Research Project Report – 2019
Southern Region Small Fruit Consortium

Title:
Development of IPM Strategies to Improve Sour Rot Management in Bunch Grapes

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Public Abstract:
Pest management in Southeastern US wine grape production is intense. Due to the hot and humid climate, the management programs required to effectively control sour rot and Botrytis bunch are particularly demanding. The bacteria and fungi that cause these rots can be distributed by drosophilid (vinegar or 'fruit') flies, such as the invasive spotted wing drosophila (SWD), which can lay eggs within intact, ripening fruit. Thus, the risk of sour rot infection is increased because SWD has the potential to directly inoculate ripening grapes, significantly increasing the potential for loss in crop yield and quality. Research from Cornell University has shown that a tank-mixed antimicrobial (OxiDate 2.0) with an insecticide treatment (Mustang Maxx) is more efficacious in reducing sour rot severity than either the antimicrobial or insecticide alone. Additionally, by creating a well-ventilated, improved spray coverage potential, and reduce fly habitat, fruit-zone leaf removal has been documented to reduce the incidence of late-season bunch rots in grape. Thus, to take bunch rot management a step further, we evaluated a factorial combination of drosophilid fruit fly control, microbial management, and fruit-zone leaf removal on the reduction and incidence of sour rot and Botrytis bunch rot in Southeastern *Vitis vinifera* L. (Chardonnay) production. After two years of trials, Numerically, for both the incidence and severity, the combination of leaf pulling and chemicals provided the lowest disease pressure and SWD infestation. Although the results were not statistically significant between the treatment interactions, the results from this second-year project substantiates the previous results demonstrating that insecticidal and microbial spray management in conjunction with fruit-zone leaf removal has potential to effectively manage sour rot and Botrytis development in Chardonnay.

Introduction:
Bunch grapes are produced on approximately 8,000 acres throughout the Southeastern region, which is worth over $32 million annually (NASS 2015 State Agricultural Overview). A demanding management program is required to effectively control the intense insect and disease pests of grapes in the hot and humid climate of the

Southeastern US. One such pest is sour rot, or summer bunch rot, which is a "complex" of acetic acid forming bacteria, ethyl acetate-producing wild yeasts, and other opportunistic fungi, which thrive in the warm, humid Southeastern climate. Sour rot results in late-season cluster decay and is accompanied by the smell of vinegar or acetic acid (hence the name) and can result in a significant reduction in yield and quality of the wine grapes. Another major disease is Botrytis bunch rot, which is caused by the fungus *Botrytis cinereal.* Similarly to sour rot, Botrytis bunch rot results in cluster decay of ripening grapes, significantly reducing yield and quality of the grapes. Invasion of the grape berries by these two rot complexes can occur at the point of grape berry injury caused by mechanical or growth cracks, wounds, or even insect damage. The bacteria and fungi that causes these rots can be distributed by drosophilid (vinegar or 'fruit') flies (Barata et al., 2012). Generally, these flies are attracted to already-damaged and/or rotting fruit, but the invasive spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura), females have a serrated ovipositor (the egg laying device) that allows her to penetrate and lay her eggs within intact, ripening fruit. While that can result in maggots in the ripe fruit, perhaps the primary concern for wine grape producers is that the penetration of the ovipositor into the fruit creates a tiny puncture wound in the grape skin, putting the fruit at risk of sour rot infection. The risk of infection is increased because drosophilids can also transmit the sour rot bacteria and fungus, thus SWD has the potential to directly inoculate ripening grapes, significantly increasing the potential for loss in crop yield and quality. In 2017, Georgia growers noted sour rot at only moderate soluble solids levels, and reported losses up to 40% in regionally-important white varieties such as Blanc du Bois and Chardonnay. We predict that sour rot is a very important issue for not only Georgia growers, but several Southeastern bunch grape growers.

There are several insecticides that highly effective at managing SWD adults, but the antimicrobial chemistries available are only moderately effective at controlling sour rot in Southeastern vineyards. Research from Cornell University has shown that a tank-mixed antimicrobial (OxiDate 2.0) with an insecticide treatment (Mustang Maxx) is more efficacious in reducing sour rot severity than either an antimicrobial or insecticide alone; this highlights the putative importance of both microbes and drosophilids in sour rot development (Hall et al. 2016). Additionally, it has also been shown that vineyard training systems have significant impact on sour rot severity, suggesting that horticultural practices can greatly impact sour rot incidence (Wilcox 2015).

Given that (1) little, if any, research has been conducted on sour rot in wine grapes in the Southeastern US; (2) both sour rot and drosophild species, including the new invasive SWD, have been observed in wine grape vineyards in the Southeast; and (3) the Southeast's climate is much warmer, and thus potentially more conducive to sour rot development than the regions where recent sour rot research on wine grapes has been conducted (Canada and New York), evaluation of sour rot management in Southeastern wine grape vineyards is necessary. Thus, we evaluated a factorial combination of drosophilid fruit fly control, microbial management, and fruit-zone leaf removal on the reduction and incidence of sour rot in Southeastern *Vitis vinifera* L. (Chardonnay) production over a two-year period.

Materials and Methods:

The project was established at one commercial vineyard in Dahlonega, GA and one in Cleveland, GA in Chardonnay vineyards with vertical shoot positioned (VSP) training systems for the vines. Treatment plots were arranged in a strip-plot design and each treatment combination was replicated six times at each site. Treatments within the main plot consisted of eight consecutive vines with either leaf removal or no leaf removal. Within those plots the chemical treatments were applied to four-vine sub plots with either the pesticide (insecticide + antimicrobial) or no pesticide.

In 2018, leaf removal was initiated on 12 June, which was at post-fruit set. Six basal-shoot leaves were removed from each of the leaf removal plots. The insecticide treatment was composed of a rotation of three chemistries effective for SWD control: Mustang Maxx (zeta-cypermethrin), Malathion, and Delegate (spinetoram). Following the labeled rates, tank mixed antimicrobial (Oxidate 2.0 and Pritine) and the insecticides were applied on a 10 day cycle starting at approximately 10°brix. Chemical applications were made on 21 July, 3

Aug., and 16 Aug. 2018 at the Dahlonega site and 1 Aug., 14 Aug., 24. Aug, and 4 Sept. 2018 at the Cleveland site.

In 2019, the trial was repeated at the Dahlonega vineyard site with leaf removal initiated on 3 June, where six basal-shoot leaves were removed from each of the leaf removal plots. Following the same protocols from 2018, the insecticide treatment was composed of a rotation of three chemistries effective for SWD control: Mustang Maxx (zeta-cypermethrin), Malathion, and Delegate (spinetoram). Following the labeled rates, tank mixed antimicrobial (Oxidate 2.0 and Pristine) and the rotating individual insecticides were applied on a 7-10 day cycle starting at approximately 10ºbrix. Chemical applications were made on 19 July, 26 July, 1 Aug., and 9 Aug. 2019.

On 23 August 2018 and 8 August 2019, coinciding with commercial harvest for each year, 26 grape clusters per sub plot were evaluated for sour rot and Botrytis incidence and severity at each site. Additionally, on 26 August 2018 and 13 August 2019, single, intact clusters from each replicated treatment combination were harvested to determine incidence of SWD infestation. Collected clusters were placed in a plastic seal-top plastic bag and combined with a salt solution (1 tablespoon of salt and 1 cup of water) for 15 minutes before observing berries for emerged larvae. Sour rot and Botrytis infections were combined and analyzed using generalized mixed model to evaluate the fixed and interaction treatments effect as well as the random block effect. Tukey's HSD was used to determine mean separation between treatments.

Results and Discussion:
In 2018, the Chardonnay vines at the Cleveland site were damaged by a late frost, killing the majority of flower buds. Secondary flowers developed and thus fruit were produced on these vines, but the fruit development and maturation was approximately two weeks delayed compared to the Dahlonega site. This delay in ripening may have influenced SWD infestation and disease development. At harvest, no sour rot was observed and no drosophilid larvae emerged from collected clusters. Interestingly, there was an atypically high incidence of bitter rot within this vineyard that was not controlled by any combination of treatments.

At the Dahlonega site in 2018, overall incidence and severity of sour rot and Botrytis in the Chardonnay vineyard were low. When comparing the application of chemical treatments (no pesticides versus Oxidate + Pristine + insecticide), significantly fewer grape clusters treated with pesticides were infected with sour rot and Botrytis (Table 1). Although not statistically significant, the disease severity was also numerically lower in the pesticide treated grape clusters (Table 2). Similarly, leaf removal decreased the incidence and severity of disease pressure, but it was not statistically significant (Table 1 and 2). For both the incidence and severity there was no significant interaction between the application of chemicals and the leaf pulling, but it does trend towards an interaction or is at least additive for decreasing sour rot and Botrytis in Chardonnay (Tables 1 and 2). Numerically, for both the incidence and severity, the combination of leaf pulling and chemicals provided the lowest disease pressure. Furthermore, from the 24 harvested grape clusters only a single drosophilid larvae emerged from a cluster collected from a vine in the pesticide plus leaf removal treatment.

We saw similar results in 2019 with the overall incidence and severity of sour rot and Botrytis in the Dahlonega Chardonnay vineyard were relatively low. Although not statistically significant ($P = 0.29$), when comparing the application of chemical treatments (no pesticides versus the Oxidate + Pristine + insecticide), fewer grape clusters treated with pesticides were infected with sour rot and Botrytis (Table 3). Similarly, while also not statistically significant ($P = 0.83$), the disease severity was also numerically lower in the pesticide treated grape clusters (Table 2). In regard to leaf removal, both incidence and severity of disease pressure were significantly reduced with leaf removal ($P = 0.001$ and $P < 0.001$, respectively; Tables 3 and 4). For both the incidence and severity there was no significant interaction between the application of chemicals and the leaf pulling ($P = 0.79$ and $P = 0.94$, respectively), but it does trend towards an interaction or is at least additive for decreasing sour rot and Botrytis in Chardonnay (Tables 3 and 4). In terms of fruit infestation, very few larvae were recovered from the grape clusters, but similar results were observed compared to the disease incidence and severity. There was a trend with decreased cluster infestation with the combination of the two treatments, there was no statistically significant effect from pesticides, leaf removal, or an interaction between the two ($P = 0.22$, $P = 0.22$, and $P = 0.53$, respectively; Table 5). Numerically, for both the incidence and severity, the combination of leaf pulling and chemicals provided the lowest disease pressure and SWD infestation.

Although the results were largely not statistically significant and somewhat inconclusive over the two year period of this project, this has been the first step in developing guidelines for insecticidal and microbial spray management in conjunction with fruit-zone vine management with leaf removal to effectively control pest(s) associated with sour rot infection. In 2018 we established that pesticide treatments were more important for rot management and in 2019 leaf-pulling had a greater effect, but in both demonstrated that insecticidal and microbial spray management in conjunction with fruit-zone leaf removal has potential to effectively manage sour rot and Botrytis development in Chardonnay. More work is needed to establish the best management practice(s) for sour rot and Botrytis in Southeastern grape production.

References cited:

Barata, A., Santos, S.C., Malfeito-Ferreira, M., and Loureiro, V.. 2012. New Insights into the Ecological Interaction Between Grape Berry Microorganisms and Drosophila Flies During the Development of Sour Rot. Microbial Ecology. 64:416-430.

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Table 1. Combined Botrytis and sour rot incidence in 2018 (% infected clusters).[z,y,x]

Leaf removal status	No pesticide treatments	Oxidate 1:100 + Pristine 12.5 oz + sequential insecticide treatments	Average
None	24.4	16.3	20.4
Leaf removal	20.5	8.3	14.4
Average	22.4 *a*	12.4 *b*	

[z]Each value is the mean of six replications.
[y]Means followed by the same letter are not significantly different ($P = 0.05$).
[x]No significant interactions were observed ($P = 0.6$).

Table 2. Combined Botrytis and sour rot severity in 2018 (% of cluster area infected). [z,y]

Leaf removal status	No pesticide treatments	Oxidate 1:100 + Pristine 12.5 oz + sequential insecticide treatments	Average
None	1.8	0.8	1.3
Leaf removal	0.8	0.1	0.5
Average	1.3	0.5	

[z]Each value is the mean of six replications.
[y]Means followed by the same letter are not significantly different ($P = 0.05$).

Table 3. Combined Botrytis and sour rot incidence in 2019 (% infected clusters).[z,y]

Leaf removal status	No pesticide treatments	Oxidate 1:100 + Pristine 12.5 oz + sequential insecticide treatments	Average
None	31.4	25.0	28.2 *a*
Leaf removal	12.2	8.3	10.2 *b*
Average	21.8 *a*	16.7 *a*	

[z]Each value is the mean of six replications.
[y]Means followed by the same letter are not significantly different ($P = 0.05$).

Table 4. Combined Botrytis and sour rot severity in 2019 (% of cluster area infected). [z,y]

Leaf removal status	No pesticide treatments	Oxidate 1:100 + Pristine 12.5 oz + sequential insecticide treatments	Average
None	8.6	8.1	8.3 *a*
Leaf removal	0.8	0.5	0.6 *b*
Average	4.6 *a*	4.3 *a*	

[z]Each value is the mean of six replications.
[y]Means followed by the same letter are not significantly different ($P = 0.05$).

Table 5. Spotted wing drosophila infestation of intact grapes in 2019 (average abundance per cluser).[z,]

Leaf removal status	No pesticide treatments	Oxidate 1:100 + Pristine 12.5 oz + sequential insecticide treatments	Average
None	0.83	0.33	0.58
Leaf removal	0.33	0.17	0.25
Average	0.58	0.25	

[z]Each value is the mean of six replications.