Control of grapevine powdery mildew using milk, oils and other natural materials

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Introduction

Powdery mildew, caused by the fungus *Erysiphe necator* (formerly *Uncinula necator* or *Oidium*), is the most economically important disease of grapevine in Australia. The disease is generally controlled by spray programs involving sulfur and synthetic fungicides in conventional vineyards, and by sulfur and vegetable oils in organic vineyards. However, sulfur can be toxic to agricultural workers and beneficial vineyard organisms, including natural antagonists of *E. necator*. In previous research on alternatives to sulfur for the control of powdery mildew, we identified milk, whey, potassium bicarbonate (Ecocarb®) and canola-based oils (Synertrol Horti-Oil®) as having potential to reduce disease severity (Crisp *et al.* 2006). Although there was no evidence of negative effects on grape quality in terms of total soluble solids, pH or titratable acidity (TA), the effects of these treatments on wine quality had not been examined. Here we report subsequent experiments to examine the efficacy of spray programs involving milk, whey and vegetable oils in a commercial organic vineyard in Langhorne Creek, South Australia, and a conventionally managed vineyard at the Waite Campus at Urrbrae, SA. The effects of selected treatments on juice and wine quality are also reported.

A new project initiated in 2009, with funding from the Australian Research Council, provides the opportunity to investigate the effects of milk on powdery mildew. The principal constituents of bovine milk are water (88.3%), lactose (4.6%), fat (3.2%) and proteins (3.2%). Milk also contains biologically active ▶

The treatments evaluated in the trial were:

Treatment	Manufacturer	Concentration	2003/04[a]	2004/05[a]	2005/06[a]	2009/10[a]	2009/10[b]
Ecocarb®	Organic crop protectants	4-6g/L	x				
Synertrol Horti-Oil® + Ecocarb®	Organic crop protectants	3mL/L-5g/L		x	x		
Whey	Murray Goulburn	25-40g/L	x	x	x		
Program 1[c]			x	x	x		
Full cream milk	Murray Goulburn	1:10-1:5	x	x	x	x	x
Skim milk	Murray Goulburn	1:10				x	
Protector[hml] wetting agent	Henry Manufacturing Ltd	0.5%				x	x
Milk + wetting agent		1:10-0.5%				x	x
Untreated			x	x	x	x	x
Sulfur	Garden King	4-6g/L	x	x	x	x	

[a]Langhorne Creek. [b]Urrbrae. [c]Mixed program of Ecocarb® (5g/L) plus Synertrol Horti-Oil® (3mL/L) in rotation with whey (25g/L).

the growing season. Severity on leaves and bunches was assessed as area affected by powdery mildew using standard area diagrams (Emmett and Wicks, pers. com. 2009). At least 10 leaves and 20 bunches were selected randomly from each replicate for assessment. Acceptable control is defined here as <5% of the bunch affected with powdery mildew.

At harvest, yield was assessed for each treatment, except in 2005/06 when yield from Shiraz was not assessed. Bunches with <5% of the surface area affected with powdery mildew were selected for quality assessment. Juice was hand-squeezed from approximately 250 grams of fruit per plot for assessment of pH, TA and °Brix, as described by Iland *et al.* (2000). In 2004/05 and 2005/06, 90 kilograms of disease-free or acceptable fruit (<5% of the bunch affected by powdery mildew) was harvested and processed as three 30kg batches. Fermentation and bottling were performed by the University of Adelaide in 2004/05 and by Provisor Pty Ltd in 2005/06. Juice from Verdelho and must from Shiraz were fermented to dryness, stabilised and bottled for at least three months prior to sensory evaluation. Juice and wine samples were assessed for differences using duo-trio tests (Amerine *et al.* 1965). Verdelho juice was also assessed by a five-person tasting panel.

Data for disease assessment, pH, TA and °Brix were subjected to analysis of variance (ANOVA) to test the hypothesis that there would be no significant difference in mean disease score or quality parameters among test materials and the control treatments. All statistical analyses were performed using GENSTAT (Lawes Agricultural Trust).

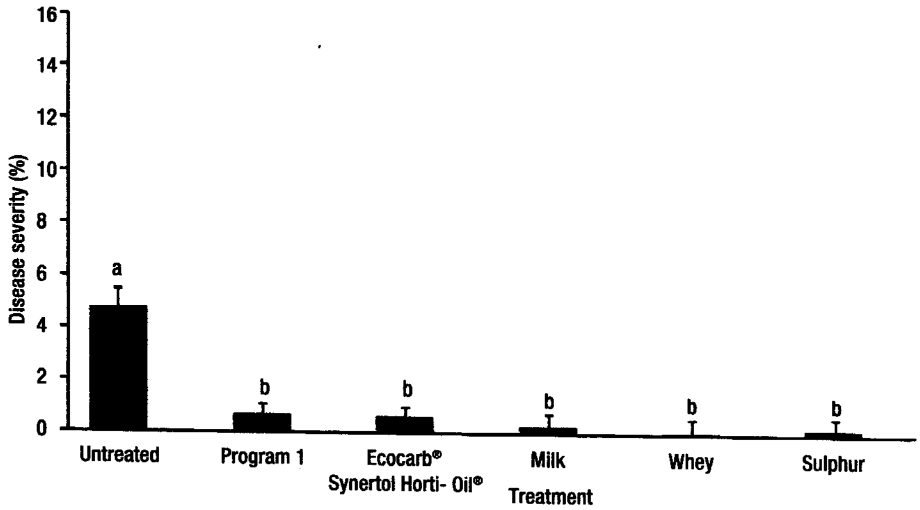

Figure 2. Disease severity (% bunch with powdery mildew) on Verdelho bunches at Langhorne Creek in 2006 for various treatments. Six replicates of eight vines per plot. Least Significance Difference (LSD) was used to assess differences between means. Different letters indicate significant differences (P<0.05).

Results and discussion

In 2003, approximately 30 flag shoots per row were identified in the Verdelho vines and immediately removed. Flag shoots were not identified in any of the following seasons. No disease was detected on Shiraz vines during the three trial seasons. In 2003/04 all treatments applied to Verdelho vines significantly reduced the severity of powdery mildew on leaves and bunches (Figure 1) compared with untreated vines. At harvest, 100% of the bunch surface area of untreated controls was covered with powdery mildew. The severity of powdery mildew on milk and whey-treated vines (both 3%) and Ecocarb® (7%) was not significantly different from that of sulfur-treated vines (2%). Based on 5% disease severity as cut-off for winemaking, disease was not acceptable on vines treated with program 1 (13%) or Ecocarb® (7%).

In 2004/05, powdery mildew was not visible on vines at Langhorne Creek. Microscopic examination revealed small colonies of powdery mildew on approximately 5% of rachi and aborted berries from all treatments. Only trace amounts of powdery mildew were detected in 2005/06 (Figure 2). At harvest the severity of powdery mildew on leaves and bunches of all treatments was significantly less than on untreated controls (4.7%). Disease severity on bunches from vines sprayed with program 1 (0.7%), Ecocarb® plus Synertol Horti-Oil® mixture (0.6%), milk (0.3%), whey (0.1%) and sulfur (0.2%) did not differ significantly among treatments. Fruit from all treatments was deemed acceptable (<5% powdery mildew) for winemaking.

Powdery mildew was not detected at Langhorne Creek in 2009/10 and was first detected on leaves of untreated Chardonnay vines in mid-November at Urrbrae. Milk (with or without wetting agent) consistently reduced mean disease severity on leaves and berries (Figure 3) compared with the untreated control. At harvest, the severity of powdery mildew on bunches of milk-treated vines (1.5%) was significantly less than that on vines treated with wetting agent (5.4%) or left untreated (7.3%). The severity of powdery mildew on vines treated with milk plus wetting agent (1.6%) was not significantly different from vines sprayed with milk alone, and the fruit was deemed acceptable (<5% powdery mildew) for winemaking, whereas

...ponents to protect the suckling young ... infection. However, the antimicrobial ...ity of milk components against plant ...ogens is poorly understood. This research, ... conducted by Dr Dale Godfrey, will ...mine the mechanisms by which selected ... components affect the fungus.

Materials and methods

Vineyard trials were conducted at Temple ... Wines at Langhorne Creek, SA, from ...03 to 2006 and in season 2009/10, using ... Shiraz and Verdelho. In 2009/10, an ...ditional trial was conducted at the Waite ...mpus at Urrbrae, SA, using cv. Chardonnay. ... randomised block design was used for all ...ls and there were buffer rows between the ...perimental rows and the remainder of the ...eyard.

The experimental area, including buffer ...s, was examined for flag shoots during ...ptember and October of each year. Flag ...oots were recorded and immediately removed ... avoid confounding results. Treatments were ...st applied when shoots were approximately ... centimetres long. Treatments were applied ...ing a Solo 475 backpack spray with a hand-...ld wand in 2003/04 and 2009/10, and in ...04/05 and 2005/06 a Silvan® Selecta 50-litre ...draulic spray with a hand-held wand was ...sed. Spray treatments were applied to both sides of each row. Spray drift was monitored using water sensitive paper and deemed to be below levels that could confound results. Depending on the incidence of disease, a total of five to eight treatments per season was applied in 2003-2006, ranging from 300L per hectare early in the season to 900L/ha as the canopy developed. Treatments were applied on a 10-14 day basis, adjusted according to the suitability of weather conditions for spraying and the severity of powdery mildew.. In 2009/10, treatments were applied on a 7-18 day basis irrespective of disease, for the purpose of quality assessment, with a total of 10 and 16 sprays at Langhorne Creek (500-1750L/ha) and Urrbrae (1000-2000L/ha), respectively. In early December 2003, untreated Verdelho vines were severely affected by powdery mildew and were subsequently sprayed with sulfur to reduce the risk of inoculum dispersal throughout the vineyard.

Disease incidence was monitored throughout ▶

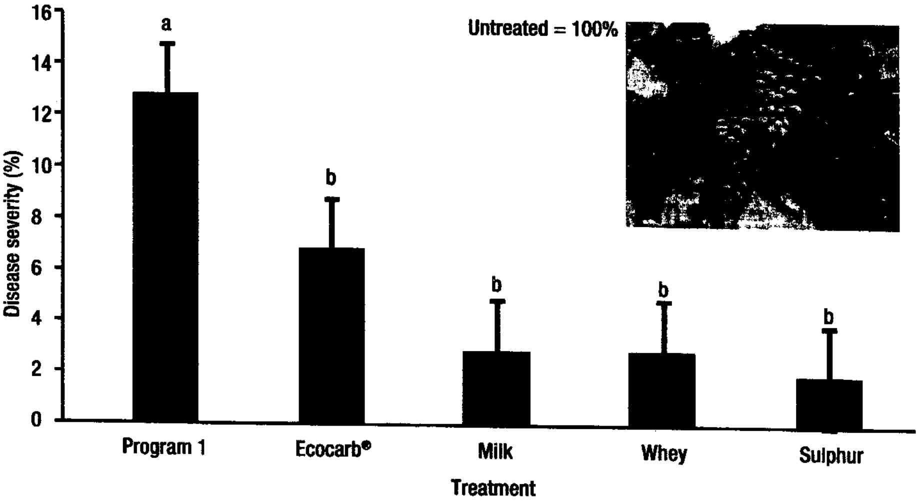

Figure. 1. Disease severity (% bunch with powdery mildew) on Verdelho bunches at Langhorne Creek in 2004 for various treatments. Six replicates of eight vines per plot. Least Significance Difference (LSD) was used to assess differences between means. Different letters indicate significant differences ($P<0.05$).

...d from untreated vines or those sprayed with wetting agent alone was not.

There were no significant differences in yield from any of the treatments, irrespective of the presence or absence of powdery mildew. Similarly, no significant differences in pH, TA or °Brix were detected in juice or wine from Verdelho or Shiraz grapes harvested from any of the treatments tested.

In duo-trio tests, there were no consistent differences between juice and wines from Verdelho and Shiraz vines treated with sulfur and those that received other treatments. However, flavour differences between Verdelho juice from vines treated with sulfur and those sprayed with whey (2003/04) or Ecocarb®/Synertol Horti-Oil® mixture (2004/05) were detected. When samples were subjected to evaluation by an expert tasting panel, differences were considered to have resulted from grape flavour character (2003/04) and pressing variation (2004/05), and not from treatments applied in the field. The same panel considered that all juices were suitable for winemaking and that the treatments were unlikely to affect wine quality.

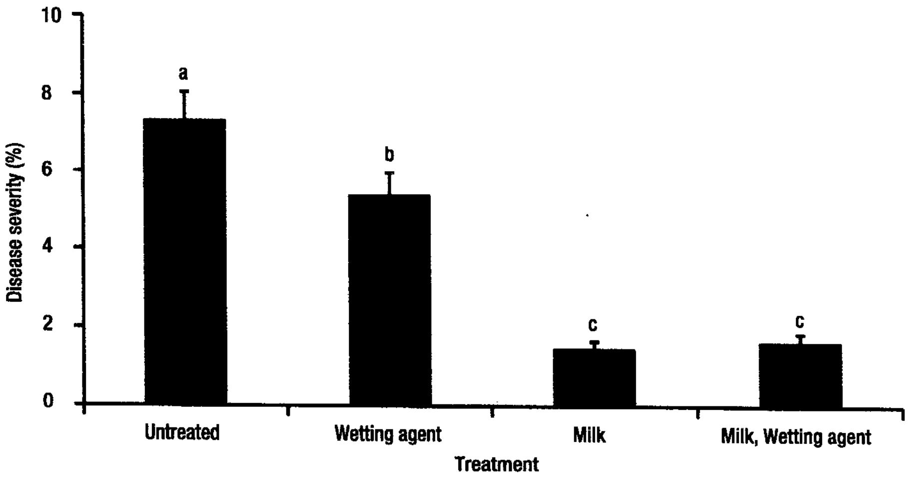

Figure 3. Disease severity (% bunch with powdery mildew) on Chardonnay bunches at Waite Campus in 2010 for various treatments. Four replicates of three vines per plot. Least Significance Difference (LSD) was used to assess differences between means. Different letters indicate significant differences (P<0.05).

Conclusions

The results from Verdelho vines at Langhorne Creek in 2003-05 and Chardonnay vines at Urrbrae in 2009/10 support findings of previous vineyard experiments (Crisp *et al.* 2006), in that the regular application of milk and whey controlled powdery mildew to acceptable levels. The addition of a wetting agent to the milk treatment did not influence efficacy in the 2009/10 trial at Urrbrae. The test materials had no obvious effect on yield, pH, TA or °Brix, irrespective of the presence or absence of powdery mildew in the trial sites. While there were some differences in the taste of juices, it is likely that they resulted from differences in ripeness of fruit or pressing characters; this will be investigated further in 2009/10.

It remains unclear why there was little or no disease at Langhorne Creek in 2004/05, 2005/06 and 2009/10. Low-level powdery mildew was detected in other parts of the vineyard, suggesting that weather conditions were conducive to the disease.

The current research initiated in 2009 aims to identify the components of milk responsible for antifungal activity against powdery mildew, and to determine their mode of action. Detached leaf experiments are now in progress to assess milk and various components of milk for efficacy in controlling powdery mildew using *in vitro* assays. Materials shown to reduce the severity of powdery mildew *in vitro* will be evaluated further in greenhouse and small plot vineyard trials to assess efficacy in a commercial environment. Ultimately, the objective of this work is to contribute to development of environmentally sustainable strategies for the management of powdery mildew.

Acknowledgements

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Australian Shiraz Disease in our backyard

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In South Australia, grapevines normally become dormant in July. However, if one looks at the vineyard just north of the Australian Centre for Plant Functional Genomics (ACPFG) building on Hartley Grove at the Waite Campus at Urrbrae, a couple of vines with bright red leaves are seen which have not yet gone dormant. These are not glory vines, rather the symptoms of virus infection.

We have named it Australian Shiraz Disease (ASD). ASD affects not only Shiraz but also Merlot, Sumoll and a few other varieties. In affected vines, shoots remain green and leaves are retained until the end of winter. Cabernet Sauvignon is resistant to it. Affected vines should not be used for top working, and must be removed. Mealybugs may transmit the disease. The only other country which has reported Shiraz Disease is South Africa. In both Australia and South Africa, the disease is associated with *Grapevine virus A, a Vitivirus*. The disease has been confirmed by Stellenbosch University's Dr Hans Moree, who visited the Waite Diagnostics group on July 7. ■

If you observe similar symptoms in your vineyard, please email nuredin.habili@adelaide.edu.au