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Note

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Occurrence of Blue Mold on Tomato Caused by *Penicillium oxalicum* in Korea

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A blue mold on tomato fruit caused by *Penicillium oxalicum* occurred sporadically in a greenhouse at Gyeongsangnam-do Agricultural Research and Extension Services. Infection usually occurred through wounds or cracks on the fruits. Symptoms began with water soaking lesions, then became watery and softened eventually. Colony of the causal fungus was white at the early growing stage, turned green on Czapek yeast extract agar and malt extract agar. Conidia were ellipsoidal in shape and 2-6×2-4 μm in size. Stipes were septate, smooth, thin walled, and 90-280×3-4 μm in size. Penicilli were mostly biverticillate. Ramuli were 1-3 groups, smooth, and 10-16×2-3 μm in size. Rami were 1-2 groups and 6-30×2-4 μm in size. Metulae were 2-3(5) verticils, smooth, and 12-20×3-4 μm in size. Phialides were 5-7 verticilate, ampulliform to cylindroidal, smooth, and 8-12×2-3 μm in size. Optimum temperature for growth was about 25°C. Pathogenicity of the fungus was proved on tomato fruit according to Koch's postulation. On the basis of mycological and pathological characteristics, the fungus was identified as *P. oxalicum* Currie & Thom. This is the first report of the blue mold on tomato fruit caused by *P. oxalicum* in Korea.

Keywords : blue mold, *Penicillium oxalicum*, tomato

Various species of *Penicillium* cause the blue mold and the green mold, also known as penicillium rots. They are the most common and the most destructive post-harvest diseases, occurring on most fruits and vegetables during storage or transport. The ubiquitous causal fungus *Penicillium* mostly enters tissues through wounds (Agrios, 2005).

In 2006 and 2007, a blue mold on the fruit of tomato (*Solanum lycopersicum*) caused by a *Penicillium* species was consistently observed in the experimental field at Gyeongsangnam-do Agricultural Research and Extension Services, Korea. The disease mainly occurred on wounded or cracked fruits. Until now, 26 diseases caused by various microorganisms have been recorded on tomato in Korea. However, the penicillium rot has not been reported on tomato in this country yet (Cho and Shin, 2004). This study was conducted to identify the causal fungus of blue mold rot on tomato and to prove its pathogenicity for the first time in Korea.

Isolate. The causal pathogen of blue mold rot on tomato was isolated from the freshly diseased fruits of tomato (cv. Momotaro) grown under a greenhouse at Gyeongsangnam-do Agricultural Research and Extension Services, Korea. The fungal fragments were picked up from the fungal mass formed on the fruit surface and transferred to potato dextrose agar (PDA). After incubation for 3 days at 25°C, a small agar block containing the fungal mycelia and conidia was transferred to a water agar and smeared for the single isolation of the fungus under a microscope. The fungal isolates originated from single conidia were cultured on Czapek yeast extract agar (CYA) and malt extract agar (MEA) for 1-2 weeks for further investigations of mycological characteristics. The isolate grown on CYA (Fig. 1C) and MEA (Fig. 1D) showed whitish color at the early growing stage and turned bluish color with heavy conidial mass at maturity. The fungus grew well between 5°C to 30°C and maximally at 25°C for 7 days on the media.

Symptom. The disease occurred only on mature fruits but not on immature or young fruits. Among the mature fruits, the disease was observed only on cracked or wounded fruits in the field (Fig. 1A). The first symptom appeared as small water soaking lesion at the wound site and developed into watery rot. It is assumed that the epidermal cells of tomato are collapsed by various causes penetration by the pathogen is promoted under a high temperature and humid conditions since the disease was severe during the summer. The infection rate of the fruit was estimated about 8% in the fields.

Scanning electron microscopy. To examine the fungal structures under scanning electron microscope (SEM), the culture was cut into small pieces ca. 5×5 mm in size with a

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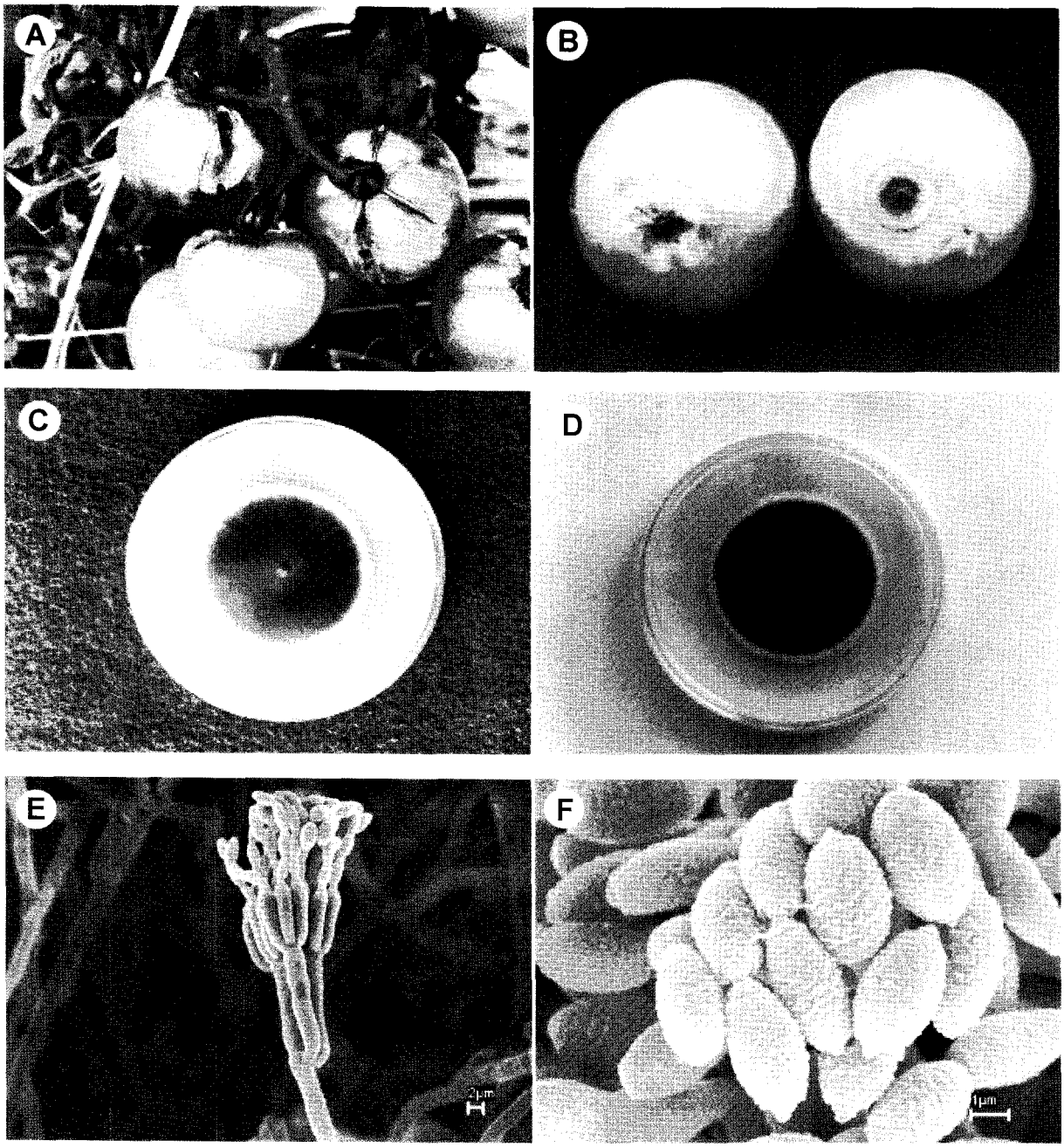

Fig. 1. Symptoms of blue mold rot on tomato and morphological characteristics of the causal fungus *Penicillium oxalicum*. Typical symptoms of the blue mold rot on tomato (A), a symptom induced by artificial inoculation (B), colony patterns of the causal fungus on CYA (C) and MEA (D), and scanning electron microscopy of conidiophore (E) and conidia (F).

surgical blade and fixed with 2.5% Karnovsky solution for 24 hrs at 4°C. After fixing the specimens were rinsed carefully with 0.05 M cacodylate buffer (pH 7.2) 10 min 3 times. Post fixing, the specimens were soaked in 1% osmium tetroxide solution for 2 hrs at 4°C and rinsed carefully 3 times with the same buffer solution. They were dehydrated through a series of ethanol solution gradient (50, 75, 90, 95 and 100%) after soaking for 20 min room temperature, and followed by isoamyl acetate 100% for 1 hr 2 times. After that, the samples were dried by critical point dryer for 1 hr and were coated by gold/palladium coating by Sputter coater.

Identification. Conidia were broadly ellipsoidal, sometimes subspheroidal in shape, 2-6×2-4 μm in size, smooth to finely roughened, thin walled, and borne in defined columns. The conidia formed very well to show thousands of ellipsoidal conidiophores and penicilli on MEA (Fig.

Table 1. Comparison of morphological characteristics of the fungus causing blue mold rot on tomato and *Penicillium oxalicum* previously described

Characteristics	Present isolate	*P. oxalicum*[a]
Conidia		
shape	ellipsoid	ellipsoid
size	2-6×2-4 μm	2.4-6.0×2.4-4.0 μm
wall	smooth to finely roughened	smooth to finely roughened
Conidiophores		
penicilli type	biverticillate	biverticillate
stipes	90-280×3-4 μm	100-300×3.2-4.0 μm
metulae	12-20×3-4 μm	15.5-21.8×3.2-3.9 μm
phialides		
shape	ampulliform to cylindroid	ampulliform to cylindroid
size	8-12×2-3 μm	9.6-12.8×2.8-3.2 μm
wall	smooth	smooth

[a]Described by Tzean et al. (1994).

1F). Most of the conidia appeared to be readily dispersed in the air. Numerous conidia were produced on the diseased, wounded and cracked fruits. Conidiophores and conidia were mostly borne from surface mycelium on MEA. Stipes were septate, smooth, thin walled, 90-280×3-4 μm in size. Penicilli were mostly biverticillate, occasionally monoverticillate. Ramuli were groups 1-3, smooth, 10-16×2-3 μm in size. Rami were groups 1-2, 6-30×2-4 μm in size. Metulae were verticils of 2-3(5), smooth, 12-20×3-4 μm in size. Phialides were appressed in verticilate of 5-7, ampulliform to cylindroidal, smooth, 8-12×2-3 μm in size, collula short, mostly very narrow (Fig. 1E, Table 1).

Since most characteristics of the fungus examined in this study matched well with *Penicillium oxalicum* described by previous workers (Tzean et al., 1994), the causal fungus of blue mold of mature tomato was identified as *P. oxalicum* Currie & Thom.

Pathogenicity. Each artificially wounded or non-wounded fruit of tomato (cv. Momotaro) was used for the pathogenicity test. The conidial suspension (50 ml) adjusted to ca. 10^8 conidia/ml were sprayed onto each six fruits placed in a plastic box. The container was moistened to reach 100% relative humidity and stored at 25°C. The typical symptoms on the wounded mature tomato appeared at 3 days after inoculation and developed rapidly (Fig. 1B). The fungus formed whitish mycelial mat at the early infection stage and produced bluish conidial mass from 5 days after inoculation. The symptoms induced by artificial inoculation were similar to those of naturally infected mature tomato. However, the disease did not developed on intact fruits. The fungus was re-isolated from inoculated fruits to confirm the Koch's postulation.

The type culture of the fungus is stored at the Korean Agricultural Culture Collection (KACC No. 42460), National Institute of Agricultural Biotechnology, Rural Development Administration, Suwon.

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