Fruitzone rainshields for high-value wine grapes: A test of concept
Southern Region Small Fruit Consortium
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Objectives:

1) Evaluate the merits of temporary fruitzone rainshields for reducing disease incidence and severity in two wine grape cultivars.
2) Collect material costs and an estimate of labor costs to deploy vine rainshields to compare with potential savings in terms of reduced disease incidence or measurable increases in grape composition and wine quality potential.
3) Evaluate the potential value of rainshields as a spring frost mitigation tool.

Introduction:

Wine grapes are a high value crop and grape growers in the Mid-Atlantic states have an excellent market for their wines. However, rainfall during the growing season and cold temperatures make vineyard management expensive and risky in the Mid-Atlantic. We designed and installed plastic, partial canopy “rainshields” in our research vineyard at Winchester to evaluate their cost and efficacy at reducing fruit wetting and potential fruit rots during the 2019 growing season.

Materials and methods:

Rainshields were installed on three non-adjacent rows of Cabernet Sauvignon at the AHS Jr. AREC research vineyard near Winchester VA. The initial row was installed on 21 June 2019, about 3 weeks post-bloom. Two additional rows were installed on 5 August 2019, at or around veraison. Non-protected rows were adjacent rows of each of the 3 rainshield rows. Rows were 416 feet long, oriented generally N/S. Vines in the trial were trained to Vertical Shoot Positioning. An aerial photo of the rainshield installed on the initial row is shown in Fig. 1.

Figure 1. Aerial view of vineyard row with rainshield installed.

A crossarm to support the rainshield was made using one-inch polyethylene well-pipe (37.5 inches wide). This was centered and attached to line posts just below the first set of canopy catch wires using 2 deck screws. Monofilament line (2.5mm Argo-line[tm]) was then strung through drilled holes near the ends of the well-pipe for the full length of rainshield rows. Two-foot wide plastic sheeting (clear, 6-mil, reinforced with an internal grid of polyethylene string) was then deployed to both sides of the canopy, and just above the fruitzones. The rainshield plastic was clipped to the catch wires above the fruitzone as well as to the monofilament line (Fig. 2). Figure 3 is a photograph illustrating the position of the rainshields relative to the canopy fruitzone and overall canopy height. The material and labor general costs, calculated on a per acre basis, are shown in Table 1.

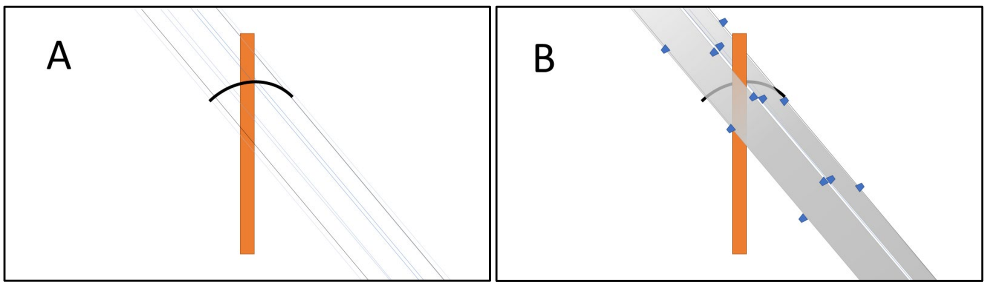

Figure 2: **A**. Trellis hardware (post and grey wires) with sheeting hardware (black crossmember and outrigger monofilament (shown in black) added. **B**. Rainshield deployed on trellis hardware. Bulldog clips (blue trapezoids) holding the sheeting (grey panels) to the trellis hardware.

Table 1: Material and labor costs for initial installation and potential redeployment of rainshields. Labor is figured at $15/hour.

Initial installation of hardware (per acre[a])		**Redeployment of rainshield in subsequent year**	
Trellis hardware (cost per acre)	$1,136	Deploy sheeting and clip (14 hours per acre)	$210
Sheeting material (cost per acre)	$4,412	Take down sheeting and clips (18 hours per acre)	$270
Installation of hardware (32 hours per acre)	$480	Clips[b]	$432
Total cost per acre	**$6,024**		**$912**

[a] 9 feet between rows, 5 feet between vines, with line posts spaced every 25 feet.
[b] 24,000 clips at $0.18 per clip.

Figure 3. Illustration of the relative position of rainshield and fruitzone of canopy.

Results:
We monitored rainshield performance, meteorological conditions, crop performance as well as our labor and observations working with the rainshields.

Clips: Wooden clothespins were initially used to hold the sheeting to the trellis wires and monofilament outrigger line. These wooden clothespins did not hold the sheeting in place with modest gusts of wind (< 25 mph). We then used stainless steel “bulldog” clips with overlapping jaws to hold the sheeting in place. These clips held well for the entire season although the highest windspeeds experienced at an exposed anemometer were only around 30 mph; windspeed at the protected level of the rainshields was probably less than this. The clips did not damage the plastic sheeting after the first season of use. The other factor that tended to dislodge the plastic sheeting was water that ponded on the plastic (Fig. 4) due to a shallow pitch of the plastic (see below) as well as insufficient compression by the wooden clothespins.

Figure 4. Rainwater ponding on plastic rainshield.

Shelter peak gap: The peak of the two sides of the rainshield was separated by the width of the canopy catch wires to which the plastic is clipped. This gap is about 2 inches wide for most of the length of the panel and still admits some rainwater into the fruitzone during rain events. With our current Vertical Shoot Positioned training system, we don't see an obvious way to close the gap at the peak of the sheeting. We used commonly available vineyard "C clips" to pinch the catch wires as closely as possible. We are still interested in a trellis/training system that kept the fruitzone away from directly beneath this gap.

Pitch of the sheeting: We tried two different pitches of the sheeting. We did this by changing the distance between the fixed catch wires on the trellis and the monofilament line supported by the crossmember. By moving the crossmember down relative to the first set of catch wires, we were able to have a steeper pitch to the sheeting and therefore we saw less ponding of water on the sheeting.

Labor efficiency: In the three rows that we deployed and collected the sheeting this year we gained efficiency with each repetition. Working with the sheeting in this research scale allows us to explore more efficient ways to complete these tasks.

Vineyard tasks: The rainshields were mounted on every-other row; to do every row (9-foot row widths) would have reduced row middle width to a point that machinery traffic would be impossible with our existing tractor/sprayer. Fungicide/insecticide spray penetration under the plastic was adequate. In fact, the presence of the rainshield raised questions as to whether continued spraying of the fruitzone was necessary or desirable.

Air Temperature and Relative Humidity: Both air temperature and relative humidity were nearly identical under the rainshield compared to above the plastic rainshield (ambient) during night-time hours of both days (figure 5). Air temperature under the plastic was typically 1 - 2 degrees warmer than ambient air temperature during daylight hours, but spiked to as much as 6 degrees warmer at some points. Surprisingly, relative humidity was generally lower under the plastic compared to ambient conditions during the day.

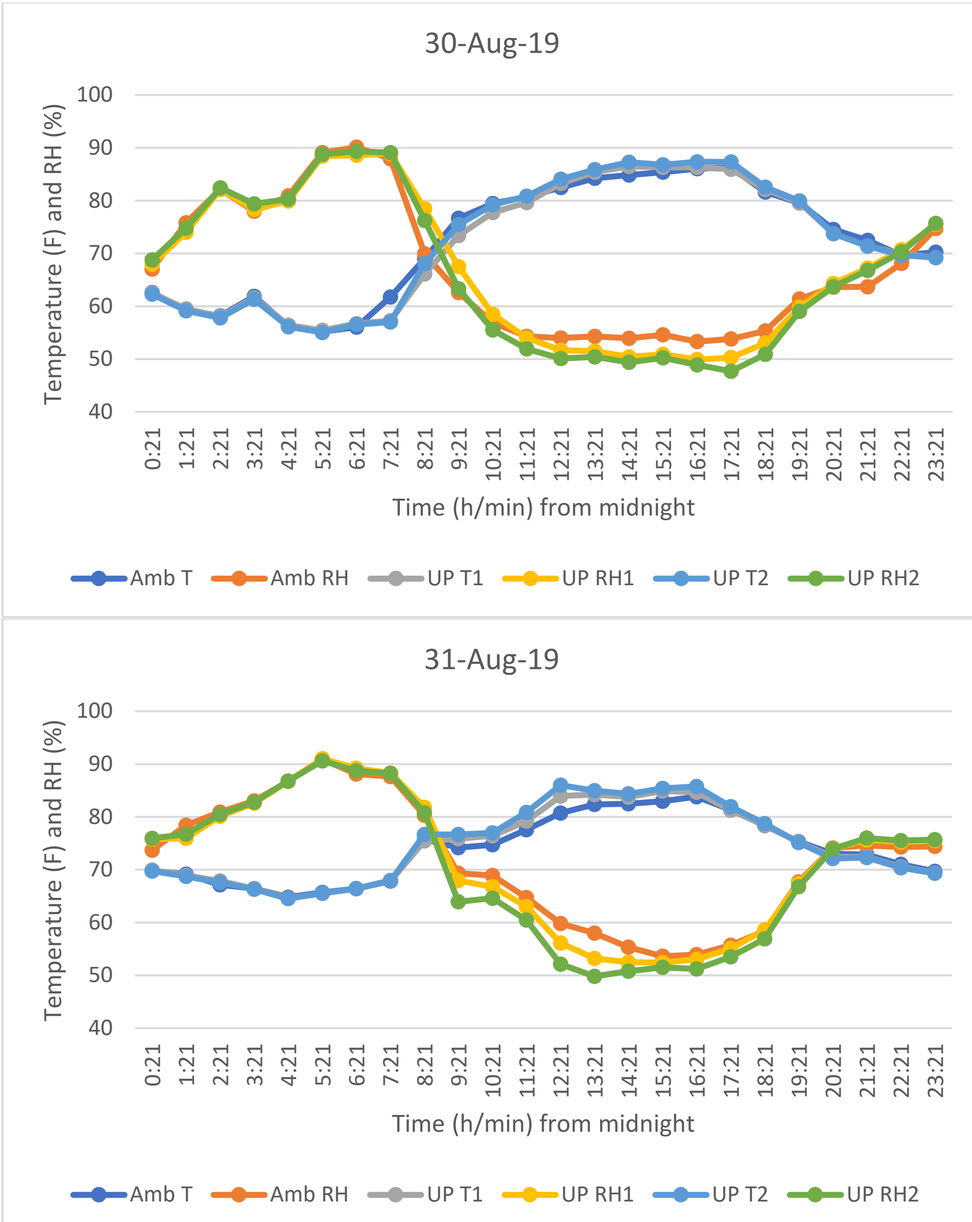

Figure 5. Air temperature (°F) and relative humidity (%) associated with plastic rain shield over 24-hour periods, 30 and 31 August 2019. Both days were clear sky conditions. Radiation-shielded sensors were mounted above the grapevine canopy and above the rain shield (Amb T and Amb RH), immediately beneath the plastic rain shield (UP T2 and UP RH2) and about 10 cm beneath the plastic rain shield (UP T1 and UP RH1).

Leaf Wetness: In addition to air temperature and humidity, we monitored leaf wetness duration (LWD) both outside of the rainshield and in the fruitzone under the rainshield. We saw a substantial increase of LWD outside the shelter compared to within the shelter, however the shelters did not eliminate LWD following rain events (Figure 6).

Components of Yield: We did not see large differences in vine components of yield due to the rainshields (Table 2), nor were differences anticipated, as the rainshields were deployed after fruit set.

Table 2: Cabernet Sauvignon components of yield at harvest with or without rainshield installed.

Rainshield	Clusters per vine	Crop per vine (lbs)	Average cluster wt. (lbs)
No	28.4±5	10.3±2.5	0.36±0.06
Yes	27.0±6	8.2±2.4	0.31±0.07

Primary fruit chemistry at harvest: We did not see large differences in primary fruit chemistry resulting from the rainshield (Table 3). We tracked the maturity of the fruit weekly for four weeks preceding harvest, but did not see a separation of treatments (data not shown).

Table 3: Cabernet Sauvignon primary fruit chemistry at harvest with or without rainshield installed. Duplicate berry samples were collected and weighed for (a) primary fruit chemistry and (b) anthocyanins and total phenolics, which have yet to me measured.

Rain shelter	60 berry wt. 1 (g)	60 berry weight 2 (g)	pH	Titratable acidity (g/L)	Brix
No	80 ±7	82±7	3.47±0.06	7.1±0.8	24.4±0.6
Yes	78±6	79±2	3.43±0.09	7.4±0.6	24.3±0.3

Disease rating: We rated disease incidence on 480 randomly selected clusters at harvest and only found 4 instances of botrytis. There were no significant differences between the treatments. The 2019 season was unusually dry and botrytis was also essentially non-existent in area vineyards. No other fruit rots were observed on the Cabernet Sauvignon.

Photosynthetically active radiation (PAR): Ambient readings of PAR were taken above and under the shield. The rainshield reduced PAR transmission by about 30 – 40%, the greater extent possibly being due to fungicide residues and plastic discoloration over time (Figure 5). Counterintuitively, PAR readings in the fruitzone were higher under the rainshields compared to fruitzones without rainshields. We suspect that the sheeting acts as a light diffuser, reducing direct sunlight but increasing indirect light, possibly by reflection.

Conclusions:

We are encouraged by the results of the first year of trial with this experiment, and plan to redeploy the rainshields in 2020. The absence of prolonged or frequent rain episodes in the latter part of the 2019 growing season did not provide sufficient disease pressure to evaluate the efficacy of the rainshield in reducing disease incidence and severity. We did not see differences in components of yield or primary fruit chemistry as a result of the rainshield. The economics of the rainshield are strong deterrent to commercial adoption at this point, without having a meaningful test of fruit quality differences. If the plastic can be reused for 3 – 4 years, the economics improve.

Deploying and removing the sheeting in the vineyard is a labor-intensive process, there is still room to improve techniques to improve labor efficiency with these tasks, including fabrication of a hydraulically operated reel to retrieve the panels at season’s end, and deploy them the following year.

We still seek means of closing the gap at the rainshield peak, or offsetting this gap from above the fruitzone. Future versions in a new vineyard will also have at least a 6”:12” pitch to help shed rainwater.

Figure 5: Total daily leaf wetness hours outside the shelter (blue bars) and inside the shelter (red bars) from 25 June through 8 October 2019.

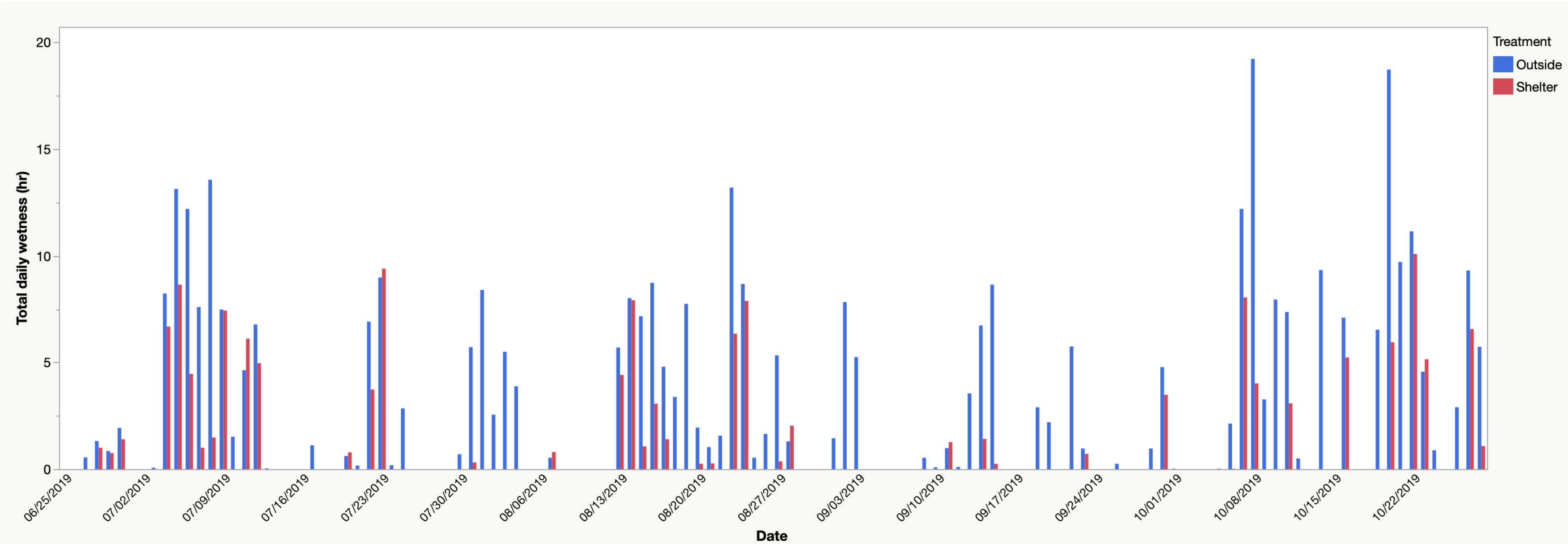

Table 4: Summary of photosynthetically-active radiation (PAR) measurements, 2019. All PAR values are in µmol $m^{-2}s^{-1}$.

Measurement period of day	Average PAR above rainshield plastic	Average PAR below rainshield plastic	Reduction of PAR by rainshield (%)	Average PAR in canopy fruitzone with rainshield	Average PAR in canopy fruitzone without rainshield
Average of 3 daily measurements	1188	789	37	67	43
Morning	959	578	40	77	55
Mid-day	1484	1067	30	89	43
Afternoon	1122	721	40	36	29