University *of Ljubljana*, Biotechnical Faculty

JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
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Project

Member of University of Ljubljana	University of Ljubljana, Biotechnical Faculty
Code	J7-9418
Project	Ionom of crop plants for safe and quality food production
Period	1.7.2018 – 30.6.2021
Range in 2018	1.34 FTE/ year
Head	Katarina Vogel-Mikuš
Research activity	Interdisciplinary (Biology/Biotechnology)
Research Organisation Partners	Jozef Stefan Institute
	National Institute of Chemistry
Co-financing Organisation	/
Abstract	Mineral malnutrition affects more than half of the world's population, while extensive use of artificial fertilizers together with pollution result in exceedingly high concentrations of potentially hazardous elements (PHE) in food crops. Iron (Fe), zinc (Zn), iodine (I) and selenium (Se) are mineral elements (ME) most often lacking in the diet, while on the other hand high contents of PHE like cadmium (Cd) and mercury (Hg) in staple food pose risks to animal and human health. Crop-based solutions, such as biofortification, represent the most cost-effective and sustainable strategy to reduce mineral malnutrition. In order to successfully implement the mentioned technology deep understanding of uptake, transport and accumulation mechanisms of ME and HE is needed as well as understanding of plant physiological responses at

	metabolome level. The ME and HE composition of an organism represents the inorganic component of cellular, tissue and organismal systems and was defined as the ionome. This project aims to correlate studies of plant ionomics and metabolomics in order to set the base for plant breeders to be able to further select/ create ME-rich and PHE-reduced crop plants. More specifically the project will address questions in the two work packages (WPs). WP1 (In collaboration with researchers from Italy) will tackle the ionomics and metabolomics of low phytic acid mutants (*lpa*) of common bean (*Phraseoulus vulgaris*) and maize (*Zea mays*) with emphasis on Fe metabolism at organ, tissue and cellular level. Recently *lpa* mutants accumulating less phytic acid and more free phosphorus (P) and cations in the grains were identified in the major grain crops. The aim is to correlate the gene expression for putative Fe and vacuolar phytic acid transporters with spatial distribution of phytic acid as well as spatial distribution and speciation of Fe in the seeds and vegetative tissues of *lpa* mutants. This will lead to a better understanding of the transport and accumulation of Fe in relation to phytic acid content and distribution that is highly linked to Fe bioavailability. In addition, linking the ionomic and metabolomic profiles of wild type and *lpa* mutants will provide knowledge on phenotypic effects, induced by knocking out the genes related to phytic acid synthesis and transport, which will enable to further tailor the *lpa* crops with high contents of bioavailable ME and good agronomical potential. WP2 will deal with effects of Se biofortification of lettuce on the uptake of ME and HE and their transfer further to the food chain by using terrestrial micro and mesocosm systems with a slug snail (*Arion* spp.) as a model bioindicator organism. To date, foliar and soil applications of Se fertilisers have proven to be feasible approaches to increase Se concentrations in the edible parts of crops; however, there is only little information on the metabolism of different Se compounds in plants and how these Se compounds may influence the plant ionome and metabolome and consequently the transport and accumulation of ME and HE further to the food chains. This knowledge would set a basis for designing high-quality Se biofortified food crops and help to evaluate toxicity and food safety aspects of Se biofortified crops in low and moderately polluted environments. In order to successfully fulfil the goals set in this project, high throughput techniques will be used for bulk analysis as well as to resolve spatial distribution of elements and selected important metabolites. Bulk mineral analyses will be performed by ICP-MS and XRF, while FTIR and MS based techniques (HPLC-MS, LC-MS) will serve to analyse profiles of the selected metabolites. Imaging of element

	distribution at tissue and cellular level will be performed by synchrotron u-XRF and u-PIXE, while MeV and KeV SIMS will be used for imaging of the spatial distribution of selected metabolites.
Researchers	http://www.sicris.si/public/jqm/prj.aspx?lang=eng&opdescr=search&opt=2&subopt=402&code1=cmn&code2=auto&psize=1&hits=1&page=1&count=&search_term=vogel-mikus&id=17367&slng=&order_by=
The phases of the project and their realization	**WP1) The ionomics of *lpa* mutants with emphasis on Fe metabolisms** **Task 1:** Objectives: To correlate the gene expression of putative Fe and vacuolar phytic acid transporters with the spatial distribution of phytic acid as well as the spatial distribution and speciation of Fe in the seeds of the wild type and *lpa* mutants of common bean and maize in order to understand the relations between Fe and phytic acid metabolisms in grains of *lpa* mutants Outputs: Publications on Fe localization and speciation in *lpa* beans and maize in correlation with gene expression; Publications on correlation of ionomic and metabolomic profiles in beans and maize, Outcomes: improved knowledge on Fe and P metabolisms in *lpa* mutants **Task 2:** Objectives: To link ionomic and metabolomic profiles of wild type and low phytic acid (*lpa*) mutants of common bean to provide information on phenotypic effects induced by knocking out the genes related to phytic acid synthesis and transport. Outputs: publications on comparison of ionome and metabolome of *lpa* plants, Outcomes: improved knowledge on *lpa* pleiotropic effects **Task 3:** Objectives: On the basis of obtained results to propose and implement guidelines for breading Fe biofortified crops Outputs: guidelines for bean and maize breeders Impact: breeding *lpa* beans and maize with good agronomical potential, - improved Fe nutrition of vulnerable populations **WP2) The effects of Se biofortification of vegetables on their ionome, metabolome and transfer of selected HE further into the food chain** **Task 1:** Objectives: To study the ionomic and metabolomic profiles of Se biofortified vegetables (e.g. lettuce) grown in differentially polluted soils to access the impact of Se biofortification on the uptake of PHE (Cd, Hg) and synthesis of selected primary and secondary metabolites in plants. Outputs: publications on effects of Se on PHE uptake, -publications on Se speciation in plants, Outcomes: improved knowledge on Se speciation in plants and role of Se compounds in PHE uptake and transport. **Task 2:** Objectives: To study the transfer of PHE (Cd, Hg) to the food chains in the presence of different Se compounds in a micro and mesocosm systems with lettuce and slug snails (*Arion* spp.) as model organisms

	to assess the effects of Se biofortification on the transfer and toxic effects of PHE to the food chain. Outputs: publications on the effects of Se on transfer and toxicity of PHE in the food chain, Outcomes: improved knowledge on the effects of Se compounds on the transfer of PHE through the food chain. **Task 3:** Objectives: on the basis of obtained results to propose and implement guidelines for breading of Se biofortified vegetables in moderately heavy metal polluted environments, Outputs: guidelines for Se biofortification in moderately polluted environment, Impact: improved Se nutrition and tolerance to PHE of vulnerable populations **WP3) Management of the project and dissemination of results** Objectives: Management of the project, communication and dissemination of the results; exploitation and implementation of the results, Outputs: Annual and final reports, publications at international conferences and in SCI journals, published guidelines, creation of a project web page.
Citations for bibliographic records	http://izumbib.izum.si/bibliografije/J20190106114724-J7-9418.html