

# The effect of chloride and sulphate application to soil on changes in nutrient content in barley shoot biomass at an early phase of growth

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## ABSTRACT

In this study experiments primarily aimed at the needs of specification of an adequate soil reserve of labile sulphur were extended by investigations of the impact on interactions in nutrient uptake by a test barley plant. Vegetation (18-day) experiments under controlled conditions of cultivation were conducted on a diverse set of 48 soils from agricultural lands. Before barley sowing the experimental set of soils was divided into two variants: A – control (with  $\text{NH}_4\text{Cl}$  application) and B – response variant [with  $(\text{NH}_4)_2\text{SO}_4$  application], and a uniform dose of 26 mg N/kg soil was used. After the experiment terminated, concentrations of N,  $\text{N-NO}_3^-$ , S,  $\text{S-SO}_4^{2-}$ , P, K, Mg, Ca, Na, Mn and B were determined. Paired *t*-test revealed significant differences between the sets of data on variants A and B in barley yield and concentrations of sulphur, sulphate, nitrate, phosphorus and boron in barley plants. Sulphate variant (B) had higher yield of barley, higher concentrations of sulphur, sulphate and boron and lower concentrations of nitrate and phosphorus compared to variant A. The lower concentrations of nitrate and phosphorus could not be reasoned by the effect of dilution resulting from the higher barley yield. A substantial decrease in nitrate concentration was related to better utilisation of plant nitrogen after the nutrient status of soil was adjusted with sulphur. Phosphorus concentration in barley adequately corresponded to the soil reserve of labile phosphorus, but only after the phosphorus concentration in barley markedly decreased to the lower level in (sulphate) variant B. Higher concentration of boron in barley could potentially be related to the depression of phosphorus uptake after sulphate application.

**Keywords:** barley; interaction; sulphur; nitrate; phosphorus; boron

Balanced nutrition of field crops is an important prerequisite of plant production effectiveness and quality. The knowledge of potential nutrient interactions in soil and in the proper nutrition of the crop at a site and discovery of new interactions are important for more exact adjustment of the nutrient status of soil and plants by the technology of rational fertilisation. Unfortunately, most nutrient interactions were determined in experiments on plants in hydroponic and sand cultures. From the optimisation aspect of the promotion and control of soil fertility the interactions concerning field conditions are crucial. Wilkinson and Grunes (2000) summarised recent findings of nutrient interactions in relation to soil. The knowledge of interactions that influence the chemical composition of plants is also necessary for correct interpretation of plant analyses when the nutrient status of crops is diagnosed (Jones et al. 1991).

Besides research on an adequate concentration of labile sulphur in the soil reserve (Matula 2004) a further objective of this study was to conduct experiments aimed at a potential impact on changes in

the chemical composition of the test plant (barley) grown under controlled conditions of cultivation on a diverse set of soils from agriculturally important localities in the Czech Republic.

## MATERIAL AND METHODS

In vegetation experiments under controlled conditions of cultivation with test plant barley cv. Akcent forty-eight soils from 28 localities of the CR were used similarly like in the paper by Matula (2004). Table 1 shows data on the nutrient status of these soils. The choice of soils for vegetation experiments was aimed at the largest possible range of the actual reserve of labile sulphur in soils of agricultural lands in the CR in relation to different soil texture. Two variants (A and B) of each soil were used with four replications of each variant:

- variant A (chloride one), application of 2.62 mg N per vegetation pot in the form of  $\text{NH}_4\text{Cl}$
- variant B (sulphate one), application of 2.62 mg N per vegetation pot in the form of  $(\text{NH}_4)_2\text{SO}_4$

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Table 1. Information about the nutrient status of the experimental set of soils

| Soil number | pH (0.2M KCl) | CEC (mmol/kg) | Soil test – H <sub>2</sub> O (1:5, w/v) |      |      |      |      |      |      |
|-------------|---------------|---------------|-----------------------------------------|------|------|------|------|------|------|
|             |               |               | K                                       | Mg   | Ca   | Mn   | P    | S    | B    |
|             |               |               |                                         |      |      |      |      |      |      |
| 1           | 6.1           | 100           | 12                                      | 12   | 41   | 0.4  | 4.4  | 4.5  | 0.17 |
| 2           | 5.8           | 246           | 47                                      | 13   | 74   | 0.5  | 9.1  | 9.4  | 0.24 |
| 3           | 6.9           | 119           | 45                                      | 10   | 161  | 0.2  | 3.0  | 7.2  | 0.25 |
| 4           | 6.5           | 195           | 89                                      | 14   | 194  | 0.3  | 5.2  | 13.6 | 0.44 |
| 5           | 6.3           | 110           | 23                                      | 6    | 98   | 0.3  | 4.8  | 7.2  | 0.14 |
| 6           | 6.2           | 249           | 32                                      | 19   | 120  | 0.5  | 3.2  | 10.3 | 0.24 |
| 7           | 5.9           | 106           | 32                                      | 11   | 65   | 1.1  | 8.5  | 10.6 | 0.29 |
| 8           | 5.5           | 176           | 30                                      | 11   | 49   | 0.5  | 5.6  | 6.1  | 0.32 |
| 9           | 5.3           | 117           | 59                                      | 22   | 135  | 1.6  | 9.9  | 9.9  | 0.23 |
| 10          | 6.3           | 181           | 21                                      | 13   | 109  | 0.4  | 4.8  | 8.4  | 0.15 |
| 11          | 5.5           | 122           | 31                                      | 14   | 58   | 0.7  | 8.8  | 12.8 | 0.24 |
| 12          | 6.0           | 125           | 37                                      | 10   | 71   | 0.5  | 10.3 | 21.9 | 0.25 |
| 13          | 5.6           | 107           | 14                                      | 9    | 62   | 0.5  | 5.2  | 5.2  | 0.14 |
| 14          | 5.7           | 145           | 39                                      | 11   | 178  | 0.7  | 7.3  | 5.8  | 0.21 |
| 15          | 5.1           | 118           | 24                                      | 7    | 43   | 0.9  | 3.7  | 7.6  | 0.21 |
| 16          | 5.7           | 184           | 17                                      | 13   | 82   | 0.5  | 4.0  | 9.8  | 0.27 |
| 17          | 6.7           | 208           | 40                                      | 18   | 138  | 0.3  | 5.0  | 11.3 | 0.31 |
| 18          | 6.6           | 195           | 34                                      | 14   | 142  | 0.2  | 7.3  | 10.2 | 0.25 |
| 19          | 5.3           | 113           | 25                                      | 8    | 42   | 0.7  | 4.3  | 10.7 | 0.28 |
| 20          | 5.1           | 159           | 14                                      | 9    | 43   | 0.6  | 3.3  | 8.4  | 0.17 |
| 21          | 6.3           | 123           | 24                                      | 7    | 86   | 0.4  | 6.7  | 12.0 | 0.21 |
| 22          | 5.8           | 118           | 39                                      | 19   | 70   | 0.8  | 8.3  | 11.8 | 0.30 |
| 23          | 4.7           | 125           | 18                                      | 6    | 42   | 0.9  | 2.8  | 9.6  | 0.21 |
| 24          | 5.0           | 126           | 36                                      | 9    | 45   | 1.3  | 3.7  | 16.3 | 0.27 |
| 25          | 5.8           | 147           | 18                                      | 8    | 62   | 0.4  | 4.1  | 6.5  | 0.29 |
| 26          | 6.3           | 95            | 21                                      | 14   | 54   | 0.3  | 6.1  | 4.9  | 0.13 |
| 27          | 5.9           | 84            | 20                                      | 9    | 51   | 0.5  | 6.1  | 5.9  | 0.07 |
| 28          | 5.6           | 132           | 28                                      | 13   | 61   | 0.8  | 4.4  | 9.0  | 0.36 |
| 29          | 6.7           | 145           | 50                                      | 12   | 105  | 0.3  | 4.2  | 10.7 | 0.28 |
| 30          | 5.5           | 122           | 25                                      | 11   | 45   | 0.6  | 5.0  | 10.4 | 0.24 |
| 31          | 6.0           | 169           | 20                                      | 14   | 54   | 0.3  | 3.7  | 12.3 | 0.29 |
| 32          | 5.4           | 120           | 33                                      | 12   | 43   | 0.7  | 5.9  | 10.3 | 0.29 |
| 33          | 5.0           | 142           | 24                                      | 9    | 61   | 0.6  | 4.5  | 8.8  | 0.26 |
| 34          | 5.9           | 114           | 32                                      | 18   | 76   | 0.6  | 6.0  | 11.0 | 0.27 |
| 35          | 5.6           | 133           | 23                                      | 10   | 78   | 0.8  | 3.9  | 26.7 | 0.17 |
| 36          | 4.9           | 119           | 26                                      | 14   | 50   | 0.8  | 6.5  | 30.2 | 0.21 |
| 37          | 5.2           | 103           | 34                                      | 7    | 39   | 0.7  | 10.3 | 8.7  | 0.15 |
| 38          | 6.8           | 197           | 37                                      | 12   | 136  | 0.1  | 4.4  | 8.1  | 0.21 |
| 39          | 6.6           | 109           | 52                                      | 6    | 89   | 0.2  | 9.7  | 7.1  | 0.14 |
| 40          | 6.5           | 291           | 24                                      | 14   | 150  | 0.1  | 2.3  | 12.0 | 0.27 |
| 41          | 6.9           | 145           | 57                                      | 9    | 139  | 0.2  | 6.6  | 9.7  | 0.31 |
| 42          | 5.2           | 112           | 35                                      | 8    | 39   | 0.5  | 5.0  | 9.9  | 0.18 |
| 43          | 6.4           | 135           | 31                                      | 16   | 72   | 0.4  | 3.5  | 11.2 | 0.22 |
| 44          | 4.5           | 112           | 41                                      | 7    | 70   | 1.0  | 9.3  | 18.5 | 0.15 |
| 45          | 6.1           | 111           | 17                                      | 14   | 80   | 0.4  | 6.4  | 11.8 | 0.16 |
| 46          | 5.3           | 129           | 18                                      | 11   | 49   | 0.4  | 4.6  | 10.4 | 0.13 |
| 47          | 6.0           | 125           | 66                                      | 18   | 74   | 0.5  | 5.9  | 33.4 | 0.44 |
| 48          | 6.8           | 207           | 237                                     | 41   | 53   | 0.2  | 40.2 | 23.1 | 0.94 |
| Mean        | 5.9           | 143           | 36.5                                    | 12.3 | 80.8 | 0.5  | 6.4  | 11.5 | 0.20 |
| v%          | 11            | 31            | 90.7                                    | 46.1 | 50.1 | 58.0 | 84.5 | 53.7 | 50.9 |

$\text{NH}_4\text{Cl}$  and  $(\text{NH}_4)_2\text{SO}_4$  were applied in 10 ml of salt solution with pipette onto the surface of the substrate in a vegetation pot (100 g of soil mixed with 80 g of coarse-grained quartz sand) before 15 barley seeds were planted. Barley seeds were covered with 25 ml of coarse-grained quartz sand. After emergence the number of plants per pot was adjusted to ten. The moistening of the substrate in vegetation pots was differentiated on the basis of an experimentally determined relation of field water capacity of the soil to the value of its cation exchange capacity (CEC) (Matula et al. 2000). In the vegetation period the moisture content was regularly adjusted according to the weight loss of vegetation pot.

Cultivation took place in a climate chamber under the light and temperature regime: daylight 16 h, 20°C; dark 8 h, 15°C; photosynthetic active radiation 500  $\mu\text{E}/\text{m}^2/\text{s}$ . The additional N-fertilisation of 6 mg N per pot, as solution of  $\text{NH}_4\text{NO}_3$ , was applied with watering on days 4, 7, 9, 11 and 14 from the experiment establishment. The experiment terminated after 18 days of cultivation. Harvested barley shoots were immediately dried at 65°C. The mineralisation of barley dry matter was carried out in a MILESTONE microwave device in the medium of nitric acid and hydrogen peroxide to determine the contents of elements (K, Mg, Ca, Mn, S, B and Na) on an ICP-OES Trace SCAN apparatus (Thermo Jarrell Ash). The content of total nitrogen and phosphorus was determined in a mineralisate of sulphuric acid with the addition of salicylic acid on a Sun Plus System SKALAR analyser. Nitrate and sulphate content in barley dry matter was determined in water extract also on a SKALAR analyser.

Statistical programme GraphPad PRISM, Ca., USA, version 3.0 and Microsoft Excel 2000 were used for experimental data processing.

## RESULTS AND DISCUSSION

Paired *t*-test indicated statistical significant differences between the sets of data from (chloride) variant A and (sulphate) variant B only in the yield of barley shoot biomass and in concentrations of sulphur, sulphate, nitrate, phosphorus and boron in barley shoot biomass (Table 2). The higher value of average yield of barley shoot biomass in sulphate variant was in accordance with the primary objective of the experiment (Matula 2004) to verify the adequate soil reserve of labile sulphur. Table 1 shows that the experimental set comprised a majority of soils with sub-optimum soil reserve of labile sulphur that were identified in the paper by Matula (2004). The higher values of sulphur and sulphate concentrations in barley shoots in variant B

were in agreement with this primary objective of the experiment (Table 2). Figures 1 and 2 document the distribution of sulphur concentration in barley plants and sulphur uptake by the yield of barley shoot mass in relation to the soil reserve of sulphur before vegetation experiments detected by  $\text{H}_2\text{O}$  (1:5) S-soil test. Logically, the closeness of correlation field was considerably higher in variant A, i.e. without sulphur application.

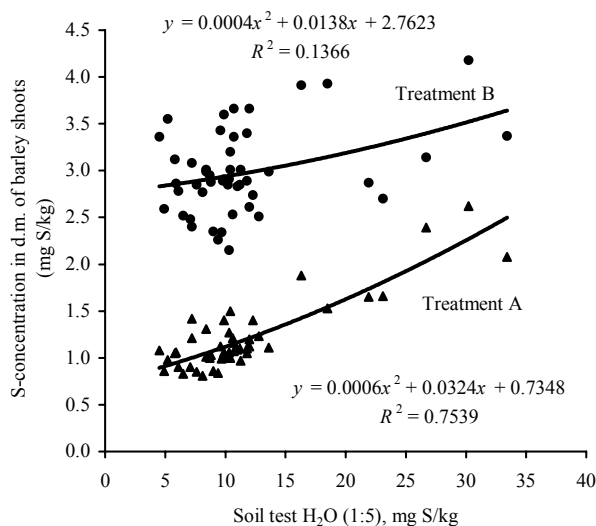


Figure 1. Relationship between the  $\text{H}_2\text{O}$  (1:5) S-soil test (sulphur determined by ICP technique) and the sulphur concentration in barley shoot biomass

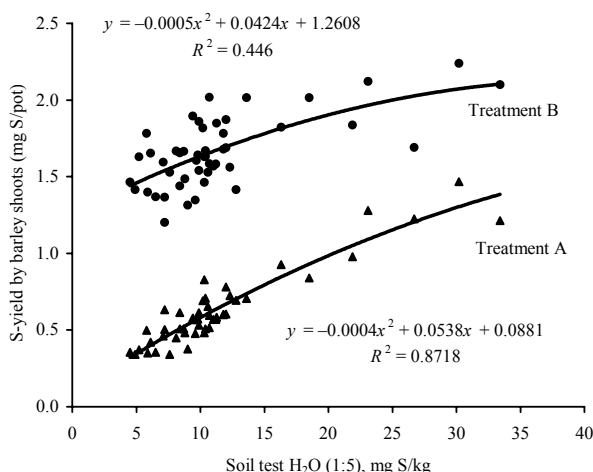


Figure 2. Relationship between the  $\text{H}_2\text{O}$  (1:5) S-soil test (sulphur determined by ICP technique) and the sulphur yield by barley shoot biomass

Table 2. Statistical evaluation of experimental results

| Statistics                                                    | Yield of<br>barley shoots<br>(g d.m./pot) |        | Sulphur<br>concentration<br>(g S/kg) |        | Sulphate<br>concentration<br>(g S/kg) |        | Nitrate<br>concentration<br>(g N/kg) |      | Phosphorus<br>concentration<br>(g P/kg) |       | Yield of P<br>by shoots<br>(mg P/pot) |        | Boron<br>concentration<br>(mg B/kg) |        |
|---------------------------------------------------------------|-------------------------------------------|--------|--------------------------------------|--------|---------------------------------------|--------|--------------------------------------|------|-----------------------------------------|-------|---------------------------------------|--------|-------------------------------------|--------|
|                                                               | A                                         | B      | A                                    | B      | A                                     | B      | A                                    | B    | A                                       | B     | A                                     | B      | A                                   | B      |
| Minimum                                                       | 0.3279                                    | 0.3931 | 0.810                                | 2.150  | 0.020                                 | 0.000  | 227                                  | 154  | 1.510                                   | 1.110 | 0.90                                  | 0.64   | 3.44                                | 5.71   |
| 25% percentile                                                | 0.4502                                    | 0.5145 | 1.000                                | 2.720  | 0.440                                 | 0.750  | 1295                                 | 390  | 2.465                                   | 1.775 | 1.235                                 | 0.96   | 4.745                               | 7.305  |
| Median                                                        | 0.5104                                    | 0.5524 | 1.085                                | 2.900  | 0.560                                 | 0.940  | 1748                                 | 527  | 3.185                                   | 2.115 | 1.50                                  | 1.11   | 5.740                               | 8.060  |
| 75% percentile                                                | 0.5623                                    | 0.6028 | 1.290                                | 3.280  | 0.965                                 | 1.235  | 2425                                 | 1104 | 3.805                                   | 2.635 | 1.950                                 | 1.515  | 6.660                               | 9.525  |
| Maximum                                                       | 0.7714                                    | 0.8383 | 2.620                                | 4.180  | 1.160                                 | 2.230  | 4004                                 | 2900 | 7.980                                   | 6.630 | 6.15                                  | 5.21   | 11.71                               | 11.97  |
| Mean                                                          | 0.5155                                    | 0.5643 | 1.2098                               | 2.9840 | 0.6442                                | 0.9933 | 1876                                 | 821  | 3.261                                   | 2.349 | 1.689                                 | 1.353  | 6.007                               | 8.373  |
| S.D.                                                          | 0.0922                                    | 0.0905 | 0.3837                               | 0.4531 | 0.3051                                | 0.4325 | 855                                  | 638  | 1.088                                   | 0.901 | 0.7988                                | 0.7178 | 1.657                               | 1.647  |
| S.E.                                                          | 0.0133                                    | 0.0131 | 0.0554                               | 0.0654 | 0.0440                                | 0.0624 | 123                                  | 92   | 0.157                                   | 0.130 | 0.1153                                | 0.1036 | 0.2391                              | 0.2378 |
| < 95% CI                                                      | 0.4887                                    | 0.5380 | 1.0984                               | 2.8524 | 0.5556                                | 0.8677 | 1628                                 | 635  | 2.946                                   | 2.088 | 1.4566                                | 1.1441 | 5.5259                              | 7.8948 |
| > 95% CI                                                      | 0.5423                                    | 0.5906 | 1.3212                               | 3.1155 | 0.7328                                | 1.119  | 2124                                 | 1006 | 3.577                                   | 2.611 | 1.9205                                | 1.5609 | 6.4879                              | 8.8515 |
| <b>Paired <i>t</i>-test, two-tailed, number of pairs = 48</b> |                                           |        |                                      |        |                                       |        |                                      |      |                                         |       |                                       |        |                                     |        |
| <i>P</i> -value                                               | <i>P</i> < 0.0001                         |        | <i>P</i> < 0.0001                    |        | <i>P</i> < 0.0001                     |        | <i>P</i> < 0.0001                    |      | <i>P</i> < 0.0001                       |       | <i>P</i> < 0.0001                     |        | <i>P</i> < 0.0001                   |        |
| Differences<br>significance                                   | yes                                       |        | yes                                  |        | yes                                   |        | yes                                  |      | yes                                     |       | yes                                   |        | yes                                 |        |
| Mean of<br>differences                                        | -0.0488                                   |        | -1.774                               |        | -0.3492                               |        | 1056                                 |      | 0.912                                   |       | 0.336                                 |        | -2.366                              |        |
| 95% CI                                                        | -0.0653 to -0.0324                        |        | -1.903 to -1.645                     |        | -0.4486 to -0.2498                    |        | 862 to 1249                          |      | 0.715 to 1.109                          |       | 0.257 to 0.415                        |        | -2.734 to -1.998                    |        |

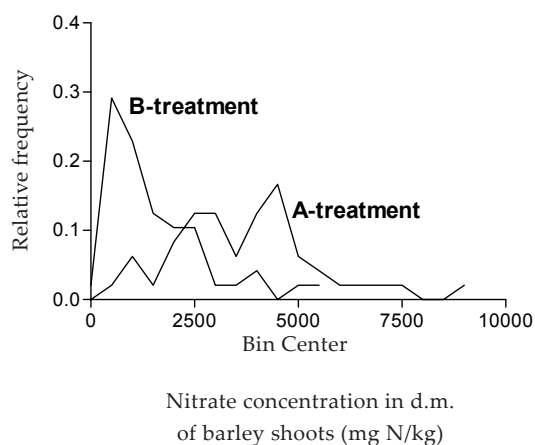


Figure 3. Frequency distribution of the nitrate concentration in barley shoot biomass

There were no significant differences in nitrogen concentration in barley shoots between the sets of data on variant A and B. Naturally, if nitrogen concentration was converted to nitrogen uptake by the yield of barley shoots, the differences between the sets of data on the two variants were statistically significant as there were significant differences in barley yield. Figure 3 shows differences in the distribution of nitrate concentration between variant A and B. A marked depression of nitrate concentration in barley plants in sulphate variant documents the need of adequate sulphur nutrition for the effectiveness of nitrogen metabolism (Dwivedi and Bapat 1998, Ahmad et al. 2001, Munshi and Juneja 2001). In sulphur-deficient nutrition of plants the process of nitrogen metabolism

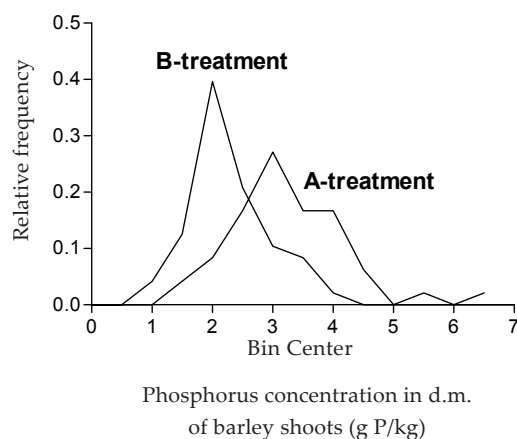


Figure 5. Frequency distribution of the phosphorus concentration in barley shoot biomass

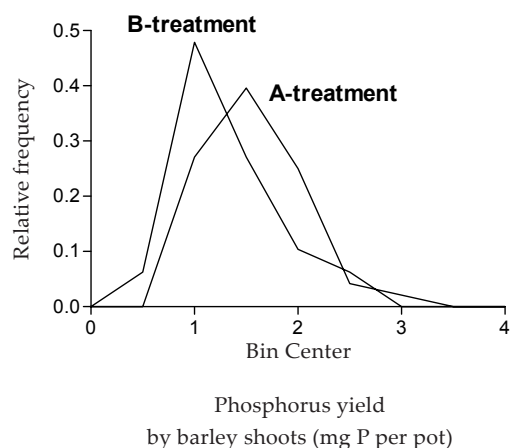


Figure 6. Frequency distribution of the phosphorus yield by barley shoot biomass

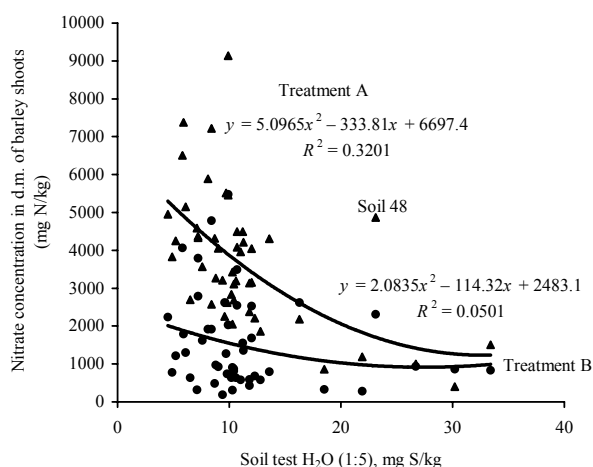


Figure 4. Relationship between the  $H_2O$  (1:5) S-soil test (sulphur determined by ICP technique) and the nitrate concentration in barley shoot biomass

is disturbed and nitrate accumulation occurs. The assumed antagonistic chloride and nitrate interaction (Inal et al. 1999) could not be expressed in our experiments due to the insufficient soil reserve of labile sulphur. Figure 4 illustrates a trend of the relation of nitrate concentration in barley to the soil level of labile sulphur. The trend of a decrease in nitrate concentration in barley was obvious in variant A, i.e. without sulphate application. The closeness of the trend was highly disturbed by a high nitrate concentration in barley cultivated on soil 48. A more comprehensive approach to the nutrient status of this soil (see Table 1, and data in Matula 2004) reveals marked disharmony of nutrients, particularly caused by the extreme level of potassium and phosphorus. The extreme content of potassium in barley (87 g K/kg dry matter) was correlated with high content of exchangeable

potassium in soil 48 (1331 mg K/kg). We can assume that surplus potassium was localised in cell vacuoles where it participated in the balancing of anion  $\text{NO}_3^-$ , the acid-base mechanism of ion balance maintenance – electroneutrality. It could be a reason for such a marked deviation from the trend of correlation field. The example of soil 48 also signals and accentuates the importance of balanced soil reserve of nutrients for the implementation of harmonic nutrition of plants that is a prerequisite of effective utilisation of nutrients taken up by plants for yield formation.

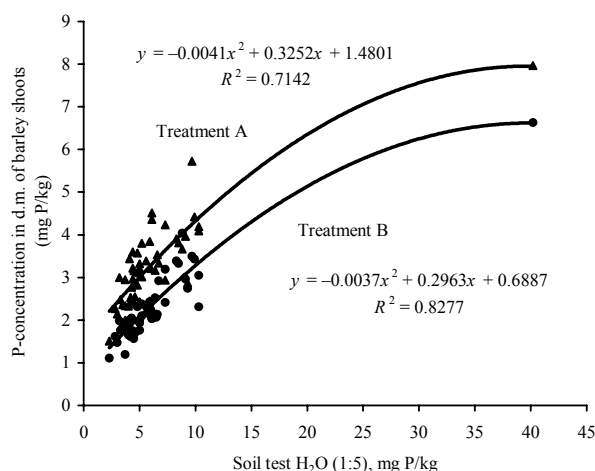


Figure 7. Relationship between the  $\text{H}_2\text{O}$  (1:5) P-soil test (phosphorus determined by ICP technique) and the phosphorus concentration in barley shoot biomass

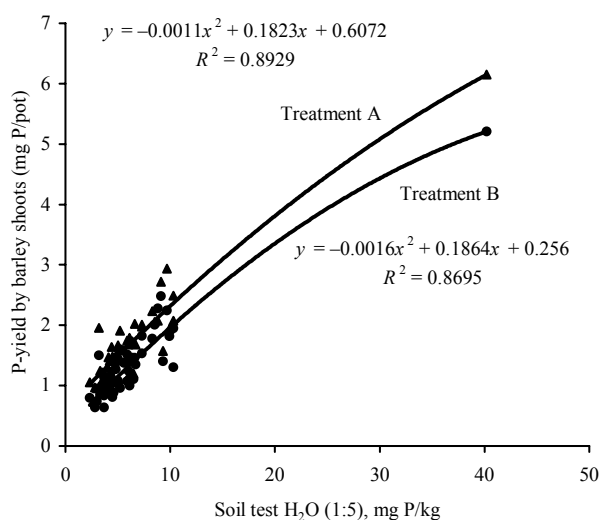


Figure 8. Relationship between the  $\text{H}_2\text{O}$  (1:5) P-soil test (phosphorus determined by ICP technique) and the phosphorus yield by barley shoot biomass

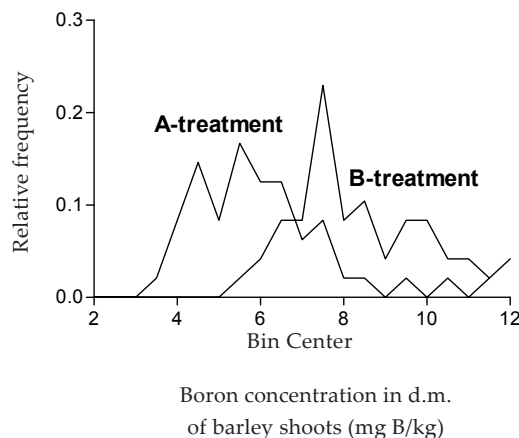


Figure 9. Frequency distribution of the boron concentration in barley shoot biomass

Phosphorus concentration in barley was significantly lower in the set of data on variant B (i.e. sulphur variant) compared to variant A (Table 2). Figure 5 shows the distribution of occurrence frequency of phosphorus concentrations within the data on variants (A and B). The lower phosphorus concentration in variant B cannot be fully explained by the effect of nutrient dilution in connection with the higher yield of barley shoot biomass because the difference was significant again after the phosphorus concentration was converted to its uptake by yield (Table 2 and Figure 6). The distribution of phosphorus concentration and its uptake by barley are in good correlation with the reserve of labile phosphorus in the set of used soils (Figures 7 and 8). Because no marked competitive relations are assumed in the uptake of anions by plants (Mengel and Kirkby 1982), the cause of the difference in phosphorus concentration in barley is ambiguous. Yadav and Yadav (1998), who studied chloride and sulphate salinity in the pea (from 10 to 40mM), reported a generally better response to phosphorus in chloride variant compared to sulphate one. In our experiments, the application of chlorides and sulphates in relation to soil irrigation approached maximally the concentration of 10mM. In interaction through soil better conditions for phosphorus uptake by plants are commonly reported due to the competitive adsorption of sulphates and phosphates by the clay fraction of soil (Geelhoed et al. 1997).

Figure 9 shows the distribution of boron concentration in barley shoot biomass in the set of data on variant A and B. The values of boron concentration in barley in the set of data on sulphate variant (B) were considerably higher (Table 2). Jones et al. (1991) described boron-phosphorus interac-



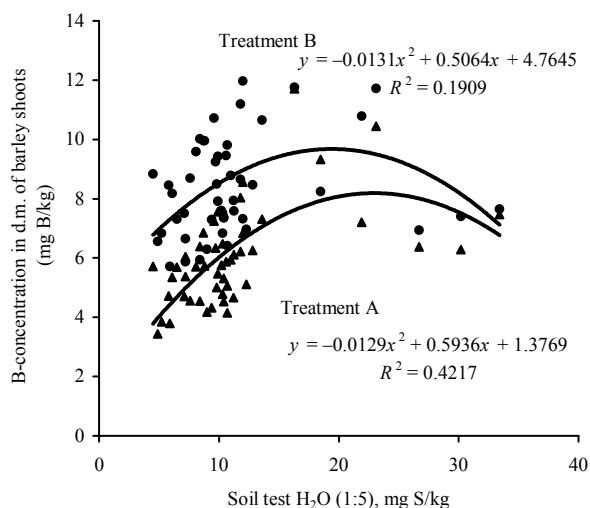


Figure 10. Relationship between the  $\text{H}_2\text{O}$  (1:5) S-soil test (sulphur determined by ICP technique) and the boron concentration in barley shoot biomass

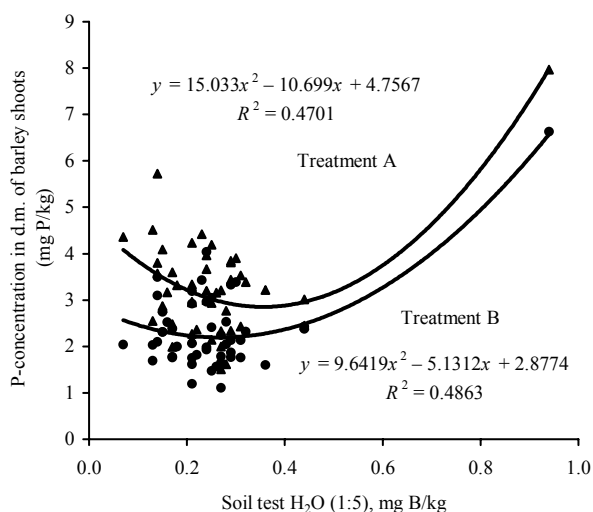


Figure 11. Relationship between the  $\text{H}_2\text{O}$  (1:5) B-soil test (boron determined by ICP technique) and the phosphorus concentration in barley shoot biomass

tion. They reported that the induced phosphorus deficiency increased boron content in leaves of grapevine and strawberries. Similarly in our experiments, in sulphate variant a decrease in phosphorus availability to barley was detected that was connected with higher boron content in barley. An antagonistic phosphorus-boron interaction was discovered in maize by Gunes and Alpaslan (2000). The application of boron induced a decrease in phosphorus concentration in maize, and on the contrary, phosphorous fertilisation decreased boron uptake. Based on these results, phosphorous ferti-

lisation was recommended to reduce boron toxicity on calcareous soils in semiarid areas. Khurana and Chatterjee (2002) and Sinha et al. (2003) described the interactions of boron, phosphorus and sulphur in mustard that were of synergistic nature.

Figure 10 shows a trend of the relation of boron content in barley to the soil reserve of labile sulphur determined by  $\text{H}_2\text{O}$  (1:5) S-soil test. In variant A the correlation was quite close, apparently the boron concentration in barley increased with increasing soil reserve of labile sulphur but only to the area of the maximum of the adequate soil reserve of sulphur (Matula 2004). The relation of soil reserve of boron to phosphorus content in barley is represented in Figure 11. A slight trend of phosphorus decrease in barley was measured for an increase in the boron level in soil in the area of the low soil reserve of boron. The correlation between an increase in phosphorus content in barley and an increase in the soil reserve of boron could potentially exist with the higher soil reserve of boron. Unfortunately, we do not have enough experimental data to confirm the validity of this correlation because our experimental set of soils comprised mostly of soils low in boron, which is typical of a majority of agricultural soil in the CR.

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## ABSTRAKT

### Vliv aplikace chloridu a síranu do půdy na změny obsahu živin v nadzemní hmotě ječmene v rané fázi růstu

Sledování rozšiřuje pokusy, primárně určené pro potřeby specifikace vhodné zásoby labilní síry v půdě, o dopad na interakce v příjmu živin testovací rostlinou ječmenem. Vegetační experimenty (18denní) za kontrolovaných podmínek kultivace probíhaly na pestrém souboru 48 půd ze zemědělsky využívaných pozemků. Před výsevem ječmene byl soubor půd členěn na dvě varianty: A – kontrolní (s aplikací  $\text{NH}_4\text{Cl}$ ) a B – odezvovou [s aplikací  $(\text{NH}_4)_2\text{SO}_4$ ], při jednotné dávce 26 mg N/kg zeminy. Po skončení pokusu byla v sušině nadzemní hmoty ječmene stanovena koncentrace N,  $\text{N-NO}_3^-$ , S,  $\text{S-SO}_4^{2-}$ , P, K, Mg, Ca, Na, Mn a B. Párovým testem byly zjištěny významné rozdíly mezi souborem dat variant A a B ve výnosu ječmene i v koncentraci síry, síranu, dusičnanu, fosforu a bóru v rostlinách ječmene. Varianta B (síranová) vykazovala větší výnos ječmene, vyšší koncentraci síry, síranu a bóru a nižší koncentraci dusičnanu a fosforu oproti variantě A. Menší koncentrace dusičnanu a fosforu nebyla odůvodnitelná tzv. efektem ředění – větším výnosem ječmene. Podstatný pokles koncentrace dusičnanu byl spojen s lepší utilizací dusíku v rostlině po korekci výživného stavu půdy sírou. Koncentrace fosforu v ječmeni dobře korespondovala se zásobou labilního fosforu v půdě, avšak při výrazném posunu koncentrace fosforu v ječmeni na nižší úroveň ve variantě B (síranové). Vyšší koncentrace bóru v ječmeni by mohla souviset s depresí příjmu fosforu po aplikaci síranu.

**Klíčová slova:** ječmen; interakce; síra; dusičnany; fosfor; bór

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