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Understorey management increases grape quality, yield and resistance to *Botrytis cinerea*

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Abstract

A bare ground control was compared with four mulch types (anaerobically and aerobically fermented marc (grape pressings), inter-row grass clippings and shredded office paper) which were applied in winter under 10-year-old Riesling vines in a 10-replicate randomized block design in New Zealand, over 2 consecutive years. Functional soil biological activity, as measured by Biolog Ecoplates and bait lamina probes, was increased 2–4 times in the two marc and paper treatments, compared with the control, an effect relating to the elevated soil moisture and reduced temperature fluctuations under these mulches. Nutrient levels and the C:N ratio were also affected in these treatments. The mulched paper lowered vine canopy density by up to 1.4 times that of the other treatments, an effect which probably led to elevated light penetration into the canopy and consequently increased canopy temperature and photosynthesis and lowered canopy humidity. These changes to soil and vine characteristics increased grape skin strength by up to 10% in the paper treatment and sugar concentrations by 1.2–1.4 °Brix in the two marc and paper treatments. The severity of *Botrytis cinerea* infections in the anaerobic marc, aerobic marc and paper treatments were reduced to 12, 3 and 2.2% of the control, respectively, in field assessments averaged over two consecutive harvests.

Keywords: *Botrytis cinerea*; Vine resistance; Mulch; Soil biological activity; Yield; Grape quality

1. Introduction

Botrytis cinerea (Pers.: Fr), a saprophytic fungus causes botrytis bunch rot in grapes, or grey mould in a variety of crops world wide (Mullins et al., 1992). In grapes, even slight infection results in wines with tainted flavours and a higher sensitivity to oxidation that are not suitable for cellaring. The disease favours temperate, moist environments and in the absence of control can cause total crop loss if these conditions are prolonged (Nicholas et al., 1994). The disease is currently managed in conventional viticulture through a combination of timed cultural and chemical practices, including rootstock selection (Pearson and Goheen, 1988), appropriate trellis system (Savage and Sall, 1984), canopy manipulation (English et al., 1993), vineyard sanitation (Nair et al., 1995) and fungicide applications (Pearson and Goheen, 1988). Fungicide applications are generally made during high risk periods associated with vine growth stages and weather conditions, but also according to *B. cinerea* presence, the threshold of which depends on the grapevine variety and climate. The use of fungicides is now on the decline due to the increasing problem of fungicide resistance in *B. cinerea* (Leroux, 2004) and more importantly, global market pressure to produce a product more sustainably (Spadoro and Gullino, 2005). The aim of the present work was to investigate the effects of organic mulches on grape vine resistance to *B. cinerea* and assess if they have an impact on botrytis bunch rot in grapes at harvest over 2 consecutive years.

2. Materials and methods

Field work was conducted at Seresin Estate Ltd., a vineyard near Blenheim, New Zealand (41.31°S, 173.48°E;

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62 m a.s.l.). The site was on a clay soil, situated over free-draining river gravels, with temperatures normally ranging from −5 to 16 °C (8 °C daytime average) in winter and from 5 to 30 °C (20 °C daytime average) in summer. The vineyard received approximately 2500 sunlight hours per year, between 650 and 700 mm rain annually and was certified as organic (www.bio-gro.co.nz/). The research site was in a block of 10-year-old Riesling vines (Clone TK05209) grafted to a phylloxera-resistant rootstock (variety 3309). Vines were grown on a vertical shoot position (VSP) trellis system, were drip irrigated, pruned to two canes, and open, narrow, canopies were maintained by the common leaf plucking and leaf trimming practices of the area. Botrytis bunch rot and powdery mildew (*Uncinula necator* (Schw.) Burr.) occasionally caused some crop losses in the vineyard and were managed through applications of fish oil (1%) and sulphur (80% a.i.) sprays. Sulphur was applied two times in the 2003 season at a rate of 2.4 kg a.i. ha^{-1}, six times in the 2004 season at a rate of 2.4–3.2 kg a.i. ha^{-1} and six times in the 2005 season at a rate of 2.4–4.8 kg a.i. ha^{-1}. The trial was conducted over 3 consecutive years from July 2003 to April 2006. The mulches were applied and replenished annually (24 July 2003, 25 June 2004 and 21 June 2005) to a total thickness of 100 mm.

Five mulch treatments were arranged in a 10-block, randomized-block design. The treatments were: a bare ground control, aerobically composted grape marc, anaerobically fermented grape marc, mulched inter-row grass and shredded office paper. Treatment plots were 0.4 m × 2 m around a single vine, an area based on the 1 m radius rooting zone common in grapes under drip irrigation systems (Bassoi et al., 2003). The mulch properties (bulk densities and nutrient analyses) were previously reported (Jacometti et al., 2007). The 10 blocks were each 12.8 m long, spanning two rows of vines. Treatments were separated by one bay of vines (3.4 m) and were randomly distributed in each block. Both the marc and the grass treatments were sourced on-site, and the shredded office paper was sourced from a local company.

2.1. Soil characteristics

Soil biological activity was assessed monthly with bait lamina probes and Biolog Ecoplates, as was soil moisture by weight from February 2005 to January 2006. Soil temperature was measured continuously from 19 November 2005 to 21 March 2006 where soil nutrients were assessed in May 2005 and carbon:nitrogen (C:N) ratios in November 2005. Bait lamina probes and soil moisture was assessed in all blocks where Biolog Ecoplates, soil temperature, soil nutrients and C:N ratio assessments were all conducted in blocks 3, 4 and 8, which were randomly selected at the start of the trial.

Biolog Ecoplates were used to indirectly measure the microbial diversity and activity of soil microbial communities (Gagliardi et al., 2001). The plates had 96 wells, with three replicates each of 31 carbon sources commonly used by soil microbial organisms and three control wells of water only. In each well there was a reducible tetrazolium dye that changed from colourless to red when the carbon source was utilised by oxidative metabolic processes. At monthly intervals, five 50 g soil samples were taken from the soil/mulch interface from each treatment in three randomly selected blocks. These five samples were combined, shaken by hand for 15 s and then sieved (5 mm mesh). A 2.5 g sample was taken from each of these, shaken for 30 min on a rotary shaker in a 22.5 ml 0.85% sterile NaCl solution, then settled for 10 min to clear the supernatant. The supernatant was then decanted and pressure-filtered through 'Whatman No. 40' filter paper. The resulting filtrate was diluted by 10^3 and a 140 μl aliquot of the resulting suspension was put in each well of the Ecoplate, which was incubated together at 20–25 °C for 2 weeks. Measurements of the dye reduction were made with a micro-plate reader (FluroStar, BMG Labtechnologies, Germany) using a 590 nm filter (BMG 241A Abs), on day 0 and day 1, then 12 hourly from day 2 to day 4, then 24 hourly from day 5 to day 8, with the last measurement on day 14. The mean percentage of wells that gave an absorbance reading of over 0.8, a colour change easily seen by eye, was then recorded. The largest differences between treatments in both rate of change and proportion of wells coloured, was seen between day 1 and day 4, so only these data were used for analysis in the current work.

Bait lamina probes are strips of rigid plastic, 6 mm × 160 mm, with sixteen 2-mm holes drilled into the lower 100 mm of the strip. The holes were filled with 'bait' comprising cellulose, agar, bentonite and bran, constituents that resemble dead plant material. The number of holes that are intact or removed, partially or completely, gives a measure of the activity of soil organisms (Kratz, 1998) at various depths in the soil profile. Three to four weeks before each soil assessment date, one probe was placed in each replicate, inserted so the tip was 40 mm below the soil/mulch interface. The probes were then removed and visually assessed at the same monthly assessment dates as the Biolog Ecoplates. All partial removals were given a score of 0.5. Due to the variability of the data, the data from each month was averaged by season and the upper and lower halves of the bait holes were averaged into shallow and deep soil. These means were then analysed.

Soil moisture was measured by taking five 50 g samples from the soil/mulch interface in each replicate and pooled for each replicate, weighed, dried for 14 days at 70 °C, reweighed and the initial percent moisture calculated.

Mean soil temperature and maximum/minimum temperatures were measured 30 mm below the soil mulch interface from each treatment in three randomly selected blocks, at 6-min intervals using data loggers (Hobo H08-004-02, 4 channel external; −20 °C to 70 °C, 0–95% RH; Onset Computer Corporation, USA), running TMC—HD water/soil temperature probes, accuracy ±0.5 °C, the data from which were retrieved monthly.