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HOLISTIC APPROACH TO CONTROL SOIL-BORNE PESTS IN ORGANIC ORCHARDS: THE CASE OF MAY BEETLE

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Abstract: The lack of plant protection products to control soil-borne pests in organic farming has resulted in Poland and several other EU countries in increasing damages by grubs of the European cockchafer (*Melolontha* sp.) to fruit orchards and plantations. We have developed a holistic strategy including various control methods and agronomical practices to control *Melolontha* spp. in organic strawberry plantations which can be potentially applied also to other fruit crops. The strategy includes measures that are targeting all the life stages of the pest' biological cycle. The results indicated that the such holistic strategy allows reducing the number of active grubs and the damage to plants.

Introduction: Damage of fruit plants by grubs of *Melolontha* sp. is becoming widely diffuse in several regions of the European Union due to limitations in the methods and products allowed in both agricultural and forestal areas (Keller 2000). Such situation has resulted in Poland in increasing damages by the European cockchafer grubs to organic strawberry plantations. Studies have been performed to control these grubs trying to find non-chemical methods suitable for organic farming, particularly based on the use of entomopathogenic fungi and nematodes (Łabanowska, Bednarek, 2011). However, the efficacy of these inocula were not sufficient to efficiently reduce the damage to plants. We have thus developed a holistic strategy that is enhacing the efficacy of the pest control based on several different methods targeting all life stages of the pest' biological cycle. We present here the major results of such strategy obtained on organic strawberry plantations characterized by high white grub population (up to 10 times the threshold level of intervention, which is 0.5 grub · m^{-2}, meaning up to 5 thousand grubs per ha).

Material and methods: Trials were established in fields dedicated to organic strawberry production in 2014-2016 in two locations, Nowa Wola and Brzostówka (Voievodship Lubelskie, Poland). Each trial was set with a randomized block design, with four repetitions.

Two control strategies were tested, both making use of different control methods: physical, mechanical, phytosanitary, biological. The first strategy consisted in four different practices: growing the soil with a pre-crop of buckwheat (*Fagopyrum esculentum*) followed by soil tillage using sharp-edged machinery during the preparation of the field before plantation. The plots were than treated with BCAs few days before planting and than again at spring time in the following

growing season. The second strategy integrated three control practices: a mechanical method based on soil tilling with different machines before the establishment of the plantation and collection of larvae during hand weeding afterward, a physical control method based on the use of mulching with fabric-like film applied in spring time on the inter-rows to reduce egg laying, and a biological method with application of BCAs in spring-summer.

In addition, catching of beetles was attempted with two kinds of light traps: a light-headed trap and a trap with 400 W halogen lamp positioned beyond a white screen of a size 1.8x2.6 m.

The assessment of the number of white grubs in the soil was carried out checking the soil gathered from 32 wells (each measuring 25cm x 25cm, depth 30cm), from the four repetitions. Evaluation of damaged plants was performed by counting the plants showing wilting and damage in the root system at the end of the growing season. Efficacy in both trials was calculated according to Abbot's formula. Data were analysed by ANOVA, after Bliss transformation in case of percentages, separating the means by Neuman's-Keuls test at $p<0.05$

Results: The implementation of agronomical practices aiming at reducing the population of white grubs before planting resulted in a quite effective reduction of plant damage during the first season after planting. The effect of ploughing or tilling, common to the two strategies, on the mortality of grubs differed considering the larval development stage, with about 30 to 55% of larvae died after a week of breeding in laboratory (Table 1). About 5 or 11 grubs per 100 m^2 were removed during the hand weeding of the plantation performed during the season (Table 1). In the soil covered with fabric mulching during the period of adults' flight, about 50% less larvae were detected (on average 20 or 5 larvae per 100 m^2, for stage L_2-L_4 or L_1, respectively) in comparison to not-mulched soil. This is showing that the method is effective in reducing egg deposition, while older larvae present on the site are not affected.

When considering the overall efficacy, under Strategy 1, the evaluation carried out in the first growing season (2015) in mid-summer (July-August) resulted in a complete absence of damaged plants (data not shown), and, at the end of the season, only about 11-12% of plants resulted damaged, without significant differences between the different BCAs tested (Table 2). The effect could thus be considered as the result of the agronomical practices. A significantly lower amount of damaged plants was observed after the BCAs treatment in comparison to the control during the second growing season, thus showing the activity of the fungal inocula. However, the efficacy of the treatments resulted not satisfactory. The Strategy 2 strongly reduced the damage to the plants, resulting in an efficacy in general above 70% (Table 2). The efficacy in trapping adults was higher for the traps having a large white screen in comparison to those formed only by the light bulb: the first method allowed to gather in only 2 hours an average of about 340 adults in 2015 (likely a gradation year) and 70 in 2016 while about 20 adults were caught with the second in both years. It is worth mentioning that the majority of captures occurred at the beginning of the flight period, e.g. beginning of May, and that the white screen attracted more males than females.

Discussion: Agronomical practices such as ploughing or tilling have been considered affecting the survival of grubs, but their efficacy differed considering the larval development stage, with higher mortality observed in L_1-L_3 larvae as compared to L_4 (Strasser & Schinner, 1996). These results are showing that a substantial number of grubs may be mechanically damaged during tillage operations and die during soil tillage or in subsequent days. Even though hand picking was used in the past and is labour intensive, it resulted in a significant reduction in the number of larvae and is thus recommendable to organic crops.

It appears that the combination of different agronomical methods is enhancing the efficacy of the biocontrol. The fungus *B. brongniartii* is considered the main natural enemy of *M. melolontha* due to its capacity of attacking all its development stages (Keller, 2000). However, an immediate effect of the fungus application should not be expected (Strasser 2004).

In conclusion, it can be stated that the holistic strategy, targeting the different biological stages of the insect with different methods can result in an effective protection from the European cockchafer. However, to achieve a satisfactory efficacy it is necessary to adapt the strategy to the environmental conditions and to apply it systematically for some years, due to the species phenological behaviour and length of its biological cycle.

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Image:

Table 1. Number of Melolontha spp. larvae collected from the fields after ploughing or tilling and during hand weeding.

Trials	Date of monitoring	Area monitored [m^2]	Number of larvae (L_1-L_4)		Ratio of dead larvae %
			Total collected	Dead	
After ploughing or tilling					
Nowa Wola	03.06.2015	6000	1800	720	40
Brzostówka	17.06.2016	4000	808	210	26
Average		5000	1304	465	33
During hand weeding					
				Number of grubs per 100 m^2 of row	
Nowa Wola	27.07. 2016	3500	166	4.7	
Brzostówka	27.07.2016	800	91	11.4	

Image 2:

Table 2. Effect of different BCAs in controlling the damage of strawberry plants from cockchafer grubs as a result of applying different control methods.

Treatment	2015	2016		
	Damaged plants (%)	Damaged plants (%)	Efficacy (%)	Grubs collected (n/m²)
	Strategy 1			
Control	14.3	40.0 a	-	1.2
B. bassiana	11.3	28.3 b	29.3	0.5
B. brongniartii	12.3	33.7 ab	16.0	1.9
	Strategy 2			
Control	-	45.2 a	-	1.63
B. bassiana	-	11.5 b	74.5	0.50
B. brongniartii	-	14.7 b	67.5	0.50

Disclosure of Interest: None Declared

Keywords: Biocontrol, European cockchafer, mechanical methods, phytosanitary practices