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Fullerene derivatives influence production process, growth and resistance to oxidative stress in barley and wheat plants(Article)

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Просмотр дополнительных организаций

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Creation of effective environment-friendly preparations to improve productivity and sustainability of agro- and ecosystems is of current interest. Carbon nanostructures, such as the water-soluble C60 and C70 fullerene derivatives presently used in biomedicine and pharmacology, are considered perspective agents for agriculture. It was shown that they can penetrate into the cell membranes owing to lipophylicity and nanosize, transport medicinal substances to target cells and have antioxidant activity. The mechanism underlying the influence of water-soluble fullerene derivatives on plants in agroecosystems remains unclear. In the paper, we for the first time report the effects of C60 fullerene derivatives on the processes that determine the net productivity and plant resistance to oxidative stress. In the study we used fullerenol and the fullerene C60 adducts with the three essential amino acids, threonine, lysine, arginine, and also with the amino acid hydroxyproline, which were previously synthesized following a one-step procedure. Stimulating effects of these fullerene derivatives on the growth of spring wheat and barley were observed in two vegetation experiments carried out in controlled conditions (aerated nutrient solution, plant growing light equipment) when the compounds were added to the root habited medium and under non-root treatment. It was shown that the biomass of leaves, stems, and roots in plants increased by 27-226 % ($p < 0.05$). Statistical analysis using the Wilcoxon test confirmed the reliability of the differences found. Fullerenol, fullerene C60-hydroxyproline, and fullerene C60-threonine caused the greatest increase when compared to the control. Obviously, the observed effect was associated with the established ability of fullerenol and C60 fullerene amino acid derivatives to exert regulatory activity on the synthesis of photosynthetic pigments and, as a consequence, on the efficiency of photosynthesis. A comparison of the reflection indexes characterizing the content of chlorophylls (ChlRI) and anthocyanins (ARI) in leaves showed that the photosynthetic apparatus with a greater potential is generally formed under the influence of fullerene derivatives. Under the influence of these derivatives, the lipid peroxidation intensity also decreased and superoxide dismutase was activated while reactive oxygen species generation in leaves and (or) roots increased (predominantly in barley) or decreased. These changes in plants were the most expressed at fullerenol, C60-threonine and C60-hydroxyproline action. Under stress modeling (UV-B irradiation, 20 kJ/m2), the UV-resistance of barley plants after not-root treatment with fullerenol, C60-threonine and C60-hydroxyproline, when estimated by the dry weight of the above ground parts and roots, was 10-20 % higher compared to that of the control irradiated plants which were of less weight (by 33 % for stems and leaves, and by 10-20 % for roots). Thus, the study revealed the positive influence of synthesized amino acid derivatives of fullerene C60 and fullerenol on the plant production process and resistance to oxidative stress. High efficiency in small concentrations, low expenses for application and

environmental friendliness indicate the perspectiveness of these compounds and necessitate further studying the mechanisms of their action on the soil-plant system to create preparations for use in plant growing.