Classification of wine grape cultivars according to their susceptibility to Botrytis Cinerea : importance of fruit maturity

Carolina Pañitrur-de La Fuente, Héctor Valdés Gómez, Jean Roudet, César Acevedo-Opazo, Christian Gary, Marc Fermaud

CLASSIFICATION OF WINE GRAPE CULTIVARS ACCORDING TO THEIR SUSCEPTIBILITY TO *BOTRYTIS CINEREA*: IMPORTANCE OF FRUIT MATURITY

CLASIFICACIÓN DE CULTIVARES DE VID VINÍFERA DE ACUERDO A SU SUSCEPTIBILIDAD A BOTRYTIS CINEREA: IMPORTANCIA DE LA MADUREZ DE LA FRUTA

Carolina PAÑITRUR-DE LA FUENTE[1], Héctor VALDÉS-GÓMEZ[2], Jean ROUDET[3], César ACEVEDO-OPAZO[1], Christian GARY[4], Marc FERMAUD[3]

[1]*Universidad de Talca, Facultad de Ciencias Agrarias, Talca, Chile;*

[2]*Pontificia Universidad Católica de Chile, Departamento de Fruticultura y Enología, Santiago, Chile;*

[3]*INRA, UMR 1065 Santé et Agroécologie du VignoblE (SAVE) – ISVV, Centre INRA de Bordeaux, France.*

[4]*INRA, UMR SYSTEM, 2 place Pierre Viala, 34360 Montpellier cedex 2, France.*

Abstract

Botrytis cinerea causes one of the most serious diseases in grapevines namely Botrytis Bunch Rot (BBR). A classification of different grapevine cultivars (cvs.) according to their susceptibility to *B. cinerea* is an essential management indicator in Integrated Pest Management. Although such classifications are available, they are based mostly on professional experience rather than experimental results. The main aim of this study was to compare and classify the susceptibility of different wine-grape cvs to *B. cinerea* and its relation to fruit maturity within two contrasting climatic and cropping conditions. Between 2011 and 2015, three field trials were carried out in Chile and France, including 13 common cvs. Both, incidence and severity of the disease were evaluated at harvest and indices of susceptibility (SI) and maturity (FMat) were calculated on a per-site basis. The significant differences in disease incidence and severity observed among cvs. led to a similar susceptibility classification in both countries. Cabernet Sauvignon, Cabernet Franc, Grenache Noir and Petit Verdot were the most resistant cvs., whereas Gewürztraminer and Sauvignon Blanc were the most susceptible ones. Moreover, an exponential and positive relationship was established between SI and maturity. The cultivar classification according to the susceptibility to *B. cinerea* was similar in both countries, despite the contrasting climatic conditions and cropping practices. These findings might be of interest for choosing cultivars more resistant to *B. cinerea* in order to reduce the number of specific anti-Botrytis fungicide applications.

Keywords: Botrytis bunch rot, Grape maturity, sustainable management, Susceptibility Index.

Resumen

Botrytis cinerea provoca una de las enfermedades más importantes en vid vinífera, llamada Botrytis Bunch Rot (BBR). Contar con una clasificación de diferentes cultivares (cvs.) de vid de acuerdo a su susceptibilidad a *B. cinerea* es una información esencial en el manejo integrado de enfermedades. Aunque en literatura es posible encontrar ciertas clasificaciones, ellas están basadas en la experiencia profesional más que en resultados experimentales. El principal objetivo de este estudio fue comparar y clasificar la susceptibilidad de diferentes cvs. de vid vinífera a *B. cinerea* y su relación con la madurez de fruta bajo dos condiciones contrastantes de clima y manejo. Entre 2011 y 2015, tres ensayos de campo fueron llevados a cabo en Chile y Francia, incluyendo 13 cultivares en común. La incidencia y la severidad de la enfermedad fueron evaluadas a la cosecha, además de calcular un índice de susceptibilidad (SI) y otro de madurez (FMat) en cada sitio. Diferencias significativas en incidencia y severidad entre los cultivares, hicieron que la clasificación de susceptibilidad fuera similar en ambos países. Cabernet Sauvignon, Cabernet Franc, Grenache Noir y Petit Verdot fueron los cvs. más tolerantes, mientras que Gewürztraminer y Sauvignon Blanc fueron los más susceptibles. La

clasificación de los cultivares de acuerdo a su susceptibilidad a *B. cinerea* fue similar en ambos países, a pesar de las condiciones contrastantes de clima y cultivo. Estos resultados podrían ser de interés como un criterio importante en la elección de un cultivar, con el fin de disminuir el número de aplicaciones fungicidas específicas contra *B. cinerea*.

Palabras clave: Botrytis Bunch Rot, Madurez de uva, manejo sustentable, Índice de susceptibilidad.

Introduction

Botrytis cinerea is a polyphagous fungus that infects more than 1400 species of cultivated plants (Elad et al. 2016). On grapevine, this fungus causes one of the most serious diseases, namely, Botrytis Bunch Rot (BBR). The pathogen can reduce drastically both the yield and quality of wine, causing substantial economic losses in grapevines, which have been estimated to be approximately 2 billion $US per annum (Elmer and Michailides 2004).

To control this disease, fungicides have long been used, leading to the generation of fungicide resistant strains (Hahn 2014) and harm to both human health and the environment (Damalas and Eleftherohorinos 2011). Therefore, new control strategies that allow growers to reduce the application of pesticides should be developed based on the principles of Integrated Pest Management (IPM) (IOBC 2007).

Grapevine cultivar susceptibility to *B. cinerea* can be considered an essential management indicator in IPM. Although different cultivar classifications according to their susceptibility to the pathogen are available in the literature, they sometimes differ greatly from one another. This situation may have come to be because the proposed classifications are based mostly on professional experience rather than experimental data. Additionally, few studies compare the cultivars under the same environmental and management conditions and no study has proposed a cultivar susceptibility ranking that considers contrasting climatic and cropping conditions, e.g., northern *vs* southern hemisphere.

Thus, the main objective of this work was to compare and classify the susceptibility to *B. cinerea* between different grapevine cultivars in two contrasting climatic and cropping conditions, in Central Chile and Western France. Additionally, the fruit maturity was simulated, and we analysed the extent to which this factor may account for the susceptibility ranking.

Materials and methods

Experimental field site: The essays were performed in three grapevine collections, two of them located in France (Aquitaine Region) and one in Chile (Maule Region). A total of 13 common cultivars were evaluated in both countries. The experimental trials were performed during three seasons in France (2011, 2012, 2014) and two seasons in Chile (2013-14, 2014-15).

Climatic characterization: To characterize the climatic conditions for the study seasons of both sites**,** an automatic weather station (AWS) (Adcon Telemetric, A730, Klosterneuburg, Austria in Chile and Cimel Electronique S.A.S, CimAGRO, Paris in France) were installed 50 m from the trial plots and provided data about the air temperature, relative humidity and precipitation at 15-min intervals. Since Chilean climatic conditions were not favourable to *B. cinerea* development, we moistened the vines during the second season (2014-15) to promote the pathogen development.

Experimental conditions: The main differences between experimental sites are the irrigation and rootstock. The use of irrigation is typical in vineyards in central Valley in Chile but not in Western France. In contrast, vines were grafted in French sites, but in Chile, the vines were planted on their own roots. Concerning disease management and with the aim to study the cultivar susceptibility to *B. cinerea*, no fungicide was applied to control this pathogen.

Disease susceptibility assessment: To determine the susceptibility of the cultivars, the incidence and severity of BBR were evaluated at harvest in each season. For that, the surface of environ 100 clusters per cultivar were observed. The incidence was obtained by dividing the number of clusters infected by the total number of clusters; whereas the severity was calculated in each cluster as the percentage of

the rotted and/or sporulating area. Both the incidence and severity were expressed as percentages. Additionally, to classify the 13 common cultivars in both countries, a susceptibility index (SI) was calculated at each season and site, using the severity data as specified in equation (1):

$$SI = \frac{Severity\ (\%) for\ cultivar\ in\ question}{Highest\ severity\ (\%) recorded\ in\ the\ season\ and\ in\ the\ most\ rotted\ cultivar} X\ 100 \quad (1)$$

The cultivars were then classified into 5 categories of susceptibility: Highly Resistant (HR) = 0-3.5%; Resistant (R) = 3.51-10%; Intermediate (I) = 10.1-25%; Susceptible (S) = 25.1-50% and Highly Susceptible (HS) = 50.1-100%.

Maturity assessment: A maturity index (F_{Mat}) was calculated to relate the berry maturity to the disease susceptibility. The index was calculated for each season and site using the Grapevine Flowering Veraison model (GFV) of Parker et al. (2011, 2013) and weather data for each study season, as indicated in equation (2). Finally, to prevent the effect of the different dates of assessment depending on the season, the FMat was adjusted (FMat_adj) in both countries by removing the value of FMat of the latest cultivar.

$$F_{Mat} = F_{B.c\ assessment} - F_{veraison} \quad (2)$$

where $F_{B.c\ assessment}$ is the timing of the *B. cinerea* assessment in each study season and $F_{veraison}$ is the timing of veraison for each cultivar, using the model proposed by Parker et al. (2011, 2013).

Statistical analyses: To establish a classification for the 13 common cultivars according to their susceptibility to *B. cinerea*, a box plot analysis was performed using together the SI data from all sites and all studied seasons. Moreover, a Kruskal-Wallis analysis and a Student-Newman-Keuls test at a significance level of 5% were performed on the SI data to compare the cultivar susceptibility. Finally, the relationship between maturity of cultivars and their susceptibility was studied and modelled using the SI and F_{Mat_adj} data in all sites and study seasons. All statistical analyses were performed using the Statistical Software Statgraphics Plus 5.1 (StatPoint Inc., Warrenton, Virginia, USA).

Results and discussion

Climatic conditions: In all years studied in France, spring and summer were characterized by humid and temperate conditions, which favoured the growth and development of *B. cinerea*. On the other hand, Chilean conditions were characterized by dry and temperate spring and summer periods, in both studied seasons, which were not conducive to disease development. The main difference in climatic conditions between both countries was the rainfall, which was much lower in Chile than in France (Figure 1). Consequently, BBR incidence and severity were higher in France than in Chile during all the study seasons (data not shown).

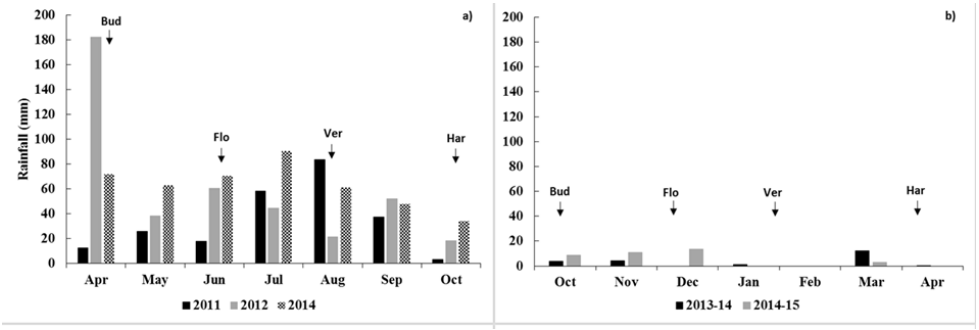

Figure 1. Monthly means for rainfall (mm) in France (a) and Chile (b) during all seasons. Bud= Budbreak; Flo= Flowering; Ver= Veraison; Har= Harvest

Classification of common cultivars: According to severity data, the cultivar classification was generally similar in the two countries (data no shown). Then and taking into account the mean susceptibility index value (SI), we classified the common cultivars evaluated in Chile and France in 5

categories. Five cultivars – Grenache Noir, Cabernet Franc, Petit Verdot, Cabernet Sauvignon and Mourvèdre – were highly resistant (SI ≤ 3.5). Three cultivars were included in the resistant category (Merlot, Syrah and Cot). Only Roussanne was classified as an intermediate cultivar. Finally, the cultivars Chardonnay and Pinot Noir were identified as susceptible, whereas Gewürztraminer and Sauvignon Blanc were highly susceptible (SI > 50). (Figure 2). These classification features confirm various previously published findings. However, for other cultivars tested, our results differ greatly from those published in the literature (Table 1). These differences could be accounted for by possible changes in agronomic conditions that could affect the plant, the pathogen, the environment and/or the interactions between these epidemiological factors. Nevertheless, the results of this study showed that the cultivar classification according to the susceptibility to *B. cinerea* was generally similar in the two countries, despite the contrasting climatic conditions and cropping practices. Thus, despite all the variations and differences possibly due to agronomic factors, the cultivar effect *per se* seems to be a major important factor.

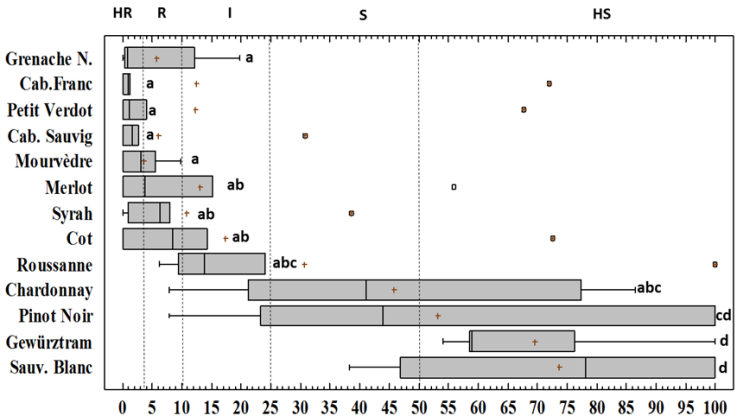

Figure 2. Box plot of cultivars according to the susceptibility index. HR = Highly Resistant; R = Resistant; I = Intermediate; S = Susceptible; HS = Highly Susceptible. The vertical line in each box and the cross represent the median and mean value of the SI, respectively.

Table 1. Comparison of the susceptibility to *B. cinerea* of 13 grapevine cultivars according sources and our results

Cultivar	Mean lit.	Sd lit.	Our res.	Sd res.
Grenache Noir	4	0.5	0	1.0
Cabernet Franc	3	1.5	0	1.6
Petit Verdot	1	0.3	0	1.6
Cabernet Sauvignon	1	0.7	0	1.2
Mourvèdre	1	-	0	0.5
Merlot	3	0	1	1.5
Syrah	2	0.8	1	1.2
Cot	3	0	1	1.5
Roussanne	4	0	2	1.2
Chardonnay	3	0.8	3	1.2
Pinot Noir	3	0.8	3	1.3
Gewürztraminer	3	1.7	4	0
Sauvignon Blanc	3	1.2	4	0.5

Effect of grape maturity on disease susceptibility: An exponential relationship between the susceptibility to the pathogen, as indicated by the SI value, and the fruit maturity of cultivars studied

in France and Chile was observed, showing clearly that the cultivars with more mature berries were the most susceptible (Figure 3). Therefore, the fruit maturity was identified as a major factor determining the cultivar susceptibility to *B. cinerea*. It could be due to increasing sugar concentration in maturing grape berries promotes infection and colonization by *B. cinerea* (Deytieux et al. 2009).

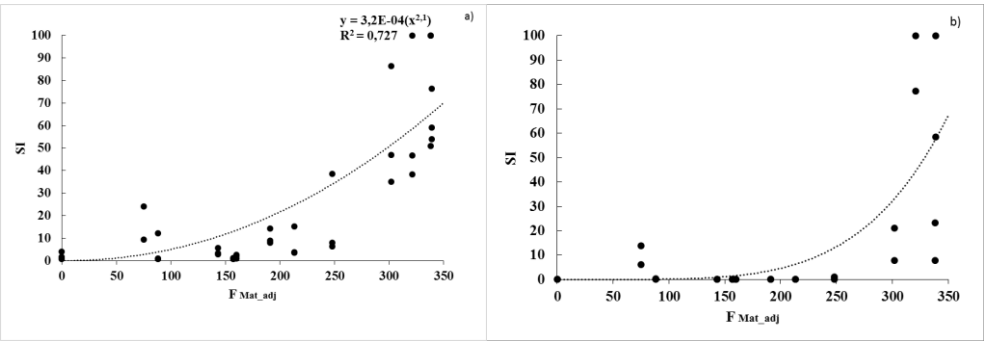

Figure 3. Relationship between the maturity of cultivars (F Mat_adj) and susceptibility to BBR (SI) at both sites, France (a) and Chile (b), during all study seasons.

Conclusion

The classification of the wine cultivars according to their susceptibility to *B. cinerea* was similar in both countries, despite the contrasting climatic conditions and management practices. Sauvignon Blanc and Gewürztraminer were the highest susceptible cultivars, whereas Petit Verdot, Cabernet Sauvignon, Mourvèdre and Syrah were rather resistant or highly resistant, confirming previous studies. For the other cvs. evaluated, their ranking differed to some extent from the literature. This difference is presumably caused by variations in agronomic and/or environmental conditions under which the field experiments were carried out. Fruit maturity, depending significantly on the cultivar, proved to be very important factors governing susceptibility to *B. cinerea*. Therefore, the susceptibility classification of cultivars remains a key parameter in decision support systems and therefore, fruit maturity could be used to support this classification.

Acknowledgments

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