

The boron content of plants and soil fertilized with composted sewage sludge

Zawartość boru w roślinach i glebie użyźnianej kompostami z osadów ściekowych

Teresa Bowszys, Jadwiga Wierzbowska, Dorota Pilejczyk

*Department of Agricultural Chemistry and Environmental Protection,
University of Warmia and Mazury in Olsztyn, Poland
e-mail: teresa.bowszys@uwm.edu.pl*

The aim of this study, conducted in 2004–2007, was to determine the effect of composted sewage sludge on the boron content of soil and produced biomass. A field experiment was established on lessive soil developed from light boulder loam, and it covered the following crop rotation cycle: potatoes, spring barley, winter rapeseed, winter wheat. Before the experiment, soil contained $0.65 \text{ mg}\cdot\text{kg}^{-1}$ of available boron, and pH was 5.04 in $1 \text{ mol KCl}\cdot\text{dm}^{-3}$. The experiment included the following 10 fertilizer treatments: control (no fertilizers), NPK, manure (10 and $2 \times 5 \text{ Mg DM}\cdot\text{ha}^{-1}$), municipal sewage sludge composted with straw (10 and $2 \times 5 \text{ Mg DM}\cdot\text{ha}^{-1}$), dried granular sewage sludge (10 and $2 \times 5 \text{ Mg DM}\cdot\text{ha}^{-1}$) and composted sewage sludge (10 and $2 \times 5 \text{ Mg DM}\cdot\text{ha}^{-1}$). Manure and composts were applied once per crop rotation cycle (potatoes) at $10 \text{ Mg DM}\cdot\text{ha}^{-1}$ and twice at $5 \text{ Mg DM}\cdot\text{ha}^{-1}$ (potatoes and winter rapeseed). In the remaining years, only mineral fertilizers were used. In treatments with manure and composts, supplemental nitrogen was applied to meet the crops' requirements, subject to the total N content of fertilizers: potatoes – up to $150 \text{ kg}\cdot\text{ha}^{-1}$, rapeseed – up to $120 \text{ kg}\cdot\text{ha}^{-1}$. Sewage sludge composted with straw had the highest boron content ($27.5 \text{ mg}\cdot\text{kg}^{-1}$), sewage sludge composted without straw contained less boron ($24.2 \text{ mg}\cdot\text{kg}^{-1}$), and the lowest boron concentrations were noted in dried granular sewage sludge ($12.0 \text{ mg}\cdot\text{kg}^{-1}$). The field experiment was followed by a model lysimeter experiment in which the natural arrangement of soil horizons was maintained, and the total amount of water applied to the lysimeter corresponded to the average annual precipitation in the Region of Warmia and Mazury, NE Poland (605 mm). The results of chemical analyses were analyzed statistically using Statistica 10[®] software.

In the first year of the study, the application of manure and composts at 10 and $5 \text{ Mg DM}\cdot\text{ha}^{-1}$ significantly increased the boron content of soil, in comparison with NPK fertilization, and a similar tendency was observed also in successive years. The concentrations of available boron increased to over $0.68 \text{ mg}\cdot\text{kg}^{-1}$ in soil fertilized with composted sewage sludge (mean of four years), and decreased in the control and NPK treatments, relative to the initial content. The boron content of potato tubers ranged from 6.35 to $9.05 \text{ mg}\cdot\text{kg}^{-1} \text{ DM}$. Higher boron content was noted in potato tubers fertilized with $10 \text{ t}\cdot\text{ha}^{-1}$ of manure ($8.02 \text{ mg}\cdot\text{kg}^{-1} \text{ DM}$) and sewage sludge composted with straw ($8.03 \text{ mg}\cdot\text{kg}^{-1} \text{ DM}$) or $5 \text{ t}\cdot\text{ha}^{-1}$ of composted sewage sludge ($9.05 \text{ mg}\cdot\text{kg}^{-1} \text{ DM}$). Among the analyzed organic substances, the application of $10 \text{ t}\cdot\text{ha}^{-1} \text{ DM}$ of dried granular sewage sludge had the most beneficial residual effect on boron concentrations in grain ($2.03 \text{ mg}\cdot\text{kg}^{-1} \text{ DM}$). The boron content of rapeseeds varied depending on fertilization, from 19.15 to $23.73 \text{ mg B}\cdot\text{kg}^{-1} \text{ DM}$. The significantly highest boron content was noted in the seeds of plants fertilized with $10 \text{ t}\cdot\text{ha}^{-1} \text{ DM}$ of manure once per crop rotation cycle. In the remaining treatments, boron concentrations in seeds were 18% lower on average. Fertilization had no significant effect on the boron content of winter wheat grain, which was higher in treatments fertilized with $2 \times 5 \text{ Mg DM}\cdot\text{ha}^{-1}$ of manure, sewage sludge composted with straw and dried granular sewage sludge. The use of organic soil amendments did not significantly increase boron leaching. The highest leaching loss of boron was observed in response to the application of 10 t of manure ($0.080 \text{ mg B}\cdot\text{dm}^{-3}$) and sewage sludge composted with straw ($0.081 \text{ mg B}\cdot\text{dm}^{-3}$). Water percolating through soil in the remaining treatments was characterized by similar boron content of 0.059 to $0.063 \text{ mg}\cdot\text{dm}^{-3}$. The highest amounts of boron were leached from soil fertilized with sewage sludge composted with straw ($476 \text{ g}\cdot\text{ha}^{-1}$) and manure ($434 \text{ g}\cdot\text{ha}^{-1}$).