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First Report of Sclerotinia Rot Caused by *Sclerotinia sclerotiorum* on Some Vegetable Crops in Korea

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Sclerotinia rot occurred severely on some vegetable crops grown in Namyangju, Yangpyung, and Yangju areas in Korea in 2001-2002. The crops infected with *Sclerotinia* sp. were *Adenophora remotiflora*, *Armoracia lapathifolia*, *Angelica acutiloba*, *Angelica archangelica*, *Anthriscus sylvestris*, *Aster tataricus*, *Beta vulgaris* var. *cicla*, *Brassica campestris* var. *marinosa*, *Brassica juncea* var. *laciniata*, *Chichorium intybus*, *Lactuca indica* var. *dracoglossa*, *Lactuca sativa* var. *oak-leaf*, *Petroselinum crispum*, and *Phyteuma japonicum*. The fungus associated with the disease was identified as *Sclerotinia sclerotiorum*, based on the morphological characteristics of the pathogen. The symptoms were water-soaked spots that enlarged later and became a watery soft rot. Infected parts became yellow and then turned brown, followed by death of the whole plant. White mycelia developed on the upper petioles and leaves and on the soil where these plant parts lay. Then black sclerotia in variable size and shape formed from the mycelial mass. Pathogenicity of the fungus was proven by artificially inoculating each crop. This is the first report of Sclerotinia rot on the listed vegetable crops in Korea.

Keywords **:** *Sclerotinia sclerotiorum*, Sclerotinia rot, vegetable crops, pathogenicity

Vegetable crops are very popular as fresh food in Korea. In Gyeonggi province, these are commonly cultivated in vinylhouses year-round. Sclerotinia rot severely occurred in some cultivated areas in recent years. One of reasons for the severe incidence of the disease is the simplified cropping system or continuous monocropping associated with year-round cultivation system. In particular, the cool and humid conditions are favorable for the occurrence of Sclerotinia rot from the early to the late growing stages of the vegetable crops. Continuous cropping also results in severe outbreaks of the disease due to the increased density of sclerotia or other inoculum in the air and soil. It was reported that the disease often occurs on crowns, petioles and leaves of vegetable crops, and that it was also named as Sclerotinia drop rot, drop, decay, watery soft rot, or white mold depending on the hosts (Jagger, 1920; Farr et al., 1989). However, the disease is commonly called Sclerotinia rot in Korea (Anonymous, 1998; Kim and Cho, 1998).

Sclerotinia sclerotiorum (Lib.) de Bary is a fungus causing destructive disease of numerous plants, particularly vegetables. Diseases caused by *S. sclerotiorum* appear in all stages of plant growth, including seedling, mature plants, and harvested products (Agrious, 1997; Coley-Smith and Cooke, 1971). It was reported that the fungus attacks more than 400 different species of plants (Purdy, 1979; Bonald and Hall, 1994). However, in Korea, the host of *S. sclerotiorum* was reported within taxonomic groups as follows: 14 families, 26 genera, and 29 species of plants (Anonymous, 1998).

The authors found Sclerotinia rots of some vegetable plants (Table 1) cultivated in vinylhouse located in Namyangju, Yangpyung, and Yangju areas of Gyeonggi province, Korea from 2001 to 2002. Vegetables in these areas are now produced all year-round. Therefore, if accurate diagnosis and control are not carried out, Sclerotinia rot caused by *S. sclerotiorum* may be a potential threat to vegetable cultivation under environmental conditions favorable to the disease. This study described the symptoms of Sclerotinia rot and identified its causal fungus.

Materials and Methods

Isolation. Vegetable crops grown in vinylhouses in Namyangju, Yangpyung, and Yangju areas were surveyed from 2001 to 2002. Incidence of Sclerotinia rot on the vegetable crops was investigated, and diseased plants were collected as listed in Table 1. *Sclerotinia* sp. was isolated from the lesions according to the method described by Kim et al. (1999). Five to 25 mm^2 lesion pieces cut from the diseased plant parts were plated on 2% water agar (WA) after surface-sterilizing with 1% sodium hypochlorite solution for 3 minutes. The fungus was isolated from the lesion pieces after 1-2 days of incubation at 22°C. The isolates were transferred to potato dextrose agar (PDA) slants and cultured for identification.

Identification. Each isolate was cultured on PDA in 9-cm-diameter petri dishes at 22°C in the dark for 20 days for the production of sclerotia. Sclerotia produced on the medium were

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Table 1. Isolates of *Sclerotinia sclerotiorum* on some vegetable plants in different areas of Korea

Host plant (Scientific name)	Korean name	No. of isolates	Geographic origin (location)	Year collected
Adenophora remotiflora	Mosidae	2	Namyangju	2001
Armoracia lapathifolia	Kyeozamu	2	Namyangju	2001
		1	Yangpyung	2001
Angelica acutiloba	Illdangui	2	Namyangju	2001
		2	Yangpyung	2001
Angelica archangelica	Sinseoncho	1	Namyangju	2001
		1	Yangpyung	2001
Anthriscus sylvestris	Jeonho	2	Namyangju	2001
Aster tataricus	Gaemichi	1	Namyangju	2001
		1	Yangpyung	2002
Beta vulgaris var. *cicla*	Geundae	1	Namyangju	2001
		1	Yangju	2002
Brassica campestris var. *marinosa*	Dachae	1	Namyangju	2001
		1	Yangpyung	2001
Brassica juncea var. *laciniata*	Kyungsuchae	1	Namyangju	2001
		1	Yangpyung	2001
Chichorium intybus	Chicory	2	Namyangju	2001
		1	Yangpyung	2001
Lactuca indica var. *dracoglossa*	Yongseolchae	1	Namyangju	2002
		1	Yangpyung	2001
Lactuca sativa var. *oak-leaf*	Oak-leaf	1	Namyangju	2001
		1	Yangpyung	2001
Petroselinum crispum	Parsley	3	Namyangju	2001
Phyteuma japonicum	Youngaza	2	Yangpyung	2002

examined for morphological characteristics and preserved in a low temperature incubator at 0°C for 1 month. The sclerotia were placed in 250-ml flasks with sterile wet sand and incubated at 15°C for 1-5 months in alternating cycles of 12-hour fluorescent light and 12-hour darkness. Apothecia produced from the sclerotia during the incubation were collected and examined for their morphological features.

Pathogenicity test. Vegetable plants recorded in Table 1 were used for pathogenicity tests. Seeds of each species were sown in a plastic pot (5 × 15 × 10 cm) filled with sterile soil. Seedlings of each species were transferred and cultivated in the greenhouse at 18-30°C. One isolate of *Sclerotinia sclerotiorum* from each host was used for pathogenicity tests to the hosts. Fresh mycelial plugs 6 mm in diameter from PDA cultures of each isolate were placed on the leaves or petioles above ground of 2~3-week-old host plants grown in plastic pots. PDA disks of the same size were placed on the leaves of control plants. The pots with inoculated plants were placed in dew chambers with 100% relative humidity at 22°C for 48 hours and then moved into the greenhouse. Virulence of the isolates was rated based on the degree of rot symptoms at 10 days after inoculation. The inoculation test was performed in three replicates.

Results

Symptoms. Sclerotinia rot commonly occurred in 14 vegetable crops grown in three areas in Korea (Table 1). The disease occurred from autumn to spring. Occurrence of the disease was in 29 of 36 vinylhouses surveyed during the growing seasons (data not shown). The disease most severely occurred, up to 70%, on *Angelica acutiloba* among the vegetable crops surveyed. The symptoms of sclerotinia rot infected with *Sclerotinia* sp. were similar to those of all vegetable crops listed in Table 1. The symptoms that often developed on the lower leaves or petioles at the soil-line were water-soaked spots, which became a watery soft rot. Infected parts became yellow or pink in color and then turned brown followed by death of the whole plant (Fig. 1). White mycelia developed on the upper petioles, leaves, and on the soil where these plant parts were laid, and black sclerotia in variable sizes and shapes formed from the mycelial mass. On above ground plant parts in some fields, sclerotia geminated to produce apothecia which released airborne ascospores (Figs. 2C, D, E, F, G, and H).

Isolation and identification. A total of 33 isolates of *Sclerotinia* sp. was obtained from lesions of sclerotinia rot on 14 vegetable crops (Table 1). All the isolates from the lesions were identified as *Sclerotinia sclerotiorum* (Lib.) de Bary based on their morphological characteristics (Table 2). Colonies of the fungus on PDA were white to gray, and globose to irregular black sclerotia were produced on the medium (Figs. 2A and B). The sclerotia measured 0.5-

Fig. 1. Sclerotinia rot symptoms on some vegetable crops naturally infected by *Sclerotinia sclerotiorum* in the field (**A** = *Adenophora remotiflora*; **B** = *Armoracia lapathifolia*; **C** = *Angelica acutiloba*; **D** = *Angelica archangelica*; **E** = *Anthriscus sylvestris*; **F** = *Aster tataricus*; **G** = *Beta vulgaris* var. *cicla*; **H** = *Brassica campestris* var. *marinosa*; **I** = *Brassica juncea* var. *laciniata*; **J** and **K** = *Chichorium intybus*; **L** = *Lactuca indica* var. *dracoglossa*; **M** = *Lactuca sativa* var. *oak-leaf*; **N** = *Petroselinum crispum*; **O** = *Phyteuma japonicum*).

9.0 × 0.4-6.1 mm. Apothecia produced from sclerotium were pale to yellowish brown and cup-shaped. The apothecial disks were cup-shaped and yellowish-brown, and 2-12 mm in diameter. The length of apothecial stalks measured 5-28 mm. Asci were cylindrical, 8-spored and measured 120-185 × 8-10 um (average 145.7 × 9.2 um). Ascospores were hyaline, ellipsoid to ovoid, and measured 10-17 × 5-8 um (average 13.2 × 6.3 um).

Pathogenicity. Fourteen isolates of *S. sclerotiorum* induced rot symptoms on the 14 vegetable crops inoculated (Table 3). The symptoms were similar to those observed in the fields. Characteristic lesions were noticed on the leaves inoculated with agar block at 1-2 days after treatment. Inoculated parts became a watery soft rot in yellow or pink color. The organ having lesions began rotting or blighting when lesions enlarged and coalesced 3-5 days after inoculation. Some of the plant parts with lesions entirely died 10 days after inoculation. *S. sclerotiorum* was re-isolated from the lesions on the plants inoculated. The re-isolated isolates also induced the lesions observed in the fields.

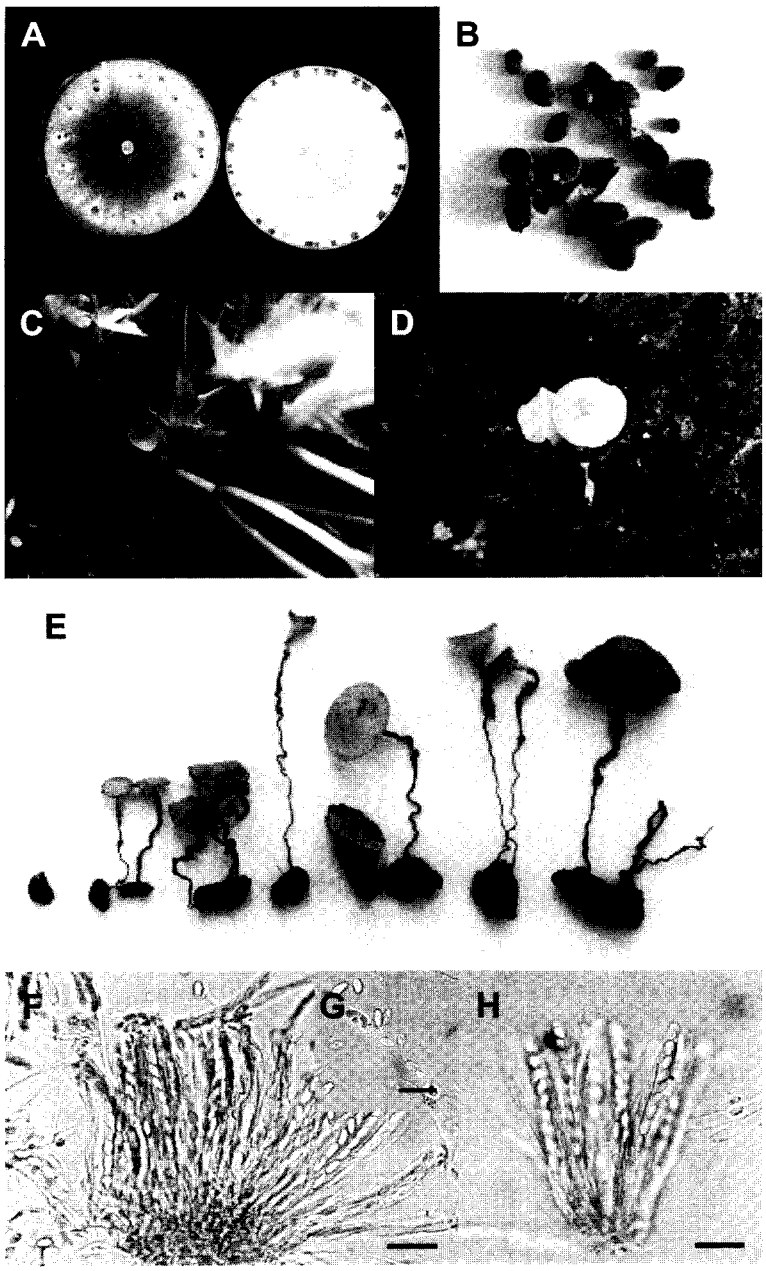

Fig. 2. Colonies grown on PDA after 20 days incubation at 25°C (**A**), Sclerotia (**B**), Apothecia (**C**, **D**, **E**), Asci and Ascospores (**F**, **G**, **H**) of *Sclerotinia sclerotiorum*. The bar represents 20 μm.

Discussion

Sclerotinia sclerotium appears to be among the most non-specific, omnivorus, and successful of plant pathogens (Abams and Ayers, 1979; Kohn, 1979b). Purdy (1979) has identified a host range within taxonomic groups as follows: 64 plant families, 225 genera, 361 species, and 22 other (cultivars, etc.), for a total of 383 species and other categories.

However, in Korea, the host range of *S. sclerotium* was reported to be within taxonomic groups as follows: 14 plant families, 26 genera, and 29 species (Anonymous, 1998). The present study revealed that *S. sclerotiorum* causes sclerotinia rot on 14 vegetable crops in Korea.

The symptoms on 14 vegetable crops were similar to those reported by other workers (Purdy, 1979; Boland and Hall, 1994; Cho et al., 1997; Kim and Cho, 2002). Infected parts became a watery soft rot in yellow or pink color and then turned brown followed by death of the whole plant. Infections of soil-line or above ground plant parts may

Table 2. Comparison in morphological characteristics of *Sclerotinia* sp. isolated from some vegetable crops and *Sclerotinia sclerotiorum*

Characteristics		Present isolate	*Sclerotinia sclerotium* [a]
Colony	Color	White to gray	White to gray
Apothecium			
Disc	Shape	Cup-shaped with yellowishbrown color	Cup-shaped with yellowishBrown color
	Size (mm)	2-12 (average 6.2)	2-8 (-10)
Stalk	Shape	Arising singly or in small groups from sclerotia, yellowish-brown to light- brown, cylindrical, smooth	Arising singly or in small groups from sclerotia, yellowish-brown to light- brown, cylindrical, smooth
Ascus	Shape	Cylindrical, hyaline, 8-spored	Cylindrical, hyaline, 8-spored
	Size (μm)	120-185 × 8-10 (average 145.7 × 9.2)	(110-)130-150 (-160) × 6-10
Ascospore	Shape	Hyaline, ellipsoid to ovoid	Hyaline, ellipsoid to ovoid
	Size (μm)	10-17 × 5-8 (average 13.2 × 6.3)	(9-)10-14 × 4-5(-6)
Sclerotium	Shape	Initially cushion-like or globular or irregular, darkbrown, finally black	Iinitially cushion-like or short-cylindrical and white, finally black
	Size (μm)	0.5-9 × 0.4-6.1 (average 3.4)	3-10

[a] Morphological data for *S. sclerotiorum* are from Kohn (1979a).

Table 3. Pathogenicity of *Sclerotinia sclerotiorum* isolates from different areas in Korea tested by artificial inoculation

Host plant	Isolate no.	Geographic origin (location)	Virulence of isolates to the host
Adenophora remotiflora	SS21009	Namyangju	++
Armoracia lapathifolia	SS21005	Namyangju	++
Angelica acutiloba	SS21016	Yangpyung	++
Angelica archangelica	SS21007	Namyangju	+
Anthriscus sylvestris	SS21008	Namyangju	+++
Aster tataricus	SS22009	Yangpyung	++
Beta vulgaris var. *cicla*	SS22010	Yangpyung	+
Brassica juncea var *laciniata*	SS21011	Namyangju	++
Brassica campestris var. *marinosa*	SS21015	Namyangju	++
Chichorium intybus	SS21012	Yangpyung	++
Lactuca indica var. *dracoglossa*	SS22015	Namyangju	+
Lactuca sativa var. *oak-leaf*	SS21015	Namyangju	++
Petroselinum crispum	SS21022	Namyangju	++
Phyteuma japonicum	SS22008	Yangpyung	++

+ = slight, ++ = moderate, +++ = severe.

result from released ascospores or sclerotia.

S. sclerotium was distinguishable from other Sclerotinia species in terms of size of sclerotia and apothecia, and size and number of ascospores. Size of sclerotia and apothecia of *S. sclerotiorum* is bigger than that of other species (Purdy, 1955; Wang and Willetts, 1975; Kim and Cho, 2002). The morphological characteristics of the species isolated by the present authors are similar to those reported by other workers in Korea (Cho et al., 1997; Kim and Cho, 1998). Kim and Cho (2002) also reported some mycological and pathological characteristics of *S. sclerotiorum* and *S. minor* causing Sclerotinia rot of vegetable crops.

All of the 14 isolates tested were virulent on vegetable plants tested. Price and Calhoun (1975) reported that there were differences in virulence of *S. sclerotiorum* isolates to individual hosts and in susceptibility of the host plants to different isolates. Kim et al. (1999) found that there were some differences in virulence of *S. sclerotiorum* isolates to cucurbitaceous vegetable crops and in susceptibility of some of the crops to the isolates. It has also been reported that there were differences in susceptibility of cultivars of some crops to the fungus (Cassells and Walsh, 1995; Grau and Bissonnette, 1974; Orellana, 1975; Porter et al., 1975). There was a significant difference in pathogenicity among the isolates examined by the present authors. All isolates were pathogenic on each crop. Isolate SS21008 was the most virulent capable of causing highly susceptible reactions of the host. Significant differences in resistance were also found among crops. *Angelica archangelica, Beta vulgaris* var. *cicla*, and *Lactuca indica var. dracoglossa* were

confirmed to be more susceptible than the other crops. Detailed researches on resistance of these crops using cross inoculation may be essential for crop rotation.

Vegetables in vinylhouses located in Namyangju, Yangpyung, and Yangju areas are now produced all year-round. Therefore, Sclerotinia rot caused by *S. sclerotiorum* may be a potential threat to vegetable cultivation under environmental conditions favorable for the disease. Infection of plant parts before harvest may also result in post-harvest disease in storage or shipping containers. Therefore, detailed epidemiological data may be essential for the development of effective and economical control programs for the disease caused by *S. sclerotiorum*.

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