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THE EFFECT OF NON-CHEMICAL AND CHEMICAL BROAD BEAN PROTECTION AGAINST DISEASES AND PESTS ON THE FEEDING OF PEA WEEVILS (*Sitona* SPP.)

Summary

The objective of the study was to compare the effect of broad bean protection against fungal diseases, black bean aphid and broad been seed beetle with the use of non-chemical products (Polyversum WP and Bioczos BR) and artificially synthesized preparations (Vitavax 200 FS, Decis 2,5 EC and Fastac 100 EC) on the harmfulness of larvae and beetles of pea weevils. The observations were conducted on broad bean of the Hangown White cultivar. Protection with the use of Polyversum WP and Bioczos BR contributed to reduction of the percentage of leaves injured by pea weevils, the area consumed and, as a consequence, the size of leaf blade loss. The Vitavax 200 FS can contribute to increase the attractiveness of broad bean leaves for adult Sitona spp. and, as a result, decrease the efficiency of later protective spraying. The used broad bean protection, both non-chemical as well as chemical, significantly influenced the decrease of the level of root nodule damage by weevil larvae in only one of three years of the study.
***Key words**: Sitona* spp.*, Bioczos BR, Polyversum WP, protection methods*

WPŁYW NIECHEMICZNEGO I CHEMICZNEGO SPOSOBU OCHRONY BOBU PRZED CHOROBAMI I SZKODNIKAMI NA ŻEROWANIE OPRZĘDZIKÓW (*Sitona* SPP.)

Streszczenie

Celem przeprowadzonych badań było porównanie wpływu ochrony bobu przed chorobami grzybowymi oraz szkodnikami z wykorzystaniem preparatów niechemicznych (Polyversum WP oraz Bioczos BR) oraz preparatów sztucznie syntetyzowanych (Vitavax 200 FS, Decis 2,5 EC i Fastac 100 EC) na szkodliwość larw i chrząszczy oprzędzików. Obserwacje prowadzono na bobie odmiany Hangown Biały. Ochrona z użyciem preparatów Polyversum WP i Bioczos BR przyczyniła się do ograniczenia odsetka liści uszkodzonych przez oprzędziki, powierzchni wyżerek oraz w konsekwencji wielkości ubytku blaszki liściowej. Zaprawa Vitavax 200 FS może przyczyniać się do zwiększenia atrakcyjności liści bobu dla dorosłych oprzędzików i w rezultacie zmniejszać efektywność stosowanych potem zabiegów ochronnych w postaci oprysków. Zastosowana ochrona bobu, zarówno niechemiczna, jak i chemiczna, wpłynęła istotnie na zmniejszenie stopnia uszkodzenia brodawek korzeniowych przez larwy oprzędzików tylko w jednym spośród 3 lat badań.
***Słowa kluczowe**: Sitona spp., Bioczos BR, Polyversum WP, metody ochrony*

1. Introduction

The search of possible reduction of pest harmfulness with the use of methods other than based on synthetic preparations constitutes challenge, which is significant from the point of view of organic farming, as well as the integrated plant protection. The Bioczos BR preparation, prepared on the basis of garlic pulp is an example of a biological plant protection product, recommended for the cultivation of broad bean for the reduction of winged aphid infestation. On the other hand, the Polyversum WP preparation, containing oospores of *Pythium oligandrum* fungi, is intended for the protection of the root zone against fungal diseases, as well as it stimulates the plant growth. Preparations based on garlic pulp have so far been tested in reference to cabbage root fly (*Delia brassicae* L.) on common radish, willow-carrot aphid (*Cavariella aegopodii* Scop.) on dill and lettuce, black bean aphid (*Aphis fabae* Scop.) on red beet, pea weevils (*Sitona* spp.) on pea (*Pisum sativum* L.) and broad bean and broad bean seed beetle (*Bruchus rufimanus* Boh.) on broad bean [2, 3, 7, 9]. The results indicate, that their efficiency is comparable to [9] or lower [2, 3] than conventional products.

Protection of arable crop against a given type of pest can have a significant effect on the occurrence of another organism, not targeted by the pest control [1, 5, 6]. Reports exist in the literature on the indirect effect of fungicides on the occurrence of pests [6] and other animals [1]. In the case of treatment of seeds with fungicides, this influence may appear in the first place for the soil-dwelling stadium. As an example, chlorothalonil and propiconazole (commonly used fungicides) reduced survival of first-instar larvae of the Japanese beetle (*Popillia japonica*), as well as reduced larvae hatching from eggs [6]. Carboxin and thiram, which are active substances of the Vitavax 200 FS preparation (used in the present experiment), exhibited lethal effect towards springtail (*Folsomia candida*), but only at the concentration of 1000 mg of active ingredient per kg of dry soil) [1].

Black bean aphid and broad bean seed beetle are the most dangerous pests of broad bean, and the most active action is usually undertaken in relation to these species. On the other hand, fungal diseases usually attack plant already at its initial growth stage and the most efficient protection consists in the treatment of the seed. Pea weevils (*Sitona* spp.) attack broad bean already at the seedling growth

stage, when the beetles destroy leaf blade, and at a later stage, when the larvae attack the underground parts. On each of their developmental stages they can be subjected to the effect of protection efforts undertaken by man.

The objective of the conducted study was to compare the effect of broad bean protection against fungal diseases, black bean aphid and broad been seed beetle with the use of non-chemical products (Polyversum WP and Bioczos BR) and artificially synthesized preparations (Vitavax 200 FS, Decis 2,5 EC and Fastac 100 EC) on the harmfulness of larvae and beetles of pea weevils.

2. Material and methods

The experiment was conducted in the period 2010–2012 at the Prusy Experimental Station, part of the University of Agriculture in Kraków. The experiment was set up in three replications, by the method of randomized blocks. The observations were conducted on broad bean (*Vicia faba* L., ssp. *maior*) of the Hangown White cultivar, protected according to the scheme presented in Table 1. Each spraying treatments were conducted depending on the weather conditions in 7–12 day intervals. The used protection was directed to reduction of the occurrence of primarily fungal diseases (via seed treatment) and black bean aphid and broad bean seed beetle (via spraying). In 2010 the spraying treatments were initiated on May 26 and completed on June 25, in 2011 the first treatment was conducted on May 25 and the last one on June 17, and in 2012 the treatments were commenced on May 11 and finished on June 11. In 2011, the treatment dates were delayed in reference to the dates of adult pea weevils feeding observations, because the main objective of the used protection was black bean aphid control, and the latter appeared relatively late in the 2011 season. The evaluation of the feeding intensity of adult pea weevils was conducted on 25 randomly selected plants from each plot, by measuring the surface area of eaten leaves, counting injured and non-injured leaves and calculating the loss of leaf blade as the result of their feeding. The damage analysis was conducted four times in each experimental season, from the moment of noticing first damages, in weekly intervals. In 2010, the observations were commenced on May 28 and finished on June 18, in 2011 the first observation was undertaken on May 4 and the last one on May 27, whereas in 2012 the observations started on May 11 and finished on June 1. The paper presents mean results from all four observations. For the determination of larvae harmfulness, the underground parts of the plants were analyzed after prior washing, by counting the general number of nodules and the number of damaged nodules. The analysis was conducted once, at the end of June. The significance of differences between means was tested via conducting single factor variance analysis (protection method) and two factor variance analysis (protection method x year) with the use of the Statistica 12.0 PL software. The means were differentiated using the NIR Fisher test at the significance level $p < 0.05$.

3. Results and discussion

The percentage of leaves injured by pea weevils imagines fluctuated considerably primarily between each year of study, the highest values were obtained in 2011 (Table 2), which could be influenced by the late carrying out of spraying and thus short period of impact on the analyzed pest. In 2010, the percentage of damaged leaves was the lowest and the highest efficiency of weevil feeding reduction was demonstrated by the maximum variant of chemical protection (object VIII), whereas both in 2011, as well as in 2012, the lowest number of leaves with damage in reference to the overall number of leaves was determined for the use of 4-times spraying with the Bioczos BR preparation for broad bean protection. Analysis of the data from all 3 years of study demonstrated a significant influence of protection method, as well as the year of study and the interaction of both factors on the analyzed parameter (Fig. 1).

Table 1. Scheme of protection of broad bean against pest and diseases
Tab. 1. Schemat ochrony bobu przed szkodnikami i chorobami

Treatments	Protection method	Preparation and dose	Date of using
I	Control	Without protection	
II	Seed treatment	Polyversum WP - 10 g·kg^{-1} of seeds	before sowing
III	Seed treatment and two-time spraying	Polyversum WP - 10 g·kg^{-1} of seeds	before sowing
		Bioczos BR - 4 briquettes per l of water (two times)	- when first aphids appear - by the end of flowering first inflorescences
IV	Seed treatment and three-time spraying	Polyversum WP - 10 g·kg^{-1} of seeds	before sowing
		Bioczos BR - 4 briquettes per l of water (three times)	- when first aphids appear - repeated after 7 days - by the end of flowering first inflorescences
V	Seed treatment and four-time spraying	Polyversum WP - 10 g·kg^{-1} of seeds	before sowing
		Bioczos BR - 4 briquettes per l of water (four times)	- when first aphids appear - repeated after 7 days - by the end of flowering first inflorescences - repeated after 7 days
VI	Seed treatment	Vitavax 200 FS - 4 ml·kg^{-1} of seeds	before sowing
VII	Seed treatment and two-time spraying	Vitavax 200 FS - 4 ml·kg^{-1} of seeds	before sowing
		Decis 2,5 EC - 0,25 l·ha^{-1}	when first aphids appear
		Fastac 100 EC - 0,09 l·ha^{-1}	by the end of flowering first inflorescences
VIII	Seed treatment and three-time spraying	Vitavax 200 FS - 4 ml·kg^{-1} of seeds	before sowing
		Decis 2,5 EC - 0,25 l·ha^{-1} (two times)	- when first aphids appear - repeated after 7 days
		Fastac 100 EC - 0,09 l·ha^{-1}	by the end of flowering first inflorescences

Source: own work / Źródło: opracowanie własne

Table 2. Percent of injured leaves of broad bean, total eaten area of leaves [mm^2/plant] and leaf blade loss (percent of total leaf area) caused by *Sitona* spp. adults depending on the used protection method in individual years

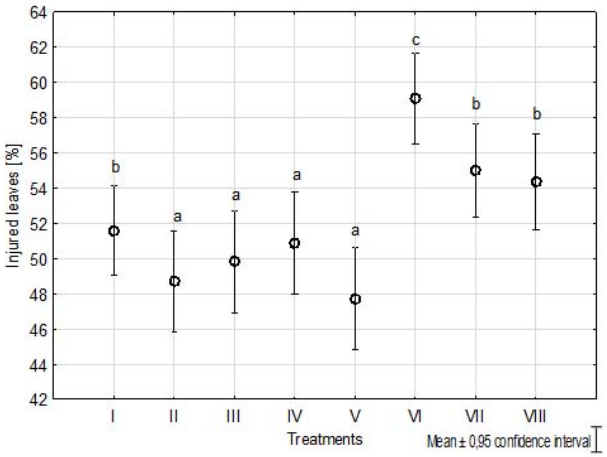
Tab. 2. Odsetek liści bobu uszkodzonych przez chrząszcze oprzędzików, całkowita powierzchnia wyżerek na liściach [mm^2/roślinę] oraz ubytek blaszki liściowej (procent ogólnej powierzchni liści) zależnie od sposobu ochrony w poszczególnych latach

Treatments	Injured leaves [%]			Total eaten area per plant [mm^2]			Leaf blade loss [%]		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
I*	21.65 ^{abc}	77.23 ^{b}	55.92 ^{ab}	380.8 ^{c}	1587.8 ^{a}	528.8 ^{a}	0.284 ^{b}	2.374 ^{b}	0.910 ^{a}
II	21.80 ^{abc}	68.10 ^{a}	56.20 ^{ab}	339.2 ^{abc}	1227.3 ^{a}	480.9 ^{a}	0.290 ^{b}	1.915 ^{ab}	0.879 ^{a}
III	24.27 ^{c}	68.10 ^{a}	57.15 ^{ab}	380.2 ^{c}	1380.5 ^{a}	492.3 ^{a}	0.296 ^{b}	1.906 ^{ab}	0.824 ^{a}
IV	22.61 ^{bc}	74.39 ^{ab}	55.67 ^{ab}	357.3 ^{bc}	1821.4 ^{ab}	455.6 ^{a}	0.291 ^{b}	2.173 ^{ab}	0.773 ^{a}
V	21.36 ^{abc}	68.10 ^{a}	53.72 ^{a}	405.9 ^{c}	1117.3 ^{a}	459.9 ^{a}	0.261 ^{ab}	1.716 ^{a}	0.777 ^{a}
VI	22.53 ^{bc}	86.93 ^{c}	67.79 ^{c}	384.4 ^{c}	2323.4 ^{b}	665.9 ^{b}	0.303 ^{b}	3.232 ^{c}	1.135 ^{b}
VII	18.47 ^{ab}	87.16 ^{c}	59.45 ^{b}	273.6 ^{a}	2339.2 ^{b}	525.3 ^{a}	0.166 ^{a}	3.195 ^{c}	0.889 ^{a}
VIII	16.37 ^{a}	87.04 ^{c}	59.68 ^{b}	276.8 ^{ab}	2331.1 ^{b}	526.2 ^{a}	0.211 ^{ab}	3.214 ^{c}	0.893 ^{a}

* For treatments explanation see table 1

**Mean values followed by the same letters in columns are not significantly different at $p < 0.05$

Source: own work / Źródło: opracowanie własne



Effects	SS*	df	MS	F	p
Protection method	13885	7	1984	7,48	0,000
Year	473975	2	236987	893,08	0,000
Protection method x year	15787	14	1128	4,25	0,000

*SS – sum of squares, df – degrees of freedom, MS – mean squares, F – Fisher – Snedecor's test, p – probability level

Source: own work / Źródło: opracowanie własne

Fig. 1. Percent of injured leaves of broad bean caused by *Sitona* spp. adults depending on the used protection method (mean in the years 2010-2012) and results of the statistical analysis. For treatments explanation see table 1. Mean values followed by the same letters are not significantly different at $p < 0.05$

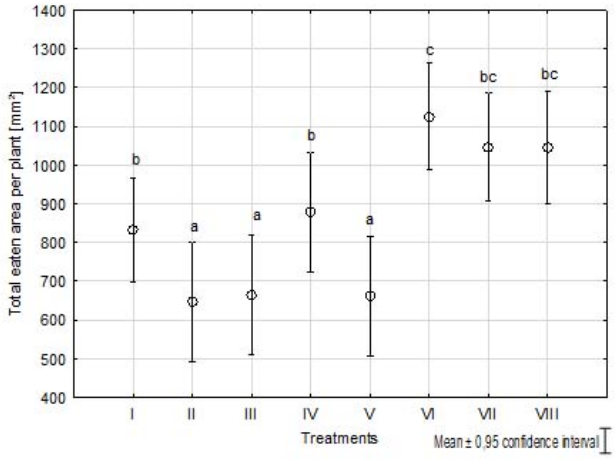
Rys. 1. Odsetek liści bobu uszkodzonych przez chrząszcze oprzędzików zależnie od sposobu ochrony (średnio w latach 2010 – 2012) oraz wyniki analizy statystycznej. Obiekty jak w tab. 1. Średnie oznaczone takimi samymi literami, nie różnią się istotnie przy $p < 0.05$

All objects protected with the use of Polyversum WP and Bioczos BR preparations were characterized by lower percentage of leaves damaged by adult weevils than the control object - not subjected to any protection, but it was also lower than on the objects protected with the use of chemical preparations. At the same time, significant increase in value of the parameter was observed for the object protected solely with the use of Vitavax 200 FS treatment. No descriptions of similar results exist in the literature. Normally, the use of fungicides may additionally contribute to reduction of the occurrence of certain pests [6] or have no effect on them [4]. Thiram, constituting one of components of the Vitavax 200 FS treatment, was an effective feeding deterrent against southern corn rootworm larvae *Diabrotica undecimpunctata howardi* Barber.

Analysis of the size of areas of leaves eaten by *Sitona* imago demonstrated similar tendencies as in the case of the percentage of damaged leaves, i.e. it was at its highest in the 2011 season (Table 2) and it was efficiently reduced with the use of synthetic preparations in the 2010 season. The area of pest feeding in the object protected using the Vitavax 200 FS treatment attained its highest value in the 2012 season. Analysis of data from three years of the study demonstrated, similarly to the previous parameter, significant influence protection method and year of study as well as the interaction of both factors toward the area of pest feeding caused by weevils (Fig. 2). However, the effect of using of the Bioczos BR preparation was not as unambiguous, as in the case of the percentage of damaged leaves, although the parameter was still more favorable than for the use of chemical protection.

The results referring to the percentage of leaf blade loss as the result of pea weevil feeding corresponded to the previously analyzed parameters, indicating the favorable role of the Vitavax 200 FS treatment for the increase in feeding intensity of weevils, which was then slightly leveled by the use of Decis 2.5 EC and Fastac 100 EC and favorable effect reducing the harmfulness of *Sitona* spp. of the Polyversum WP treatment and spraying with the use of the Bioczos BR preparation (Table 2, Fig. 3). However, it should be emphasized, that the calculated leaf blade loss was minor and averaged approx. 0.9–1.6%.

Our previous study using the broad bean cultivar Windsor White exhibited higher efficiency of chemical protection for the reduction of *Sitona* spp. beetles harmfulness in comparison to protection with the use of Bioczos BR and Polyversum WP preparations [2]. The observed differences could result from the fact, that *Sitona* spp. beetles preferred the Windsor White cultivar. Damage caused by weevils on the cultivar were greater than on the Hangdown White cultivar, thus the effect of chemical preparations was more noticeable. Similarly to the current study, seasonally favorable effect of the Polyversum WP treatment on the reduction of weevil feeding was observed.



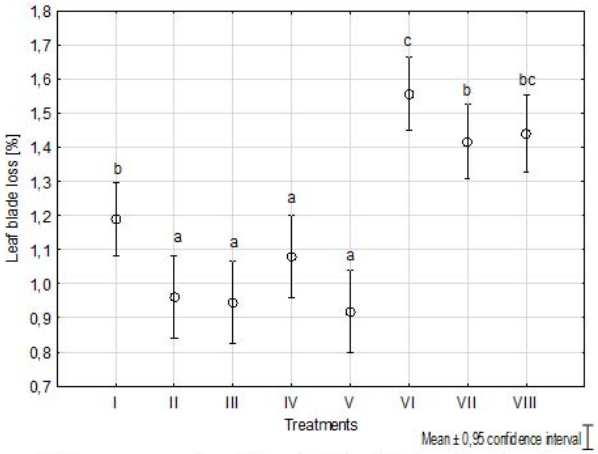
Effects	SS*	df	MS	F	p
Protection method	35572334	7	5081762	6,768	0,000
Year	352593399	2	176296700	234,797	0,000
Protection method x year	59781950	14	4270139	5,687	0,000

*SS – sum of squares, df – degrees of freedom, MS – mean squares, F – Fisher – Snedecor's test, p – probability level

Source: own work / Źródło: opracowanie własne

Fig. 2. Total eaten area per plant caused by *Sitona* spp. adults depending on the used protection method (mean in the years 2010-2012) and results of the statistical analysis. For treatments explanation see tab. 1.

Rys. 2. Całkowita powierzchnia wyżerek na roślinie spowodowanych przez chrząszcze oprzędzików zależnie od sposobu ochrony (średnio w latach 2010 – 2012) oraz wyniki analizy statystycznej. Obiekty jak w tab. 1.



Effects	SS*	df	MS	F	p
Protection method	60,581	7	8,654	18,613	0,00
Year	727,274	2	363,637	782,056	0,00
Protection method x year	88,805	14	6,343	13,642	0,00

*SS – sum of squares, df – degrees of freedom, MS – mean squares, F – Fisher – Snedecor's test, p – probability level

Source: own work / Źródło: opracowanie własne

Fig. 3. Leaf blade loss of broad bean caused by *Sitona* spp. adults (percent of total leaf area) depending on the used protection method (mean in the years 2010-2012) and results of the statistical analysis. For treatments explanation see table 1.

Rys. 3. Ubytek blaszki liściowej bobu spowodowany przez chrząszcze oprzędzików (procent ogólnej powierzchni liści) zależnie od sposobu ochrony (średnio w latach 2010 – 2012) oraz wyniki analizy statystycznej. Obiekty jak w tab. 1.

The conducted analysis of root nodules did not reveal significant influence of the used protection on the level of their damage by weevil larvae in 2010 and 2011 (Table 3), only in 2012 a lower level of damage was determined for the objects in which Decis 2.5 EC and Fastac 100 EC were used as well as the Polyversum WP treatment and Polyversum WP jointly with 4-time spraying with the Bioczos BR preparation. Analysis of results from three years of the study demonstrated significant influence of the year of study as well as the interaction of year and protection method with the level of root nodule damage. Similar effects were obtained for the Windsor White broad bean cultivar [2].

Table 3. Damage of root nodules caused by *Sitona* spp. larvae (percent of total nodule number) depending on the used protection method in individual years

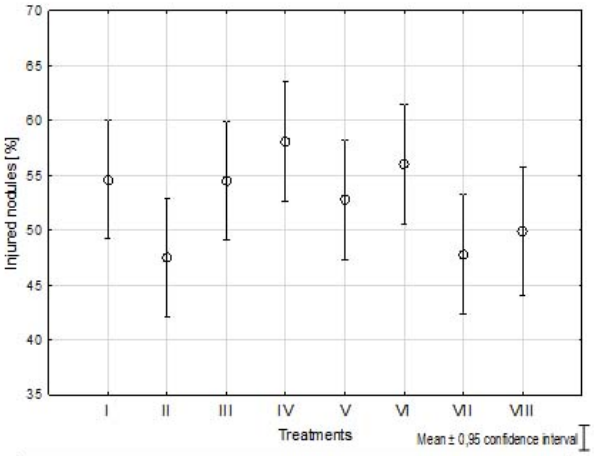
Tab. 3. Uszkodzenie brodawek korzeniowych przez larwy oprzędzików (procent ogólnej liczby brodawek) zależnie od sposobu ochrony w poszczególnych latach

Treatments	Injured nodules [%]		
	2010	2011	2012
I*	33.01 ^{a}	46.45 ^{a}	84.42 ^{d}
II	38.47 ^{a}	39.34 ^{a}	61.55 ^{a}
III	39.74 ^{a}	44.82 ^{a}	78.92 ^{bcd}
IV	46.00 ^{a}	47.27 ^{a}	80.95 ^{cd}
V	41.13 ^{a}	56.87 ^{a}	60.27 ^{a}
VI	37.34 ^{a}	48.85 ^{a}	81.68 ^{cd}
VII	35.96 ^{a}	37.57 ^{a}	69.91 ^{abc}
VIII	39.33 ^{a}	45.12 ^{a}	65.35 ^{ab}

* For treatments explanation see table 1

**Mean values followed by the same letters in columns are not significantly different at $p < 0.05$

Source: own work / Źródło: opracowanie własne



Effects	SS*	df	MS	F	p
Protection method	7669	7	1096	1,947	0,060
Year	108213	2	54106	96,177	0,000
Protection method x year	14804	14	1057	1,880	0,026

*SS – sum of squares, df – degrees of freedom, MS – mean squares, F – Fisher – Snedecor's test, p – probability level

Source: own work / Źródło: opracowanie własne

Fig. 4. Damage of root nodules caused by *Sitona* spp. larvae (percent of total nodule number) depending on the used protection method (mean in the years 2010-2012) and results of the statistical analysis

Rys. 4. Uszkodzenie brodawek korzeniowych przez larwy oprzędzików (procent ogólnej liczby brodawek) zależnie od sposobu ochrony (średnio w latach 2010-2012) oraz wyniki analizy statystycznej

4. Conclusions

1. Protection of the Hangdown White cultivar of broad bean against pests (aphid and broad bean seed beetle) and fungal diseases with the use of Polyversum WP and Bioczos BR contributed to reduction of the percentage of leaves injured by pea weevils, the area of eaten leaves and, as a consequence, the size of leaf blade loss.
2. The Vitavax 200 FS can contribute to increase the attractiveness of broad bean leaves for adult *Sitona* spp. and, as a result, decrease the efficiency of later protective spraying.
3. The used broad bean protection, both non-chemical as well as chemical, significantly influenced the decrease of the level of root nodule damage by weevil larvae in only one of three years of the study.

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