Dry Bubble of Oyster Mushroom Caused by *Verticillium fungicola*

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ABSTRACT

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Dry bubble disease of oyster mushroom (*Pleurotus ostreatus*) was first noted in a commercial planting in California in 1981. The disease, caused by *Verticillium fungicola*, is characterized by a gross malformation and pitting of sporophores. The pathogen also causes dry bubble of the common cultivated mushroom (*Agaricus bisporus*) and several wild mushroom species.

For many years, the oyster mushroom (*Pleurotus ostreatus* Jacq. ex Fr.) has been cultivated extensively throughout Japan. Recently, commercial production of oyster mushrooms has increased in the United States, China, India, and several countries in Europe. The emerging interest in the cultivation of oyster mushrooms has nurtured several studies regarding the biology, genetics, and culture of this fungus (1,3–5,10,12,20), although little is known about the diseases of this species. In this paper we report a new disease of oyster mushroom known as dry bubble, caused by *Verticillium fungicola* (Preuss) Hassebrauk.

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MATERIALS AND METHODS

Isolation. Diseased sporophores were immersed in a 1% sodium hypochlorite solution for 1 min, rinsed briefly with sterile distilled water, and cut longitudinally into halves. Small pieces of tissue were sampled from the internal regions of the pileus and plated on Difco cornmeal agar.

Identification. *V. fungicola* was identified by C. T. Rogerson of New York Botanical Garden.

Pathogenicity tests. Oyster mushroom and the common cultivated mushroom (*Agaricus bisporus* (Lange) Imbach) were cultured in trays measuring 60 × 90 × 20 cm following standard commercial practices (16,19,20). For inoculation, two isolates of *V. fungicola*, one from oyster mushroom and another from the common cultivated mushroom, were grown on potato-yeast-dextrose agar plates for 2 wk at 25 C. A mixture of mycelium and conidia of each isolate was transferred to flasks of sterile distilled water and manually agitated. The fungal suspensions were applied to the production beds with a Jet-pak sprayer (No. 350, Badger Air Brush Co., Franklin Park, IL 60131) at daily intervals for 7 days beginning 14 days after spawning for the oyster mushroom and immediately after casing for the common cultivated mushroom. For each mushroom variety,

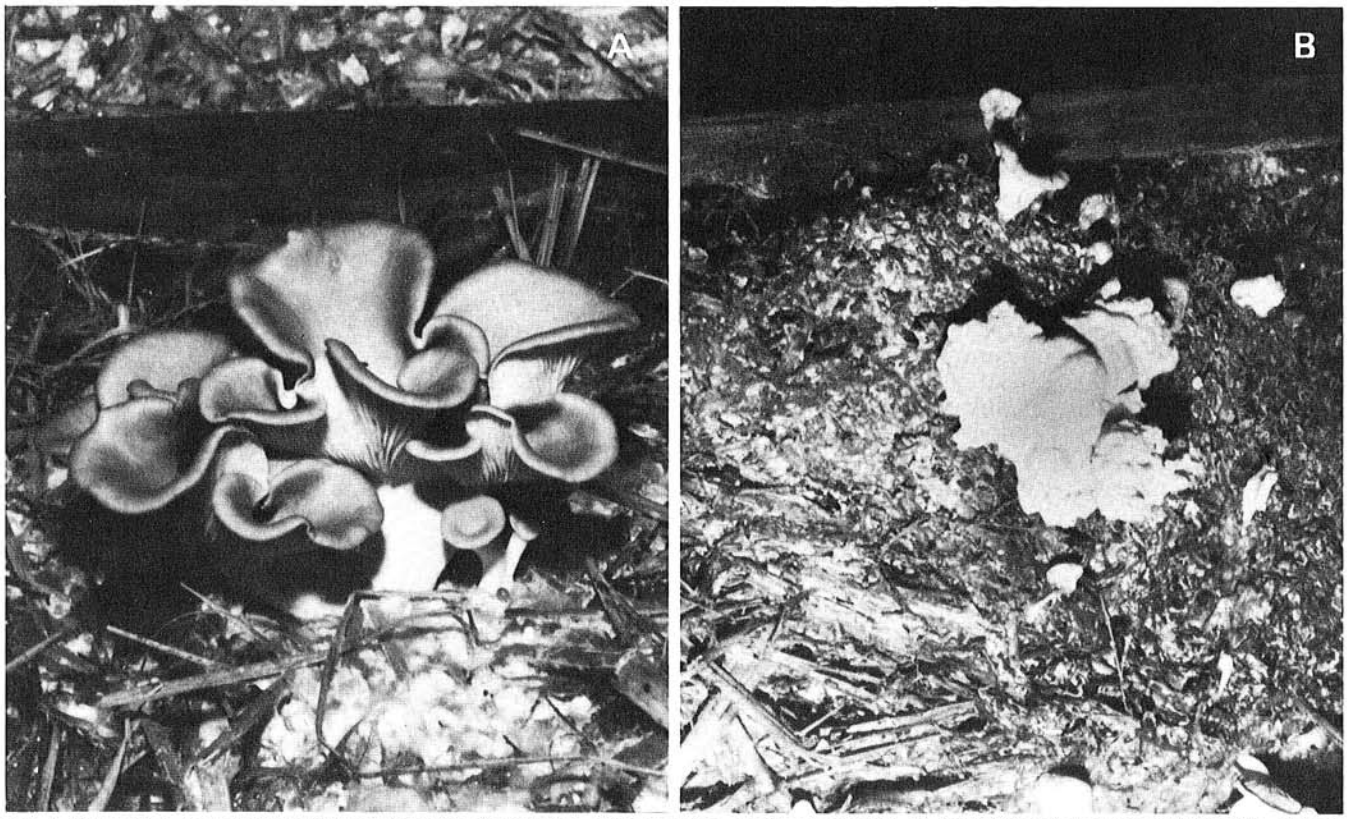

Fig. 1. Symptoms on oyster mushroom following inoculation with an oyster mushroom isolate of *Verticillium fungicola*: **(A)** Healthy, mature sporophore. **(B)** Typical bubble symptoms in young, developing sporophores.

six replicate trays were inoculated with the oyster mushroom isolate of *V. fungicola*, six were inoculated with *V. fungicola* isolated from the common cultivated mushroom, and six remained uninoculated.

RESULTS AND DISCUSSION

Symptoms and signs. Two distinct symptom syndromes were observed depending upon the developmental stage of the sporophores at the time of infection. Infection of sporophores at the pin or button stage resulted in the development of typical dry bubbles, amorphous masses of sporophore tissue (Fig. 1). In contrast, mature sporophores showed cracking and curling of the tissues and depressed, brown, necrotic areas. In advanced stages, a gray weft of mycelium and conidia frequently covered the surface of infected sporophores. *V. fungicola* was readily isolated from affected sporophores (Fig. 2).

Pathogenicity. Inoculation of oyster mushrooms with an oyster mushroom isolate of *V. fungicola* reproduced the symptoms that were observed during natural outbreaks of the disease. *V. fungicola* was reisolated from the diseased mushrooms. This isolate also produced typical dry bubble disease symptoms in the common cultivated mushroom. In the reciprocal test, *V. fungicola* isolated from the common cultivated mushroom was also observed to be pathogenic to both mushroom species and induced symptoms that were indistinguishable from those of the oyster mushroom isolate. The virulence of the two isolates was comparable, a 30–40% reduction in yield resulting in both mushroom species. The uninoculated mushrooms in the control trays remained healthy.

Our results demonstrate that *V. fungicola*, the pathogen of dry bubble of the common cultivated mushroom (15,18), causes a similar disease of oyster mushroom. Based on the similarities in symptoms, "dry bubble" seems an appropriate name for the disease as it occurs in oyster mushrooms. In addition to *P. ostreatus* and *A. bisporus, V. fungicola* is pathogenic to several other basidiomycetes including *A. bitorquis* Imbach, *Laccaria laccata* (Fr.) Berk. and Br., *Coltricha perennis* (L. ex Fr.) Murr., and *P. sapidus* Kalcher (6,9,11,14,18).

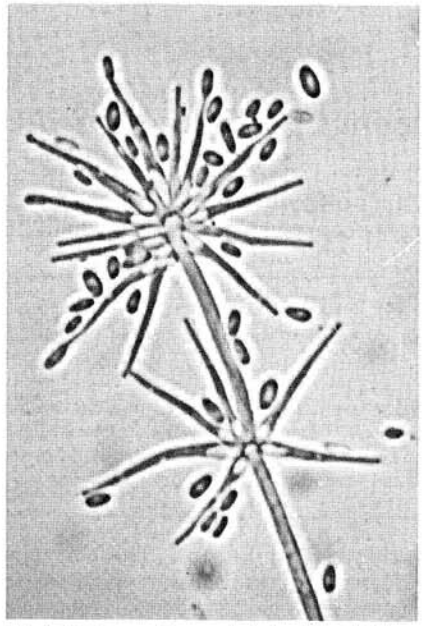

Fig. 2. Oyster mushroom isolate of *Verticillium fungicola* (× 1,000).

The fact that such genetically diverse species are susceptible to Verticillium disease suggests that resistant varieties of *P. ostreatus* and, for that matter, *A. bisporus* may not exist.

Undoubtedly, an increased incidence of dry bubble can be anticipated as cultivation of oyster mushrooms intensifies. The environmental conditions that are optimal for the culture of oyster mushrooms are also conducive to disease development (2,14–16,18,20). Spores disseminated by workers, flies, and water splashing are considered important in the epidemiology of the disease (14,18). We suspect that spores transported by workers from nearby production houses of the common cultivated mushroom served as the primary source of inoculum for the disease outbreaks in the plantings of oyster mushrooms. Control of dry bubble in the common cultivated mushroom is achieved through strict hygiene, regulation of the environment, and a routine chemical spray program (7,8,13,14,17). Considering the potential threat of the disease to the large-scale commercial production of oyster mushrooms, further research should focus on the development of effective ecologic and chemical control procedures.

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