STUDY OF HEAVY METALS IN THE SOIL-PLANT SYSTEM

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Abstract: The effects of soil and climatic properties was studied on the winter wheat (*Triticum aestivum L.*) concerning on the heavy metal content of the plants. During this study the distribution of cobalt, copper, iron, manganese, nickel, and zinc was studied within a plant. Sampling was carried out in the same period of subsequent three years between 1995 and 1997. Our hypothesis was that the individuals of the same species has similar physiological answer for the same environmental properties. In this study we found no significant differences among the different plant's parts and years. Our results can reveal that the ecological indication of plants could be major driver of agro-environmental studies to recognize unusual patterns of soil attributes.

Keywords: heavy metal, winter wheat, plant uptake, distribution

Introduction

Related to the heavy metal moving in the soil-plant system it is important how much heavy metal is uptaken by the plants from a particular soil type and how these metals distribute in the plants. The uptaking of the heavy metals by different plants have been studied many times (Csathó 1994, Kádár 1995, Szalai 1998, Prokisch et al. 2006, Szalai et al. 2006). The most reliable results come from field experiments, but the small pot experiments provide important data as well (Bíró and Takács 2006, Pál et al. 2006). The stress-experiments are also very instructive (Szabó and Szegedi 2006, Rékási and Filep 2006, Rékási 2006, Schmidt and Szakál 2006), a lot of questions could be answered only by these ones, at the same times the studies in natural circumstances pretty important as well. This kind of experiment is shown in our study, in its framework the heavy metal uptaking of the winter wheat (*Triticum aestivum L.*) is studied on Ramann-brown forest soil. The individuals of a species has adapted to similar environmental properties this adaptation can provide causes to refer the similar group of biological entities (individuals) as species. We suppose that, the individuals of the same species have similar physiological answer for the same environmental properties. These general approaches were summarized in the following hypothesis: we suggest that the environmental factors have consistent influence on the development of individuals. The individuals of a population can reflect the same level of environmental properties, we expect that all studied individuals have similar distribution of heavy metals. We called this individual consistency hypothesis (ICH). The aim of this paper to present the effects of soil and climatic properties on the winter wheat using the heavy-metal content as a marker of variation among the individuals of the same population.

Materials and methods

The wheat-samples were collected from 1995 to 1997 in the south forefront of the Bükk Mountain near Cserépfalu. The samples were collected during the 2nd week of July every year. The organs of the collected and dried plants were homogenized and then 2

grams of them were being cremated at 500 °C during 16 hours. The ash were dissolved in 10 ml 20% HCl by heating at 50°C for 30 minutes. The solution was diluted with deionized water to 20 ml.
The soil samples were taken from the root-zone of the wheat. Cc. HNO_3-H_2O_2 digestion were applied and measured by Perkin Elmer F-AAS both in the case of the soil and the plant samples. Besides the pH of the soil the organic content (by Tyurin method), $CaCO_3$-content (by Scheibler-method) and the particle composition were measured by Köhn-pipette. The precipitation data were taken from hydro-geography year-books.
In order to portray the overall trends of data, we used multipanel dotplots using Trellis/Lattice package (Becker et al. 1996). In order to study the relationship between the amount of studied elements and their distribution among the parts of the plant, we applied Redundancy Analysis (RDA) (Palmer 1993, Ter Braak, 1986). Finally, we applied an ANOVA like permutation test to reveal the trends and the model. The analyses were carried out in R 2.6.0. using Vegan package (Oksanen et al. 2007).

Results and discussion

Table 1 gives information about the heavy metal content and the studied attributes of the soil samples. There is not significant difference in point of the organic content whereas there is in the particle size composition. In the samples collected in the first year the rate of the clay fraction were very high (over 40%), while it were much lower (approximately 20%) in the second and third years. However the soil samples with the highest clay content were characterized with the lowest pH value. There was difference in the precipitation among the years. In the first studied year the depth of rainfall was 701 mm, while the third year was rather dry with 460 mm precipitation.

Table 1. The data of the soil samples derived from the same place like the wheat samples in the first, second and third sampling periods

	Mn mg kg^{-1}	Cu mg kg^{-1}	Ni mg kg^{-1}	Co mg kg^{-1}	Fe mg kg^{-1}	Zn mg kg^{-1}	Sand %	Silt %	Clay %	Humus %	pH
1. year	705	8,7	33,4	10,5	26967	69	28.5	29,5	42,0	3,6	6,0
2. year	655	10,4	23,8	9,8	23740	50	37,2	41,5	21,3	3,2	7,0
3. year	652	18,9	24,4	9,1	22460	64	37,9	44,4	17,7	3,2	6,9

Studying the distribution of the particular heavy metals within the plants it can be stated that the highest concentrations were measured in the roots at all metals in all years. (Figure 1). In the case of manganese, nickel and iron the second highest concentration were detected in the leaves, but in the case of copper and zink it was measured in the wheat grain crops. At cobalt, iron and nickel the lowest concentrations were in the grain crops, but at manganese and copper it were in the leaves.
In the RDA (Figure 2), metal elements changes remarkably among the plant's parts. In the RDA ordination, the most of the studied metal elements were located in the center left indicating their accumulation associated in the roots and leaves. However, the zink, manganese, nickel, cobalt, and copper has an association with the root system. While the iron was associated with the leaves.

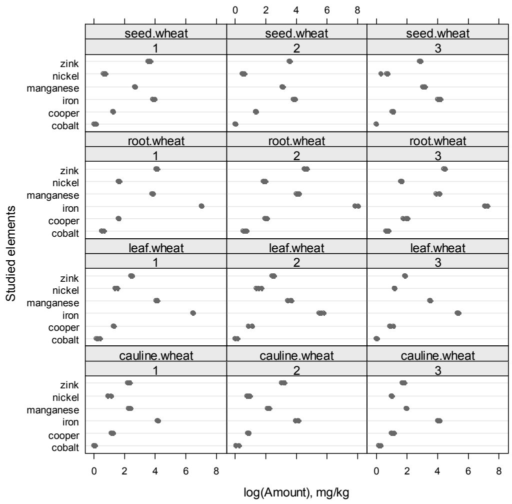

Figure 1. Summary tables of studied elements among the different plant parts and years. The element scores was logarithmically transformed (ln[x+1]).

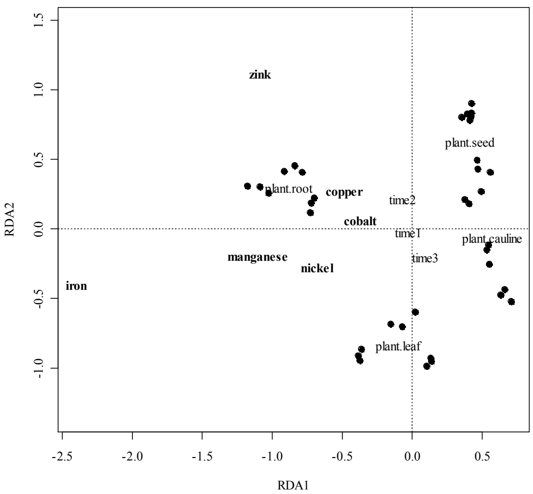

Figure 2. The results of RDA for the studied elements and plant's parts. The element scores was logarithmically transformed ln(x+1).

The time of collection has no significant influence on the distribution of the elements among the parts of the plant. In the RDA the sum of all the unconstrained eigenvalues was 0.26 and the eigenvalues of the first two gradients were 3.018 and 5.36. These axes explained 71% cumulative variance of the elements dataset and 40% cumulative variance of the elements-parts relationship. The permutation test was revealed the model (Table 2).

Table 2. Summary table of model confirmation, based on ANOVA and 200 permutation (formula = amount ~ plant. + time, data = bo.env)

	Df	Var	F	N. Perm	Pr (>F)
plant.	3	3.594	27.5922	200.000	<0.005 ***
time	2	0.101	1.1641	200.000	0.01 **
Residual	6	0.260			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Conclusions

In this study we found no significant differences among the different plant's parts and years. This prompted us to suggest that the individuals of the species can have similar physiological answer (or adaptation) for environmental change. Our results can reveal that the ecological indication of plants could be major driver of agro-environmental studies to recognize unusual patterns of soil attributes.

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