

SUMMARY

The effect of lead on the generation of signalling molecules in pea seedlings (*Pisum sativum* L.) 'Cysterski' in response to the feeding of pea aphid [*Acyrtosiphon pisum* (Harris)]

Under natural conditions we may frequently observe the impact of multiple stressors occurring simultaneously or sequentially. The main aim of this study was to understand the regulation of biosynthesis of signalling molecules in the defense mechanism of a plant during the interaction of an abiotic and biotic factor. It is important to recognize this regulation at the physiological, biochemical and molecular level in *Pisum sativum* L. under the influence of various concentrations of lead, low inducing metabolic status of the plant, causing hormetic effect and high causing toxic effect, and during feeding of the phytophagus insect with piercing-sucking mouthpiece, i.e. pea aphid [*Acyrtosiphon pisum* (Harris)].

The first aim of the study was to determine the correlations between lead concentration and intensity of signaling molecules generation, i.e. phytohormones such as salicylic acid (SA) and abscisic acid (ABA) and reactive oxygen species, i.e. hydrogen peroxide (H₂O₂) in the roots and leaves of pea seedlings (*P. sativum* L.cv. Cysterski). Then it was important to determine the effect of lead and pea aphid (*A. pisum*) on the generation of these molecules in the leaves of pea seedlings. In addition, it was also important to understand sequence of generation of these molecules and the time-dependent aspect of induction of defense responses. The second aim was to determine the level of gene expression and activity of selected enzymes involved in the biosynthesis of signal molecules, i.e. phenylalanine ammonia-lyase (PAL) in SA biosynthesis and superoxide dismutase (SOD) in H₂O₂ biosynthesis.

The third aim of the study was to determine the effect of lead and *A. pisum* on the stimulation of other defense reactions, i.e. the level of free radicals generation (superoxide anion radical and semichinone radicals), changes in manganese concentration affecting changes in the redox status of cells, changes in antioxidant enzyme activity (superoxide dismutase and peroxidase) and the total antioxidant capacity and the level of flavonoids, in particular pisatin - phytoalexin characteristic for pea. In addition, it was important to determine the level of lipid peroxidation caused by oxidative stress. The fourth aim of the study was to determine the lead content both in the roots and in the leaves of pea seedlings and in the body of pea aphid, as well as to determine the relationship between the level of lead in the leaves of pea seedlings and the feeding of *A. pisum*.

The fifth objective of the study was to determine the effect of lead on demographic parameters and the pea aphid feeding process using the electrical penetration graph (EPG).

Significant accumulation of total salicylic acid (TSA) and its glycoside (SAG) and abscisic acid (ABA) was found in the roots and leaves of pea seedlings growing on the medium with lead, and then during colonization with aphids. Increased production of these phytohormones strongly increased the biosynthesis of flavonoids, including phytoalexin pisatin. Studies have revealed that in pea seedlings growing at low lead concentrations, the phase of nonprobing of floem sap by pea aphid *A. pisum* was short, the phloem was reached faster and the phase of taking the floem sap was extended. The low concentration of lead did not cause decrease in the longevity of aphid in contrast to the toxic concentration, only the reduction of the net reproductive rate was observed.

These studies provide new information about interaction between abiotic factor (lead) and the biotic factor (aphid feeding) at the level of generation of signalling molecules and their role in the induction of flavonoid biosynthesis. The response of pea seedlings to low and sublethal doses of lead followed by the feeding of *A. pisum* differed significantly and depended on the direct contact of the stress factor with the organ (Pb with roots and *A. pisum* with leaves).