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Janina GOSPODAREK[1]

EFFECT OF MAGNESIUM TREATMENT ON BEAN BEETLE (*Bruchus rufimanus* BOH.) FEEDING ON BROAD BEAN (*Vicia faba* L. ssp. *maior*) IN CONDITIONS OF SOIL CONTAMINATION WITH HEAVY METALS

WPŁYW NAWOŻENIA MAGNEZOWEGO NA ŻEROWANIE STRĄKOWCA (*Bruchus rufimanus* BOH.) NA BOBIE (*Vicia faba* L. ssp. *maior*) W WARUNKACH SKAŻENIA GLEBY METALAMI CIĘŻKIMI

Abstract: The aim of the research was to determine the effect of magnesium treatment on the harmfulness of bean beetle (*Bruchus rufimanus* Boh.) for broad bean growing in conditions of soil contaminated with single heavy metals on III level of pollution acc. to the IUNG classification. The observations were conducted on broad bean (*Vicia faba* L. ssp. *maior*), White Windsor c.v. cultivated in two series: in soil subjected to magnesium fertilization and unfertilized with it. In each series the plants were cultivated in the following objects: unpolluted soil with natural heavy metal content (Control); unpolluted soil with natural heavy metal content with mineral fertilization (Control + NPK); cadmium contaminated soil (4 mg $\cdot$ kg^{-1} d.m.); soil polluted with lead (530 mg $\cdot$ kg^{-1} d.m.); soil polluted with copper (85 mg $\cdot$ kg^{-1} d.m.); soil polluted with zinc (1000 mg $\cdot$ kg^{-1} d.m.) and soil contaminated with nickel (110 mg $\cdot$ kg^{-1} d.m.). Identical magnesium fertilization applied for all objects was 20.4 mg Mg $\cdot$ kg^{-1} d.m.

The level of magnesium treatment applied to the soil contaminated with single heavy metals did not significantly affect broad bean seed yield, degree of injuries caused by bean beetle or their germinating ability. Magnesium treatment may slightly improve germination energy of broad bean seeds originating from plants growing in soil polluted with cadmium.

Keywords: heavy metals, magnesium fertilization, *Bruchus rufimanus* Boh.

Soil concentrations of heavy metals, such as copper, lead or cadmium reaching the level of elevated content or medium pollution according to the IUNG classification do not affect negatively the amount or quality of broad bean seeds [1, 2]. Therefore soil polluted with these metals may be used for broad bean seed crop cultivation. Magnesium fertilization may additionally beneficially affect the growth and crop yield quality, also when the plants are growing in heavy metal polluted soil [3]. It is due to potential

[1] Department of Agricultural Environment Protection, University of Agriculture in Krakow, al. A. Mickiewicza 21, 31-120 Kraków, Poland, email: rrjgospo@cyf-kr.edu.pl

reduction of the heavy metal uptake by plants as a result of the application of this measure and diminishing the harmfulness of some agrophages [3–5].

The studies were undertaken to determine the effect of magnesium treatment on the harmfulness of bean beetle (*Bruchus rufimanus* Boh.) for broad bean growing in soil contaminated with single heavy metals on the III level of pollution according to the IUNG classification. Assessed were also the energy and germination ability of seeds both injured by broad bean beetle and healthy ones.

Material and methods

The experiment was conducted in 2005 on degraded chernozem developed from loess revealing acid reaction and organic carbon concentration 1.13 %. Observations were conducted on broad bean (*Vicia faba* L., ssp. *maior*), White Windsor c.v. cultivated in the following objects: unpolluted soil with natural content of heavy metals (Control); unpolluted soil with natural heavy metal content receiving mineral fertilization (Control + NPK); soil contaminated with cadmium dosed: 4 mg $\cdot$ kg^{-1} d.m.; soil contaminated with lead dosed: 530 mg $\cdot$ kg^{-1} d.m.; soil contaminated with copper dosed: 85 mg $\cdot$ kg^{-1} d.m.; soil polluted with zinc dosed: 1000 mg $\cdot$ kg^{-1} d.m.; and soil polluted with nickel dosed 110 mg $\cdot$ kg^{-1} d.m. The same magnesium fertilization, with 20.4 mg Mg $\cdot$ kg^{-1} d.m., was applied in all objects.

The analyzed level of soil heavy metal pollution corresponded to the III class of pollution according to the IUNG classification [6]. The heavy metals in the form of water solutions of the following salts: $3CdSO_4 \cdot 8H_2O$, $NiSO_4 \cdot 7H_2O$, $CuSO_4$, $ZnSO_4 \cdot 7H_2O$ and $Pb(NO_3)_2$ were supplied to the soil in the year preceding the experiment. Basic fertilization, the same on all objects (except for the non-fertilized control), dosed: 0.7 g N (in NH_4NO_3); 0.8 g P_2O_5 (in KH_2PO_4); 1.2 g K_2O (in KCl) per pot (9.8 kg of soil d.m.) was applied simultaneously with heavy metal addition to the soil. In the year of the experiment some pots containing the contaminated soil received magnesium fertilization. The dose of the magnesium fertilizer was established on the basis of the soil analysis conducted by the Agro-Chemical Station in Krakow. The content of bioavailable magnesium in the initial soil was 7.2 mg $\cdot$ 100g^{-1} of soil dry mass. Magnesium was added to the soil as water solution of $MgSO_4 \cdot 7H_2O$.

The harmfulness of bean beetle was estimated on the basis of the weight of injured seeds in relation to the total seed weight. The germination energy and ability of broad bean seeds were assessed in laboratory conditions according to the generally accepted standards. The test was performed on Petri dishes on filter paper as the substratum. Germinating energy was assessed after 4 days and germination ability after 14 days. Seeds injured by bean beetle (*Bruchus rufimanus* Boh.) and healthy seeds were assessed separately.

Results and discussion

Soil pollution with zinc and nickel inhibited broad bean plant growth so that they were unable to develop seeds. Applied magnesium fertilization did not lead to any major changes in the soil reaction [7]. No statistically significant effect of the level of magnesium treatment applied to the soil contaminated with individual heavy metals was registered with respect to the obtained broad bean seed yield and the level of their injury due to bean beetle (Table 1). The largest number of seeds was gathered from plants growing in lead and cadmium contaminated soil when magnesium treatment was applied in the object where the soil was polluted with lead and fertilized with magnesium also the highest proportion of seeds injured by bean beetle was found, significantly higher than in the control receiving mineral fertilization.

Table 1

Characteristics of broad bean seeds from plants cultivated in natural soil and in heavy metal contaminated soil with applied magnesium treatment, and degree of injuries due to *Bruchus rufimanus* Boh.

Object	Average seed weight per plant [% in relation to NPK]	Weight of seeds injured by *Bruchus rufimanus* Boh. [% in relation to NPK]
Cu+Mg	88.22 ab	137.62 ab
Cu	117.13 ab	110.66 ab
Pb+Mg	173.33 b	176.86 b
Pb	139.92 ab	167.37 ab
NPK+Mg	118.12 ab	163.22 ab
NPK	100.00 ab	100.00 a
Cd+Mg	153.64 ab	130.34 ab
Cd	139.41 ab	114.55 ab
K+Mg	52.12 a	155.15 ab
K	116.69 ab	161.42 ab

A greater germination energy was observed in seeds uninjured by bean beetle from plants growing in cadmium contaminated soil and fertilized with magnesium than when this measure was not applied. The situation was similar in the control object where mineral fertilizers were used. In the other objects no significant effect of magnesium fertilization on seed germination energy was observed (Fig. 1b). Also the seeds injured by bean beetle originating from plants cultivated in cadmium polluted soil subjected to magnesium treatment were germinating faster than the seeds from the object contaminated with cadmium but not fertilized with magnesium (Fig. 2b). The cadmium content in roots decreased ca 2.5 times as a result of magnesium fertilization. On the other hand, no effect of magnesium fertilization was observed on the concentrations of this element in broad bean shoots. Magnesium fertilization had a similar effect in the case of copper and lead – diminished metal concentrations as a result of this measure was observed only in the underground parts [7].

The analysis of the germination of the seeds uninjured by bean beetle did not reveal a statistically significant effect of magnesium treatment (Fig. 2a). No major differences in seedling condition were registered, either (Table 2). Bean beetle feeding considerably inhibited seed germination ability (Fig. 2b). Also in this case no statistically significant differences were found between objects subjected to magnesium fertilization and ones non-fertilized with this element. Seeds from the control, from the object with mineral fertilization and additional magnesium treatment and from the lead contaminated object revealed the greatest germination ability.

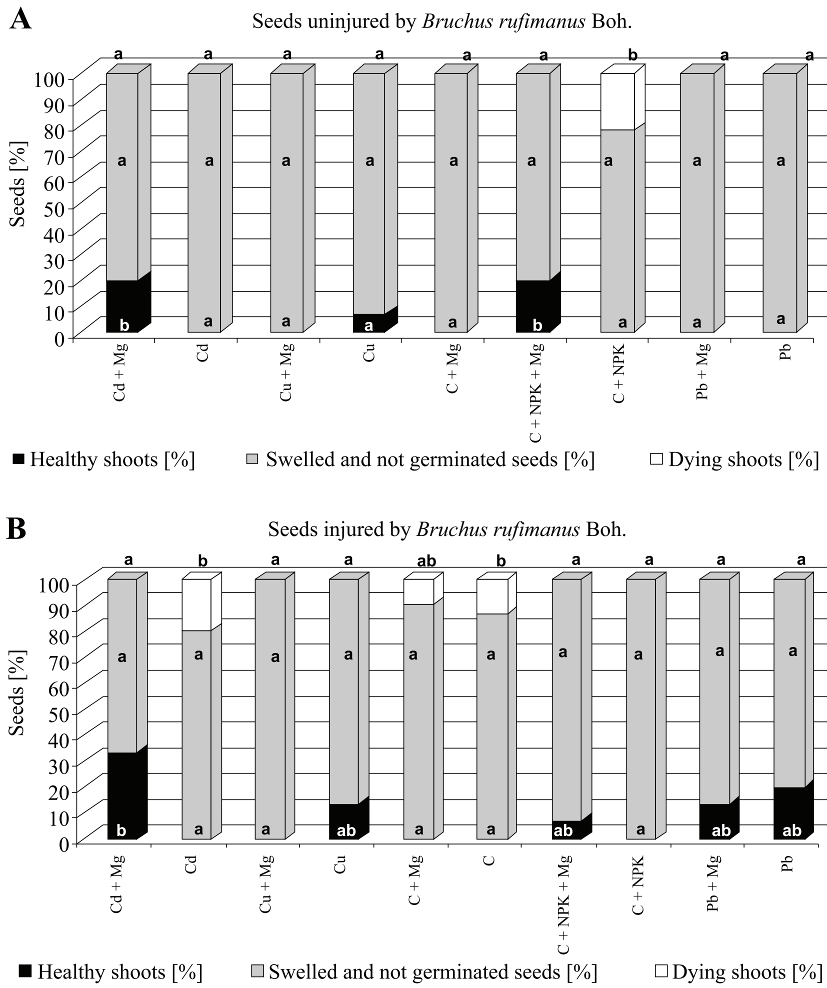

Fig. 1. Germination energy of broad bean seeds uninjured (A) and injured (B) by *Bruchus rufimanus* Boh. originating from plants growing in natural and heavy metal contaminated soil with magnesium fertilization. Values for individual metals or control and for individual features, marked by different letters in columns are statistically different (p = 0.05).

Table 2

Characteristics of germinating broad bean seeds (injured or uninjured by *Bruchus rufimanus* Boh.) from plants cultivated in natural soil and in heavy metal contaminated soil with applied magnesium treatment.

Objects	Shoot length [cm]		Underground part length [cm]		Number of lateral roots > 2 mm	
	Uninjured seeds	Injured seeds	Uninjured seeds	Injured seeds	Uninjured seeds	Injured seeds
Cu + Mg	5.99 a	2.76 a	10.60 ab	4.33 ab	6.82 a	7.92 a
Cu	7.22 a	5.19 a	8.80 ab	8.32 ab	12.88 ab	12.61 a
Pb + Mg	8.12 a	8.03 a	6.25 ab	9.59 ab	8.45 ab	11.44 a

Table 2. contd.

Objects	Shoot length		Underground part length		Number of lateral roots > 2 mm	
	Uninjured seeds	Injured seeds	Uninjured seeds	Injured seeds	Uninjured seeds	Injured seeds
Pb	9.10 a	8.80 a	9.35 ab	12.65 b	13.50 ab	10.49 a
NPK + Mg	15.62 a	4.77 a	8.50 ab	6.85 ab	17.00 ab	6.88 a
NPK	9.03 a	5.40 a	5.50 a	4.60 ab	10.05 ab	5.35 a
Cd + Mg	10.66 a	5.68 a	12.94 b	6.91 ab	15.05 ab	6.53 a
Cd	9.10 a	2.36 a	9.00 ab	2.78 a	11.00 ab	4.89 a
K + Mg	14.00 a	0.73 a	7.00 ab	2.98 a	18.00 b	7.75 a
K	–	5.98 a	–	8.92 ab	–	15.19 a

Values for individual metals or control marked by different letters in columns are statistically different (p = 0.05).

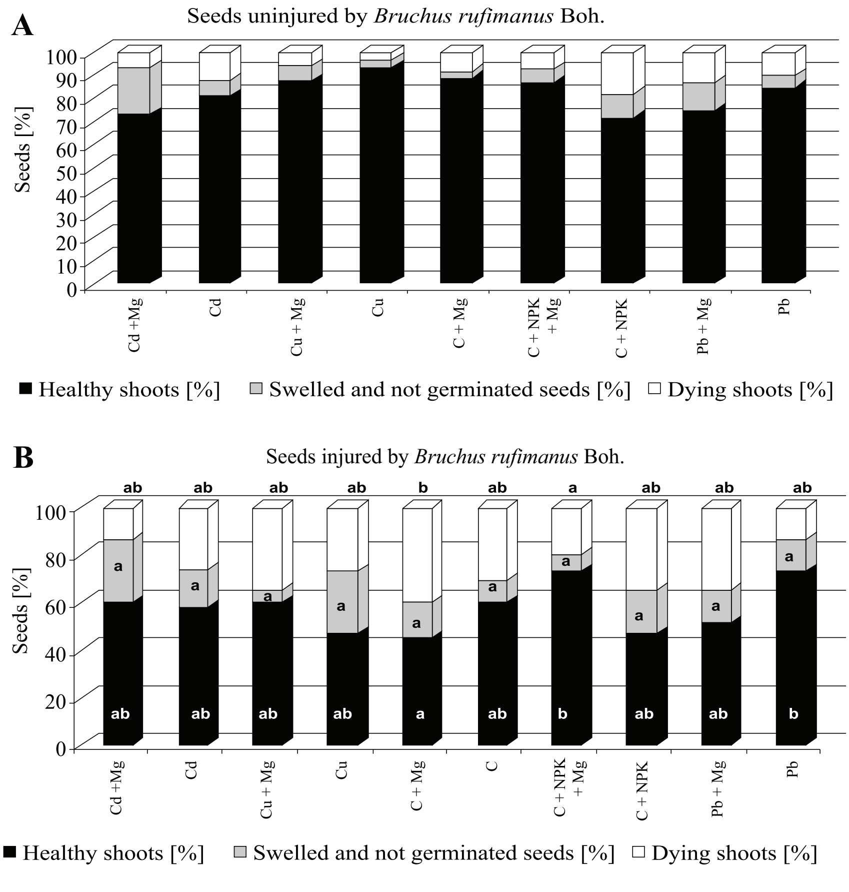

Fig. 2. Germination ability of broad bean seeds uninjured (A) and injured (B) by *Bruchus rufimanus* Boh. originating from plants growing in natural and heavy metal contaminated soil with magnesium fertilization. Values for individual metals or control and for individual features, marked by different letters in columns are statistically different (p = 0.05).

Conclusions

1. The applied level of magnesium fertilization of soil contaminated with single heavy metals does not significantly affect either broad bean seed yield, or the degree of injuries caused by bean beetle, or their germination ability.

2. Magnesium treatment may slightly improve the germination energy of broad bean seeds from plants growing in cadmium contaminated soil.

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WPŁYW NAWOŻENIA MAGNEZOWEGO NA ŻEROWANIE STRĄKOWCA (*Bruchus rufimanus* BOH.) NA BOBIE (*Vicia faba* L. ssp. *maior*) W WARUNKACH SKAŻENIA GLEBY METALAMI CIĘŻKIMI

Katedra Ochrony Środowiska Rolniczego, Uniwersytet Rolniczy w Krakowie

Abstrakt: Celem podjętych badań było określenie wpływu nawożenia magnezowego na szkodliwość strąkowca bobowego (*Bruchus rufimanus* Boh.) dla bobu rosnącego w warunkach gleby zanieczyszczonej pojedynczymi metalami ciężkimi na poziomie III stopnia zanieczyszczenia wg klasyfikacji IUNG. Obserwacje prowadzono na bobie (*Vicia faba* L. ssp. *maior*) odm. Windsor Biały uprawianym w dwóch seriach: na glebie poddanej nawożeniu magnezowemu i nienawożonej magnezem. 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 (Kontrola + NPK); gleba zanieczyszczona kadmem w dawce: 4 mg $\cdot$ kg^{-1} s.m.; gleba zanieczyszczona ołowiem w dawce: 530 mg $\cdot$ kg^{-1} s.m.; gleba zanieczyszczona miedzią w dawce: 85 mg $\cdot$ kg^{-1} s.m.; gleba zanieczyszczona cynkiem w dawce: 1000 mg $\cdot$ kg^{-1} s.m.; gleba zanieczyszczona niklem w dawce: 110 mg $\cdot$ kg^{-1} s.m. Nawożenie magnezowe zastosowano jednakowe dla wszystkich obiektów: 20,4 mg Mg $\cdot$ kg^{-1} s.m.

Zastosowany poziom nawożenia magnezowego gleby skażonej pojedynczymi metalami ciężkimi nie wpływa znacząco na plon nasion bobu, stopień ich uszkodzenia przez strąkowca bobowego ani też ich zdolność kiełkowania. Nawożenie magnezowe może nieco zwiększać energię kiełkowania nasion bobu pochodzących z roślin rosnących w glebie zanieczyszczonej kadmem.

Słowa kluczowe: metale ciężkie, nawożenie magnezowe, *Bruchus rufimanus* Boh.