

Occurrence of Clubroot on Pak-Choi Caused by *Plasmodiophora brassicae*

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Clubroot symptoms occurred severely on roots of Pak-Choi (*Brassica campestris* ssp. *chinensis*) grown in greenhouses in Gwangju city, Gyeonggi province, Korea in September, 2008. The incidence of the disease symptoms reached as high as 90% in three greenhouses investigated. The root galls collected from the greenhouses were sectioned using a scalpel and observed by light microscope. Many resting spores were found in the cells of the root gall tissues. Suspension of resting spores was prepared from the root galls and inoculated to roots of healthy Pak-Choi plants. Each of five resting spore suspensions caused clubroot symptoms on the roots, which were similar to those observed during the greenhouse survey. Resting spores of the pathogen were observed in the cells of the affected roots. The clubroot pathogen was identified as *Plasmodiophora brassicae* based on its morphological and pathological characteristics. This is the first report that *Plasmodiophora brassicae* causes clubroot of Pak-Choi.

KEYWORDS : *Brassica campestris* ssp. *chinensis*, Clubroot, Pak-Choi, Pathogenicity, *Plasmodiophora brassicae*

Pak-Choi (*Brassica campestris* L. ssp. *chinensis* Jusl.) is grown primarily in Asian countries and is a popular vegetable in Korea. Clubroot symptoms were observed on roots of Pak-Choi grown in greenhouses in Gwangju city, Gyeonggi province, Korea, during a disease survey per-

formed in September, 2008. The symptoms appeared as galls on the roots (Fig. 1A). The infected plants were retarded in growth and wilted at the late stage of growth (Fig. 1B). Three greenhouses of Pak-Choi were investigated for disease occurrence. The incidence of the dis-

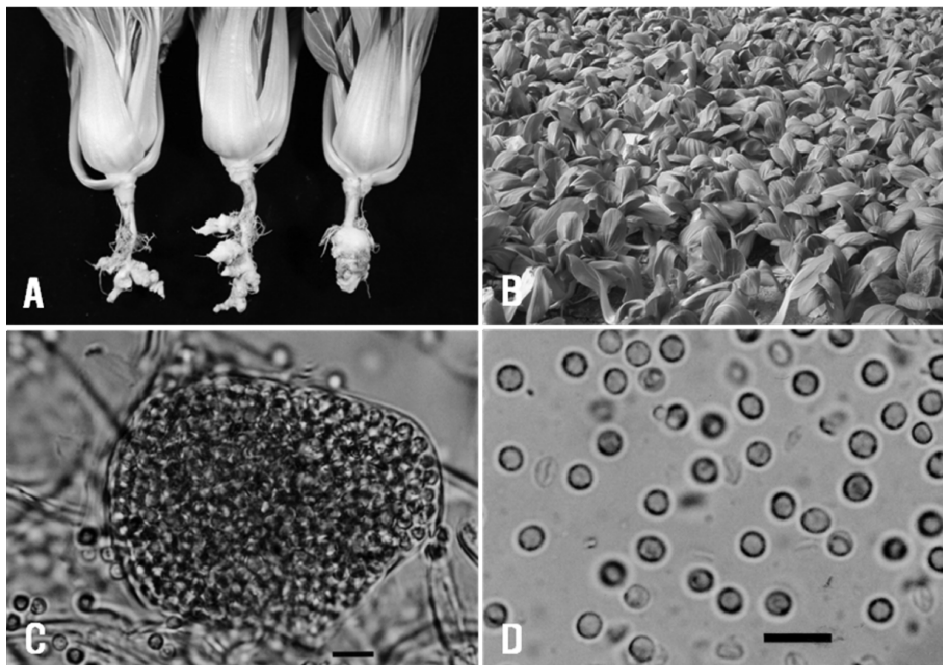


Fig. 1. Clubroot symptoms on Pak-Choi plants observed in the greenhouse and observation of root tissue sections by light microscope. A, galls produced on the roots; B, infected plants showing wilt; C, a cell including resting spores and resting spores released from the cell (scale bar = 10 μ m); D, resting spores released from cells (scale bar = 10 μ m).

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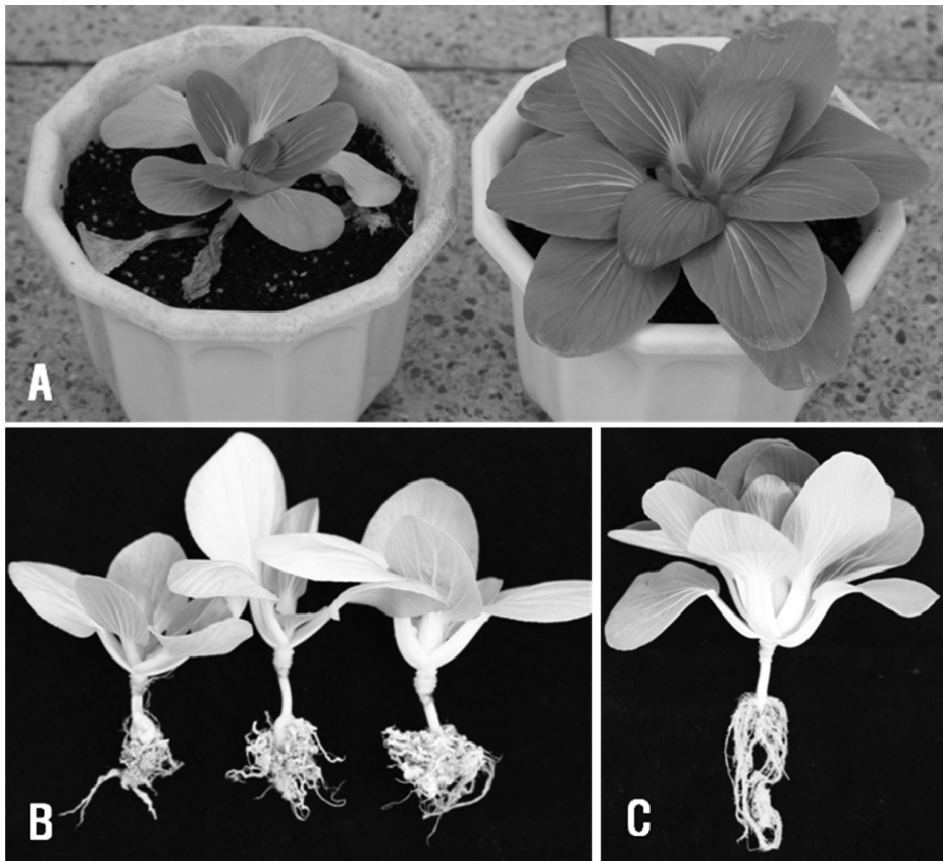


Fig. 2. Clubroot symptoms produced on healthy Pak-Choi plants 48 days after inoculation with resting spore suspensions of the pathogen. A, an inoculated plant showing growth retardation (left) and a non-inoculated plant showing normal growth (right); B, inoculated plants with root galls; C, a non-inoculated plant showing normal growth of roots.

ease symptoms ranged from 1 to 90% in the greenhouses investigated.

Root galls of Pak-Choi were collected from the greenhouses for examination and inoculation experiments. The root galls were sectioned using a scalpel and observed by light microscope. Many resting spores were found in the cells of the root gall tissues (Fig. 1C and 1D). The resting spores were hyaline, spherical and measured 2.5~4.0 μm in diameter.

Five root galls of Pak-Choi collected were used for inoculum preparation of the pathogen. Suspension of resting spores was prepared from each of the collected root galls by the procedure of Cho *et al.* (2003). The suspension was adjusted to a concentration of $5\sim6 \times 10^6$ spores/ml using a hemocytometer. The 20 ml suspension prepared from each gall was inoculated to roots of 30-day-old Pak-Choi plants in a greenhouse at 18~28°C, as previously described (Cho *et al.*, 2003). The same quantity of sterile distilled water was used as the control. Disease ratings were made based on the degree of gall formation on the roots 48 days after inoculation. The inoculation test was performed in three independent replicates.

Each of five resting spore suspensions caused clubroot symptoms on the roots, which were similar to those observed during the greenhouse survey (Fig 2). Resting spores of the pathogen were observed in the cells of the affected roots. The clubroot pathogen was identified as *Plasmodiophora brassicae* Woronin based on its morphological and pathological characteristics, which were consistent with those described by Buczacki (1979). It was reported that *P. brassicae* causes clubroot of crucifers (Buczacki, 1979; Cubeta *et al.*, 1998; Linnasalmi and Toiviainen, 1991). The disease has been a major problem in areas where Chinese cabbage and some other cruciferous crops are cultivated in Korea (Cho *et al.*, 2003; Kim and Oh, 1997). Pak-Choi is a cruciferous crop and cultivated commonly in Asian countries. However, there has been no report on the disease occurrence in the crop. This is the first report that *P. brassicae* causes clubroot of Pak-Choi.

Diverse physiologic races based on the pathogenicity of *P. brassicae* isolates have been reported attacking crucifers (Ayers, 1957; Buczacki *et al.*, 1975; Johnston, 1968; Williams, 1966). Further study is needed to identify races of the pathogen attacking Pak-Choi.

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