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Research Note

Overwintering of *Uncinula necator* in Austrian vineyards

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S u m m a r y : Studies on the overwintering of *Uncinula necator* in Austrian vineyards were carried out from 1994 to 1998. There was no evidence of mycelium overwintering in infected buds and only a negligible number of cleistothecia were found overwintering on bark. They were, however, discovered on canes in all the vineyards examined. The density of cleistothecia on these canes was closely related to the fungicide treatment applied during the preceeding season and there were marked annual differences in density, which peaked in 1994 and 1995. The middle part of the canes was more frequently contaminated with cleistothecia than the basal or upper parts. *U. necator* cleistothecia are more frequent in Austrian vineyards than hitherto supposed and might be a source of primary inoculum for grapevine powdery mildew infections.

K e y w o r d s : Uncinula necator, grapevine powdery mildew, cleistothecia, flag shoot, overwintering.

Introduction: *Uncinula necator* (Schwein.) Burr, the causal agent of grapevine powdery mildew, was widespread in most Austrian grape-growing regions in the early 1990s (much more so than had been the case for many years). This prevalence was due to both weather conditions favouring the spread of the disease and control problems. Accordingly, there has been interest in Austria in the overwintering of the fungus. As in most northern European viticultural areas, this overwintering has been attributed to mycelium surviving in dormant buds. Recently, cleistothecia have also been identified as a principal source of inoculum for some northern European areas (PEZET and BOLAY 1992; KAST 1994; HILL 1997) and this new possibility has been subject to intense discussion in Austria.

The objective of the research presented here was to investigate the overwintering of *U. necator* in Austrian vineyards, and to estimate the extent to which cleistothecia are a possible source of initial inoculum for grapevine powdery mildew infections under Austrian grape-growing conditions.

Material and methods: D e v e l o p m e n t o f f l a g s h o o t s : Canes that had developed from highly-infected vines (with varying degrees of infection, as identified from the size and spread of infected patches) were collected from January to April 1994-1996 and placed in water for about 24 h to ensure consistently good watering. Subsequently, cuttings with two buds were taken, with the lower bud being removed. The cuttings were then cultivated on well-soaked substratum (Leca GmbH, Fehring, Austria) in a growth chamber for 60 d at 24-28 °C, with a relative humidity of 60-95 % and a daylight period of 16 h. In addition to the laboratory investigations, periodical surveys were carried out in numerous vineyards (from bud break onwards) in order to identify primary infections with *U. necator*.

O c c u r r e n c e o f c l e i s t o t h e c i a : Canes with 10 nodes up from the basal node were collected between February and April and cut into 10 pieces consisting of one node and the following internode. Cleistothecia were counted under a stereomicroscope.

Cleistothecia from bark were harvested in March 1997 and 1998 by brushing them off the upper trunks and cordons of 5 vines in each vineyard. The samples were shaken vigorously in 1000 ml water and the resultant suspension poured through 300 µm and 105 µm sieves which were examined under the microscope; the number of cleistothecia was recorded.

Results and Discussion: D e v e l o p m e n t o f f l a g s h o o t s : Neither size and spread of patches arising from shoot infections (<10 to >50 %) nor the minimum winter temperature (between -5 and -14 °C) had any influence on the growth of shoots under laboratory conditions. 84-98 % of the buds burst and developed shoots. Only one of these shoots developed a *U. necator* infection which appeared as a small spot on the sixth expanded leaf and was therefore not considered to be a typical flag shoot. Furthermore, perennating bud infection was not observed in any of the vineyard surveys. The size and spread of patches resulting from shoot infection by grapevine powdery mildew may be taken as an indicator of the extent of infestation of the previous year and could be considered an inauspicious portent for the development of flag shoots, particularly in 1994 and 1995. Nevertheless, flag shoots never developed in the laboratory studies, as has been reported by VAN DER SPUY (1977), SALL and WRYSINSKY (1982) and HILL (1997). Moreover, extensive vineyard surveys also ruled out the possibility that *U. necator* was overwintering as mycelium in dormant buds. As shown by HILL (1990), cold winter temperatures (<-12 °C) appear to kill infected buds already stressed by grapevine powdery mildew. In the present investigation, cuttings originating from vineyards exposed to very low temperatures did not show evident differences in shoot development and powdery mildew infection. Furthermore, at all locations examined, powdery mildew infections developed comparatively late, at the onset of flowering or later. However, buds at the basal insertions are formed before flowering and pass to a stage of dormancy in July (PRATT 1979; KOUSSA *et al.* 1994).

D e n s i t y o f c l e i s t o t h e c i a o n c a n e s : The occurrence of *U. necator* cleistothecia on canes was dependent on the fungicide treatment applied during the preceeding season (Tab. 1). Canes from plots treated with triadimefon had a significantly higher density of cleistothecia than canes from plots treated with pyrifenox and 0.2 % sulphur. Cleistothecia density declined considerably over the period of the study (1994-1998). The significantly highest density of cleistothecia was observed in 1994, with an average number of nearly 470 cleistothecia per cane. In 1996, 1997 and 1998 there was a sharp drop in cleistothecia density.

The greatest number of cleistothecia on a single cane was found at Türkenschanze in 1994 (see Tab. 2),

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Table 1

Density of cleistothecia of *Uncinula necator* on canes (10 nodes per cane) of Grüner Veltliner at Türkenschanze 1994-1998

Treatment	Mean density of cleistothecia				
	1994	1995	1996	1997	1998
Triadimefon	469.2	70.4	1.2	0.2	0.4
Pyrifenox + 0.2 % sulfur	54.0	1.1	0.0	0.0	0.0
Mean	261.6 c	35.8 b	0.6 a	0.1 a	0.2 a
F-value years	160.71 ***				
F-value treatments	70.44 ***				
F-value years x treatments	9.87 ***				

Means followed by different letters are significantly different.

Table 2

Maximum density of *Uncinula necator* cleistothecia in canes at four locations in spring, 1994-1998

Year	Türken-schanze	Mitter-berg	Pisen-kopf	Holz-gasse
1994	948	19	178	*)
1995	286	44	*)	*)
1996	3	*)	13	254
1997	1	2	1	40
1998	1	33	8	6

*) no survey carried out.

with 948 cleistothecia, though the density at this site subsequently declined to only one cleistothecium per cane in 1997 and 1998. Densities at Mitterberg and Pisenkopf reached a minimum in 1997 and rose only slightly in 1998 (although cleistothecia were abundant on leaves in autumn 1997 (STEINKELLNER and REDL 1998)). The densities of cleistothecia at Holzgasse followed a similar trend to that of Türkenschanze, although the densities in 1996 and 1997 were markedly higher compared to all other locations. It should be noted that large and widespread patches arising from shoot infections by grapevine powdery mildew were (in most cases) not inevitably accompanied by a higher density of cleistothecia on canes. GADOURY and PEARSON (1988) examined cleistothecia (at densities of 113-608·m^{-2}) on canes in spring and noted that up to 92 % had died during winter and failed to release ascospores. The density of cleistothecia on canes at Türkenschanze (10 canes·m^{-2}) reached up to 4692·m^{-2} in 1994. Even at just 8 % viability, this would mean that cleistothecia could still be an important source of primary inoculum. Further attention should be paid to the fact that insertions from the middle part of canes were more frequently infected with cleistothecia than insertions from the basal or upper parts (STEINKELLNER, unpubl.); thus training systems with cane pruning might increase the risk of *U. necator* infections.

Density of cleistothecia on bark: At each of the 4 vineyards examined, more cleistothecia were found on bark from cordons (between 0.3 and 10.6 cleistothecia per vine) than on bark from trunks (between 0.0 and 2.4). However, following the cane pattern, only a very small number was found on bark in 1997 and 1998. PEARSON and GADOURY (1987), GADOURY and PEARSON (1988), CORTESI *et al.* (1995) and MAGAREY *et al.* (1997) have found a high percentage of viable cleistothecia overwintering on bark and showed that these cleistothecia are of major importance for perennation of the fungus. However, given the negligible number of cleistothecia found to be overwintering on bark, their importance as a starting point for grapevine powdery mildew infections should not be overestimated.

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