

## Occurrence of Potato Powdery Scab Caused by *Spongospora subterranea* in Korea

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Potato tubers with scab lesions were found in several regions of Gangwon province in Korea during disease surveys in 2000 and 2001. The lesions appeared as shallow scabs with torn and raised skin around the periphery of the lesion. Sometimes the lesions expanded on tuber surface and formed hollowed-out areas. The causal organism was identified as *Spongospora subterranea* based on morphological characteristics using light and electron microscope. Ten cultivars of potato were evaluated to select resistant cultivars against powdery scab. Among the 10 cultivars, Jowon, Superior, and Atlantic were resistant, while Sephody, Gawon, and Irish Cobbler were susceptible to powdery scab. In the pathogenicity test, typical symptoms of powdery scab were formed on potato tubers, and galls developed on root hairs. This is the first report of powdery scab of potato caused by *S. subterranea* in Korea.

**Keywords :** potato, powdery scab, *Spongospora subterranea*.

Powdery scab of potato (*Solanum tuberosum* L.) caused by *Spongospora subterranea* (Wallr.) Lagerh. f. sp. *subterranea* Tomlinson, is a blemish disease that has become increasingly important worldwide in recent years (Harrison et al., 1997). Potato tubers with scab lesions were found in several regions of Gangwon province in Korea during

disease surveys in 2000-2001. Incidence of the disease ranged from 0 to 20% in 52 of 145 fields surveyed (Table 1), and several fields in Ginbumyeon, Naemyeon, and Imgyemyeon were severely infested. However, there have been no records of powdery scab of potatoes in Korea (The Korean Society of Plant Pathology, 1998).

The typical lesions appeared as shallow scab with torn and raised skin around the periphery of the lesion (Fig. 1A). At the start of the infection, the symptoms were purplish brown lesions. The next stage was the appearance of tan, pimple-like swellings. Mature lesions on tubers had the ruptured periderm with scab-like appearance and were filled with fine brown "powder" (Fig. 1B). When the powdery mass got detached from the lesion, the hollowed-out area appeared as cavity. Under extremely wet conditions, the lesion expanded into a canker, first appearing like a common scab. Symptoms of powdery scab were often confused with common scab, another blemish disease of potato. The symptoms of common scab are characterized by shallow, raised, and pitted scab lesions (Loria et al., 1997). Hence, common scab caused by *Streptomyces* spp. was at first suspected to be the cause of scab tubers, but no *Streptomyces* species were isolated from surface sterilized tubers with scab lesions. Milky white galls of *S. subterranea*, 1-7 mm in diameter, developed on roots

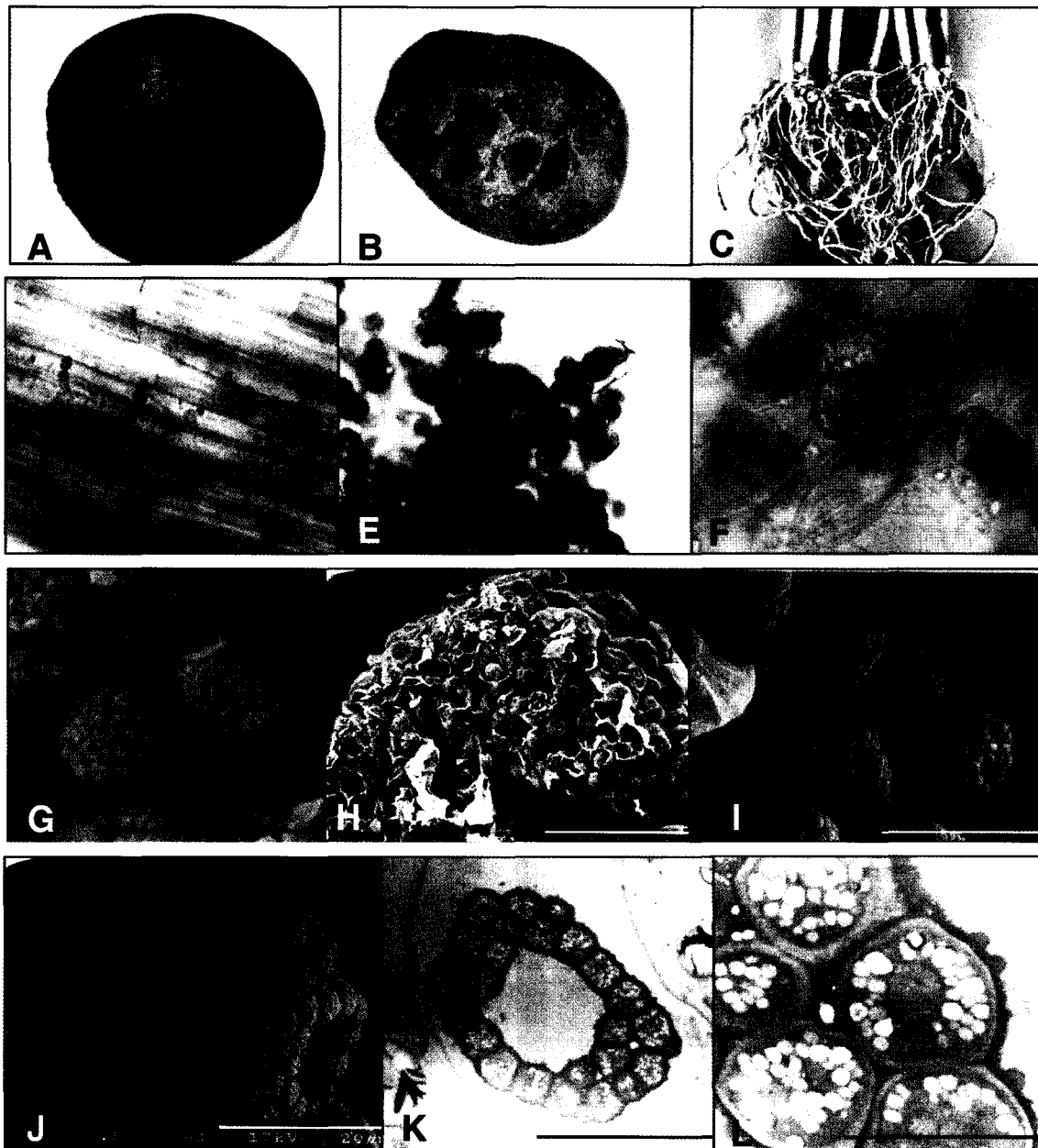
**Table 1.** Incidence of powdery scab of potato in Gangwon province in 2000-2001

Location		Investigated field	Infected field	% range of infected tuber
Pyeongchang	Doammyeon	33	12	0.1-6.5
	Jinbumyeon	15	5	0.2-10.0
Hongcheon	Naemyeon	34	20	5-20.0
Jeongsun	Imgyemyeo	10	4	0.1-10.0
	Bukpyeongmyeon	8	3	0.5-5.0
Gangneung	Chodangdong	30	5	0-2.0
	Wangsanmyeon	15	3	0-1.0
Total		145	52	0-20.0

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**Fig. 1.** Symptoms of powdery scab and morphological features of *Spongospora subterranea*. **A** and **B**, mature powdery scab lesions on potato tubers; **C**, potato roots with galls; **D**, young plasmodia formed in epidermal cells of tomato root; **E** and **F**, sporeballs from the lesion of potato tuber and root gall of potato observed by light microscope; **G**, resting spores observed on the lesion of potato tuber; **H** to **L**, ultrastructure of sporeballs in a root gall observed by SEM (**H** to **J**) and TEM (**K** and **L**). Bars represent 5 (**G** and **L**), 400 (**H**), 50 (**I**), and 20  $\mu$ m (**J** and **K**), respectively.

and stolons in wet conditions (Fig. 1C). Powdery scab could be identified by observing it under light and electron microscopes.

For observation of the lesions and root galls of potatoes by transmission electron microscopy (TEM), samples were fixed in 3% glutaraldehyde. After postfixation in 2% Osmium tetroxide in 0.05 M cacodylate buffer, pH 7.2, dehydration was carried out in a graded ethanol series. The

materials were then embedded in Spurr resin, ultrathin sectioned, stained with uranyl acetate and lead citrate, and observed with a Hitachi TEM (H-7100, 75 kV). For scanning electron microscopy (SEM), the dehydrated materials were further 'critical point' dried using liquid carbon dioxide, coated with gold-palladium, and observed with a Hitachi SEM (CS-2460N, 17 kV).

The resting spores on the lesions of tuber were usually

ovoid, 2.3-4.2  $\mu\text{m}$  in diameter with yellow-brown to brown walls (Fig. 1G). Many spore balls were observed on the lesions of potato tubers (Fig. 1E) and in the root gall (Fig. 1F) of potato by the light microscope. The spore balls (sporosori) were ovoid, irregular, elongate, 20-60  $\mu\text{m}$  in diameter (Fig. 1H-L), and consisted of numerous cysts, which stuck together to form a hollow irregularly channeled sponge-like structure. The morphological characteristics of this organism were consistent with those described in previous work (Table 2). Hims and Preece (1975) also described primary and secondary zoospores as ovoid or spherical, 2.5-4.6  $\mu\text{m}$  in diameter, with unequal flagella. For observation of zoospores, tomato seedlings were planted as baiting plants in small vials containing lesions of powdery scab. At 10 days after planting, the roots of plants were stained with trypan blue and observed under the light microscope. Many zoospores near root hairs and young plasmodia in epidermal cells of tomato root were observed (Fig. 1D).

The incidence of potato powdery scab is increasing in commercial potato fields because of the persistence of *S. subterranea* in soil and lack of sources of resistance (reviewed in Harrison et al., 1997). Furthermore, *S. subterranea* is a vector of *Potato mop-top virus*, another economically important pathogen (Johns and Harrison, 1969). Hence, effective identification system needs to be established to detect this pathogen from tuber and soil especially in seed tuber production areas. Harrison et al. (1993) and Wallace et al. (1995) described an enzyme-

linked immunosorbent assay (ELISA) system, using polyclonal and monoclonal antisera. Recently, polymerase chain reaction (PCR) has been developed for a more sensitive detection using primers designed from the ITS sequence (Bulman and Marshall, 1998).

To select resistant cultivars against potato powdery scab, ten potato cultivars were planted in infested field and were harvested at 100 days after planting. Resistance was evaluated by disease incidence and severity. Among ten cultivars, Jowon, Superior, and Atlantic were found resistant, while Sephody, Gawon, and Irish Cobbler were susceptible to powdery scab (Table 3).

For the pathogenicity test, potato cv. Dejima was used. Tubers were surface-sterilized with 1% sodium hypochlorite solution and sterilized water, and planted in plastic pots (30 cm  $\times$  40 cm) containing bed soil (Ssugssugi, Nongwoo Bio Tech Inc.) in the glasshouse. After 30 days of planting, suspension of spore balls adjusted at  $10^4$  spore balls/ml was inoculated into the pots. After inoculation, the plants were watered twice a day to maintain enough moisture, and temperature of the glasshouse was maintained at  $20 \pm 5^\circ\text{C}$ . At 60 days after inoculation, tubers were harvested. The symptoms were very similar to those of tubers grown in infected field. The lesions on potatoes were various in symptoms from small spots in the early stage associated with lenticels to mature lesions filled with brown powdery mass. Also, many root galls developed on root hairs. This is the first report of powdery scab of potato caused by *Spongospora subterranea* in Korea.

**Table 2.** Morphological characteristics of *Spongospora subterranea* observed from diseased potato tubers

Characteristics	Present isolate	<i>S. subterranea</i> (Hims and Preece, 1975)
Resting spore		
Color	Yellow to brown walls	Yellow-brown to brown walls
Shape	Ovoid	Polyhedral
Surface	Smooth	Smooth
Size ( $\mu\text{m}$ )	2.3-4.2 (diam.)	3.5-4.5 (diam.)
Sporosorus		
Color	Yellow to brown	Yellow to brown
Shape	Ovoid, irregular, elongate	Ovoid, irregular, elongate
Surface	Sponge-like, hollow	Sponge-like, partially hollow
Size ( $\mu\text{m}$ )	20-60 (diam.)	19-85 (diam.)

**Table 3.** Disease incidence and severity of powdery scab on different potato cultivars

Parameter	Cultivars									
	Jp <sup>a</sup>	IC	Sp	Cb	Dj	Ja	At	Su	Jw	Gw
DI (%) <sup>b</sup>	9.4	21.3	35.5	4.1	10.7	8.2	3.3	3.5	1.7	30.8
DS (%) <sup>c</sup>	2.4	8.2	17.2	1.0	4.0	2.0	0.1	1.0	0.1	11.2

<sup>a</sup> Jp, Jopung; IC, Irish Cobbler; Sp, Sephody; Cb, Chubaek; Dj, Dejima; Ja, Jasim; At, Atlantic; Su, Superior; Jw, Jowon; Gw, Gawon.

<sup>b</sup> Disease Incidence (%): (No. of diseased tubers / Total no. of tubers observed)  $\times$  100.

<sup>c</sup> Disease Severity (%):  $(0n+1n+2n+3n+4n)/(\text{Total no. of tubers observed} \times 4) \times 100$ .

0 = No symptom; 1 = Diseased area is 0.1-5%; 2 = Diseased area is 5.1-10%; 3 = Diseased area is 10.1-20%; 4 = Diseased area is 20.1%.

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