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Efficacy of fenhexamid treatments against *Botrytis cinerea* in grapevine as affected by time of application and meteorological conditions

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ABSTRACT

Grape bunch rot caused by *Botrytis cinerea* is one of the major fungal diseases of grapevine (*Vitis vinifera* L.) worldwide. Besides crop cultural measures, botryticides are used on a regular basis for controlling bunch rot. To investigate the impact of (i) the time of application and (ii) the meteorological conditions on the efficacy of a single botryticide treatment per year (active ingredient: fenhexamid), field trials were conducted over a six year period (2011–2016) on the cultivars Riesling and Pinot gris. The median levels of efficacy compared to the untreated control at 100 days after growth stage BBCH 68 were 6.7%, 23.1%, 34.8%, 25.6%, 16.0%, 34.5% or 9.0% for Riesling and 13.9%, 16.5%, 23.7%, 9.8%, 6.6%, 9.3% or 14.1% for Pinot gris for applications at 0, 2, 4, 6, 8, 10 or 12 weeks after BBCH 68, respectively. Generally, the levels of efficacy as well as the delays of the epidemics caused by the fenhexamid treatment (i) were lower than those attainable by cultural measures and (ii) decreased with increasing temporal distance between BBCH 68 and the date of assessment as well as with the level of disease severity. Results indicate that in Riesling, fenhexamid treatments before bunch closure and shortly after veraison were most effective, whereas this was the case for Pinot gris only around bunch closure. The rather low overall efficacies suggest that a limited number of targeted botryticide applications may represent a facultative component in the complex bunch rot control strategy primarily based on efficient crop cultural measures. The delay of the epidemic induced by a single fenhexamid treatment was significantly affected by the annual meteorological conditions in the different stages of grape development even outside the application period suggesting that plant physiological factors also contribute to the overall effect.

1. Introduction

Grey mould or bunch rot caused by *Botrytis cinerea* Pers.:Fr. (teleomorph: *Botryotinia fuckeliana* (de Bary) Whetzel) is one of the major fungal diseases of grapevine (*Vitis vinifera* L.) and many other fruits (Aktaruzzaman et al., 2017) worldwide. Bunch rot causes economic losses by reducing yield and wine quality (Wilcox et al., 2015). In the past, bunch rot control strategies were mainly based on routine applications of fungicides (Shtienberg, 2007) specific to *B. cinerea* (botryticides). Targeted selection of propagating material, adapted canopy and soil management as well as several crop cultural measures such as leaf removal in the cluster zone, cluster division or postponing first shoot topping resulting in less compact clusters and/or a better sun- and wind-exposure have been identified as valuable components of a bunch rot control strategy (e.g., Evers et al., 2010; Molitor et al., 2011b; Molitor et al., 2011a; Molitor et al., 2012; Molitor et al., 2015a; Molitor et al., 2015b; Spring and Viret, 2011). Another approach to decrease the probability of severe bunch rot damage is the cultivation of intraspecific varieties with a reduced sensitivity towards *B. cinerea*, such as Gamaret (Gamay x Reichensteiner), Carminoir (Pinot noir x Cabernet Sauvignon) or Galotta (Ancelotta x Gamay) (Dupraz and Spring 2010). However, when growing traditional cultivars, botryticides are recommended in addition to appropriate cultural measures in many grapegrowing regions (Wilcox et al., 2015).

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Table 1
Treatments, application dates (identical in both cultivars) and phenological stages (BBCH code according to Lorenz et al. (1995)) in the two cultivars Riesling (Rie) and Pinot gris (Pg).

Treatment		2011			2012			2013			2014			2015			2016		
		Date	Rie	Pg	Date	Rie	Pg	Date	Rie	Pg	Date	Rie	Pg	Date	Rie	Pg	Date	Rie	Pg
C	Untreated control																		
0	BBCH 68 + 0 weeks	06.06.	69	69–71	22.06.	65	68	08.07.	69	71	16.06.	71	71	18.06.	67–68	68–69	29.06.	69	71
2	BBCH 68 + 2 weeks	21.06.	73–75	73–75	06.07.	73	73	22.07.	73–75	75-(77)	01.07.	73	73–75	01.07.	73	73-(75)	12.07.	73	73–75
4	BBCH 68 + 4 weeks	04.07.	75–77	77	20.07.	75	77	05.08.	77–79	79	15.07.	77	77	17.07.	77–79	79	26.07.	77–79	77–79
6	BBCH 68 + 6 weeks	18.07.	77–79	79	03.08.	77	77–79	19.08.	79	79	29.07.	79	79	30.07.	79	79	09.08.	79	79
8	BBCH 68 + 8 weeks	01.08.	79	79	17.08.	79	79–81	02.09.	80–81	82–83	12.08.	79	81	13.08.	79	82	23.08.	79	83
10	BBCH 68 + 10 weeks	17.08.	81	81	31.08.	83	85	16.09.	85	85	26.08.	85	85	27.08.	85	85	06.09.	85	85
12	BBCH 68 + 12 weeks	30.08.	85	85	14.09.	85	85	30.09.	85	85	09.09.	85	85	10.09.	85	85	20.09.	85	85

Since chemical bunch rot control measures are becoming more and more criticized and restricted (Shtienberg, 2007), well-timed application of botryticides might contribute to a reduced use of pesticides, paving the way to a more sustainable viticulture.

Traditionally, potential application dates for botryticides are focused on the following growth stages (Wilcox et al., 2015):

(i) mid-bloom (BBCH stage 65 according to Lorenz et al. (1995)) to fruit-set (BBCH 71) (to prevent establishment of latent infections and to limit colonisation of floral debris);
(ii) before berries touch (BBCH 77) (last opportunity to completely cover berry surfaces and rachises);
(iii) beginning of veraison (BBCH 81) (to protect healthy berries becoming susceptible for new infections and to suppress the re-activation of latent infection by systemic or penetrating botryticides);
(iv) 2–4 weeks after veraison (approximately BBCH 85) (to combat secondary spread) (Wilcox et al., 2015).

Meteorological conditions have been demonstrated to strongly impact bunch rot epidemics (Molitor et al., 2016). However, little is known so far about the specific impact of meteorological conditions on the efficacy of botryticide treatments. Consequently, recommendations concerning the optimal timing of specific treatments vary among regions and years according to the annual meteorological conditions (Edder et al., 2009; Petit et al., 2011; Wilcox et al., 2015).

The *Vitis vinifera* cultivars Pinot gris and Riesling are two of the most widely grown grape cultivars in Luxembourg as well as across Central Europe in general. Due to their tendency to form compact clusters, both are highly susceptible tobunch rot.

Fenhexamid, a hydroxyanilide derivative inhibiting germ-tube elongation and mycelial growth of *B. cinerea,* is considered as one of the most effective botryticides (Petit et al., 2011) and is registered under the trade name Teldor® for bunch rot control in Luxembourg.

The objectives of the present six year-study (2011–2016) using single applications of Teldor® were the identification of (i) the timings of application that result in the highest bunch rot control efficacy and (ii) time frames during the vegetation period when meteorological conditions amplify or weaken fungicide efficacy.

2. Material and methods

2.1. Vineyard site

Field trials were carried out in the experimental vineyards of the Institut Viti-vinicole in Remich, Luxembourg (lat. 49.54°N; long. 6.35°E) between 2011 and 2016 in the white *Vitis vinifera* L. cultivars Pinot gris and Riesling. Both cultivars were planted in 2000 and the vines, grafted onto SO4 rootstocks, were trained to a vertical shoot positioning system (VSP). The space per plant was 2.4 m^2 (2 m between rows, 1.2 m between vines) (Molitor et al., 2015a).

2.2. Experimental design

Experiments were realized using randomized complete block designs with four replicates of eight vines per plot.

Treatments were the same in all years and defined as follows:

- C: untreated control;
- 0: botryticide application 0 weeks after BBCH 68
- 2: botryticide application 2 weeks after BBCH 68
- 4: botryticide application 4 weeks after BBCH 68
- 6: botryticide application 6 weeks after BBCH 68
- 8: botryticide application 8 weeks after BBCH 68
- 10: botryticide application 10 weeks after BBCH 68
- 12: botryticide application 12 weeks after BBCH 68

Application dates and phenological plant growth stages at application dates are shown in detail for both cultivars in Table 1.

Botryticide applications (Teldor®; active ingredient 500 g/kg fenhexamid; treatment concentration: 0.1%) in treatments 0 to 12 were carried out manually using a backpack sprayer (Solo Akku 416, Solo Kleinmotoren GmbH, Sindelfingen, Germany) equipped with injector noozles (Albuz AVI 80, Agrotop Spray Technology, Obertraubling, Germany). No additional wetting agents or surfactants were used. Clusters were treated from both sides until run-off. In all treatments, 800 L of water were applied per ha resulting in a final fenhexamid dose of 0.4 kg/ha.

Background applications against *Plasmopara viticola* (Berk. & M.A. Curtis) Berl. & De Toni and *Erysiphe necator* Schwein were carried out in all seasons in intervals of 10–12 days. Prior to the first experimental botryticide application, cluster-zone leaf-removal was conducted on the south-east exposed sides of the rows between full flowering (BBCH stage 65) and 80% of flowerhoods fallen (BBCH 68). No cluster thinning took place.

2.3. Meteorological and phenological data

Meteorological data were recorded during the period of examination by a weather station of the national agricultural administration ASTA (Administration des services techniques de l'agriculture) located in Remich/Luxembourg (49.54° N, 6.35° E; 207 m a.s.l.) in direct proximity (distance < 100m) of the experimental vineyard. Air temperatures were measured at 2 m and precipitation at 1 m above the ground.

Phenological stages were recorded according to the BBCH (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie) scale as defined by Lorenz et al. (1995). Monitoring intervals were usually two to three days. Plant growth stages were recorded when 50% of vines or shoots exhibited the respective stage. Key meteorological and phenological data are given in Table 2.