2. Streszczenie w języku angielskim (abstract)

Plants are exposed to constant stress caused by abiotic factors, such as water deficiency or excess, pollutants and biotic factors. In response to unfavourable environmental factors, plant cells produce, among others, reactive oxygen species, which in excess lead to damage to proteins, lipids and DNA, which can lead to cell death. Plants have developed several mechanisms that minimise the adverse effects of a changing environment. Metallothioneins (MTs) are low molecular weight proteins rich in cysteine residues (Cys). MTs have been detected in bacteria, mammals and plants. Due to their ability to bind metal ions in cells, these proteins participate in maintaining metal homeostasis and in detoxification processes. In plants, MTs are divided into four types, depending on the number and arrangement of Cys. The thiol group -SH of Cys can react with reactive oxygen species, protecting cells from oxidative stress.

This study aimed to identify the *MT* genes of *Avena sativa* L. (*AsMT*) and determine the role of the proteins they encode in the response of oat to abiotic (drought stress, osmotic stress, heavy metals) and biotic (presence of *Trichoderma viride* fungi) factors.

In *A. sativa* L. genome, 21 MT genes belonging to four types (*AsMT1-4*) were identified. The promoter sequences of these genes contained *cis*-elements responsible for the plant response to heavy metals, phytohormones, light, water deficiency and biotic factors, and those related to plant development. MTs are necessary for the proper plant growth and development. In the first hours of oat seed germination, changes in the expression of *AsMT1-4* were observed, while total number of *AsMT* transcripts remained the same. An analysis carried out to understand the function of AsMT, showed that bacteria carrying *AsMT1-4* were characterised by greater tolerance to osmotic stress and stress induced by the presence of Zn and Cd. The presence of metal ions (Zn, Cd and mixture of Zn and Cd) caused variations in the level of *AsMT1-4* transcripts in the roots and shoots of oat seedlings. Under stress conditions induced by heavy metals, an increase in the content of phenols and hydrophilic and lipophilic antioxidants was observed in 21-day-old oat plants, and these changes correlated with the expression of *AsMT*. Oat plants growing with *T. viride* and without the fungus were subjected to long-term stress induced by Cd ions in the soil. It was shown that with the increase in Cd in the soil, the biomass of plants and the number of seeds produced decreased, while the concentration of Cd in

the above-ground part of the plants increased. Changes in the expression of *AsMT1-3* were observed in the presence of *T. viride*. In contrast, the presence of Cd did not cause statistically significant changes in the content of transcripts of these genes, which indicates the participation of AsMT in the interaction of plants with microorganisms. Osmotic and drought stresses caused changes in the expression of *AsMT* genes in shoots and roots. Moreover, those stresses increased the activity of antioxidant enzymes, the content of abscisic acid, phenolic compounds and sugars.

The studies indicate that oat MTs participate not only in response to the presence of metal ions in the environment but are also an integral element of the response to osmotic and drought stresses and presence of microorganisms. In common oats, individual types of AsMT perform diverse functions, and their expression correlates with biochemical changes occurring in plant cells under stress. AsMT2 may be a molecular marker of drought, and AsMT3 may be a marker of osmotic stress. In response to Cd the expression of *AsMT1* changed first. Thus, this gene may indicate stress induced by heavy metals. The results may be used for producing transgenic varieties of oat with increased tolerance to stresses, especially those caused by dehydration and environmental pollution, which is important in the era of climate change.

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