Mycobiology

Research Note

Outbreak of Rust Caused by *Coleosporium asterum* on *Solidago virgaurea* var. *gigantea* in Ulleung-do

Chang-Gi Back[1], Gu-Youn Nam[1,2], Seung-Yeol Lee[1] and Hee-Young Jung[1,3,*]

[1]*School of Applied Biosciences, Kyungpook National University, Daegu 702-701, Korea*
[2]*Ulleunggun Agriculture Technology Center, Ulleung 799-802, Korea*
[3]*Institute of Plant Medicine, Kyungpook National University, Daegu 702-701, Korea*

Abstract From June to October 2012, severe outbreaks of rust disease on *Solidago virgaurea* var. *gigantea* were observed in 5 different regions of Ulleung-do, Korea. Typical rust symptoms appeared as yellow spots, uredinia on leaves, and massive urediniospores covering the entire plant. Severely infected plants became discolored and died. On the basis of its morphological and molecular characteristics, the causal agent was identified as *Coleosporium asterum*. This pathogen has been reported as rust disease on *S. virgaurea* in the Canada and United States. In Korea, rust disease on *S. virgaurea* var. *gigantea* was reported as *Uromyces rudbeckia* in 1992. To the best of our knowledge, *C. asterum* is a novel rust pathogen on *S. virgaurea* var. *gigantea* in Korea.

Keywords *Coleosporium asterum*, Korean goldenrod, Phylogenetic analysis, Rust disease, 28S rDNA

Solidago virgaurea var. *gigantea* (Nakai, kitam; English name: Korean goldenrod) is a perennial herb belonging to the Asteraceae [1]. This plant is cultivated as a culinary vegetable in Ulleung-do and is used commonly in Korean folk medicine [2]. Accordingly, this plant has been cultivated widely on 72.3 ha out of 385 ha, making it the third most cultivated crop with an estimated value of 2.7 billion won in Ulleung-do. From June to October of 2012, outbreaks of rust disease with yellow spots and uredinia were observed consistently in all cultivation areas in Ulleung-do. Indeed, it is estimated that the production of *S. virgaurea* var. *gigantea* was reduced by over 10% due to rust disease on leaves. The leaves infected by rust fungi showed massive urediniospores on the stem and lower leaf surface with corresponding small yellowish to chlorotic lesions on the upper surface (Fig. 1A and 1B). No symptoms were observed on flowers. Severe infections often resulted in leaf distortion, drying, and premature senescence (Fig. 1C). In February 2013, rust disease was observed on the leaves of overwintered *S. virgaurea* var. *gigantea*. Even though these plants were covered with snow, diseased brown leaves were observed with uredinia and urediniospores on the lower leaves (Fig. 1D). *Coleosporium asterum* infected by *Aster pilosus* has been reported to overwinter in the uredinial state in Korea [3].

The morphological characteristics of uredinia and urediniospores were observed by light microscopy and electron microscopy as described by Back *et al.* [4], and yellow-orange and rounded uredinia with a diameter of 340~360 μm were observed on the surfaces of lower leaves (Fig. 1E). The urediniospores were subglobose to ellipsoid, but somewhat irregular and variable in shape, yellow-orange, verrucose, and 31.0~36.5 × 26.5~29.0 μm in size (Fig. 1F and 1G). Orange-red and flat rounded telia were observed in late July. Teliospores were one-celled, obovoid, yellowish, and 73.0~86.5 × 22.0~37.0 μm in size (Fig. 1H). On the basis of the morphological characteristics of urediniospores and teliospores, this pathogen was identified as *Coleosporium asterum* (Dietel) Syd. & P. Syd. [5]. Total genomic DNA was extracted from urediniospores on the lower surface of diseased leaves collected from 5 different areas. A portion of the 28S rDNA gene was amplified using the primers NL1 and NL4 (5'-GCA TAT CAA TAA GCG GAG GAA

Mycobiology 2014 March, **42**(1): 79-81
http://dx.doi.org/10.5941/MYCO.2014.42.1.79
pISSN 1229-8093 • eISSN 2092-9323

***Corresponding author**
E-mail: heeyoung@knu.ac.kr

Received December 1, 2013
Revised February 11, 2014
Accepted February 23, 2014

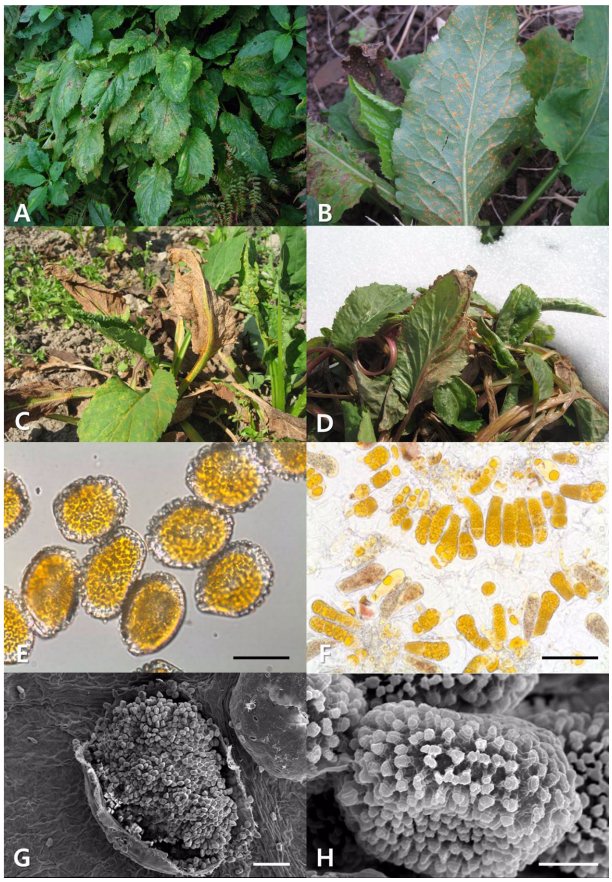

Fig. 1. Symptoms of rust disease on Korean goldenrod leaves and morphological characteristics of urediniospores and teliospores; yellow spots on the upper side of leaves (A) and lower side of leaves (B), severely infected and defoliated symptoms of leaves (C), rust symptoms still observed on overwintered leaves in February (D), globose-shaped urediniospores (E), yellow-orange color ellipsoid-shaped teliospores (F) as observed by light microscopy. Scanning electron micrograph of uredinia (G) and urediniospores (H) of *Coleosporium asterum* (scale bars: E = 20 μm, F, G = 100 μm, H = 5 μm).

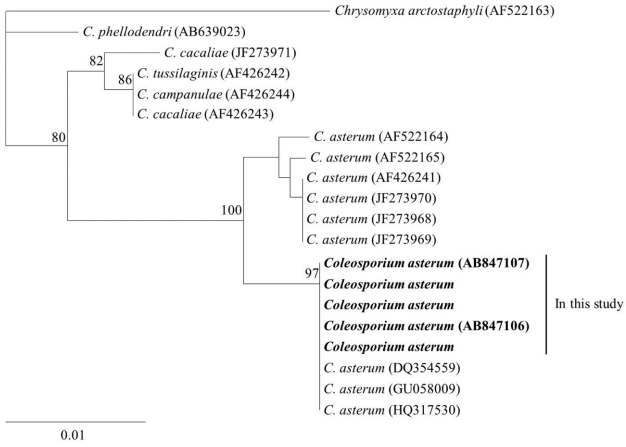

Fig. 2. Phylogenetic trees constructed by the neighbor-joining method based on partial 28S rDNA sequences of *Coleosporium asterum* on *Solidago virgaurea* var. *gigantea* and other *Coleosporium* species from GenBank. *Chrysomyxa arctostaphyli* (AF522163) was used as the outgroup. Numbers above the branches represent the bootstrap values obtained for 100 replicates (only 80% values were shown). The bar represents a phylogenetic distance of 0.01%.

AAG-3' and 5'-GGT CCG TGT TTC AAG ACG G-3', respectively) and directly sequenced [6]. The resulting sequences of the 5 isolates had an identity of 100%. All sequences of these isolates were deposited in the DDBJ/GenBank database with the accession number (AB847106, AB847107). An NCBI BLAST search showed that the present sequences had an identity of 99% with those of *C. asterum* on *Aster* sp. and *Solidago* sp. The partial 28S rDNA sequences were compared with other sequences deposited in the NCBI GenBank database using the GENETYX-WIN ver. 3.2 program (GENETYX Co., Tokyo, Japan) and found to have an identity of 99.8~100% with *C. asterum* infected by *Solidago* sp. in Canada and the United States and 98.8~99.0% identity with *C. asterum* caused by *A. pilosus* in Korea. The sequences were aligned using DNASTAR programs (DNASTAR Inc., Madison, WI, USA) and a phylogenetic tree of 28S rDNA was obtained using the neighbor-joining method in CLUSTALW [7]. The phylogenetic tree was visualized using the TreeView program (Win32, ver. 1.6.1). Bootstrap analysis with 100 replications was performed to determine support for various clades. The results revealed that the Korean goldenrod rust isolates were *C. asterum* (Fig. 2). The rust fungi *C. asterum* has been reported on *Solidago* sp. from Canada and the United States [8], and *A. pilosus* rust caused by *C. asterum* has been reported in Korea [3]. However, these isolates had different morphologies and 28S rDNA sequences than those observed in the present study. The causal agent of the rust disease of *S. virgaurea* var. *gigantea* was reported to be *Uromyces rudbeckia* in Ulleung-do in 1992 [9]. Since our study started in 2011, no rust pathogens of *U. rudbeckia* have been observed on *S. virgaurea* var. *gigantea*. Recently, the pathogen responsible for outbreaks of rust disease on *S. virgaurea* var. *gigantea* was identified as *C. asterum*. This rust pathogen is dominant in cultivated areas in Ulleung-do and was first reported on *S. virgaurea* var. *gigantea* in Korea. Rust disease on *S. virgaurea* var. *gigantea* occurs annually and leads to considerable economic losses in Ulleung-do. Thus, additional investigations of the ecological and mycological characteristics of rust pathogens to enable the prevention and control of rust disease are warranted.

REFERENCES

1. Jang CS, Yang SG, Oh BU. A taxonomical review of *Solidago japonica* and its relatives (Asteraceae). Korean J Plant Taxon 2012;42:40-9.
2. Lee SO, Lee HJ, Yu MH, Im HG, Lee IS. Total polyphenol contents and antioxidant activities of methanol extracts from

vegetables produced in Ullung Island. Korean J Food Sci Technol 2005;37:233-40.
3. Park MJ, Kakishima M, Lee SK, Shin HD. Rust disease of *Aster pilosus* caused by *Coleosporium asterum* in Korea. Plant Pathol J 2012;28:332.
4. Back CG, Nam GY, Nang KK, Lee SY, Kang IK, Lee SC, Jung HY, Ohga S. Characterization of *Coleosporium phellodendri* causing rust disease on Japanese prickly-ash tree. J Fac Agric Kyushu Univ 2012;57:379-82.
5. Hiratsuka N, Sato S, Katsuya K, Kakishima M, Hiratsuka Y, Kaneko S, Ono Y, Sato T, Harada Y, Hiratsuka T, et al. The rust flora of Japan. Takezono: Tsukuba Shuppankai; 1992. p. 204-5.
6. O'Donnell K. Fusarium and its near relatives. In: Reynolds R, Taylor JW, editors. The fungal holomorph: mitotic, meiotic and pleomorphic speciation in fungal systematics. Wallingford: CAB International; 1993. p. 225-33.
7. Thompson JD, Higgins DG, Gibson TJ. CLUSTAL W: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. Nucleic Acids Res 1994;22:4673-80.
8. Farr DF, Rossman AY. Fungal Databases, Systematic Mycology and Microbiology Laboratory [Internet]. Washington, DC: Agricultural Research Service, United States Department of Agriculture; 2013 [cited 2013 Aug 1]. Available from: http://nt.ars-grin.gov/fungaldatabases/.
9. Lee TS, Lee MW, Shin HD. Rust fungi collected from Ullung Island in Korea. KSM News Lett 1997;9:170.