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Occurrence of Sclerotinia Rot in Solanaceous Crops Caused by *Sclerotinia* spp.

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Solanaceous crops grown in greenhouses and fields in Korea were surveyed from 1994 to 2000. Sclerotinia rot most severely occurred up to 60% in potato. Incidence of the disease was as high as 20% at its maximum in tomato and 5% in eggplant, but as low as less than 1% in red pepper. Symptoms of Sclerotinia rot commonly developed on stems of the solanaceous crops but rarely on fruits of eggplant and tomato. A total of 169 isolates of *Sclerotinia* species was obtained from the diseased solanaceous crops. Out of the isolates, 165 isolates were identified as *S. sclerotiorum*, and the others as *S. minor* based on their morphological and cultural characteristics. *S. sclerotiorum* was isolated from all the solanaceous crops, while *S. minor* was only isolated from tomato. Eight isolates of *S. sclerotiorum* and two isolates of *S. minor* were tested for their pathogenicity to the solanaceous crops by artificial inoculation. All the isolates of the two *Sclerotinia* spp. induced rot symptoms on stems of the solanaceous crops tested, which were similar to those observed in the fields. The pathogenicity tests revealed that there was no significant difference in the susceptibility of the solanaceous crops to the isolates of *S. sclerotiorum*. However, in case of *S. minor*, the potato cultivar Sumi was relatively less susceptible to the pathogen.

KEYWORDS: Pathogenicity, Sclerotinia rot, *Sclerotinia sclerotiorum*, *S. minor*, Solanaceous crops

Solanaceous crops are cultivated throughout the world as important vegetables or a food source. In Korea, most solanaceous crops except potato are cultivated in the greenhouse conditions. The greenhouse conditions are favorable for occurrence of fungal diseases on the crops due to the high humidity. Especially, Sclerotinia rot is apt to readily occur under cool and moist conditions (Purdy, 1979; Willetts and Wong, 1980).

Severe outbreaks of stem or fruit rot symptoms with sclerotial formation were sometimes observed during a disease survey of solanaceous crops in several locations in the country during the cool seasons. *Sclerotinia* spp. were consistently isolated from the diseased plants. The disease of the crops caused by *Sclerotinia* spp. has been generally called as Sclerotinia rot (Cho *et al.*, 1997; Kim and Cho, 1998). The disease was also recorded as Sclerotinia stem rot, Sclerotinia fruit rot, fruit and stem rot, fruit rot, stem blight and rot, white mold or pink joint depending on the species of the solanaceous crops (Farr *et al.*, 1989).

It has been reported that *Sclerotinia sclerotiorum* (Lib.) de Bary and *S. minor* Jagger cause Sclerotinia rot in a variety of plants (Boland and Hall, 1994; Farr *et al.*, 1989; Melzer *et al.*, 1997; Purdy, 1979; Tai, 1979). In Korea, Cho *et al.* (1997) briefly described symptomatical and developmental characteristics of the disease in three solanaceous vegetable crops with some mycological characteristics of the causal *Sclerotinia* species. Kim and Cho (1998) also reported some mycological and pathological characteristics of *S. sclerotiorum* and *S. minor* causing Sclerotinia rot of vegetable crops. Few studies have been conducted on the detailed characteristics of the disease occurrence and the pathogenicity of the causal *Sclerotinia* species on solanaceous crops. This study was conducted to reveal trends of the disease occurrence in solanaceous crops in Korea, and the pathological aspects of the causal *Sclerotinia* spp.

Materials and Methods

Disease survey and collection of diseased samples. Solanaceous crops grown in greenhouses and fields in Korea were surveyed from 1994 to 2000. Incidence of Sclerotinia rot on the crops was investigated, and diseased plants were collected. The severity of the disease was rated in terms of percentage of infected plants among 50 to 100 plants observed with three replicates in each infected field.

Isolation. *Sclerotinia* spp. were isolated from the lesions according to the method described previously (Kim *et al.*, 1999). Nine to 25 mm^2 lesion pieces cut from the diseased plant parts were placed on 2% water agar (WA) after surface-sterilizing with 1% sodium hypochlorite solution for 1 minute. The plates were incubated for 1~2 days at 22°C. The fungi grown from the lesion pieces were transferred to potato dextrose agar (PDA) slants and cul-

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tured for identification.

Examination of morphological and cultural characteristics. Each isolate was cultured on PDA in 9-cm-diameter petri dishes at 22°C in the dark for 12 days for the production of sclerotia. Sclerotia produced on the medium were examined for morphological characteristics, and were preserved in a low temperature incubator at 0°C for 3 days. Then, the sclerotia were placed in 250-m*l* flasks with sterile wet sand and incubated at 15°C for 1~5 months in alternating cycles of 12-hr fluorescent light and 12-hr darkness to induce the formation of apothecia. Apothecia produced from the sclerotia during the incubation were collected and examined for the morphological features. Nuclei in the ascospores were stained with DAPI (Martin, 1987), and were observed under a fluorescent light microscope.

Colony morphology of each isolate on PDA was examined 12 days after incubation at 22°C in the dark. Temperature range for mycelial growth of the isolates was examined in PDA culture. Optimum temperature was determined based on the mycelial growth length of the isolates per 24 hours.

Pathogenicity test. Two cultivars each of solanaceous crops such as eggplant (*Solanum melongena* L.), potato (*S. tuberosum* L.), red pepper (*Capsicum annuum* L.), and tomato (*Lycopersicon esculentum* Mill.) were used for pathogenicity tests. Potato seed tubers and the other crop seeds of each cultivar were sown in circular plastic pots (29 cm in height and 21 cm in diameter) filled with sterile soil in a greenhouse at 18~28°C. After germination of the seed tubers and seeds, selected one plant per pot was cultivated in the greenhouse.

Two isolates of each *Sclerotinia* species from each host were used for the pathogenicity tests to the solanaceous crops. Fresh mycelial mats (6 mm in diameter) of each isolate grown on PDA were placed on the stems of 5 to 10 cm above ground of 30-day-old plants of potato and 46-day-old plants of the other crops grown in the plastic pots. PDA disks of the same size were placed on the stems of the plants as a control. The pots with inoculated plants were placed in a dew chamber with 100% relative humidity at 22°C for 48 hr and then moved into the greenhouse. Virulence of the isolates was rated based on the degree of rot symptoms induced 20 days after inoculation. The inoculation test was performed with three replicates.

Results

Disease incidence and symptoms. Sclerotinia rot commonly occurred in four solanaceous crops grown in several locations in Korea (Table 1). Occurrence of the disease was observed in 7 out of 38 tomato-growing locations, and in one each out of 11 eggplant-, 8 potato-, and 56 red pepper-growing locations surveyed during the growing seasons. The disease severely occurred up to 60% in potato. Incidence of the disease was as high as 20% at its maximum in tomato and 5% in eggplant, but as low as less than 1% in red pepper.

Symptoms of Sclerotinia rot commonly developed on stems of the solanaceous crops but rarely on fruits of eggplant and tomato (Fig. 1). Infected plant parts rotted with white to gray yellow discoloration. Cottony mycelia frequently developed on the infected plant parts. Globose to irregular black sclerotia were produced on the infected plant parts at the late stages of the disease development.

Isolation and identification. A total of 169 isolates of *Sclerotinia* species was obtained from lesions of Sclerotinia rot in four solanaceous crops (Table 2). The *Sclerotinia* species were isolated from stems of all the solanaceous crops and fruits of eggplant and tomato. Out of the 169 isolates, 165 isolates were identified as *S. sclerotiorum*, and the others as *S. minor* based on their morphological and cultural characteristics as described by previous workers (Jagger, 1920; Kohn, 1979; Willetts and Wong,

Table 1. Incidence of Sclerotinia rot in solanaceous crops in Korea from 1994 to 2000

Host (No. of locations surveyed)	Location where disease occurred	No. of fields investigated	No. of fields infected	% infected plants[a]
Eggplant (11)	Yeoju	43	7	1-5
Potato (8)	Jeju	41	11	5-60
Red pepper (56)	Hadong	7	4	less than 1
Tomato (38)	Boryeong	29	3	less than 1
	Cheongwon	48	8	1-20
	Iksan	42	2	less than 1
	Jangseong	12	1	less than 1
	Jeju	5	1	less than 1
	Namyangju	8	8	2-20
	Yesan	28	1	less than 1

[a]Fifty to 100 plants in each infected field were investigated with three replicates.

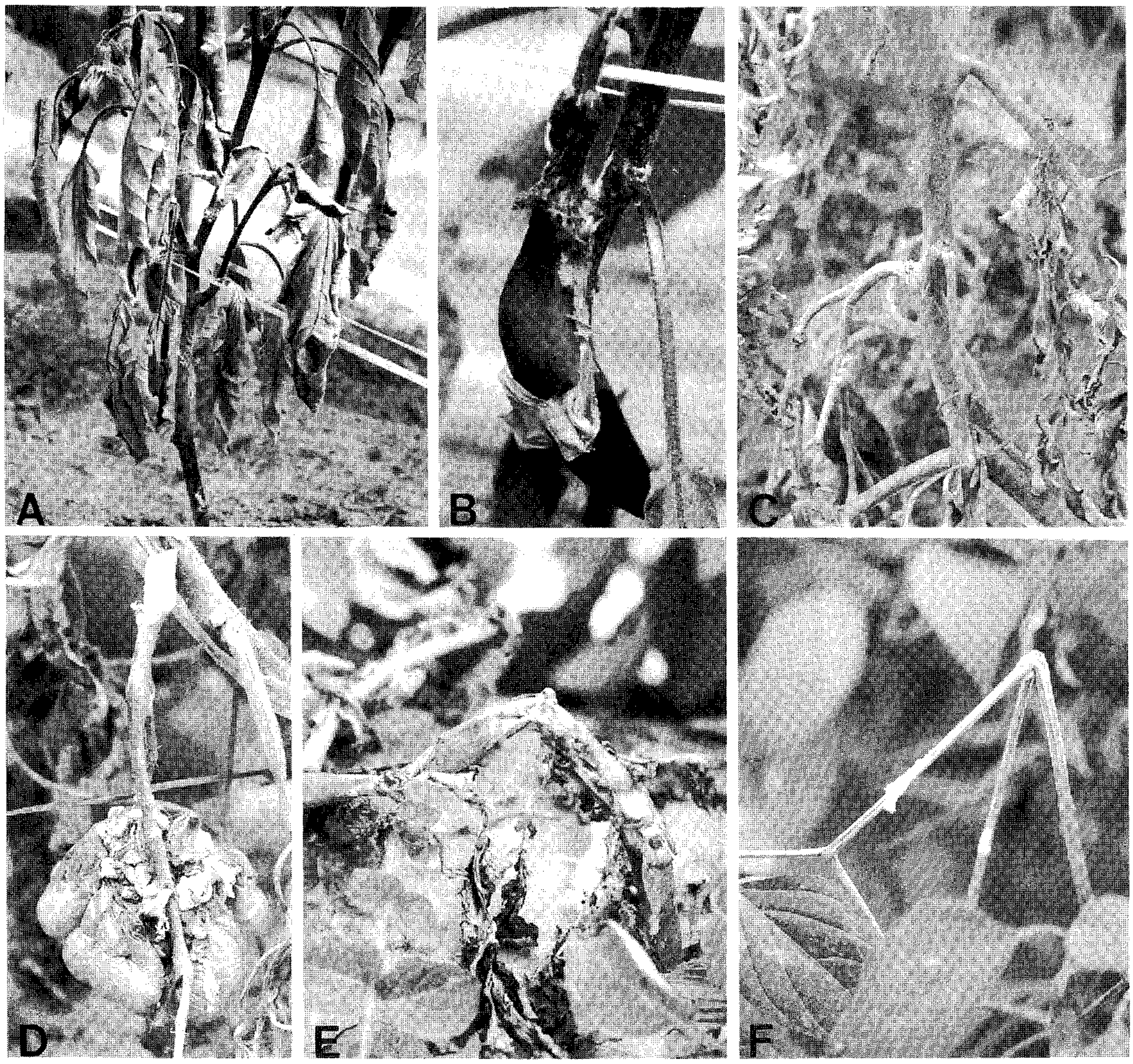

Fig. 1. Symptoms of Sclerotinia rot in four solanaceous crops grown in the fields. A and B, eggplant; C and D, tomato; E, potato; F, red pepper.

Table 2. Isolation and identification of *Sclerotinia* spp. from diseased plant parts of four solanaceous crops

Host	No. of isolates obtained			No. of isolates identified	
	Stem	Fruit	Total	*S. sclerotiorum*	*S. minor*
Eggplant	29	3	32	32	0
Potato	26	0	26	26	0
Red pepper	20	0	20	20	0
Tomato	84	7	91	87	4
Total	159	10	169	165	4

1980). *S. sclerotiorum* was isolated from all the solanaceous crops, while *S. minor* was only isolated from tomato.

Morphological and cultural characteristics. Colonies of *S. sclerotiorum* on PDA consisted of white to gray mycelia and globose to irregular and black sclerotia (Fig. 2A). *S. minor* produced a lot of sclerotia on the medium, which were small, globose to irregular and black (Fig. 2D). A sclerotium of *S. sclerotiorum* produced one to several apothecia (Fig. 2B), and that of *S. minor* produced one or two apothecia (Fig. 2E). Asci of *S. sclerotiorum* and *S. minor* were very similar, which were cylindrical and 8-spored (Fig. 2C and F). Ascospores of the two species were also very similar, which were hyaline, ellipsoid to ovoid. The morphological and cultural characteristics of the two species differed in terms of number of sclerotia formed on the medium, size of sclerotia and apothecia, and number of nuclei in the ascospores (Table 3).

Pathogenicity. Eight isolates of *S. sclerotiorum* and two isolates of *S. minor* induced rot symptoms on stems of the four solanaceous crops inoculated (Table 4). The symptoms were similar to those observed in the fields. *Sclerotinia* spp. were re-isolated from the lesions of the plants inoculated. The pathogenicity tests revealed that there was

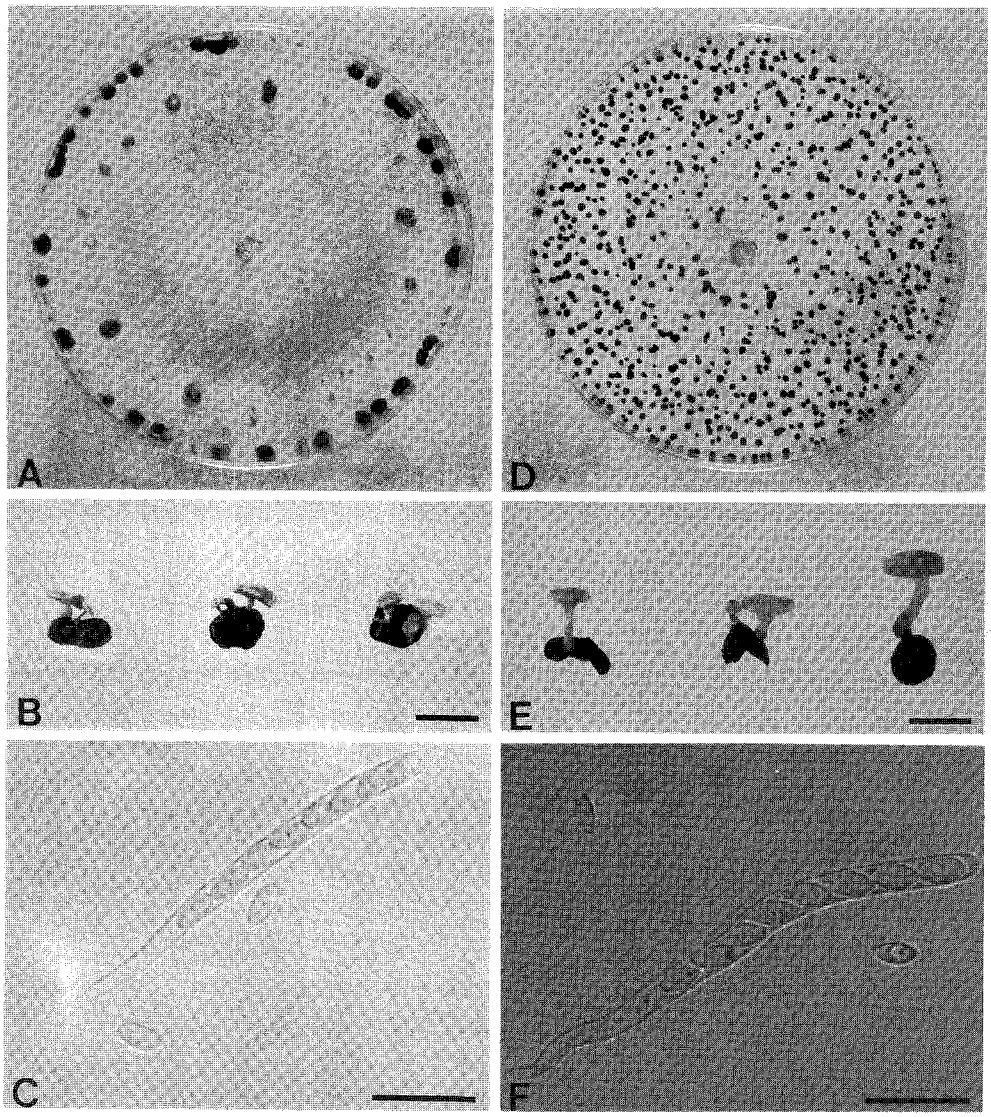

Fig. 2. Cultural and morphological features of *Sclerotinia sclerotiorum* (A-C) and *S. minor* (D-F) isolated from solanaceous crops. A and D, 12-day-old colonies on PDA at 22°C in the dark; B (scale bar = 4 mm) and E (scale bar = 3 mm), apothecia produced from sclerotia; C and F, asci and ascospores (scale bar = 30 mm).

no significant difference in virulence between the isolates of *S. sclerotiorum* and *S. minor* to the solanaceous crops. Also, there was no significant difference in the susceptibility of the solanaceous crops to the isolates of *S. sclerotiorum*. However, in case of *S. minor*, the potato cultivar Sumi was relatively less susceptible to the pathogen.

Discussion

S. sclerotiorum and *S. minor* have been reported to be the pathogen of Sclerotinia rot of solanaceous crops (Dennis, 1981; Farr *et al.*, 1989; Gonzalez *et al.*, 1998; Purdy, 1979; Tai, 1979). The present study showed that *S. sclerotiorum* and *S. minor* were associated with the occurrence of Sclerotinia rot in four solanaceous crops in Korea. *S. sclerotiorum* was isolated from all the solanaceous crops, and its pathogenicity to the hosts was confirmed by artificial inoculation. However, *S. minor* was only isolated from tomato inducing typical Sclerotinia rot symptoms in all the solanaceous crops by artificial inoculation. Based on the pathogenicity test, *S. minor* may have caused the disease in eggplant, potato, and red pepper in the field although it was not isolated from the three solanaceous crops.

S. minor is known to have somewhat narrower host range than *S. sclerotiorum* (Kohn, 1979; Willetts and Wong, 1980). The isolation frequency of *S. sclerotiorum* from four solanaceous crops was much higher than that of *S. minor*, suggesting that the former species is widely distributed in the field and is the main pathogen of Sclerotinia rot of the solanaceous crops. The tendency in the isolation frequency of the two *Sclerotinia* spp. from solan-

Table 3. Morphological and cultural characteristics of *Sclerotinia sclerotiorum* and *S. minor* isolated from solanaceous crops

Examination	Division	Description of characteristics	
		S. sclerotiorum	*S. minor*
Sclerotium	Formation	18~40/petri dish	500~800/petri dish
	Color	Black	Black
	Shape	Globose to irregular	Globose to irregular
	Size	0.6~10.0x0.6~6.5 mm	0.5~3.8x0.5~2.2 mm
Apothecium	Formation	1-8/sclerotium	1-2/sclerotium
	Shape	Cup-shaped	Cup-shaped
	Diameter of disks	1.7~8.2 mm	0.8~2.8 mm
	Length of stalks	1.2~9.0 mm	1.2~4.2 mm
	Width of stalks	0.5~0.9 mm	0.5~0.8 mm
Ascus	Shape	Cylindrical	Cylindrical
	Size	116~190x8~10 μm	116~194x8~14 μm
Ascospore	Shape	Ellipsoid to ovoid	Ellipsoid to ovoid
	Size	10~18x6~8 μm	10~18x6~9 μm
	No. of nuclei	2	4
Mycelial growth	Minimum temperature	1°C	0°C
	Maximum temperature	30°C	29°C
	Optimum temperature	22~24°C	20~22°C

Table 4. Pathogenicity of isolates of *Sclerotinia sclerotiorum* and *S. minor* in four solanaceous crops by artificial inoculation

Sclerotinia species	Isolate	Isolate source	Virulence of isolates on stems of cultivars[a]							
			Eggplant		Potato		Red pepper		Tomato	
			DH[b]	HM	DJ	SM	MN	MD	SG	GM
S. sclerotiorum	S97-133	Eggplant	++	++	++	++	++	++	++	++
	S97-155	Eggplant	++	++	++	++	++	++	++	++
	S98-001	Potato	++	++	++	++	++	++	++	++
	S98-016	Potato	++	++	++	++	++	++	++	++
	S00-006	Red pepper	++	++	++	++	++	++	++	++
	S00-018	Red pepper	++	++	++	++	++	++	++	++
	S96-172	Tomato	++	++	++	++	++	++	++	++
	S97-169	Tomato	++	++	++	+	++	++	++	++
S. minor	S94-001	Tomato	++	++	+	+	++	++	++	++
	S94-004	Tomato	++	++	++	+	++	++	++	++
Control	–	–	–	–	–	–	–	–	–	–

[a]Disease severity was rated 20 days after inoculation. ++ = above 1.0 cm of lesion length or wholly rotted; + = 0.5~0.9 cm of lesion length; – = no symptom.
[b]Abbreviation for cultivars. DH = Daeheukjang; HM = Heukmajang; DJ = Dejima; SM = Sumi; MN = Mannyang; MD = Manidda; SG = Seogwang; GM = Gwangmyeong.

aceous crops is similar to that from other crops in Korea (Kim and Cho, 2002, 2003). In general, sclerotia of *Sclerotinia* spp. can survive in nature for many years (Adams and Ayers, 1979) and play the important role as an inoculum source of the disease occurrence (Willetts and Wong, 1980). It has not yet been studied on the sclerotial density and viability of the two *Sclerotinia* spp. in the field of solanaceous crops.

There have been reports on differences in virulence of *S. sclerotiorum* isolates to individual plants and in susceptibility of some plants to the isolates (Kim *et al.*, 1999; Price and Calhoun, 1975). It has been also reported that there are differences in susceptibility of cultivars or lines of some crops to the pathogen (Cassells and Walsh, 1995; Grau and Bissonnette, 1974; Orellana, 1975; Porter *et al.*, 1975). However, the present study showed that there was no significant difference in virulence of *S. sclerotiorum* isolates to solanaceous crops, as reported by previous workers in other crops (Kim and Cho, 2002, 2003). On the other hand, *S. minor* was relatively less virulent on the potato cultivar Sumi than on another one, suggesting that there might be some differences in susceptibility of potato cultivars to *S. minor*. Further study is needed to reveal the resistance of the potato cultivar to the pathogen.

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