

**Biological Control of Powdery Mildew by a Hyperparasite, *Ampelomyces quisqualis* 94103:
From isolation to a commercial biofungicide product.**

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Total 291 isolates of *Ampelomyces quisqualis* were obtained from 32 species of powdery mildew fungi and a selected isolate, *Ampelomyces quisqualis* 94013 (AQ94013) effectively hyperparasitized 6 species of *Sphaerotheca* and one species of *Erysiphe* which cause serious damage on many important crops in Korea. Moreover, AQ94013 showed antagonistic effects against 12 major fungal plant pathogens as well. Results indicated that the present isolate is not a host specific hyperparasite and has a broad spectrum of biocontrol potential. Providentially, AQ94013 revealed resistance to a number of agrochemicals so as to be applied with the chemicals reciprocally.

Cultural and physical traits of *A. quisqualis* could be slightly different depending on isolates. However, AQ94013 grew best at 26°C and pH 6.5, and the barley medium was found to be the most effective for growth and conidial mass production. Hashioka (1974) reported that *A. quisqualis* directly penetrated into the host hyphae and remained as a hyphal stage to disturb metabolisms of the host fungus. However, scanning electron microscopy demonstrated that AQ94013 readily produced pycnidia inside the host cells and the host became malformed and died only after pycnidial formation. Additionally, a haustorium-like structure formed ahead of penetration was firstly observed in this study.

Effect of *A. quisqualis* 94013 on the control of cucumber powdery mildew was well established in the greenhouse and in the field. However, the fungal population was decreased if there is no host pathogens, but increased when treated on the diseased cucumber leaves. This result explained why the pre-treatment was protective against cucumber powdery mildew only for 9 days and required 7-day interval application. In greenhouse trials, we found that relatively high humidity conditions enhance conidial germination and penetration to the host pathogen resulting in improved hyperparasitic activity of the agent. Therefore, we suggested that 0.05% mineral oil supplemented with the conidial suspension sustains relatively high humidity and thereby increases biocontrol efficacy of the agent.

Fermentative conditions such as media, temperature, pH, and agitation were also confirmed for mass production of the agent. By the culturing conditions, spores of AQ94013 were reached up to 1×10^8 /ml within 5 days. Processing from fermentation to formulation (wettable powder) of AQ 94013 developed in 2002 can be divided by 9 steps in which include seed cultivation, main cultivation, filtration, concentration of spores, mixing with inert ingredients, dry, grinding, sorting of powder size, and packing. The technical grade of AQ94013 WP was registered as a biofungicide of cucumber powdery mildew in March 2003 in Korea. The AQ94013 WP also showed a broad spectrum of biocontrol ability against powdery mildew fungi including six species of *Sphaerotheca*

and one species of *Golovinomyces*, *Blumeria*, and *Uncinula* as causal agents of powdery mildew on cucumber, pumpkin, oriental melon, melon, water melon, strawberry, eggplant, tomato, legularia, bean, barley, wheat, grape, gerbera and rose in Korea.

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