MANAGEMENT AND CONTROL OF *AGRILUS AURICHALCEUS* REDT. (COLEOPTERA: BUPRESTIDAE) IN BIOLOGICAL RASPBERRY PRODUCTION

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Abstract

The study was carried out in a raspberry plantation (2013-2015) in the experimental field of the Institute of Agriculture – Kyustendil. The purpose of this study is to investigate the effect of organic fertilizer application on the stock larvae of *Agrilus aurichalceus* and population management, using biological plant protection products. According to the results of this study, it has been proved that fertilizing with organic fertilizers has a reductive effect on the survival of the *A. aurichalceus* population and does not affect the population of the larval endoparasitoid *Ttrastichus heeringi* in the cultivars 'Willamette' and 'Lyulin'. The relationships between *A. aurichalceus* and *T. heeringi* in the conditions of organic raspberry production have been studied. The established degree of parasitism of the larvae by *T. heeringi* (32.7-68.4%) is capable of reducing and controlling the population of *A. aurichalceus* in the 'Willamette' without chemical control. Two treatments with bioinsecticides have been carried out for the protection of plants from cultivar 'Lyulin' due to a significantly lower degree of parasitism (18.1-50.0%). The most effective insecticides to the control of adults of *A. aurichalceus* have been identified: Pyrethrum FS EC-0.05% and NeemAzal®-T/S - 0.3 %. The adult control scheme involves two treatments with bioinsecticides of infested shrubs. The first treatment should be done during the buttoning, the second treatment during the mass flight of beetles (only at an established density of 3-4 beetles/m^2).

Keywords: organic fertilizers, biological control, Rose stem girdler.

Introduction

Rose stem girdler (*Agrilus aurichalceus* Redtenbacher 1849) is one of the most important pests of raspberries in organic fruit production in all regions of Bulgaria. Its population density fluctuates strongly during vegetation under the influence of various factors: abiotic, biotic, agricultural, organisational and economic resources (Zapryanov 1980, Tsalbakov 1983, Karov et al. 2006, Tsolova and Stoyanova 2007, Ivanov, 2009). Particular interest presents the parasitoids of this insect pest, as they are not yet well studied. In Bulgaria *Tetrastichus heeringi* Delucchi (Hymenoptera: Eulophidae) is reported to be a parasitoid on the larvae of *Agrilus cuprescens* Men of Staikov (1954), Nikolova (1968), Velcheva et al. (2008), Vétek and Pénzes (2004, 2005). Studies on the biological features of *T. heeringi* in rose plantation were carried out by Zapryanov (1980) and Tsalbukov (1983). Parasitoid is designed to reduce the natural host population by about 50% and in some years above these values Vétek, Thuróczy and Pénzes (2007).
The aim of the study is to investigate the density of the wintering population of larvae of *A. aurichalceus* under the conditions of organic raspberry production.

Material and methods

The investigations were carried out during the period 2013-2015 at the Institute of Agriculture in Kyustendil, Department of Berries in Kostinbrod. The organic raspberry plant was created in 2010 with the 'Willamette' and 'Lyulin' cultivars. The experience was set by block method in four variants and four replicates. The drip irrigation was applied at 80% evapotranspiration. Four types of liquid organic fertilizers were tested, applied three times by foliar treatment of the plants during the buttoning, the beginning of flowering and the formation of the green joint; in the following variants: V0 (untreated); V1 (Humustim - 100 mL/da); V2 (Haemosim bio N5 – 5L/da + Haemofol H4 - 400 mL) and V3(Biohumax® - 1000 mL/da). The between rows were maintained by mowing and mulching.

The experimental plants were grown, using authorized fertilizers and plant protection products according to Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. The degree of attack by insect pest on the stem was determined annually 2 times a month (May-October) on 100 shoots of each variant. The material for determining the wintering stock of harmful and beneficial species was collected during January and February by cutting of shoots different ages to the soil surface and processed in laboratory conditions.

Under field conditions during 2014-2015, a test of biological efficacy of pyrethrum and azadirachtin was carried out: pyrethrum in three concentrations (0.05, 0.06, 0.08%) and azadirachtin in 0.25; 0.30; 0.35%; in four replication. The data was converted into per cent mortality by using following formula given by Abbott (1925) and modified by Henderson and Tilton (1955). The statistical analysis of the results obtained was done by two-factor dispersion analysis (ANOVA).

Results and discussion

The meteorological characteristics of the area during the 2013-2015 give the data in Table 1. They can be considered as one-sided with these characteristic areas but with their respective specific features.

Data analysis allows to note that the average daily temperature during the flowering of plants of remontant raspberry cultivars was optimal. The precipitation was below the normal, the air humidity was for the entire vegetation season. The flowering in the cultivar ′Willamette′ was over 20 day, and in the cultivar ′Lyulin′ over 60 days.

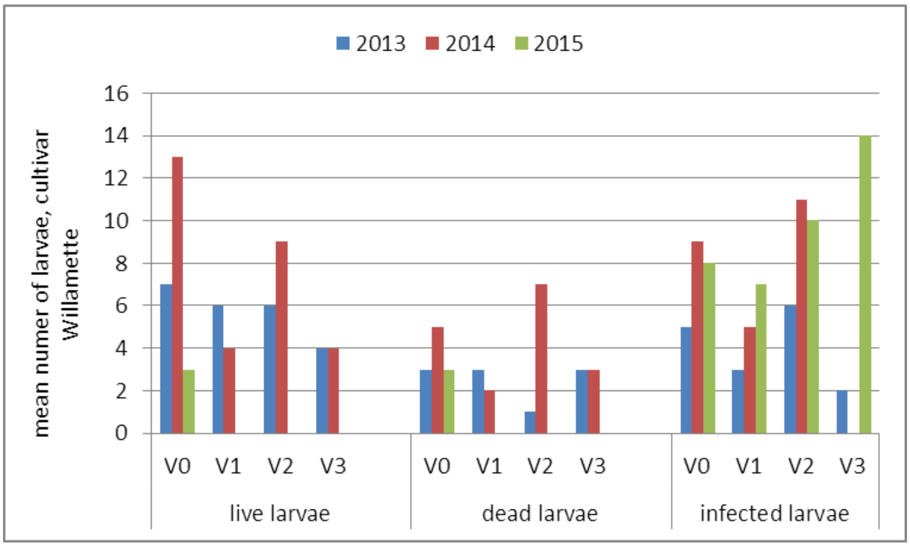

Figure 1. Over-wintering stock of *Agrilus aurichalceus* larvae in cultivar ′Willamette′ in 2013-2015

The wintering stock of larvae was presented in Figure 1. The survival of the population ranged widely from 46.9% (2013) to 5.3% (2015). In terms of experience, the number of wintering larvae was highly variable and was influenced by the climatic conditions of the area. The number of wintering larvae was analyzed by fertilization variants, it was rather diverse, with variants (V1 and V2) being almost the same (12.2%) for 2013-2014. In the cultivar ′Lyulin′ (Figure 2), during the study period, a pronounced tendency to decrease the population of the species by about twice from 57.9% to 32% was observed. It is interesting to note that during the three years of the study, the population of live larvae is highest in Humustim (V1) fertilization and with lower values in Biohumax® fertilization (V3).

The parasitism of larvae was highest (50%) in 2014, and twice lowers in 2013 (18.1%).

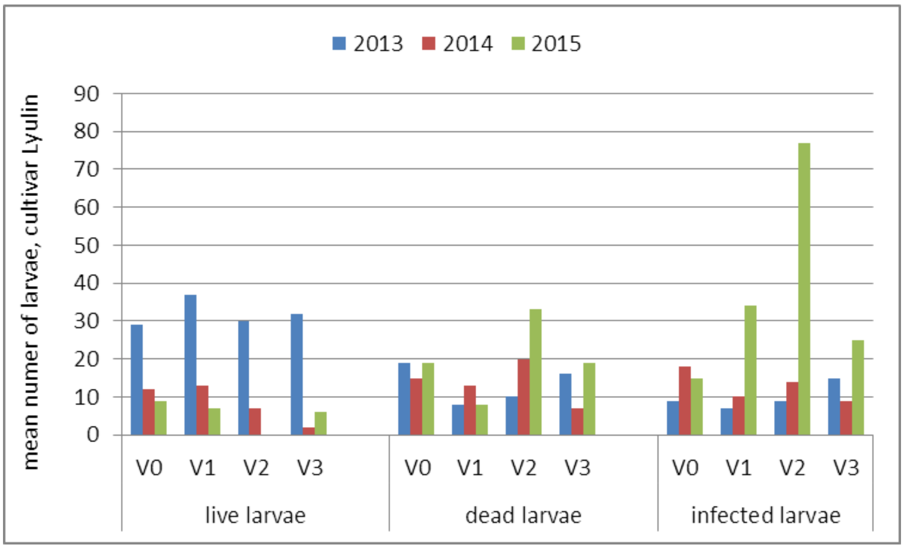

Figure 2. Over-wintering stock of *Agrilus aurichalceus* larvae in cultivar 'Lyulin' in 2013-2015

Tables 2 and 3 present the data from the statistical analysis of the results of observations on the wintering stock of live, dead and infected larvae of *A. aurichalceus.* in the cultivars 'Willamette' and 'Lyulin' in 2013-2015. It is evident that the period of study (years) affected the stock of live larvae of A. aurichalceus in the cultivars 'Willamette' and 'Lyulin'. The differences between the fertilization variants during years of research have been statistically significant. There were no significant differences between the different variants for a given year in both cultivars. The mortality rate of the *A. aurichalceus* population is not directly dependent on fertilization.

Table 2. Two-factor dispersion analysis (ANOVA) of the effect of the fertilization variants on the over-wintering stock of *Agrilus aurichalceus* larvae in cultivar Willamette in 2013-2015

live larvae						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Fertilization	44,66667	3	14,88889	3,748252	0,079128	4,757063
Years	98,16667	2	49,08333	12,35664	**0,007455**	5,143253
Error	23,83333	6	3,972222			
Total	166,6667	11				
dead larvae						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Fertilization	7	3	2,333333	0,8	0,537552	4,757063
Years	24,5	2	12,25	4,2	0,072338	5,143253
Error	17,5	6	2,916667			
Total	49	11				
parasitism of *Agrilus aurichalceus* larvae by parasitoid *Ttrastichus heeringi*						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Fertilization	31,33333	3	10,44444	0,801706	0,536774	4,757063
Years	67,16667	2	33,58333	2,577825	0,155585	5,143253
Error	78,16667	6	13,02778			
Total	176,6667	11				

The organic fertilizers have no effect on the infected larvae by *T. heeringi* in both cultivars. The reported low population of rose stem girdler in 2015 in cultivar 'Lyulin' is most likely due to the two-fold plant treatments carried out in 2014, resulting in the species population being reduced to less than 10%, and in the cultivar Willamette to the high degree of parasitism (68.4%) by the endoparasitoid *T. heeringi*.
According to the conducted studies on the relationships between A. aurichalceus and T. heeringi have shown that the degree of parasitism must be over 70% to be able to reduce the *Agrilus* population.

Table 3. Two-factor dispersion analysis (ANOVA) of the effect of the fertilization variants on the over-wintering stock of *Agrilus aurichalceus* larvae in cultivar Lyulin in 2013-2015

live larvae						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Fertilization	84,66667	3	28,22222	2,247788	0,183201	4,757063
Years	1684,667	2	842,3333	67,0885	**7,84E-05**	5,143253
Error	75,33333	6	12,55556			
Total	1844,667	11				
dead larvae						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Fertilization	213,5833	3	71,19444	1,601875	0,284932	4,757063
Years	104,6667	2	52,33333	1,1775	0,370352	5,143253
Error	266,6667	6	44,44444			
Total	584,9167	11				
parasitism of *Agrilus aurichalceus* larvae by parasitoid *Ttrastichus heeringi*						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Fertilization	31,33333	3	10,44444	0,801706	0,536774	4,757063
Years	67,16667	2	33,58333	2,577825	0,155585	5,143253
Error	78,16667	6	13,02778			
Total	176,6667	11				

These results required two bioinsectice treatments (Tsolova and Stoyanova, 2007). The results of the application of Pyrethrum FS EC® and NeemAzal-T/S against adults showed that the effect of three single application doses (0.05%, 0.06% and 0.08%) was unsatisfactory.The efficacy of Pyrethrum FS EC® in the second treatment was highest at a concentration of 0.05% and during the two years of the experimental period. Similar results were obtained at a concentration of 0.06%, but the differences were negligible. The single treatment with Neemazal-T/S 0.3% against rose stem girdler also showed unsatisfactory results from 58.8 (2014) to 69.1% (2015) and double (90.1-91.8%). Double treatment with Pyrethrum FS EC® at a concentration of 0.05% and Neemazal-T/S -0.3% showed efficacy 90% over the years of the study. The results of the obtained data allow the two products to be used for pest control in integrated and organic raspberry production (Table 4).

Conclusions

The duration of fertilization with organic fertilizers under the conditions of organic production of raspberries has a reductive effect on the survival of *A. aurichalceus*. The tested fertilization variants do not have a direct influence on the mortality of A. aurichalceus and the infestation of the larvae by *T. heeringi* in the cultivars Willamette and 'Lyulin'. The endoparasitoid *T. heeringi* has been shown to exhibit cultivar selectivity. The cultivar Willamette was characterized by a high degree of parasitism as the 'Lyulin' by low. It was found that the rose stem girdler can be successfully controlled with two treatments (pre-blossoming and post-blossoming) with Pyrethrum FS EC® - 0.05% and Pyrethrum FS EC® 0.3%. The application of single post-blossoming treatment with botanical insecticides does not produce good results.

Table 4. Efficacy of bioinsecticides against *Agrilus aurichalceus* adults under field conditions in 2014-2015

Variants	Conc. %	Number of treatments					
		Single treatment		Efficacy %	Double treatment		Efficacy %
		Damaged shoots, number			Damaged shoots, number		
		before treatment	after treatment		before treatment	after treatment	
2014							
Untreated	0.00	21.2	9.2	-	11.4	3.9	-
Pyrethrum FS EC®	0.05	16.4	6.3	61.6	14.7	0.4	90.5
	0.06	13.3	5.2	60.9	10.4	0.6	90.9
	0.08	10.6	4.2	60.1	5.7	1.3	87.4
Untreated	0.00	10.6	4.7	.-	7.1	2.0	-
Neemazal-T/S	0.25	9.4	3.9	58.5	8.4	1.5	85.2
	0.30	10.2	4.2	58.8	5.1	0.3	93.7
	0.50	9.6	4.1	63.2	6.6	1.4	90.1
2015							
Untreated	0.00	13.1	8.5	-	9.1	4.4	-
Pyrethrum FS EC®	0.05	14.4	9.9	61.8	7.6	0.5	91.2
	0.06	10.3	8.8	64.4	10.8	0.9	90.1
	0.08	9.9	6.4	59.9	12.5	1.2	90.4
Untreated	0.00	12.3	6.8	-	10.2	5.5	.-
Neemazal-T/S	0.25	11.1	5.6	63.1	10.3	1.9	86.9
	0.30	9.9	3.4	69.1	5.3	0.4	91.8
	0.50	7.7	5.5	58.8	7.6	1.2	89.6

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