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

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20th GiESCO International Meeting

Mendoza, Argentina

November 5th – 10th 2017

20ma Reunión Internacional de GiESCO

Mendoza, Argentina

5 -10 de noviembre de 2017

Book of Full Manuscripts /
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CLASSIFICATION OF WINE GRAPE CULTIVARS ACCORDING TO THEIR SUSCEPTIBILITY TO *BOTRYTIS CINEREA*: IMPORTANCE OF FRUIT MATURITY

CLASIFICACIÓN DE CULTIVARES DE VIDPARA VINODE ACUERDO A SU SUSCEPTIBILIDAD A BOTRYTIS CINEREA: IMPORTANCIA DE LA MADUREZ DE LA FRUTA

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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 aim of this study was to compare and classify different wine-grape cvs.according to their susceptibility to *B. cinerea* and to study the influence of fruit maturity on this classification. Between 2011 and 2015, three field trials were carried out under two contrasting climatic and cropping conditions, 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, despite the contrasting climatic conditions and cropping practices. Cabernet Sauvignon, Cabernet Franc, Grenache Noir, Petit Verdot and Mourvèdre 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. 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

Botrytiscinerea provoca una de las enfermedades más importantes en vides, llamada Pudrición gris(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 objetivo de este estudio fue comparar y clasificar diferentes cvs. de vid vinífera de acuerdo con su susceptibilidad a *B. cinerea* y estudiar la influencia de la madurez de fruta en esta clasificación. Entre 2011 y 2015, tres ensayos de campo fueron llevados a cabo bajo dos condiciones contrastantes de clima y manejo, 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, a pesar de las condiciones contrastantes de clima y cultivo. Cabernet Sauvignon, Cabernet Franc, GrenacheNoir, PetitVerdot y Mourvècre fueron los cvs. más tolerantes, mientras que Gewürztraminer y SauvignonBlanc fueron los más susceptibles. Además, una relación exponencial y positiva fue establecida entre SI y la madurez. 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: Pudrición gris, 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 grape yield and quality of wine, causing substantial economic losses in viticulture, 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 developedbased on the principles of Integrated Pest Management (IPM) (IOBC 2007).

Grapevine cultivar susceptibility to *B. cinerea* can be considered as an essential management indicator in IPM. Although different cultivar classifications according to their susceptibility to the pathogen are available in the literature, they may differ greatly from one another. This situation could be due to the fact that proposed classifications have beenbased 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 under two contrasting climatic and cropping conditions, in Central Chile and Western France. Additionally, the fruit maturity was simulated, and we analysed to which extent this factor may account for the susceptibility ranking.

Materials and methods

Experimental field:The assays 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 studied seasons in the two sites**,** an automatic weather station (Adcon Telemetric, A730, Klosterneuburg, Austria in Chile and CimelElectronique 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. For this, the vines were water sprayed using a knapsack sprayer (Solo 435, Sindelfingen, Germany). At two consecutive days, close to harvest (approximately 25°Brix), a total of 2 L of water was applied per vine, every 2 hours from 8 pm (day 1) to 9 pm (day 2), resulting in the fruit being moistened for a period of 36 hours.

Experimental conditions: In general, grapevine management conditions were similar in both countries, except for irrigation and rootstock. The use of irrigation is typical in vineyards in central Valley in Chile but not in Western France. Also, vines were grafted in French sites(3309 and S04 rootstocks), 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 specific 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 harvestin each season. For that, the surface of about 100 clusters per cultivar was 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 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):

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

The cultivars were then classified into 5 categories of susceptibility: Highly Resistant (HR) = 0-3.5%; Resistant (R) = 3.51-10%; Intermediate (I) = 10.1-25.0 %; Susceptible (S) = 25.1-50.0 % 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 weather data and the Grapevine Flowering Veraison model (GFV) of Parker et al. (2011, 2013), as indicated in equation (2).

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

Where $F_{B.c\ assessment}$ is the timing ofthe *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).

Finally, to prevent the effect of the different dates of assessment depending on the season, the F_{Mat} was adjusted (F_{Mat_adj}) in both countries by removing the value of F_{Mat} of the latest cultivar.

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 to BBR was modelled using the SIand 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). Even if the grapevines were water sprayed in Chile, this effect was temporary and did not allow the pathogen to develop to a large extent, as may occur under natural wet conditions such as e.g., under oceanic conditions.Consequently, BBR incidence and severity were higher in France than in Chile during all the study seasons(data not shown).

Classification of common cultivars: According to severity data, the cultivar classification was generally similar in the two countries (data no shown). Taking into accountthe 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 (Robinson 1986, Galet 1988, Dry and Gregory 1990, Dubos 2002). 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.

Effect of grape maturity at harvest on susceptibility to botrytis: 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 that promotes infection and colonization by *B. cinerea*(Deytieux*et al*. 2009).

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(including wetting the foliage in dry conditions to initiate disease). Sauvignon Blanc and Gewürztraminer were the most susceptible cultivars, whereas Cabernet Sauvignon, Cabernet Franc, Grenache Noir, Petit Verdot and Mourvèdre were the most resistant cvs. For some cultivars evaluated, their ranking differed to some extent from the literature. This difference is presumably caused by variations in the agronomic and/or environmental conditions under which the field experiments were carried out. Fruit maturity, which depends significantly on the cultivar, proved to be a very important factorgoverning susceptibility to *B. cinerea*. Therefore, the susceptibility classification of cultivars remains a key parameter in decision support systems and thefruit maturity could be used to support this classification.

Acknowledgments

The research was supported by the National CONICYT Doctoral Fellowship 2013 N° 21130505 and by the Chilean projects CONICYT-FONDECYT/Regular 1130763. We are grateful to Panguilemo Experimental Station, to the Château La Tour Blanche, to the INRA Grande Ferrade experimental unit and INRA UMR EGFV (1287) for the vineyard plots and scientific and technical help. We are also grateful to the ConseilInterprofessionnel du Vin de Bordeaux (CIVB) for its financial support. This study has been performed in the framework of the French Cluster of Excellence COTE, Bordeaux.

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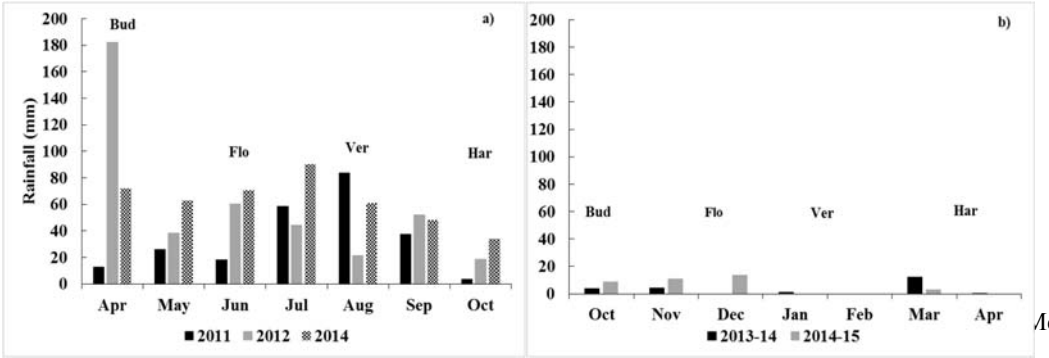

Figure 1. Monthly means for rainfall (mm) in France (a) and Chile (b) during all seasons. Bud= Budbreak; Flo= Flowering; Ver= Veraison; Har= Harvest

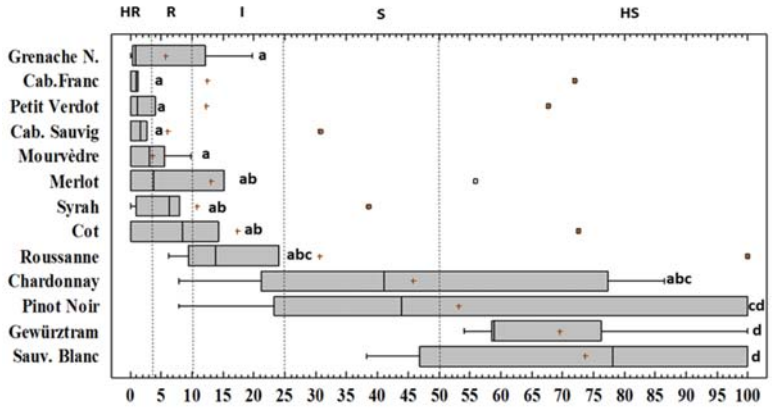

Figure 2. Box plot of cultivars according to the susceptibility index assessed in both Chile and France. HR = Highly Resistant; R = Resistant; I = Intermediate; S = Susceptible; HS = Highly Susceptible. The vertical line in each box and the cross represent the median and mean value of the SI, respectively.

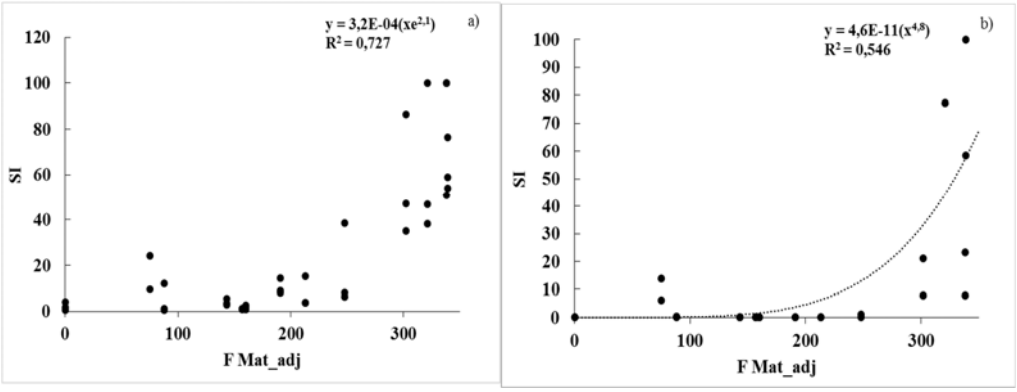

Figure 3. Relationship between the maturity of cultivars (F_{Mat_adj}) and susceptibility to BBR (SI) at both sites, France (a) and Chile (b), during all study seasons.