Structural and functional studies of the plant enzymes of arginine metabolism as molecular targets of novel plant protection products

Sustainable crop cultivation, safe for people and natural environment, is one of the key challenges for the expanding human population. Rising safety concerns (health-related and ecological) related to the commercially available plant protection have led to their progressive withdrawal from the market. However, **efficiency of agriculture is compromised without plant protection products.** Additionally, rapid climate change facilitates migration of pest and weeds. Therefore, **novel, and most importantly, safe solutions for agriculture are of the essence**. The fact that many popular substances in agriculture were introduced in the past to the market without the full understanding of the mode of their action, as well as, without basic knowledge of the essential processes in plant organisms.

Rational development of novel solutions for agriculture is hindered without the scientific insights into the key plant metabolic pathways. One of them is biosynthesis of arginine, amino acid with the role in plants that reaches much further than serving as a building block of proteins. Arginine is used as a storage for nitrogen, the element that impedes plant growth and development the most on degraded soil. Arginine serves as a precursor of various substances that defend plants from various stress conditions, like extreme temperatures, lack of water and nutrients, or pathogens and pest attack. Many aspects of arginine metabolisms in plants has not been studied and remain as hypotheses.

The project is focused on the studies of seven selected enzymes, from model plant organisms (*Arabidopsis thaliana* or *Medicago truncatula*) that are strictly involved in arginine production and utilization. The major goals of the project are **full characterization of the structures and the function of selected enzymes**, as well as **determination of the key features of these proteins that are essential to carry out specific chemical reactions.** During the project high-resolution molecular structures of subjected enzymes will be determined. They will be complemented with a full biochemical and biophysical protein characterization. It will allow to for the precise description of unknow plant enzymes. Encouraging initial results of the studies on plant arginases (they are responsible for initial activation of stored arginine) show their extraordinary architecture. The obtained crystal structures indicate unique mode of interactions with substrates, not seen in human arginases. This feature has a potential for practical use in agriculture – design compounds that precisely block arginases in weeds, keeping human arginase intact. Such compounds, in the case of human consumption, would not be harmful for human health. Similar features found in other studied plant enzymes **will be very useful for investigations of substances that specifically block or facilitate arginine metabolism in plants, which could find practical application in agriculture**.

Potential of this approach can be seen in published research, where arginase produced in tomatoes harmed pest larvae. It was shown that stress conditions induce defensive compounds strictly derived from arginine metabolism. Therefore, **proposed studies on boosting arginine metabolism could be used to increase plant resistance to extreme temperatures or drought**. Additionally, it could potentially facilitate nitrogen uptake by plants from fertilizers, which would **decrease use of expensive substances that are harmful for the environment**.

On the other hand, substances that selectively block arginine metabolism in weeds could be used as novel herbicides. It was shown that naturally-occurring toxins that impede arginine production in attacked plants. The disease and consequential death of the pant caused by toxin, facilitates pathogen expansion. The structural studies planned for the project will help to find or design substances that block arginine production in plants. It will lead to the possible development of herbicides with the novel mode of action, based on naturally-occurring compounds, that are safer than old synthetic herbicides.