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UTILIZATION OF NON-CHEMICAL (MECHANICAL AND PHYSICAL) METHODS TO CONTROL SOIL-BORNE PESTS IN ORGANIC STRAWBERRY PLANTATIONS

Summary

Pests living in the soil cause great damage to horticultural crops every year, particularly those managed by organic farming methods. The most damaging pests are larvae of the genera Melolontha. The purpose of the research was to develop and evaluate the efficacy of a variety of non-chemical methods to reduce the damage caused by the grubs on organic strawberry plantations. The used mechanical methods included soil ploughing and tilling, and hand picking grubs from damaged plants during inspection or manual weed control. The used physical methods were: soil and plants mulching with white agro-textile to limit egg laying and light traps to attract and collect adults. The results indicate even though each method alone is not sufficient to effectively protect organic strawberry crops against Melolontha spp grubs, their integrated use could drastically reduce the population pressure of the insect on the crop and thus increase also the efficacy of other methods, e.g. based on biocontrol mechanisms.
***Key words**: Melolontha spp., mechanical and physical pest control*

WYKORZYSTANIE METOD NIECHEMICZNYCH (MECHANICZNEJ I FIZYCZNEJ) DO ZWALCZANIA SZKODNIKÓW ŻYJĄCYCH W GLEBIE W TRUSKAWCE UPRAWIANEJ SYSTEMEM EKOLOGICZNYM

Streszczenie

Szkodniki żyjące w glebie, co roku powodują duże szkody w uprawach różnych roślin, także na truskawce, szczególnie prowadzonej systemem ekologicznym. Największe szkody powodują: pędraki chrabąszcza majowego Melolontha melolontha. Celem prowadzonych badań było opracowanie i ocena różnych niechemicznych metod między innymi mechanicznej: stosowanie orki i wszelkiego rodzaju zabiegów uprawowych maszynami z ostrymi elementami oraz wybieranie pędraków spod uszkodzonych roślin podczas lustracji lub ręcznego odchwaszczania plantacji. Z metod fizycznych zastosowano: agrowłókninę do przykrycia roślin i gleby (rodzaj bariery) by ograniczyć składania jaj do gleby przez samice chrabąszczy oraz pułapki świetlne do wabienia i odławiania chrabąszczy w celu redukcji liczby pędraków. Wyniki wskazują, że chociaż każda z tych metod nie wystarcza do skutecznego zabezpieczenia ekologicznych upraw truskawek przed uszkodzeniami powodowanymi przez larwy chrabąszcza majowego, to ich zintegrowane użycie mogłoby drastycznie zmniejszyć populację owadów w uprawach, a tym samym zwiększyć skuteczność innych metod, np. metody biologicznej, czyli stosowanie grzybów i nicieni entomopatogenicznych.
***Słowa kluczowe**: Melolontha spp., zwalczanie, mechaniczne, fizyczne*

1. Introduction

Poland is one of the leading producers of strawberries in the world (FAOSTAT, 2014). Strawberry plantations can be managed in accordance with Integrated Pest Management (IPM) standards, allowing the use of synthetic chemicals, or following organic farming methods. However, according to the EU Regulation 1107/2009, the availability of chemical plant protection products for control of soil-borne pest is very limited and, at present, there are no chemicals registered for this purpose in Poland [18]. Even though the control against the beetles in other areas, particularly in woods, helped to limit their number in the environment [11, 12], they have been causing great damage to the strawberry plantations, particularly those managed by organic farming methods. Studies have been performed trying to find non-chemical methods suitable for this method of production [22, 13]. Biological methods based on the use of entomopathogenic fungi have been also tested [9, 23] developing also methods to support the evaluation of their efficacy and inoculum persistence in the soil [3, 4]. Moreover, the use of entomopathogenic nematodes is also studied [19, 20], and some phytosanitary methods are proposed based on buckwheat cultivation [23].

The aim of the present study was to evaluate strategies to reduce the number of larvae and adults of *Melolontha spp*. using mechanical and physical methods. Experiments were carried out on strawberry plantations or in fields certified for organic farming, often characterized by high pest population.

2. Materials and methods

Trials were established in fields for organic strawberry production in 2015 and 2016 in two locations, Nowa Wola and Brzostówka (Voievodeship Lubelskie).

Two methods of control were tested: a mechanical method based on soil tilling with different machines before the establishment of the plantation and collection of larvae during hand weeding, and a physical control method based on the use of mulching or traps.

Ploughing and tillage using sharp-edged machinery, such as a tiller and saucers, was carried out during the preparation of the fields before plantation. The grubs emerging on the ground during the ploughing were collected by hand. In 2015 the treatment was applied on June 3 in Nowa Wola and on July 13 in Brzostówka, on fields where cereal mixtures were previously grown. In 2016 the

treatment was carried out in 6 fields: on 1 and 7 June in Nowa Wola (potato was the previous crop), 17 and 28 June in Brzostówka (clover was the previous crop) and 15 July and 20 September in Brzostówka (strawberry was the previous crop). The living larvae collected during the treatments were transported to the laboratory in special containers, fed with carrots, and after 3-4 days their survival was determined, counting live specimens.

Collection of larvae was also carried out during the normal hand-weeding process of plantations, from under damaged plants. In 2016, manual removal of larvae from damaged plants was evaluated at three dates: July 27th, August 3rd and August 18th on several strawberry plantations in both locations. Plants showing symptoms of damage from larvae were up-rooted and checked for the presence and abundance of larvae.

To create a barrier to egg laying, by female beetles, the soil after planting was covered with fabric-like mulching on the row during the period of mass flights of adults (Fig. 1). The trial was conducted in three plantations in New Wola in 2015, covering from May 8 to June 5, and in two plantations in 2016, from May 7 to May 31. The number of larvae in soil was assessed by the end of September in 2015 and end of August in 2016. For this purpose, the count was done on soil samples taken from a total of 2 m^2 of field area from each treatment (with or without mulching), by digging 32 wells having a size of 25cm x 25cm and depth of 30 cm (4 repetitions of 8 wells each).

Two kinds of light traps were utilized for trials carried out on two plantations, spaced about 1.5 km apart, located in Brzostówka: a light-headed trap (Fig. 2) with a battery-powered Led lamp with 10 W in 2015, and a trap with 400 W halogen lamp positioned beyond a white screen of a size 1.8x2.6 m in 2016 (Fig. 3). The light-headed traps were placed in the strawberry plantation at a distance of about 100 m from the place where adult were found feeding, while the traps with screens were positioned near these sites. The catches were made three times during the season: 20, 28, 29 May 2015 and 10, 11, 12 May 2016, from 19:00 to 24:00. The trapped beetles were taken to the laboratory to determine their number, sex and species.

Source: own work / Źródło: opracowanie własne

Fig. 1. The soil after planting plants was covered with fabric-like mulch

Rys. 1. Gleba przykryta agrowłókniną po posadzeniu roślin

Source: own work / Źródło: opracowanie własne

Fig. 2. The light-headed trap

Rys. 2. Pułapka świetlna

Source: own work / Źródło: opracowanie własne

Fig. 3. The white screen

Rys. 3. Biały podświetlany ekran

3. Results and Discussion

3.1. Mechanical methods of control

The effect of ploughing or tilling on the mortality of grubs differed considering the larval development stage. The larvae in plots not being tilled were considered as not possible to be damaged, thus the data presented are showing the effect of the treatment under different soil and infestation conditions. About 30 to 55% of larvae died after a week of breeding in laboratory (Table 1), with higher mortality observed in L_1-L_3 larvae as compared to L_4 (data not shown). A similar trial carried out in Austria [17], showed that up to 60-90% of larvae could be damaged and killed by this method. The obtained results provide further evidence that a substantial number of grubs may be mechanically damaged during tillage operations with sharp machinery and die directly during soil tillage or in subsequent days [14]. However, the efficacy of the method is deemed insufficient to reduce the damage to the plants under conditions of limited tillage [8] or when the pest population is high.

It has been found that during the monitoring of the plantation, a significant number of damaged plants can be detected and disposed, thus eliminating the feeding larvae (Table 2). In the trials, depending on the size of the population or the level of damage, from 1 to 6 larvae per 100 m^2 were removed. Considering the economical threshold level for this pest (1 larvae/2m^2), the data showed that not all fields could be considered heavily infested, thus providing an important information for the growers about the measures to be taken. Even though the method is labor-intensive, it resulted in a significant reduction in the number of larvae and is thus applicable to organic crops. Such method was advised to be used prior to the introduction of chemical agents [1, 23].

Table 1. Number of *Melolontha* spp. larvae L_1 – L_4 collected from eight fields after ploughing or tilling and their mortality after a week of laboratory breeding. Brzostówka, Nowa Wola, 2015-2016

Tab. 1. Liczba larw Melolontha spp w stadium L_1 - L_4 zebranych z ośmiu pól podczas orki oraz ich śmiertelność po tygodniu hodowli laboratoryjnej. Brzostówka, Nowa Wola, 2015-2016

Trials	Date of observation	Area monitored [m^2]	Number of larvae (L_1-L_4) *Melolontha* spp		Ratio of dead larvae
			Total collected	Dead	
Nowa Wola (field 1)	03.06.2015	6000	1800	720	40,0
Nowa Wola(field 2)	13.07.2015	7800	2600	1000	38,5
Nowa Wola (field 1)	01.06.2016	6750	360	176	32,8
Nowa Wola (field 2)	07.06.2016	6750	195	74	37,9
Brzostówka (field 1)	17.06.2016	4000	808	210	26,0
Brzostówka (field 2)	28.06.2016	4000	292	90	30,8
Brzostówka (field 3)	15.07.2016	4800	216	45	20,8
Brzostówka (field 4)	02.10.2016	5000	2300	600	26,1
Average		5478,6	1071,4	364,4	31,6

Source: own work / Źródło: opracowanie własne

Table 2. Number of grubs (*Melolontha* spp.) collected under damaged plants during monitoring of seven plantations. Brzostówka, Nowa Wola, 2016

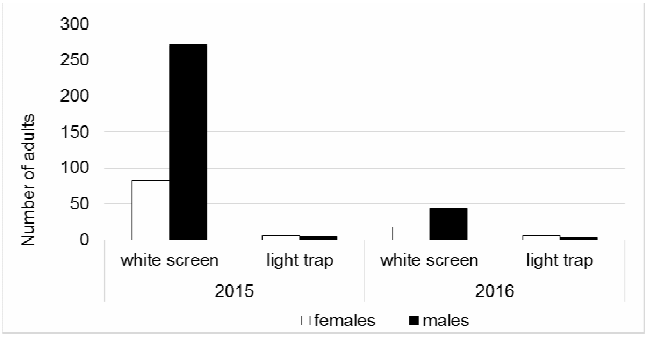
Tab. 2. Liczba larw (Melolontha spp.) zebranych podczas monitorowania uszkodzonych roślin na siedmiu plantacjach. Brzostówka, Nowa Wola, 2016

Location	Date of monitoring	Area under plants monitored [m^2]	Number of found grubs	Number of grubs per 100 m^2 of row
Brzostówka (field 1)	27.07.	800	91	11.4
Brzostówka (field 2)	27.07.	500	85	17.0
Nowa Wola (field 1)	27.07.	3500	166	4.7
Brzostówka (field 3)	3.08.	1482	62	4.2
Brzostówka (field 4)	18.08.	257	10	24.2
Nowa Wola (field 2)	18.08.	670	16	2.4
Nowa Wola (field 3)	18.08.	353	30	8.5
Average	--	1557	65.7	4.2

Source: own work / Źródło: opracowanie własne

3.2. Physical methods

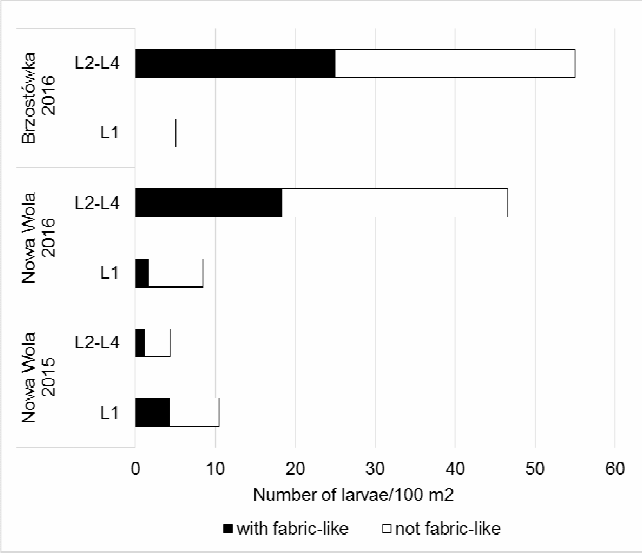
The efficacy in trapping adults was much higher for the traps having also a large white screen in comparison to those formed only by the light bulb (Fig. 4). Even though they were not positioned very close to each other (about 1.5 km apart) they were located in similar environment, in fields very close to an artificial wood characterized by species normally used by adults for feeding. It is worth noting that the majority of captures occurred at the beginning of the flight period, i.e. early May, which gives an additional indication about the possibility to increase the efficacy of this control measure. The traps with white screen attracted more males than females, while in the others a slightly higher number of females was found (Fig. 4). A possible interpretation of such result derives from the evening behaviour of males, in search of females [15]. The smaller traps could be less effective due to an insufficient light and the higher number of females could be due for being them positioned in the middle of the strawberry plantation, close to the place of laying eggs [15]. The inconsistency in the number of adults captured in the two seasons (in 2015, the adults caught were more than 5 times than in 2016 - Fig. 4) can be related to the biological cycle of the insect, which is characterized by a mass outbreak of beetles usually every 3-4 years [10]. It should also be mentioned that spring in 2016 was warmer than 2015, thus the period of adults' flight started at the end of April, which account for the slight anticipation of the captures. In the soil covered with fabric mulching during the period of adults' flight, nearly 2-3 fold less larvae were detected, particularly those of stage L_1, in comparison to unmulched soil (Fig. 5). In 2015, there were less L_2-L_4 larvae then L_1, while the opposite was found in 2016, both in covered and uncovered soil, which is consistent with the biological development cycle of the insect and with the results obtained from the traps trials (Fig. 4). The fabric mulch is normally utilized to protect plants against spring frosts and accelerate fruiting [16, 21]. Mulching has been found to reduce above ground insect infestation [5]. Other physical barriers have been considered to reduce the damage from soil-borne insects [2]. However, we have not found any report considering using fabric mulching as a physical barrier to reduce eggs laying by insects as we propose here.



Source: own work / Źródło: opracowanie własne

Fig. 4. Average number and gender of European cockchafer adults (*M. melolontha*) captured by the two kinds of light traps, Brzostówka 2015-2016

Rys. 4. Średnia liczba i płeć chrabąszcza majowego (M. melolontha) odłowionych przez dwa rodzaje świetlnych pułapek, Brzostówka 2015-2016



Source: own work / Źródło: opracowanie własne

Fig. 5. Number of larvae (Melolontha spp.) at different stages of development detected in the field covered with fabric mulch and uncovered. Brzostówka, Nowa Wola 2015-2016

Rys. 5. Liczba larw (Melolontha spp.) w różnych stadiach rozwojowych stwierdzonych na plantacji przykrytej agrowłókniną i nie przykrytej. Brzostówka, Nowa Wola 2015-2016

4. Conclusions

Mechanical and physical methods have shown to reduce the number of larvae and beetles of *Melolontha* spp. on organic strawberry plantations. Soil tillage reduced up to 50% the number of larvae in the soil. Plantation monitoring, at least 2-3 times per season, and collection of larvae from damaged plants further reduced their number. Light traps mounted during the period of mass flight on illuminated screens may contribute to a significant reduction of adults and thus of laid eggs by females. Row mulching with fabric mat also reduced the number of young larvae, creating a physical barrier to laying females.

Even though each method alone is not sufficient to effectively protect strawberry crops against *Melolontha* spp. grubs, their integrated use could drastically reduce the population pressure of the insect on the crop and thus increase also the efficacy of other methods, e.g. based on biocontrol mechanisms.

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