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Investigations on the trace element geochemical interaction between soil and vegetation; concentration of manganese, zinc, copper and lead in the soil and in Dactylis glomerata L.

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Abstract: The author investigated the trace element content in Dactylis glomerata L. with respect to four elements of special importance in plant physiology (Mn, Zn, Cu, Pb), as well as their relation to the soluble trace element content of certain levels of the soil sections deepened in the vicinity of the sampling sites. In course of the examinations it was found that the amount of manganese accumulated in Dactylis glomerata is not depending on the variation of the amount in the soluble manganese of the soil, the zinc present in Dactylis glomerata is in correlation with the zinc content soluble from the upper part of the soil whereas that of lead is in close correlation with the amount of lead soluble from the lower part of the soil level. The amount of copper present in plants is in negative correlation with the amount of copper soluble from the soil.

INTRODUCTION

The study of the relationship between the trace element content of the soil and the trace elements accumulated in plants is very important. The lack of certain trace elements in the soil, or its occassional superfluous abundance can influence the trace element balance of the plants growing on the soil proper. If the access to a given trace element is not sufficient, certain deficiency symptoms may occur, while a superfluous amount of certain trace elements can lead to a toxication of plants, and through the plants, of animals and even humans. Therefore it is very important to define the optimal amount of the individual trace elements for the plants as well as the amount of trace elements, especially that of the soluble trace elements present in the soil. If the distribution of the latter is unfavourable, certain procedures like artificial fertilization can help to influence it positively. To promote this type of research was the primary aim of this work. Similar studies were reported from several authors, among others REDOY, C.N. & PATRICK, W.H. (1977), JACKSON, K.S. & SKIPPEN, G.B. (1978), DAVIS, D. & BECKETT, P.H.T. (1978), HABLY, L. (1982).

AREA, SAMPLING AND EXPERIMENTAL

The territory investigated is situated in the vicinity of Mezőnagymihály, NE Hungary. Some soil sections were deepened here (Fig. 1) and analysed in details (SZAKMÁNY in press). Among the soil sections, there were four with humic washlands (sections 24, 25, 27, 28) while one was of meadow washland type (section 29). We sampled the vegetation in the immediate neighbourhood of the soil sections, that was composed of, prevailingly, from Dactylis glomerata L., thus we chose this species as a subject for our studies.

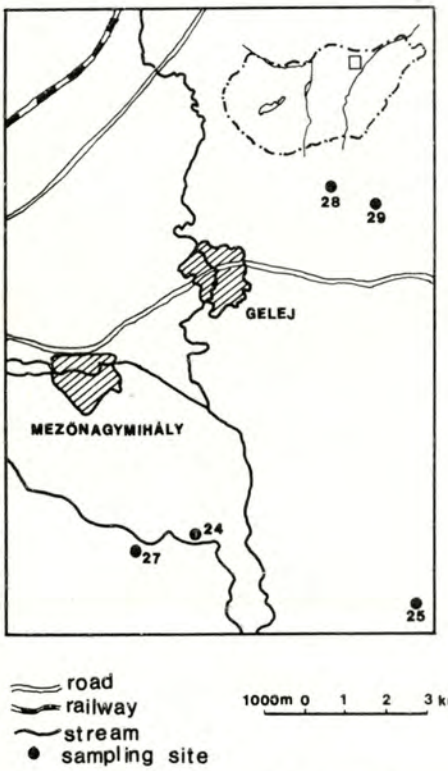


Fig. 1. Location of the area and the sampling sites

The total content of Mn, Zn, Cu, and Pb of the plants as well as that of the soluble trace element quantity of the soil were measured by atomic absorption spectrophotometry. As the experimentals for preparing the soil samples and the evaluation of the data have been already published in a previous study (SZAKMÁNY in press), thus we concentrate on the data relevant to this present study only (Table 1).

In course of the preparation of the plant samples the specimens were washed in distilled water, dried in a desiccator on 105 C^{o}, then ground, and an amount of 1.000 g apportioned for analysis. This was evaporated with 15 ml of concentrated nitric acid on sand bath. After the complete evaporation, 5 ml of concentrated nitric acid and 5 ml of concentrated hydrogene peroxide was added to it, and the evaporation repeated. The operation was performed two times more, and the last distillate was solved in 5 ml of concentrated nitric acid by moderate heating and poured into retorts, and completed to 25 ml with tridistilled water. On the plant samples prepared this way we measured the quantity of Mn, Zn, Cu and Pb. The trace element content of the plant samples are presented on Table 2.

THE RESULTS OF THE MEASUREMENTS

As a result of the atomic absorption analyses it was found that the trace element content of the Dactylis glomerata L. sampled on the territory was relatively constant in case of the sections near the humic washland soil (24, 25, 27, 28). Near the meadow washland soil section (29), the quantity of Zn, Cu and Pb is somewhat higher. A possible explanation for this might be that in the upper level of this soil the pH is relatively low (6 pH), promoting a better solution for certain trace elements as well as their better absorbtion (REDOY & PATRICK 1977, JACKSON & SKIPPEN 1978), while the soil of the more humic sections is of higher pH in its upper levels (about 6.5-7.5 pH).

The manganese content of the plant samples is about one order of degree lower than the quantity of Mn soluble from the soil. The concentration of Zn, Cu and Pb is approximately equal to that of the soluble trace element content in the deeper soil levels (Levels B and C).

Table 1. The soluble trace element content of the individual soil sections and their average soluble trace element content (ppm). Analysed by L. Hoffmann, ELTE, Dept. of Petrology and Geochemistry

Number of the section		24	25	27	28	29
Average	Mn	134.64	324.37	183.75	168.13	115.42
	Zn	0.84	0.86	0.44	0.79	0.62
	Cu	2.07	0.33	1.86	3.26	0.36
	Pb	4.38	5.21	4.52	5.88	7.14
A	Mn	329.80	508.30	405.80	371.88	114.00
	Zn	2.32	2.98	0.74	2.29	3.37
	Cu	6.96	0.97	4.39	8.12	0.62
	Pb	9.80	8.83	9.49	12.25	9.79
B	Mn	42.25	45.48	48.10	111.49	91.16
	Zn	0.24	0.24	0.35	0.33	0.28
	Cu	0.13	0.13	0.97	1.69	0.40
	Pb	1.94	2.55	1.88	3.86	6.33
C	Mn	113.90	511.23	176.32	105.97	146.10
	Zn	0.28	0.43	0.38	0.44	0.36
	Cu	0.09	0.21	1.39	2.34	0.26
	Pb	3.29	6.07	4.11	4.55	7.49

Table 2. Total amount of trace elements measured in Dactylis glomerata L. (ppm). Analysed by L. Hoffmann, ELTE, Dept. of Petrology and Geochemistry

specimen number	Mn	Zn	Cu	Pb
24	52.75	0.35	0.45	4.12
25	56.00	0.45	0.50	4.44
27	61.75	0.06	0.45	4.58
28	63.28	0.35	0.35	4.86
29	57.50	0.72	0.75	9.16

THE RELATIONS OF THE TRACE ELEMENT CONTENT SOLUBLE FROM THE SOIL AND AMOUNT ACCUMULATED IN PLANTS

For a better knowledge on these relations calculations of correlations were made and diagrams compiled. The method for the calculation is described in the followings:

$$r = \frac{SP}{MQ_x \cdot MQ_y}$$ where

$$MQ_x = \sum_{i=1}^{n} x_i^2 - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n}$$

$$MQ_y = \sum_{i=1}^{n} y_i^2 - \frac{\left(\sum_{i=1}^{n} y_i\right)^2}{n}$$

$$SP = \sum_{i=1}^{n} x_i \cdot y_i - \frac{\sum_{i=1}^{n} x_i \cdot \sum_{i=1}^{n} y_i}{n}$$

r = correlation coefficient
x_i = the corresponding number of the first series
y_i = the corresponding number of the second series
n = the number of the members of the series

The value of the correlation coefficient can vary between -1 and + 1. If
- 0.5 r - 1 or
0.5 r +1 then we can speak of a correlation between the two series. Naturally, the better the value of r nears -1 or +1, the stronger the relation is between the two series.

In course of the correlation calculations the quantity of Mn, Zn, Cu and Pb measured in the plants was compared to that of the quantity of the corresponding soluble trace element content measured in the A, B, C soil levels, as well as the avarage quantity of the soluble trace elements in the whole soil section (Table 3). For the sake of a better comparison, the individual values are demonstrated here on diagrams as well (Figs 2-5).

Evaluating the results, we can conclude the followings. Among the four trace elements investigated, the quantity of manganese occurring in plants and that of the soluble manganese content of the soil are not in correlation with each other. Only a very slight correlation of the manganese content of the soil level B and that of the plants could be seen, but irrespective of this we can state that there is no significant connection between the Mn accumulate' in Dactylis glomerata L. and that of the Mn content soluble from the soil. We can possibly explain it by the fact that the Mn accumulated in the Dactylis glomerata is one order of degree smaller than the amount in the soil, thus it is very probable that in the uptake of this element the role of the amount soluble from the soil is insignificant. The quantity of zinc accumulated in the Dactylis glomerata is seemingly in strong correlation with the soluble zinc content of the top soil layers (A) especially.

Copper is the very element where the samples from all soil levels are more or less in correlation with the quantity measured in the Dactylis glomerata. The connection is seemingly somewhat stronger in the upper soil level than in the lower ones. The correlation coefficient is relatively high in respect of the average trace element content soluble from the soils. It is remarkable that the correlation was negative in all cases, that is, the higher the soluble Cu content of the soil was, the less we found in Dactylis glomerata.

The quantity of lead found in Dactylis glomerata is first of all in very strong correlation with the soluble lead content of the lower soil layers (B, C), thus from this respect it acts contrary to zinc. The amount of lead in plants is also in good correlation with the average lead content soluble from the whole soil section.

SUMMARY

Summing up we can state that the amount of the different trace elements taken up by plants and that of the soluble corresponding trace element content of the soil are generally in close connection. In case of manganese, however, we have seen that it is not always so. Another important

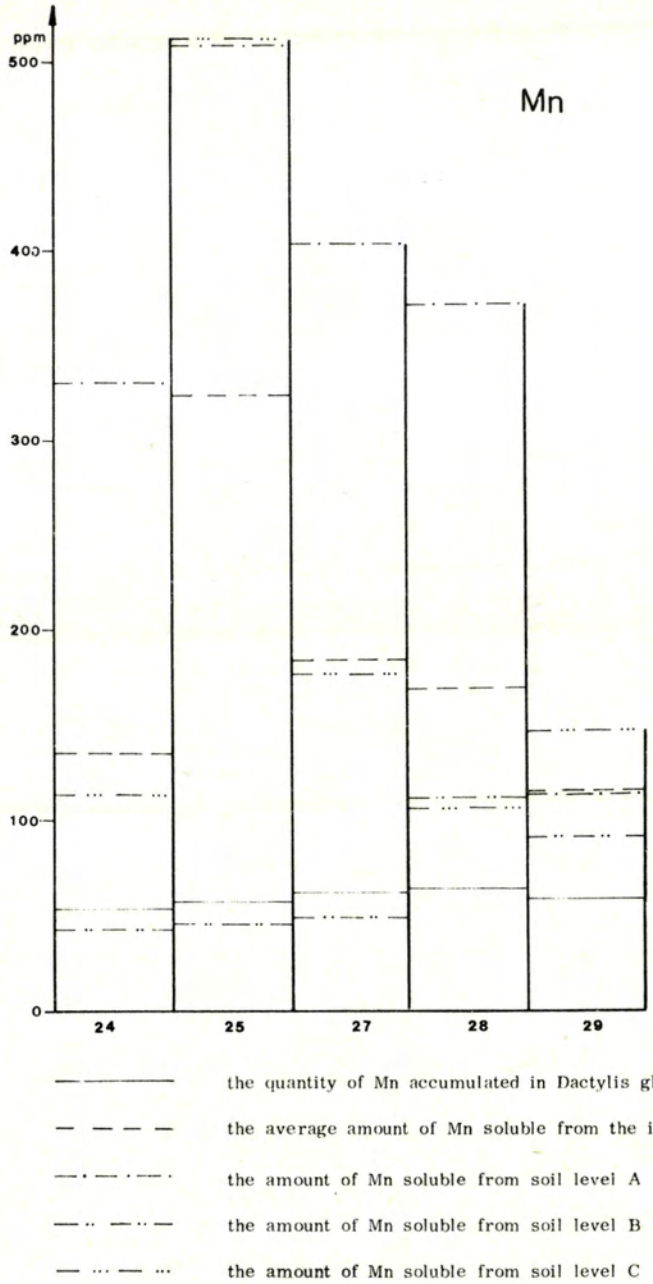


Fig. 2. The amount of the soluble Mn in the soil levels A, B, and C, as well as the average of the individual sections, and the quantity of manganese accumulated in Dactylis glomerata

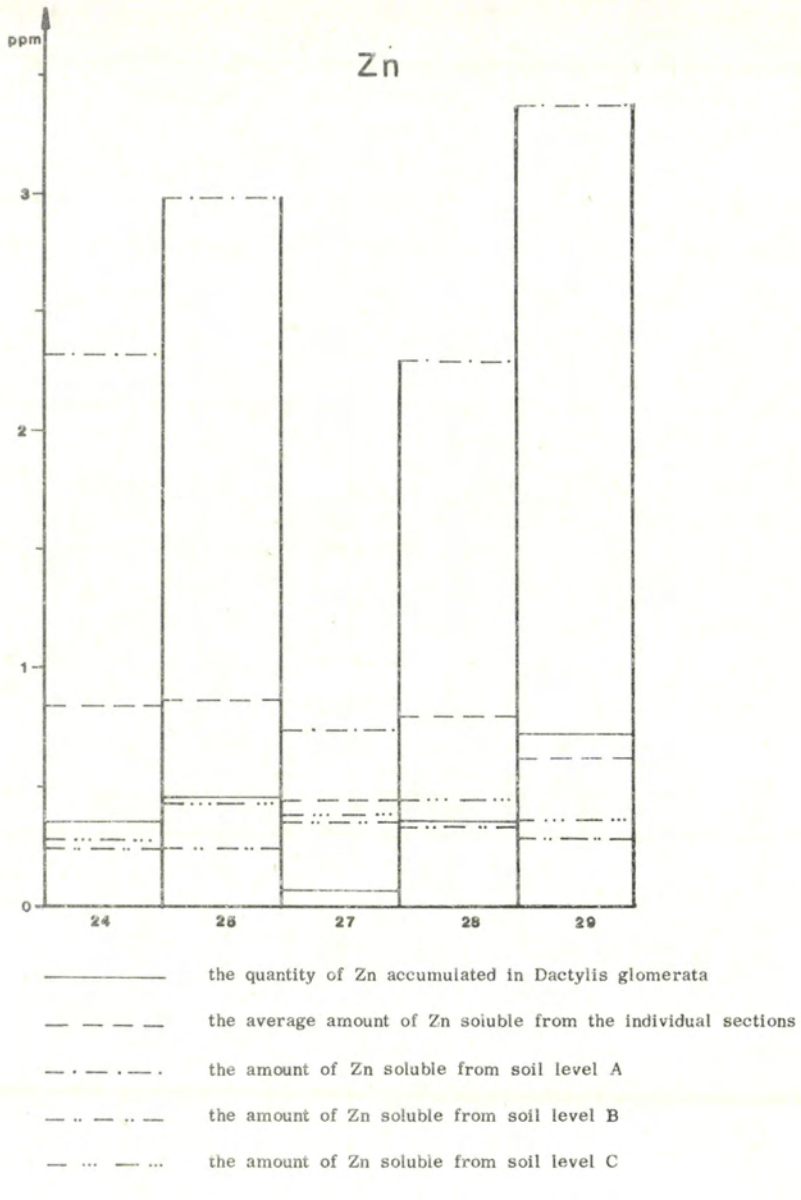


Fig. 3. The amount of the soluble Zn in the soil levels A, B, and C, as well as the average of the individual sections, and the quantity of zinc accumulated in Dactylis glomerata

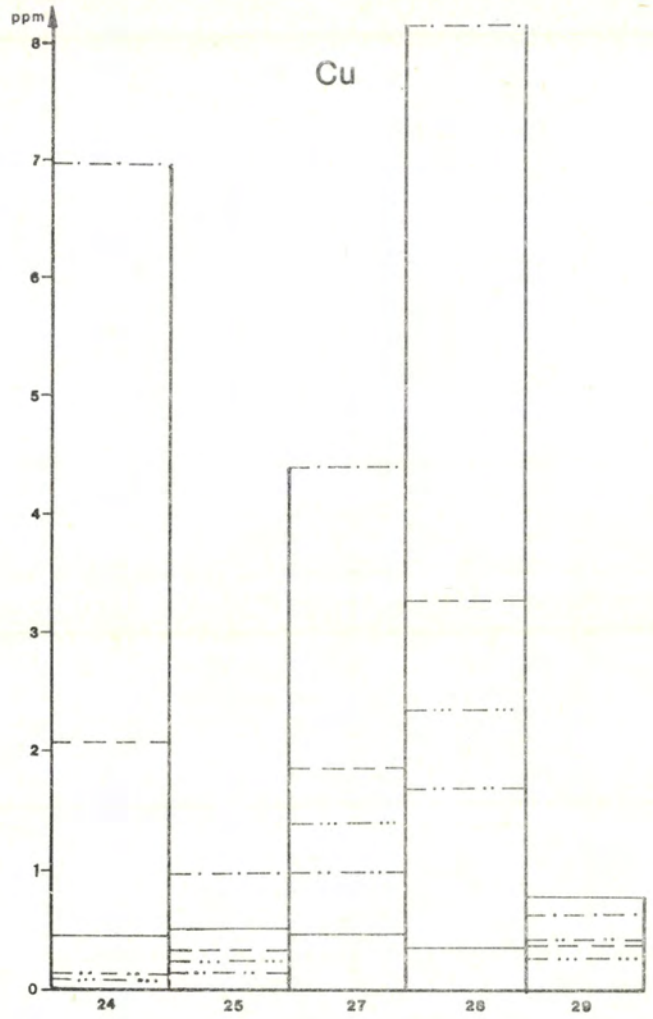


Fig. 4. The amount of the soluble Cu in the soil levels A, B, and C, as well as the average of the individual sections, and the quantity of copper accumulated in Dactylis glomerata

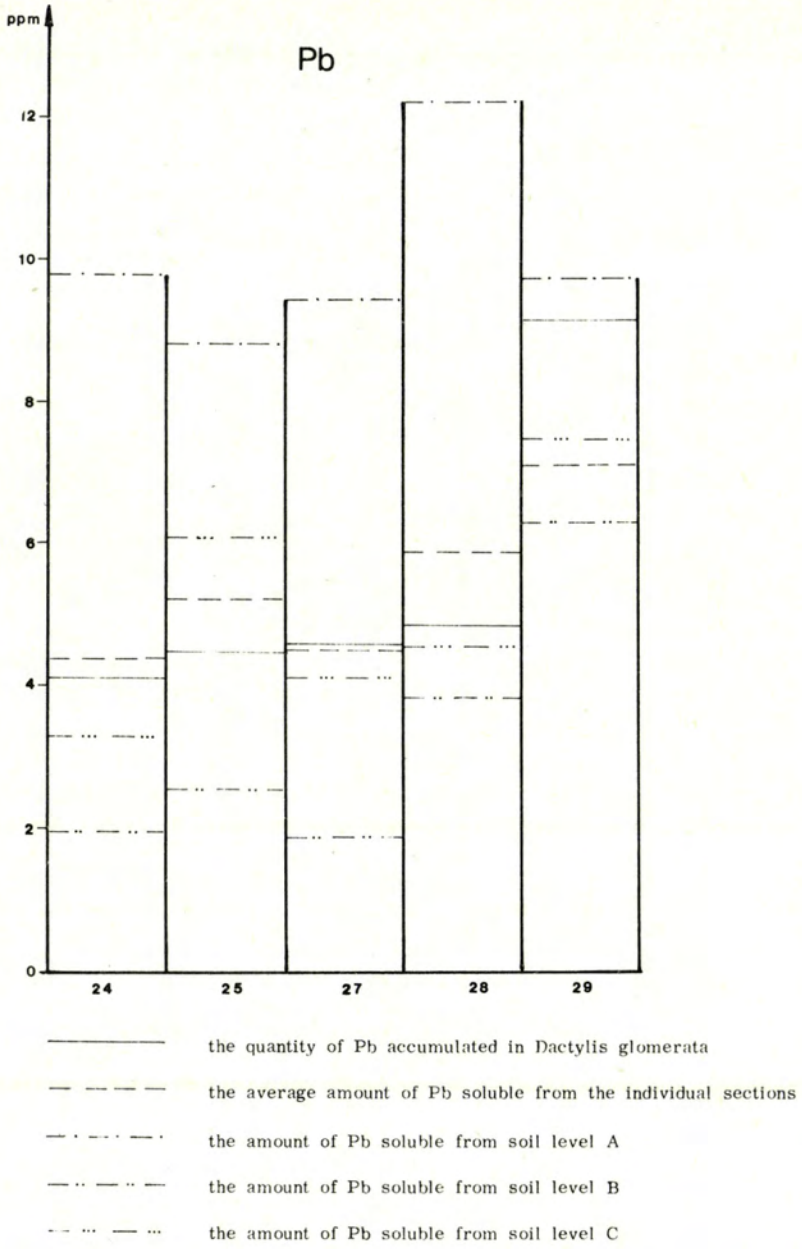


Fig. 5. The amount of the soluble Pb in the soil levels A, B, and C, as well as the average of the individual sections, and the quantity of lead accumulated in Dactylis glomerata

Table 3. Correlation coefficients of the trace elements soluble from the A, B, C soil levels and average soil section and that of the trace element accumulated in Dactylis glomerata

		correlation coefficient
Mn	average of the section	-0.05
	A soil level	0.10
	B soil level	0.60
	C soil level	-0.25
Zn	average of the section	0.36
	A	0.96
	B	-0.54
	C	-0.03
Cu	average of the section	-0.80
	A	-0.80
	B	-0.52
	C	-0.61
Pb	average of the section	0.90
	A	-0.02
	B	0.94
	C	0.82

thing is, that the trace elements taken up by plants can be related to the upper soil level (e.g. zinc), in other instances however, the quantity of trace elements accumulated in the plants are in strong correlation with the soluble trace element content of the lower soil levels (e.g. lead). Apart from these, there are elements like copper, where the quantity accumulated in the plants is in connection with the average of the soluble trace element content in the whole section. This connection can mean, as we have seen in case of copper, a negative correlation.

These results draw the attention to the fact that in case of similar trace element studies it is not sufficient to sample only the top soil levels. Most expedient is to investigate the complete soil section for a more accurate knowledge on the exact nature of the relations.

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