Epidermal patterns of leaf blades in Korean sedge taxa characterized by SEM and LM (III. *Scirpus*)

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주사전자현미경과 광학현미경에 의한 고랭이속(*Scirpus*)식물의 잎의 표피형 연구

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(성신여자대학교 자연과학대학 생명학과)

Abstract

The epidermal patterns of four taxa (3 species and 1 subspecies) of Korean *Scirpus* were investigated by using SEM and LM. Epidermal patterns of the leaf blades are characteristics and useful in identification and classification of *Scirpus* species. As the result of this study, the shape of epidermal elements such as subsidiary cells, wavy of intercostal cell walls, shape of interstomatal cells, cuticle, papillae, prickles, silica body and the arrangement of each element are considered to be significant taxonomic characters in the sedge taxa.

Introduction

I have published several papers on the epidermal patterns of the leaf blades on Korean sedge (1980a,b, 1985a,b, 1987a,b, 1988) since 1979 and have confirmed the epidermis as the important taxonomic characters for the sedge identifications. In this study, the results on the epidermal patterns by LM were compared with those by SEM in some *Scirpus* taxa. And it was proposed that the epidermal patterns of leaf blades were valuable taxonomic characters at the species level.
Materials and Methods

Herbarium specimens of three species and one subspecies stored in the department of Biology, Sungshin Women’s University (SWU) were used in this study (Table 1). The leaf blade in basal leaves were taken at the widest portion in boiling water for 30 min. or 1 hr. and fixed in FAA. The epidermis of each species was peeled and observed under an Olympus BH-light microscope. The measurement of stomatal size was carried out in the lateral subsidiary cells, and each numeral in table 2 was average value obtained from 10 measurements. The unit of each numeral is micrometer. For SEM observation, the fixed leaves were prepared by dehydrated in the gradient acetone series, affixed on stubs and then coated with gold/palladium by ion sputter JFC-1,100. Epidermal patterns were observed at the accelerating voltage of 15 kv by JEOL, JSMT 300 SEM. Micrographs were taken with Kodak Vp 20 and printed contactly on Kodakbromide paper. The terminology used here by Metcalfe (1964), Ellis (1979) and Palmer and Tucker (1981) is followed by Hilu (1984).

Results

Epidermal characters and key of the four species of the Korean Scirpus by SEM and LM were as below: Scirpus fuirenooides Maxim. subsp. jaluanaus T. Koyama.

LM: Subsidal cell dome-shaped. Stomata 31-34-36 μm long and 16-18-19 μm wide. Five rows of stomata present at the intercostal zone. Long celled 63-87-110 μm long and 11-15-22 μm wide, the cell walls very sinusous (Metcalfe, 1960). The stomata rarely present at the adaxial surface of leaf blades. Silica body Al-shaped (Metcalfe & Gregory, 1964). SEM: Intercostal zones; many rows long celled, square-long and narrow, non-uniform, walls sinusous, raised. Stomata; 5 rows in each zone, subsidiaries parallel to low-dome shaped, non-inflated,

Table 1. List of voucher specimens for epidermal patterns of the leaf blades on the genus Scirpus in Korea

<table>
<thead>
<tr>
<th>Specimens</th>
<th>Locality</th>
<th>Date and Collectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scirpus fuirenooides Maxim. subsp. jaluanaus T. Koyama</td>
<td>Songhunri, Kangwondo</td>
<td>Aug. 18, 1967 Y.C. Oh</td>
</tr>
<tr>
<td>S. maritimus L.</td>
<td>Kunja, Kyunggido</td>
<td>Aug. 4, 1969 Y.C. Oh &amp; Lee, Y.N.</td>
</tr>
<tr>
<td>S. mitsukurianus Makino</td>
<td>Ilyong, Kyunggido</td>
<td>Sept. 20, 1969 Y.C. Oh</td>
</tr>
<tr>
<td>S. radicans Schkuhr</td>
<td>Changcha pond, Seoul</td>
<td>June 11, 1967 Y.C. Oh</td>
</tr>
</tbody>
</table>
interstomatals long and narrow, ends straight, V-shaped (Hilu, 1984). Cuticle well developed thick, and covered at the both leaf surfaces (Figs. 1, 2).

*S. maritimus* L.

LM: Subsidal cell dome-shaped. Stomata 31-34-36 µm long and 14-18-22 µm wide. The stomata scattered at the intercostal zone. Long celled 50-62-78 µm long and 13-15-19 µm wide, the cell walls shallowly wavy. Silica body A2-shaped (Fig. 11). SEM: Intercostal zones; many rows long celled, square-long and narrow, uniform, walls sinuous. Stomata; scattered in each zone, subsidiaries parallel to low-dome shaped, non-inflated, interstomatals long and narrow, ends straight, shortly, U-shaped. The stomata rarely present at the adaxial surface (Figs. 3,4).

*S. mitsukurianus* Makino

LM: Subsidal cell dome-shaped. Stomata 33-37-42 µm long and 17-18-21 µm wide. The stomata scattered at the intercostal zone. Long celled 63-80-90 µm long and 13-17-21 µm wide. The cell walls very sinuous. Silica body A2-shaped. SEM: Intercostal zones; many rows long celled, long and narrow, uniform, the walls very sinuous, papillae and prickles present. Stomata; surrounded by papillae, scattered in each zone, subsidiaries parallel to dome-shaped, swelled, non-inflated, interstomatals short and narrow, ends shortly, V-shaped. Cuticle well developed at the adaxial surface. Prickles were present at both surfaces and papillae were present at abaxial surface of leaf blades (Figs. 7-9).

*S. radicans* Schkuhr

LM: Subsidal cell dome-shaped. Stomata 31-35-35 µm long and 17-20-22 µm wide. Five or nine rows of stomata present at the intercostal zone. Long celled 53-72-113 µm long and 9-14-17 µm wide, the cell walls deeply wavy. Silica body A2-shaped (Figs. 12, 13). SEM: Intercostal zones many rows long celled, square-rectangular, non-uniform, walls sinuous. Stomata; 5-9 rows in each zone, subsidiaries parallel to low-dome shaped, non-inflated, interstomatals short and narrow, ends shortly, V-shaped. Cuticle well developed at the abaxial surface (Figs. 5, 6).

**Key to the Korean Scirpus species by the leaf epidermal characters using SEM**

A. Cell walls are deeply wavy .................................................. *Scirpus radicans*.

A. Cell walls are shallowly or sinuously wavy.
B. Cell walls are shallowly wavy, silica body A2-shaped .......................................................... *S. maritimus*.
B. Cell walls are sinuously wavy, silica body A1-shaped or A2-shaped.
C. Silica body A1-shaped ........................................................... *S. fujienoides* subsp. jaltuanus.
C. Silica body A2-shaped ........................................................... *S. mitsukurianus*.
Table 2. Some important characters of Korean Scirpus observed by LM

<table>
<thead>
<tr>
<th>Species</th>
<th>Shape of sub-sidal cells</th>
<th>Size of stomata(μm)</th>
<th>Wavy of ordinary cell walls</th>
<th>Shape of SB**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scirpus fiorenoides</td>
<td>dome</td>
<td>34×18*</td>
<td>very sinuously wavy</td>
<td>A₁</td>
</tr>
<tr>
<td>subsp. jaluanaus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. maritimus</td>
<td>dome</td>
<td>34×18</td>
<td>shallowly wavy</td>
<td>A₂</td>
</tr>
<tr>
<td>S. mitsukurianus</td>
<td>dome</td>
<td>37×18</td>
<td>very sinuously wavy</td>
<td>A₃</td>
</tr>
<tr>
<td>S. radicans</td>
<td>dome</td>
<td>35×20</td>
<td>deeply wavy</td>
<td>A₂</td>
</tr>
</tbody>
</table>

* Numerals represent average length and width in microns
** Silica body

Key to the Korean Scirpus species by the leaf epidermal characters using SEM

A. Papillae and prickles present on both leaf surfaces ............... S. mitsukurianus.
A. Papillae and prickles absent on both leaf surfaces.

B. The shape of intercostal long cells are long, narrow and uniform or non-uniform.

C. Intercostal long cells are uniform, stomata are low-dome shaped, non-inflated, V-shaped ................................................. S. fiorenoides subsp. jaluanaus.

C. Intercostal long cells are non-uniform, stomata are low-dome shaped, non-inflated, U-shaped ................................................. S. maritimus.

B. The shape of intercostal long cells are rectangular, non-uniform .......................................................... S. radicans.

In results of this study, the similar size of stomata on the leaf blade of Scirpus fiorenoides Maxim. subsp. jaluanaus (31-34-36 μm long and 16-18-19 μm wide (Fig. 10)), S. maritimus (31-34-36 μm long and 14-18-22 μm wide (Fig.11)) and S. mitsukurianus (33-37-42 μm long and 17-18-21 μm wide) were present. However, S. radicans was the largest among the Scirpus taxa in which the stomata was measured as 31-35-35 μm long and 17-20-22 μm wide (Fig. 12). All four species of Scirpus showed dome-shaped subsidiary cells (Figs. 10-12). The wall of the intercostal cells had various sinuously, shallowly, and deeply (Figs. 10-13). The wall of the intercostal cells were deeply wavy in S. radicans (Figs. 12, 13), sinuously wavy in S. fiorenoides Maxim. subsp. jaluanaus (Fig. 10) and S. mitsukurianus. Especially, papillae and sometimes prickles present in the wall of the intercostal cells of S. mitsukurianus. Therefore, the stomata were surrounded by papillae. The cell walls of S. maritimus were shallowly wavy. The A1-shaped silica body were present on the S. fiorenoides Maxim. subsp. jaluanaus and A2-shaped were present on the S. maritimus, S. mitsukurianus and S. radicans (Figs. 10-13).
<table>
<thead>
<tr>
<th>Species</th>
<th>Characters</th>
<th>Shape and wavy of ordinary cells</th>
<th>Shape of stoma &amp; interstomatales</th>
<th>ab: I II III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scirpus fuiroides subsp. jahuanus</td>
<td>long and narrow</td>
<td>low-dome</td>
<td>+ - -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>non-uniform</td>
<td>non-inflated</td>
<td>+ - -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sinuously wavy, raised</td>
<td>V-shaped</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. maritimus</td>
<td>long and narrow</td>
<td>low-dome</td>
<td>- - -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>uniform</td>
<td>non-inflated</td>
<td>- - -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sinuously wavy</td>
<td>U-shaped</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. mitsukurianus</td>
<td>long and narrow</td>
<td>low-dome</td>
<td>- + +</td>
<td></td>
</tr>
<tr>
<td></td>
<td>uniform</td>
<td>non-inflated</td>
<td>+ - +</td>
<td></td>
</tr>
<tr>
<td></td>
<td>very sinuously wavy</td>
<td>V-shaped</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. radicans</td>
<td>rectangular</td>
<td>low-dome</td>
<td>+ - -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>non-uniform</td>
<td>non-inflated</td>
<td>- - -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sinuously wavy</td>
<td>V-shaped</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I: Cuticle, II: papillae, III: prickles, ab: abaxial surface, ad: adaxial surface, +: present, -: absent

These SEM epidermal characters shown in the shape of intercostal long cells were as follow: long and narrow, and non-uniform were observed in S. fuiroides Maxim. subsp. jahuanus (Fig. 12); long and narrow, and uniform in S. maritimus and S. mitsukurianus (Figs. 3, 4, 7-9); rectangular, non-uniform in S. radicans (Figs. 5, 6). The wall of the intercostal long cells were the sinuously wavy and raised in S. fuiroides subsp. jahuanus (Figs. 1, 2), the sinuously wavy in S. maritimus (Figs. 3, 4) and S. radicans. The stomata were low-dome shaped, non-inflated and ends shortly, V-shaped in S. fuiroides subsp. jahuanus, S. mitsukurianus and S. radicans (Figs. 1, 2, 5-9). And the stomata was low-dome shaped, non-inflated and ends shortly, U-shaped in S. maritimus. The cuticle were present at the both leaf surfaces of S. fuiroides subsp. jahuanus, at the adaxial surface of S. mitsukurianus (Fig. 8) and at the abaxial surface of S. radicans (Fig. 5). The papillae and prickles were present at the leaf surface of S. mitsukurianus (Figs. 7, 9), the stomata of the species were almost surrounded by papillae (Fig. 7).
Discussion

In this study, epidermal characters were found to be important for the species classification and identification of Korean sedge; the shape of subsidiary cells, the wavy of intercostal cell walls, presence or absence of papillae and prickles and forms of silica bodies. Several botanist (Schuyler, 1971; Walter, 1975; Toivonen and Timonen, 1976; Denton, 1983; Oh, 1988) studied the leaf blades and achenes epidermis patterns of several sedge with scanning electron microscope, and they used them to identify and classify of the sedge groups. According to the study, these characters can be used demarcating taxa below the species level. LM observation was different from SEM observation on the epidermal characters of some taxa of the sedge. In LM observation of genus Scirpus, each plant was distinguished by wavy of intercostal cell walls. On the other hand, in SEM observation it was by shape of ordinary long cells and shape of interstomatals. Furthermore, presence of cuticle, papillae and prickles were observed in SEM.

In conclusion the epidermal patterns of Scirpus seem to be very useful characteristics for classifying species. It is required to further study that the epidermal characters by combining LM and SEM might be very useful for the study of sedge family taxonomy.

Acknowledgement

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Literature Cited


**Explanation of Figures**

Figures 1-9. Scanning electron microphotographs of epidermal patterns of leaf blades in genus *Scirpus*. Odd numbers abaxial and even numbers adaxial (Bar = 1 μm).


Figures 10-13. Light microscopephotographs of epidermal patterns of leaf blades in genus *Scirpus*. All abaxial except Fig. 13. Magnification × 250.

Fig. 10. *S. fuirenoideus* Maxim. subsp. *julianus* T. Koyama. Fig. 11. *S. maritimus* L. Fig. 12. *S. radicans* Schkuhr. Fig. 13. *S. mitsuakuranus* Schkuhr.