Summary

The changes in the profile of selected polar metabolites in germinating seeds and seedlings of pea (*Pisum sativum* L.) under abiotic stresses

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To meet increasing demand for vegetable protein for food, feed and industrial purposes and to diversify supply, it is necessary to increase the production of domestic legumes seeds. The pea (*Pisum sativum* L.) are the most important, due to the high protein content in seeds, high yield potential, beneficial effect on soil nitrogen abundance and phytosanitary condition of soil. A significant obstacle in increasing pea crops is high sensitivity to the effects of mainly abiotic stress factors, contributing to the yield failure. Therefore, a fuller understanding of the mechanisms underlying the pea resistance to abiotic stresses is an urgent challenge.

The presented study attempts to determine how the metabolic profile of tissues changes in the earliest stages of vegetative pea growth - during seed imbibition and germination, as well as initial growth of seedlings, exposed to desiccation, osmotic stress, low temperature and the presence of nanoparticles and silver ions in the environment. Carrying out comparative analysis of composition and content of polar metabolites (using gas chromatography - GC and gas chromatography coupled with mass spectrometry GC-MS) in the different organs - the embryonic axis and cotyledons of germinating seeds, in the root, epicotyl and cotyledons of seedlings several days old, made it possible to identify early (after a few hours) and later (after a few days) changes in the metabolic profile of the tissues in response to stress. The intensity of the stress factors was selected in such a way that it was possible to trace the changes after the stress disappeared, when the seedlings resumed growth. The dynamically changing metabolic profile of tissues during seed germination, growth and development of seedling was strongly modified after the tested stress factors. The greatest changes (both qualitative and quantitative) concerned mainly soluble sugars (sucrose, raffinose family oligosaccharides, monosaccharides) and amino acids (non-protein

homoserine and some protein amino acids - proline, aspartic acid, glutamic acid and their amides).

The basic reaction of germinating pea seeds and seedlings to disturbances homeostasis in cell water (during desiccation and osmotic stress) was the rapid accumulation of sucrose with the use of monosaccharides already present in the tissues and/or requiring accelerated mobilization of reserve materials - primary, such as raffinose family oligosaccharides or the main ones - such as starch. At the same time, tissues begin to produce and accumulate proline, a widely recognized osmoprotectant. However, changes in the composition and content of amino acids indicate a presumably greater importance of homoserine - a non-protein amino acid that was quantitatively dominant in the tissues of the developing seedling, and the content significantly increased during stress. The changes were relatively quick - in 5-day-old seedlings during desiccation, even slight changes in the water content after 4-8 hours, changed the concentration gradient of sugars and amino acids between the tissues of individual growth zones - the allocation of sucrose and proline from the cotyledons to the tips of the root growth and epicotyl. The change in the distribution of amino acids was also indicated by the accumulation of larger amounts of glutamic acid and glutamine in the root tip and asparagine in the epicotyl. The accumulation of larger amounts of metabolites could also be due to their reduced use by cells, whose growth was inhibited as a result deficiency or loss of water, decreased turgor, low temperature or the presence of nanoparticles/silver ions inhibiting metabolism. An important result is the lack of influence of the raffinose family oligosaccharides on the maintenance of the resistance of germinating seeds to desiccation. On the other hand, the knowledge of factors inducing their synthesis (mainly raffinose) in seedlings during water stress and low temperature, as well as the importance for the resistance of seedlings to stress, requires further research. The role of homoserine in the regulation of nitrogen metabolism of pea seedlings under stress also remains unclear.