Application of advanced statistical methods in modeling of environmental impacts on metabolism and physiology of terrestrial plants

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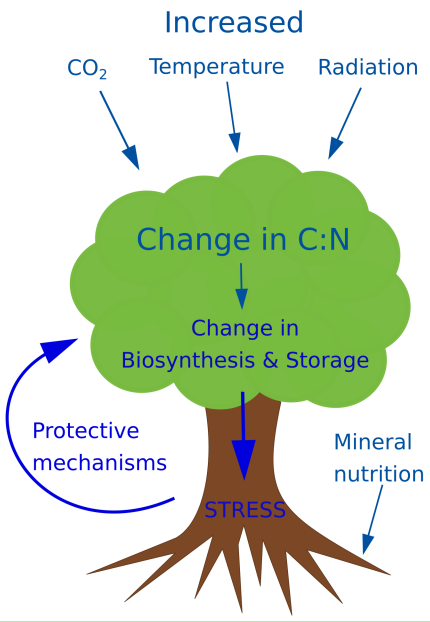
The increased concentration of carbon dioxide (CO_2) and other greenhouse gases has led to global warming, which has resulted in climate change, increased temperatures and changes in the hydrological cycle, affecting the growth, development and biosynthesis, which undoubtedly will be difficult to predict and generalize because the physiological processes of plants are multidimensional.

Hypothesis

1) Increased atmospheric CO_2 concentration, temperature, mineral nutrition (nitrogen) and radiation (intensity, spectral composition) induce changes in the balance between CO_2 assimilation rate and carbon storage capacity of plants (sink), leading to a change in C:N stoichiometry in plants.

2) Changes in the C:N ratio subsequently modify biosynthesis, spectrum, and storage of both primary and secondary metabolites and antioxidant enzymes.

3) These changes in the plant metabolome increase the plant's resistance to subsequent stressors like ultraviolet (UV) radiation. The hypothesis that so-called "cross-tolerance" occures in plants, when acclimation to one type of stress factor activates protective mechanisms applicable to other types of stress factors will be tested.



Methods

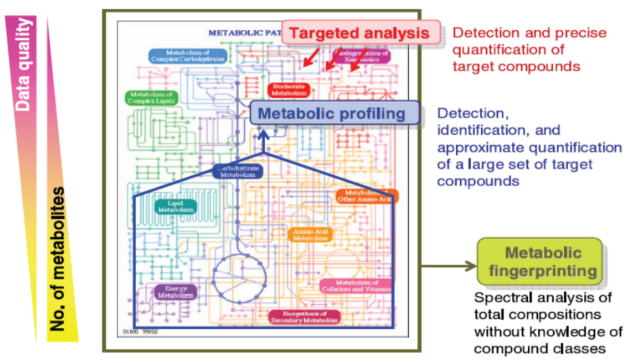
These hypotheses will be studied mainly on model tree species typical for temperate zone in the Czech Republic (spruce, beech, oak). Model tree species will be cultivated in laboratory conditions (seedlings placed in growth chambers) and in field conditions (juvenile trees grown in the so-called cultivation spheres in the Bílý Kříž).

Experimental ecological workplace Bílý Kříž, Moravian-Selesian Beskids

Ecophysiological data, such as photosynthesis and other physiological processes, will be obtained by gazometric and fluoroscence methods. To complete the whole picture, metabolomic data obtained by chromatographic techniques will be used, which will provide mechanistic evidence for biochemical processes that are relevant to stress[1]. Samples will be obtained from plant organs such as leaves, roots, stems but also from the environment (soil, atmosphere). The main goal is mathematically described metabolic fingerprint - environment inprint transcribed to chemical compounds.

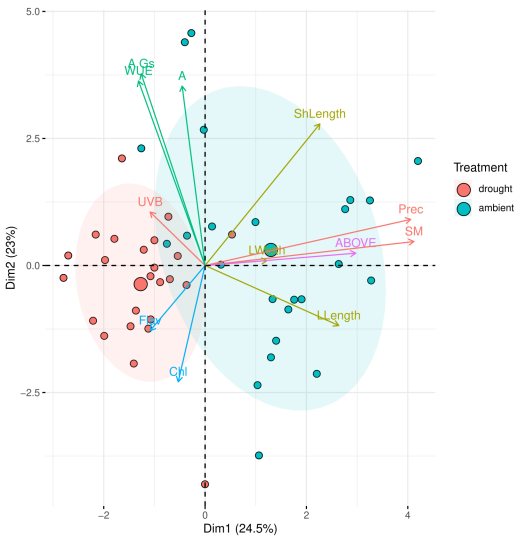
Gas exchange system (Li-Cor)

Chlorofyll fluoroscence camera (PSI, CZ)



Statistical methods

- Regression modeling (ANOVA, T-test,...)
- TBM (Terrestrial biosfere models) - prediction of nutrient cycles
- Models of metabolic pathways using available databases (KEGG)
- Ordination analysis (PCA, RDA, MDS,...)
- Cluster analysis



Example of PCA on data concerning *Holcus mollis*, with two levels of precipitation (drought, ambient) and factors of the environment and physiological parametres.

This type of analysis helps better understand multidimensional data and the relations between samples. In this case, samples of the two treatments are very clearly distinguishable. The above-ground biomass has the greatest influence on the separation of groups, however, flavonols also contribute substantially. This proves a key role of flavonols in photoprotection against excessive and short-wave radiation[2] as antioxidants in stressed plants[3].

http://nase-stromy.szm.com/

References

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