Small Fruit News

Summer 2023 Edition, Vol. 23 No. 3 www.smallfruits.org

Inside this issue:

Agricultural water safety and treatment options

Achyut Adhikari and Juan Moreira

Louisiana State University AgCenter School of Nutrition and Food Science

Water is an essential resource for small fruit growers, as it is crucial for irrigation and post-harvest activities. However, ensuring the microbial safety of water used in these processes is vital to minimize the risk of contamination and protect consumer health. The Food Safety Modernization Act (FSMA) Produce Safety Rule requires all agriculture water must be safe and of adequate sanitary quality for its intended use. Open surface water sources such as ponds, lakes, rivers, and collected rainwater are exposed to the environment and susceptible to microbial contamination. In this article, we will provide an overview of various options available to commercial small fruit growers, as well as other measures to improve water quality.

Practices to minimize microbial contamination such as vegetative filter strips, diversion ditches, avoiding animal access to water sources, and water treatment are effective in reducing microbial risk. In addition, growers can explore two other corrective measures to reduce the microbial risk to produce irrigation with contaminated water. The first measure involves establishing time intervals between irrigation and harvest to allow bacteria to naturally die off from fruit surfaces. This can help reduce microbial load and minimize contamination risks. The second measure involves regularly inspecting irrigation systems to maintain optimal conditions and identify any repairs needed. By ensuring the proper functioning of irrigation systems, growers can prevent potential sources of contamination.

If these corrective measures are not sufficient to reduce the microbial load present in the field to an acceptable level, growers have several options for water treatment that can significantly reduce microbial risks. Treatment options are divided into chemical and non-chemical treatments. It is important to note that any chemical method applied must be approved by the Environmental Protection Agency (EPA) and used according to the guidelines specified on the product label.

One of the most common and readily available chemical treatment options is chlorination. Chlorine-based compounds, such as chlorine gas or sodium hypochlorite, are added to the irrigation system to disinfect the water. Chlorine is effective for killing or inactivating a wide range of harmful microorganisms, including bacteria and viruses. Small fruit growers can use chlorine tablets or solutions following EPA guidelines to achieve the desired chlorine concentrations for effective water treatment. However, it is important to monitor chlorine levels regularly and maintain them within the appropriate range to ensure effective disinfection without negatively impacting plants or fruit quality. Any residual chlorine in the irrigation water can negatively affect the beneficial microflora of the soil.

Non-chemical treatments for water sources involve the use of physical methods that have been scientifically proven to reduce microbial risks. These treatments include ozonation units, ultraviolet (UV) light systems, and filter systems. Ozonation is an effective method commonly used in the agricultural industry. It involves injecting ozone, a powerful oxidizing agent, into the water supply. Ozone rapidly kills bacteria, viruses, and other microorganisms by breaking down their cellular structures. One advantage of ozone treatment is that it does not leave any chemical residues, making it an environmentally friendly option. However, small fruit growers should consider the cost and complexity of ozonation systems before implementation.

UV disinfection is another non-chemical method that utilizes UV light to kill microorganisms. UV radiation damages the genetic material of bacteria, viruses, and parasites, rendering them unable to multiply. UV disinfection systems are easy to install and require minimal maintenance. However, growers must follow scientifically validated UV methods with specific light sources, application times, and water turbidity requirements to ensure an appropriate UV dose for microbial inactivation.

Filtration is a water treatment method that removes particles, sediment, and microorganisms through a porous medium. Small fruit growers can choose from various filtration options, including sand filters, cartridge filters, and membrane filtration. Filtration helps in reducing the microbial load but may not eliminate all microorganisms. The selection of the filtration system should be based on specific water quality requirements and the operational capacity of the grower. Reverse osmosis (RO) is an advanced filtration process that effectively removes dissolved solids, contaminants, and microorganisms from water. RO systems use a semipermeable membrane to separate impurities from the water, producing high-quality, purified water. RO can be an excellent option for small fruit growers who need to treat water with high mineral content or specific contaminants. However, it is important to note that RO systems can have a higher initial cost and require regular maintenance.

Before exploring specific water treatment options, it is essential for growers to understand the importance of preventive practices in maintaining water quality. Implementing good agricultural practices, such as proper sanitation, reducing potential contamination sources, and regular monitoring, can significantly reduce microbial risks. In addition to the treatment options mentioned above, small fruit growers should regularly monitor water quality through testing. If any changes in the microbial quality of the irrigation water are detected, prompt actions can be taken to address the issue. Conducting microbial analysis and water quality tests can provide valuable insights into the effectiveness of the chosen treatment methods and enable growers to make necessary adjustments.

Furthermore, if treatment methods prove to be costly or ineffective over time, growers should consider the possibility of changing their water source. Choosing a clean and reliable water source can significantly reduce the need for extensive treatment. Surface water sources, such as ponds or rivers, are more prone to microbial contamination. On the other hand, groundwater often has better microbial water quality compared to sources exposed to the environment. Municipal water is the safest source of water due to proper water treatment applied by municipal authorities, although this may not always be a viable option for growers.

Figure 1: Dr. Adhikari from LSU AgCenter giving a demonstration of different water treatment systems using a mobile water treatment unit. (Photo by Juan Moreira)

Growers invited to participate in strawberry survey

Gabriel Kwesi Yeboah, Ph.D. Scholar

Hampton Roads Agricultural Research and Extension Center, Virginia Tech, Virginia Beach, VA

I am conducting research on the topic 'Impact of Plant Patent and License Values on the Growth of the Strawberry Industry in the USA' under the supervision of Dr. Jayesh Samtani. I am interested in the legal and economic variables affecting the strawberry industry and I believe that more research should be conducted that could improve this strawberry industry in the USA. Would you be willing to assist me in studying these issues?

Participation would involve completing this survey https://forms.gle/NvjXGP8N8r28qCsk7. Survey questions are related to your specific experiences, business information, and opinions about sustainability and can be completed within 25 minutes. Completed entries will be entered into a drawing to win one of two $40 Amazon gift cards. The drawing will be at the end of the survey period and winners will be contacted via email. If you wish to discontinue participation before completing the survey questions, you can skip to the end and submit the form, but you will not be entered into the drawing. The information about this survey was sent out via other avenues so kindly disregard this note if you have already taken the survey. The requested deadline to complete the survey is July 31, 2023. Please contact me at gkyeboah@vt.edu if you have any questions.

Strawberry Greenhouse Production in the Southeast: Soil-less substrate research in NC

Mark Hoffmann, Austin Wrenn, Brian Jackson and Amanda Lewis

Department of Horticultural Science, NC State University.

Video production and editing: Amanda Lewis

Photo credits: Amanda Lewis, Austin Wrenn and Mark Hoffmann

Austin Wrenn, 3rd generation strawberry farmer, and the current president of the North Carolina Strawberry Association shares his experience as a strawberry grower and researcher, and his views on strawberry greenhouse production in the Southeastern US.

Video. Farmer and recent Master's in Horticultural Science graduate Austin Wrenn is discussing his background and research on soil-less strawberry production in North Carolina.

<https://www.youtube.com/watch?v=aBiSFTP_mBs>

Austin Wrenn keeps his family farm growing in Zebulon (North Carolina) through innovative solutions and active research at NC State University. During his unique journey from student to president of the North Carolina Strawberry Association, Austin was grounded in his family's multi-generational farm, always focused on growing strawberries. After international experiences in Europe and Australia, he returned to North Carolina to jump-start his family farm and the strawberry greenhouse production industry in the Southeast.

Most strawberry production in the Eastern US occurs in open-field plasticulture (Figure 1A). These systems require the use of fumigants and pesticides to remain productive. Climate controlled greenhouses however need significantly less pesticide input (Figure 1B), less water, labor, and can lead to higher yields. However, transitioning into greenhouse strawberries requires high up-front costs, productive cultivars, and a highly skilled set of knowledge.

These are high barriers for the industry currently. But with increasing labor and supply costs, pesticide restrictions and climate change, greenhouse strawberry production may be on the horizon to become a potential niche production system in the US in the years to come, fulfilling local market demands at times when other systems cannot. One key component of strawberry greenhouse production is the use of soil-less substrates. In Austin's master project, the impact of six different soil-less substrates on strawberry yield were evaluated on a day-neutral cultivar ('Albion'). Soil-less substrates included a 50:50 peat moss and pine bark mix, a 50:50 peat moss and coco coir mix, a 50:50 peat moss and perlite mix, a 50:50 peat moss and wood fiber mix, 100% coco coir, and a European peat mix (BVB) (Figure 2A).

Substrates were evaluated in a randomized complete block design in a tabletop growing system over a fall and spring double cropping cycle (2021/2022). Plants transplanted as 250cc tray plants (Figure 2B)

Marketable yields were assessed as well as primary berry chemistry. Result highlights showed a significantly higher yield was seen in peat moss and wood fiber mix, comparable to European peat mix, while the peat moss and perlite mix showed the lowest yield (Table 1).

Figure 1.
A. Open field plasticulture system for strawberry production (picture taken in North Carolina) is the predominant strawberry production system in the US.

B. Strawberry greenhouse production (picture taken in North Carolina) faces a large set of challenges currently in the US, including high investment costs and a lack of expertise in the field.

Figure 2.
A. Substrate trials were established in plastic containers in a NC greenhouse.
B. 250cc tray plants were used as planting material ('Albion').

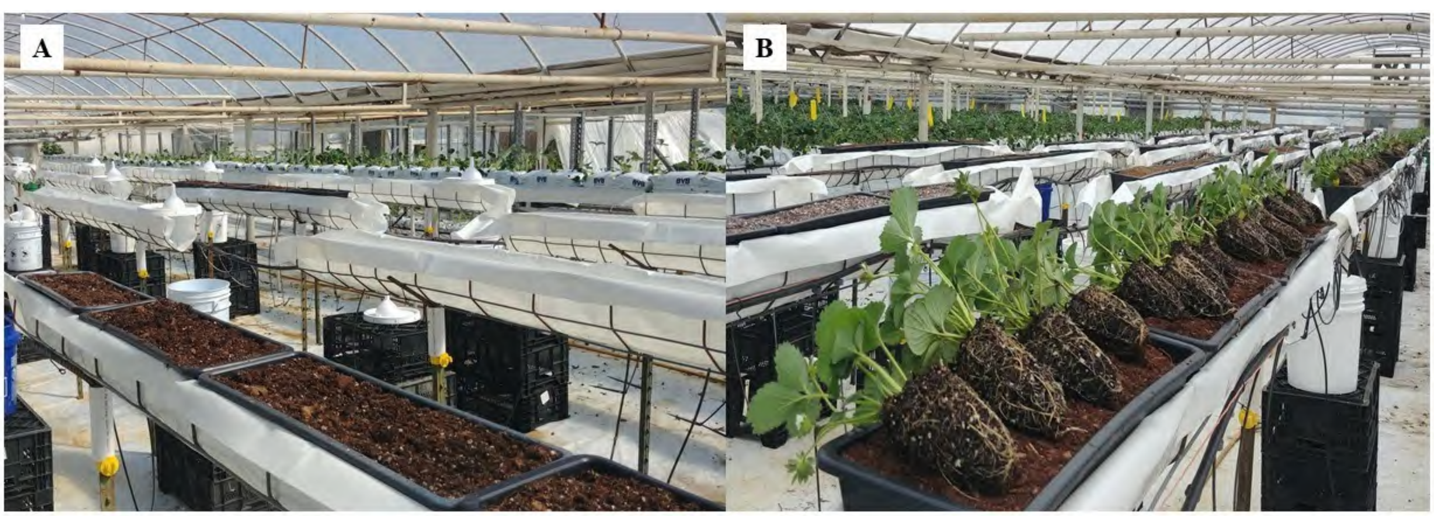

Table 1. Marketable yield (g) and count of marketable berries per plant ('Albion') in the 2021-2022 double cropping season.

Treatment	Marketable yield (grams per plant)	Marketable count (fruit per plant)
100 % coco fiber	882.90g ABC	37.80 ABC
100% European peat	973.70g A	40.28 A
50 % Canadian peat / 50 % pine bark	860.75g BC	34.75 BC
50% Canadian peat / 50% coco fiber	907.48g ABC	38.27 AB
50 % Canadian peat / 50% perlite	810.96g C	34.18 C
50 % Canadian peat / 50 % wood fiber	958.4g AB	40.46 A

Conclusions

While it is a long way for the Southeast towards a larger strawberry greenhouse production industry, Austin's research has pivoted him to use wood fiber/peat moss mixes in the next cropping cycle. Wrenn's farm was established in 1967 and grows strawberries since the 1980s. Today it has evolved to a cut-flower and strawberry operation, with a farm stand and value-added products. Research such as Austin's is essential to be better prepared for other strawberry growing systems in the future. Young farmers like Austin are vital to the future agriculture business in the US. This research was supported partially by the USDA specialty crops block program and the North Carolina Department of Agriculture and Consumer Services.

Supplementary foliar chemical and shade cloth evaluation in blackberry production

Tianyou (Hope) Xu and Yun Yin, Department of Food Science and Technology, Virginia Tech, Blacksburg; Jayesh Samtani and Patricia Richardson, Hampton Roads Agricultural Research and Extension Center, Virginia Beach and Amanda McWhirt, Department of Horticulture, University of Arkansas

Blackberry (*Rubus* spp.) is a popular fruit due to its delightful taste and notable health benefits. The objective of this study was to determine the effectiveness of pre-harvest foliar treatments and shade application on yield, white drupelet disorder, post-harvest attributes and aroma profile of two blackberry varieties Prime-Ark® Traveler and Prime-Ark® Freedom.

Virginia study. In Virginia Beach, a field study was repeated in 2021 and 2022 growing seasons at the Hampton Roads Agricultural Research and Extension Center in a completely randomized design. Grower standard control (GSC), shade cloth with 30% light reduction (SHA), calcium (CAL) and salicylic acid (SAL) foliar applications were randomly assigned to each variety (Photo 1). The grower standard control plants and plants in all other treatments were given ~80 to 100 lb N/acre over spring, summer, and fall each year by alternating fertigation with water-soluble Plantex 20-20-20 (Master Plant-Prod Inc., Brampton, ON), Multi-K® potassium nitrate (Haifa Chemicals, Haifa Bay, Israel) and Calcinit® calcium nitrate (Yara North America, Inc., Tampa, FL) using the Dosatron® drip fertilizer injector (Gempler's, Janesville, WI) every two weeks. The foliar calcium spray (Nutri-Cal®; CSI Chemical Corporation, Bondurant, IA) was applied as a fine mist to ensure good overall coverage of the blackberry plants but without causing run-off. The SAL treatment is not registered for blackberry crop production and was only for research purposes. A 30% light reduction shade cloth was purchased from Greenhouse Megastore (West Sacramento, CA) and installed in late May to provide a reduction of direct solar radiation and heat stress for the plants.

Photo 1. Plants upfront in the photo include grower standard control plots to the left and shade-treated plants to the right.

Table 1. Application rates and dates for treatments applied in 2021 and 2022 growing seasons.

Treatment[1]	Application Rate	2021 Growing Season	2022 Growing Season
CAL	Four applications at concentration of 2 fl.	6/15; 6/24; 7/1; 7/13	6/15; 6/25; 7/5; 7/14
SAL	Two applications at concentration of 276	6/15; 7/13	6/15; 7/14
SHA	30% light reduction	Installed on 6/2	Installed on 6/15

[1] CAL: Calcium; SHA: Shade cloth; SAL: Salicylic acid

Fruit yield and physicochemical attributes of the blackberry were collected and analyzed and aroma-active compounds in blackberries were identified by use of head-space-solid-phase microextraction-gas chromatography-mass spectrometry-olfaction (HS-SPME-GC-MS-O).

In Virginia, shade cloth significantly reduced the white drupelet disorder (WDD) in Prime-Ark® Freedom but it also reduced the Total soluble solid content (°Bx) and °Bx/% Titratable acidity (a ratio indicates sweet & sour balance for fruit) for both varieties. No significant improvement was found in the yield, °Bx, TA, and firmness of blackberries treated with CAL and SAL. Sixteen consistent aroma-active compounds were found across treatments for both varieties and growing seasons. Foliar and shade application did not alter the aroma profile of either blackberry variety. However, higher volatile contents were found in 2021 than in 2022, possibly due to climate variation. Clear distinction on aroma profiles of the above two varieties were also observed: PrimeArk® Freedom was higher in compounds possessing "fruity" and "floral" notes, while PrimeArk® Traveler featuring more "green" and "fresh" characteristics.

Arkansas study. During the 2021 growing season in Arkansas, CAL applications were made to floricane fruit on Prime Ark® Traveler and Osage varieties at a grower's location in White County, AR and compared to water applications (zone 7b). These applications were made using a pump sprayer and to ensure good coverage but not to drip. The application of foliar CAL was not found to impact any measured characteristic of fruit quality or post-harvest quality in Arkansas.

***Conclusion*.** Regional berry growers should be more conservative when adopting foliar and shade applications due to potential seasonal variations surpassing the significance of agronomic treatments. There were some distinctions in aroma profiles for the two varieties evaluated in Virginia.

Funding acknowledgment. Virginia Department of Agriculture and Consumer Services, Specialty Crop Block Grant and Southern Region Small Fruit Consortium.

Blueberry stem blight survey in Alabama

Ayodele Amodu[1], Sejal Patel[2], Kathy Lawrence[3], Jenny Koebernick[2], Elina Coneva[1], Sushan Ru[1]
[1]Department of Horticulture, [2]Department of Crop, Soil, and Environmental Sciences, [3]Department of Entomology and Plant Pathology, Auburn University.

Stem blight: a major blueberry disease in the Southeast

Blueberry production in the Southern United States is greatly challenged by diseases like Botryosphaeria stem blight, which is caused by fungi pathogens in the family of Botryosphaeriaceae. Botryosphaeria stem blight can cause sudden wilting and chlorosis of leaves and stems, and in severe cases plant death (Milholland 1972) (Fig. 1). Managing Botryosphaeria stem blight remains challenging in blueberries, as no fungicide, cultural practice, or cultivar alone can effectively prevent or control this disease (Ru et al. 2022). As a result, growers in Florida have identified Botryosphaeria stem blight the most economically costly disease (Wright and Harmon 2010). Botryosphaeria stem blight is also the top limiting disease in Alabama.

Figure 1. Plants infected with Botryosphaeria stem blight. Pictures from Ru et al. (2022)

Early studies consider *Botryosphaeria dothidea* the causal pathogen for stem blight, and therefore the name Botryosphaeria stem blight. However, the use of DNA sequencing and phylogenetic tools in newer studies have revealed many other genera and species associated with Botryosphaeria stem blight (Ru et al. 2022). Identifying the distribution and causal pathogens of Botryosphaeria stem blight is crucial for developing effective management strategies (Babiker et al. 2019). However, such information is limited for Alabama, with the only report from Flor et al. (2022). Our study aims to expand our knowledge on the distribution of stem blight in Alabama by surveying blueberry farms in Alabama and some neighboring states.

Distribution and causal pathogens of blueberry stem blight in Alabama

A total of 47 symptomatic plants were collected between 2021 and 2023, from Alabama, Georgia, and Mississippi (Table1). Small twigs measuring about 1 inch were cut from each sample, surface disinfected with 10% bleach (for 1 minute) and 70% alcohol (for 30 seconds), and then rinsed with sterile water. The twigs were cultured on acidified potato dextrose agar (APDA) and incubated at 28℃ for about 7 days. Pure culture of the pathogens was subcultured from the primary culture by transferring a small portion of fungal mycelium into fresh APDA plates and incubated at 28℃ for 7 days (Fig. 2). The DNA from each cultured fungal plate was extracted and PCR was conducted. Three genomic regions: the internal transcribed spacer region (ITS), Beta tubulin gene (BT2), and translation elongation factor (*tEF*) were sequenced at Eurofins Genomics. The resulting DNA sequences were then compared to similar pathogens previously identified from other regions, using available data on NCBI database.

Table 1. Summary of disease samples collected in 2021 and 2022.

Location	Time of collection	No. of plant samples	No. of isolates
Auburn, AL	03/11/22 - 07/26/22	10	10
Brewton, AL	10/06/22 - 03/20/23	5	5
Chilton, AL	03/01/22 - 06/10/22	6	7
Fairhope, AL	05/20/22	3	4
Jemison, AL	09/02/21	3	3
Shorter, AL	04/22/22 - 06/12/22	8	9
Hahira, GA	09/10/21	1	1
Lake Park, GA	04/15/22	8	9
Poplarville, MS	05/09/22	3	4
Total		**47**	**52**

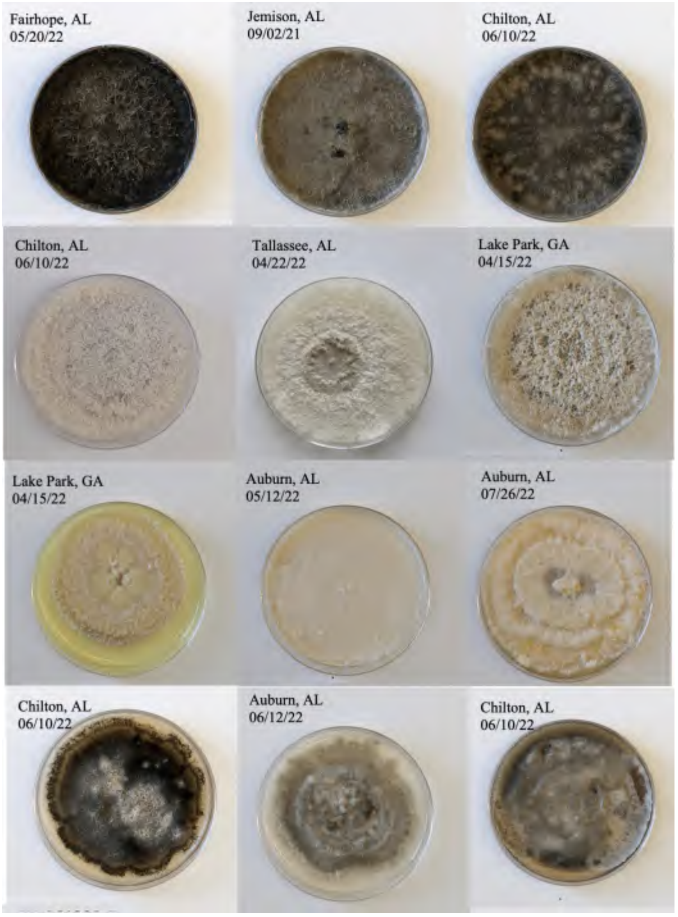

Figure 2. Colonial morphologies of fungal isolates. Botryosphaeriaceae (row1), Diaporthaceae (row2) Sporocadaceae (row 3), and Pleosporaceae.

Botryosphaeriaceae (36%) was the most common; however, not the only family associated with stem blight samples. Eleven other fungal families have been identified, among which the Diaporthaceae (13%), Sporocadaceae (11%), and Pleosporaceae (11%) are the major families (Fig. 3). In the Botryospshaeriaceae family, *Neofusicoccum* is the most common genus. Phylogenetic analysis is being conducted to further classify isolates to the species level.

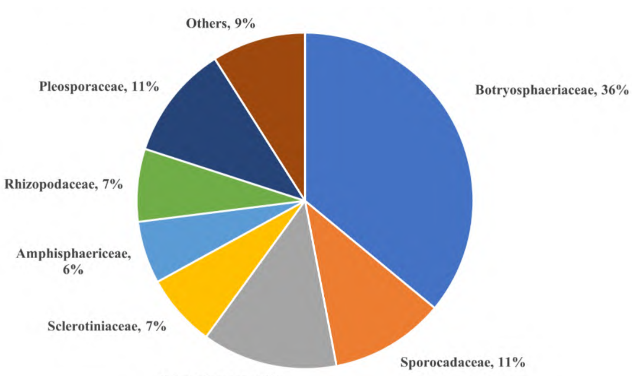

Figure 3. Distribution of stem blight pathogens in Alabama and neighboring states

Pathogenicity test and cultivar screening

Preliminary pathogenicity test was conducted in spring 2023 in a walk-in growth chamber at the Plant Science Research Center of Auburn University, Alabama. Mycelia of isolates within three families: Botryosphaeriaceae, Diaporthaceae and Sporocadaceae were used to artificially inoculate three stems of one Vernon blueberry plants following an attached-stem assay. The growth chamber was conditioned for 12 hours daylight/12 hours night, 60% relative humidity, and 25℃ (Fig. 4). The initial findings of our study revealed that 25 out of a total of 28 isolates tested (89%) caused stem lesions within two weeks of inoculation (Table 2). Botryosphaeriaceae and Diaporthaceae tended to be more aggressive than Sporocadaceae based on the average lesion length across each family. We are currently testing the virulence of pathogenic isolates with three plants and nine stems per isolate to confirm out preliminary findings.

Figure 4. Artificial inoculation of stem blight pathogens. Attached-stem assay (top) and lesions observed 7 days after inoculation (bottom).

Isolate			Lesion length(mm)				
Family	Location	Cultivar	Rep1	Rep2	Rep3	Average/ plant	Average across family
Botry-osphaeriaceae	Chilton, AL	Pink Lemonade	56.8	67.9	78.1	67.6	
	Jemison, AL	RE[a] cultivar	58.9	49.6	54.9	54.5	
	Chilton, AL	Titan	33.5	43.6	51.8	43.0	
	Lake Park, GA	Kirra	17.8	66.9	24.2	36.3	
	Fairhope, AL	SHB[b]	34.2	43.1	30.7	36.0	
	Fairhope, AL	SHB[b]	26.2	29.2	41.1	32.2	
	Tallassee, AL	Blue Ribbon	17.2	26.2	52.2	31.9	
	Poplarville, MS	SHB[b]	7.6	22	6.6	12.1	
	Lake Park, GA	Kirra	2.3	6.6	4.9	4.6	
	Auburn, AL	SHB[b]	1.6	5.3	5.9	4.3	
	Poplarville, MS	SHB[b]	5.1	5.1	0	3.4	
	Lake Park, GA	Kirra	4	2.7	2	2.9	
	Auburn, AL	Baldwin	1.8	2	4	2.6	**25.5**
Di-aporthaceae	Fairhope, AL	SHB[b]	47.3	44.7	55.7	49.2	
	Tallassee, AL	SHB[b]	37.7	43.2	42.6	41.2	
	Chilton, AL	Premier	31.6	40.4	37.7	36.6	
	Tallassee, AL	Blue Ribbon	30.8	2.7	28.6	20.7	
	Lake Park, GA	Patrecia	3	11.7	3.3	6.0	
	Auburn, AL	Brightwell	0	9.2	3.9	4.4	**26.3**
Sporocada-ceae	Auburn, AL	Star	18.2	5.6	15.8	13.2	
	Auburn, AL	SHB[b]	11.2	11	1	7.7	
	Auburn, AL	Star	4.8	4.6	5.1	4.8	
	Lake Park, GA	Kirra	10	10	10.8	10.3	
	Chilton, AL	Climax	8.8	10.8	8.9	9.5	
	Tallassee, AL	SHB[b]	43.3	59.9	52.9	52.0	**9.1**
	Control 1		0	0	0	0.0	
	Control 2		0.3	0	0	0.1	**0.1**

Table 2. Preliminary data on pathogenicity testing of isolates of Botryosphaeriaceae, Diaporthaceae and Sporocadaceae. Only results on pathogenic isolates are presented.

Note: RE[a] stands for rabbiteye, SHB[b] stands for southern highbush

References:

Babiker EM, Stringer SJ, Sakhanokho HF, Smith BJ (2019) Characterization and pathogenicity of stem blight complex isolates associated with stem blight disease on *Vaccinium species*. HortScience 54(7):1199 – 1203. https://doi.org/10.21273/HORTSCI14033-19.

Wright AF, Harmon PF, (2010) Identification of species in the Botryosphaeriaecae family causing stem blight on Southern highbush blueberry in Florida. Plant Disease:94(8): 966 – 971.

Milholland RD (1972) Histopathology and pathogenicity of Botryosphaeria dothidea on Blueberry stems. Phytopathology 62:654 - 660.

Creswell TC, Milholland RD, (1987) Responses of blueberry genotypes to infection by Botryosphaeria dothidea. Plant Disease 71:710 - 713.

Flor NC, Wright AF, Huguet-Tapia J, Harmon PF, Liberti D (2022) Identification of Fungi in the Botryosphaeriaceae family associated with stem blight of Vaccinium spp. in the Southeastern United States. Fungal Biology 126: 342-355. https://doi.org/10.1016/j.funbio.2022.03.004

Ru S, Ding S, Oliver JE, Amodu A (2023) A Review of Botryosphaeria Stem Blight Disease of Blueberry from the Perspective of Plant Breeding. *Agriculture* 13 (1):100. https://doi.org/10.3390/agriculture13010100

Scarlett KA, Shuttleworth LA, Collins D, Rothwell CT, Guest DI, Daniel R (2018) Botryosphaeriales associated with stem blight and dieback of blueberry (*Vaccinium spp*.) in New South Wales and Western Australia. Australasian Plant Pathology 2019 (48):45 - 57.

Next issue of the Small Fruit News: October 2023

Small Fruit News Editorial Team

Weed Science, Chief Editor: **Jayesh Samtani,** Entomology**: Doug Pfeiffer**

Horticulture/Production: **Edgar Vinson,** Plant Pathology**: Mary Helen Ferguson**