5 - 45 Effects of Carbon Ion Beam Irradiation on Soybean Unifoliate Leaves at Phenotype and Physiology Level

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The contemporary effect of heavy ion beam radiation on plants is a combination of physiological damage and genetic variation. Different biological traits respond differently to radiation, therefore, studying the changes in growth and oxidative stress of M1 plants that derived from carbon ion beam radiation in soybean can provide essential data for future breeding.

Leaves are important nutritional organs of plants, and their traits and physiology reflect the adaptation of plants to exogenous stimulus and other factors. Leaf size depends on the number of cells at the initiation stage of leaf primordia, cell proliferation, and expansion. To cope with damage caused by ionizing radiation, plants tend to provide temporal and spatial conditions for damage repair by delaying cell division and elongation, accelerating cell senescence and apoptosis. In the present study, the dry seeds of soybean were irradiated by carbon ion beams that produced by the Heavy Ion Research Facility in Lanzhou (HIRFL), the irradiation dose was 80 Gy. Compared with control, the unifoliate leaves of M_1 plants that derived from carbon ion irradiation at 80 Gy were narrower and smaller with a 19.72% decrease in leaf length (Fig. 1(a)), 30.89% decrease in leaf width (Fig. 1(b)), 20.07% increase in ratio of length to width (Fig. 1(c)), and 44.74% decrease in leaf area compared with the control (Fig. 1(d)).

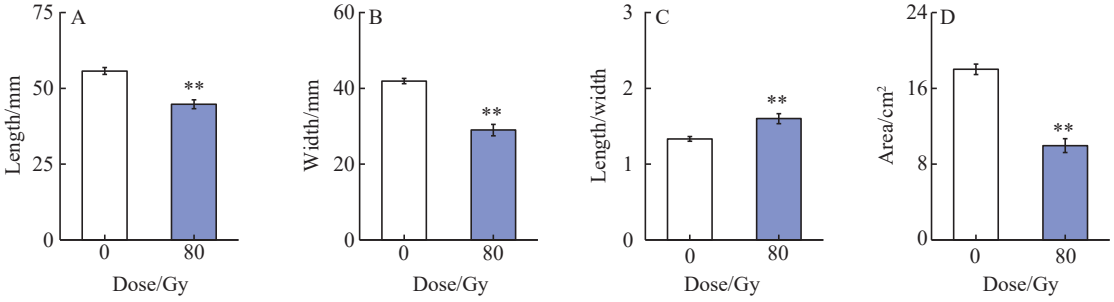

Fig. 1 (color online) Effects of carbon ion beam irradiation on unifoliate leaf index.

Ionizing radiation can affect plant tissues or cells directly, leading to toxic effects, or it can affect biomolecules in cells, especially water molecules, leading to excessive accumulation of reactive oxygen species such as superoxide anions, hydroxyl radicals, singlet oxygen and hydrogen peroxide, which in turn cause oxidative stress in plant cells. Once sensing the abiotic stress stimulus signals, plants activate rapidly their own defense systems such as enzymatic antioxidants, non-enzymatic antioxidants, osmoregulatory substances and glyoxalase systems to complete cellular damage repair in a relatively short time, And when the damage is severe, they can initiate apoptosis, autophagy and senescence. In this study, the relative conductivity, superoxide dismutase (SOD) and catalase (CAT) of the unifoliate leaves were determined. Compared with control, the relative conductivity in treated group was increased by 49.39% (Fig. 2(a)), and the activities of SOD and CAT were decreased by 28.75% and 16.30%, respectively (Fig. 2(b) and (c)). These results indicate that the antioxidant system was damaged or inhibited in the unifoliate leaves that from the irradiated group, and this further led to a severe oxidative stress to M1 plants which reflected in a increase of the cell membrane permeability.

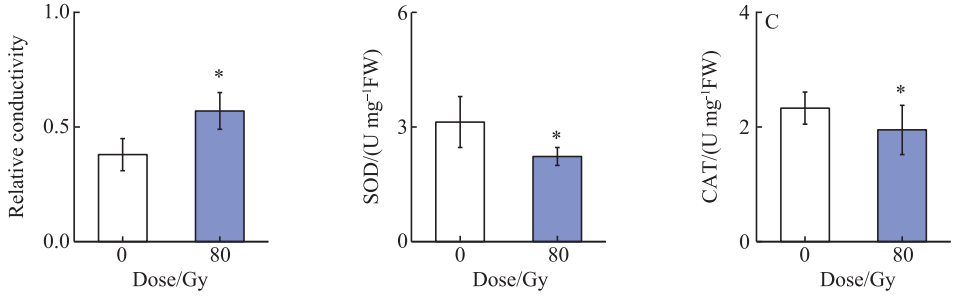

Fig. 2 (color online) Effect of carbon ion beam on antioxidant enzyme activity and membrane damage of unifoliate leaves.