FRAC]	*RATE	NOTES
Lime Sulfur [M2]	10.0 gals	Dormant Fall Sanitizer
JMS® Stylet Oil [NC]	1.0 gal	Apply Temp 35-85° F
Kocide® DF [M1]	2.0 lbs	Other Fixed Coppers
Captan® 50W [M4]	2.0 lbs	General Protectant
Ziram® 76DF [M3] (Except for Strawberry use **Thiram®**)	5.0 lbs	General Protectant
Sulfur 95W [M2] (Grape variety sensitivity)	3.0 lbs	General Protectant
Rally®40W [3] (Except for blueberry use **Tilt®**)	4.0 ozs	Powdery Mildew & Black Rot
Pristine® [7/11]	14.5 ozs	Fruit Rots, Fruit Spots, Powdery & Downy Mildew & Cane Blight
Elevate® 50 WG [17]	1.5 lbs	Botrytis & Powdery Mildew
Switch® 62.5 WG [9/12]	11.0 ozs	Anthracnose, Mummy Berry, Phomopsis, Sour Rot & Botrytis
Phostrol® [33]	4.0 pts	Downy Mildew & Red Stele
Ph-D® WDG [19] (Strawberries and grapes only)	6.2 ozs	Botrytis & Powdery Mildew
INSECTICIDES: [IRAC]	***RATE**	**NOTES**
Provado® Admire ® [4A] or Actara® [4A]	4.0 ozs	SWD, Grubs, Aphids, Hoppers, Curculio & Whitefly
Brigade® WSB [3]	12.0 ozs	BMSB, SWD, Clipper Beetle, Plant Bug, Mites & Root Weevil
Malathion [1B]	2.0pts	SWD, Scale, Fruit Moths & Whitefly
Sevin® 50W [1A]	4.0 lbs	SWD, Japanese Beetles, Hornets & Sap Beetles

***Rate for 50-100gal Acre Concentrate Spray**
****Be sure to follow all labels closely for PHI and REI!**

Multi-Small Fruit Spray Calendar*

March 5 - Spring Dormant Spray
JMS® Stylet Oil 1.0 gal (Scales & Mites)

April 10 - Early Strawberry Bloom
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Thiram® 75WDG 5.0 lbs (Strawberry Only)

April 15 - Strawberry Bloom/ Blueberry Early Bloom
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Ziram 76DF 5.0 lbs (Except Strawberry)
Brigade ®WSB 12.0 ozs (Clipper Beetle, 0-3-day PHI)

April 25 - Strawberry Full bloom/Blueberry Mid-Bloom/ Grape Bud Break
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Pristine® 14.5 ozs
Brigade®WSB 12.0 ozs (Clipper Beetle, 0-3-day PHI)

May 5 - Strawberry 1st Cover & Early Harvest Spray/ Blueberry Full Bloom/Grape & Bramble Shoot Growth
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Elevate ®1.5 lbs (0-day PHI)
Provado® 4.5 ozs (Curculio & Aphids; 7-Day PHI)

May 15 - Strawberry 2nd Cover & Harvest Spray/ Blueberry 1st Cover/Grape Bloom Spray/Bramble Cane Development
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Switch® 11.0 ozs (0-day PHI)
Malathion® 2.0 pts (Curculio, Scale & Fruit Moths; 0-3-day PHI)

June 1 - Strawberry 3rd Cover & Harvest Spray/Blueberry 2nd cover/Grape 1st Cover/Bramble Bloom
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Pristine® 14.5 ozs (0-day PHI)
Malathion® 2.0 pts(Curculio, Scale & Fruit Moths; 0-3-day PHI)

June 15 - Strawberry 4th Cover & Harvest Spray/Blueberry 3rd Cover & Early Harvest/ Bramble 1st Cover/ Grape 2nd Cover
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Ph-D® 6.2 ozs (0-day PHI)
Sevin® 50W 4.0 lbs (sap beetle, 5-Day PHI)

July 1- Strawberry Renovation/Blueberry 4th Cover & Harvest/ Bramble 2nd Cover & Early Harvest/ Grape 3rd Cover
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Pristine® 14.5 ozs (0-day PHI)
Rally 40 W 4.0 ozs (Except Blueberry, 0-day PHI))
Brigade®WSB 12.0 ozs (0-3-day PHI)

July 15 - Strawberry Post Harvest/ Blueberry 5th Cover & Harvest/ Bramble 3rd Cover & Harvest/ Grape 3rd Cover & Veraison
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Switch® 11.0 ozs (0-day PHI)
Sulfur 95W 3.0 lbs (0-day PHI)
or Kocide DF 2.0 lbs (0-day PHI)
Malathion 2.0 pts (0-3-day PHI)

August 1- Strawberry Post Harvest/ Blueberry 6th Cover & Harvest/ Bramble 4th Cover & Harvest/ Grape 4th Cover & Early Harvest
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Pristine® 14.5 ozs (0-day PHI)
Sevin® 50W 4.0 lbs (Japanese Beetle, 5-Day PHI)

August 15 - Strawberry, Blueberry & Bramble Post Harvest/ Grape 5th Cover & Harvest
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Elevate ®1.5 lbs (0-day PHI)
Phostrol® 4.0 pts (0-day PHI)
Sevin® 50W 4.0 lbs (Hornets – 5-Day PHI for All Fruit)

September 1 - October 30 Strawberry Post Harvest/ Grape 6th Cover & Harvest
Captan® 50W 2.0 lbs (0-3 Day PHI & 2-Day REI)
Phostrol® 4.0 pts (0-day PHI)
Sevin® 50W 4.0 lbs (Hornets – 5-Day PHI for All Fruit)

November 25 Fall Dormant
Lime Sulfur 10.0 gals
Kocide DF 2.0 lbs (0-day PHI)

HERBICIDES: [HRAC]	*RATE	NOTES
Gramoxone ® [22]	1.0 qts	Burndown, Directed Spray
Roundup ® [9]	1.0 qts	Burndown, Shielded & Directed Spray
Devrinol ® 50 DF [15]	4.0 lbs	Spring/Summer 35-day PHI
Princep ® 4L [5]	1.0 qts	Spring Dormant, Avoid High pH Soils
Solicam® [12] (Except strawberry)	2.5 lbs	Spring/Fall Dormant, 1-yr Established
Aim® [14] or Shark® [14]	2.0 ozs	Directed Spray to Weeds, 3-day PHI
Venue [14] (Grapes only)	2.0 ozs	Directed Spray, 0-day PHI
Chateau [14] (Except brambles)	12.0 ozs	After Harvest to Spring Bud Swell
Surflan® [3] (Except strawberry)	2.0 qts	Spring/ Summer, Prowl 60-day PHI
Poast® [1]	1.5 pts	Summer Grasses, Variable PHI
Sinbar ® [5]	4.0 ozs	Fall Dormant, 1-yr Established

***Lowest Use Rate Recommended Initially**

Organic Approach Substitutions:

Conventional Product	Organic Certified Product (OMRI)
Captan®	Surround® or Sulfur or Lime Sulfur
Rally®	Kaligreen® (Powdery Mildew Eradicant)
Listed Insecticides	Neem® or Pyganic® or Entrust® or Dipel®
Gramoxone® or Roundup®	Avenger® or Burnout®or AXXE®/BioSafe® or (Scythe® no OMRI label)

*** Important Note: The calendar spray dates given are an average estimate for Anne Arundel and Prince George's County small fruit production, and may vary by location in Southern Maryland. Be sure to adjust your spray schedule application dates accordingly. The above recommendations very closely reflect the current spray program utilized at the University of Maryland Research and Education Center, Upper Marlboro Facility for its research fruit plots. Remember to always "Read the Label".**

R. David Myers
Principal Agent, Agriculture
myersrd@umd.edu

Food Safety Fridays: A How-To Webinar Series

This monthly webinar series, hosted by the Maryland Food Safety Network, will focus on how to comply with key provisions of the Food Safety Modernization Act's Produce Safety Rule (PSR) from enacting practices to efficient record keeping strategies.

How to: Effectively and Efficiently Train Your Workers
May 22, 2020 @ 12:00 p.m.

How to: Make Water Risk Assessments
June 19, 2020 @ 12:00 p.m.

How to: Get A Handle On Water Quality
July 17, 2020 @ 12:00 p.m.

How to: Manage Wildlife
August 21, 2020 @ 12:00 p.m.

How to: Develop A Sanitation Program
September 18, 2020 @ 12:00 p.m.

How to: Apply, Handle and Store Biological Soil Amendments
October 16, 2020 @ 12:00 p.m.

How to: Put It All Together in A Food Safety Plan
November 20, 2020 @ 12:00 p.m.

Register for the webinars today at foodsafetyfridays.eventbrite.com

Anyone with questions about the webinars can contact Sarah Everhart at severhart@law.umaryland.edu or 410-706-7377

Produce Safety Rule: True or False?

I'm showing all my employees the Cornell Health and Hygiene video; that's good enough for training.

False. While showing the video is a great component of training, the Rule also states that employees need training (with a record) specific to their job duties.

I have to clean and sanitize all my food contact surfaces after every *use.*

False. The Rule allows for the farmer to determine the cleaning and sanitizing schedule they deem appropriate based on assessment of risk.

I don't have to keep a wildlife monitoring log for the PSR.

True. There is no wildlife monitoring record required for the PSR, although you may need to keep one for certain GAP audits.

Funding for this series of webinars was made possible, in part, by the Food and Drug Administration through grant PAR-16-137. The views expressed in written materials or publications and by speakers and moderators do not necessarily reflect the official policies of the Department of Health & Human Services; nor does any mention of trade names, commercial practices, or organization imply endorsement by the United States Government.

Maryland Pick-Your-Own Operations During COVID-19 State of Emergency

FREQUENTLY ASKED QUESTIONS

As a pick-your-own farm operator…

What do I need to do to protect myself, my employees, my customers, and the public from COVID-19?

All Marylanders are advised to take precautions to slow the spread of COVID-19. Any place where people congregate is a possible opportunity for COVID-19 to spread. It is absolutely essential that pick-your-own farm operators do what they can to reduce the risk of transmission.

In general, operators are advised to:

- Require customers and staff to follow Governor Hogan's 20-04-15 Executive Order requiring the use of a face covering including face masks or cloth face coverings.
- Keep customers and workers from grouping too close to one another, in no case closer than 6 feet.
- Provide signage that urges customers to keep a 6-foot distance away from others, and discouraging groups of 10 or more from assembling together in one area.
- Allow for customers to be spaced 6 feet or more apart when they are picking and paying for the produce. Use flags, cones, and tape, or otherwise demark areas available for picking in the fields. Allow for sufficient space when customers are waiting to pay for the produce.
- Do not let anyone work or pick who is sick or is experiencing fever, body aches, nausea, cough, sore throat, or shortness of breath or may have been exposed to individuals with these symptoms. You can use signage like, "Do not pick if you are sick!"
- If a worker becomes sick during the work day, have them go home and isolate themselves from other staff and customers immediately.

How do I prepare my pick-your-own operation?

- Put up signage and provide information on websites and social media to explain any changes to the operation or extra precautions taken to limit exposure to COVID-19.

- Have fully stocked handwashing and sanitizing stations in place at multiple locations and post signs that inform customers the correct way to wash hands. Workers and customers should wash their hands for at least 20 seconds with soap and warm water if available, or use hand sanitizer, before and after handling produce.
- Consider on-line ordering, alternate pick-up, drive-through, or delivery options to keep crowd levels low.
- Schedule harvest times to limit the number of people picking including, but not limited to, scheduling a harvest time reserved for those who are most vulnerable to COVID-19.
- Limit and control access to the farm to ensure proper social distancing by establishing clearly marked entrance and exit points for customers.
- Postpone or cancel any scheduled events at the farm.
- Offer picked and packaged for sale items in single use containers to minimize crowds and contact with produce.
- Instead of customers bringing their own containers, provide them in one weight or size (ex. pulp quarts and cardboard flats). Consider modifying your pricing structure to accommodate the containers and allow you to cover your costs. This will allow a quick count of containers when charging at checkout, and not only increases efficiency but also minimizes the handling of containers by multiple people.
- Use credit card readers that allow customers to swipe their own credit cards or use touchless payment systems. Disable the signature function on your point of sale (POS) system to limit contact from multiple customers. Discourage payments by cash.
- Clean reusable bulk containers thoroughly by first using detergent and water then a food contact surface-approved sanitizer before reuse. Use disposable liners in reusable containers.
- Maintain clean and sanitized food contact surfaces and frequently touched objects and consider a more frequent cleaning schedule. Provide wipes or clean carts for customers prior to use.

Can I still offer samples of my produce at the farm?

Generally, the more food is handled, the more likely it is to be a source of exposure to viruses like COVID-19. MDH strongly advises against food sampling during the state of emergency.

Can my customers pre-order and pick-up at the farm?

Customers can pre-order and pick-up products regulated by MDA or MDH. Follow all recommendations for social distancing and other public health precautions when handling orders.

How do I prepare my staff?

- Have clear policies on illness and COVID-19. No employee should work if ill or has been exposed to someone who is ill. Employees and managers should check themselves for symptoms of COVID-19 (fever, cough, flu-like symptoms). All employees should notify their supervisor and stay home if they are sick.

- Stagger employee lunch and break times to encourage social distancing.

- If workers develop COVID-19 — either suspected, diagnosed by a medical professional, or confirmed by laboratory diagnosis — they should be isolated at home and not allowed to return to work until:
    - There has been no fever for at least 72 hours (i.e. three full days of no fever without the use of medicine that reduces fevers); AND
    - Other symptoms have improved (cough may persist for 1–2 weeks) ; AND
    - At least 7 days have passed since symptoms first appeared.
- Require customers and staff to follow Governor Hogan's 20-04-15 Executive Order requiring the use of a face covering including face masks or cloth face coverings..

What food safety practices should I implement on the farm to minimize the risk for COVID-19 transmission to my customers from produce?

- Basic employee health and hygiene practices such as frequent hand washing, glove policies, restroom use, clean clothes, and other basic health and hygiene practices help reduce the risk of COVID-19 transmission. Use of disposable gloves and more frequent changing of gloves when handling fruits, vegetables and currency is an additional safeguard that can be implemented.
- Sick workers should stay home and should NOT be reassigned to non-food contact duties.

I have extra fruit and vegetables, can I still make jams and jellies and other value-added products to sell at the farm?

- Yes, extra fruit can be used to make jams and jellies.
- Fruits must be high-acid with a natural pH of 4.6 or less (e.g., apples, apricots, blackberries, boysenberries, cherries, grapes, peaches, etc.).
- Jams and jellies must be labeled with: the common name of the food; the list of ingredients (and sub-ingredients) in descending order by weight; a declaration of artificial color or flavor and chemical preservatives; a declaration of the quantity of the package contents by weight in both metric and English units; the name and place of business of the manufacturer, packer, or distributor; nutrition labeling if not exempt; and the name of the food source for each major food allergen (unless the food source is already part of the common or usual name).
- If you are currently licensed by MDH as an on-farm home processor or food processor, extra fruits and vegetables can be used to make those value-added products that have been approved by MDH. More information is available here: Processing and Selling Value-Added Food Products in Maryland
- Fresh produce can be shipped to consumers in Maryland without a license. Shipments to other states may be restricted in some cases.

- Cottage food businesses can ship properly labeled, allowable foods (high-acid jams and jellies and non-potentially hazardous baked goods) to customers in Maryland. Please visit the Maryland Department of Health's Cottage Food Businesses website for additional information.

If a worker or customer becomes sick while working or picking, and you are physically near them (less than 6 feet) for more than 3 minutes without protective equipment like masks, gloves, and eye protection, you may have been exposed to the virus. You should immediately isolate yourself at home and call your healthcare provider.

Additional COVID-19 Resources:

Guidance for Businesses and Employers: The Centers for Disease Control and Prevention (CDC) has provided interim guidance for businesses and employers, and additional business-specific guidance can be found on Maryland's Business Express website.

Food Safety Guidance: The Maryland Department of Health (MDH) has provided specific guidance on food safety here. For more information on farm worker health, hygiene training, or other produce safety questions, please email produce.safety@maryland.gov. Additional information is available on the Maryland Department of Agriculture's (MDA) website.

University of Maryland Extension: The University of Maryland Extension and other state extension programs have worked to create a factsheets regarding COVID-19 for home consumers, retail-food service, grocery shopping, farms and PYOs, and foodbanks. Materials are also available in Spanish and Chinese, and updated weekly. Visit: https://extension.umd.edu/foodsafety

Cleaning and Disinfection Guidelines: The CDC's website has general cleaning and disinfection guidelines.

Maryland
Department of Agriculture
Office of the Secretary

Agriculture | Maryland's Leading Industry

Larry Hogan, Governor
Boyd K. Rutherford, Lt. Governor
Joseph Bartenfelder, Secretary
Julianne A. Oberg, Deputy Secretary

The Wayne A. Cawley, Jr. Building
50 Harry S. Truman Parkway
Annapolis, Maryland 21401
www.mda.maryland.gov

410.841.5880 Baltimore/Washington
410.841.5914 Fax
800.492.5590 Toll Free

Maryland Farmers Markets Operations During COVID-19 State of Emergency

FREQUENTLY ASKED QUESTIONS

As a farmers market vendor…

If I am a vendor at a farmers market, what do I need to do to protect myself, my employees, and the public from COVID-19?

All Marylanders are advised to take precautions to slow the spread of COVID-19. Any place where people congregate is a possible opportunity for COVID-19 to spread. It is absolutely essential that farmers and farmers markets do what they can to reduce the risk of transmission. Vendors are advised to:

- Keep customers from grouping too close to one another and to staff.
- Provide signage that urges customers to keep a 6-foot distance away from others, and discouraging groups of 10 or more from assembling together in one area.
- Space the checkout stations 6 feet or more apart. If space is limited, limit checkout to one person at a time.
- Keep your staff 6 feet apart from one another.
- Do not let anyone work who is sick or is experiencing fever, body aches, nausea, cough, sore throat, or shortness of breath or may have been exposed to individuals with these symptoms.
- If a worker or manager becomes sick during the work day, have them isolate themselves from staff and customers immediately.
- If someone becomes sick while you are working, and you are physically near them (less than 6 feet) for more than 3 minutes without protective equipment like masks, gloves, and eye protection, you may have been exposed to the virus. You should immediately isolate yourself at home and call your healthcare provider.
- Require staff to follow CDC recommendations on the use of cloth face coverings.

Review the Centers for Disease Control and Prevention's (CDC) interim guidance for businesses and employers.

Additional information for businesses on planning and responding to COVID-19 is available on Maryland's Business Express website.

The Maryland Department of Health (MDH) has provided specific guidance on food safety here.

How do I prepare my stand at the farmers market?

- Pre-bag/package items in single use containers to minimize hand contact with produce. Use single-use bulk containers when possible. Clean reusable bulk containers thoroughly by first using detergent and water then a food contact surface approved sanitizer before reuse. Use disposable liners in reusable containers.
- Minimize produces' direct contact with the stand, surfaces, and customers.
- Clean and sanitize transport vehicles and minimize direct contact of produce with transport vehicles.
- Wash your hands for at least 20 seconds with soap and warm water if available, or use hand sanitizer before handling produce.
- Maintain a clean and sanitized food stand. This includes all food contact surfaces and frequently touched surfaces. Consider a more frequent cleaning schedule.

General cleaning and disinfection procedures and guidelines are provided on the CDC website.

How do I prepare my staff?

- Have clear policies on illness and COVID-19. No employee or manager should work if ill or has been exposed to someone who is ill. Employees and managers should check themselves for symptoms of COVID-19 *(fever, cough, flu-like symptoms)*. All employees should notify their supervisor and stay home if they are sick.
- If a member of the work crew becomes ill and other workers are 6 feet or closer to the worker for more than 3 minutes while the person is experiencing symptoms, those workers should immediately isolate themselves at home and call their healthcare provider.
- If workers develop COVID-19 — either suspected, diagnosed by a medical professional, or confirmed by laboratory diagnosis — they should be isolated at home and not allowed to return to work until:
    - There has been no fever for at least 72 hours *(that is three full days of no fever without the use of medicine that reduces fevers)*; **AND**
    - Other symptoms have improved *(cough may persist for 1–2 weeks)*; **AND**
    - At least 7 days have passed since symptoms first appeared.
- Require staff to follow CDC recommendations on the use of cloth face coverings.

Review the CDC's interim guidance for businesses and employers. Additional information for businesses on planning and responding to COVID-19 is available on Maryland's Business Express website.

Do I need to sanitize my stand?

- Routinely clean and disinfect frequently touched objects and surfaces using standard cleaning practices.
- The U.S. Food and Drug Administration has emphasized the need to maintain clean and sanitized facilities, including food contact surfaces. Consider a more frequent cleaning schedule.

Check out the CDC's website for general cleaning and disinfection guidelines. Review the CDC's interim guidance for businesses and employers.

What food safety practices should I implement on the farm to minimize the risk for COVID-19 transmission to my customers from produce?

- Although the CDC has indicated, "Currently there is no evidence to support transmission of COVID-19 associated with food" they have also indicated, "It may be possible that a person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes, but this is not thought to be the main way the virus spreads."
- Basic employee health and hygiene practices such as frequent hand washing, glove policies, restroom use, clean clothes, and other basic health and hygiene practices help reduce the risk of COVID-19 transmission. Use of disposable gloves and more frequent changing of gloves when handling fruits and vegetables and currency is another additional safeguard that can be implemented.
- Sick workers should stay home and should **NOT** be reassigned to non-food contact duties.

All growers that need food safety information on farm worker health and hygiene training or other produce safety questions, please email produce.safety@maryland.gov. Additional information is available on the Maryland Department of Agriculture's (MDA) website.

I have extra fruit and vegetables, can I still make jams and jellies and other value-added products to sell at the farmers market?

- **YES.** Extra fruit can be used to make jams and jellies for sale at farmers markets.
- Fruits must be high-acid with a natural pH of 4.6 or less *(i.e., apples, apricots, blackberries, boysenberries, cherries, grapes, peaches, etc.)*
- Jams and jellies must be labeled with: the common name of the food; the list of ingredients *(and sub-ingredients)* in descending order by weight; a declaration of artificial color or flavor and chemical preservatives; a declaration of the quantity of the package

contents by weight in both metric and English units; the name and place of business of the manufacturer, packer, or distributor; nutrition labeling if not exempt; and the name of the food source for each major food allergen *(unless the food source is already part of the common or usual name)*.

- If you are currently licensed by MDH as an on-farm home processor or food processor, extra fruits and vegetables can be used to make those value-added products that have been approved by the department. More information here:
    - Processing and Selling Value-Added Food Products in Maryland [PDF]

I want to direct ship to consumers. Are there any regulations that I need to follow?

- Fresh produce can be direct shipped to consumers in Maryland without a license. Shipments to other states may be restricted in some cases.
- Meat and poultry inspected by USDA can be direct shipped to consumers. Those currently licensed by MDH as an on-farm storage processor are required to:
    - Notify MDH by emailing mdh.envhealth@maryland.gov that you intend to direct ship and provide your on-farm storage processor license number in the email; **AND**
    - Provide the process that will be used to maintain temperature during shipment.
- Poultry and rabbit producers regulated by MDA can directly ship meat to consumers in Maryland **ONLY** and are required to notify the department by emailing Deanna Baldwin at deanna.baldwin@maryland.gov when they intend to ship and provide the process they will use to maintain temperature during shipment.
- Cottage food businesses can ship properly-labeled, allowable foods *(high-acid jams and jellies and non-potentially hazardous baked goods)* to customers in Maryland. Please visit the Maryland's Cottage Food Businesses website for additional information.

Can I still sample my product at the farmers market?

Generally, the more food is handled, the more likely it is to be a route of transmission for viruses like COVID-19. **MDH strongly advises against food sampling during the state of emergency.**

Can my customers pre-order and pick-up at the farmers market?

Customers can pre-order and pick-up products regulated by MDA or MDH, including table eggs, poultry and rabbit meat *(from MDA-certified Food Safety Inspection Service exempt producers)*, produce, meats processed at a U.S. Department of Agriculture facility, and cheeses. Follow all recommendations for social distancing and other public health precautions when handling orders.

I am a producer and I have partnered with a local restaurant. Can they sell their meals at the farmers market?

- Refer to the Governor's Executive Orders and Maryland's Business Express website to determine what businesses can remain open during the emergency: Maryland Coronavirus (COVID-19) Information for Business.
- Local restaurants must contact their local health department to obtain a Temporary Food Service Facility License in order to participate in a farmers market.
    - For contact information for local health departments, please visit: coronavirus.maryland.gov/pages/lhd-resources.
    - To contact your local health department's food program, please visit: phpa.health.maryland.gov/OEHFP/OFPCHS/Pages/LHD-Food-Contact.aspx. ***Please note that some local health departments have reduced their services during the state of emergency.***

Can other vendors besides agricultural producers sell at farmers markets *(i.e., crafts, soaps, woodworking, etc.)*? Can I sell bedding plants, cut flowers, or potted flowers at farmers markets?

Refer to the Governor's Executive Orders and Maryland's Business Express website to determine what businesses can remain open during the state of emergency.

Is there an approved list of food products that can or cannot be sold at the farmers market?

- Raw agricultural products, products that are not potentially hazardous and do not require refrigeration that are processed in a licensed food processing plant, and MDA-regulated eggs can be sold at farmers markets.
- Additionally, farmers and individuals offering cottage foods have restrictions on what types of foods can be offered. More information here:
    - **MDH** – Maryland's Cottage Foods Businesses
    - **MDH** – Processing and Selling Value-Added Food Products in Maryland [PDF]
    - Restaurants and food vendors that are not farmers or individuals selling cottage foods, should contact their local health department for food licensing requirements in order to participate in the market.
        - For contact information for local health departments, please visit: coronavirus.maryland.gov/pages/lhd-resources.
        - To contact your local health department's food program, please visit: phpa.health.maryland.gov/OEHFP/OFPCHS/Pages/LHD-Food-Contact.aspx. ***Please note that some local health departments have reduced their services during the state of emergency.***

As a farmers market manager…

Do I have to monitor the number of customers in the market at the same time?

- Businesses are encouraged to monitor crowd size and encourage social distancing. Posting signs reminding the public to social distance is advisable. Signage related to COVID-19, and social distancing are available on the MDH Coronavirus 2019 resource webpage.
- For current social distancing guidelines refer to the CDC's interim guidance for business and employees.
- Markets should require staff, vendors and customers to follow CDC recommendations on the use of cloth face coverings.

How much space should I have between vendors' stalls\tables to ensure social distancing?

Keep customers from grouping too close to one another, around staff and produce. Provide signage that urges customers to keep a 6-foot distance away from others, and discouraging groups of 10 or more from assembling together in one area. Space the checkout stations 6 feet or more apart. If space is limited, limit checkout to one person at a time.

Read the CDC's interim guidance for business and employees to stay up-to-date with current social distancing guidelines.

Will farmers accept Supplemental Nutrition Assistance Program (SNAP) at the market?

MDA is working with the Maryland Department of Human Services to keep them informed of all individual farmers accepting SNAP as well as farmers markets accepting SNAP. Farmers markets and farmers accepting SNAP are identified on MDA's website and in the Maryland Farmers Market Directory.

Will farmers accept FMNP checks at the market?

At this time, Women Infants and Children (WIC) Farmers Market Nutrition Program checks and Senior FMNP checks will be issued as scheduled. Farmers will be accepting them. Markets with farmers accepting checks are identified in the Maryland Farmers Market Directory and on MDA's website.

Ultraviolet-C Light Technology and Automation for Control of Strawberry Diseases and Pests

Fumiomi Takeda[1], Wojciech Janisiewicz[1], Tracy Leskey[1], and Adam Stager[2]

[1]*US Department of Agriculture, Agriculture Research Service, Appalachian Fruit Research Station, Kearneysville, West Virginia 25430 and* [2]*University of Delaware, Department of Plant and Soil Sciences, Newark, DE 19711*

This article summarizes the work of Drs. Fumiomi Takeda, Wojciech Janisiewicz, Tracy Leskey and Adam Stager on strawberry disease and arthropod pest management using robotic UV-C irradiation machine (Fig. 1). Their desire to develop novel approaches for sustainable strawberry culture (*e.g*. non-chemical and safer use of ultraviolet light) was based on the limitations of pesticides, increasing consumer demands for fruit free of pesticide residue, a need for automation to reduce labor input in the field, and approaches less intrusive to harvest and normal cultural practices.

The idea of using ultraviolet (UV) light to control fungal diseases of strawberry fruit came from a discussion between Drs. Janisiewicz and Takeda in 2010 about problems with use of fungicides and needs for alternative control methods. UV light includes electromagnetic radiation with wavelengths between100 and 400 nanometers (nm) which is shorter than that of visible light but longer than X-rays. UV radiation is present in sunlight, but much of the UV light produced by the Sun is filtered out by the atmosphere and absorbed by ozone layer in the stratosphere. UV light can also be produced by specialized lights, such mercury-vapor lamps and tanning lamps. UV radiation is subdivided into three general classes based on their wavelengths (*e.g*. UV-A ranges from 315 to 400 nm, UV-B ranges from 280 to 315 nm, and UV-C ranges from 100 to 280 nm). Research on the UV-A has shown that insect behavior could be altered by modulation of UV-A irradiation levels. Research on the UV-B showed that a nightly ~3-hour exposure time was necessary to achieve adequate control of diseases such as powdery mildew on grapes and strawberry. UV-C irradiation is used to kill microorganisms in different situations including sterilization of air in hospitals, water treatments, or sterilizing laboratory benches. The US Food and Drug Administration has determined that ultraviolet light can be used to surface sterilize food products and considers UV light as generally safe when safety precautions are taken by the user. However, the use of UV light in crop production has been limited because of high energy costs and the doses required to kill plant pathogens have also damaged plants.

UV-C irradiation kills microorganisms by damaging their DNA, but the microbes have a special mechanism for repairing the damaged DNA that is light activated. This meant that microbes had a way of repairing DNA damage caused by UV light during daylight hours. Thus, we asked, "What happens if the microbes are irradiated with UV-C at night and they are kept in the dark for certain periods of time?" The reasoning for this approach was a) that the dark period following UV-C irradiation will prevent the activation of this DNA repair mechanism that needed sunlight to be active and b) without the ability to repair the damage to DNA, the organism would not be able to replicate, infect plant and eventually will die.

In 2011, USDA initiated a project to explore the use of germicidal UV-C irradiation for the control of major fungal diseases of strawberries (e.g. gray mold, anthracnose, and powdery mildew). As work progressed the project expanded to include management of insects and mites

and development of an autonomous vehicle to apply UV-C treatments. We were aware that research on using UV-B and UV-C irradiation to control diseases and arthropod pests on various crops have been conducted for more than two decades in various laboratories around the world including the United States, Brazil, Canada, Japan, Brazil, Norway, and the Netherlands. Their research consistently reported plant damage described as burns, leaf curls, and defoliation after the irradiation with doses required to control diseases and arthropod pests.

In our approach, we focused on new ways of using UV-C light and explored ways to kill strawberry pathogens without damaging the strawberry plant. Our initial studies clearly demonstrated that a dark period of 2 to 4 hours immediately after a short UV-C exposure of up to one minute prevented microbes from repairing DNA damage (*e.g*. repair mechanism requires daylight) caused by UV-C irradiation and prevented the disease to develop on fruit and leaves. This method of UV-C irradiation at night resulted in lowering effective doses needed to kill the microbes that cause gray mold, powdery mildew, and anthracnose. The reduced doses required to kill plant pathogens caused no apparent damage to strawberry plants. Further analyses revealed there was *a*) no damage to chlorophyll, *b*) no reduction in photosynthetic activity, and *c*) no loss in pollen viability, ability of tube to grow through the style, and development of fruit. Another aspect of our research program has been the study of the microbial community of strawberry leaves and fruit because UV-C irradiation indiscriminately kills beneficial and pathogenic microbes. When plant surfaces are "sterilized" by UV-C irradiation, it creates a temporary microbial void. We decided to fill this microbial void by introducing two beneficial yeasts to strawberry plants which were excellent colonizers of strawberry flowers and leaves and were also good biocontrol agents against gray mold. The combination of applying UV-C at night and spraying the beneficial yeasts afterward was more effective than either of the two applied alone.

We also showed that night-time UV-C treatments were also effective against insects and mites. A detailed study with plants artificially infested with ~100 two-spotted spider mite (TSSM) revealed that nightly 60 second UV-C irradiation of plants for six weeks had reduced mite populations to below a commercial treatment threshold of 5 mites per mid-canopy leaflet while mite population on untreated strawberry plants exploded to over 300 mites per leaf. Tomato plants artificially infested with greenhouse whitefly (GWF) were irradiated for just 16 sec nightly. The results showed a decline in adult, nymph, and egg populations on UV-C treated plants. We also conducted studies on spotted wing drosophila (SWD). In that study, store-bought strawberries were artificially infested with female SWD and then were subjected to a pulsed UV-C treatment for 24 hours. Average number of SWD emergence from untreated control fruits was more than 12 per berry compared to only 0.02 per treated berry. We have plans to refine the UV-C light regime and application technology to make the UV-C technology more practical for the commercial berry production environment.

To make UV-C technology commercially useful for open-field strawberry growing systems and nurseries, a robot for applying UV-C is desirable. USDA is now collaborating with TRIC Robotics (https://www.tricrobotics.com) in Newark, DE which builds robots for autonomous field UV-C application (Fig. 1). The video of the robot in the field can be accessed at: https://www.youtube.com/watch?v=dn-M_94TfHE&t=48s. It is important to develop a platform that will be useful and affordable to small-acre strawberry growers in the Northeast many of which are certified organic berry growers. To fund this aspect of our UV-C research project, we received a grant in 2020 from the USDA Northeast Sustainable Agriculture Research and

Education (SARE) program to improve control of diseases and arthropod pests of strawberry. Now it is not so much a question of whether a robotic system will be built for strawberry growers, but rather exactly when this will happen and how many growers would be able to afford to use this technology in their fields.

Additional information on ultraviolet light technology can be requested from F. Takeda (fumi.takeda@usda.gov) and W. Janisiewicz (wojciech.janisiewicz@usda.gov) and in the following scientific articles:

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Acknowledgement: This project is funded by USDA Agricultural Research Service, USDA Northeast SARE, and TRIC Robotics.

Fig. 1. Prototype, single-row autonomous UV-C application platform being tested by TRIC Robotics in a commercial strawberry field The robot is programmed to autonomously traverse multiple rows during each night-time session without the tires damaging the plastic mulch. It performs turns at the end of the row and enter another row. It does not require workers to be present in the field during application of irradiation. The prototype can cover ¼-acre each night treating one row at a time. The modular design in the next-generation robot will allow it to be scaled up to cover more acreage.

“Choosing cultivars from the USDA-strawberry breeding program at Beltsville”

Kim Lewers (Kim.Lewers@usda.gov; 240-463-5654), USDA-ARS, Genetic Improvement of Fruits and Vegetables Laboratory, Building 010A BARC-West, 10300 Baltimore Ave., Beltsville, MD 20705-2350

The two most recently released cultivars from the USDA-ARS strawberry breeding program at Beltsville, MD are ‘Flavorfest’ and ‘Keepsake’. Both are mid-season cultivars (Fig. 1). Both were selected from fields with no fumigants or fungicides, in a decades-long effort to develop cultivars with resistance or tolerance to a wide range of diseases commonly found in the Mid-Atlantic. For nearly 100 years, this project partnered a strawberry pathologist with a strawberry breeder. Disease-specific assays were used to increase selection pressure on each year’s seedlings and selections, and to determine each new cultivar’s disease response to each important disease. Since the last pathologist left in 2006, the breeding program has had to rely on natural disease development in the field and multiple years of testing. Diseases regularly observed include anthracnose fruit rot, Botrytis fruit rot, bacterial angular leafspot, blight, scorch, and powdery mildew. Occasionally, common leaf spot and charcoal rot have been observed. Crown deaths are recorded, but the cause is rarely determined; rather, if a selection has one or more years when one of six plants dies from disease-related crown death, the selection is discarded. If two plants succumb to crown death in any plot in any year, the selection is discarded. Both ‘Flavorfest’ and ‘Keepsake are good cultivars to choose for resistance to anthracnose fruit rot.

‘Flavorfest’ is the cultivar to choose if your top priorities are high yields and large berries (Figs. 2,3). The berries are not traditionally shaped, and appear as if they are “pleasingly plump” and “bursting with flavor” (Fig. 4). ‘Flavorfest’ berries do not become dark in refrigerated storage like ‘Chandler’ and ‘Camarosa’ berries do, but ‘Flavorfest’ berries will lose moisture, and appear less glossy and a little wrinkled in refrigerated storage, compared to fresh. ‘Flavorfest’ berries do not retain quality in refrigerated storage as well or as long as ‘Keepsake’ berries (Fig. 5). ‘Flavorfest’ was top-rated by trained panelists for overall quality, strawberry flavor intensity, and sweetness (Fig. 6, Table 1). ‘Flavorfest’ was released in 2012 (Lewers et al. 2017). Since its release there have been some reports that flavor can be negatively affected by sandy soils and nitrogen fertilizer rates that are too high. In 2018 and 2019 there have been some reports from plasticulture growers of crown death suspected to be caused by some type of *Phytophthora*. Some growers have kindly submitted plants for testing by the University of Maryland and the University of Florida. Until these tests are complete, it would be prudent to proactively treat ‘Flavorfest’ plug-plants for *Phytophthora* and avoid over-watering. ‘Flavorfest’ is available from several nurseries, and demand still exceeds supply.

‘Keepsake’ is the cultivar to choose for extraordinary flavor and better quality after refrigerated storage after harvest. ‘Keepsake’ is the first cultivar resulting from our increased effort to select for better fruit quality in cold storage (Lewers et al., 2019). Compared with other current cultivars and breeding selections evaluated after two weeks in cold storage, ‘Keepsake’ strawberries had a low proportion of degraded and decayed fruits (Fig. 5). A bonus is the outstanding flavor (Table 1). The fruits have high soluble solids and moderate acidity. They have a pleasing texture and are juicy when eaten, though they are decidedly firm and tough enough for handling (Table 2). ‘Keepsake’ was not available for comparison in the study by trained panelists

(Fig. 6) (Lewers et al., 2020). Although the yield and berry size are statistically the same as those for 'Flavorfest', 'Keepsake' yield consistently seems a little lower (Fig. 2), and the berries a little smaller than those of 'Flavorfest' (Figs. 3, 6). 'Keepsake' berries have a traditional strawberry shape (Fig. 6). 'Keepsake' plants were distributed by a few nurseries in 2019; availability should increase through time. Please let your favorite nursery know if you want to try 'Keepsake'.

Both 'Flavorfest' and 'Keepsake' are mid-season cultivars. Anthracnose-resistant cultivars in order of season from earliest to latest include, Sweet Charlie (very early), Earliglow (early), Galletta and Northeaster (early-mid), Flavorfest and Keepsake (midseason), Allstar (late-mid), and Ovation (late). Some of these cultivars are difficult to find, because some nurseries have dropped them from their offerings (Sweet Charlie, Galletta, Northeaster, Ovation) or because they are too new (Keepsake). Some strawberry growers in the Mid-Atlantic have expressed a need for a late-season, anthracnose-resistant cultivar with very high yield of very large, firm, tough berries with excellent shelf life. That cultivar is on the way and will be announced in Fall 2020. Please let your favorite nursery know of your interest.

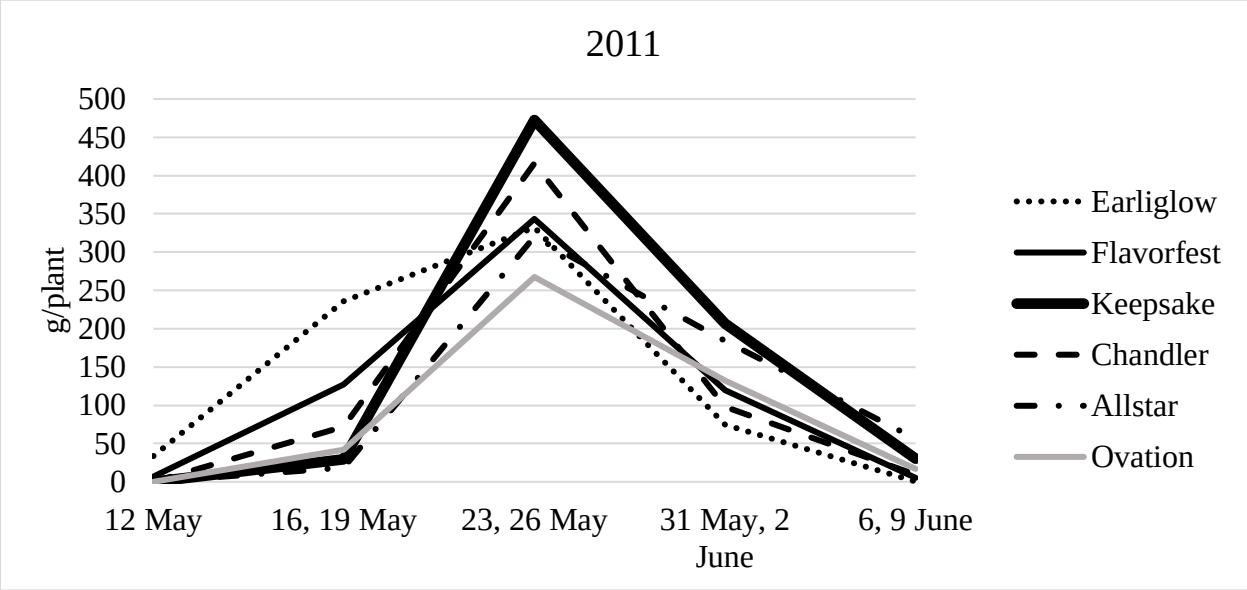

Fig. 1. Fruiting seasons of several cultivars harvested 2011 at the USDA-ARS Beltsville Research Center, Beltsville, MD, a year representative of the season relationships between these cultivars. Plots were harvested twice weekly, and the harvests combined for each week. Yields were adjusted for plant stands and reported as g/plant each week. 'Earliglow' is an early-season cultivar, 'Keepsake', 'Camarosa', 'Chandler', and 'Flavorfest' fruited midseason, 'Allstar' is a late-mid-season cultivar, and 'Ovation' is a late-season cultivar.

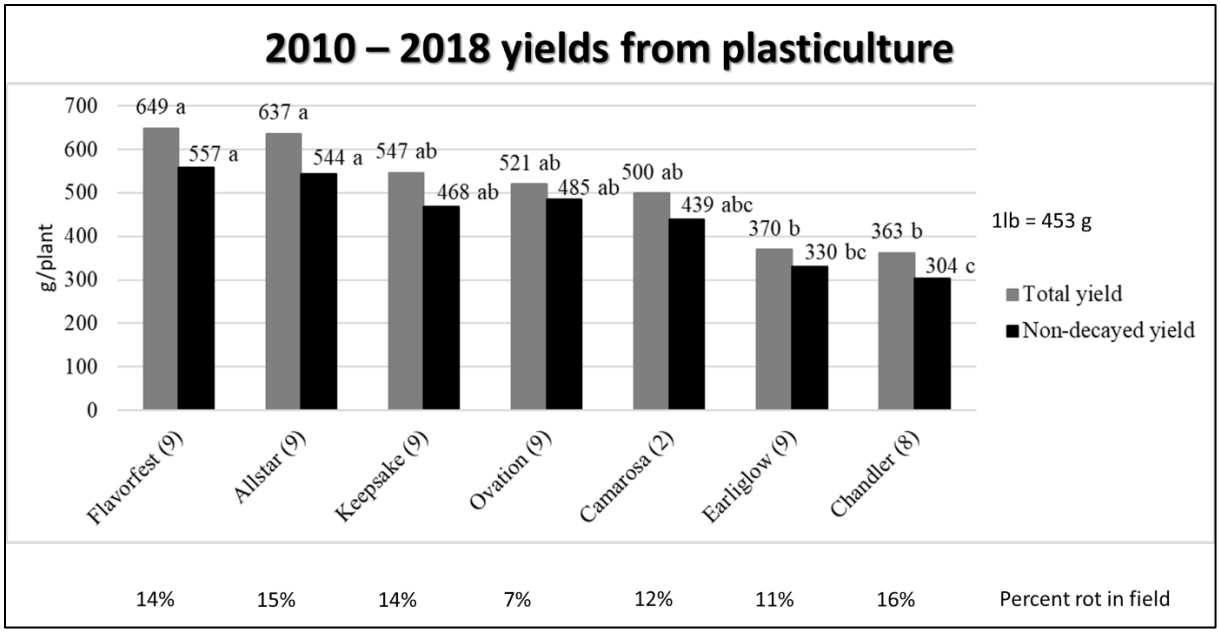

Fig. 2. Total annual yield and non-decayed yield of several strawberry cultivars grown in plasticulture at the USDA-ARS Beltsville Research Center, Beltsville, MD, from 2010 through 2018. For each plot at each harvest, decayed fruits were harvested into separate containers from fruits that showed no sign of decay. The containers were weighed separately. Yields were adjusted for plant stands. Each year, ANOVAs were performed for total yield and non-decayed yield for comparison within year. The yearly estimates for total yield and non-decayed yield were used in a second ANOVA for genotypic comparison across multiple years. Numbers in parentheses after cultivar names indicate the number of years evaluated.

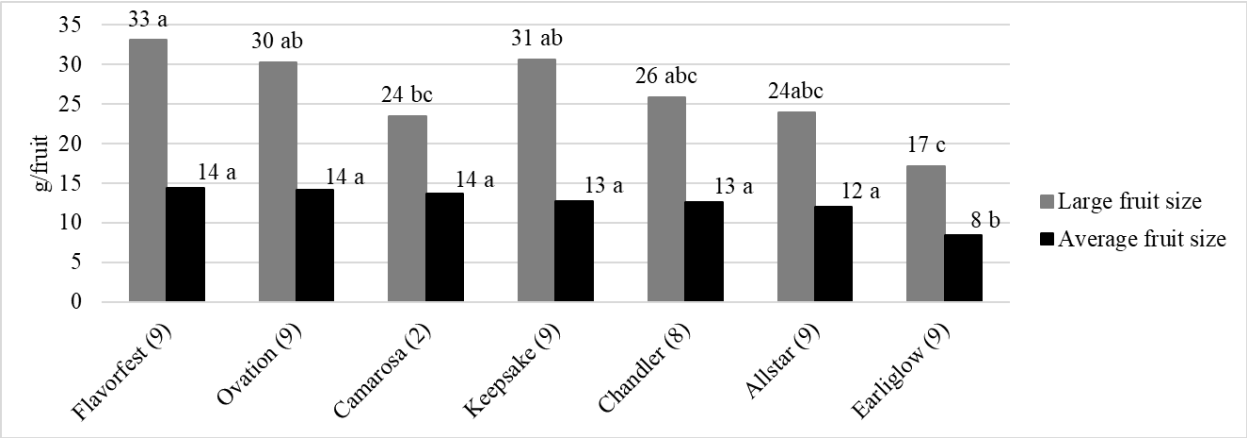

Fig. 3. Strawberry fruit size of several cultivars grown in plasticulture at the USDA-ARS Beltsville Research Center, Beltsville, MD, from 2010 through 2018. Ten randomly selected non-decayed fruits were weighed to obtain an average fruit weight for each plot and harvest. The average of all plot × harvest averages for a cultivar was reported as that cultivar's ''average fruit size'' for the year. The largest of those plot × harvest averages was reported as that cultivar's ''large fruit size'' for the year. Each year's average for average fruit size (g/fruit), and largest average fruit size (g/fruit) for each cultivar was used in an ANOVA. Numbers in parentheses after cultivar names indicate the number of years evaluated.

Fig. 4. ‘Flavorfest’ strawberries grown in annual plasticulture.

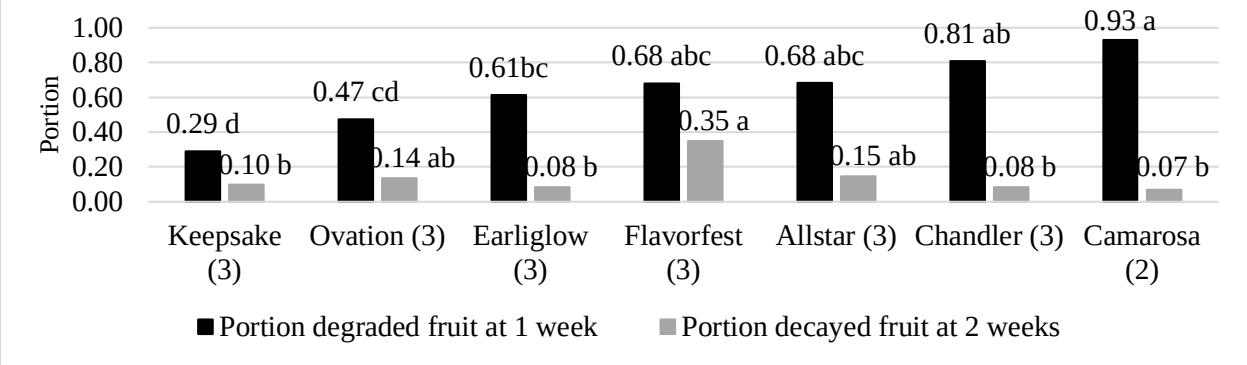

Fig. 5. Storage quality of fruit from several strawberry cultivars grown in plasticulture at the USDAARS Beltsville Research Center, Beltsville, MD, from 2016 through 2018. From field harvests of fruits showing no signs of decay, up to 12 fruits were selected for shelf life evaluation and placed in a labeled clear plastic egg carton, calyx down. These fruits were further selected to be free of signs of injury and relatively uniform in size, shape, and maturity. Fruits in the egg cartons were stacked in plastic egg boxes stacked two boxes high and covered in a black plastic trash bag. The fruits were stored in a walk-in cooler set at 0°C. At one week and two weeks, the numbers of fruits in each egg carton that showed signs of decay or degradation were recorded. A single fruit could be both decayed and degraded. The yearly estimates for decayed or degraded fruits at one week and two weeks were used in an analysis of variance (ANOVA) for genotypic comparison across years. Portion degraded at one week provided greater separation of means than at two weeks. Portion decayed at two weeks showed greater separation of means than at one week. Numbers in parentheses after cultivar names indicate the number of years evaluated for this analysis.

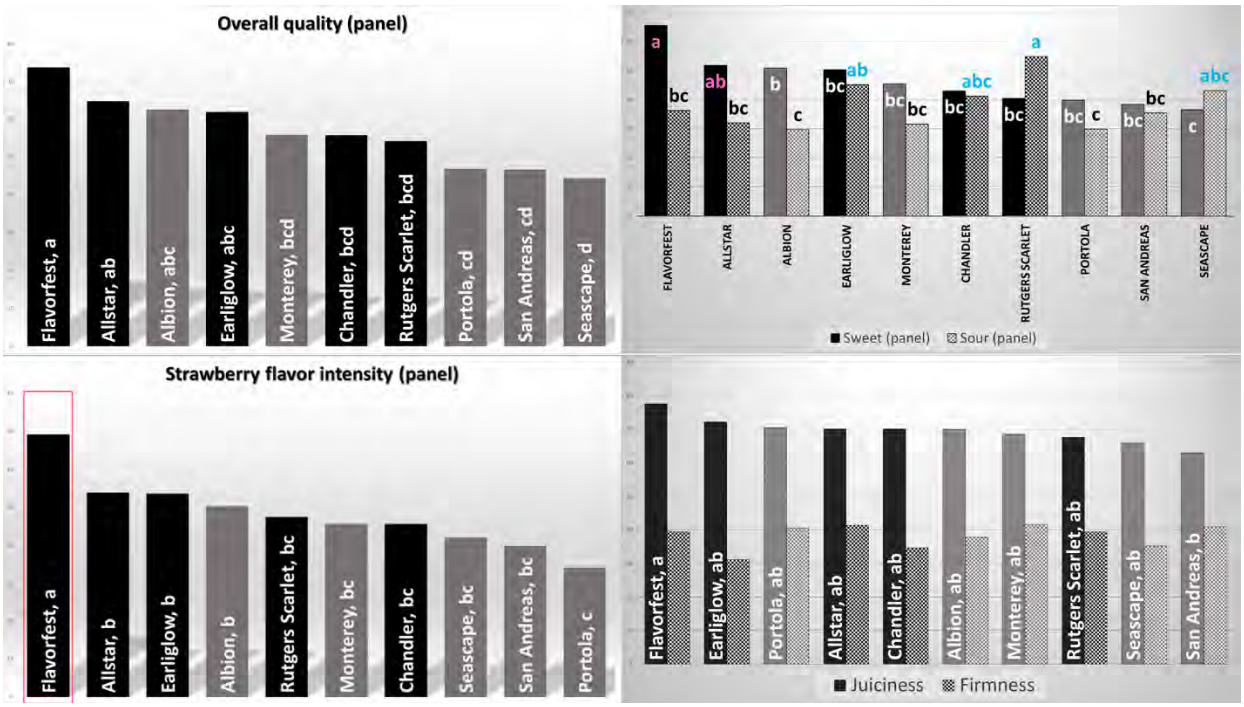

Fig. 6. Strawberry cultivars compared by trained panelists and rated for several traits on a scale of 0 to 100. Black bars represent short-day cultivars grown at the UMD-WREC. Grey bars represent dayneutral cultivars grown under low tunnels at USDA-Beltsville, Md. Cultivar names followed by the same letters were rated similarly by the panelists. (Lewers et al., 2020)

Table 1. Strawberry fruit quality of several cultivars grown in plasticulture at the USDA-ARS Beltsville Research Center, Beltsville, MD, from 2010 through 2018. Flavor was a subjective rating, agreed on by two researchers for each plot. The juice of three to five fruits from a six-plant plot, hand squeezed in the field, was measured with a ‘‘Pocket refractometer PAL-1’’ (ATAGO USA, Inc., Bellevue, WA) to obtain estimates of percentage soluble solids, and a “LAQUAtwin-pH-22” (HORIBA Scientific, Edison, NJ) to obtain estimates of acidity (pH).

	Soluble solids (%)		Acidity (pH)		Flavor	
Cultivar	Average	Range	Average	Range	Average	Range
Allstar	7.3	6.1 to 8.6	3.6	3.2 to 4.0	7.4	7.0 to 8.0
Camarosa	6.9	6.4 to 7.3	3.4	3.4	7.3	7.0 to 7.5
Chandler	7.4	5.0 to 9.1	3.5	3.4 to 3.8	7.4	7.0 to 8.0
Earliglow	8.2	5.7 to 10.7	3.5	3.3 to 3.8	7.8	7.5 to 8.5
Flavorfest	7.6	6.3 to 10.3	3.6	3.2 to 4.0	7.8	7.0 to 8.0
Keepsake	8.7	6.6 to 10.5	3.6	3.3 to 3.8	8.1	7.5 to 8.5
Ovation	8.3	7.1 to 10.0	3.5	3.1 to 3.8	7.5	6.5 to 8.0

Table 2. Strawberry fruit firmness and toughness of several cultivars grown in plasticulture at the USDA-ARS Beltsville Research Center, Beltsville, MD, from 2010 through 2018. Firmness, and skin toughness were subjective ratings, agreed on by two researchers for each plot. Firmness

was determined with a gentle hand squeeze. Skin toughness was determined by gently rubbing a thumb across each fruit.

	Firmness		Skin toughness	
Cultivar	Average	Range	Average	Range
Allstar	7.7	7.0 to 8.0	7.7	7.5 to 8.0
Camarosa	7.8	7.5 to 8.0	7.5	7.0 to 8.0
Chandler	7.1	7.0 to 7.5	7.5	7.0 to 8.0
Earliglow	7.2	7.0 to 7.5	7.3	7.0 to 8.0
Flavorfest	7.6	7.0 to 8.0	7.6	7.0 to 8.0
Keepsake	7.8	7.5 to 8.0	8.1	8.0 to 8.5
Ovation	7.5	7.0 to 7.5	7.2	7.0 to 7.5

Fig. 7. 'Keepsake' strawberry fruits, produced in plasticulture at the USDA-ARS Beltsville Agricultural Research Center, Beltsville, MD.

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Lewers, K.S., J.M. Enns, P. Castro. 2019. 'Keepsake' strawberry. HortScience 54(2):362-367.

Kim S. Lewers, Michael J. Newell, Eunhee Park, Yaguang Luo. 2020. Consumer preference and physiochemical analyses of fresh strawberries from ten cultivars. International Journal of Fruit Science. https://doi.org/10.1080/15538362.2020.1768617

“Choosing strawberry cultivars and film types for low tunnels”

Kim Lewers (Kim.Lewers@usda.gov; 240-463-5654), USDA-ARS, Genetic Improvement of Fruits and Vegetables Laboratory, Building 010A BARC-West, 10300 Baltimore Ave., Beltsville, MD 20705-2350

Growing repeat-fruiting strawberries under low tunnels can extend a strawberry harvest season from a few weeks to several months (Condori et al., 2017; Lewers et al., 2017). The most challenging aspect of developing a low-tunnel production system has been the choice of plastic film to cover the low tunnels. Our goals were to find out if some films would be more beneficial during some months, and if some cultivars would perform better under some films. Traits analyzed included total yield, percent rotted yield, berry weight, percent marketable yield, and average market score.

Four tests were established, one test in each of four years (2014, 2015, 2016, and 2017). All four tests compared Clear TIII 0.102 mm thick polyethylene film (“standard clear” or SC film) and TIII TES/IR 0.102 mm thick polyethylene film (TES film) (Berry Plastic Corporation, Greenville, SC). The TES film was purported to diffuse light after it passes through the film, so it would remain trapped under the low-tunnel, warming the air and plants below. The first two tests (2014 and 2015) also included TempCool™ 0.102 mm thick polyethylene film (TC film) (Berry Plastic Corporation, Greenville, SC). The second two tests (2016 and 2017) also included Kool Lite Plus 0.152 mm thick polyethylene film (KL film) (Klerks Hyplast Inc., Chester, SC). Temp-Cool and Kool Lite films were purported to block more UV light to keep the air and plants below cooler. TC and KL films transmitted 10-15% less photosynthetically active radiation, (PAR, 400-700 nm) and near infrared radiation (NIR, 700-1100 nm) than the SC and TES films (Fig. 1). TC and KL films also transmitted less ultraviolet radiation (UV, 200-400 nm) than SC and TES films. All four tests compared five repeat-fruiting strawberry cultivars developed in California: Albion (PP16,228), Monterey (PP19,767), Portola (PP20,552), San Andreas (PP19,975), and Seascape (PP7,614). The cultivar Sweet Ann (PP22,472) was included in the first three tests. The three cultivars that performed above average were ‘Albion’, ‘Monterey’, and ‘Portola’.

Yield, berry weight, market score and percent marketable yield all generally increased from the first harvests until some point following summer heat when all these traits decreased (Fig. 2), and all generally were positively correlated (Lewers et al., 2020a). As summer heat abated, all these traits increased again and remained high in the following May and June harvests until they decreased again in late June. Growers producing low-tunnel fields in succession will have June yields that, when combined, are similar to the monthly yields of September or October, and have good market scores.

There was a significant division in yield and percent marketable yield the year of planting compared with the year after planting (Fig. 3). Yields from ‘Albion’ and ‘Monterey’ were greater the year of planting than the year after planting, but yields from ‘San Andreas’, ‘Seascape’, and ‘Sweet Ann’ were greater the year after planting. Yields for ‘Portola’ were generally greater the year of planting, except for the 2015 planting. Yields were generally greater in the year of planting for strawberries grown under SC, TC, and KL films, but higher in late fall and the following year for those grown under TES film (Fig. 3). Significantly higher percent marketable

yield was produced under TES film in three of four Novembers and higher percent marketable yield in both Decembers, though the difference was significant in only December 2017 (Lewers et al., 2020a). Therefore, TES film may provide a more productive environment in and following colder months.

Percent rotted yield negatively impacted percent marketable yield and was more affected by weather events and management practices than the month of the year. Mucor can be managed by watering only immediately after harvest. Botrytis was made worse by the use of both row covers and overhead sprinklers for frost protection. Lewers et al., (2012) found humidity in the field (without low-tunnels) a few days before harvest to play a role in botrytis development in postharvest storage, and it may be that humidity facilitates botrytis development in the low-tunnel environment to a greater degree that previously recognized in open-field studies which focused on the effect of rainfall. It may be possible to manage the row covers in a way that does not exacerbate botrytis development. For example, they may be relied on as the only frost protection method, rather than in conjunction with overhead sprinklers, so they don't freeze in place and may be removed each morning to reduce humidity (Mike Newell, personal communication).

'Albion' performed above average for all traits except yield. In a separate study comparing strawberry cultivar fruit quality by trained panelists, 'Albion' fruit was the highest rated "dayneutral' cultivar (Fig 4)(Lewers et al., 2020b). 'Albion' performed better overall under TES or SC films. In the 2014 and 2015 tests, 'Albion' had above average yield, berry weight, and percent marketable yield under all three films, below average percent rotted yield under TES film, and above average market scores under SC and TES films. In the 2016 and 2017 tests, 'Albion' had above average yield under TES and KL films, below average percent rotted yield and above average berry weight under all three films, above average percent marketable yield under SC and KL films, and above average market scores under TES film.

'Monterey' performed above the cultivar average for all traits. In the taste-panel study, 'Monterey' fruit had good appearance but were not rated as highly as 'Albion' for flavor (Fig 4)(Lewers et al., 2020b). 'Monterey' performed better overall under TES or KL films. 'Monterey' had above average yield and market score under SC or TES films, below average percent rotted yield under TC or TES films, similar berry weight and percent marketable yield under all films. In the 2016 and 2017 tests, 'Monterey' had above average yield and percent marketable yield under KL and TES films, below average rotted yield and above average berry weight under all three films, and higher market score under the KL film.

'Portola' performed above average for all traits except percent rotted yield. 'Portola has very high yield of large fruit, but the fruit a are orange-colored most of the year and have very little flavor (Fig. 4)(Dong et al., 2019; Lewers et al., 2020b). 'Portola' performed better overall under SC, KL, and especially TES film. The TES film was the film under which 'Portola' had below average percent rotted yield. This was the one trait that 'Portola' was generally below average for, so it was interesting that the TES film may have compensated for 'Portola's weakness. In the 2014 and 2015 tests, 'Portola' had below average percent rotted yield under TES and TC films, above average yield, percent marketable yield, and market score under TES and SC films, above average berry weight under SC film. In the 2016 and 2017 tests, 'Portola' had below average

percent rotted yield under TES film, above average yield, berry weight, and percent marketable yield under all three films, and above average market scores under KL and SC films.

Conclusion: At this time, we recommend growing 'Albion' under TES film for nine-month production in the Mid-Atlantic.

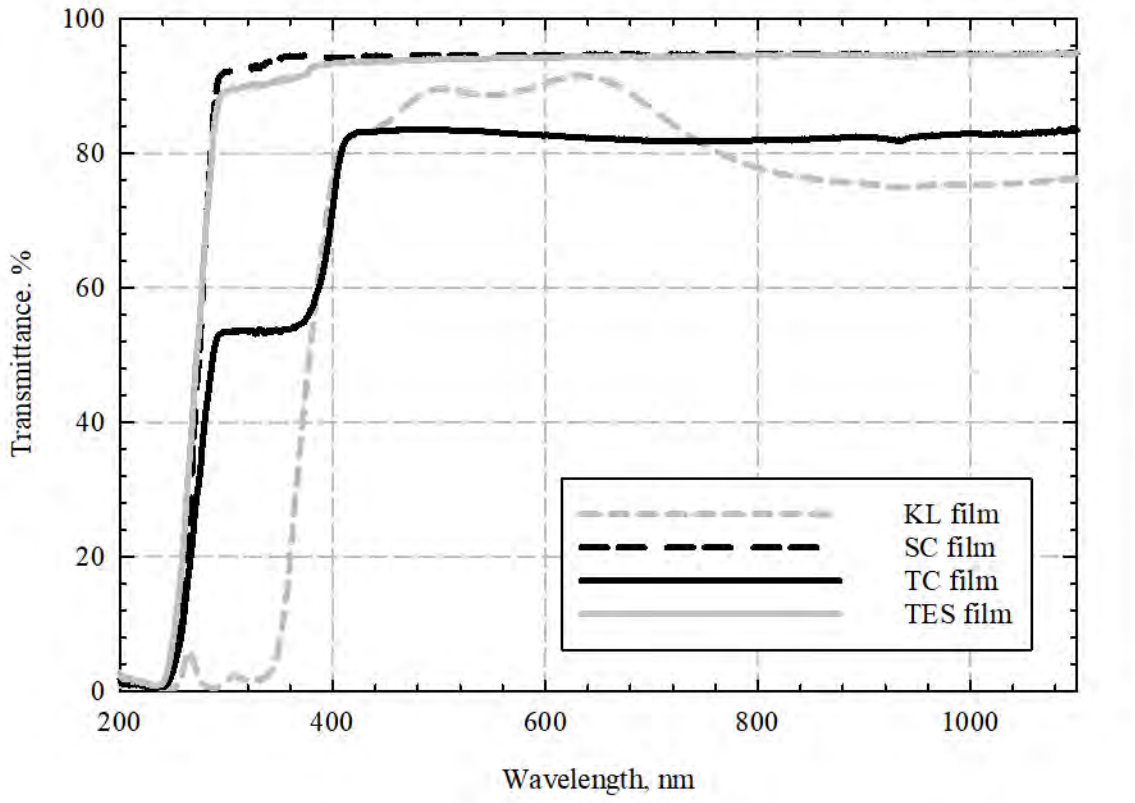

Fig. 1. Percentage transmittance of radiation through clear plastic films used to cover low tunnels for strawberry production. Transmittance through the plastic film was measured with an integrating sphere coupled with a single-mode fiber optic probe to a spectroradiometer across the 350 to 2500 nm wavelength range at 1 nm intervals. Films used were TempCool™ 0.102 mm thick film (TC film) (Berry Plastic Corporation, Greenville, SC), Clear TIII 0.102 mm thick film ("standard clear" or SC film), TIII TES/IR 0.102 mm thick film (TES film) (Berry Plastic Corporation, Greenville, SC), and Kool Lite Plus 0.152 mm thick Poly film (KL film) (Klerks Hyplast Inc., Chester, SC).

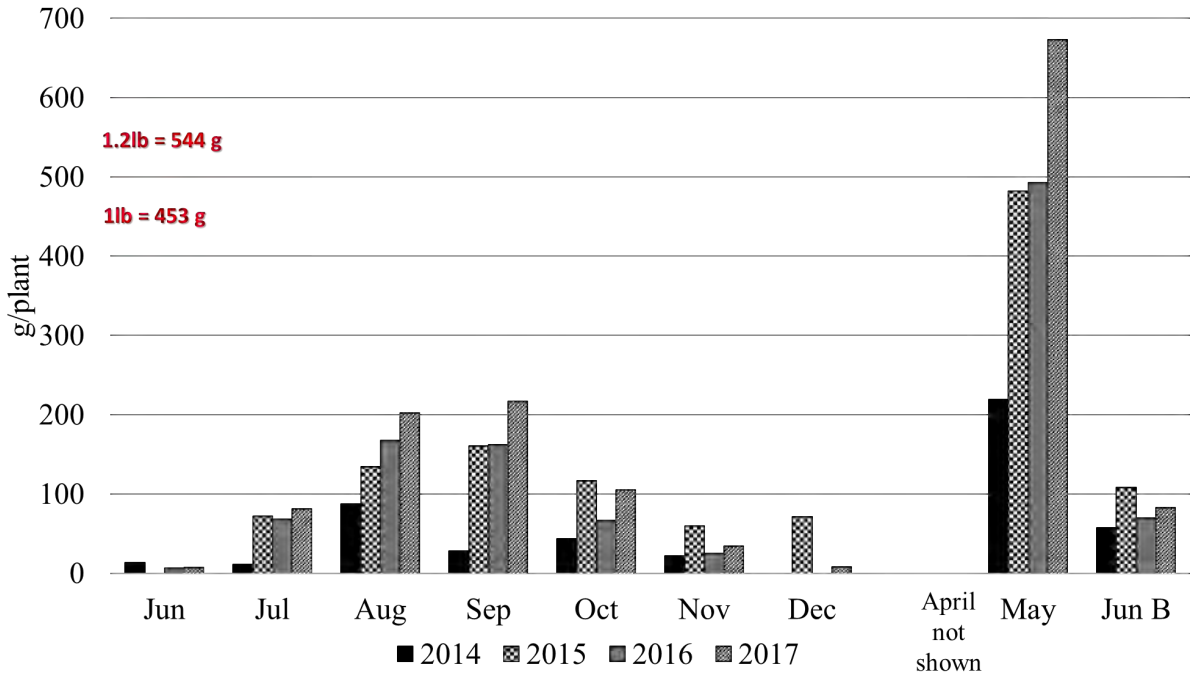

Fig. 2. Averaged monthly yield from six "dayneutral" strawberry cultivars grown under low tunnels. Work was done in five years through four test plantings (2014, 2015, 2016, 2017). Each test was harvested from June or July of the year of planting through November or December, and then again the following April or May through June.

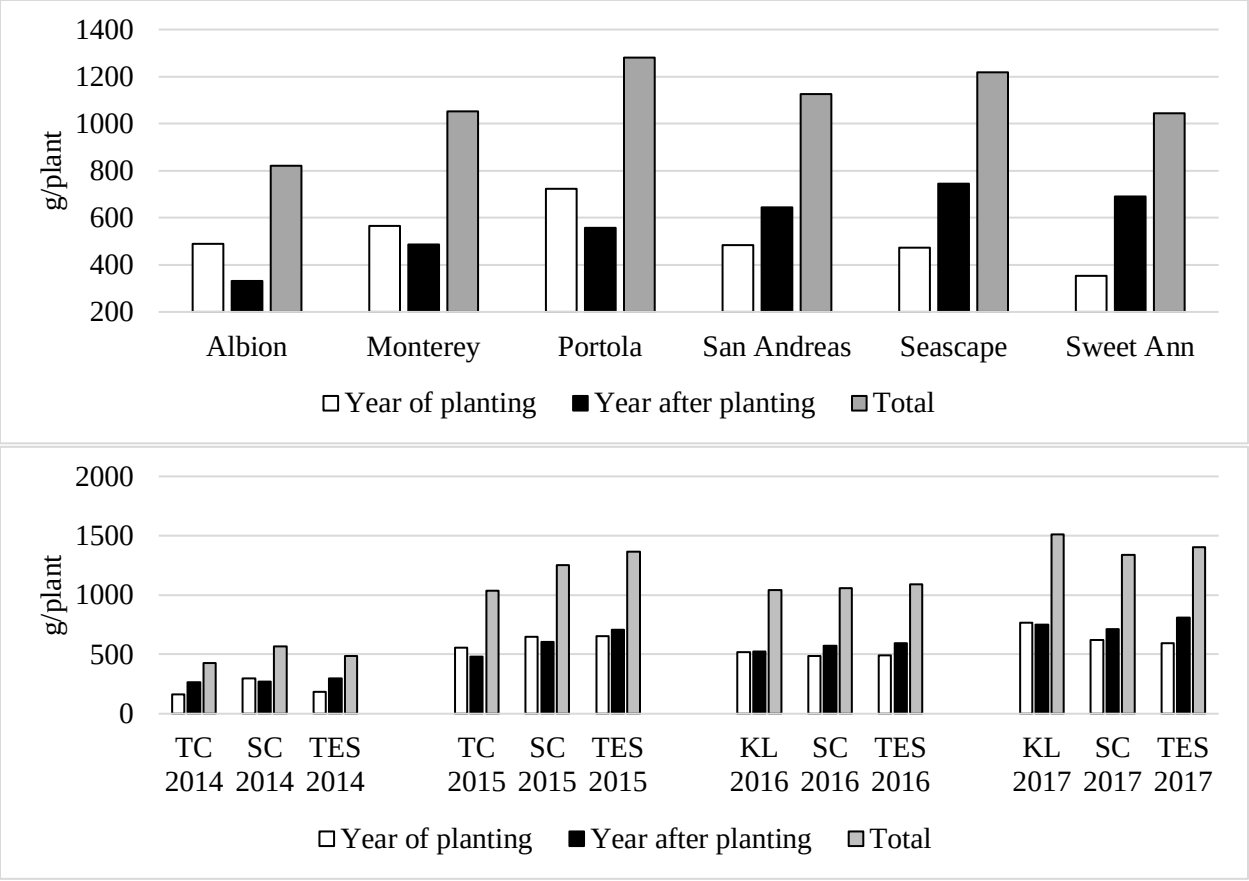

Fig. 3. Yield from six strawberry cultivars grown under low tunnels. Work was done in five years through four test plantings (2014, 2015, 2016, 2017). Each test was harvested from June or July of the year of planting through November or December, and then again the following April or May through June. Cultivar yields were averaged across all four tests for each month, then monthly harvests were totaled for the months in the year of planting, and totaled separately for the months following the year of planting. Film yields were averaged within test then totaled.

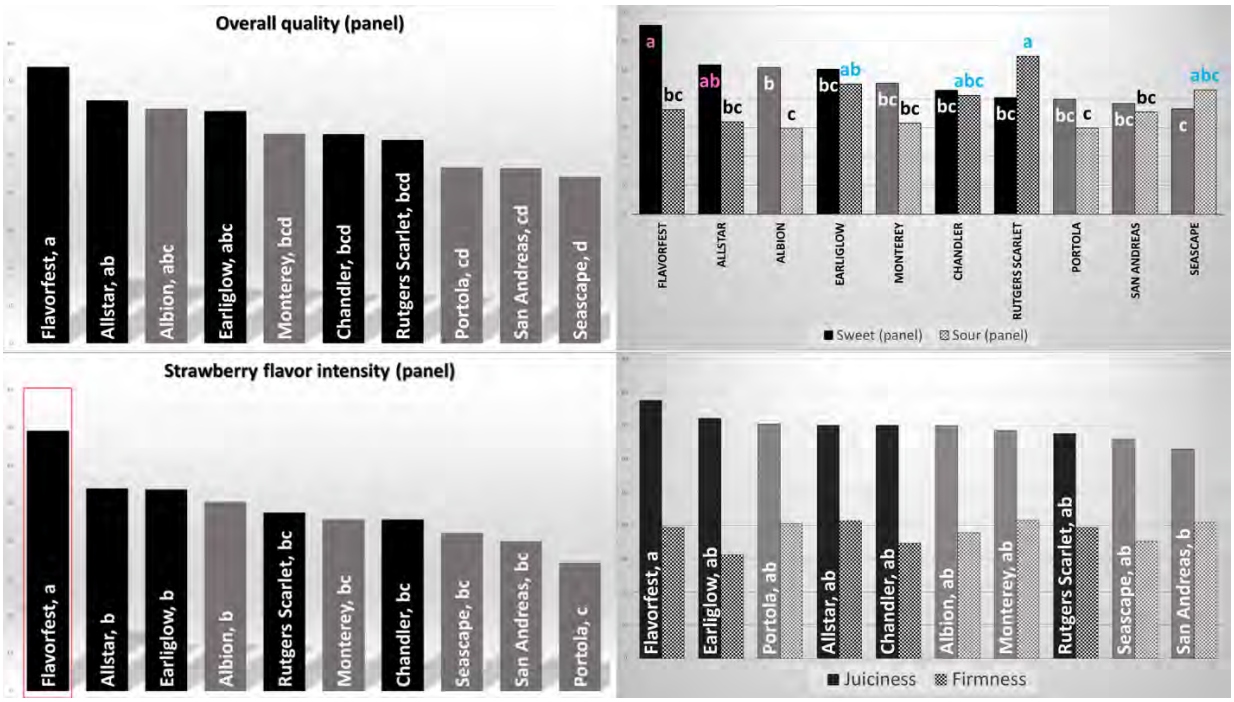

Fig. 4. Strawberry cultivars compared by trained panelists and rated for several traits on a scale of 0 to 100. Black bars represent short-day cultivars grown at the UMD-WREC. Grey bars represent dayneutral cultivars grown under low tunnels at USDA-Beltsville, Md. Cultivar names followed by the same letters were rated similarly by the panelists. (Lewers et al., 2020)

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