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APHID (*APHIS FABAE* SCOP.) OCCURRENCE ON BROAD BEANS (*VICIA FABA* L. SSP. MAIOR) DEPENDING ON LIMING AND MAGNESIUM TREATMENT OF SOIL CONTAMINATED WITH HEAVY METALS

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S u m m a r y. Observations on aphid occurrence were carried out on broad beans (*Vicia faba* L. ssp. maior), White Windsor c.v. The experiment was conducted to learn how magnesium treatment and magnesium fertilization coupled with liming of soil with elevated heavy metal concentrations (1st class of pollution according to ISSPC classification) affect the occurrence and dynamics of plant viral disease vector, i.e., *Aphis fabae* Scop. Magnesium treatment carried out on heavy metal contaminated soil influenced a decrease in cadmium and nickel contents in pods and enhanced liming activity in limiting lead, nickel and cadmium uptake by broad bean roots and zinc by roots and some above-ground parts. Magnesium fertilization of heavy metal contaminated soil contributed to lowering the numbers of *A. fabae* aphids during the period of its most intensive occurrence. Broad bean plants grown in heavy metal contaminated soil were less settled by the pest when magnesium treatment and liming were applied.
K e y w o r d s: heavy metals, liming, magnesium treatment, *Aphis fabae* Scop.

INTRODUCTION

Soil contamination with heavy metals is a factor in increasing aphid (*Aphis fabae* Scop.) numbers on broad beans [3]. Changes in the pest biology due to altered chemical composition of plant feed may be a possible cause. Magnesium treatment and liming of soils are counted as methods of limiting heavy metal uptake by plants [2]. Also the effect of soil liming on some pest population control was observed [5.6].

The studies focused on finding out the possibilities of restraining *Aphis fabae* occurrence under conditions of increased heavy metal contents in soil using magnesium treatment and joint magnesium fertilization and liming.

MATERIAL AND METHODS

The field experiment in pots was carried out in 2000 in a field situated at Zagaje Stradowskie in the Świętokrzyskie province in an area of unpolluted air. The plants were cultivated as the following experimental objects: soil polluted with heavy metals (2.6 mg Cd, 27.8 mg Ni, 38.2 mg Cu, 122.9 mg Zn and 108.2 mg Pb kg^{-1}soil d.m.); soil polluted with heavy metals with additional magnesium treatment dosed 50 kg MgO·ha^{-1}; soil polluted with heavy metals receiving magnesium fertilization and limed with 2900 kg of CaO ha^{-1}. Magnesium dosage was calculated on the basis of the soil analysis conducted by the Station of Agricultural Chemistry in Cracow. The available magnesium content in the initial soil was 72 mg Mg kg^{-1} g of soil dry matter. Magnesium was added to the soil as a water solution of $MgSO_4$ $7H_2O$ together with heavy metals. Liming, with $Ca(OH)_2$, was carried out two weeks prior to the outset of the experiment. The dose was calculated on the basis of the soil's hydrolytic acidity before the experiment outset. The hydrolytic acidity, measured by Kappen's method, was 3.45 cmol (+) kg^{-1}. The soil used for the experiment was a degraded chernozem developed from loess revealing acidic reaction (pH in 1mol dm^{-3} solution was 4.51 and in water 5.03) and 11.3 g C kg^{-1} content of organic carbon. Heavy metals were supplied to the soil as water solutions of the following salts: $3CdSO_4$ $8H_2O$, $NiSO_4$ $7H_2O$, $CuSO_4$, $ZnSO_4$ $7H_2O$, and $Pb(NO_3)_2$. Because on the objects where $Pb(NO_3)_2$ was used a certain amount of nitrogen was supplied to the soil, the element dose was appropriately diminished in the basic fertilization. The soil reaction (pH) was determined in 1 mol KCl dm^{-3} solution by potentiometer and organic carbon content by Tiurin's method. Heavy metal concentrations approximate to the total were assessed after soil samples were absorbed in a 2:1 mixture of nitric and perchloric acids. The plant materials were dry mineralised at 550°C. Heavy metal concentrations in the extracts were determined by atomic absorption spectrometry (AAS).

Observations of *Aphis fabae* Scop. occurrence on broad beans (*Vicia fabae* L., ssp. maior), White Windsor c.v. were conducted twice a week during the whole period of the pest appearance. All larvae, wingless females and winged migrants were counted. Once a week the percentage of plants settled by aphids was counted on the whole plot, including plants free of the pest and settled by it. The aphid species was determined using the key by Achremowicz [1].

RESULTS AND DISCUSSION

Magnesium treatment of heavy metal contaminated soil caused a decrease in cadmium and nickel concentrations in broad bean pods. Joint magnesium treatment and liming were instrumental in limiting lead, cadmium and nickel uptake by broad bean roots and zinc uptake by leaves, pods and seeds (Tab. 1). No significant

Table 1. Heavy metal contents (mg kg^{-1}) in dry matter of broad bean cultivated in heavy metal contaminated soil receiving liming and magnesium treatment

Objects	Roots	Shoots	Leaves	Pods	Seeds
			Copper		
Metals	45.41 a	10.52 a	13.88 a	13.74 a	18.25 a
Metals + Mg	47.38 a	11.22 a	12.61 a	12.21 a	18.59 a
Metals + Mg + CaO	42.88 a	10.06 a	14.59 a	12.34 a	19.13 a
			Lead		
Metals	50.23 ab	3.76 a	6.51 a	4.02 a	4.59 ab
Metals + Mg	60.12 b	3.23 a	8.91 b	3.88 a	2.68 a
Metals + Mg + CaO	38.89 a	4.66 a	11.56 c	5.76 a	5.08 b
			Cadmium		
Metals	7.99 ab	0.74 a	1.55 a	1.1 b	0.23 a
Metals + Mg	11.22 b	0.79 a	1.94 a	0.54 a	0.36 a
Metals + Mg + CaO	6.82 a	0.67 a	1.38 a	0.40 a	0.26 a
			Nickel		
Metals	58.66 b	5.11 a	9.14 a	15.39 b	16.61 a
Metals + Mg	56.45 b	8.88 b	8.21 a	10.22 a	14.26 a
Metals + Mg + CaO	38.38 a	6.67 a	8.18 a	8.59 a	14.92 a
			Zinc		
Metals	386.57 b	75.29 a	255.36 b	93.13 b	79.33 ab
Metals + Mg	433.87 b	103.66 b	256.12 b	79.02 b	93.04 b
Metals + Mg + CaO	171.86 a	75.64 a	207.31 a	51.24 a	76.71 a

*means individual elements marked with the same letters in columns do not differ significantly (p=0.05)

differences were found among the investigated objects concerning macroelement concentrations in individual plant parts.

First migrants were spotted on broad bean plants in early June. At that time aphid numbers on the studied plots were similar (Fig. 1). Aphids settled the least number of plants on the plots where magnesium treatment and liming were applied (Tab. 2). However, in comparison to other objects the differences fell within the experimental error range. Aphids reached their maximum numbers the earliest on the object where neither magnesium treatment nor joint magnesium and liming were applied. Also, at that time aphid numbers on heavy metal contaminated soil were between 3 and 5 times higher than when magnesium fertilization and joint magnesium treatment and liming were used (Fig. 1, Tab. 2). The differences were also similar by the end of aphid feeding on broad beans (Tab. 2). In the objects where magnesium fertilisation

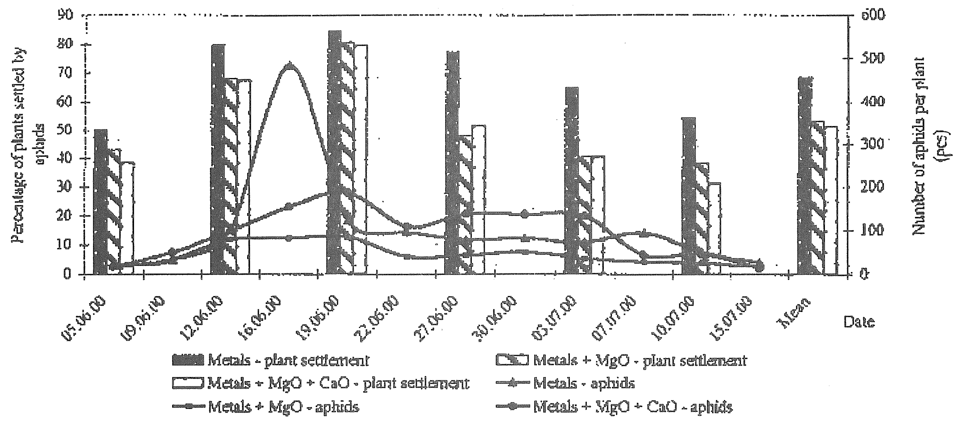

Fig. 1. Dynamics of *Aphis fabae* Scop occurrence on broad bean plants cultivated in heavy metal contaminated soil receiving liming and magnesium fertilization

and joint magnesium treatment and liming were applied, aphid population did not increase rapidly in order to decrease its numbers in the same way, but over the whole period of time remained on the same moderately high level. It allowed its natural enemies efficient impairing of the negative effect of *Aphis fabae* on plants.

As the aphid population developed, also the number of plants settled by them increased, almost equally on all plots (Fig. 1). At the peak of aphid occurrence the numbers of plants settled by the pest in individual objects ranged between 80 and 90%. Bigger differences were noticed on the objects receiving magnesium treatment and joint magnesium and liming, where 1/3 less plants were settled than on the contaminated soil.

In their studies on *A. fabae* biology the authors found out that magnesium fertilisation of heavy metal contaminated soil influenced the decreased fertility of wingless females, while joint magnesium treatment and liming caused their shortened life span [4]. So, it might have been the reason for lower aphid numbers on these objects. Sądej [6] obtained similar results with liming. In the field experiment where soil liming was applied a lower numbers of *Aphis fabae* population were noticed in comparison with the control. In pot experiments lower doses of $CaCO_3$ stimulated a development of this species population, whereas a higher dose checked it.

Table 2. Selected information on *Aphis fabae* Scop. occurrence on broad bean plants grown in heavy metal contaminated soil receiving liming and magnesium treatment (date of first migrant appearance I decade of June)

Aphid occurrence	Metals	Metals + Mg	Metals + Mg + CaO
Percentage of plants settled by first migrants	50.24 a	42.91 a	38.43 a
Date of most numerous aphid occurrence	16.06	19.06	19.06
Percentage of plants settled by aphids in the period of the pest most numerous occurrence 20.06)	84.57 a	80.75 a	79.62 a
Mean number of aphids in the period of their most numerous occurrence (pcs/plant)	486.11 b	84.93 a	79.62 a
Percentage of plants settled by aphids a week after peak of broad bean settlement (27.06)	77.39 b	48.05 a	51.63 a
Mean number of aphids a week before the end of feeding (pcs/plant))	93.01 b	26.75 a	42.70 a
Mean number of aphids in season (pcs/plant)	104.73 a	43.81 a	93.16 a

Means marked with the same letter in lines do not differ significantly (p=0.05)

CONCLUSIONS

1. Magnesium treatment of heavy metal contaminated soil limits the numbers of *Aphis fabae* Scop., aphids on broad beans, especially in the period of its intensified presence.

2. Joint magnesium treatment and liming also cause a decrease in the number of broad bean plants settled by the pest.

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WYSTĘPOWANIE MSZYCY (*APHIS FABAE* SCOP.) NA BOBIE (*VICIA FABAE* L. SSP. MAIOR) W ZALEŻNOŚCI OD WAPNOWANIA I NAWOŻENIA MAGNEZEM GLEBY ZANIECZYSZCZONEJ METALAMI CIĘŻKIMI

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S t r e s z c z e n i e. Obserwacje nad występowaniem mszycy prowadzono na bobie (*Vicia fabae* L., ssp. maior) odmiany Windsor Biały. Celem doświadczenia było rozeznanie, jak nawożenie magnezowe i łączne nawożenie magnezowe z wapnowaniem gleby o podwyższonej zawartości metali ciężkich (I klasa zanieczyszczenia zgodnie z klasyfikacją IUNG) wpływa na występowanie i dynamikę populacji wektora chorób wirusowych roślin, jakim jest mszyca *Aphis fabae* Scop.

Nawożenie magnezowe w warunkach gleby skażonej metalami ciężkimi wpłynęło na obniżenie zawartości kadmu i niklu w strąkach i wzmogło efekt wapnowania w ograniczeniu pobierania ołowiu, kadmu i niklu przez korzenie bobu oraz cynku przez korzenie i niektóre części nadziemne. Magnezowanie gleby zanieczyszczonej metalami ciężkimi przyczyniło się do obniżenia liczebności mszycy *A. fabae* w okresie nasilenia jej występowania. Rośliny bobu uprawiane w glebie zanieczyszczonej metalami ciężkimi przy zastosowaniu nawożenia magnezowego i wapnowania były w mniejszym stopniu opanowane przez tego szkodnika.

S ł o w a k l u c z o w e: metale ciężkie, magnezowanie, wapnowanie, *Aphis fabae* Scop.