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Effect of Y-trellis and vertical shoot positioning training systems on downy mildew and botrytis bunch rot of grape in highlands of southern Brazil

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ABSTRACT

Downy mildew (*Plasmopara viticola*) and botrytis bunch rot (*Botrytis cinerea*) are important diseases in the highlands of Santa Catarina State, a relatively new wine-growing region in Brazil. Although it is known that training systems can affect microclimate and subsequent disease development, this has not been examined in the highlands of Brazil. Thus, the purpose of this study was to evaluate the influence of Y-trellis (YT) and vertical shoot positioning (VSP) training system on downy mildew and botrytis bunch rot disease development in 'Cabernet Sauvignon' cultivar. Experiments were carried out in commercial vineyards in São Joaquim, SC Municipality, southern Brazil, during the year 2012–2013 and 2013–2014 growing seasons. Downy mildew incidence and severity were quantified weekly from the first symptoms appearance on leaves and botrytis bunch rot incidence was evaluated at harvest. Disease progress curves were constructed compared according to: (a) beginning of symptoms appearance; (b) time to maximum disease incidence and severity; (c) maximum disease incidence and severity; and (d) area under the incidence and severity disease progress curve. Results showed significant differences in downy mildew and botrytis bunch rot intensity among grape training systems, where VSP training system showed significantly lower area under the incidence and severity disease progress curve and intensity of downy mildew and botrytis bunch rot in both 2012–2013 and 2013–2014 growing seasons. Collectively, the results of this study suggest VSP training system should be recommended for grapevine production to reduce both downy mildew and botrytis bunch rot in the highlands regions of southern Brazil.

1. Introduction

In the last decade, the highlands of southern Brazil have been a rapidly growing region for wine grape (*Vitis vinifera* L.) production, where local consumer demands and favorable growing conditions make this location ideal. In particular, production sites at altitudes up to 1400 m above sea level allow grapevines to complete a long ripening cycle, which improves ripening and develops better quality wines, especially from *V. vinifera* varieties (Protas et al., 2006). These same climatic conditions are also favorable to many fungal pathogens that can significantly reduce both yield and fruit quality.

Downy mildew [*Plasmopara viticola* (Berk. and Curt) Berl. and de Toni] and botrytis bunch rot (*Botrytis cinerea* Pers.: Fr.) are the main problems affecting grape production in southern Brazil (Chavarria et al., 2007). Downy mildew occurs worldwide and in all wine-producing regions of Brazil and in southern Brazil, is considered to be the most devastating grape pathogen. Depending on the year, production of grapes in southern Brazil has been estimated to be at a loss of 100% when warm, moist, and humid environment occurs (Garrido et al., 2004; Naves, 2006). Similarly, botrytis bunch rot is a common problem wherever grapes are grown, especially for varieties and cultivars with compact clusters. Unlike downy mildew, botrytis bunch rot primarily affects developing grape clusters, which can cause serious losses in both yield and fruit quality when weather conditions favor the disease. Infection is optimal at 15–20 °C when free water is available or when humidity is greater

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than 90%, which can result in yield loss up to 70% when it coincides with veraison (Chavarria et al., 2007). Grape cultivars with dense canopies, thin skins, and/or tight clusters are more susceptible to botrytis bunch rot (Pezet et al., 2003; Ky et al., 2012; Mundy et al., 2012). Both downy mildew and botrytis bunch rot occurrence are closely related with environmental conditions like humidity, temperature and light.

Disease control is generally achieved by use of triazoles, phenylamide, strobilurin fungicides, but is not always possible or effective due to the phenological stage of the plant, pre-harvest spray interval restrictions, and/or environmental conditions. Chemical alternatives, such as shoot thinning and leaf removal before fruit set have been shown to reduce botrytis bunch rot (Sanzani et al., 2012) and pruning has been shown to minimize leaf wetness and reduce downy mildew (Alonso-Villaverde, 2011; Yu et al., 2012). An additional benefit to these cultural practices is that basal leaf removal, shoot positioning and trellising have been shown to improve fruit composition by altering canopy microclimate (Zahavi et al., 2001).

Over the past two decades, advancements in vineyard design, training systems, and canopy management practices have dramatically improved wine grape productivity and fruit quality in southern Brazil. Prior to this period, a standard 'Tendone'/trellised vineyard system was used throughout the region. Little attention was paid to site-specific factors influencing vine vigor, such as climate, growing region, soil type, and rootstock. Now significant effort is made to match vineyard design and trellis system to the site-specific factors that influence potential vine growth. As a result, a wide range of plant densities and training/trellis systems are routinely employed in southern Brazil

Vertical Shoot Position (VSP) and Y-trellis (YT) are the most common training systems used in southern Brazil because of simplicity, effectiveness and ability to reduce labor required for canopy management. In the VSP system, vine shoots are trained upward in a vertical, narrow curtain with the fruiting zone below. A VSP trellis system can consist of four to six levels of wire. For vines with small vine size, the VSP trellis is ideal. VSP can ease the work of many cultural practices such as leaf removal, shoot removal, and cluster thinning, while also providing for more efficient spray coverage. It is particularly suited to the natural upward growth of *V. vinifera* vines. VSP also has the advantage of being compatible with vineyard mechanization. The Y-Trellis (YT) or lyre vine training system uses wide rows, an open canopy, and shoot positioning to increase grape maturity and quality while maintaining production levels. "Y" trellis systems usually support arms extended 1.8–2.6 m apart, and the overhead gable systems (Peacock, 1993).

Intensity of disease epidemics depends on initial inoculum pressure and climatic conditions. It is also influenced by canopy architecture and of host receptivity to infection over time, therefore raising three primary questions: (i) can architecture modify inoculum interception, (ii) how does architecture drive the occurrence of microclimatic conditions favorable to disease development, and (iii) can architecture change the dynamics of tissue receptivity? (Tivoli et al., 2013). Leaf density measured through the leaf area index (LAI) had an effect on the physiological barrier increasing with canopy LAI. Similar effects were observed for *Colletotrichum acutatum* on strawberry (Yang et al., 1990; Madden et al., 1993), suggesting that the physiological barrier effect is a major plant architectural phenomenon that influences a wide range of pathosystems. In apple trees, Tivoli et al. (2013) suggested that some trimming systems led to a higher aeration and therefore shorter periods of wetness, hence less apple scab infection (*Venturia inaequalis*). Generally, it can be concluded that plant canopy architecture unfavorable to an aerial epidemic may result in the total avoidance of disease, but more frequently reduces disease severity rather than preventing infection completely. Thus, Bregaglio et al. (2011) suggested that in addition to genetic resistance, the use

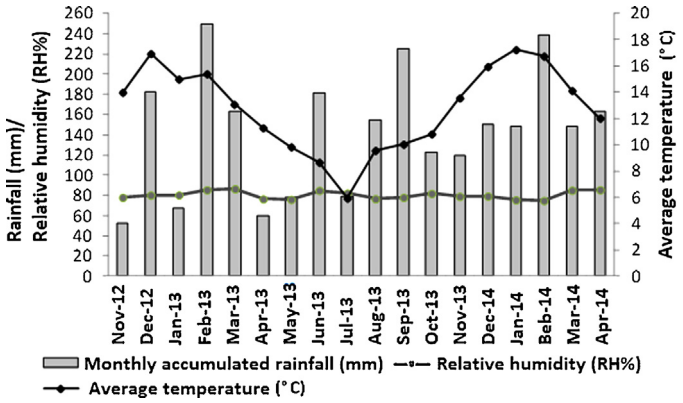

Fig. 1. Average monthly accumulated rainfall (mm), relative humidity (RH%) and average temperature (°C) at Sao Joaquim municipality, southern Brazil, across both the 2012/2013 and 2013/2014 growing seasons.

of a plant architecture that produces less favorable microenvironmental conditions for fungal infection could significantly reduce disease. In the case of grapevine canopy architecture, although it is known that vine trellising and training systems may have a direct impact on disease development, direct comparison of different canopy management systems on intensity of downy mildew and botrytis bunch rot has not yet been examined.

This study was undertaken to test the effects of two training systems Y-trellis (YT) and vertical shoot positioning (VSP) of Cabernet Sauvignon cultivar on the intensity of downy mildew and botrytis bunch rot in a vineyard in the highlands regions of Santa Catarina State, southern Brazil, during the year 2012–2013 and 2013–2014 growing seasons.

2. Materials and methods

Experiments were carried out in two nearby commercial vineyards located in São Joaquim municipalities, State of Santa Catarina (SC), southern Brazil, during the year 2012–2013 and 2013–2014 growing seasons. São Joaquim/SC municipality is located at (28°17′39″S and 49°55′56″W), at an altitude of 1430 m above sea level. The climate of the region is humid mesothermic according to Köppen classification and soil type is cambisol, which is characterized as having high clay (492 g kg^{-1}) and organic matter (71 g kg^{-1}). In this region, high precipitation occurs from October to March, during which, rainfall averages approximately 138 mm per month. Daily rainfall, relative humidity, and hourly temperatures were recorded at the Santa Catarina Hydrology and Environmental Resources Center–Epagri (Fig. 1). The soil is a Cambisol with high values of clay (521 g kg^{-1}) and organic matter (83 g kg^{-1}).Vineyards consisted of approximately 1500 vines (30 rows of approximately 50 vines) of 10-year-old *V. vinifera* cv. 'Cabernet Sauvignon' cultivar grafted onto rootstock 'Paulsen 1103' and either trained to a Y-trellis (YT) or vertical shoot positioning (VSP) at distances of 3.0 m × 1.2 m. In both training systems, vines were pruned to one directional horizontal cordon at 1.0 m height. This cultivar is susceptible to downy mildew, and disease was present in vineyards in previous years. Low rates of Cimoxanyl and Metalaxyl combined with others fungicides were applied to maintain low levels of downy mildew and others foliar diseases, yet still allow sufficient disease to evaluate training systems. Vineyards were irrigated and maintained as recommended to commercial growers in this region (Brasil, 2011). Irrigation was usually unnecessary because of adequate rainfall, where annual rainfall in this region was between 1.520 and 1.620 mm and regularly distributed throughout the year. Annual relative humidity averaged 80% and temperatures averaged 13.4 °C, with a temperature range of 9.4 °C–18.9 °C.