Control of *Agrilus aurichalceus* Redt. (Coleoptera: Buprestidae) in biological raspberry production

Elena Tsolova[1], Lilyana Koleva[2*]
[1]Institute of Agriculture, Kyustendil
[2]University of Forestry, Sofia
*Corresponding author: *liljanamarkova@abv.bg*

Citation
Tsolova, E & Koleva, L. (2019). Control of *Agrilus aurichalceus* Redt. (Coleoptera: Buprestidae) in biological raspberry production. *Rastenievadni nauki*, 56(4), 26-31

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 was 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 was 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%) was 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 of cultivar ′Lyulin′ due to a significantly lower degree of parasitism (18.1-50.0%). The bioinsecticides Pyrethrum FS EC-0.05% and NeemAzal®-T/S - 0.3% were applied for control of adults. The adult control scheme involves two treatments with bioinsecticides of infested shrubs. The first treatment should be applied 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

The organic farming is advisable as an alternative to the conventional management in order to reduce the excessive use of pesticides, which have serious effects on the environment and cause immediate and long term damage to ecosystems (Rivera-Becerril et al., 2017; Rao & Ravishankar, 2019).

Frias-Moreno et al. (2019) found that raspberries produced with organic management contained higher levels of phytochemicals and antioxidant capacity than conventionally produced fruits. Raspberries have shown greater antioxidant capacity with organic fertilization management (Jin et al., 2012). Therefore, further investigations are needed, even concerning the improvement of pest and diseases control and long-term sustainability of organic systems and long-term sustainability of organic systems.

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 & 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 & Pénzes, 2004, 2005). Zapryanov (1980) and Tsalbukov (1983) carried out studies on the biological features of *T. heeringi* in rose plantation. Parasitoid is designed to reduce the natural host population by about 50% and in some years above these values (Vétek et al., 2007).

The aim of the study was to investigate the effect of organic fertilizer application of the density of the wintering population of larvae of *A. aurichalceus* under the conditions of organic raspberry production and the management of the adult population using biological pesticide

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 – 5 l/da + Haemofol H4 - 400 ml) and V3(Biohumax® - 1000 ml/da). The rows in between 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. The shoots were cut lengthwise and all larvae were removed, divided into groups: live, dead and parasitized. Some of them were left to grow to adult insects and then their species was identified.

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 (4x5m^2), with an area of 20 m^2 for each variant. 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).

RESULT AND DISCUSSION

During the survey period, no significant deviations from the weather conditions were observed. 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, although the air humidity was optimal for the entire vegetation season. The flowering in the cultivar ′Willamette′ was over 20 day, and in the cultivar ′Lyulin′ over 60 days.

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 parasitized 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 lower in 2013 (18.1%).

Tables 1 and 2 present the data from the statistical analysis of the results of observations on the wintering stock of live, dead and parasitized larvae of *A. aurichalceus* in the cultivars ′Willamette′ and ′Ly-

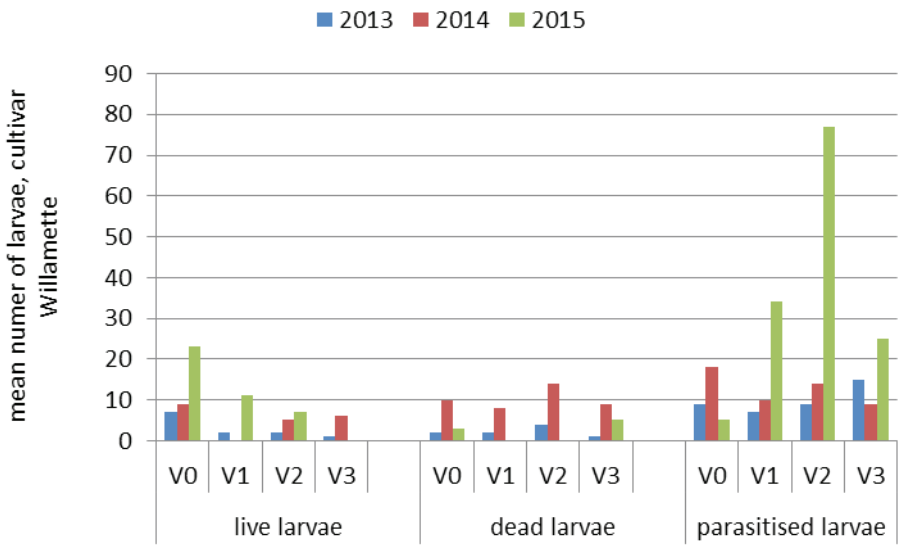

Figure 1. Over-wintering stock of *Agrilus aurichalceus* larvae in cultivar 'Willamette' in 2013-2015

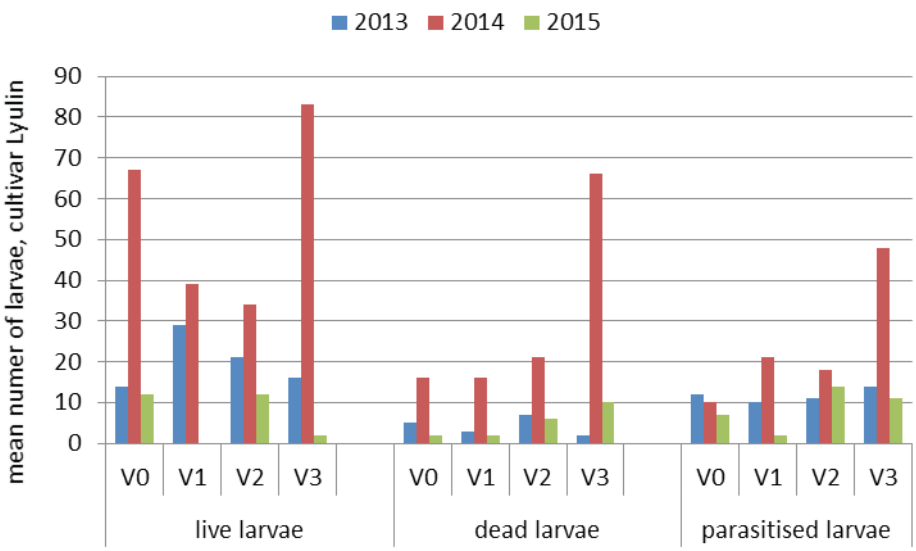

Figure 2. Over-wintering stock of *Agrilus aurichalceus* larvae in cultivar 'Lyulin' in 2013-2015

ulin' in 2013-2015 It is evident that the stock of live larvae of *A. aurichalceus* in the cultivars. It is evident that the stock of live larvae of *A. aurichalceus* in the cultivars 'Willamette' and 'Lyulin'during the period of study (years) is decreasing. The differences between the fertilization variants during years of research have been statistically significant. There were no significant differences between the different variants in a given year in both cultivars. The mortality rate of the *A. aurichalceus* population is not directly dependent on fertilization. The organic fertilizers have no effect on the parasitized 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*.

Joshi et al. (2015) find that the using of vermicompost is an effective organic fertilizer and biocontrol agent. The study suggested that treatments of humic acids, plant growth promoting bacteria

Table 1. 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				

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 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				

can be used for a sustainable agriculture discouraging the use of chemical fertilizers.

According to the studies by Tsolova and Stoyanova (2007) 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. Our results required two bioinsectice treatments. 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 3).

CONCLUSIONS

• The tested fertilization variants do not have a direct influence on the mortality of *A. aurichalceus*

Table 3. 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

and the parasitisation 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.

REFERENCES

Calbukov, P. (1983). Vzajmootnosheniia mezhdu agrilusa po maslodajnata roza i tetrastihus heeringi. *Rastitelna zashtita*, *7*, 2-3 (Bg).

Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91

Frias-Moreno, M. N., Olivas-Orozco, G. I., Gonzalez-Aguilar, G. A., Benitez-Enriquez, Y. E., Paredes-Alonso, A., Jacobo-Cuellar, J. L., & Parra-Quezada, R. A. (2019). Yield, Quality and Phytochemicals of Organic and Conventional Raspberry Cultivated in Chihuahua, Mexico. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *47*(2), 522-530.

Henderson, C.F. & Tilton, E. W. (1955). Tests with acaricides against the brow wheat mite. *Journal of Economic Entomology*, *48*,157-161.

Ivanov, A. (2009). Biologichno proizvodstvo na plodove ot niakoi ovoshtni vidove. Sofiia, Dionis, p. 255 (Bg).

Jin P, Wang SY, Gao H, Chen H, Zheng Y, Wang CY. (2012). Effect ofcultural system and essential oil treatment on antioxidant capacity in raspberries. Food Chemistry 132(1), 399-405.

Joshi, R., Singh, J., & Vig, A. P. (2015). Vermicompost as an effective organic fertilizer and biocontrol agent: effect on growth, yield and quality of plants. *Reviews in Environmental Science and Bio/Technology*, *14*(1), 137-159.

Karov, S., Mitov, P., Andreev, R., & Karov, S. (2006). Biologichno proizvodstvo na malini. Asociaciia za biologichno zemedelie „Ekofarm“, Plovdiv, p.30 (Bg).

Rao, A. P., & Ravishankar, S. (2019). Alternatives to Pest and Disease Control in Preharvest, and Washing and Processing in Postharvest Levels for Organic Produce. In *Safety and Practice for Organic Food* (pp. 213-226). Academic Press.

Rivera-Becerril, F., van Tuinen, D., Chatagnier, O., Rouard, N., Béguet, J., Kuszala, C., ... & Martin-Laurent, F. (2017). Impact of a pesticide cocktail (fenhexamid, folpel, deltamethrin) on the abundance of Glomeromycota in two agricultural soils. *Science of the Total Environment*, *577*, 84-93.

Tsolova, E., & Stoyanova, N. (2007). Biological peculiarities of Tetrastichus heeringi del (Hymenoptera: Eulophidae) and its role in regulating the density of Agrilus ribesi schaffer (Coleoptera: Buprestidae). *Plant Science*.

Velcheva, N., Baeva, G., Bakardzhieva, N., Colova, E., Ivanova, M., & Cenova, M. (2008). Rakovodstvo za integrirano upravlenie na vreditelite pri loza i iagodoplodni kulturi. MZH, NSRZ, 1-96 (Bg).

Vétek, G., & Pénzes, B. (2004). The occurrence of raspberry mosquito (Resseliella theobaldi Barnes) and rhubarb (Agrilus aurichalceus Redt.) In various cultivated raspberry plantations. 50th Scientific Days of Plant Protection, 24-25 February 2004, Budapest. *Summaries of lectures*, 67 (Hu).

Vétek, G., & Pénzes, B. (2005, August). New data about the damage and life cycle of Rose stem girdler (Agrilus cuprescens Ménetriés). In *5th International Conference of PhD Students. University of Miskolc, Hungary* (pp. 14-20).

Vétek, G., Thuróczy, C., & Pénzes, B. (2007). Some important notes on the parasitoids of raspberry cane midge, *Resseliella theobaldi*, and rose stem girdler, Agrilus cuprescens. In *6th Workshop on Integrated Soft Fruit Production* (pp. 24-27).

Zaprianov, A. (1980). The study of the features of biology and the role of the larval parasite Ttrastichus heeringi Del (*Hymenoptera: Eulophidae*) in reducing the number of agrilus oilseed-Agrilus cuprescens Men (*Coleoptera: Buprestidae*) Q: The study of predators and parasites of the pentafoss. *Reports of the International Symposium*, NAPS, 25-27 (Ru).