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THE EFFECT OF BROAD BEAN INTERCROPPING WITH CORIANDER AND FENNEL ON DYNAMIC OF *SITONA* SPP. BEETLES FEEDING

Summary

The aim of the study was to assess the impact of intercropping White Windsor broad beans with coriander (Coriandrum sativum L.) and fennel (Foeniculum vulgare Mill.) on the dynamics of adult pea weevils (Sitona spp.) feeding and the degree of nodules damage caused by Sitona spp larvae. The experiment was conducted in the period 2011–2012 at the Prusy Experimental Station, which belongs to the University of Agriculture in Krakow. The experiment involved the following objects: broad beans in a homogeneous crop (control); broad beans intercropped with coriander; broad beans intercropped with fennel. 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. For the determination of larvae harmfulness, root nodules were analyzed at the end of June. Intercropping with coriander and fennel significantly reduced the feeding of pea leaf weevils on the White Windsor variety of broad beans. The effect was particularly visible in the initial period of plant growth, which is important due to the greatest impact of pests' feeding activity during that period. The proximity of the examined herb species did not affect the number of root nodules produced by broad beans, or the degree of root nodules damage caused by Sitona sp. larvae.
***Key words**: Vicia faba L., Coriandrum sativum L., Foeniculum vulgare Mill, intercropping, Sitona spp., number of root nodules, plant injuries*

WPŁYW UPRAWY WSPÓŁRZĘDNEJ BOBU Z KOLENDRĄ SIEWNĄ I KOPREM WŁOSKIM NA DYNAMIKĘ ŻEROWANIA OPRZĘDZIKÓW (*SITONA* SPP.)

Streszczenie

Celem badań było określenie wpływu uprawy współrzędnej bobu odmiany Windsor Biały z kolendrą siewną (Coriandrum sativum L.) i koprem włoskim (Foeniculum vulgare Mill.) na przebieg dynamiki żerowania chrząszczy z rodzaju oprzędziki (*Sitona spp.*) *oraz na stopień uszkodzenia brodawek korzeniowych przez larwy tych szkodników.*
Doświadczenie przeprowadzono w latach 2011 – 2012 w Stacji Doświadczalnej – Prusy należącej do Uniwersytetu Rolniczego w Krakowie. Obejmowało ono następujące obiekty: bób wysiewany jako uprawa jednorodna (Kontrola); bób uprawiany współrzędnie z kolendrą siewną; bób uprawiany współrzędnie z koprem włoskim. Przebieg dynamiki żerowania chrząszczy oceniano na 25 losowo wybranych roślinach z poletka poprzez mierzenie powierzchni wyżerek, liczenie liści uszkodzonych i nieuszkodzonych oraz wyliczenie ubytku blaszki liściowej w wyniku ich żerowania. W końcu czerwca wykonywano także analizę stopnia uszkodzenia brodawek korzeniowych przez larwy oprzędzików. Uprawa współrzędna z kolendrą siewną i koprem włoskim istotnie ograniczała żerowanie chrząszczy oprzędzików na bobie odmiany Windsor Biały. Efekt był szczególnie wyraźny w początkowym okresie wzrostu rośliny, co jest istotne ze względu na największe znaczenie żerowania szkodnika w tym okresie. Sąsiedztwo badanych gatunków ziół nie wpływało na ilość wytwarzanych przez bób brodawek korzeniowych, jak również stopień ich uszkodzenia przez larwy Sitona spp.
***Słowa kluczowe**: Vicia faba L., Coriandrum sativum L., Foeniculum vulgare Mill, uprawa współrzędna, Sitona spp., liczba brodawek korzeniowych, uszkodzenia roślin*

1. Introduction

Broad beans are appreciated for their high content of proteins, phosphorous, and B vitamins. The plant has the ability to fix atmospheric nitrogen, which makes it a valuable component of crop rotation on organic farms. Beetles of the genus *Sitona* spp. are among the major pests attacking the plant already at the earliest stage of its growth. Damage is caused by both adults eating the edges of leaf blades, and larvae destroying the root nodules [2, 4, 11]. The available literature contains little data on the possibilities of protecting papilionaceous plants against *Sitona* beetles by means of natural methods which are recommended in organic farming [9, 21].

The introduction of companion plants alongside cultivation of the main plant is mentioned among useful methods for pest reduction [13, 15]. A special role among the plants used in intercropping is assigned to those producing large amounts of pollen and nectar, as these substances constitute an important source of food for numerous beneficial insects, such as Diptera from the hoverfly family, or the parasitic Hymenoptera [12, 19]). These plants include coriander (*Coriandrum sativum* L.) and fennel (*Foeniculum vulgare* Mill.) [1, 3, 6]. Coriander used as a groundcover plant in tomato cultivation reduced whitefly (*Bemisia tabaci* Gennadius) abundance [8]. When grown as a companion to lettuce, it contributed to an increase in the number of Syrphidae larvae [13]. In chickpea cultivation, it enhanced the ac-

tivity of the parasitoid *Campoletis chlorideae* Uchida [16]. Fennel, on the other hand, ranks among the plants flowering in the later period of the vegetation season most frequently visited by Diptera from the hoverfly family [3, 14]. In addition to the benefits mentioned above, the plants may also hinder herbivores from locating the host plant by producing deceptive visual and aromatic stimuli.

The aim of the study was to assess the impact of intercropping White Windsor broad beans with coriander (*Coriandrum sativum* L.) and fennel (*Foeniculum vulgare* Mill.) on the dynamics of adult pea weevils (*Sitona* spp.) feeding and the degree of damage caused to root nodules by the *Sitona* spp larvae.

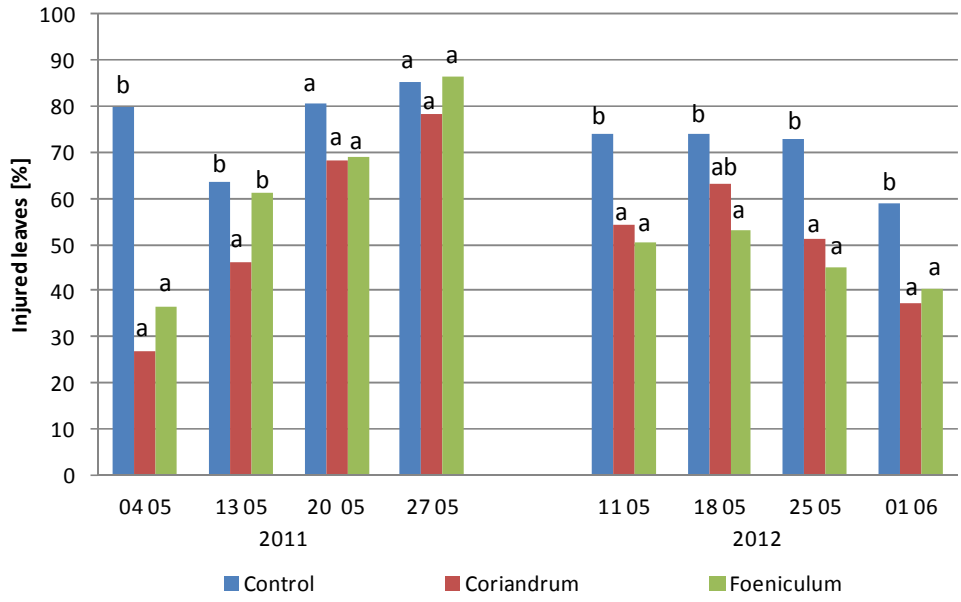
2. Material and methods

The experiment was conducted in the period 2011–2012 at the Prusy Experimental Station, which belongs to the University of Agriculture in Krakow. 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 Windsor Biały cultivar. The experiment involved the following objects: broad beans in a homogeneous crop (control); broad beans intercropped with coriander; broad beans intercropped with fennel. 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 (using plotting paper), 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. 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 a single factor variance analysis (cultivation method) and two factor variance analysis (cultivation method x year) with the use of the Statistica 12.0 Software. The means were differentiated using the NIR Fisher test at level $p < 0.05$.

3. Results and discussion

In 2011, *Sitona* spp. beetles damaged approximately from 28% to more than 80% of leaves (Fig. 1). In the initial phase of feeding, significantly fewer leaves with damages were noted in the objects where broad beans were intercropped with herbs, as compared to homogeneous crop. The pests' feeding that takes place between the plant emergence and the development of 4 true leaves has the greatest impact on the later crop yield [18]. The observations carried out in the following weeks revealed an increase in the number of damaged leaves in all objects under study. At the same time, it was noticed that the presence of coriander decreased the percentage of damaged leaves for a longer time compared to fennel. Starting from the second half of May, no significant differences were recorded between the objects under study. In the 2012 season, pea leaf weevils damaged fewer leaves (from 35% to about 75% of all leaves). For almost the entire research period, both coriander and fennel contributed significantly to reducing the percentage of leaves damaged by pea leaf weevils. Our earlier studies involving the use of the same companion plants to White Hangdown broad beans did not reveal a significant effect of fennel and coriander on the percentage of leaves damaged by pea leaf weevils [9].



Source: own work / Źródło: opracowanie własne

Fig. 1. Leaves of broad bean injured by *Sitona* spp. adult (percent of total number of leaves) depending on cultivation method. Mean followed by the same letter in a given date respectively are not significantly different at $p<0.05$, factor: cultivation method. Control - broad beans in a homogeneous crop; *Coriandrum* - broad beans intercropped with coriander; *Foeniculum* - broad beans intercropped with fennel

Rys. 1. Liście bobu uszkodzone przez chrząszcze oprzędzików (odsetek ogółu liści) zależnie od sposobu uprawy. Średnie oznaczone takimi samymi literami odpowiednio dla danego terminu, nie różnią się istotnie przy p<0,05, czynnik: sposób uprawy. Control – bób jako uprawa jednorodna; Coriandrum – bób uprawiany współrzędnie z kolendrą siewną; Foeniculum – bób uprawiany współrzędnie z koprem włoskim

Likewise, other authors who analysed the effects of using lacy phacelia as a companion plant did not detect an unequivocal trend with regard to the percentage of leaves damaged by pea leaf weevils [21]. Apart from the percentage of damaged leaves, another important indicator of the degree of *Sitona* feeding is the surface area of the eaten leaves and the resulting loss of leaf blade. The calculated mean surface area of eaten leaves increased as the adult pea leaf weevils continued their feeding, especially in the 2011 season (Fig. 2).

As was the case with the percentage of damaged leaves, a significantly smaller surface area of eaten leaves in the objects with companion plants was recorded in the initial stage of pests' feeding; in later stages the differences became blurred. In 2012, the surface area of leaves eaten by pea leaf weevils was smaller and the beneficial effects of coriander and fennel were visible during all phases of observation, except for the last one. Our earlier tests involving the Hangdown White variety did not reveal such beneficial effects of the herbs under study [9]. The loss of leaf blade was relatively low and ranged from 0.5% to 3.5%, depending on the phase of observation (Fig. 3).

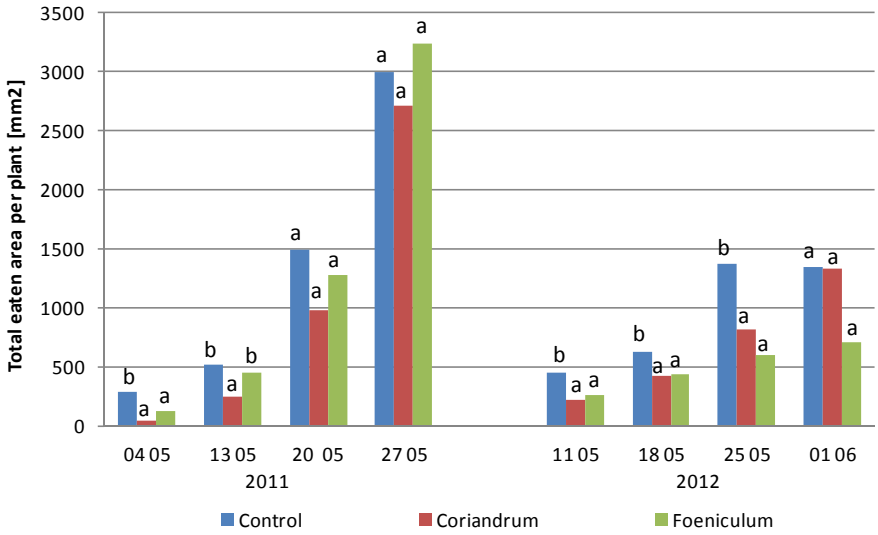


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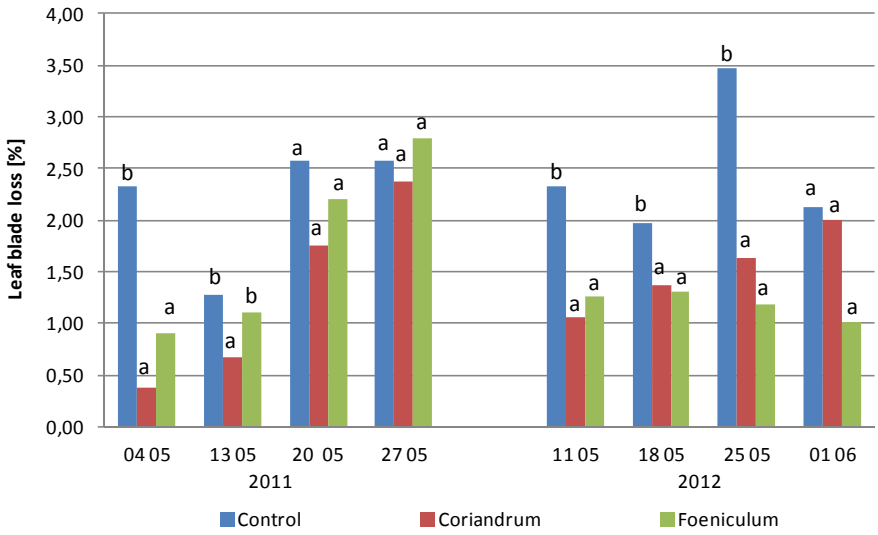
Fig. 2. Total eaten area per plant (mm^2) caused by *Sitona* spp. adult depending on cultivation method. Mean followed by the same letter in a given date respectively are not significantly different at p<0.05, factor: cultivation method. For treatments explanation see fig. 1

Rys. 2. Powierzchnia wyżerek z rośliny (mm^2) spowodowanych przez chrząszcze oprzędzików zależnie od sposobu uprawy. Średnie oznaczone takimi samymi literami odpowiednio dla danego terminu, nie różnią się istotnie przy p<0,05, czynnik: sposób uprawy. Objaśnienia obiektów jak na rys. 1



Source: own work / Źródło: opracowanie własne

Fig. 3. Leaf blade loss of broad bean (percent of total leaf area) caused by *Sitona* sp. adult depending on cultivation method. Mean followed by the same letter in a given date respectively are not significantly different at p<0.05, factor: cultivation method. For treatments explanation see fig. 1

Rys. 3. Ubytek blaszki liściowej bobu (procent ogólnej powierzchni liści) spowodowany przez chrząszcze oprzędzików zależnie od sposobu uprawy. Średnie oznaczone takimi samymi literami odpowiednio dla danego terminu, nie różnią się istotnie przy p<0,05, czynnik: sposób uprawy. Objaśnienia obiektów jak na rys. 1

During both research seasons, the loss of leaf blade as a result of *Sitona* feeding was smaller in those objects where broad beans were intercropped with coriander or fennel, especially in the initial period of plant growth. In the 2012 season, the effects persisted until the third decade of May.

Based on the mean values for particular research seasons (Fig. 4), it was demonstrated that the method of cultivation had a significant impact on the percentage of damaged leaves and the loss of leaf blade (Table 1). The last parameter was also significantly affected by both the method of protection and the year of research. As regards the surface area of eaten leaves, it was significantly influenced by the conditions prevailing in a particular year of research. The data concerning the effect of intercropping on pea leaf weevil feeding is varied. It was noticed that the damage to pea was smaller when the plant was intercropped with wheat [10, 17], while the damage to field beans increased when the plant was intercropped with barley or wheat [5].

The number of root nodules produced by broad beans was significantly dependent on the year of research, whereas the presence of companion plants did not have a significant impact on that parameter (Tables 1 and 2). Also, no significant dependence was detected between the method of broad beans cultivation and the percentage of root nodules damaged by *Sitona* larvae. Similar result were obtained in previous experiments involving the use of the herbs under study [7]. Other companion plants, e.g. mustard, were found to decrease the damage suffered by broad beans from *Sitona* larvae [20].

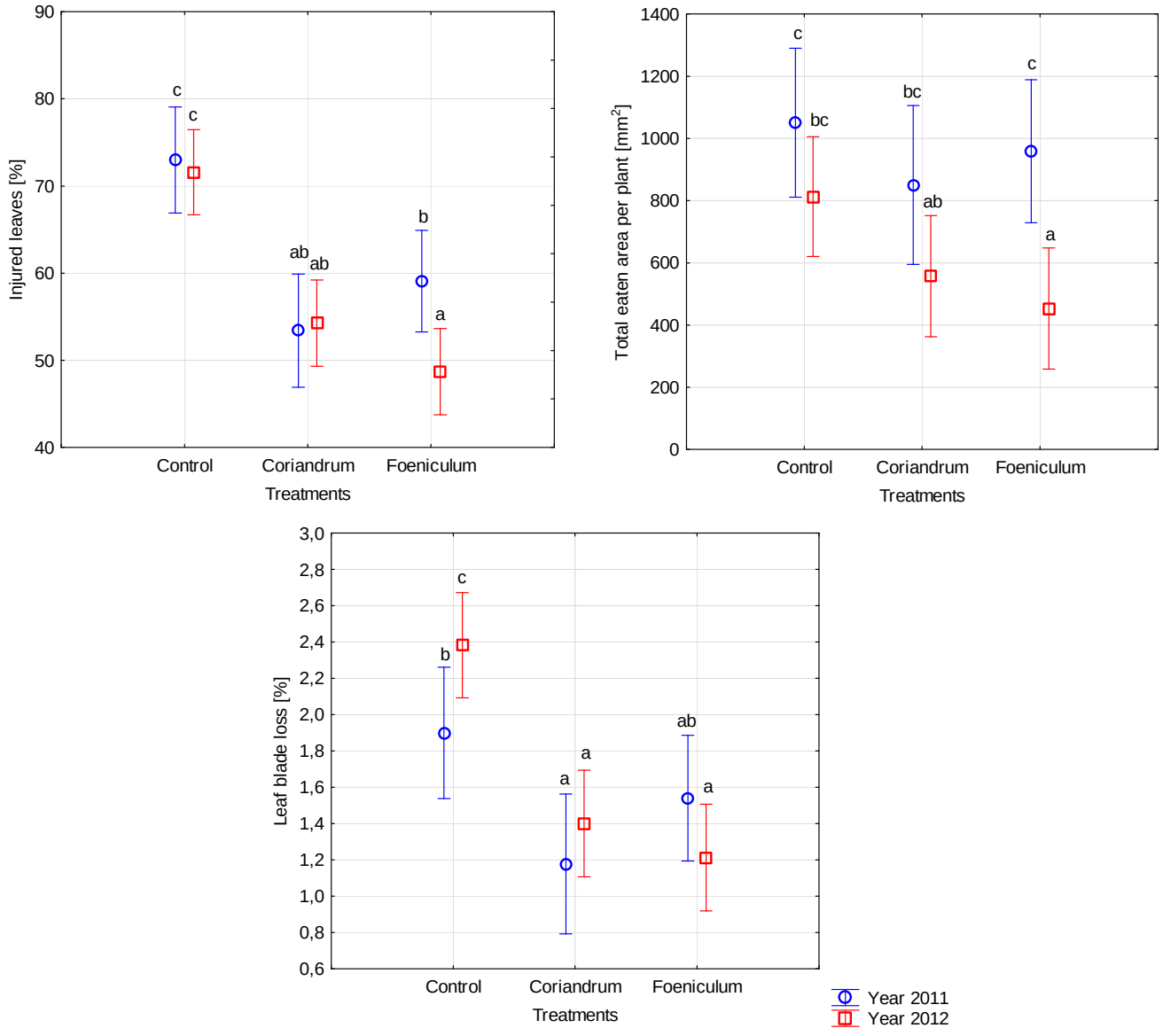


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Fig. 4. Damage of broad bean caused by *Sitona* sp. adult depending on cultivation method (mean in the years of experiment). Mean followed by the same letter are not significantly different at p<0.05, factors: cultivation method x year. For treatments explanation see fig. 1

Rys. 4. Uszkodzenia bobu przez chrząszcze oprzędzików zależnie od sposobu uprawy (średnio w latach badań). Średnie oznaczone takimi samymi literami nie różnią się istotnie przy p<0,05, czynniki: sposób uprawy x rok. Objaśnienia obiektów jak na rys. 1

Table 1. The results of statistical analysis of feeding intensity of adult pea weevils, number of root nodules and damage of root nodules (seasonal means)

Tab. 1. Wyniki analizy statystycznej odnośnie intensywności żerowania chrząszczy oprzędzików, liczby wytworzonych brodawek korzeniowych i ich stopnia uszkodzenia (średnie sezonowe)

Effects	SS*	df	MS	F	p
Injured leaves [%]					
Cultivation method	31665	2	15832	28.490	0.000000
Year	1378	1	1378	2.480	0.116041
Cultivation method x year	2496	2	1248	2.246	0.107074
Total eaten area per plant [mm^2]					
Cultivation method	4791201	2	2395601	2.7814	0.063064
Year	12411932	1	12411932	14.4106	0.000168
Cultivation method x year	1444646	2	722323	0.8386	0.433001
Leaf blade loss [%]					
Cultivation method	61.147	2	30.574	15.5930	0.000000
Year	1.660	1	1.660	0.8469	0.357954
Cultivation method x year	12.347	2	6.173	3.1485	0.043903
Nodule number/plant					
Cultivation method	11654.5	2	5827.3	1.8494	0.161103
Year	69780.7	1	69780.7	22.1461	0.000006
Cultivation method x year	6429.9	2	3215.0	1.0203	0.363106
Damage of root nodules [%]					
Cultivation method	682.62	2	341.31	1.5265	0.220843
Year	21647.55	1	21647.55	96.8168	0.000000
Cultivation method x year	120.73	2	60.36	0.2700	0.763791

*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

Table 2. Total number of root nodules and its damage caused by *Sitona* sp. larvae (percent of total nodule number) depending on cultivation method

Tab. 2. Ogólna liczba brodawek korzeniowych oraz ich uszkodzenie przez larwy oprzędzików (procent ogólnej liczby brodawek) zależnie od sposobu uprawy

Treatments	Nodule number/plant [pcs]		Damage of root nodules [percent of total nodule number]	
	2011	2012	2011	2012
Control*	51.30 ^{ab**}	86.35 ^{c}	38.95 ^{b}	11.66 ^{a}
Coriandrum	52.27 ^{ab}	116.89 ^{c}	33.76 ^{b}	8.06 ^{a}
Foeniculum	44.63 ^{a}	80.89 ^{bc}	37.26 ^{b}	14.54 ^{a}

* For treatments explanation see fig. 1

**Mean followed by the same letter for a specific parameter are not significantly different at $p<0.05$, factors: cultivation method x year

Source: own work / Źródło: opracowanie własne

4. Conclusions

1. Intercropping with coriander and fennel significantly reduced the feeding of pea leaf weevils on the White Windsor variety of broad beans. The effect was particularly visible in the initial period of plant growth, which is important due to the greatest impact of pests' feeding activity during that period.
2. The proximity of the examined herb species did not affect the number of root nodules produced by broad beans, or the degree of damage caused to root nodules by *Sitona* sp. larvae.

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