

## Variation in micronutrients concentration in lupine, pea and maize during the vegetation period on sandy soils

Research communication

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**Abstract.** In a two-year field experiment, established on sandy soil, tendencies in the changes in Cu, Zn, Mn and B concentrations in aerial parts of lupine, pea and maize were observed, from early vegetation season to the inflorescence stage. In each year, plant material samples were collected four times at 10-day intervals. Soil properties and total precipitation from the onset of the vegetation season to the termination of sample collection affected the level of the four microelements in plants. The effect was particularly strong in the case of copper. Although the concentrations of the microelements were different in the two years, certain tendencies in the modification of their levels could be observed during the vegetative season. The content of Cu in aerial parts of all the test plants tended to decrease distinctively as the plants grew older. Fluctuations in the levels of Zn, Mn and B, which depended on the plant species and environmental conditions, did not produce such clearly defined tendencies.

**key words:** papilionaceous plants, maize, microelements in plants, changes in concentration of microelements

### INTRODUCTION

As plants grow and develop, they experience changes in the chemical content of the tissues. It is commonly believed that the concentration of nutrients in young plants is higher than in more mature ones. Many studies have focused on the dynamics of nitrogen uptake (Plenet, Lemaire, 2000) and other macroelements (Beale, Long, 1997; Fricks et al., 2001), or else on the seasonal changes in the mutual ratios of particular macroelements in plants (Guillard, Allinson, 1989). However, there is scarcity of reports on the dynamics of the uptake of microelements during the vegetation season. Most of such papers deal with the uptake of heavy

metals on polluted soils (Joner, Leyval, 2001; Yang et al., 2006).

The purpose of the present study has been to determine the direction of changes in the concentration of microelements in aerial parts of two papilionaceous plants and maize on sandy soils, from the early vegetative growth to the inflorescence stage.

### MATERIALS AND METHODS

The material for the research was composed of plant samples collected in 2005–2006 from fields at the IUNG-PIB Experimental Station in Jelcz-Laskowice, cropped with lupine, pea and maize. The forecrop for cv. Taper yellow lupine and cv. Wiato pea was spring barley followed by winter wheat. The maize cultivar LG 2244 was also grown in a crop-rotation system after cereals. In both years, N fertilization was applied as ammonium nitrate and the PKMg nourishment was introduced as a complex fertilizer Polimag 305. The rates of the nutrients introduced under lupine and pea were: N – 40 kg ha<sup>-1</sup>, P – 25 kg ha<sup>-1</sup>, K – 70 kg ha<sup>-1</sup> and Mg – 17 kg ha<sup>-1</sup>. Under maize, the following doses were applied: N – 150 kg ha<sup>-1</sup>, P – 28 kg ha<sup>-1</sup>, K – 80 kg ha<sup>-1</sup> and Mg – 19 kg ha<sup>-1</sup>. Pea and lupine were sown on 11 April 2005 and 24 April 2006, whereas maize was sown on 23 May 2005 and 24 May 2006.

Fields under the crops differed for the properties of the arable layer of soil (Table 1). In general, they were sandy soils, containing little organic carbon. The soil reaction was acidic or strongly acidic. Soil analyses were performed according to the methods used in chemical and agricultural stations. The content of P and K plant available forms was determined with Egner-Riehm method and Mg was tested using Schachtschabel method. The micronutrients were extracted from soil using 1 M HCl, after which Cu, Zn and Mn were determined with the AAS method and the level of B was established by colorimetry.

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Table 1. Some physicochemical properties of the top soil layer in the trial fields.

Field	Percentage of fraction in mm			C org. [%]	pH in KCl	Concentration [mg kg <sup>-1</sup> ]						
	1.0–0.1	0.1–0.02	<0.02			P	K	Mg	Cu	Mn	Zn	B
Pea 2005	57	26	17	0.65	4.4	49	159	33	3.3	186	7.2	0.9
Pea 2006	44	36	19	0.67	5.3	74	156	32	3.0	181	9.6	0.8
Lupin 2005	55	28	16	0.50	4.3	46	123	31	3.7	158	7.1	0.8
Lupin 2006	36	40	24	0.60	5.0	58	152	43	3.0	166	8.1	0.6
Maize 2005	62	23	15	0.74	4.8	65	90	44	2.8	156	7.0	0.6
Maize 2006	53	26	21	0.69	5.2	71	189	30	2.9	177	8.6	0.7

Table 2. Weather data from the onset of the vegetation season to the last date of sample collection.

Year	Average temperature [°C]					Sum of precipitation [mm]				
	March	April	May	June	March–June	March	April	May	June <sup>#</sup>	March–June
2005	1.3	9.3	14.2	17.0	10.5	12.3	20.3	86.2	21.6	140.4
2006	0.0	9.4	14.1	18.3	10.8	28.9	50.2	29.9	45.8	154.8

<sup>#</sup> the data for June comprise the information only for the 1<sup>st</sup> and 2<sup>nd</sup> decade of this month.

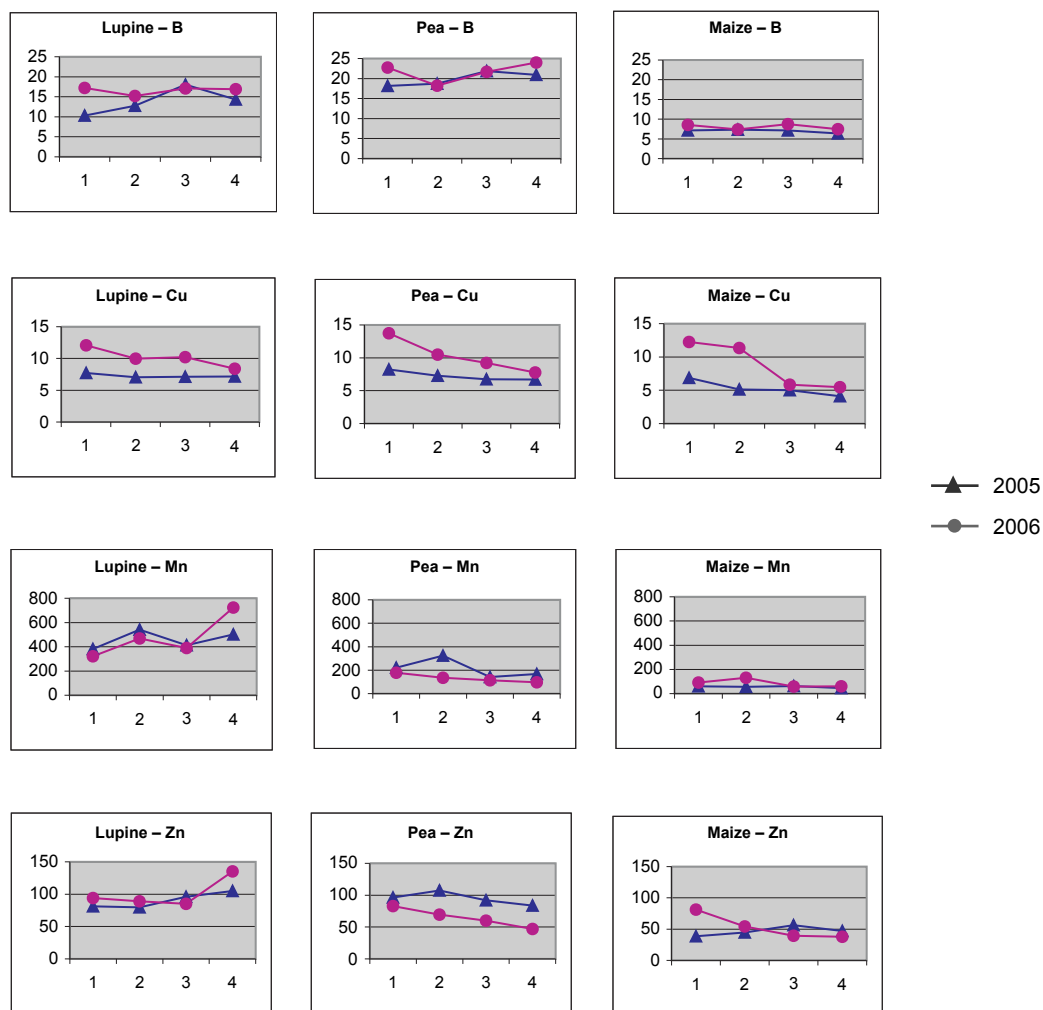


Fig. 1. Content of microelements [mg kg<sup>-1</sup>] in dry matter of aerial parts of plants on four dates during the vegetation season (1-4) in both years.

The weather conditions between the two years, from the early vegetative growth to the last date of sample collection, varied greatly (Table 2). Particularly large differences occurred in the total rainfall and rainfall distribution.

Plant samples were taken from 12 fixed points, each covering 4 m<sup>2</sup>, set up on each plot. In each year, aerial parts of plants were sampled on four dates, at 10-day intervals, starting on the thirtieth day after sowing. The growing stages of plants agreed in both tested years. On each of the four dates, whole aerial plant parts were cut over an area of 1 m<sup>2</sup>.

Once the plant samples were dry ashed in a muffle furnace, hydrochloric acid dilutions were prepared to determine the content of B by ICP method, and the content of Cu, Mn and Zn by AAS method. For determinations of B and Mn, certification material NCSZC 76008 was used, while the determinations of Cu and Zn were conducted using the in-house material – IPE plant samples (Cu – IPE 06.2.4, Zn – IPE 06.2.4) obtained from interlaboratory research work conducted in the Netherlands.

## RESULTS AND DISCUSSION

The levels of the analysed microelements were varied depending on the plant species and environmental conditions, especially soil properties and weather. The level of Cu for all the three plant species was evidently higher in 2006 than in 2005 (Fig. 1). It can be assumed that the availability of this microelement for plants in the year 2006 was superior. The soil from crop fields in 2006 had larger sorptive complex than the fields in 2005, as indicated by a higher content of <0.02 mm fraction and usually organic carbon (Table 1). The content of total Cu is higher in soils of larger exchange complex, and the mobility as well as availability of this element is conditioned by levels of organic matter in soil (Kabata-Pendias, Pendias, 2001). The mobility of Cu is enhanced by organic compounds, which are released during the decomposition of organic matter. Solubility of copper in soil depends mainly on the presence of dissolved organic carbon (Roömkens et al., 1999; Impellitteri et al., 2002). In 2006, the total rainfall was larger, particularly in the season preceding the sampling. The amount of precipitation in March and April 2006 was twice as large as in the analogous time in 2005 (Table 2). Soil moisture is another important aspect in decomposition of organic matter. Higher soil moisture content in 2006 facilitated the release of copper to soil solution, which meant better availability of this element to plants.

Differences in the concentrations of the other microelements in the plants, caused by the differences in the climatic and soil conditions, were not as big as for copper. Noteworthy is the higher level of Zn and Mn in pea plants in 2005, which may have been a result of the soil pH being lower than in 2006 (Fig. 1, Table 1).

Although the concentrations of the microelements in plants were different between the two years, certain ten-

dencies in their fluctuations could be observed as the plants continued to mature (fig. 1). Modifications in the Cu content were decreasing during the vegetation season, with the decline being larger in maize rather than in the two papilionaceous plants. The other two elements, Mn and Zn, remained stable or tended to decrease only in maize and pea. In lupine plants, the concentration of Mn and Zn immediately before the flowering stage was higher than initially. The content of B in plants gradually increased in the consecutive growing stages or else remained unchanged during the whole period examined.

## CONCLUSIONS

1. Among the studied four micronutrients a clear alteration of their concentration in plants over the successive phases of growth (independent of plant species), occurred only for copper. The content of Cu in the aboveground parts of peas, lupins and maize decreased as the plants aged.
2. Changes in the content of Zn, Mn and B over the growing season were not consistent and depended on plant species, soil conditions and weather.

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