Species of plant Brassicaceae as a component of an autotrophic element of bioregenerating life support systems of a spacecraft

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Introduction

Mankind's space exploration ambitions boosted the study of an impact of microgravity and ionizing radiation on plants as autotrophic elements of spacecraft bioregenerating life support systems. Results of the study of adaptation of plants toward these factors lay the theoretical foundation of the development of technology for plant cultivation in space.

Years-long study has established a number of regular patterns in microgravity influence over morphogenesis, spatial orientation and polarity of organogenesis, physiology of basic functions, cellular metabolism biochemistry, gene expression, cell reproduction and differentiation, i.e. processes fundamental for the growth and evolution of organisms [1, 2]. But the problem of an impact of ionizing radiation on individual cell organs is still scantily explored. It is known that radioresistance of plants depends on their specie and individual characteristics. Brassicaceae family of plants is considered to be particularly radioresistant. Their cells have endoplasmic bodies (ER-bodies) that constitute cisternae of rough endoplasmic reticulum and contain β-glucosidase ferment. This ferment protects cells of the plants [5, 7]. Study of the role of β-glucosidase in securing radioresistance of Brassicaceae family of plants is a key to understanding the mechanism of their adaptation towards space-vehicle conditions.

Methods and subjects of analysis

In course of the experiment 3- and 13-day-old sprouts of *Arsbidopsis thaliana* (L.) Heynh of Columbia (Col−0) ecotype were X-rayed with Roentgen apparatus *РУМ-17* (dose rate 0.43 cGy/s) in Petri dishes in doses of 0.5, 1, 2, 4, 6, 8, 10 and 12 Gy (separate dish for each dose). Every dish contained 200 sprouts. Treated sprouts were examined 2 hours and 10 days after the irradiation. Untreated sprouts of the same age were used as control samples.

β-glucosidase activity was determined by the amount of 4-nitrophenyl formed in the reaction [6]. Measurement results were denominated as nM 4-nitrophenyl/h/mg of protein (hereinafter referred to as ‘‘activity units’’). Optical density was measured with *СФ2000* Ukrainian spectrophotometer at a wavelength of 420 nm. Protein concentration was determined by the Bradford assay.

Experiment results and their interpretation

In control samples 3-day-old sprouts had dark green oval cotyledonary leaves with solid lamina. Primary roots had bases of lateral roots. 13-day-old control sprouts had regular-shaped rosettes (four leaves of more than 1 mm). Leaves of rosettes were oval in shape, deep green in color and had serrate edges. Roots comprised main roots and branched lateral roots. Leaves of rosettes and roots of both 3-day-old and 13-day-old sprouts were in turgor.

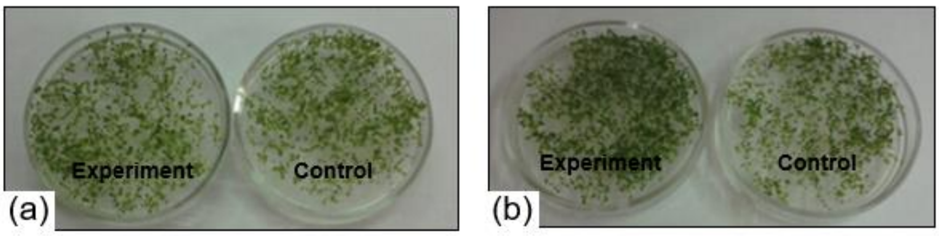

Figure 1. Control samples of 13-day-old sprouts of *A. thaliana* and experiment samples after irradiation in doses of 0.5 Gy (a) and 8 Gy (b).

The morphology of irradiated 3-day-old and 13-day-old sprouts, including dimensions, color and turgidity of leaves of rosettes and primary roots, was similar to that of control samples (see Figure 1).

β-glucosidase activity in control 3-day-old sprouts was 0.42 activity units. β-glucosidase activity fluctuated 2 hours after irradiation with various doses (see Figure 2). An increase in dose caused a non-linear increase in ferment activity.

β-glucosidase activity was especially high under 0.5, 8 and 12 Gy, more than doubled that of control samples (see Figure 2). Such an increase in β-glucosidase activity 2 hours after irradiation can be indicative of the role of this ferment in cell reaction to ionizing radiation and other exciters.

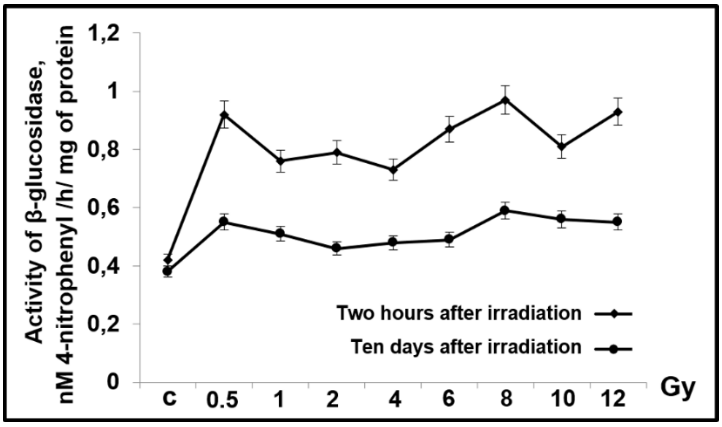

Figure 2. Activity of β-glucosidase in *A. thaliana* sprouts in control (c)
and irradiated samples (Gy – Gray).

Thus mechanical injury, eating by herbivorous insects and, exposure to pathogens and chemicals also cause an increase in β-glucosidase activity of *A. thaliana* [3-5, 7].

β-glucosidase activity of 13-day-old control sprouts constituted 0.38 activity units. Figure 2 presents the results of a study of β-glucosidase activity 10 days after irradiation with various doses of x-rays.

The most active was the dose of 8 Gy. Its effect lasted 10 days after irradiation. β-glucosidase activity of 13-day-old sprouts irradiated at this dose was 1.5 times higher than that of the control samples. We can infer that β-glucosidase as hydrolyzing ferment catalyzes hydrolytic processes of cell regeneration after being irradiated with X-rays.

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Short Summary

Study show that morphology of irradiated 3-day-old and 13-day-old A. thaliana sprouts, including dimensions, color and turgidity of leaves of rosettes and primary roots, was similar to that of control samples. The obtained data show an increased β-glucosidase level in A. thaliana seedlings after X-radiation.