VOLATILE ORGANIC COMPOUNDS EMISSION FROM PLANTS

Volatile organic compounds (VOC's) emitted by plants are estimated to be around 100,000 mainly being secondary metabolites. From those, around 1700 are known to be isoprenoides (including isoprene, mono-, homo- sesqui- and diterpene or even triterpenes). Plants emissions consist of a complex blend of chemically heterogeneous volatile isoprenoids. The composition of BVOC blends is species specific and is affected by external conditions. A vast array of volatile compounds - terpenes (mono- and sesquiterpenes), lipoxygenate pathway compounds, ethylene, nitric oxide, methanol, ethanol are involved in stress-dependent signalling within a single plant as well as communication between plants and between plants and insects.

The present work described from the different point of view volatile organic compounds (constitutively or induced) which are emitted by the plants. The thesis comprises two distinct parts: one based on the author's articles which have been published in different journals and another one dedicated to future plans and ideas related to continuing the research in this specific field of science with high potential for applications in agriculture and environment.

In the first chapter Henry_s law constants (H_{pc}, Pa m^3 mol^{-1}) and octanol/water partition coefficients (K_{OW}, mol mol^{-1}) were determined for 10 important plant monoterpenes at physiological temperature ranges (25–50 ^oC for H_{pc} and 20–50 ^oC for K_{OW}). A standard EPICS procedure was established to determine H_{pc} and a shake flask method was used for the measurements of K_{OW}. The presence of a salt in an aqueous solution changes the water structure in the vicinity of the solute. The magnitude of the salting-out effect was found to be large enough to have a significant influence on mass transfer rate of monoterpenoids in natural processes. As well, pH and low-molecular organic compounds such as sugars, amino acids and organic acids affect the partitioning of monoterpene between water and air phases (H_{pc}) and between water and lipid phases (K_{OW}).

In the second chapter, heat stress resistance of foliar photosynthetic apparatus was investigated in the Mediterranean monoterpene-emitting evergreen sclerophyll species *Quercus ilex*. Leaf feeding with fosmidomycin, which is a specific inhibitor of the chloroplastic isoprenoid synthesis pathway, essentially stopped monoterpene emission and resulted in the decrease of the optimum temperature of photosynthetic electron transport. The heat stress resistance was partly restored by fumigation with 4 to 5 nmol mol^{-1} air concentrations of monoterpene α-pinene but not with fumigations with monoterpene alcohol α-terpineol.

In the 3^{th} chapter, the hypotheses that monoterpenes can be uptaken by the plants which are not emitters have been proved. The foliar uptake potential of the hydrophobic monoterpene limonene in 13 species of contrasting leaf structure and lipid contents have been determine.

Furthermore, we proved that the accumulation of monoterpenes improves plant resistance to abiotic stresses (heat, cold or other oxidative stress). We then demonstrated that a significant uptake of hydrophobic monoterpenes occurred when monoterpene ambient air concentration is high and are released when the concentration is low, and these findings should be included in large-scale monoterpene emission models to obtain more reliable results.

In the 4th chapter, a standardized experimental protocol for BVOC estimations has been proposed. It has been shown the importance of different limitation for estimation of emission factors due to diverse approaches used by researchers such as sampling systems lack of detailed technical specifications, influences of variation in sampling protocols, analytical uncertainties introduced by the inter-laboratory measurements. It has to be mentioned that in the thesis only several directions have been emphasised including measurement chambers, sampling and determination of VOC's.

The larger chapter is dedicated to determination of VOC's from different stressed plants. Often, several stresses can simultaneously or in sequence affect plant performance. We have been shown that flooding induced different VOC's emission and even more the species acclimation potential matched the waterlogging tolerance ranking, and that the VOC and NO emission measurements can provide quantitative insight into time-course of species waterlogging acclimation. As well the effects of cold and heat shock treatments on leaf photosynthesis and the emission of the volatile products of the lipoxygenase pathway (LOX, also called green leaf volatiles) and mono- and sesquiterpene emissions in tomato (*Solanum lycopersicum* cv. Mato) have been studied to gain quantitative insights into temperature stress-elicited volatile emissions. Then we studied the effect of antibiotics and textile dyes on the plants of *Triticum aestivum*. These data suggested that analysis of leaf volatiles can provide a novel sensitive assay to gauge the toxicity of different chemical compounds. Thus, monitoring volatile emissions is a promising tool for quantitative evaluation of the toxicity of different chemical stressors on the plants.

The biotic stresses are exemplified by the infection process with the biotrophic fungus *Melampsora* spp on the willow hybrid clone (*Salix burjatica* Nasarow x *S. dasyclados*) and by the feeding of *Cabera pusaria* larvae on the leaves from *Alnus glutinosa*. It has been shown that the LOX and sesquiterpene emission, which is triggered by several elicitors, also depended on the stage of rust infection. In the second case, we demonstrated that biotic stress effects on plant volatile emissions are quantitative for ubiquitous monoterpenes, (*Z*)-β-ocimene and (*E*,*E*)-α-farnesene while DMNT can serve as a signal for predators and parasitoids of the presence of herbivores. As well we have been shown that alder plants exposed to mild drought prior to herbivore attack become primed to subsequent different type of stress and are less sensitive to herbivory by the larvae of *M. pulveratum*.

In the last chapter have been studied the vertical distribution of ambient biogenic volatile organic compounds (BVOC) concentrations within a hemiboreal forest canopy over a period of one year.

The future research plans of the author are including the following directions:

1. Development of newly established laboratory for measurements of volatile organic compounds from the Institute of Research, Development and Innovation in Technical and Natural Sciences of the University "Aurel Vlaicu" from Arad
2. A screening of different plants, mainly from Romanian flora for determination of the emission factors of terpene compounds
3. A campaign for measuring volatile compounds in air and aerosols in Romania
4. Achieving a stable measurement station in the western part of Romania
5. Using bioremediation agents to remove heavy metals from soil
6. Determination of compound pollutants in wastewater from textile industry and their influence on plants