Use of advisory systems and plastic covering in the control of downy mildew on vines of São Paulo, Brazil

Ester Holcman[1], Paulo Cesar Sentelhas[2], Marcel Bellato Spósito[3] and Marco Antônio Fonseca Conceição[4]

[1]PhD, University of São Paulo, Av. Pádua Dias, n.11, CEP 13.418-900, Piracicaba/SP, Brazil. E-mail: esterholcman@yahoo.com.br
[2]Associate Professor, Department of Biosystems Engineering, University of São Paulo (ESALQ/USP), Av. Pádua Dias, n.11, CEP 13.418-900, Piracicaba/SP, Brazil. E-mail: pcsentel.esalq@usp.br. CNPq scholar
[3]Professor Dr., Department of Crop Science, University of São Paulo (ESALQ/USP), Av. Pádua Dias, n.11, CEP 13.418-900, Piracicaba/SP, Brazil. E-mail: mbsposito@usp.br.
[4]Dr., scientific researcher, EMBRAPA Tropical Viticulture and Grape Wine, Jales/SP, Brazil. E-mail: marco.conceicao@embrapa.br

Abstract. The Northwest region of the State of São Paulo is one of the main producers of table grapes in Brazil. However, the climate of this region is highly favorable for fungal diseases during the growing season. The use of disease advisory systems and plastic covers are promising alternatives for rationalize the use of fungicides for disease control. Thus, the objective of this study was to evaluate the efficacy of the combination of advisory systems and plastic covering in the control of downy mildew (*Plasmopara viticola*) on vineyards of the Northwest region of State of São Paulo, Brazil. The experiments were carried out at the EMBRAPA - Tropical Viticulture Experimental Station, located in Jales, SP, Brazil. Three rows of 120 m of the seedless grape cultivar 'BRS Morena' (*Vitis vinifera*), spaced with 3.0 m between plants were conducted during 2012 and 2013 growing seasons. Half of the vineyard was covered with braided polypropylene plastic film installed over a metallic arc-shaped structure and the other half with black screen, with 18% of shading. The experimental design was randomized blocks composed of five treatments, with six repetitions per covered environment. The treatments were defined by the different grapevine downy mildew management : (*CO*) Control (no sprays against downy mildew); (*CA*) Conventional control (calendar); (*BA*) Advisory system 'Rule 3-10'; (*MA25*) Advisory system with low-infection efficiency - $i_0 > 25\%$; and (*MA75*) Advisory system with high infection efficiency – $i_0 > 75\%$. According to the results, the plastic cover alone was not effective in controlling downy mildew. Under plastic cover, all advisory systems tested were as effective as the control provided by treatment calendar (*CA*), however, with 75% less fungicide application (*MA75*) than CA.

Introduction

The São Paulo State is the 3rd largest Brazilian producer of grapes, with 165 thousand tons, of which 99.2% are for the fresh fruit market. The São Paulo State northwestern region, responsible for 21% of production, has very favorable environmental conditions to fungal diseases occurring during the entire crop cycle, especially in the rainy season (November to March), increasing the risk of losses and rising production costs due to the intense phytosanitary control [17; 13]. In this region, the sprays are made preventively reaching the range of 101 to 150 sprays per production cycle [8]. This number of applications is mainly to control downy mildew [6].

The downy mildew (*Plasmopara viticola*), oomycete of Peronosporaceae family (Berk. & Curt) Berl. & Of Toni, [1], in vines cause irreversible necrosis and defoliation, which promotes the decrease of carbohydrates production and plant yield, affecting also the next cycles [9]. When the pathogen infects the vine during the flowering period, the yield losses may reach 100% [15]. The use of advisory systems and plastic covering are promising alternatives to minimize the occurrence of downy mildew in vineyards, however they are not yet adopted by Brazilian producers.

Advisory systems are decision support tools to assist farmers to determine the best time of plant diseases control [11], decreasing the frequency of spraying through the risk of epidemics monitoring in the field [14], limiting the chances of pathogens resistance to chemicals development [12] and reducing production costs and time spent with the unnecessary sprays [10]. The infection cycle of *P. viticola* has close relationship with meteorological variables [19; 9], and many simulation models have been proposed to describe this relationship [19], using meteorological variables as input data [11]. Advisory systems represent one of the main alternatives recommended currently for achieving a more sustainable and efficient production, bringing economic, environmental and social benefits. However, the vast majority of grape producers does not perform monitoring of diseases [8].

Another method that are bringing results in control of fungal diseases on grapevine is the use of plastic covering on the vineyards, which promotes specific micrometeorological changes resulting, in many cases, in reduction or inhibiting of epidemics development even with a significant amount of inoculum in the environment. [4] found that even with the zoospores presence (*P. viticola* primary inoculum), there were no infections in the vines covered. This phenomenon is largely attributed by the non-occurrence of free water on the vines tissues under the plastic covering [2]. Plastic cover also prevents the removal of fungicides used in vines by rainwater and reduces the incidence of ultraviolet radiation on the plants, which are responsible for the fungicides active principles degradation.

The incidence of grapevine downy mildew reduction under plastic covering promotes reduced need for fungicide application along the crop cycle. Therefore, the use of plastic covering combined with the application of advisory systems could be an alternative to rationalize the use of fungicides in vineyards, reducing the number of applications, the cost of production and damage to the field workers and improving the quality of the product for the consumers, by decreasing the fungicides residues in the grapes. Therefore, the aim of this study was to evaluate the effect of using different advisory systems for downy mildew control in grapevine cv 'BRS Morena' cultivated under plastic coverings in the northwestern region of São Paulo State, Brazil.

Material and Methods

The experiment was conducted at the EMBRAPA Grape and Wine - Tropical Viticulture Experimental Station in Jales, SP, Brazil (latitude of 20°16’08” S; longitude of 50°32’45” W and altitude of 478 m). According to the Köppen classification, the climate of the region is type Aw, tropical humid, with rainy summer and moderate to severe drought in the winter. The experimental are comprises three rows of 120 m of the seedless grape cultivar ‘BRS Morena’ (*Vitis vinifera* L.), spaced 3.0 m between plants and 2.5 m between lines. Half of the vineyard was covered with braided polypropylene plastic film installed over a metallic arc-shaped structure and the other half with black screen with 18% of shading. In each of the environments, the experimental design was randomized blocks composed of five treatments, with six repetitions.

The treatments were defined by the different grapevine downy mildew management: (*CO*) Control (no sprays against downy mildew, only three maintenance applications); (*CA*) Conventional management (calendar), corresponding to a weekly application in dry periods and three applications per week in the rainy periods; (*BA*) advisory system 'Rule 3-10' [3]: fungicide application when occurred simultaneously, air temperature less than 10 °C, branches with at least 10 cm in length and at least 10 mm of rain within 48 h; (*MA25*) advisory system with moderate-infection efficiency [15]: model based on air temperature (T) and leaf wetness duration (LWD) data, being the fungicide application advised when $i_0 > 25\%$ (i_0 is given by the ratio of the current infection efficiency (i) and the maximum infection efficiency (i_{max}); and (*MA75*) advisory system with high infection efficiency [15]: the fungicide application was advised when $i_0 > 75\%$. A single specific fungicide for the grapevine downy mildew control (Ridomil Gold MZ ®) was used. For the other pests and diseases the control was handled with pesticides normally used by the growers.

The incidence and severity of downy mildew on grapevines leaves, from anthesis to ripening, were performed weekly. For the evaluation of the downy mildew incidence (%) in vine branches, 24 branches were selected by treatment in each of the studied environments. The average incidence of the disease was obtained accounting for the number of leaves that showed symptoms in relation to the total number of leaves per branch. For the evaluation of downy mildew severity (%) in vine leaves, the same selected branches for the assessment of incidence were used, but with the aid of a diagrammatic scale. For the yield evaluation, all the plants fruits were harvested and the mass of grape per plant (kg plant^{-1}) was Determined. The results were submitted to analysis of variance, and averages compared by Duncan test at 5% of probability.

Results and Discussion

Under black shading screen, the advisory systems adopted (*BA*, *MA25* e *MA75*) reduced the downy mildew intensity in relation to control (*CO*), but were not efficient enough for the disease control (Table 1). Under the plastic screen, all treatments, with the exception of *CO*, were similar to each other in relation to the downy mildew incidence in symptomatic leaves of BRS 'Morena' branches. The advisory systems used (*BA*, *MA25* and *MA75*) showed similar levels of disease control in relation to the calendar system (*CA*) (Table 1).

Table 1. Incidence (I) and severity (S) of downy mildew on BRS Morena, number of sprays per cycle and grape yield (kg branch^{-1}) for each treatment: *CO* = Control; *CA* = Calendar; *BA* = 'Rule 3-10' [3]; *MA25* = moderate-infection efficiency [15] – i_0 of 25%; *MA75* = high infection efficiency [15] – i_0 of 75%; in both environments: vineyard under braided polypropylene plastic film and vineyard under black screen with 18% of shading, in Jales, SP, Brazil

	I (%)		S (%)		Nº pulv.	Prod. (kg branch^{-1})	
Braided polypropylene plastic film							
CO	31.88	a	1.18	a	3	1.87	b
CA	0.31	b	0.02	b	20	7.83	ab
BA	1.36	b	0.06	b	8	6.94	ab
MA25	0.46	b	0.01	b	7	7.11	ab
MA75	1.05	b	0.01	b	5	11.45	a
Black shading screen							
CO	67.31	a	11.38	a	3	-	
CA	22.03	c	0.24	b	19	-	
BA	45.41	b	2.61	b	7	-	
MA25	46.86	b	3.01	b	6	-	
MA75	42.52	b	1.79	b	5	-	

The plastic screen, even though it has avoided of the rain interception by the leaves, do not stop pathogen infection since symptoms were observed mainly in the control treatment (*CO*). The leaf wetness caused by guttation, dew, high relative humidity and air vapor pressure saturation, on rainy days or not, was enough to promote mildew infection.

Another important aspect related to the use of plastic covers is the fact that it acts as a physical barrier, preventing the fungicides to be removed from the leaves by the rainfall. Therefore, the residual effect of fungicide increases, improving the efficiency of the product, promoting better disease control in the vines [16]. On the other hand, black screen with 18% of shading allowed the passage of rain water, reaching the plants and removing part of the fungicide applied [18].

Under plastic screen, the best efficiency advisory system to control downy mildew in the leaves of grapevine 'BRS Morena' was the *MA75*. This advisory system reduced the number of fungicide applications and the level of disease control was similar to the conventional management based on calendar. Such results demonstrate the the great advantage os combining these two techniques in terms of production cost, grapes quality and also socio-environmental benefits, resulting in minor contamination of the environment and of the people involved in the productive process and consumption of grape. *MA75* advisory system reduced the number of applications in 75% in relation to the treatment based on the calendar system and was the only one that differed from the control treatment in relation to production per plant, with 11.45 kg (Table 1). Under shading screen, the vines did not produce fruits because the disease infected all the plants since of the flowering period.

Conclusion

The plastic covering alone was not effective to control downy mildew. Under plastic covering, all advisory systems tested were as effective as the control provided by the calendar treatment (*CA*), however, with 75% less fungicide application (*MA75*) than *CA*.

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