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Viburnum Foliar Pathogen Identification and Fungicide Efficacies

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Central Florida nursery growers have reported disease management challenges since 2004 impacting the production of ornamental *Viburnum* spp. Reported symptoms included blighting and rapid defoliation that were historically known as downy mildew (DM). Growers indicated that common labeled fungicides failed to provide acceptable levels of disease control. In the spring of 2020, symptomatic plant samples were collected from local nurseries in Hillsborough and Manatee Counties. Identification of isolated fungi revealed the presence of multiple pathogens throughout the growing seasons (spring, summer, and fall), including *Plasmopara* sp., *Cercospora* sp., *Corynespora* sp., *Colletotrichum* sp., *Phoma* sp., *Phyllosticta* sp., and *Pestalotiopsis* sp. These diseases had symptom progression very similar to DM and were not easily identified. Two fungicide trials were conducted at a commercial nursery. The first trial, conducted during July and August, evaluated 13 fungicides available to nursery growers. The second trial, conducted during September and October, evaluated 7 fungicides. Both trials included a non-treated control, with all treatments replicated (n=6) and arranged in randomized complete blocks. Not surprisingly, fungicides that target DM oomycetes (i.e., *Plasmopara* sp.), containing ametoctradin, cyazofamid, dimethomorph, fluopicolide, mandipropamid, mefenoxam, and oxathiapiprolin, failed to reduce disease severity. Fungicides containing benzovindiflupyr, difenoconazole, fluxapyroxad, and pyraclostrobin that typically target true fungi, statistically reduced disease severity. Copper sulfate and mancozeb, or the systemic fungicide, flutriafol, failed to reduce disease severity, while a generic phosphite gave an intermediate level of control. Results stress the importance of an appropriate disease diagnosis to avoid making ineffective fungicide applications.

Viburnum sp. is an important woody ornamental crop for nursery growers in Florida. The main varieties grown in the Central Florida region are *V. suspensum* (Sandankwa viburnum), *V. odoratissimum* (sweet viburnum), and *V. obovatum* (Walter's viburnum). Viburnums are quick growing shrubs that reach an average height of about 30 ft. if left alone. They produce small white flowers and drupe fruit. They are used popularly in the landscape as hedges or screen plants. Around 2004, Central Florida nursery growers began to report severe disease management challenges impacting the production of ornamental *Viburnum* spp. especially during high humidity, mist propagation (Elwakil et al. 2021). Previously, viburnum cuttings would root with ease around 100% propagation success rate. When disease started to present itself, propagation success rates could easily drop to 0%. Reported symptoms included reddish to dark foliar spots followed by blighting and rapid defoliation of cuttings. Young plants, liners that were potted in one- or three-gallon containers also showed intense disease symptoms (Fig 1.). The problem was originally identified as downy mildew (DM) caused by the oomycete *Plasmopara viburni*. This fungus is spread with the movement of air and water. High humidity, leaf wetness, plant overcrowding, foggy days, and cooler weather favor the growth of DM (Salgado-Salazar, 2017). Around 2014, growers indicated that common labeled fungicides targeting DM failed to provide acceptable levels of disease management. It was thought that maybe DM became resistant to fungicides rendering control unsatisfactory. Research was necessary to determine efficacies of

Fig. 1. Foliar symptoms observed during Viburnum propagation in liners (top) and recently potted plants (bottom) showing the issues of propagating from diseased plants.

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commercially available fungicide chemistries for the management of DM on *Viburnum* sp. to increase profitability and economic sustainability.

Materials and Methods

Symptomatic foliage of Sandankwa viburnum (*V. suspensum*) and Awabuki viburnum (*V. odoratissimum* var. awabuki) was collected from local nurseries for pathogen identification throughout the growing seasons (spring, summer, and fall) in Hillsborough and Manatee Counties.

Two fungicide trials were conducted at a commercial nursery in Hillsborough County. The first trial was conducted during July-August using naturally infected *V. suspensum* plants grown in 3-gallon containers at a commercial production plant nursery. The trial was designed in completely randomized blocks with 6 replicates including 13 fungicide treatments representing 12 modes of action (MOA) and water control (Table 1). A second trial was conducted during September–October using the same setup as the first trial but focused on seven fungicides with a water control (Table 2).

All fungicide spray treatments were applied twice at a 14-day interval, except for copper sulfate, mancozeb, and a phosphite that were applied weekly, using a handheld pump sprayer, calibrated to deliver fungicide treatments in 0.5L volume at recommended products' spray rates. In the second trial, flutriafol was applied as a soil drench per manufacturer's recommendation. Plants were fertilized and overhead irrigated according to grower production standards. The percentage of symptomatic foliage was rated weekly for six weeks to calculate the area under the disease progression curve (AUDPC).

Pathogenicity tests were performed in a growth chamber to confirm pathogenicity of isolated fungal species from collected nursery plant samples. This included isolating the fungal species and culturing them for phenotypical identification and creating mass inoculum. Healthy plants were inoculated in a growth chamber using an inoculum solution spray. Disease development of inoculated plants in addition to a water control was monitored daily.

Data analysis was conducted using a generalized mixed model analysis (PROC GLIMMIX) within SAS (version 9.4) with blocking as a random variable and fungicide treatment as a fixed effect. Mean separations were performed using Fisher's protected LSD at a 95% level of confidence.

Results and Discussion

Identification of isolated fungi revealed the presence of multiple pathogens throughout the growing seasons (spring,

Table 1. List of fungicide treatments applied to V. suspensum in the first trial conducted in July through August 2020 and area under disease progression curve (AUDPC) representing disease severity.

Product	Active ingredient	FRAC	Rate/100 gal	AUDPC[z,y]
Protect	Mancozeb	M3	2 lb	1586 a
Cuprofix Ultra 40D	Copper sulfate	M1	1.9 lbs	1857 a
Subdue Maxx	Mefenoxam	4	2 fl oz	1277 ab
Micora	Mandipropamid	40	8 fl oz	1594 a
Orvego	Dimethomorph + ametoctradin	40 + 45	14 fl oz	1360 ab
Ryora (Topguard)	Flutriafol	3	14 fl oz	1855 a
Adorn	Fluopicolide	43	4 fl oz	1069 abc
Stature	Dimethomorph	40	12.25 fl oz	1045 abc
Segovis	Oxathiapiprolin	49	3 fl oz	1213 ab
Segway	Cyazofamid	21	6 fl oz	968 abc
Phostrol	Phosphite	33	64 fl oz	836 abc
Orkestra	Pyraclostrobin + Fluxapyroxad	11 + 7	10 fl oz	649 bc
Postiva (Miravis Top)	Benzovindiflupyr + Diffenoconazole	7 + 3	28 fl oz	521 c
Water control	--	--	--	1716 a

[z]Area Under the Disease Progression Curve (AUDPC), calculated using final four disease severity ratings.
[y]AUDPC means followed by the same letter are not significantly different at the 95% level of confidence. *P*-value: 0.0122.

Table 2. List of fungicide treatments applied to *V. suspensum* in the second trial conducted in September through October 2020 and area under disease progression curve (AUDPC) representing disease severity.

Product	Active ingredient	FRAC	Rate/100 gal	AUDPC[z,y]
Protect	Mancozeb	M3	2 lb	139 c
Phostrol	Phosphite	33	2 qt	193 abc
Cuprofix Ultra 40D	Copper sulfate	M1	1.9 lb	160 bc
Orkestra	Pyraclostrobin + Fluxapyroxad	11 + 7	10 fl oz	144 bc
Postiva (Miravis Top)	Benzovindiflupyr + Diffenoconazole	7 + 3	28 fl oz	90 c
Ryora (Topguard)	Flutriafol (drench applied)	3	14 fl oz	290 a
Segovis	Oxathiapiprolin	49	3 fl oz	261 ab
Water control	--	--	--	172 abc

[z]Area under the disease progression curve (AUDPC), calculated using final four disease severity ratings.
[y]AUDPC means followed by the same letter are not significantly different at the 95% level of confidence. *P*-value: 0.0312.

Fig. 2. Viburnum leaf exhibiting symptioms of downy mildew (top) caused by *Plasmopara* sp., with sporulation showing on leaf underside (bottom left), through a hand lens (bottom center), and through a microscope (bottom right).

Fig. 3. Common foliar symptoms observed on Viburnum spp. caused by one or a combination of *Cercospora* sp., *Corynespora cassiicola*, *Colletotrichum* sp., and *Phyllosticta* sp. Disease symptoms similarities highlight difficulties to accurately diagnose.

summer, and fall), including *Plasmopara* sp., *Cercospora* sp., *Corynespora* sp., *Colletotrichum* sp. and *Phyllosticta* sp. Many caused symptoms of leaf spotting, blighting and defoliation similar to DM. Repeated sampling during trials failed to detect *Plasmopara* sp., the cause of downy mildew. Additional surveys of diseased viburnum from other nursery sites also failed to identify *Plasmopara* sp. in winter and spring of 2021. Controlled inoculations confirmed pathogenicity for *Colletotrichum* sp. and *Corynespora* sp., while *Pestalotiopsis* sp. appears to be an opportunistic saprophyte. Pathogenicity tests for *Phyllosticta* sp. and *Phoma* sp. are in progress. Each fungal genus designation was confirmed based on internal transcribed spacer region sequence. Additional sequencing is in progress for proper phylogenetic placement at the species level. These results stress the importance for growers to get an appropriate disease diagnosis to avoid making ineffective fungicide applications.

At the initiation of the first trial (Table 1), the initial survey of viburnum found *Plasmopara* sp. (downy mildew) (Fig. 2), *Cercospora* sp. and *Colletotrichum* sp. as the primary pathogens present. However, subsequent sampling failed to find any sign of downy mildew. Rather, *Colletotrichum* sp., *Corynespora cassiicola*., *Phyllosticta* sp., *Phoma* sp., and a *Pestalotiopsis* sp. were recovered from symptomatic foliar tissues (Figs. 3 and 4). Not surprisingly, the fungicides containing ametoctradin, cyazofamid, dimethomorph, fluopicolide, mandipropamid, mefenoxam, and oxathiapiprolin that specifically target oomycetes (i.e., *Plasmopara* sp.), failed to reduce disease severity at a level that was statistically significant relative to the non-treated control based on AUDPC. Benzovindiflupyr, difenoconazole, fluxapyroxad, and pyraclostrobin fungicides that are typically applied for the management of true fungi, reduced disease severity at a statistically significant level.

In the second trial, seven fungicides (Table 2) were re-evaluated on a new set of younger plants. In this trial, lower disease pressure from *Cercospora* sp., *Colletotrichum* sp., *Corynespora cassiicola*., *Phyllosticta* sp. produced more variable results. Numerically, the fungicides flutriafol and oxathiapiprolin appeared to increase disease severity relative to the non-treated control. Based on AUDPC, only benzovindiflupyr + difenoconazole reduced disease severity at a statistically significant level relative

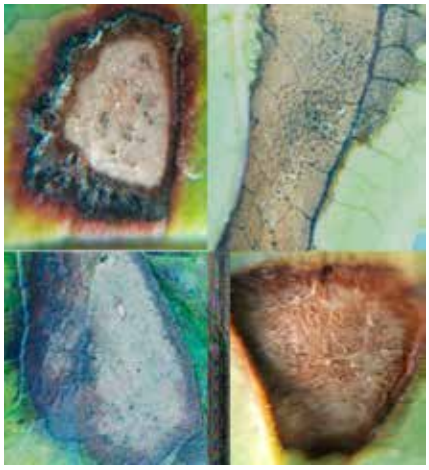

Fig. 4. Hand lens view of Viburnum leaf lesions associated with *Colletotrichum* sp. (top left), *Cercospora* sp. (top right), *Phyllosticta* sp. (bottom left), and *Corynespora* sp (bottom right).

to the non-treated control; while pyraclostrobin + fluxapyroxad numerically also gave some control based on the final disease severity rating. At the time of submission of this paper, the trial was being repeated.

Conclusion

Our findings align with the growers' reports of challenges with foliar disease management in viburnum while shedding a light on the components of this management puzzle. Growing season and environmental conditions play a key role in management decisions as a result of the multiple foliar diseases of *Viburnum* sp. occurring throughout the year. These results stress the importance of correct disease and pathogen diagnosis to select the appropriate fungicide treatments. Recommendations for foliar disease management of viburnum can be adjusted based on this research which includes correct disease identification, the timing of preventative broad-spectrum and pathogen-specific fungicide treatments based on environment and season, and fungicide ro-

tations. It is essential that growers selectively propagate plants from clean nursery or landscape stock and manage propagation intensely due to environmental conditions that favor disease outbreak. Future research will include pathogenicity testing of isolated fungi (*Phyllosticta* and *Phoma*), repeated fungicide efficacy testing, and additional sequencing for phylogenetic placement to the species level.

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