(Korean J. Crop Sci.) 43(4) : 205~208(1998)

Characteristics of Phytolith on Rice Leaf

Eui Shik Rha* and Jin Key Kim**

ABSTRACT

Silica bodies (phytoliths) are becoming of wide use for pedology, archaeology, paleobotany and paleoecology in botany. This study investigated morphological differences of silica bodies in the lamina of wild, indica type, and japonica type rice. Phytoliths in the epidermis of lamina showed noticeable difference among tested plants. Besides, there were also significant differences in the shape and distribution of the silica bodies around stomata and trichomes. Silica bodies in the lamina of the rice plants could be used to classify subspecies of *Oryza* genus.

Key words : phytolith, silica body, classification, rice

The silicon is the most common element except oxygen on the earth, and is a component of many organisms. These silica bodies (phytoliths) in a organisms remained in soil after their death could give important information on the paleontology, taxonomy and evolution of plants especially, origin and propagation of crops. An archaeological study where the silica bodies were investigated on fossil plants in the rock of the third stage of the Miocene epoch, showed that the type and position of silica bodies in the fossils of gramineae and broad leaf trees to be useful for estimating similarities to present-day plants in addition to taxonomical study of these plants (Thomasson et al., 1986).

The silicon accumulation appears in specific organs and tissues, or lies sporadically in the whole plant depending on plant species. The formation of regional silica body has not been fully studied, but grasses, the most representative silicon storing plants, accumulate more silicon in shoots, mainly in epidermal tissue, than in roots (Kaufman et al., 1985; Sangter et al., 1983). Phytoliths in the epidermal tissue of grasses are vary greatly in size and shape being dumbbell, saddle, round, or needle type in the short cell, the long cell, or stomata (Metcalfe, 1960; Chen & Wang, 1995).

Rice is closely related to the development of civilization, and it is meaningful to know the origin and evolution of the rice plant in every aspect. However, no conclusive theory has been established up to now. Even for the origin of Asian cultivating rice, there are many different centers of origin suggested by various scholars including the Hindustan center, Yunnan center, Henan center, Indian center, and the Yangtse Belt. It is generally accepted from biotaxonomical studies that the present cultivated rice might have been formed from the ancestral wild rice, *Oryza rufipogon* Griff. But there are still great differences of opinions on which ecotype originally differentiated from *O. rufipogon* (Oka, 1988; Ellis, 1979).

The form of silicon projected on the surface of rice glumes which is the distinguishing feature of gramineae is worth applying to the study of the origin of rice culture or the discrimination of subspecies such as wild japonica type, and indica type rices (Chen & Wang, 1995; Watanabe, 1968) at family or subfamily level. But no study on the silica body in the leaf of rice plants has been carried out for classification at subspecies level. This study was aimed to check differences in morphological characteristics of silica bodies on the surface of rice leaves among wild, japonica type, and indica type rices. Some possible clue for classifying rice plants at subspecies level was expected.

MATERIALS AND METHODS

Oryza rufipogon Griff., *O. glaberrima*, and *O. sativa* cv. Taichung 65 (japonica type) and *O. sativa* cv. Taichung Native 1 (indica type) were obtained from the Chung Hsing University in Taiwan, and *O. sativa* cv. Dongjinbyeo was supplied from the Honam Agricultural Experiment Station in Korea. Rice plants were grown in pots. Flag leaves were collected just before the heading stage and observed with scanning electron microscope (SEM). For SEM, rice flag leaves were examined using fresh samples fixed in FAA. All samples were then dehydrated in a graded series of acetone concentrations. Dried samples mounted on aluminum stubs were coated with gold using an Eiko Model IB-3 ion coater at 6 mA for three minutes, and examined and photographed using an Akashi Model SX-40 SEM.

RESULTS AND DISCUSSION

Silica body of lamina epidermis

Plate 1 shows the surface views of silica bodies on the leaf surfaces of *O. rufipogon*, *O. glaberrima*, and *O. sativa* of indica and japonica cultivars. Silica bodies of *O. rufipogon* are scattered at the interveinal epidermis, and

* Institute of Agricultural Science and Technology, Chonbuk National Univ., Chonju 561-756, Korea.
** College of Agriculture, Chonbuk National Univ., Chonju 561-756, Korea.
Received 10 April 1998.

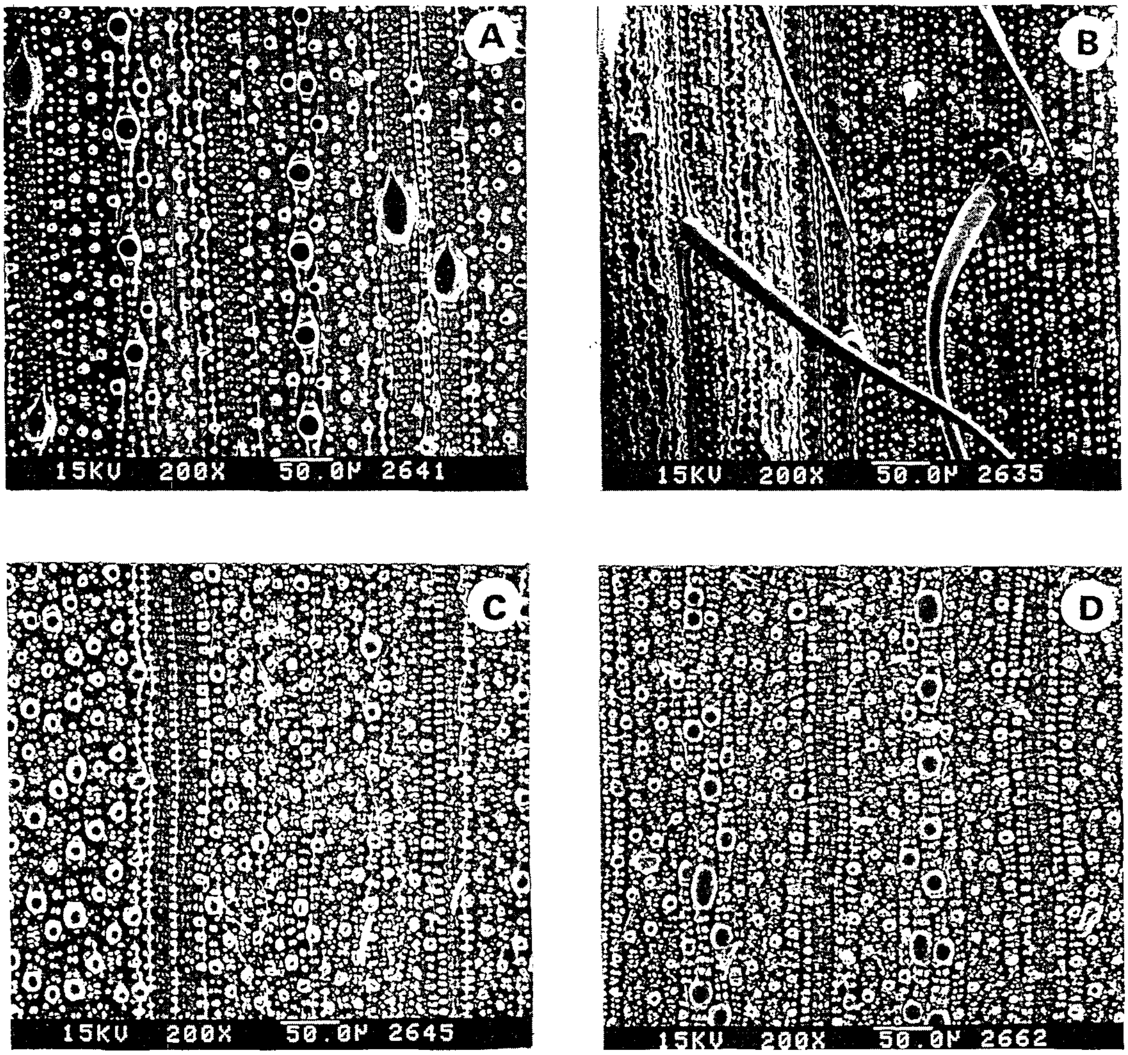

Plate 1. Surface view of the long cell phytoliths of abaxial leaf blades in the genus *Oryza*.

LP, long cell phytolith; SB, silica body; SSB, small silica body; NSB, nipplelike silica body. A : *O. rufipogon*, B : *O. glaberrima*, C : *O. sativa* cv. Taichung Native 1, D : *O. sativa* cv. Taichung 65.

on a long cell there are one 5~8 μm large papillate silica body at regular intervals and some small papillate silica bodies around it forming a regular band with a row in the center (Plate 1-A). In *O. sativa* two ecotypes show difference in silica bodies; indica type rice has small to medium size papillae of silica bodies scattered irregularly on the interveinal epidermis (Plate 1-C), while japonica type rice has large size papillae as well as medium size papillae of silica bodies irregularly distributed (Plate 1-D). *O. glaberrima* has only small nipple like silica bodies (Plate 1-B) with a great difference in silicon body distribution from *O. rufipogon* or *O. sativa*.

So far chromosome number, regional distribution, genome analysis, or characteristics in shape of rice plants have been used to classify inter-Oryza genera (Oka, 1988; Tang et al., 1993). Chen & Wang (1995) also showed that shape sketch of phytoliths existing in a glume had a great difference among wild, indica and japonica type rices. The result of this study shows the diverse appearance and distribution of silica bodies on the leaf surface of *O. rufipogon*, *O. glaberrima*, indica type and japonica type of *O. sativa*, and implies that silica bodies of lamina could be a useful method in grouping plants of *Oryza* genus at species or subspecies level.

Silica body around special cell (trichome)

Silica bodies are commonly formed at the basal part of the special cell (Baker, 1960). Different shapes of the special cell and silica bodies are observed in the rice leaf surface. *O. rufipogon* has 40~50 μm long prick hairs distributed irregularly and very small silica bodies in the base of the prick hairs (Plate 1-A). *O. glaberrima* has microhairs around the base of which silica bodies are also observed (Plate 1-B). However, on the surface of lamina of Taichung 65 and Taichung Native 1 of *O. sativa*, only microhairs are observed but no silica body was distributed at the base of the microhairs (Plate 1-C, D). Vaughan (1989) classified wild rice into perennial or annual by trichome existence. Likewise, the result of this study also implies that rice plant could be identified by referring the morphological differences of trichomes as well as silica bodies located at the base of the trichome on the leaf.

Silica body around stomata

Silica bodies are located variously in guard cells of the stomata. Four papillae of silica bodies are distributed regularly at the edge around stomata of *O. rufipogon* (Plate 2-A), while that of *O. glaberrima* has five or more papillae around the stomata (Plate 2-B). Two cultivars have a great difference in the number and arrangement of silica bodies around the stomata. Taichung Native 1, indica type, has papillae of silica bodies around the center of the stomata forming an inequality sign (Plate 2-C), but Dongjinbyeo, japonica type, has eight small papillae of silica bodies at the rim of the stomata (Plate 2-D). The accumulation process of silicon commences when roots absorb water soluble silicon in soil, and is completed by accumulation in intra or inter-cell. The genetic background of the higher plants is known to outweigh their habitat factors in formation of silica bodies (Piperno, 1988; Chen & Wang, 1995). Namely, a different groups of plants form different silica bodies. Therefore, the pattern of papillae of silica bodies around the stomata of lamina also could be used as a criterion in grouping rice plants.

Phytoliths on the leaf of the rice plant could offer very useful information on identifying, classifying and syste-

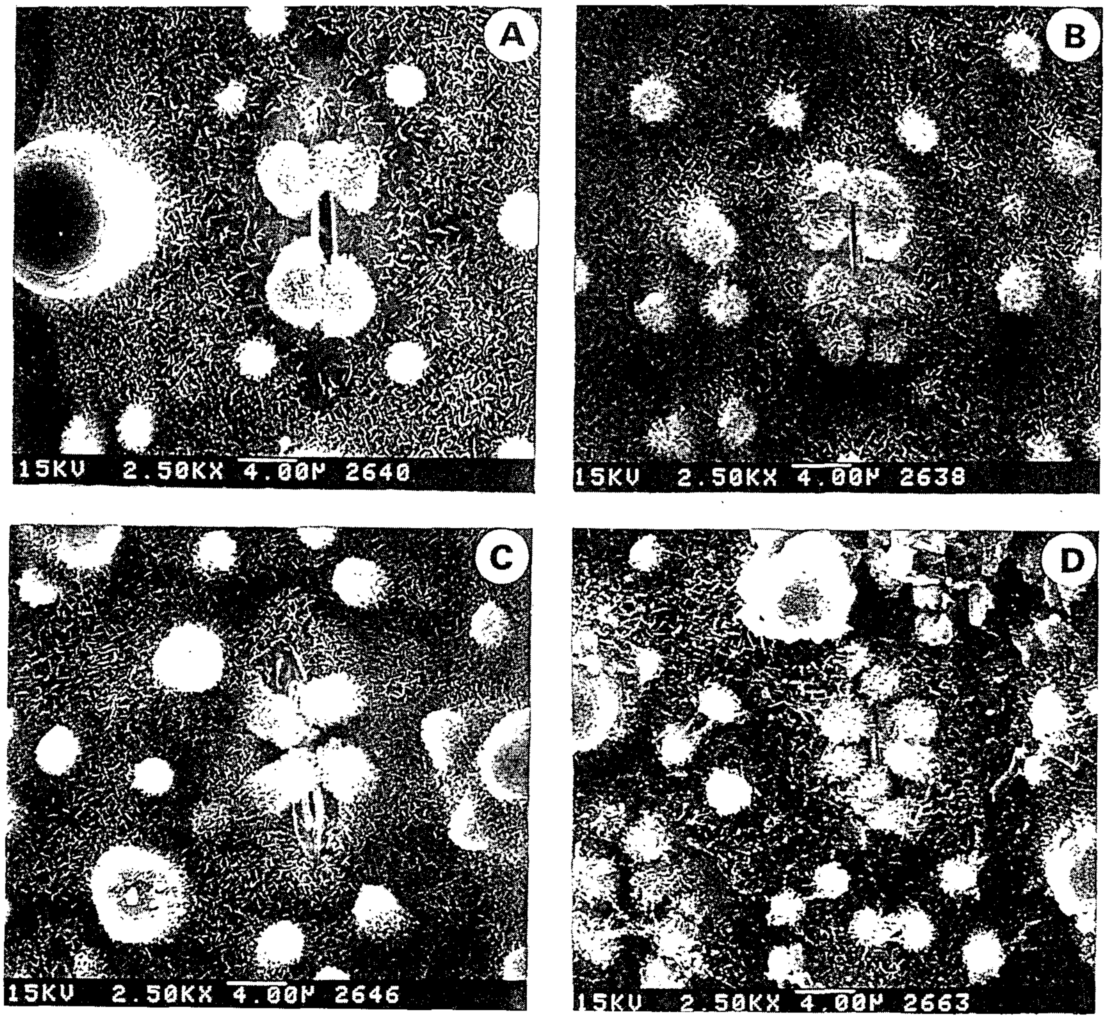

Plate 2. Leaf epidermis showed composed stomata cells which developed into phytoliths.
LP, long cell phytolith; SCP, stomatal complex phytolith; PP, papillae phytolith. A : *O. rufipogon*, B : *O. glaberrima*, C : *O. sativa* cv. Taichung Native 1, D : *O. sativa* cv. Dongjinbyeo

matizing various plant groups if further study on phytoliths follows widely and wholly.

REFERENCES

Baker, G. 1960. Fossil opal-phytoliths and phytolith nomenclature. Australian Journal of Science 21:305-306.

Chen B. and X. Wang. 1995. A preliminary study on phytolith of caryopses of rice and its significance. Chinese J. Rice Sci. 9:242-244.

Ellis, R. P. 1979. A procedure for standardizing comparative leaf anatomy in the Poaceae. Ⅱ. The epidermis as seen in surface view. Bothalia, 21:641-676.

Kaufman, P. B., P. Dayanandan, C. I. Franklin, and Y. Takeoka. 1985. Structure and function of silica bodies in the epidermal system of grass shoots. Ann. Bot. 55:487-507.

Metcalfe, C. R. 1960. Anatomy of the Monocotyledons. I. Gramineae. Oxford University Press, London. pp. 340-343.

Oka, H. I. 1988. Origin of Cultivated Rice. Japan Sci. Soc. Press, Tokyo, pp. 1-54.

Piperno, D. R. 1988. Phytolith analysis: An archaelogical and geological perspective. San Diego Academic Press, New York. pp. 50-108.

Sangster, A. G., M. J. Hodson, D. W. Parry, and J. A. Rees. 1983. A developmental study of silicification on the trichomes and associated epidermal structures of the inflorescence bracts of the grass, Phlaris canariensis L. Ann. Bot. 52:171-187.

Tang, S., S. Min, and Y. I. Sato. 1993. Exploration on origin of keng rice(japonica) in China. Chinese J. Rice Sci. 7:129-136.

Thomasson, J. R., M. E. Nelson, and R. J. Zakrzewski 1986. A fossil grass (Gramineae-Chloridoideae) from the Miocene with Krantz anatomy. Science 233: 876-878.

Vaughan, D. A. 1989. The genus *Oryza* L. current status of taxonomy. IRRI Research Paper Series Number 138:1-21.

Watanabe, N. 1968. Spodographic evidence of rice from prehistoric Japan. J. Facul. of Sci. Univ. Tokyo, (Sect. Ⅴ) 3:217-235.