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**RESIDUAL EFFECT OF SOIL CONTAMINATION
WITH HEAVY METALS ON *Sitona* sp. BEETLES FEEDING
ON BROAD BEAN (*Vicia faba* L.)**

**NASTĘPCZY WPŁYW SKAŻENIA GLEBY METALAMI CIĘŻKIMI
NA ŻEROWANIE CHRZĄSZCZY OPRZĘDZIKÓW (*Sitona* sp.)
NA BOBIE (*Vicia faba* L.)**

Abstract: The research aimed at an assessment of heavy metal soil contamination effect on the intensity of *Sitona* beetles feeding on broad beans cultivated in the soil three years after the moment of pollution, from the perspective of possibly enhanced attractiveness of this host plant as food. Broad bean (*Vicia faba* L.), White Windsor c.v. was cultivated in two series differing by the date of the soil contamination with heavy metals. The soil was contaminated in 2002 (III) and 2005 (0). In each series the plants were cultivated in the following objects: unpolluted soil – with natural content of heavy metals (Control); unpolluted soil with natural content of heavy metals and fertilized minerally (NPK); soil polluted with a dose of $4 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ of cadmium; soil polluted with a dose of $530 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ of lead; soil polluted with a dose of $85 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ of copper; soil contaminated with zinc dosed $1000 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ and soil polluted with a dose of $110 \text{ mg} \cdot \text{kg}^{-1} \text{ d.m.}$ of nickel. The harmfulness of *Sitona* sp. beetles was assessed by measuring the leaf surface losses caused by their feeding, the consumed area and by counting the percentage of injured leaves. After 3 years from the soil contamination with nickel, zinc, copper, lead and cadmium no increase of attractiveness of the plants for *Sitona* sp. beetles was observed.

Keywords: heavy metals, soil pollution, *Sitona* sp.

Soil contamination with lead, cadmium, copper and nickel either on the I or III level of pollution in the IUNG classification does not cause any significant seasonal changes in the degree of plant injuries caused by the beetles from *Sitona* species [1]. However, a reduced feeding of *Sitona* beetles was observed on the plants growing in the soil contaminated with zinc on a higher level. Significant differences were noted also in the course of *Sitona* feeding dynamics on broad bean growing in the soil contaminated with various heavy metals [2]. The research conducted to assess the degree of *Sitona* harmfulness for broad bean cultivated in heavy metal polluted soil in the year of the

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analysis, a year before and two years before, revealed that at the early development stage, plants growing in the soil contaminated with zinc and nickel (in the same year as the analysis) proved the least attractive for *Sitona* beetles. For the object where the soil was contaminated with nickel and copper, the tendency was observed also at the later stage of the pest feeding [3].

The present research aimed at an assessment of heavy metal soil contamination effect on the intensity of *Sitona* beetles feeding on broad beans cultivated in the soil three years after the moment of pollution, from the perspective of possibly enhanced attractiveness of this host plant as food.

Material and methods

The experiment was conducted in 2005 under field conditions. The experimental soil was a degraded chernozem formed from loess with acid pH and 1.13 % organic carbon content. Broad bean (*Vicia faba* L.), White Windsor c.v. was cultivated in two series differing by the date of the soil contamination with heavy metals. The soil was contaminated in 2002 (III) and 2005 (0). In each series the plants were cultivated in the following objects: unpolluted soil – with natural content of heavy metals (Control); unpolluted soil with natural content of heavy metals and fertilized minerally (NPK); soil polluted with a dose of $4 \text{ mg} \cdot \text{kg}^{-1}$ d.m. of cadmium; soil polluted with a dose of $350 \text{ mg} \cdot \text{kg}^{-1}$ d.m. of lead; soil contaminated with zinc dosed $1000 \text{ mg} \cdot \text{kg}^{-1}$ d.m. and soil polluted with a dose of $110 \text{ mg} \cdot \text{kg}^{-1}$ d.m. of nickel. The plants were grown in plastic pots with 9.8 kg of soil d.m. The heavy metals were added to the soil as water solutions of the following salts: $3\text{CdSO}_4 \cdot 7\text{H}_2\text{O}$, $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$, CuSO_4 , $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$, $\text{Pb}(\text{NO}_3)_2$. Because on the object receiving $\text{Pb}(\text{NO}_3)_2$ some amount of nitrogen was already supplied into the soil, its dose was adequately diminished in the applied basic fertilization. Basic fertilization, the same on all objects (except the unfertilized control), dosed 0.7 g N (as NH_4NO_3); 0.8 g P_2O_5 (as KH_2PO_4) and 1.2 g K_2O (as KCl) per pot of 9.8 kg d.m. of soil, was applied in the first year of the investigations.

The data on the methods applied for soil chemical analyses were presented in other papers [4–5].

The harmfulness of *Sitona* sp. beetles was assessed by measuring the leaf surface losses caused by their feeding, the consumed area and by counting the percentage of injured leaves. The analysis of injuries was conducted at the early stage of plant development (several leaves stage – 21.05.2005) and two weeks later (2.06.2005). The significance of differences between the means was tested by a one-way ANOVA. The means were differentiated using the Duncan test on the significance level $p < 0.05$.

Results and discussion

On the first of the analyzed dates *Sitona* sp. beetles injured ca 23 % of leaves (depending on the object). The greatest number of leaves with consumed area were observed in the year when the research was conducted on the plants growing in nickel contaminated soil. At that time no leaf injuries were spotted yet in the object where the

soil was contaminated with zinc 3 years prior to the observations (Fig. 1A). No statistically significant differences were found either in the total consumed area caused by the beetles between the analyzed objects at that time. When the observations were carried out 2 weeks later the percentage of injured leaves was between 27 and 77 % (depending on the object) (Fig. 1B). In the case of cadmium contaminated soil, no significant differences in the degree of injuries due to *Sitona* sp. beetles were assessed between the objects contaminated on various dates (Fig. 1B and 2B). The analysis of heavy metal contents in broad bean plants revealed that with time elapsing from the soil cadmium contamination moment, its concentrations in broad bean shoots remained on a similar level or even slightly increased [6].

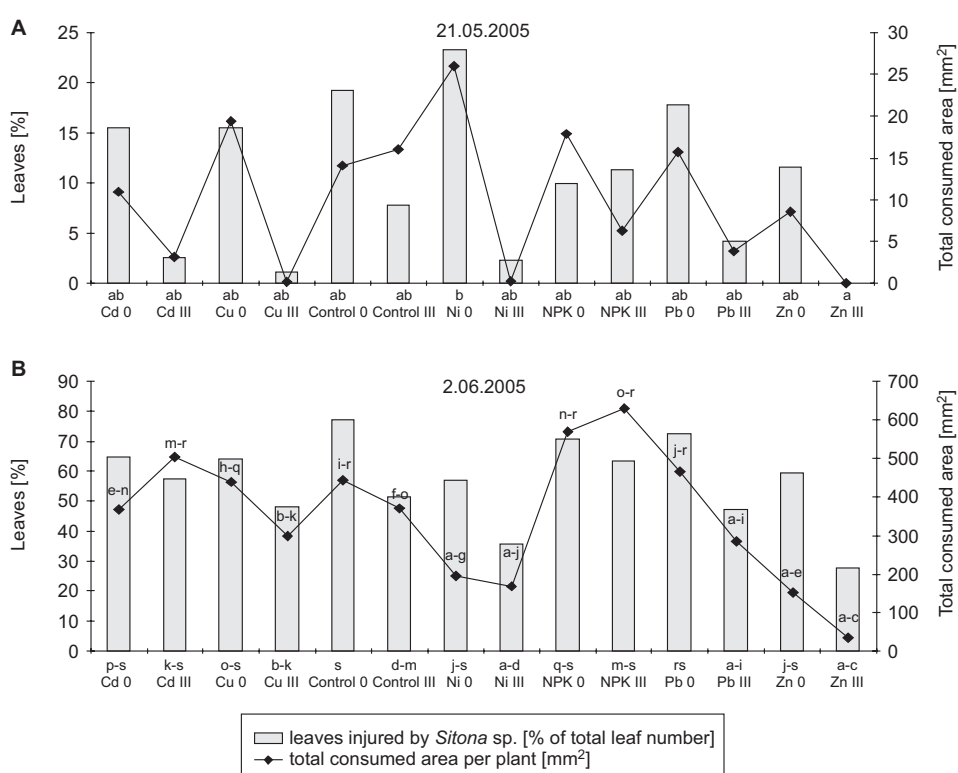


Fig. 1. Injuries of broad bean growing in natural soil (Control, NPK) and in soil contaminated with individual metals (III – soil contaminated three years earlier, 0 – soil contaminated in the year of the observations) caused by *Sitona* beetles. Values for individual metals or control and for individual features marked by different letters are statistically significantly different ($p < 0.05$). Assessments were presented only if there was statistical differentiation between objects. In other cases differences were statistically insignificant

Under conditions of the soil polluted with copper 3 years before the observation date a smaller number of leaves injured by *Sitona* sp. beetles was observed, as well as smaller consumed area than on broad bean growing under conditions of the soil

contaminated in the year of the experiment (Fig. 1B). In former investigations, increased attractiveness of broad bean plants as feed for *Sitona* was observed one or two years after the pollution moment [3]. A significant decrease in copper content in broad bean shoots was registered as time elapsed from the moment of the soil contamination with this metal. This metal concentrations in the plants cultivated in the soil contaminated 3 years earlier were only about 1.5 times higher than in the control plants, whereas the concentrations in the plants growing in the soil contaminated in the year of the analysis were almost 4 times higher than in the plants growing in the unpolluted soil [6].

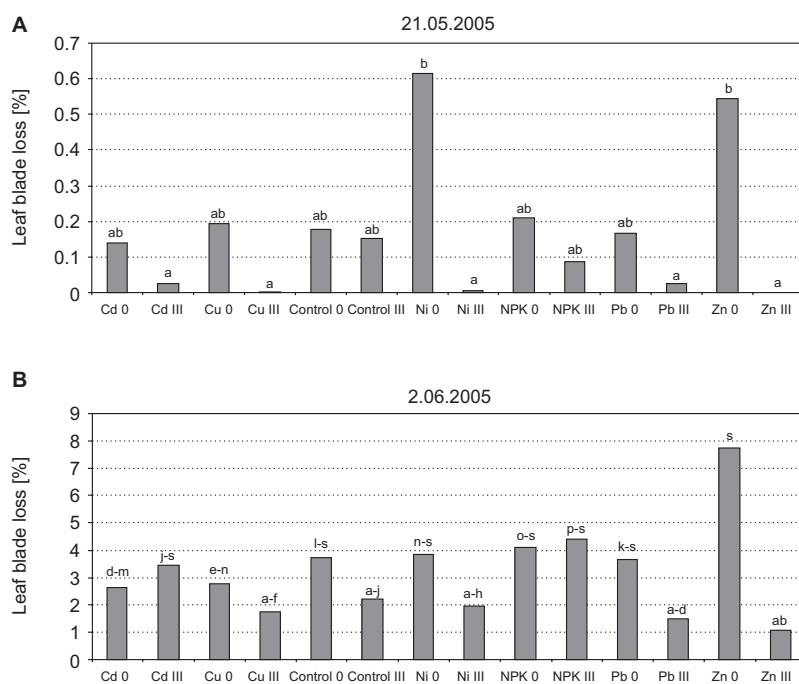


Fig. 2. Leaf blade loss as a result of *Sitona* beetles feeding (per cent of total leaf area) on broad bean growing in natural soil (Control, NPK) and in soil contaminated with individual metals (III – soil contaminated three years earlier, 0 – soil contaminated in the year of the observations). Values for individual metals or control and for individual features marked by different letters are statistically significantly different ($p < 0.05$). Assessments were presented only if there was statistical differentiation between objects. In other cases differences were statistically insignificant

Former research registered an increase in the degree of broad bean plant injuries with the lapse of time (one or two years) from the soil contamination with lead [3]. In the presented research, a decreased harmfulness of *Sitona* beetles was already noticed under conditions of soil contaminated 3 years before. The analysis of lead content in broad beans revealed that 3 years after the soil contamination, this metal content in broad bean shoots was about 4 times lower than in the plants growing in the soil contaminated in the year when the analysis was conducted. Similarly to in the former investigations, the

smallest consumed area was observed under conditions of soils contaminated with nickel and zinc. The percentage of injured broad bean leaves growing in the soil polluted with nickel and zinc 3 years earlier was significantly lower than in the case of soil contaminated with these metals in the year of the experiment. Also leaf blade loss was lower. The value of the latter parameter might have resulted from improved condition of plants growing in the soil polluted with heavy metals earlier in comparison with the plants cultivated in the “freshly contaminated soil”. Nickel concentrations in broad bean shoots cultivated in the soil 3 years from the contamination moment were over twice lower than under conditions of soil contaminated in the year of the experiment, zinc content decreased by about 20 %. Changes in plant attractiveness for phytophages feeding on them might result not only from changes in heavy metal content in plants as such, but also changes in other biochemical and physiological plant parameters, which are modified by the presence of these pollutants [7, 8].

Conclusions

After 3 years from the soil contamination with nickel, zinc, copper, lead and cadmium no increase of attractiveness of the plants for *Sitona* sp. beetles was observed.

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NASTĘPCZY WPŁYW SKAŻENIA GLEBY METALAMI CIĘŻKIMI NA ŻEROWANIE CHRZĄSZCZY OPRĘDZIKÓW (*Sitona* sp.) NA BOBIE (*Vicia faba* L.)

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Abstrakt: Celem podjętych badań była ocena wpływu skażenia gleby metalami ciężkimi na intensywność żerowania chrząszczy oprzędzików *Sitona* sp. na bobie uprawianym w glebie po upływie 3 lat od momentu skażenia, pod kątem możliwości wzrostu atrakcyjności tej rośliny żywicielskiej jako pokarmu. Bób (*Vicia faba* L.) odm. Windsor Biały uprawiany był w 2 seriach, różniących się datą skażenia gleby metalami ciężkimi. Glebę skażano w latach: 2002 i 2005. W każdej serii rośliny uprawiano w następujących obiektach: gleba niezanieczyszczona – o naturalnej zawartości metali ciężkich (Kontrola); gleba niezanieczyszczona – o naturalnej zawartości metali ciężkich nawożona mineralnie (NPK); gleba zanieczyszczona kadmem w dawce: 4 mg · kg⁻¹ s.m., gleba zanieczyszczona ołowiem w dawce: 530 mg · kg⁻¹ s.m., gleba zanieczyszczona miedzią w dawce: 85 mg · kg⁻¹ s.m., gleba zanieczyszczona cynkiem w dawce: 1000 mg · kg⁻¹ s.m., gleba zanieczyszczona niklem w dawce: 110 mg · kg⁻¹ s.m. Szkodliwość chrząszczy

oprzędzików (*Sitona* sp.) oceniono, mierząc ubytek powierzchni liści na skutek ich żerowania, powierzchnię wyżerek oraz licząc odsetek uszkodzonych liści. Po upływie 3 lat od momentu zanieczyszczenia gleby niklem, cynkiem, miedzią, ołowiem lub kadmem nie obserwuje się wzrostu atrakcyjności roślin bobu dla chrząszczy *Sitona* sp.

Słowa kluczowe: metale ciężkie, zanieczyszczenie gleby, *Sitona* sp.