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POSSIBILITY OF GYPSY MOTH CONTROL IN CERTIFICATED FORESTS BY CHEMICAL INSECTICIDES OF THE THIRD GENERATION

Mara Tabakovic-Tosic*, Snezana Rajkovic,
and Vesna Golubovic-Curguz

Institute of Forestry, Kneza Viseslava 3, Belgrade, Serbia.
*E-mail: mara.tabakovic@gmail.com

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Abstract

In certificated forest ecosystems in Serbia, *Bacilus thuringiensis* ssp. *kurstaki* insecticides are well-accepted and most widely used pesticides for control of one of the most important economically harmful defoliators of *Lepidoptera* order – gypsy moth (*Lymantria dispar* Linne, 1758), in progradation phase, when number of pests is relatively small. When number is greater, it is assumed that so-called "soft" ecotoxicologically favourable preparations Avaunt®, Alverde®, Coragen®, registered for application in agriculture, but not in forestry, can be used for inhibition of multiplication. The experiments of biological efficacy of those pesticides were established in the period 2009–2010, during the third larval instar of the gypsy moth. From the beginning of feeding till the end of the two groups of experiments the caterpillars were fed with natural (Pedunculate oak leaves) and synthetic food, but from the third instar the food was shortly soaked in water solutions of the analysed doses of the preparation. Results of laboratory studies of biological efficiency of above preparations showed that they have preconditions for application in forest ecosystems. The high biologic efficiency (90.52% and 100% for Avaunt®, 99.53% and 100% for Coragen®, 97.16% and 100% for Alverde®), mechanism of rapid inhibition of larvae feeding, and thereby inhibition of leaf mass damage, resistance to water rinsing, high selectivity, and small quantities of application, anticipated a bright future for them.

Key words: Avaunt®, Alverde®, Coragen®, biological efficiency.

Introduction

The rapid growth of the world population, accelerated industrialisation and urbanisation, imposed the need for thinking about the use and management of forests in a completely new way.

Forest certification is one of the fastest growing methods which can be used for the adaptation of forestry to the modern concept of "sustainable management", by meeting the requirements of the FSC (Forest Stewardship Council) standard. There is a general understanding in the world and in this country that the management of the forest resources should be sustainable, economically profitable, ecologically acceptable and socially justified, which also implies the improvement of the methods of work and development of responsibility. By joining the process of forest certification, Serbia was obligated to meet the principles of FSC policy in the use of pesticides (Forestry Stewardship Council Pesticides Policy).

In certificated forest ecosystems in Serbia, biological insecticides based on *Bacillus thuringiensis* var. *kurstaki* (*Btk*) have been generally accepted and lately most applied pesticides in the suppression of one of the most important economically harmful species of defoliators of *Lepidoptera* order – the gypsy moth (*Lymantria dispar* L.) during its progradation phase, when the density is low (Tabakovic-Toshic 2006). This is in correlation with the fact that their biological efficacy is never 100% and that a part of the target population always remains alive. During the culmination phase of the outbreak, when the density of the target insect is maximal (several tens of thousands of egg masses per hectare), if biological preparations are applied even with the excellent efficacy, the part of the population which remains alive often causes the damage to such an extent that, at the first glance, it makes the efficacy of the preparation doubtful (Tabakovic-Toshic 2005).

Btk insecticides which are used for the control of gypsy moth show the best efficacy on the younger larval instars (L_1 and L_2). The older instars require higher lethal doses, so very often the applied rates of the preparation cause sublethal effects and the loss is even greater than one caused by the larvae in the untreated areas, because one of the consequences of sublethal doses is the prolonged larval development. This fact is especially emphasised during the unfavourable meteorological conditions which lead to prolonged hatching and to washing down of a part of the applied preparation. As a consequence, the age structure of the treated population larvae is most often from L_1 to L_4, and the rate of the active ingredient is reduced so that it does not have the lethal potency (Tabakovic-Toshic 2005, 2008).

It is hypothesised that the above problems can be solved by using the chemical (biotechnical) insecticides of the third generation such as Avaunt®, Alverde® and Coragen®.

Material and Method

Avaunt® 15 SC (active ingredient – indoxacarb), Coragen® 20 SC (active ingredient – chlorantraniliprole) and Alverde® 240 SC (active ingredient – metaflumizone) are modern chemical (biotechnical) non-systemic pesticides of the third generation, active by ingestion, less by contact. Indoxacarb and metaflumizone inhibits the sodium ions entry into nerve cells, which paralyses the larvae and causes the cessation of feeding and insect death (US EPA 2009, Klein and Oloumi 2005). This mode of action requires no metabolism for toxicity to target insects. Chlorantraniliprole is a diamide insecticide. The mode of action of chlorantraniliprole is the activation of insect ryanodine receptors. This activation stimulates the release of calcium from the internal stores of smooth and striated muscle which causes impaired muscle regulation, paralysis and insect death (Ioriatti et al. 2009).

After foliar applications, most of the active ingredients remain on the leaf

Table 1. Variants (rates) of the applied preparations in the laboratory tests of their biological efficacy.

Code*	Name	Dose
1a, 1b	Avaunt® 15 SC	250 $ml.ha^{-1}$ + 750 $ml.ha^{-1}$ white oil + water up to 1000 $l.ha^{-1}$
2a, 2b	Coragen® 20 SC	200 $ml.ha^{-1}$ + 800 $ml.ha^{-1}$ white oil + water up to 1000 $l.ha^{-1}$
3a, 3b	Alverde® 240 SC	100 $ml.ha^{-1}$ + 900 $ml.ha^{-1}$ white oil + water up to 1000 $l.ha^{-1}$
4a, 4b	distilled water	1000 $l.ha^{-1}$

*a – natural food; b – synthetic food.

surface and a small amount penetrates into the leaf tissue. They are highly potent and active at low rates on target species, which are mainly Lepidoptera and also some Coleoptera and Diptera. The Reduced Risk Committee categorized indoxacarb, chlorantraniliprole and metaflumizone as the "reduced risk" pesticides.

The experiments of biological efficacy of pesticides presented in Table 1 were established in May 2009, February and April 2010, during the third larval instar of the gypsy moth. From the beginning of feeding till the end of the two groups of experiments the caterpillars were fed with natural (Pedunculate oak leaves) and synthetic food, but from the third instar the food was shortly soaked in water solutions of the analysed doses of the preparation (Table 1). During the experiments, temperature and light conditions were constant (temperature 21°C, light regime – 10 hours night, 14 hours a day) The potency was controlled 72, 144 and 216 hours after the establishment of the experiments, and the individuals which survived in the treated and control groups were monitored till the end of the development. All experiments were established in the complete random block pattern in four repetitions (Scheme 1), where the blocks for each variant present 3 Petri dishes with the corresponding number of larvae (15)

Scheme 1. Plan of experiments - the complete random block pattern in four repetitions.

I Blok			II Blok			III Blok			IV Blok		
Avaunt® 15 SC			Avaunt® 15 SC			distilled water			distilled water		
12*	**31**	**41**	**2**	**39**	**46**	**14**	**20**	**48**	**8**	**19**	**29**
Alverde® 240 SC			distilled water			Avaunt® 15 SC			Coragen® 20 SC		
1	**21**	**23**	**3**	**13**	**32**	**4**	**33**	**44**	**26**	**45**	**47**
Coragen® 20 SC			Coragen® 20 SC			Alverde® 240 SC			Alverde® 240 SC		
6	**22**	**35**	**11**	**15**	**24**	**10**	**28**	**42**	**5**	**7**	**25**
distilled water			Alverde® 240 SC			Coragen® 20 SC			Avaunt® 15 SC		
16	**17**	**30**	**27**	**38**	**40**	**9**	**34**	**43**	**18**	**36**	**37**

* number of Petri dish

(EPPO/OEPP 1990). The statistical processing consisted of the analysis of variance, the calculation of the mean value of the number of alive larvae, efficacy by Abbott (E), as well as the testing of the differences of mean values of survival (LSD test).

Results and Discussion

In the 2009 and 2010, the biological efficacy of chemical insecticides of the third generation (Avaunt®, Alverde®, Coragen®), were studied in the Institute of Forestry in Belgrade, in the aim of the maximal increase of biological efficacy in the suppression of gypsy moth (*Lymantria dispar*) outbreak at the density when the application of the microbiological insecticide does not produce the satisfactory results. The study results are presented in Tables 2 and 3.

In laboratory conditions, 144 hours after the experiment was established, in 2009 and 2010 respectively, the best biological efficacy was attained by Avaunt® 15 SC (100%), then by Alverde® 240 SC (97.72 and 99.52%), and somewhat lower by Coragen® 20 SC (96.55 and 98.99%). All caterpillars were fed with natural food.

After 216 hours, this group showed a maximum of 100% biological efficiency. Biological efficiency in the experimental group with synthetic food, was slightly lower for all insecticides (Table 2). The same conclusions were

Table 2. Biological efficacy of the tested insecticides in the suppression of the third larval instar of the gypsy moth (experiments performed in 2009 (a) and 2010 (b)).

a)

Code	Number of alive larvae per repetition								X mean		E by Abbott, %	
	I		II		III		IV					
	a	b	a	b	a	b	a	b	a	b	a	b
72 hours after the test establishment												
1	0.0	8.3	0.0	9.3	0.0	6.3	0.0	6.3	0.0	7.6	100	47.40
2	3.0	14.0	2.7	12.7	2.0	12.0	6.0	11.7	3.4	12.6	76.41	12.76
3	3.0	11.0	1.3	14.7	0.3	14.0	3.7	12.7	2.1	13.1	85.65	9.29
4	15.0	14.7	15.0	13.7	15.0	14.3	13.0	15.0	14.5	14.4		
144 hours after the test establishment												
1	0.0	1.7	0.0	6.7	0.0	2.7	0.0	2.0	0.0	3.2	100	77.19
2	0.3	0.7	0.3	1.0	0.0	1.7	1.3	0.0	0.5	0.8	96.55	94.24
3	0.0	4.7	0.0	4.0	0.0	2.7	1.3	3.3	0.3	3.2	97.72	78.02
4	15.0	14.7	15.0	13.7	15.0	14.3	13.0	15.0	14.5	14.4		
216 hours after the test establishment												
1	0.0	0.0	0.0	1.7	0.0	0.3	0.0	0.3	0.0	0.6	100	95.93
2	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.5	100	96.53
3	0.0	0.7	0.0	1.0	0.0	0.0	0.0	0.3	0.0	0.5	100	96.53
4	15.0	14.7	15.0	13.7	15.0	14.3	13.0	15.0	14.5	14.4		

b)

Code	Number of alive larvae per repetition								X mean		E by Abbott, %	
	I		II		III		IV					
	a	b	a	b	a	b	a	b	a	b	a	b
72 hours after the test establishment												
1	2.7	14.0	3.0	13.7	2.7	14.0	1.3	13.7	2.42	13.85	83.87	7.67
2	2.7	13.3	3.0	12.3	2.0	14.3	3.7	15.0	2.85	13.72	81.00	8.53
3	6.0	14.0	1.3	15.0	1.3	13.0	2.0	14.3	2.65	14.08	82.33	6.13
4	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0		
144 hours after the test establishment												
1	0.0	13.0	0.0	11.0	0.0	14.0	0.0	11.3	0.00	12.32	100	17.04
2	0.3	1.7	0.0	4.0	0.0	6.7	0.3	5.7	0.15	4.52	98.99	69.56
3	0.0	7.0	0.0	9.7	0.0	9.7	0.3	10.3	0.07	9.17	99.52	38.25
4	15.0	14.7	15.0	14.7	15.0	15.0	14.7	15.0	14.92	14.85		
216 hours after the test establishment												
1	0.0	1.3	0.0	1.7	0.0	1.3	0.0	1.3	0.00	1.40	100	90.52
2	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.00	0.07	100	99.53
3	0.0	0.7	0.0	0.0	0.0	0.7	0.0	0.3	0.00	0.42	100	97.16
4	15.0	14.7	15.0	14.7	15.0	15.0	14.7	14.7	14.92	14.77		

1 – Avaunt® 15 SC; 2 – Coragen® 20 SC; 3 – Alverde® 240 SC; 4 – distilled water;
a – natural food; b – synthetic food.

made when the mean values for the period 2009-2010 were compared, since there were no great deviations in the values of the biological efficacy attained in the individual years per experimental groups, tested preparations, blocks and repetitions (Table 3).

In the third evaluation (216 hours after exposure), the analysis of variance showed statistically significant differences between all three tested preparations from the experimental group fed with the foliage and Coragen from the group fed with the synthetic food on the one hand , and both control groups, and other experiments with synthetic food on the other hand. LSD test showed that, at the end of the experiment, the study preparations formed four homogeneous groups within which there were no statistically significant differences (Table 4) of biological efficacy in the suppression the gypsy moth larvae.

Conclusion

The results of the laboratory studies of the biological efficacy of three chemical insecticides of the third generation (Avaunt®, Alverde®, Coragen®) in the suppression of gypsy moth (*Lymantria dispar*), showed that their biological efficacy was maximal. They have all

Table 3. Biological efficacy of the tested insecticides in the suppression of the third larval instar of the gypsy moth (in the period 2009–2010).

Code*	Number of alive larvae per repetition								X mean		E by Abbott, %	
	I		II		III		IV					
	a	b	a	b	a	b	a	b	a	b	a	b
72 hours after the test establishment												
1	1.35	11.15	1.50	11.50	1.35	10.15	0.65	10.00	1.21	10.70	91.80	27.26
2	2.85	13.65	2.85	12.50	2.00	13.15	4.85	13.35	3.14	13.16	78.71	10.54
3	4.50	12.50	1.30	14.85	0.80	13.50	2.85	13.50	2.36	13.59	84.00	7,61
4	15.00	14.85	15.00	14.35	15.00	14.65	14.00	15.00	14.75	14.71		
144 hours after the test establishment												
1	0.00	7.35	0.00	8.85	0.00	8.35	0.00	6.65	0.00	7.80	100	46.39
2	0.30	1.20	0.15	2.50	0.00	4.20	0.80	2.85	0.31	2.69	97.89	81.51
3	0.00	5.85	0.00	6.85	0.00	6.20	0.80	6.80	0.20	6.42	98.64	55.88
4	15.00	14.70	15.0	13.85	15.00	14.65	13.85	15.00	14.71	14.55		
216 hours after the test establishment												
1	0.00	0.65	0.00	1.70	0.00	0.80	0.00	0.80	0.00	0.99	100	93.18
2	0.00	0.00	0.00	0,65	0.00	0.50	0.00	0.00	0.00	0,29	100	98.00
3	0.00	0.70	0.00	0.50	0.00	0.60	0.00	0.30	0.00	0.52	100	96.42
4	15.00	14.7	15.00	13.85	15.00	14.65	13.85	14.85	14.71	14.51		

* Legend in Table 2

the necessary properties (high biological efficacy, mechanism of action, resistance to watering and a small amount of application) for use in forest ecosystems.

In addition, these insecticides may be used as part of an Integrated Pest Management program to control pest which can include biological, cultural, and genetic practices aimed at preventing economic pest damage.

Table 4. Test of the least significant differences per experiment groups.

Code*	Homogeneous groups						Code	Homogeneous groups					Code	Homogen. groups			
period 2009-2010, X mean																	
After 72 hours							After 144 hours						After 216 hours				
1a	▓						1a	▓					3a	▓			
3a	▓	▓					3a	▓					1a	▓			
2a		▓					2a	▓					2a	▓			
1b			▓				2b		▓				2b	▓	▓		
2b				▓			3b			▓			3b		▓	▓	
3b					▓	▓	1b				▓		1b			▓	
4b						▓	4b					▓	4b				▓
4a						▓	4a					▓	4a				▓

* Legend in Table 2

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References

EPPO/OEPP 1990. Guideline on design and analysis of efficacy evaluation trials. Bulletin EPPO/OEPP, 152, 20/3.

Ioriatti C., Anfora G., Angeli G., Mazzoni V., Trona F. 2009. Effects of chlorantraniliprole on eggs and larvae of *Lobesia botrana* (Denis & Schiffermüller) (Lepidoptera: Tortricidae). Pest Management Science, vol. 65 (6): 717–722.

Klein C.D., Oloumi H. 2005. Metaflumizone: A New Insecticide For Urban Insect Control From BASF. Proceedings of the Fifth International Conference on Urban Pests, Chow-Yang Lee and William H. Robinson (editors), Printed by Perniagaan Ph’ng @ P&Y Design Network, Malaysia: 101–105.

Tabakovic-Toshic M. 2005. Major factor for successful application of commercial *Bacillus thuringiensis* var. *kurstaki* against gypsy moth outbreaks in forests. Proceedings of 25th Jubilee Assembly of East Palaearctic Regional Section, Budapest, Hungary: 185–189.

Tabakovic-Toshic M. 2006. Integral forest protection in forestry of the Republic of Serbia. Proceedings of International Scientific Conference „Sustainable Use of Forest Ecosystems – The Challenge of the 21st Century“, Donji Milanovac, Serbia: 265–274.

Tabakovic-Toshic M. 2008. Entomopathogenic bacterium *Bacillus thuringiensis* ssp. *kurstaki* the important component of the integral protection of forest ecosystems. Institute of forestry Belgrade, special editions, Belgrade: 1–148.

US EPA – Office of Prevention, Pesticides and Toxic Substances 2009. Pesticide Fact Sheet – Indoxacarb. Available: www.epa.gov/opprd001/factsheet/indoxacarb.pdf