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The development of silica phytoliths in plants can be artificially modified to produce the particles of requested features

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Silicon is the second most abundant element in Earth´s crust [1]. Many plant species are able to take up, transport, and after the distribution to accumulate high amounts of silicon in their bodies [2]. Among those species an agronomic important *Sorghum bicolor* L. is able to accumulate silicon in the amount of several % of dry weight. Silicon is either spread in the form of compounds in the cell walls or accumulated in the relatively large deposits in the intercellular spaces and inside the cells [3]. These deposits are called silica phytoliths and according to the International code for phytolith nomenclature 1.0 [4] *Sorghum* root endodermal cells develop the specific silica phytoliths of semi-globular shape. The silica phytoliths start to develop on the inner tangential (centripetal) parts of endodermal cells in the space between plasma membrane and the cell walls (many times protruding to the cell wall matrix). Their shape, size and distribution are uniform [3]. There is a potential to use the silica phytoliths, because of their physical and chemical features, stable and repeatable morphology, in electro-technical and building industry [5]. The goals of this study were to characterise the endodermal cell wall modifications of *Sorghum* root related to the silica phytoliths development and to test the possibility to change the size and morphology of silica phytoliths with the aim to produce particles of requested features for industry.

It is known that cadmium affects genetic and metabolic processes in living organisms. We have used this metal element in the form of cadmium nitrate tetrahydrate to test its effect on silica phytoliths development. Tested plants of *S. bicolor* were cultivated in hydroponics containing wide concentration ranges of Na_2SiO_3, as silicon source, and of cadmium. After three-day treatment the seminal roots of plants were investigated by light (with a combination of negative phase contrast and differential interference contrast), fluorescent (with a use of fluorescent indicators for silicon – Rhodamine B and for suberin lamellae – Fluorol yellow 088), transmission and scanning electron microscopy (equipped with EDXA) to characterise the development, exact localisation, shape and morphology of silica phytoliths related to the composition of cultivation media and to the endodermal cell wall modifications. For better observation of endodermal silica phytoliths the tissues lying centrifugally to endodermis (rhizodermis, exodermis, mesodermis) were removed by peeling off [3].

At the concentrations of silicon above 0.8 µmol/L the silica phytoliths form uniformly in almost all endodermal cells of *S. bicolor* seminal roots with a positional effect – they development starts firstly opposite to the phloem poles and later opposite to the xylem poles – consistent with a gradual development of a secondary stage (with a formation of suberin lamellae). The low silicon concentrations in the hydroponic media affect negatively the size of silica phytoliths and the continuous size-dependent gradient shifts towards the base of the root. The cadmium affects not only the size, but also the exact localisation of phytoliths. With increasing cadmium concentration they become smaller, not uniform in size, and tend to be formed ectopically outside the central axis of endodermal tangential cell walls (typical for physiological conditions without the presence of this toxic metal). At still relatively low concentrations of cadmium the phytoliths stop to form and the silicon is spread ectopically in the tissues of root.

Based on the results although the silica phytoliths are formed uniformly under natural conditions, their development, size and morphology can be changed by use of compounds affecting the silicon metabolism and/or mechanisms of phytoliths formation in plants. *Sorghum* root is an excellent model for investigation of silica phytoliths development in plants. The further investigation, understanding, and modification of processes involved in the phytoliths development can help to produce particles of requested features for industry.

1. T.I. Balakhnina et al., Plant Growth Regulation 67 (2012), p. 35-43.
2. M.J. Hodson et al., Annals of Botany 96 (2005), p.1027-1046.
3. A. Lux et al., New Phytologist 158 (2003), p. 437-441.
2. M. Madella et al., Annals of Botany 96 (2005), p. 253-260.
5. S. Neethirajan et al., Trends in Biotechnology 27 (2009), p. 461-467.
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