Silicon deposition in roots of forage grasses

Jun Abe [1], Alexander Lux [2], Satoru Muranaka [3], Taiichiro Hattori [4], Wataru Tsuji [5]

[1] AE-Bio, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 113-8657 Tokyo, Japan
[2] Department of Plant Physiology, Faculty of Natural Sciences, Comenius University in Bratislava, Mlynská dolina B-2, SK 842 15 Bratislava, Slovakia
[3] International Institute of Tropical Agriculture (IITA), Kano Station, Sabo Bakin, Zuwo Road, Kano, PMB 3112, Nigeria
[4] National Agricultural Research Center for Kyushu Okinawa Region, NARO, Nishino-omote, Kagoshima 891-3102, Japan
[5] Arid Land Research Center, Tottori University, Hamasaka, Tottori 680-0001, Japan
Contact: Jun Abe E-Mail JunAbe@agrobio.jp

ABSTRACT

Silicon (Si) is deposited in specific root and shoot tissues at various concentrations depending on plant species. In this study, we compared location and quantity of Si deposition in the roots and leaf blades of four forage grasses using X-ray microanalysis. Seedlings of two C3 temperate grasses (timothy, tall fescue) and two C4 tropical grasses (sudangrass, rhodesgrass) were grown in sand culture with application of potassium silicate under the green house condition to analyze Si deposition in seminal roots. The grasses were also grown in pots filled with an Andosol soil for the analysis of Si deposition in nodal roots and leaves of mature plants. At the seedling stage, Si deposited in endodermal cell walls in primary seminal roots of timothy and sudangrass, but not in those of tall fescue or rhodesgrass. In mature plants, Si deposition in endodermal cell walls of nodal roots was detected in all the species except rhodesgrass. The Si content (wt%) in the root endodermis was 0.7% in timothy, 0.8% in tall fescue, and 3.6% in sudangrass, respectively. Sudangrass formed Si aggregates on the inner cell walls of endodermis. Aged nodal roots of rhodesgrass sometimes accumulated Si in the cell walls surrounding the aerenchyma. The pattern of Si deposition on leaf surface was also much varied among four grass species. These differences could be related to the degree of Si effects to stress tolerance and forage quality of each grass species.
KEYWORDS: *Chloris gayana*, EDX-type X-ray microanalyzer, ESEM, *Festuca arundinacea*, *Phleum pratense*, *Sorghum sudanense*

1. INTRODUCTION

Silicon (Si) is often deposited in specific shoot and root tissues at various concentrations in Poaceae plants. Silicon is expected to improve stress tolerance of plants (Datnoff et al., 2001), whereas silicon deposition may diminish the quality of forage grasses. In this study, silicon deposition, namely the location and quantity, in leaf blades and roots of four forage grasses was investigated using X-ray microanalysis.

2. MATERIALS AND METHODS

In Experiment 1, seedlings of two C3 temperate grasses [timothy grass (*Phleum pratense* L. cv. Kunpu) and tall fescue (*Festuca arundinacea* Schreb. cv. Southern cross)] and two C4 tropical grasses [sudangrass (*Sorghum sudanense* Piper cv. Beru Sudan) and rhodesgrass (*Chloris gayana* Kunth cv. Asatsuyu)] were grown by sand culture with application of calcium silicate in a green house in 2004. Silicon location and content in cross sections at basal part of primary seminal root were analyzed by X-ray microanalysis.

In Experiment 2, the same four grass species were grown in pots filled with Andosol (loamy soil) without silicon fertilizer for the analysis of silicon deposition in the surface of leaf blades and cross section of nodal roots of mature plants (70 days old) in 2005. An upland rice cultivar (*Oryza sativa* L., IRAT109) was grown in the same conditions for a reference. Nodal roots emerged from the 3rd node counted basipetally from the highest rooting node and 5th leaf counted basipetally from the top in main stem were used for the Si analysis. In addition, prop roots formed on the 2nd highest rooting node (20-30mm above soil surface) of sudangrass and aged nodal roots formed on 6-7th highest rooting nodes of rhodesgrass were used for Si analysis.

An ESEM (Nikon ESEM 2700) equipped with an EDX-type X-ray microanalyzer (Philips EDAX DX4) was used for X-ray microanalysis with the procedure described by Lux et al. (2003)

3. RESULTS AND DISCUSSIONS

In Experiment 1, Si was deposited in endodermal cell walls in primary seminal roots of timothy and sudangrass, but not in those of tall fescue and rhodesgrass.

In Experiment 2, Si deposition in endodermal cell walls of nodal roots was detected in all the species except rhodesgrass; the Si content (wt%) in the root endodermis was 0.7% in timothy, 0.8% in tall fescue, 3.6% in sudangrass, and 1.7% in upland rice, respectively. Sudangrass accumulated high content of Si and formed Si aggregates on the inner cell walls of endodermis similar to those found in sorghum roots. These endodermal Si aggregates in sudangrass roots were observed even in the aerial basal part of prop roots, suggesting that the silicon for deposition can be supplied not only by inward flow from root surface to stele xylem but also by outward flow as predicted by Lux et al. (2003). Silicon impregnation of the root endodermis is well studied in cereal plants, but Si may also deposit in other tissues of roots in some grass species (Hodson, 1986). In this study, Si accumulation by 1.5-2 wt% in the cell walls surrounding the aerenchyma was found in some of aged nodal roots of rhodesgrass.

The distribution and degree of Si deposition in leaf blade surface also varied among the species in Experiment 2. The Si wt% of adaxial leaf surface (excluding the midrib) was higher than that in the abaxial side of leaves except for rhodesgrass. A remarkably high Si content in the midrib of the leaf blade, as formerly reported in sorghum, was detected in timothy, sudangrass and rhodesgrass but not in tall fescue. The Si contents of leaf in these four forage grass species except in the midrib of sudangrass were lower than those of upland rice.

It was not likely that the classification as C3-temperate and C4-tropical grasses affects silicon deposition in leaf or root. The differences in the pattern and degree of Si deposition could be related to the degree of Si effects to stress tolerance and forage quality of the four grass species.

ACKNOWLEDGEMENTS

This study was supported by Joint Research Program of Arid Land Research Center, Tottori University, and by Grant-in-Aid for Scientific Research (C) No. 20580010.

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