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EFFECT OF LIMING AND MAGNESIUM TREATMENT OF THE SOIL CONTAMINATED WITH HEAVY METALS ON THE CHEWING PESTS OF BROAD BEAN (*VICIA FABA* L., SSP. MAIOR)

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S u m m a r y. The present investigations aimed at the determination of the effect of liming and magnesium treatment of the soil with elevated heavy metal concentration levels on the occurrence and harmfulness of the beetles and larvae of sitona (*Sitona* sp.) and broad bean seed beetle (*Bruchus rufimanus* Boh.). The field experiment was set up in two series: on the unlimed and limed soil. In each series broad bean plants (*Vicia faba* L. ssp maior), white Windsor c.v. were also grown in the control soil (with natural levels of heavy metals content); in the soil contaminated with heavy metals, doses corresponding to the 1st level of pollution according to ISSPC classification and in the soil contaminated with heavy metal receiving magnesium fertilization. Magnesium fertilization applied in the soils polluted with heavy metal polluted positively affected broad bean growth. Sitona beetles were feeding more eagerly on the plants growing in the control soil with a natural content of heavy metals. Liming positively influenced a decrease of areas damaged by the pest feeding. A loss of an assimilative area due to the sitona feeding was very low and did not exceed 2%. Sitona larvae injured between 16 and 36% of broad bean verrucasan on average. Broad bean seed beetle injured between 13 and 26% of broad bean seeds. No significant influence of magnesium treatment and liming was found in the soil with elevated heavy metal concentration levels on the harmfulness of beetles and larvae of sitona and broad bean seed beetle.

K e y w o r d s: heavy metals, liming, magnesium treatment, chewing pests

INTRODUCTION

Soil liming worsens feeding conditions for some pests as it changes composition and availability of microelements which affects fertility and viability of insects [7]. The above measure is also recommended as a way to limit a negative effect of heavy metals on plants, especially on acidic soils [1]. It is important to balance liming and magnesium treatment to achieve the best yield-forming results [3]. A positive effect of magnesium on the conditions for microorganisms in the soil polluted with heavy metals was also observed [6].

The present study aimed at the determination of the effect of liming and magnesium treatment applied to the soil with increased heavy metal concentration levels on the chewing pests of broad bean (*Vicia faba* L. ssp. maior).

MATERIAL AND METHODS

A field experiment was carried out on an arable field at Zagaje Stradowskie in the Świętokrzyski Voivodeship in 2000. It was set up in two series: on unlimed and limed soil (2900 kg CaO ha^{-1}). In each series broad bean (*Vicia faba* L. ssp. maior), White Windsor c.v. was cultivated in the following experimental objects: control (soil with a natural heavy metals content of: 8.2 mg Cu, 52.9 mg Zn, 28.2 mg Pb, 12.8 mg Ni and 0.6 mg Cd kg^{-1} of soil dry matter) and unfertilized; a control receiving NPK mineral treatment; a soil receiving NPK mineral treatment and contaminated with heavy metals at the following doses: 2 mg Cd, 15mg Ni, 30 mg Cu, 70 mg Zn and 80 mgPb kg^{-1} of soil dry matter; a soil receiving NPK mineral fertilization and magnesium treatment (50 kg MgO ha^{-1}) and polluted with heavy metals. The following doses of basic fertilizers were applied: 30 kg N ha^{-1} as ammonium nitrate, 90 kg P_2O_5 ha^{-1} as granulated simple superphosphate and 90 kg K_2O ha^{-1} as potassium salt. A detailed soil characteristics, the way in which heavy metals were supplied to the soil and the methods used for chemical analyses were described elsewhere [4].

Harmfulness of sitona beetles was determined by the measuring of leaf area and counting injured and uninjured leaves. The underground parts were analysed to assess the harmfulness of larvae. For this reason, plant roots were removed and after a thorough rinsing, a total number of verrucas was counted and a number of the injured ones was assessed.

Harmfulness of broad bean seed beetle (*Bruchus rufimanus* Boh.) was assessed at full seed maturity on the basis of weight and number of the injured seeds in relation to the total weight and number of seeds.

RESULTS AND DISCUSSION

No significant effect of liming on broad bean plant growth was found in the soils contaminated with heavy metals (Tab. 1). An addition of magnesium together with heavy metals positively influenced the above-ground biomass. On the unlimed plots, it was almost 3 bigger as compared with shoot weight with leaves of the plants grown in the soil contaminated heavy metals without magnesium addition. A similar beneficial influence of magnesium on some morphological plant traits was observed in the limed plots, but it was less pronounced there (differences ranged within the limits of the experimental error).

Table 1. Features of broad bean plants cultivated in the soil with natural heavy metal content and in the soil polluted with heavy metals receiving liming and magnesium treatment

Treatments	Mean shoot length (cm)	number of shoots per plant (pcs)	number of leaves per plant (pcs)	shoot weight with leaves (g)	assimilative area of leaves per plant (cm^2)
Untreated control	70.16 c	3.27 c	19.30 a	69.09 c	2849.56 d
Control + NPK	67.20 c	3.10 bc	17.82 a	68.89 c	2285.87 c
NPK + metals	55.79 ab	2.59 ab	16.67 a	36.17 a	920.39 ab
NPK + Mg + metals	58.45 b	2.27 a	19.65 a	47.68 b	1166.33 b
Untreated control +CaO	73.04 c	3.24 c	18.23 a	67.13 c	2316.97 c
Control + NPK + CaO	70.90 c	3.38 c	18.27 a	74.23 c	2479.31 c
NPK + CaO + metals	55.97 ab	2.46 a	17.36 a	37.15 a	832.10 ab
NPK + Mg + CaO + metals	56.80 b	2.63 ab	17.20 a	36.04 a	1079.54 ab

Mean values marked with the same letter in the columns do not differ significantly (p=0.05)

A loss in the leaf assimilative area due to sitona feeding was very small and did not exceed 2% (Fig. 1). Hence, it did not have any significant effect on plant development. It has been reported that at 12.5% of leaf area damage, a decline in yield is 8% and when it is 50% of the leaf area, a decline in yield reaches 46% [2]. Plants growing in the unlimed control soil, where mineral treatment had been applied, were characterised by the biggest area injured by the feeding of sitona beetles. The total injured area per plant was significantly bigger in comparison with the other objects (Fig. 1). A percentage of damaged leaves was also notably higher in the above object than in the objects where soil was contaminated with heavy metals, except for the limed soil contaminated with heavy metals where the number of injured leaves was slightly higher. Liming positively affected a decrease in areas damaged by insect feeding on the control plot where soil was fertilized with NPK. Similar results were obtained in the case of chewing insects on grasses [5]. Liming influenced a decrease in the number of injuries caused by the chewing insects.

On the other hand, no notable effect of liming and magnesium treatment was observed on the extent of lamina damage due to sitona on the plots where soil was

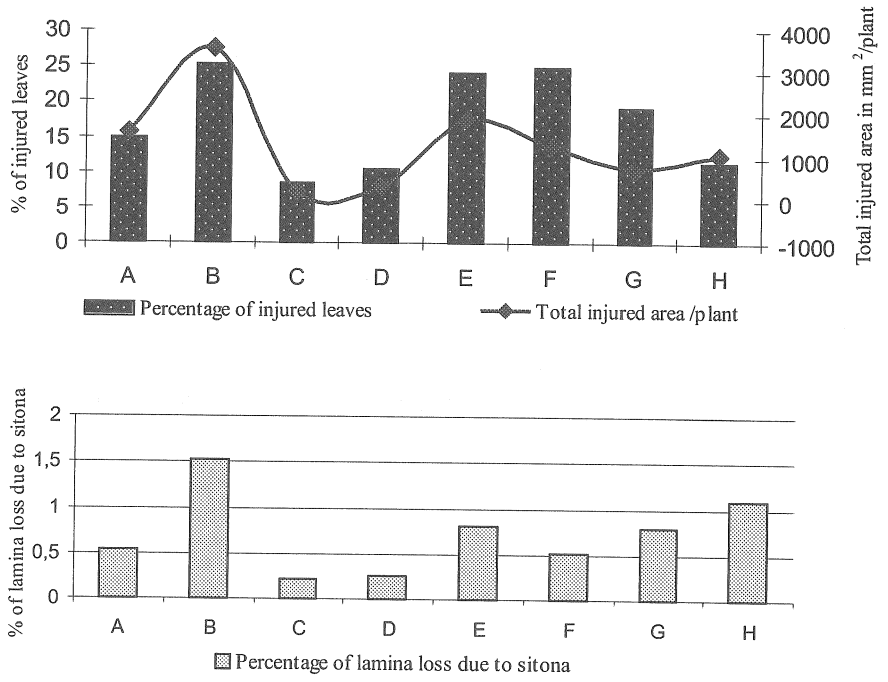

Fig. 1. The extent of lamina injuries caused by sitona beetles on broad bean plants cultivated in the natural soil and the soil contaminated with heavy metals receiving liming and magnesium treatment. A - untreated control, B - control + NPK, C - NPK + metals, D - NPK + Mg + metals, E - untreated control + CaO, F - control + NPK + CaO, G - NPK + CaO + metals, H - NPK + Mg + CaO + metals

contaminated with heavy metals. Despite an increase in the above-ground biomass, as a result of magnesium treatment, beetles did not cause any higher number of injuries than in the plot where the soil was polluted but did not receive magnesium fertilization.

Plants growing in the natural and untreated soil produced a higher number of verrucas, significantly more than plants from the soil contaminated with heavy metals. Liming caused a slight increase in the verruca number in contaminated plants. However, the above differences ranged within the limits of the experimental error (Fig. 2). No effect of magnesium treatment on the verruca formation was observed. There were no significant differences in the extent of verruca injuries caused by sitona larvae among the investigated objects. On average, between 16 and 36% of verrucas were injured.

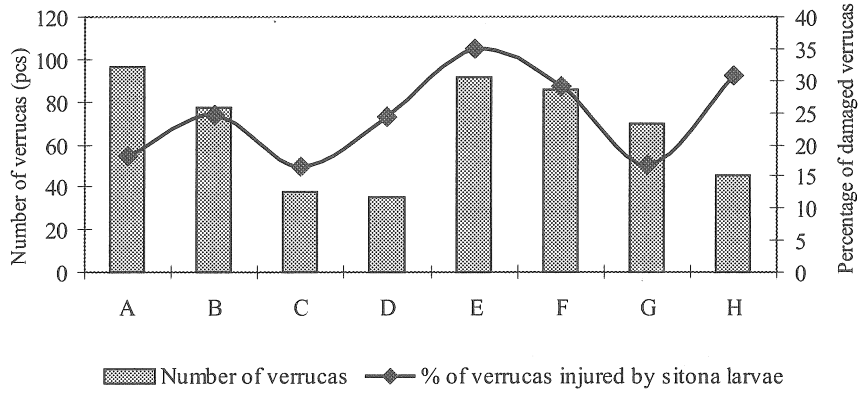

Fig. 2. Number of verrucas produced by broad bean plants grown in the natural soil and in the soil contaminated with heavy metals receiving liming and magnesium treatment and the extent of damage by sitona larvae. A - untreated control, B - control + NPK, C - NPK + metals, D - NPK + Mg + metals, E - untreated control + CaO, F - control + NPK + CaO, G - NPK + CaO + metals, H - NPK + Mg + CaO + metals

Table 2. Features of seeds from broad bean plants grown in the soil with natural content of heavy metals and in the polluted soil receiving liming and magnesium treatment and the extent of damage by broad bean seed beetle

Treatments	Single seed weight (g)	Mean			
		number of seeds per plant (pcs)	number of seeds per pod (pcs)	number of damaged seeds (in % of total seed number)	weight of damaged seeds (in % of total seed weight)
Untreated control	1.23 a	21.71 c	3.02 a	16.14 a	15.47 a
Control + NPK	1.23 a	21.17 bc	3.08 a	19.11 a	19.81 a
NPK + metals	1.15 a	12.63 ab	2.67 a	18.50 a	19.30 a
NPK + Mg + metals	1.27 a	10.81 a	2.86 a	12.71 a	11.84 a
Untreated control +CaO	1.06 a	19.15 abc	2.91 a	24.09 a	22.25 a
Control + NPK + CaO	1.08 a	15.01 abc	2.76 a	22.08 a	19.38 a
NPK + CaO + metals	1.10 a	10.56 a	2.90 a	18.64 a	16.32 a
NPK + Mg + CaO + metals	1.08 a	11.10 a	2.92 a	26.07 a	24.76 a

Mean values marked with the same letter in columns do not differ significantly (p=0.05)

No apparent influence of liming and magnesium treatment on the number of seeds produced, number of seeds per pod or a single seed weight was noticed (Tab. 2). Broad bean seed damaged by beetle ranged between 12 and 25% of broad bean seeds. No significant effect of liming and magnesium treatment of the soil polluted with heavy metals on the degree of broad bean seed damage by pest was observed.

CONCLUSIONS

1. Healthy and unpolluted plants provide more attractive feed for sitona beetles than plants growing in the soil with elevated heavy metal concentration levels. Soil liming is a factor decreasing the extent of broad bean leaf damage due to pest.

2. Liming and magnesium fertilisation of soils polluted with heavy metals does not cause an increase in the scope of leaf injuries by sitona beetles.

3. Liming and magnesium treatment of the soil with elevated heavy metal content does not affect the extent of broad bean verruca injuries by sitona larvae or seed injuries by broad bean seed beetle.

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WPŁYW NAWOŻENIA MAGNEZOWEGO I WAPNOWANIA W WARUNKACH GLEBY ZANIECZYSZCZONEJ METALAMI CIĘŻKIMI NA SZKODNIKI GRYZĄCE BOBU (*VICIA FABA* L., SSP. MAIOR)

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S t r e s z c z e n i e. Celem badań było określenie wpływu wapnowania i nawożenia magnezowego gleby o podwyższonej zawartości metali ciężkich na występowanie i szkodliwość chrząszczy i larw oprzędzików (*Sitona* sp.) oraz strąkowca bobowego (*Bruchus rufimanus* Boh.). Doświadczenie polowe założono w dwóch seriach: na glebie niewapnowanej i wapnowanej. W każdej serii rośliny bobu (*Vicia faba* L. ssp. maior) odm. Windsor Biały uprawiano na glebie: - kontrolnej (z naturalną zawartością metali ciężkich); - skażonej metalami ciężkimi w dawce odpowiadającej I stopniowi zanieczyszczenia zgodnie z klasyfikacją IUNG; i skażonej metalami ciężkimi z dodatkowym nawożeniem magnezowym. Nawożenie magnezowe w warunkach gleby zanieczyszczonej metalami ciężkimi wpłynęło korzystnie na wzrost bobu. Chrząszcze oprzędzików chętniej żerowały na roślinach rosnących w glebie kontrolnej o naturalnej zawartości metali ciężkich. Wapnowanie wpłynęło tutaj korzystnie na zmniejszenie powierzchni wyżerek powodowanych przez tego szkodnika. Ubytek powierzchni asymilacyjnej w wyniku żerowania oprzędzików był bardzo niski – nie przekraczał 2%. Larwy oprzędzików uszkodziły średnio od 16 do 36% brodawek korzeniowych bobu. Strąkowiec bobowy uszkodził od 13-26% nasion bobu. Nie stwierdzono istotnego wpływu nawożenia magnezowego i wapnowania w warunkach gleby o podwyższonej zawartości metali ciężkich na szkodliwość chrząszczy i larw oprzędzików oraz strąkowca bobowego.

S ł o w a k l u c z o w e: wapnowanie, magnezowanie, metale ciężkie, szkodniki gryzące