**Evaluation of HydroShield to Manage Sour Rot in Wine Grapes**

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**Abstract:** The objective of this project was to evaluate the effectiveness of the novel, food-grade, agricultural product "HydroShield", a hydrophobic plant cuticle supplement, to manage the pervasive wine grape rot complex 'sour rot'. Hydroshield produces a hydrophobic spray film around fruit, preventing water ingress during wetting events (rain or dew). It has also been reported to increase cuticular thickness and decrease spotted wing drosophila (SWD) penetration and oviposition in other commodities. Sour rot is a complex disease; drosophila insects, to include SWD, transmit yeast and acetobacter to damaged grapes where these pathogens establish disease symptoms – producing the equivalent of vinegar in the grapes and rendering them useless for wine production. Decreased drosophila activity in grapes would theoretically result in decreased sour rot. Therefore, two HydroShield formulations were tested for their effectiveness as indirect sour rot management tools in wine grape vineyards in north and west Georgia. Both Hydroshield formulations were applied at a 0.5% v/v rate, calculated to deliver 50 gallons of total spray volume per acre. At each location, five replications of each treatment were applied to a randomized complete block with a $CO_2$ backpack sprayer to runoff. An untreated control was included. Applications were initiated on BB or pea-sized fruit, depending on phenology at project initiation, and were conducted at approximately two-week intervals till shortly before harvest. All other IPM practices were those utilized and provided by the vineyard managers for each site. Test were conducted in Carroll, Fannin, Lumpkin, Union, and White counties. Where observed, sour rot incidence (% infected clusters) and severity (average % damage per cluster) were rated at commercial harvest on all clusters within an experimental unit. Efficacy of Hydroshield against sour rot was not consistently observed. No phytotoxic responses were observed on fruit at any location, but significant leaf damage was observed on Blanc dubois and Vidal blanc hybrids, and very minor damage was confirmed on Pinot grisio. Marginal leaf burn was observed with all three varieties where damage occurred, but other symptoms, such as yellowing and bronzing of leaves, was also observed on some varieties.

**Objective:** The objective of this project was to evaluate the effectiveness of the newly developed, food-grade, agricultural product "HydroShield", a novel hydrophobic plant cuticle supplement, to manage the pervasive wine grape rot complex 'sour rot'.

**Description and Justification:** A demanding vineyard management program is required to effectively control the intense insect and disease pests of wine grapes in the humid, subtropical climate of the southeastern US. Sour rot (Figure 1), a disease complex caused by yeast, acetic acid bacteria (both already present in and on the grapes), opportunistic fungi, Drosophila fruit flies, and wounds, has received increased recognition by stakeholders and researchers as of late. Sour rot widely affects wine grapes close to harvest in southeastern US viticultural regions. Sour rot results in late-season cluster decay and is accompanied by the smell of vinegar. Sour rot can result in a significant reduction in yield and quality of

wine grapes. Invasion of the sour rot complex occurs at the point of grape berry injury caused by mechanical or growth cracks, wounds, or even insect feeding.

Until recently (Blaauw et al. 2018), very little research has been conducted on sour rot management in wine grapes grown in the southeastern US. That work found fruit zone leaf removal in combination with tank mixes of antimicrobial compounds and insecticides to offer improved sour rot control relative to using pesticide applications alone (without fruit zone leaf removal). While fruit zone leaf removal offers an opportunity to improve rot control, it has been shown to inconsistently manage sour rot (Hickey et al. 2018 and 2019) and is often impractical to implement in commercial vineyards due to its costly and laborious nature. Thus, chemical management offers a more practical sour rot control opportunity for southeastern US stakeholders. The risk of an increase in sour rot infection severity is exacerbated due to the fact that drosophilids can transmit the sour rot causal organisms (Barata et al. 2012), significantly increasing the potential for loss in crop yield and quality. In an attempt to manage sour rot and its spread, growers are sometimes applying weekly antimicrobial and insecticide sprays beginning at 15 Brix (sometimes 4-5 weeks before harvest) to manage this disease. These weekly chemical applications are a financial burden to growers and represent a significant time commitment, often at the busiest time of the growing season. Further, researchers have expressed concern about the effect of the number of sprays applied in the vineyard, especially in the wake of finding fruit flies to be resistant to commonly used insecticides in New York vineyards (Sun et al. 2019).

Despite implementing recommended sour management protocols (weekly spray applications of Oxidate 2.0 and Mustang Maxx), 50% of growers in Georgia, North Carolina, and Virginia characterized their problems with sour rot as either “moderate” or “severe” in a recent survey in 2019. Survey responders cited sour rot to be a particular issue in many of the popular, white-berried, *V*. *vinifera* and hybrid cultivars, including Chardonnay, Riesling, Sauvignon blanc, Gruner Veltliner, Chardonel, and Traminette. Quantitatively, survey responders estimated that sour rot affected 38% of the acreage in Georgia, 25% in North Carolina, and 20% in Virginia. Thus, given that crop losses continue to be incurred despite using current sour rot management recommendations, we feel it necessary to evaluate alternative and practical means to manage the pervasive, sour rot complex in wine grape vineyards.

HydroShield, a food grade, agricultural product developed by Dr. Clive Kaiser at Oregon State University, is a hydrophobic spray that forms a film around fruit and prevents water ingress when it rains. HydroShield increases cuticular thickness and reduces water loss from fruit. HydroShield is at least 90 µm thick and simulates xerophytic plant cuticles, slowing the movement of water out of leaves and fruit. HydroShield has been shown to increase cuticular thickness in cherry and blueberry, decrease spotted wing drosophila (SWD) penetration and oviposition (Walton et al. 2018), and thus decrease blueberry and cherry crop loss due to unmarketability. HydroShield has not been evaluated for its ability to manage sour rot in wine grapes. However, since SWD is an important component in the etiology of sour rot development in wine grapes (Hall et al. 2018, Vogel et al. 2020), limiting SWD-induced injury could ultimately reduce sour rot development. Further, increasing skin thickness and berry firmness could maintain wine grape skin integrity and limit sour rot ingress. A recent conversation with Dr. Clive Kasier has confirmed that HydroShield has great potential to manage sour rot, and possibly other late season bunch rots, in wine grapes. HydroShield is currently in patent pending status but does not require registration to be “labelled” for use on commodities, as it is a food grade product (made of celluloses and pectins) and has no pesticidal

components. Further, HydroShield may prove to be a sustainable, environmentally safe sour rot management tool that does not incur risk of pest resistance development. Hydroshield forms a film on the grape clusters, canes and leaves. The product should provide a means of preventing berry dehydration, splitting of berries, disease development, and reduction of drosophila damage (to include the SWD). Theoretically, SWD slips on the film and cannot oviposit.

**Procedures:** Two HydroShield formulations were tested for their effectiveness as sour rot management tools in wine grape vineyards in north and west Georgia. Both Hydroshield formulations (palm oil and other oils or fatty acids that are food grade) were applied at a 0.5% v/v rate, calculated to deliver 50 gallons of total spray volume per acre. HydroShield 1 is commercialized, and the HydroShield 2 treatment is an experimental formulation. At each location, five replications of each treatment were applied to a randomized complete block with a $CO_2$ backpack sprayer (R & D Sprayers, Opelousas, LA) with a TeeJet adjustable cone tip nozzle (5500-PPX12) (TeeJet Technologies, Wheaton, IL) at a pressure of 25 psi to runoff. An untreated control was included. Applications were initiated on BB or pea-sized fruit, depending on phenology at project initiation, and were conducted at approximately two-week intervals till shortly before harvest (Table 1). All other IPM practices were those utilized and provided by the vineyard managers for each site. Where observed, sour rot incidence (% infected clusters) and severity (average % damage per cluster) were rated at commercial harvest on all clusters within an experimental unit. Phytotoxicity was also rated. Rating dates by county were: Carroll (21 Jul), Fannin (15 Sep), Lumpkin (26 Aug), Union (4 Sep), and White (26 Aug). Treatments were analyzed using the Student's t test statistic in JMP statistical software (SAS Institute, Inc., Cary, NC).

**Results:** Depending on location, HydroShield 1 and HydroShield 2 were successfully applied 3-6 times (Table 1). For all trial sites, spray initiation occurred prior to veraison, the presumed timeframe in which drosophila damage can initially occur and in which sour rot initiates. Neither sour rot nor significant phytotoxicity were observed in Union or Lumpkin counties (Table 1), so no data was collected from these locations. Though no damage was observed on fruit at any location, significant leaf damage was observed at two sites (Blanc dubois [Carroll County] and Vidal blanc [Fannin County]) (Table 2), and very minor damage was confirmed at a third (Pinot grisio [Lumpkin County]). Marginal leaf burn was consistent as a symptom of damage (Figures 2-5), but other symptoms, yellowing (Figures 2 and 4) and bronzing of leaves (Figure 5), was specific to particular cultivars. Sour rot was present in plots from Fannin and White counties, but sour rot management was not consistently controlled with either HydroShield formulation (Table 3).

**Discussion:** It is unlikely that HydroShield has been tested on a large number of hybrid grape varieties, and very limited phytotoxicity was observed on *V*. *vinifera* cultivars or one hybrid, Seyval blanc. However, significant leaf phytotoxicity was observed on two hybrids. Oils are known to interact with captan products to produce phytotoxicity, but oil is also potentially dangerous with sulfur, lime sulfur, and likely other chemicals. Both varieties that exhibited severe symptoms of scorch, yellowing, and bronzing had *V*. *aestivalis* in the parentage, and this species is known to be sensitive to some chemicals. Other grape species have also been observed to have particularly negative responses to specific chemicals. In the case of the phytotoxicity observed in this trial, the HydroShield products could be negatively interacting with specific (or multiple) chemicals, grape parentage, environment, or various interactions of all of these. Application of chemicals through use of backpack sprayers can provide increased phytotoxicity as

compared to the same chemicals applied with an airblast or other commercial sprayer – an artifact of the system. However, the potential for phytotoxicity is revealed by such trials, and it cannot be ignored; commercial testing may indicate that HydroShield products are in fact safe, but this would be an important next step prior to market introduction.

**Impact:** The information provided by these trials allowed for on-farm research with varied cultivars of grape; for each vineyard, the background of producer chemical applications provided a screen of potential phytotoxic chemicals that could interact with oils, such as those in HydroShield. The observed phytotoxicity, though limited mainly to hybrids, indicates that additional research should be conducted with this product prior to market release. Though HydroShield products have potential utility other than that of sour rot management, the initial data did not provide evidence that HydroShield is strongly and consistently efficacious against this disease complex.

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**Table 1.** Trial site information by county.

| Location (County) | Variety | Genus species | Application dates | Leaf phytotoxicity | Producer products applied (date/products)* |
|---|---|---|---|---|---|
| Carroll | Blanc dubois | *Vitis vinifera* X *V. smalliana* X *V. aestivalis* X *V. simpsonii* X *V. labrusca* | 15 Jun<br>29 Jun<br>13 Jul | Yes; significant | 29 May; Manzate, Fungi-Phite, Delegate, Pristine<br>6 Jun; Sevin<br>19 Jun; Revus Top, Fungi-Phite, Sevin<br>26 Jun; Revus, Fungi-Phite, Captan<br>5 Jul; Pristine, Ranman, Assail, Fungi-Phite |
| Fannin | Vidal blanc | *V. vinifera* X *V. rupestris* X *V. aestivalis* | 24 Jun<br>8 Jul<br>22 Jul<br>5 Aug<br>19 Aug<br>2 Sep | Yes; significant | Spray program not provided. |
| Lumpkin | Pinot grigio | *V. vinifera* | 25 Jun<br>10 Jul<br>24 Jul<br>7 Aug<br>20 Aug | Yes; minor | 16 Jun; Carbaryl, Ridomil Gold Copper, Cohere, Oxidate<br>26 Jun; Topsin M, Scala, Suffa, Ranman<br>8 Jul; Carbaryl, Cohere, K-Phite, Pristine<br>14 Jul; Admire Pro, Zinc, Epsom Salt<br>23 Jul; Switch, Zampro, Cohere, K-Phite<br>5 Aug; Captan, K-Phite, Assail, Cohere<br>11 Aug; Captan, K-Phite, Cohere, Quintec, Mustang Maxx<br>18 Aug; Captan, Cohere, Assail, Oxidate<br>27 Aug; Captan, Cohere, Delegate, Oxidate<br>3 Sep; Elevate, K-Phite, Cohere, Mustang Maxx, Oxidate |
| Union | Seyval blanc | *V. vinifera* X *V. rupestris* X *V. licencumii* | 1 Jul<br>15 Jul<br>29 Jul<br>12 Aug<br>26 Aug | No | May-Jun; Mancozeb, Rally, Inspire, Carb-o-nator, Revielle<br>Jul-Sep; Captan, Rally, Inspire, Elevate, Carb-o-nator, Revielle |
| White | Syrah | *V. vinifera* | 24 Jun<br>8 Jul<br>31 Jul<br>18 Aug | No | 20 Jun; Suffa, Captan, K-Phite, Carbaryl 4L<br>4 Jul; Suffa, Captan<br>13 Jul; Suffa, Captan<br>24 Jul; Captan, K-Phite, Revus Top, Malathion<br>31 Jul; Captan, K-Phite, Revus Top, Oxidate<br>5 Aug; Captan, K-Phite, Revus Top, Oxidate<br>14 Aug; Captan, K-Phite, Revus Top<br>20 Aug; Captan, K-Phite, Oxidate |

* Products applied across all trial sites during a time in which the Hydroshield could have interacted to develop phytotoxictiy: Admire Pro (imidocloprid), Assail (acetamiprid), Captan (captan), Carbaryl (carbaryl), Carb-o-nator (potassium bicarbonate), Cohere (alkanolamide surfactants + alkylaryl polyethoxyethanol sulfates + 1,2-propanediol), Delegate (spinetoram), Elevate (fenhexamid), Epsom salts (magnesium sulfate), Fungi-Phite (mono- and di-potassium salts of phosphorous acid), Inspire (difenoconazole), K-Phite (mono- and di-potassium salts of phosphorous acid), Manzate (mancozeb), Mustang Maxx (zeta-cypermethrin), Oxidate (hydrogen peroxide + peroxyacetic acid), Pristine (boscalid + pyraclostrobin), Quintec (quinoxyfen), Rally (myclobutanil), Ranman (cyazofamid), Reveille (potassium phosphite), Revus (mandipropamid), Revus Top (difenoconazole + mandipropamid), Ridomil Gold Copper (mefenoxam + copper hydroxide), Scala (pyrimethanil), Sevin (carbaryl), Suffa (sulfur), Switch (cyprodinil + fludoxonil), Topsin M (thiophanate methyl), Zampro (ametoctradin + dimethomorph), Zinc

**Table 2.** Phytotoxicity ratings for Hydroshield products applied to wine grapes in Georgia.

| | Leaf phytotoxicity[a] (Carroll County) | | Leaf phytotoxicity (Fannin County) | |
|---|---|---|---|---|
| | Scorch and yellowing | | Scorch and yellowing | Bronzing |
| Treatment | Incidence (% leaves damaged) | Severity (avg. % leaf damaged) | Severity (avg. % leaves damaged) | Severity (avg. % leaf damaged) |
| Untreated control | 2.0 b[b] | 0.1 b | 5.0 b | 0.0 b |
| Hydroshield 1 | 54.0 a | 14.0 a | 35.0 a | 65.0 a |
| HydroShield 2 | 54.0 a | 13.5 a | 30.0 a | 60.0 a |

[a]Leaf phytotoxicity was assessed on 21 Jul (Carroll County) and 15 Sep (Fannin County).

[b]Means within columns followed by the same letters are not significantly different when comparing each pair using Student's t test statistic (*P*=0.05).

**Table 3.** Efficacy results of spray trials of HydroShield products for management of sour rot.

| | Sour rot[a] (White County) | | Sour rot (Fannin County) | |
|---|---|---|---|---|
| Treatment | Incidence (% infected clusters) | Severity (% cluster infected) | Incidence (% infected clusters) | Severity (% cluster infected) |
| Untreated control | 68.0[b] | 8.4 ab | 70.0 a | 6.8 |
| Hydroshield 1 | 44.0 | 3.8 b | 55.0 ab | 5.5 |
| HydroShield 2 | 72.0 | 11.8 a | 43.3 b | 4.0 |

[a]Sour rot incidence and severity was assessed on 26 Aug (White County) and 15 Sep (Fannin County).

[b]Means within columns followed by the same letters are not significantly different when comparing each pair using Student's t test statistic (P=0.05).

**Figure 1.** Symptoms of sour rot on Vidal blanc (15 Sep). Sour rot is caused by a disease complex that includes yeast, acetic acid bacteria (both already present in and on the grapes), opportunistic fungi, Drosophila fruit flies, and wounds.

**Figure 2.** Phytotoxicity on Blanc du bois grape leaves in Carroll County, Georgia (USA) (21 Jul). Symptoms of phytotoxicity were consistently observed on leaves of Blanc du bois treated with both HydroShield formulations. Hydroshield treatment resulted in marginal leaf burn, especially where the product settled or drained to the lower leaf margins. In addition, yellow discoloration occurred on many leaves. No phytotoxicity was observed on fruit.

**Figure 3.** Phytotoxicity from application of HydroShield formulations on Pinot grigio grapes in Lumpkin County, Georgia (26 Aug). Phytotoxicity (marginal scorch and yellowing of leaves) was observed, especially where the product drained to the lower leaf margins. However, as a percentage of leaves treated, phytotoxicity was very low (estimated at <1%) and would have been deemed inconsequential. No phytotoxicity was observed on fruit.

**Figure 4.** Phytotoxicity from applications of HydroShield products on Vidal blanc (15 Sep). Marginal leaf burn and yellowing of leaves was observed throughout the canopy – without regard to formulation. No phytotoxicity was observed on fruit.

**Figure 5.** Phytotoxic bronzing of leaves of Vidal blanc following application of HydroShield (15 Sep). “Bronzing” of leaves was also observed, and in general, the plants treated with either HydroShield formulation has a distinct bronzed appearance, similar to that caused by spider mite infestations.