Occurrence of Hyphae of *Uncinula necator* in Buds of Grapevine

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ABSTRACT

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Hyphae of *Uncinula necator* were found inside buds of grapevine cultivar Trollinger by scanning electron microscopy. Hyphae 3–4 μm in diameter with characteristic lobate appressoria were observed on the adaxial surfaces of prophylls (bud scales) dissected from the interiors of green buds on infected shoots. Green shoots with primary powdery mildew (flag shoots) were found most frequently at node positions 3–5 on 1-yr-old canes.

Additional key words: *Oidium, Vitis vinifera*

Dormant-season survival by the grape powdery mildew fungus (*Uncinula necator* (Schw.) Burr) has been studied since the late 1800s. Although cleistothecia are produced abundantly in many viticultural regions of the world, their significance in the survival of the fungus is uncertain (4).

In 1893, Viala (12) reported that he had observed shoots at budbreak covered with conidia of *U. necator*. Furthermore, as he separated the first leaves, he found the fungus at their bases and in the interior of the bud. He concluded that conidia of *U. necator* overwinter between the bud scales and speculated that the buds became infected in autumn. In 1900, Wortmann (13,14) also speculated that *U. necator* (*Oidium tuckeri*) overwinters in buds of grapevines but stated that he was never able to prove it. In 1904, Appel (1) reported that he, like Wortmann, had failed to find mycelium in the buds and suggested that mycelium overwinters on the surface of bark. Istvanffi (6) sectioned buds collected in October and reported seeing mycelium under the outer scales at their nonsuberized bases. Despite this evidence for the occurrence of hyphae in mature buds, Istvanffi did not believe this means of overwintering was important and felt that survival on the exteriors of canes was more important. Today, few pathologists believe mycelial fragments or conidia of *U. necator* survive the dormant season on the surfaces of grapevines, whereas several scientists have claimed observational evidence for survival of hyphae in buds (2,7,10).

Recent investigations on survival of *U. necator* in buds of grapevines have provided indirect evidence for this phenomenon based on field observations and greenhouse studies (9,11). Sall and Wrysinski (9) dissected swollen buds and reported the presence of septate mycelia on shoot and leaf primordia as evidence of hyphae of *U. necator* in unopened buds. However, other fungi have also been found in dormant buds of grapevines (3,5). Despite the lack of drawings or photographs documenting the occurrence of hyphae of *U. necator* in buds, many grape pathologists believe the fungus overwinters in this manner (4). This report provides direct observational evidence for the occurrence of hyphae of *U. necator* in axillary buds of growing shoots.

MATERIALS AND METHODS

Grapevine (*Vitis vinifera* L. cv. Trollinger) shoots infected with *U. necator* and located adjacent to shoots showing signs and symptoms of primary powdery mildew, referred to as flag shoots (2), were collected at Bernkastel-

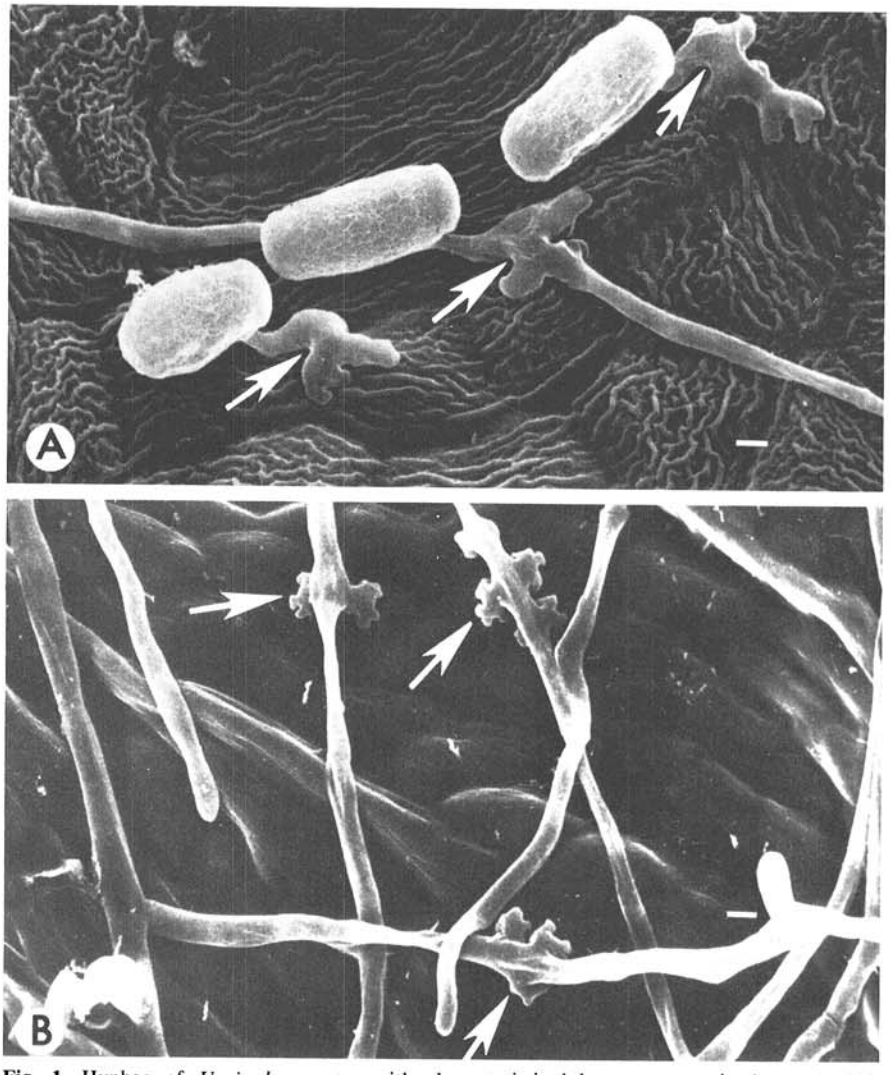

Fig. 1. Hyphae of *Uncinula necator* with characteristic lobate appressoria (arrows). **(A)** Germinating conidia of *U. necator* on grape leaf. **(B)** Mycelium of *U. necator* on exterior surface of a green bud. Bars = 4 μm.

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Kues, Mosel, Federal Republic of Germany, 3 mo after the onset of shoot growth. Green buds in leaf axils were removed from the shoots and interior prophylls (bud scales) were dissected from the buds. Prophylls were fixed in formalin acetic acid for 2 wk, rinsed in several changes of water for 1 day, and dehydrated in an ethanol series. After an absolute ethanol treatment, specimens were transferred to amyl acetate for 6 hr before critical-point drying. After critical-point drying, the prophylls were mounted on scanning electron microscope (SEM) stubs with copper print (GC Electronics, Rockford, IL) and sputter-coated with gold using an Edwards S 150 sputter coater. Specimens were examined at 15 kV with a Nova Scan 30 SEM or at 20 kV with an Etec Autoscan SEM.

A vineyard survey was conducted to determine the node position of mildew flag shoots on 1-yr-old canes. A cultivar Riesling vineyard at Graach, Mosel, Federal Republic of Germany, with a history of severe powdery mildew was surveyed on 9 June at the beginning of bloom, about 6 wk after budbreak. All 1-yr-old canes with at least one flag shoot were examined and the node positions of flag shoots recorded. Vines were trained in the traditional Mosel system of two or three canes (each with 15–20 nodes) tied to the trunk in a heart shape. Shoots from the basal nodes of these canes or shoots from two or three bud spurs were retained as fruiting canes the subsequent year. Remaining shoots were pruned during the growing season to expose clusters.

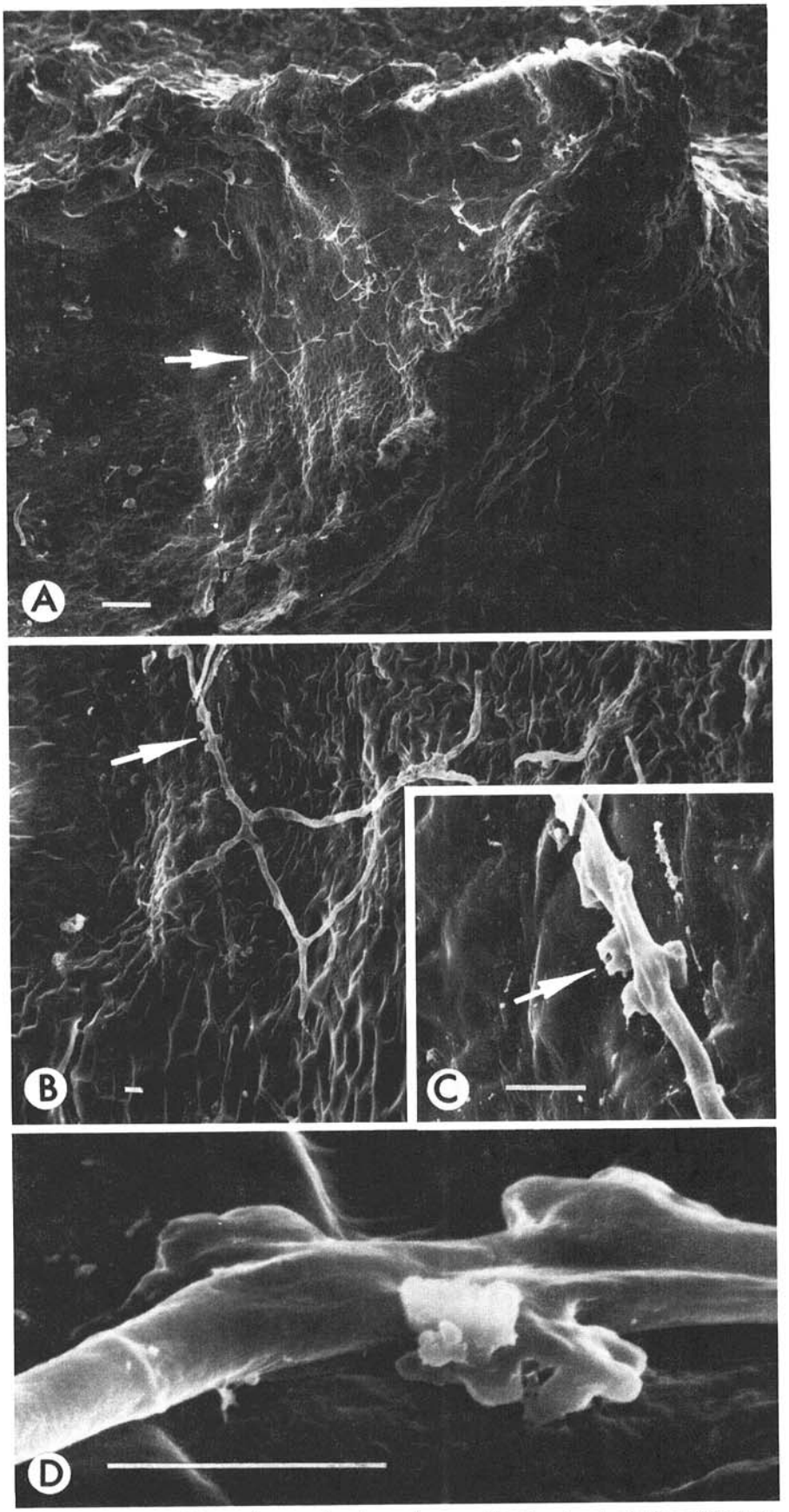

Fig. 2. (A–D) Series of photomicrographs at increasing magnification showing hyphae of *Uncinula necator* on the adaxial surface of a prophyll from the interior of a green axillary bud. Characteristic lobate appressoria (arrows) are evident. Bars = 100 μm in A and 10 μm in B–D.

RESULTS AND DISCUSSION

Grape (cultivar Trollinger) leaf tissue containing germinated conidia of *U. necator* and intact green buds infected with *U. necator* were fixed and examined with the SEM before examination of dissected buds. On leaf surfaces, germinating conidia of *U. necator* produced hyphae 3–4 μm in diameter with lobate appressoria (Fig. 1A), the two criteria used for identification of hyphae of *U. necator*. The mycelia on the exterior of buds had hyphae with characteristic lobate appressoria and hyphae that typically crossed over other hyphae (Fig. 1B). Fusion of hyphae was rarely observed. In examination of prophylls dissected from the interiors of green buds collected in late July, hyphae 3–4 μm in diameter with characteristic lobate appressoria were found on the adaxial surfaces of the prophylls (Fig. 2A–D).

In the vineyard survey, most flag shoots were found at the bases of 1-yr-old canes and were most frequently located at node positions 3–5 (Fig. 3). Fifty percent of the flag shoots were stunted and had six or fewer nodes.

Because observations on green bud infection were made relatively early in the growing season, we believe perennating bud infections occurred early in the season rather than in autumn as suggested by Viala (12). Early-season control measures, applied as soon as mildew flag shoots are observed, besides protecting the current season's crop (9), are probably justified for protection of

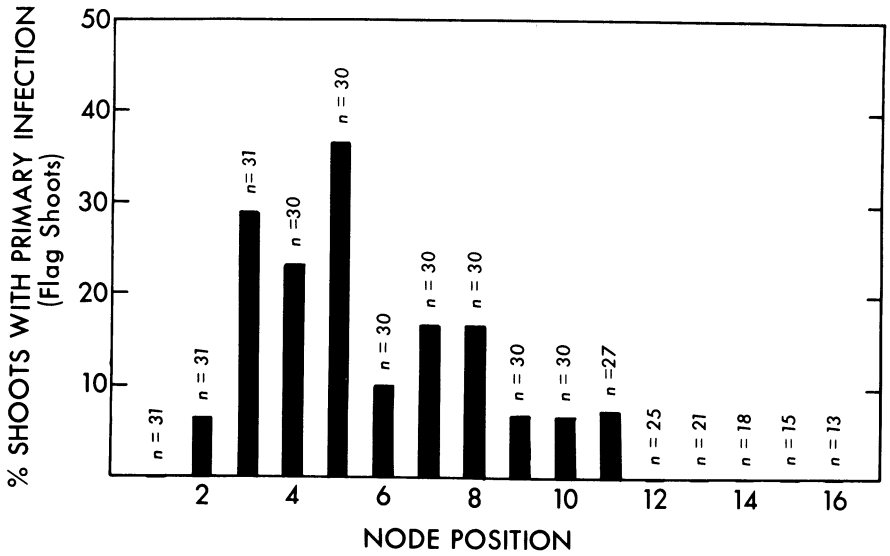

Fig. 3. Percentage of primary infections of *Uncinula necator* (flag shoots) at each cane node position (1 = most basal node) on 1-yr-old cultivar Riesling canes with at least one flag shoot. *n* = Total number of shoots examined at each cane node position.

developing axillary buds. These are the buds that will be retained during the dormant pruning period, and by bloom, they already contain differentiated inflorescences that will provide next year's crop (8).

We found more infected shoots at the bases of canes (nodes 1 and 2) than Boubals (2) reported, although his observation that flag shoots occur most frequently at node positions 3–5 was confirmed in this study. It is unknown why flag shoots are most frequently found at node positions 3–5 and seldom observed at nodes 1 or 2. The high frequency of bud infection at nodes 3–5 may be related to a favorable microclimate in the vicinity of these nodes within the canopy. Perhaps buds at these nodes become infected before application of the first fungicide treatment for control of powdery mildew. Generally, shoot growth exposing these nodes occurs before this treatment. Sall and Wrysinski (9) noted that buds with perennating infections may open slightly later than uninfected buds. Perhaps buds at nodes 1 and 2 are no longer as susceptible to infection when flag shoots emerge and conidia for secondary spread are produced.

Studies to determine the stage of bud development at the time of bud infection are needed. Furthermore, studies are needed to determine the host or environmental conditions necessary for resumption of growth of hyphae of *U. necator* on the prophylls that results in colonization of the shoot primordium.

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