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THE EFFECT OF BIOLOGICAL CONTROL OF THE CARROT FLY (*Psila rosae*) ON THE YIELD AND QUALITY OF CARROT (*Daucus carota* L.) STORAGE ROOTS

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Abstract. Non-chemical methods of agrophage control have gained increasing popularity recently, and particular attention has been paid to enhancing biodiversity in agrocenoses. Intercropping, i.e. growing of two or more crops (onions, carrots, dill, beans, Lacy phacelia, mustard) simultaneously in the same field, reduces pest infestations. The rationale behind intercropping is that different crops planted together act as attractants for beneficial insects (hoverflies, ladybirds) and effectively disorientate the pests (aphids, carrot flies) which are then unable to find host plants. This study was conducted in the Experimental Garden of the University of Warmia and Mazury in Olsztyn, in the growing seasons of 2009–2010. The experiment was established on brown soil of quality class IV b, and ridges were prepared in line with the generally observed standards of organic farming. The first experimental factor were six carrot cultivars differing with respect to the growth and development period: 'Deep Purple F_1', 'Florida F_1', 'Interceptor F_1', 'Joba', 'Kazan F_1' and 'Purple Haze F_1'. The second experimental factor were three methods of carrot fly biocontrol, compared in the following treatments: control – unprotected plants, the application of the biocontrol agent Bioczos BR containing paraffin-coated garlic pulp (10 g cubes), carrots intercropped with dill cv. 'Szmaragd' and carrots intercropped with Welsh onions cv. 'Parade'. Carrot-dill and carrot-Welsh onion intercropping effectively reduced damage to carrot roots caused by carrot fly larvae. The applied biological control methods had a significant effect on carrot yield. The application of Bioczos BR and carrot-Welsh onion intercropping had a beneficial influence on the total and marketable yield of carrot storage roots. Carrot-dill intercropping resulted in a significant yield decrease. The content of dry matter, total sugars and L-ascorbic acid in carrot roots was affected by the cultivar and the cultivar × biocontrol method interaction. Higher concentrations of dry matter and L-ascorbic acid were noted in carrot cultivars with purple-colored roots, 'Deep Purple F_1' and 'Purple Haze F_1'. The average nitrate content of carrot storage roots did not exceed the maximum permissible levels set out in the Regulation of the Minister of Health.

Key words: *Daucus carota* L., biocontrol agent, intercropping, chemical composition of carrot roots.

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INTRODUCTION

The carrot fly (*Psila rosae*) belongs to the most dangerous pests attacking carrots. The larvae of the carrot fly feed on the outer layer of the carrot root, thus considerably affecting the crop of carrots. In organic farming, intercropping of vegetable plants, which act as barriers and replace insecticides, helps to limit outbreaks of crop pests. The results of previous studies show that carrot-onion intercropping significantly reduces attacks by the onion fly on onions and by the carrot fly on carrots, but it does not protect the plants completely against infestation by the above pests [Uvah and Coaker 1984, Varis 1991, Finch 1993, Wiech and Jeleń 1995].

Biodiversity may contribute to maintaining soil fertility and protecting crops against pests and diseases [Szafirowska and Kłosowski 2008]. Interactions between different plant species were first observed in ancient times. The biological phenomenon of allelopathy is today studied as part of chemical ecology which focuses on the effects of biochemicals produced by plants and microorganisms that influence the growth, survival, and reproduction of other species in natural ecosystems and plant communities [Einhellig 1995, Jezierska-Domaradzka and Kuźniewski 2007].

Studies conducted in the United Kingdom have demonstrated that insects find it easier to locate their host plants grown in monoculture [Finch and Collier 2003]. Organic control of the carrot fly relies on alternative biological methods, including intercropping (or mixed cropping) strategies. In the intercropping system, insects need more time to search for their host plants, and they stay longer on companion plants.

The aim of this experiment was to determine the effectiveness of three biocontrol methods applied to protect carrots against the carrot fly, and to estimate their influence on the yield and quality of carrot storage roots.

MATERIALS AND METHODS

A two-factor field experiment was carried out in the Experimental Garden of the University of Warmia and Mazury in Olsztyn, in the growing seasons of 2009–2010, on brown soil of quality class IV b, in the third year after manure application. Carrots were grown after cruciferous vegetables. In the spring, soil mineral deficiencies were supplemented to the following levels: N – 100 mg·dm^{-3}, P – 70 mg·dm^{-3}, K – 200 mg·dm^{-3}, and ridges (height – 25 cm, width – 25 cm) were formed, with two rows 8 cm apart. The distance between neighboring rows was 67 cm.

The experiment was performed in a randomized block design, in three replications. The first experimental factor were six carrot (*Daucus carota* L.) cultivars differing with respect to the growth and development period: 'Deep Purple F_1', 'Florida F_1', 'Interceptor F_1', 'Joba', 'Kazan F_1' and 'Purple Haze F_1'. The second experimental factor involved an analysis of the effect of three methods of carrot fly (*Psila rosae*) biocontrol on the yield and quality of carrot storage roots. The following treatments were applied:

1. carrots grown in monoculture (two rows, 8 cm apart),
2. carrots grown in monoculture (two rows, 8 cm apart), protected with Bioczos BR (currently sold under the trade name "Himal garlic cubes") at a dose of 50 g·dm^{-3} per

10 m^2, applied during the invasion of first- and second-generation carrot flies, at intervals determined based on the number of carrot flies caught on yellow sticky traps,

3. carrots intercropped with dill (*Antheum graveolens* L.) (one row of carrots and one row of dill, 8 cm apart),

4. carrots intercropped with Welsh onions (*Allium fistulosum* L.) (one row of carrots and one row of Welsh onion sets, 8 cm apart).

In monoculture, 25 carrot plants were grown per running meter of each row (50 plants per running meter of each ridge, in two rows). When carrots were intercropped with dill cv. 'Szmaragd', 25 carrot plants were grown per running meter of each ridge, in one row, and 20 dill plants were grown in the other row, 8 cm apart. When carrots were intercropped with Welsh onions cv. 'Parade', 25 carrot plants were grown per running meter of each ridge, in one row, and 10 onion sets (at the two- or three-leaf stage) were planted in the other row, 8 cm apart. During carrot emergence, two yellow sticky carrot fly traps measuring 24 × 17 cm were placed in each plot. The traps were collected and replaced every 7 days.

Carrot and dill seeds were sown 2 cm deep, on 8 May in each year of the study. First seedlings emerged towards the end of May. Cultivation practices were applied over the growing season, including hand weeding performed three times (28–30 May, mid-June, the first week of July).

Early and late carrot varieties were harvested in the first week of September and towards the end of October, respectively. After harvest, 100 carrot roots were collected from each treatment to determine the percentage of roots infested by the carrot fly (*Psila rosae*). In order to compare carrot yielding levels in experimental treatments, the total and marketable yield of carrot storage roots was determined according to the Commission Regulation (EC) No. 730/1999 laying down the marketing standards for carrots [Marchew. Wymagania…]. The marketable yield consisted of healthy (not forked) carrot roots with a diameter of 2.5 to 6 cm.

Fifteen roots sampled from the marketable yield in each treatment were subjected to chemical analyses to determine the content of: dry matter – by drying the collected plant material at 105ºC to constant weight [PN-90/A-75101/03], L-ascorbic acid – by the Tillmans' method modified by Pijanowski [PN-90A-75101/11], total sugars – by the method proposed by Luff-Schoorl [PN-90/A-75101/07], nitrates – colorimetrically, using salicylic acid [Krauze and Domska 1991].

The obtained results were processed statistically by an analysis of variance (ANOVA). The significance of differences between means was evaluated with the use of Tukey's test at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Research findings show that carrot fly infestation can be effectively reduced by carrot-Welsh onion and carrot-dill intercropping (tab. 1). The highest pest infestation levels were noted in the control treatment (monoculture), where damaged roots accounted for 14.6% on average, compared with 3.3% in the Bioczos BR treatment and 0% in the carrot-dill intercropping treatment. The above results were validated statistically. According to Legutowska and Plaskota [1986], carrot fly populations can be reduced when carrots are grown with dill as a companion plant because carrot flies invades tall-growing herbaceous plants which provide shelter from wind, rain and high temperatures as well as food sources, including pollen and honeydew. As demonstrated by Aliteri and Doll [1978], dill acts as a physical barrier to flying insects, but it also serves as a host plant for the larvae of some beneficial insects, while its aroma deters other insects. The beneficial influence of onions includes the secretion of specific allelopathic compounds [Kaczmarek 2009].

Table 1. The effect of cultivar and methods of protection plant on the infestation of carrot roots (means of 2009–2010)
Tabela 1. Wpływ odmiany i metody ochrony roślin na porażenie korzeni spichrzowych marchwi przez larwy połyśnicy marchwianki (średnio z lat 2009–2010)

Cultivar – Odmiana	% Infested roots % porażenych korzeni				Mean Średnio
	control kontrola	Bioczos BR	dill koper	onions cebula	
Deep Purple F_1	23.0	10.0	0.0	0.0	8.2
Florida F_1	10.0	0.0	0.0	0.0	2.5
Interceptor F_1	20.0	5.0	0.0	0.0	6.2
Joba	10.0	0.0	0.0	0.0	2.5
Kazan F_1	5.0	0.0	0.0	0.0	1.2
Purple Haze F_1	20.0	5.0	0.0	0.0	6.2
Średnio – Mean	14.6	3.3	0.0	0.0	-
$LSD_{\alpha = 0.05}$ – $NIR_{\alpha = 0,05}$					
Cultivar – Odmiana (a)			n.s.		
Crop protection method – Metoda ochrony (b)			2.6		
Interaction – Współdziałanie (a × b)			1.0		

Non-chemical methods of agrophage control have gained increasing popularity recently, and particular attention has been paid to enhancing biodiversity in agrocenoses. Intercropping, i.e. growing of two or more crops (onions, carrots, dill, beans, Lacy phacelia, mustard) simultaneously in the same field, reduces pest infestations. The rationale behind intercropping is that different crops planted together act as attractants for beneficial insects (hoverflies, ladybirds) and effectively disorientate the pests (aphids, carrot flies) which are then unable to find host plants [Jankowska et al. 2009, Wiech et al. 2009].

The total and marketable yield is a key criterion used to evaluate the effectiveness of different crop protection methods (tab. 2). The highest total and marketable yield of carrot storage roots was obtained in the Bioczos BR treatment, followed by the carrot-onion intercropping treatment. The highest yield variation was noted in the carrot-dill intercropping treatment. This resulted from the height difference between carrot and dill plants, which competed for nutrients, light and water, leading to a decrease in carrot

Table 2. The effect of cultivar and methods of plant protection on the total and marketable yield of carrot storage roots (mean of 2009–2010)
Tabela 2. Wpływ uprawianej odmiany marchwi i metody ochrony roślin na plon ogółem i handlowy korzeni spichrzowych (średnio z lat 2009–2010)

Cultivar – Odmiana	Total yield – Plon ogółem ($t \cdot ha^{-1}$)				Mean Średnio	Marketable yield – Plon handlowy ($t \cdot ha^{-1}$)				Mean Średnio
	control kontrola	Bioczos BR	dill koper	onions cebula		control kontrola	Bioczos BR	dill koper	onions cebula	
Deep Purple F_1	69.0	70.3	50.8	83.9	68.5	40.7	43.0	23.0	48.3	38.7
Florida F_1	68.2	80.1	34.0	68.9	62.8	44.9	41.8	11.8	44.3	35.7
Interceptor F_1	54.8	76.8	23.8	53.3	52.2	30.7	49.7	9.1	30.3	29.9
Joba	58.5	80.2	36.9	75.6	62.8	42.9	54.9	21.8	50.4	42.5
Kazan F_1	62.3	64.7	55.1	72.5	63.6	47.9	53.2	42.0	49.4	48.1
Purple Haze F_1	37.4	52.0	32.0	38.0	39.8	19.2	30.0	13.2	28.6	22.8
Mean Średnio	58.4	70.7	38.8	65.4	-	37.7	45.4	20.2	41.9	-
$LSD_{\alpha = 0.05}$ – $NIR_{\alpha = 0,05}$										
Cultivar – Odmiana (a)			12.2					9.9		
Crop protection method – Metoda ochrony (b)			8.5					6.9		
Interaction – Współdziałanie (a × b)			6.7					5.9		

yield. The optimal solution was growing carrots with Welsh onion sets, since there was no competition for nutrients, light and water between carrot and onion plants. As a result, carrots intercropped with onions produced yield comparable with that obtained in the Bioczos BR treatment. The analyzed experimental factors were found to be statistically significant.

In another experiment, Bioczos BR had a positive impact on strawberry yield. Products containing garlic extracts are known to effectively suppress the growth of fungi and other phytopathogenic microorganisms [Orlikowski et al. 2002, Marjańska-Cihoń and Sapieha-Waszkiewicz 2010], and to reduce pest populations [Rogowska 2003].

The chemical composition of carrot roots is a varietal feature, and it varies widely in response to changing habitat conditions [Gajewski et al. 2007]. In our experiment, there was a significant correlation between the dry matter content of carrot roots and cultivar. The dry matter content of the edible parts of carrots was comparable with that noted by Łoś-Kuczera [1990], Wierzbicka et al. [2004], Majkowska-Gadomska and Wierzbicka [2010], and it ranged from 7.6 to 15.4% (tab. 3). The methods of biological crop protection had a significant effect on dry matter levels.

Table 3. The effect of cultivars and methods of protection plant on the dry matter content of carrot roots (means of 2009–2010)
Tabela 3. Wpływ uprawianej odmiany i metody ochrony roślin na zawartość suchej masy w korzeniach spichrzowych marchwi (średnio z lat 2009–2010)

Cultivar – Odmiana	Dry mater – Sucha masa (%)				Mean Średnio
	control kontrola	Bioczos BR	dill koper	onions cebula	
Deep Purple F_1	12.0	11.5	12.9	15.4	12.9
Florida F_1	11.0	9.0	9.9	7.6	9.5
Interceptor F_1	10.9	10.8	14.4	14.7	11.4
Joba	11.4	9.9	9.9	11.3	10.6
Kazan F_1	10.9	10.6	11.6	10.7	10.9
Purple Haze F_1	13.8	13.6	14.5	13.3	13.8
Mean – Średnio	11.7	10.9	12.2	12.2	-
$LSD_{\alpha = 0.05}$ – $NIR_{\alpha = 0,05}$					
Cultivar – Odmiana (a)			1.1		
Crop protection method – Metoda ochrony (b)			1.1		
Interaction – Współdziałanie (a × b)			n.s		

The content of total sugars and L-ascorbic acid in carrot roots was significantly affected by the cultivar and the cultivar × biocontrol method interaction (tab. 4). The biocontrol method alone had no significant influence of the nutrient content of carrots.

The edible parts of cv. ‘Interceptor F_1’ were characterized by a significantly higher total sugars content, compared with the other cultivars. The roots of cv. ‘Joba’ had the lowest total sugars content, but significant differences were noted only relative to the edible parts of cv. ‘Interceptor F_1’. The best results were obtained when carrots cv. ‘Interceptor F_1’ and ‘Deep Purple F_1’ were intercropped with Welsh onions

Table 4. The effect of cultivar and methods of plant protection on the content of total sugars and L-ascorbic acid in carrot storage roots (mean of 2009–2010)

Tabela 4. Wpływ uprawianej odmiany marchwi i metody ochrony roślin na zawartość cukrów ogółem i kwasu L-askorbinowego korzeni spichrzowych (średnio z lat 2009–2010)

Cultivar – Odmiana	Total sugars – Cukry ogółem ($g \cdot 100 g^{-1}$)				Mean Średnio	L-ascorbic acid – Kwas L-askorbinowy ($mg \cdot 100 g^{-1}$)				Mean Średnio
	control kontrola	Bioczos BR	dill koper	onions cebula		control kontrola	Bioczos BR	dill koper	onions cebula	
Deep Purple F_1	5.5	4.2	1.1	8.1	4.7	5.1	5.6	4.7	5.6	5.3
Florida F_1	4.6	5.1	2.8	4.4	4.2	4.4	3.8	3.3	3.8	3.8
Interceptor F_1	4.2	7.0	6.0	8.4	6.4	5.1	3.6	4.8	4.1	4.4
Joba	3.5	3.5	3.8	3.5	3.6	2.9	4.2	3.7	3.5	3.6
Kazan F_1	3.9	4.4	3.3	3.7	3.8	4.8	4.1	3.6	4.2	4.2
Purple Haze F_1	3.6	5.4	3.3	3.6	4.0	4.4	4.2	4.8	4.9	4.6
Mean – Średnio	4.2	4.9	3.4	5.3	-	4.4	4.2	4.2	4.3	-
$LSD_{\alpha = 0.05}$ – $NIR_{\alpha = 0,05}$										
Cultivar – Odmiana (a)			1.1					0.5		
Crop protection method – Metoda ochrony (b)			n.s.					n.s.		
Interaction – Współdziałanie (a × b)			0.6					0.7		

(8.4 g·100 g^{-1} and 8.1 g·100 g^{-1}, respectively). The total sugars content of the studied carrot cultivars was similar to the findings of Jagosz et al. [2000], Majkowska-Gadomska and Wierzbicka [2010].

Carrot roots contain small quantities of L-ascorbic acid. The highest quantities of L-ascorbic acid were accumulated by purple root carrots. A statistical analysis revealed that the interaction of experimental factors led to significant differences in L-ascorbic acid levels. Bioczos BR exerted a particularly beneficial influence on L-ascorbic acid concentrations in carrots cv. 'Deep Purple F_1'. Our findings are consistent with the data published by Jagosz et al. [2000].

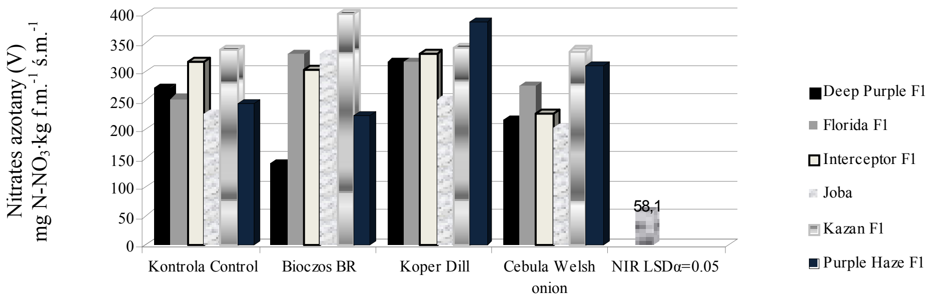

Fig. 1. The effect of cultivar and methods of plant protection on the nitrate content of carrot roots (means of 2009–2010)

Rys. 1. Wpływ uprawianej odmiany oraz metody ochrony roślin na zawartość azotanów (V) w korzeniach spichrzowych marchwi (średnio z lat 2009–2010)

Previous research has shown that nitrate levels in the edible parts of vegetable crops are determined genetically and therefore they are different in various species and varieties, but they can also be modified by environmental conditions and agronomic factors [Michalik 1996, Wierzbicka et al. 2004, Majkowska-Gadomska and Wierzbicka 2010]. The average nitrate content of carrot storage roots did not exceed the maximum permissible levels set out in the Regulation of the Minister of Health of 22 December 2004 (fig. 1). It ranged from 142.0 to 400.0 mg $N\text{-}NO_3$·kg f.m.$^{-1}$, depending on the carrot cultivar and the cultivar x crop protection method interaction. The crop protection method alone had no significant effect on nitrate levels. The noted values were insignificantly higher than those reported by Wierzbicka et al. [2004], Murawa et al. [2008], and Majkowska-Gadomska et al. [2009].

CONCLUSIONS

1. Carrot-dill and carrot-Welsh onion intercropping effectively reduced damage to carrot roots caused by carrot fly larvae.

2. The applied biological control methods had a significant effect on carrot yield. The application of Bioczos BR and carrot-Welsh onion intercropping had a beneficial

influence on the total and marketable yield of carrot storage roots. Carrot-dill intercropping resulted in a significant yield decrease.

3. The content of dry matter, total sugars and L-ascorbic acid in carrot roots was affected by the cultivar and the cultivar × biocontrol method interaction. Higher concentrations of dry matter and L-ascorbic acid were noted in carrot cultivars with purple-colored roots, 'Deep Purple F_1' and 'Purple Haze F_1'.

4. The average nitrate content of carrot storage roots did not exceed the maximum permissible levels set out in the Regulation of the Minister of Health of 22 December 2004. It ranged from 142.0 to 400.0 mg $N\text{-}NO_3 \cdot kg\ f.m.^{-1}$, depending on the carrot cultivar and the cultivar x crop protection method interaction. The crop protection method alone had no significant effect on nitrate levels.

REFERENCES

Aliteri M.A., Doll J.D., 1978. Some limitations of weed biocontrol in tropical ecosystems in Columbia. Proc. IV Internat. Symp. on Biological Control of Weeds. Univ. of Florida, Gainesville,74–82.

Einhellig F., 1995. Allelopathy: Current Status and Future Goals. Am. Chem. Soc. Symp. Series 582, 1–24.

Finch S., 1993. Integrated pest management of the cabbage root fly and the carrot fly. Crop Protection.12, 6, 423–430.

Finch S., Collier R.H., 2003. Insects can see clearly now the weeds have gone Biologist 50(3), 132–135.

Gajewski M., Szymczak P., Elkner K., Dąbrowska A., Kret A., Danilcenko H., 2007. Some aspect of nutritive and biological value of carrot cultivars with orange, yellow and purple-colored roots. Veg. Crops Res. Bull. 67, 149–161

Jankowska B., Poniedziałek M., Jędrszczyk E., 2009. Effect of intercropping white cabbage with French Marigold (*Tagetes patula nana*) and Pot Marigold (*Calendula officinalis* L.) on the plants colonization by herbivorous pest insects. Folia Horticul. 21 (1), 95–103

Jezierska-Domaradzka A., Kuźniewski E., 2007. Allelopatyczny wpływ wodnych wyciągów z *Capsella bursa-pastoris* (L.) Medik i *Stellaria media* (L.) Vill. na kiełkowanie i juwenilne stadia *Ocimum basilicum* L. i *Origanum majorana* L. Annales UMCS. Sec. E, Agricultura LXII(2), 10–16.

Jagosz B., Żukowska E., Zabagło A., Czeladzka B., Michalik B., 2000. Porównanie składu chemicznego korzeni mieszańców F_1 i linii rodzicielskich marchwi (*Daucus carota*). Zesz. Nauk. AR Kraków 364(71), 109–112.

Kaczmarek S., 2009. Wykorzystanie potencjału allelopatycznego roślin w wybranych uprawach rolniczych. Prog. Plant Protection/Post. Ochr. Roślin.49(3), 1502–1511

Krauze A., Domska D., 1991. Ćwiczenia specjalistyczne z chemii rolnej. Wyd. UWM Olsztyn.

Legutowska H., Plaskota E., 1986. Influence of environmental conditions and cultural practices on two pests of vegetable crops: the carrot fly (*Psila rosae* Fab.) and the leek moth (*Acrolepiopsis assectella* Z.). Influence des conditions d'environnement et de culture sur deux ravageurs des plantes maraicheres: la mouche de la carotte (*Psila rosae* Fab.) et la teigne du poireau (*Acrolepiopsis assectella* Z.). Colloques-de-l'INRA. 36, 61–73.

Łoś-Kuczera M., 1990. Food products, composition and nutritive value. Prace IŻŻ. Warszawa, 54, 153.

Majkowska-Gadomska J., Arcichowska K., Wierzbicka B., 2009. Nitrate content of the edible parts of vegetables and spice plants. Acta Sci. Pol., Hortorum Cultus, 8(3), 25–35.

Majkowska-Gadomska J., Wierzbicka B., 2010. The yield and nutritive value of selected carrot cultivars with orange – and purple – colored storage roots. Acta Sci. Pol., Hortorum Cultus, 9(4), 75–84.

Marchew. Wymagania Jakości Handlowej. Rozporządzenie Komisji (WE) nr 46/2003. www.ijhar-s.gov.pl/download/Marchew.

Marjańska-Cichoń B., Sapieha-Waszkiewicz A., 2010. Skuteczność preparatów biotechnicznych opartych na ekstrakcie z czosnku w zwalczaniu szarej pleśni na truskawce. Prog. Plant Protection/Post. Ochr. Roślin 50 (1), 378–382.

Michalik H., 1996. Zawartość azotanów a warzywach w zależności od gatunku i odmiany. Hod. Rośl. Nasien., 3, 15–18.

Murawa D., Banaszkiewicz T., Majewska E., Błaszczuk B., Sulima J., 2008. Zawartość azotanów (III) i (V) w wybranych gatunkach warzyw i ziemniakach dostępnych w handlu w Olsztynie w latach 2003–2004. Bromat. Chem. Toksykol. – HLI, 67–71.

Orlikowski L.B., Skrzypczak C., Wojdyła A., Jaworska-Marosz A., 2002. Wyciągi roślinne i mikroorganizmy w ochronie roślin przed chorobami. Zesz. Nauk. AR Kraków 387, 19–32.

PN-90/A-75101/ 03. Oznaczanie zawartości suchej masy metodą wagową.

PN-90/A-75101/07. Oznaczanie zawartości cukrów i ekstraktu bezcukrowego.

PN-90/A -75101/11. Oznaczanie zawartości witaminy C.

Rogowska M., 2003. Bioczos płynny w ochronie wczesnych warzyw przed szkodnikami. Prog. Plant Protection/Post. Ochr. Roślin 43 (2), 880–883.

Rozporządzenie Ministra Zdrowia z dnia 22 grudnia 2004 r. Dziennik Ustaw nr 2, poz. 9. 2005. w sprawie maksymalnych poziomów zanieczyszczeń chemicznych i biologicznych, które mogą znajdować się w żywności, składnikach żywności, dozwolonych substancjach dodatkowych, substancjach pomagających w przetwarzaniu albo na powierzchni żywności.

Szafirowska A., Kłosowski S., 2008. Wykorzystanie allelopatycznych właściwości roślin w uprawie warzyw. Inż. Rol. 1, 117–122.

Uvah I., Coaker T., 1984. Effect of mixed cropping on some insect pests of carrots and onions. Ent. Exp. Appl.36:159–167.

Varis A.L., 1991. Effect of intercroping carrots and onions on damage caused by the carrot fly, (*Psila rosae* (F.) *Dipt., Psilidae*). J. Agric. Sc. Finland, 63, 411–414.

Wiech K., Jeleń A., 1995. Wpływ współrzędnej uprawy marchwi z cebulą na występowanie roślinożernej entomofauny. Mat. Ogól. Konf. Nauk. „Nauka Praktyce Ogrodniczej", AR Lublin, 371–373.

Wiech K., Wnuk A., Wojciechowicz-Żytko E., Jankowska B., 2009. Wpływ infrastruktury ekologicznej na agrofagi i organizmy pożyteczne w uprawach warzyw. Prog. Plant Protection/Post. Ochr. Roślin, 49 (3), 1124–1132

Wierzbicka B., Majkowska-Gadomska J., Pierzynowska-Korniak G., 2004. Wpływ metod uprawy na zawartość wybranych składników pokarmowych w korzeniach spichrzowych marchwi. Folia Univ. Agric. Stetin., Agricultura 239(95), 411–414.

WPŁYW EKOLOGICZNYCH METOD OCHRONY ROŚLIN PRZED POŁYŚNICĄ MARCHWIANKĄ (*Psila rosae*) NA WIELKOŚĆ I JAKOŚĆ PLONU KORZENI SPICHRZOWYCH MARCHWI (*Daucus carota* L.)

Streszczenie. We współczesnej ochronie roślin w coraz większym stopniu powraca się do metod niechemicznego zwalczania agrofagów. Dużą uwagę zwraca się na wzbogacenie bioróżnorodności agrocenoz. Zastosowanie współrzędnej uprawy różnych gatunków roślin, np. cebula, marchew, koper ogrodowy, fasola, facelia lub gorczyca, ogranicza liczebność szkodników. Metoda ta wprowadza dezorientację wizualną (mszyce), zapachową (połyśnica marchwianka) lub przywabia organizmy pożyteczne (bzygowate, biedronkowate). Doświadczenie założono w Ogrodzie Dydaktyczno-Doświadczalnym Uniwersytetu Warmińsko-Mazurskiego w Olsztynie, w sezonie wegetacyjnym 2009–2010. Przeprowadzono je na glebie brunatnej, klasy IV b, na redlinach, które przygotowano zgodnie z wymaganiami ekologicznej uprawy. Pierwszym czynnikiem badań było 6 odmian marchwi o zróżnicowanym okresie wegetacji: ‘Deep Purple F_1’, ‘Florida F_1’, ‘Interceptor F_1’, ‘Joba’, ‘Kazan F_1’, ‘Purple Haze F_1’. Drugi czynnik stanowiła proekologiczna ochrona marchwi, w której porównywano następujące metody: obiekt kontrolny – rośliny niechronione, ekologiczna ochrona biopreparatem Bioczos BR, zawierającym miazgę czosnkową w otoczce parafinowej w opakowaniu jednostkowym (kostce) 10 g, współrzędna uprawa marchwi z koprem ogrodowym odmiany ‘Szmaragd’ oraz współrzędna uprawa marchwi z cebulą siedmiolatką odmiany ‘Parade’. Współrzędna uprawa marchwi z koprem ogrodowym i z rozsadą cebuli siedmiolatki skutecznie ograniczała uszkodzenia korzeni spichrzowych przez larwy połyśnicy marchwianki. Zastosowane metody ochrony roślin różnicowały istotnie plon ogółem i handlowy marchwi. Wykazano korzystny wpływ Bioczosu BR i współrzędnej uprawy marchwi z cebulą siedmiolatką na plon ogółem i handlowy korzeni spichrzowych. Istotne zmniejszenie plonu uzyskano z uprawy współrzędnej marchwi z koprem ogrodowym. Zawartość suchej masy, cukrów ogółem i kwasu L-askorbinowego zależała od odmiany oraz jej współdziałania z metodą ochrony roślin. Większą zawartością suchej masy i kwasu L-askorbinowego charakteryzowały się korzenie odmian o zabarwieniu purpurowym ‘Deep Purple F_1’ i ‘Purple Haze F_1’. Zawartość azotanów (V) w korzeniach badanych odmian marchwi kształtowała się poniżej dopuszczalnych norm wyznaczonych przez Ministra Zdrowia.

Słowa kluczowe: *Daucus carota* L., biopreparat, uprawa współrzędna, skład chemiczny korzeni marchwi

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