INFLUENCE OF BIORATIONAL PESTICIDES ON USEFUL ENTOMOFAUNA IN THE REPUBLIC OF MOLDOVA

DINA Elisovetskaya, SHLEAHTICH Vladimir, MOHAMMED Musleh, DINA Cristman

Abstract. The use of biorational pesticides in the integrated protection system of stone fruit crops in the conditions of the Republic of Moldova against pests and diseases has contributed to the preservation of natural entomofauna in plum and peach orchards. The application of the natural insecticide Pelecol (8.0 l/ha) has reduced the density of aphid colonies (*Hyalopterus pruni*) both on plum and peach trees less than threshold values. The population of the natural predators was higher than in the chemical standard. Among aphidophagous in plum and peach tree orchards, the following species predominated: *Coccinella septempunctata*, *Harmonia axyridis* and *Adalia bipunctata*) (Coleoptera: Coccinellidae); *Chrysopa carnea* and *Chrysopa formosa* (Neuroptera: Chrysopidae), as well larvae and imagoes of syrphid (Diptera: Syrphidae). The following species were met in sufficient amounts *Forficula auricularia*, *F. tomis* (Dermaptera: Forficulidae), as well as representatives of the class Arachnida (Aranea). In both orchards of plum and peach trees, the species *H. axyridis* dominated among Coccinellidae. It was established that the reduction of chemical treatments, as well as the placement of forest shelter belts along orchards contribute to the accumulation of biota and increase the amount of predators in orchards, thus favouring the quality and quantity of the obtained crop.

Keywords: biorational pesticides, entomofauna, enthomophages, aphidophagous, plum, peach, stone fruit crops, integrated protection system, Aphididae, Coccinellidae, Chrysopidae, Syrphidae.

Rezumat. Influenţa pesticidelor bioraţionale asupra entomofagilor utili în Republica Moldova. Utilizarea pesticidelor bioraţionale în protecţia integrată a dăunătorilor şi bolilor culturilor pomicole sâmburoase în condiţiile Republicii Moldova, a contribuit la conservarea entomofaunei naturale în livezile de pruni şi piersici. Utilizarea insecticidului natural Pelecol (8,0 l / ha) a redus densitatea coloniilor de afide (*Hyalopterus pruni*) la piersic sub valorile pragului. Numărul prădătorilor naturali, în acest caz a fost mai mare decât în etalonul chimic. Printre afidofagii în livada de prun şi piersic predominau speciile: *Coccinella septempunctata*, *Harmonia axyridis* şi *Adalia bipunctata*) (Coleoptera: Coccinellidae); *Chrysopa carnea* şi *Ch. formosa* (Neuroptera: Chrysopidae), larvele şi imago de sirfide (Diptera: Syrphidae). S-au întâlnit în cantităţi suficiente *Forficula auricularia*, *F. tomis* (Dermaptera: Forficulidae) şi reprezentanţii ai clasei Arachnida (Aranea). În ambele grădini de pruni şi piersici între Coccinellidae domina specia *H. axyridis*. S-a stabilit că reducerea tratamentelor chimice, precum şi plasarea de-a lungul livezilor a perdelelor forestiere de protecţie contribuie la acumularea biotei şi asigură creşterea prădătorilor în livadă, favorizând astfel calitatea şi cantitatea recoltei obţinute.

Cuvinte cheie: pesticidelor bioraţionale, entomofagi, afitofagi, prun, piersic, culturi pomicole sâmburoase, protecţia integrată, Aphididae, Coccinellidae, Chrysopidae, Syrphidae.

INTRODUCTION

The Republic of Moldova occupies one of the leading places among the Eastern Europe countries on quality of cultivated fruits due to the peculiarities of the climate and soil fertility. Among the cultivated stone fruit crops, the leading role in the republic is held by plum tree (more than 55%). The second place is occupied by peach tree and the rest is distributed between apricot, sweet cherry and cherry trees. The main plantings are in the Central (more than 55%) and Northern (approximately 40%) parts, the total the area of fruit-bearing plum orchards covering approximately 20 thousand hectares. The surface of peach tree orchards reaches 5.5 thousand hectares, which are concentrated mainly in the south of Moldova. From one hectare of fruit-bearing orchard, the manufacturers receive 8-10 tons of plums and 10-12.5 tons of peaches on average (GATYNA, 1989; RUSSU, 2009). In the last years, in the republic, there have been developed plum and peach orchards from seedlings of new, district and registered varieties, which are delivered from Italy, France, Germany, Holland and Poland. In the new orchards, cultivated according to the industrial technology in conditions of a high agrotechnology, it is possible the increase crop capacity minimum twice a year. However, in practice, quite frequently, the plantings cannot manifest their potential possibilities. It is explained by many reasons, beginning with the mistakes committed when establishing orchards and finishing with that the new high-productive varieties became more receptive to harmful organisms. In addition, in the conditions of intensive control of crops, there are created more favourable conditions for the development of many agents of diseases and pests, and, as a result, there occur significant changes in agrobiocoenoses. In its turn, it provokes the increase of injuriousness of organisms, which in usual conditions, does not significantly influence the crop yield.

The complex of pests, distributed on a plum tree, is sufficiently varied – here are gooseberry red spiders, aphids, tortoise scales, tube-builder, tussock moths, sawflies, curculio, *Euproctis chrysorrhoea*, *Eurytoma schreineri*, fall webworm and many others. However, the main damage to fruits is brought by plum moth. Among the most harmful diseases of plum tree, the majority of authors mention “sharka” disease of plum, bacterial blight of rind, cytospora canker, bacterial spot of leaves, anthracnose, rust and brown fruit rot (GATYNA, 1989; VOINEAC & MUSLEH, 2013). Among the peach tree diseases, the most harmful are nettlehead and pustular spot, but among pests the great losses may be generated by the oriental moth, as well as by peach moth, coccids and aphids (VANEK et al., 1989; KLECHKOVSKIY,

2005). Aphids, besides the direct harm brought to the plant, being the carrying agents of many harmful virus diseases, may significantly influence the quality of crops and market condition of the fruits.

It is known that not all organisms, which populate the ecosystem, play the same important role in its functioning and influence on production quantity. The determining influence on biocoenosis, conditioned by population and biomass, has relatively few species – ecologically dominants. For the quantitative characteristics of the relations of an organism complex, populating the ecosystem, there are used such indices as economic level of injuriousness, economic threshold of pest population and biotic index (DOSPEHOV, 1979). The main danger is represented by insects (and agents), which directly damage the fruits. As a rule, the economic threshold of injuriousness of such species is so much low so that, in order to reduce its population, there are recommended chemical measures. In the second group, conventionally, there are included the species, whose influence on the crop is mediated through the damage of vegetable organs of the plants. It is the majority of leaf-damaging phytophages and suctorial insects and mites. For this group it is very difficult to establish the economic thresholds of the population, because it is difficult to make a correlation between the population density, fall of assimilation and reduction of crop (especially for perennial plantings). Therefore, the indices accepted nowadays are conditional, and as a rule understated in order to be the definite reliability margin for prevention of crop losses. At a balanced biocoenosis, the second group of insects is controlled effectively by the predators and parasites. And in such a case, the reasonability of application of chemical means should be determined not only based on the economic threshold, but also according to the biotic index. That is why, at the elaboration of protective measures it is necessary to take into consideration the whole spectrum of problems and coordinate the scheme according to appearance of one of another threat.

Nowadays, in plant protection, it is observed the tendency to reduce pesticide load on agrobiocoenoses. The environmental safety of carried out measures becomes the first-priority request of economic management, summon to protect the environment against the negative impact of anthropogenic factors. Just that is explained the increased interest to the development of new schemes of integrated protection of fruit crops with application of biorational pesticides. The experience, obtained in the process of development of the integrated protective systems of plants against pests and diseases, demonstrates that the control and use of the natural entomo-acariphages is the important part in the control of pest populations (VOINEAC, 2003).

That is why the aim of our researches consisted in studying the influence of biorational pesticides in the integrated protection of stone fruit crops in the conditions of Moldova on species composition and populations of aphidophagous species.

MATERIALS AND METHODS

The experiments were carried out in plum tree (4.0 hectares, “Stenlei” and “Cabardinca raniaia” varieties, established in the year 2000) and peach tree (6.0 hectares, “Colins”, “Reithoven” varieties, established in the year 1999) orchards Ltd. „Agrobrio”, Bacioi village, Ialoveni, Central part of Moldova during the vegetation growing season 2013 according to generally accepted methods (*Îndrumări metodice*, 2002). The formation of tree crowns is typical, both orchards are situated in good agro-technical conditions, the soil between the rows and in rows – chernozem.

The control and mass capture of the main pests (*Grapholitha funebrana* (Treitschke, 1835), *Grapholita molesta* (Busck, 1916), (Lepidoptera: Tortricidae) and *Anarsia lineatella* (Zeller, 1839), (Lepidoptera: Gelechiidae) were carried out with the help of standard pheromone traps (of laminated carton in the form of prism “Delta” type), produced in the Institute of Genetics, Physiology and Plant Protection, Academy of Sciences of Moldova (IGPPP ASM). To forecast the terms of appearance of the pests, the traps beforehand, till the beginning of flowering, were located in each orchard on peach and plum trees by 3 traps/ orchard against each species of the pest at a height of 2-2.5 m from the ground. From the capture of the first moths, the traps were located evenly on the whole orchard by 10 traps/ha (against each species of the pest, the distance between the traps is 30x30 m, the height of traps from the ground level – 2-2.5 m). The control of males in the traps (and their removal from the traps) was carried out once in five days till the end of the summer. The dispensers with pheromone were changed each 30 days, sticky liners as necessary. At the end of the season the traps were removed from the orchard and burnt out. The determination of the biological effectiveness of the mass capture method was carried out in the period of mass hatching out of larvae and appearance of pupae, against each generation of the pests according to generally accepted methods. In each variant, there were analysed 300 shoots and 300 fruits at 10 controlled trees (DOLJENKO, 2004).

To control the aphid populations there was used the method of direct calculations (DUNAYEV, 1997). The economic threshold of injuriousness for aphid begins at a population of 25% of leaves. As the reproductive rates of the aphid are very high, the control of their population at peach and plum trees during the vegetation growing season was carried out regularly as it follows:

– in the budding phenophase – the beginning of the green cone, there was examined the bark of trunks, scaffold branches, and then the branches were shaken (4 branches/tree) – at ten trees, situated diagonally in the orchard. The population of aphid should not exceed 30 eggs at 2 running meters of one-three years branches;

– in the phase of moving-out – the beginning of the separation of buds, there were viewed 100 flower rosettes at 10 trees. The threshold of injuriousness is established at 10 larvae at 100 leaves;

– during the phonological stage the white bud – till flowering, there were examined 100 rosettes at 10 trees. The threshold of injuriousness is established at 10 larvae at 100 leaves;

– in the phase of end of flowering – the fall of physiological drop there were examined 100 leaf rosettes or ovaries at ten trees. The threshold of injuriousness is established at 15 larvae at 100 leaves;

– in the period of fruit ripening (during the summer) the controls were carried out every week. The aphid population in this period should not exceed 6-8 colonies at 100 controlled leaves or branches.

Simultaneously, there was carried out the control of the population of eggs, larvae and imagoes of Chrysopidae and Coccinellidae, as well as the population of larvae of Syrphidae according to the methods for control of the insects of tree layer:

– shaking of the tree branches on a white cloth situated under the tree. The fallen or flying insects were taken into consideration and, if necessary, they were gathered in tubes.

– visual control of test trees, in the process of which there are visually examined the branches, leaves, trunk, flowers and fruits.

For specific determination of the gathered material there were used the corresponding determinants of insects and magnifying arrangements (NARTSHUK, 2003; SHAPOSHNIKOV, 1964).

The determination of diseases and carrying out of protective measures were made according to standard methods (*Îndrumări metodice*, 2002). The main pathogen agrocoenoses of stone fruit crops of Moldova are the following: Coccomyces (*Coccomyces hiemalis* Higgins.), monilia (*Monilia cinerea* Bon.), Coryneum (*Clasterosporium carpophilum* Aderh.), curl leaf (*Taphrina deformans* Pul.), polystigmosis (*Polistigma rubrum* DC). Alongside with the indicated dominated diseases in the last years it was also noticed the increase of injuriousness and secondary: rust (*Trahzschelia prunispinosae* Pers.), plum pocket disease (*Taphrina pruni*.), colonization of plum shoots by the agent of conidial stage of black mildew – fungus *Fumago vagans*, etc. Therefore we have carried out the monitoring of all described diseases.

Our researches were directed towards the elaboration of an integrated protection system of stone fruit crops (plum and peach) against pests and diseases with the use of biorational pesticides and growth and immunity promoting factors, allowed by the Regulation for Ecological Agriculture (Regulament (CE) NR. 889/2008). As fungicides the preparation Funecol was used (s.a. – compound complex 2 - (NH) 4OH + + helator adjuvant) with low content of copper (8%) in a dose of 4.0 l/ha, as well as biological fungicides – Trihodermin (with content of spores and/or mycelium of fungus *Trichoderma lignorum*) and Rizoplan (with content of liquid culture *Pseodomonas fluorescens*) in a dose of 5.0 l/ha and 2.0 l/ha respectively. As an insecticide of natural origin, Pelecol was applied (s.a. fatty acids esters + adjuvant of surface-active substances) in a dose of 8.0 l/ha.

Usually, for fruit-bearing plum tree orchards it is recommended to carry out up to 13 treatments with insecticides and up to four – with fungicides. To protect the peach against pests and diseases, it is recommended to carry out up to seven treatments with insecticides and up to four – with fungicides. To reduce the pesticide load, we have decreased both the number of chemical treatments and concentration of active substances of some preparations. Thus, in the experiment, it was used fungicide Funecol with low content of copper (8%), two chemical treatments against mites and aphid were replaced to a treatment with an insecticide of natural origin Pelecol, and two chemical treatments against the pests were cancelled, as the method of mass male catching was applied (Table 1).

Table 1. Scheme of treatment of plum and peach tree orchards, "Agrobrio" Ltd., Bacioi village, Central part of Moldova.

Dates of treatments	**Scheme of protection with application of biorational pesticides**		**Chemical standard**	
	preparation	**dose**	**preparation**	**dose**
Plum tree				
November 9, 2012	Funecol	4.0 l/ha	Bordeaux	2%
April 9, 2013	Funecol	4.0 l/ha	Cupromax +Calipso	3.0 l/ha + 1.0 l/ha
May 3, 2013	Funecol	4.0 l/ha	Nureld +Antracol	1.5 l/ha + 3 kg/ha
May 20, 2013	Funecol + Recol	4.0 l/ha + 2.0 l/ha	Confidor + Belacon	0.5 l/ha + 2.5 l/ha
June 7, 2013	Rizoplan +Recol	2.0 l/ha + 2 l/ha	Scala + Nureld	0.8 l/ha + 1.5 l/ha
June 10, 2013	Rizoplan + Recol	2.0 l/ha + 2.0 l/ha	Masai	0.5 l/ha
July 24, 2013	Trihodermin	5.0 l/ha	Treatment with microelements	
August 9, 2013	Trihodermin	5.0 l/ha	Scala	1.2 l/ha
Peach tree				
November 9, 2012	Funecol	4.0 l/ha	Bordeaux	2%
April 9, 2013	Funecol	4.0 l/ha	Cupromax + Trend	5.5 l/ha +0.3 l/ha
April 19, 2013	Funecol + Recol	0.5 l/ha +2.0 l/ha	Dilan + Trend	1.0 l/ha +0.3 l/ha,
May 18, 2013	Rizoplan +Recol	2.0 l/ha +2.0 l/ha	Antracol + Topaz + Bi 58 + Belacom	2.0 l/ha + 0.5 l/ha +2.0 l/ha +2.5 l/ha
June 17, 2013	Trihodermin	5.0 l/ha	Scala + Impact + Actafit + Trend	0.8 l/ha + 0.3 l/ha + 0.25 l/ha + 0.2 l/ha

Additionally, as immunity inducers and growth promoting factors there were used preparations of the natural origin in orchards, namely three versions: Reglalg (the preparation was elaborated under the direction on the basis of the natural extracts from algae) in a dose of 8.0 l/ha, Recol (on the basis of the vegetable extract from *Reynoutria sachalinensis* (F. Schmidt) Nakai) in a dose of 5.0 l/ha and Albit (with content of purified active substances from the

soil bacteria *Bacillus megaterium* and *Pseudomonas aureofaciens*) in a dose of 0.5 l/ha. The preparations may stimulate the protective functions of the plants, increasing their resistance to the pests and diseases. Albit as well is a universal growth regulator of the plants with the properties of fungicide and combined fertilizer. All the above mentioned test preparations were elaborated by the collaborators of IGPPP ASM.

The terms of treatments were determined on the basis of carried out phytosanitary expertise.

RESULTS AND DISCUSSIONS

As a result of the pheromone monitoring of the main pests of plum and peach trees, there was established that the flight of the *G. molesta* began on April 29, 2013, but *A. liniatella* and *G. funebrana* on May 7 and 8, respectively. The capture of males of *G. molesta* has not exceeded 15.1 individuals/trap during 5 days on plum tree and 26 individuals/trap/5 days on peach. The capture of males of *A. lineatella* on peach made up 16.0 individuals/ trap/5 days, but the capture of males of *G. funebrana* on plum tree made up at an average of 10 individuals/trap/5 days. The aphid population has exceeded the threshold values. After carrying out of the protective measures, as a result of the controls, there was established that the biological effectiveness of the mass capture method of the males of *G. molesta* and of *A. liniatella* on peach tree before the harvest was 93.4% on fruits and 41.9% on shoots in comparison with the control. The biological effectiveness of the mass capture method of males of *G. funebrana* on the plum trees before the harvest reached 81.3% (on fruits injuriousness) in comparison with the control.

We have determined that the replacement of the chemical preparation with the natural fungicide Funecol (4.0 l/ha) on plum tree has led the decrease of monilia evolution by 1-2%. In the chemical standard, the affection of the fruits with monilia has reached 4%. As well, it was established that the percentage of distribution and development of red spotting (polystigmosis, agent - *Polystigmina rubra* Sacc.) and bacterial spotting (agent – bacterium *Xantomonas pruni* (Smith.) Dowson) on plum tree was at the level of the chemical standard and has not exceeded the threshold value. The biological effectiveness of the preparation Funecol against monilia on peach tree was at the level of the chemical standard. There was detected that the percentage of distribution and development of the peach leaf curl (agent - exoascale fungus *Taphrina deformans* Tul.), powdery mildew (agent *Sphaerotheca pannosa* Lev. var. persicae Woronich.) and cytosporosis (agents – fungi of type Cytospora – *C. leucostoma* (Pers.) Sacc., *C. schulzeri* Sacc. et Syd.) was at the level of the chemical standard and has not exceeded the threshold value. At examination, there was noticed that, in 2013, in the orchards under study neither plum nor peach trees were injured by other diseases, besides the above mentioned ones.

At the development of a new protection system against pests and diseases, special attention was paid to the study of the influence of biorational pesticides on species composition and dynamics of some aphidophagous species in stone fruits plantings. In spite of that the agricultural crops are injured by more than 250 species of Aphididae (belonging to the families Adelgidae, Phylloxeridae and Aphididae), only some species have a great economic importance (VERESHCHAGINA & VERESHCHAGIN, 1966; VERESHCHAGIN & ANDREYEV, 1981; ANDREYEV, 1982; BLACKMAN & EASTOP, 2000; MILLER & FOOTTIT, 2009). According to our observations of many years in the conditions of Moldova, the plum tree is very often injured by *Hyalopterus pruni* Geoffr. (Homoptera: Aphididae), *Brachycaudus helichrysi* Kalt., *B. cardui* L. and *Phorodon humuli* Schrk, and the peach tree by *H. pruni*, *Myzodes persicae* Sulz., *Brachycaudus* (*Appelia*) *schwartzi* (Börner), *Pterochloroides persicae* Choi., *B. persicae* Passerini and *M. varians* Davidson. As a result of the carried out controls there was established that in 2013 both the plum and peach trees in the Central part of Moldova in the farm "Agrobrio" Ltd., Bacioi village, were injured generally by *Hyalopterus pruni*. The primary hosts of this phytophage are the plum alycha and other representatives of the genus *Prunus* Mill., the second - common reed grass (*Phragmites australis* (Can.) Trin. ex Steud.). For stone fruit breeds, the mealy plum aphid is one of the most harmful pests: aphid colonies cover the leaves completely, causing a light deformation of the edge of lamina and discoloration of the whole leaf. The sacchariferous emissions of the aphids promote the development of saprophytic fungi. As a result of water and nutrients loss, the plants become significantly weakened. In the middle of summer, the leaves and fruits may fall. The remained fruits are mutilated and tainted.

In the conditions of Moldova, on the primary hosts (on peach and plum trees), this species of aphid develops usually 2-3 generations, reaching the maximum population in May-June, and after that for a second time in July-August. The greatest harm of aphid is caused in spring to buds and to young expanded leaves during May and June. The economic threshold of injuriousness (ETI) against *H. pruni* in phase of "asleep buds" makes up 25-30 eggs at 2 running meters of branches, and in the phase of "green cone" – 200-400 larvae at 100 buds. In May and June, ETI against *H. pruni* occurs ~~at~~ in case of 25% of leaves. Therefore, the first treatment against aphid usually is carried out before flowering, the second one – after that. To reduce the population of aphids both in plum and peach trees, we applied one treatment with the natural preparation Pelecol (8.0 l/ha), at that biological effectiveness made up 85%, which was at the level of the chemical standard. The insufficient high effectiveness of the preparation against *H. pruni* could be associated with the fact that the colonies of this species are covered with a wax-like bluish-white indumentums and, therefore, poorly exposed to the treatment. However, it is necessary to notice that the preparation Pelecol worked very well against swarmers *H. pruni*.

As the aphid population in the, notwithstanding the carried out treatments, may increase sharply in very short terms, a significant role in the control of population density of the pest is played by their natural predators and parasites. At the optimal correlation of the pest population and their natural enemies it is possible to exclude the carrying out of the further destructive measures in the orchard. According to the data of many authors in aphid colonies there were detected more than 70

specialized species (mono- and oligophages) and more than 80 species of polyphagous aphidophagous species, but the greatest variety of aphids is noticed in case of Coccinellidae family, hoverflies and lacewing (ADASHKEVICH, 1975; ASPÖCK et al., 1980; IZHEVSKIY, 2005; GONTARENCO & BICHINA, 1983; ZAHARENCO & KRIVOHATSKIY, 1993). The controls carried out by us on plum and peach trees also revealed a great variety of the predators, among which the following species were dominant: *Coccinella septempunctata* (Linnaeus, 1758), *Harmonia axyridis* (Pallas, 1773) and *Adalia bipunctata* (Linnaeus, 1758) (Coleoptera: Coccinellidae); *Chrysopa carnea (*Stephens, 1836*)* and *Chrysopa formosa* (Brauer, 1850) (Neuroptera: Chrysopidae), as well as larvae and imago of the syrphid fly (Diptera: Syrphidae) (Table 2, Figs. 1-7). There were notice sufficient amounts of *Forficula auricularia* (Linnaeus, 1758), *F. tomis* (Kolenati, 1846) (Dermaptera: Forficulidae and representatives of the Class Arachnida (Aranea) (Table 2).

Table 2. Species composition and population of aphidophagous species in plum and peach tree-orchards, "Agrobrio" Ltd., Bacioi village.

Order: Family	**Scheme of protection with application of biorational pesticides**			**Chemical standard**		
	Quantity for one tree			**Quantity for one tree**		
	Eggs	**Larvae**	**Imago**	**Eggs**	**Larvae**	**Imago**
Plum tree						
Coleoptera: Coccinellidae	10.0	6.0	0.6	8.0	4.0	0.4
Neuroptera: Chrysopidae	2.6	2.3	0.1	1.9	1.2	0.1
Diptera: Syrphidae	-	8.0	0.1	-	6.0	0.1
Arachnida: Aranea	-	-	3.0	-	-	2.0
Dermaptera: Forficulidae	-	-	0.1	-	-	0.1
Peach tree						
Coleoptera: Coccinellidae	9.0	5.0	0.6	8.0	4.0	0.4
Neuroptera: Chrysopidae	2.4	2.1	0.1	1.8	1.2	0.1
Diptera: Syrphidae	-	10.0	0.1	-	8.0	0.1
Arachnida: Aranea	-	-	3.0	-	-	2.0
Dermaptera: Forficulidae	-	-	0.1	-	-	0.1

It was mentioned that in both orchards, among Coccinellidae, the species *H. axyridis* dominated (Table 2, Fig. 9). The second species as occurrence was *C. septempunctata*. It is known that *C. septempunctata* prefers aphids germinated on plants and only a small part of their population passes to trees and bushes (IZHEVSKIY, 2005). However, we revealed that in the spring of 2013 (before and after the flowering of the orchards) the population of *C. septempunctata* was significantly high both in plum and peach trees. In trees, infested by aphids, the population of the predator has reached up to 5 individuals (imago) per tree, at the average of 0.15 individuals/tree. *A. bipunctata* was the third species of Coccinellidae as frequency of occurrence. It was mentioned that in both orchards there were present also individuals of some other species of Coccinellidae, but in very insignificant amounts.

Figure 1. Eggs of *Chrysopa formosa* (Brauer, 1850) (Neuroptera: Chrysopidae). (original).

Figure 2. An imago of *Chrysopa carnea* (Stephens, 1836) (Neuroptera: Chrysopidae). (original).

Our observations regarding the dynamics of the predator population in the orchard demonstrated that, during the summer, the species *H. axyridis* practically excluded the rest of the species of Coccinellidae. In literature, in the last years, it is actively discussed the problem of the replacement of indigenous species of Coccinellidae by the invasive species of *H. axyridis* (ORLOVA-BIENKOWSKAJA, 2013; BROWN et al., 2011; UKRAINSKY, 2013; IAZLOVETCHII & SUMENCOVA, 2013). Indisputably, it is practically a proved fact that, due to a high engorgement and adaptability, *H. axyridis* expands the areal of its habitation with high rates, excluding from biocoenoses not only indigenous species of Coccinellidae, but also the other species of predators. In addition, researchers have detected that, in the genome of *H. axyridis*, in the cells of their body, there are contained many genes of antibiotics necessary for the control of microspores (HRAMOV, 2013). At the same time, the other species of Coccinellidae (for example, *C. septempunctata*) have only one such gene and

therefore may be infected by parasites when eating the eggs and larvae of *H. axyridis*. Our observations demonstrated that *H. axyridis* is a very active predator of aphids, which reacts fast to the change of density of pest colonies. Thus, after spending a short time on one branch of a tree infested by aphids, 2 to 10 imagoes of *H. axyridis* moved fast along the trunk, looking not only for pest colonies, but also for single females - telotroches. The population of Coccinellidae in the orchard during the vegetation period strongly varied and was directly related to the pest population and weather conditions, and, therefore, for comparative characteristics, we used the average values. The analysis of obtained data demonstrated that the application of the protection system with the use of biorational pesticides preserves the population of Coccinellidae at a more high level in comparison with the chemical standard (Table 2).

Figure 3. A larva of Syrphidae sp. eating an aphid (plum). (original).

Figure 4. A larva of Syrphidae sp. eating an aphid (peach). (original).

Figure 5. An imago of *Harmonia axyridis* (Pallas, 1773) eating an aphid (peach). (original).

Figure 6. Coupling of the imagos of *H. axyridis*. (original).

Figure 7. An imago of *Harmonia axyridis* (Pallas, 1773) eating an aphid (plum). (original).

Figure 8. Various stages of the development of predators on a cherry plum tree. (original).

As stated before, on peach and plum trees, we noticed some species of Chrysopidae with predominance of the species *C. carnea* in the agrocoenosis of both orchards. It was determined that the population of Chrysopidae imagoes registered a similar evolution when applying the biorational pesticides and the chemical treatment. However, it was revealed that the population of eggs and larvae of Chrysopidae on the plants used in the experiment was considerably higher than in the chemical standard (Table 2).

The researches carried out in 2013 on plum and peach trees also revealed a high population of larvae of Syrphidae, their population reaching up to 2 larvae on a leaf, on average – from 6 till 10 larvae on a tree (Table 2, Figs. 1-2). It was noticed, that the population of predators was insufficiently higher on peach trees as compared to the plum trees. Obviously, for the syrphid larvae, it was observed the same tendency as in case of Coccinellidae: in the orchards where the system was applied, including the biorational pesticides, the larvae population of this predator was rather higher than in the chemical standard.

Besides the abovementioned groups of predators, in plum and peach tree orchards, there were detected numerous representatives of Arachnida: Aranea. Their population, in the variant with the application of biorational pesticides, was as well rather higher than in chemical standard (Table 2).

The controls carried out by us demonstrated that in the dynamics of the development of insects in orchards, it was observed the delay in the occurrence of the maximum population of entomophages in relation to phytophages, particularly – aphidophagous in relation to aphid. For example, the greatest amount of Coccinellidae was noticed a week after the mass appearance of larvae of aphids. Therefore, we consider that even when using chemical preparations, the treatments in the phase of budding till flowering of the plum and peach trees, causes, at least the death of the entomophages.

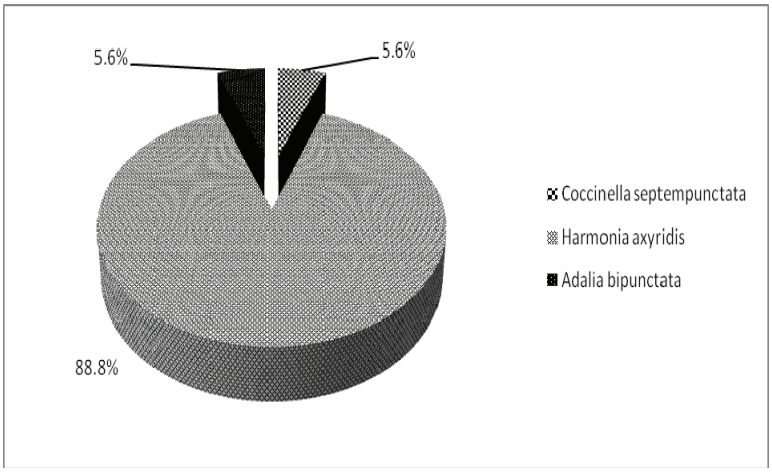

Figure 9. Shared correlation of species of Coccinellidae in plum and peach tree orchards (average values)
Bacioi village, Central part of Moldova.

The researches of the aphidophagous species composition and population in stone fruit orchards where biorational pesticides are used, on the basis of analysis of existent situation, allow determining the necessary treatments against aphids. It is known that the value of each species of entomophage in the dynamics of aphid reproduction is determined by the level of their specialization to victim, quantity and engorgement of some species. To determine the level of effectiveness of aphidophagous it should be considered the total number of fed stages (larvae, imago) of all the predators, particularly those specialized. It was established that the optimal level of effectiveness of such aphidophagous as Coccinellidae, Chrysopidae and Syrphidae, at favourable weather conditions for aphid reproduction, corresponds the correlation of one predator per 15-20 aphids (ADASHKEVICH, 1975; GONTARENCO & BICHINA, 1983). In our experiment, the single application of the natural insecticide Pelecol in the phase of budding till flowering has reduced the population of aphid colonies below the threshold values. The population of the natural predators was preserved at a level higher than in case of the chemical standard, the correlation predator: victim displaying an average of 1:10-15. Thereby, in the experimental orchards, there were created all preconditions for a successful activity of aphidophagous in repression of the pest.

It is necessary to notice that along the plum and peach tree orchards where our researches were carried out, there was a forest belt with the total area of 0.5 ha. Among the species in the forest belt, we mention some plants of *Prunus cerasifera* Ehrhart (Rosaceae), which were also very infected by aphids (more than 50% of the leaves), as well as the species *H. pruni*, *M. persicae* and some others. This area has not undergone any treatment, therefore has served as a natural reserve for entomophages (Fig. 8). On the plants of *P. cerasifera*, infected by aphids, particularly high density was reached by the population of *H. axyridis*.

So, summarizing we may say that the integrated protection system of plum and peach trees applied by us by the use of biorational pesticides has demonstrated the high effectiveness against both pests and diseases. The decrease in number of the chemical treatments and replacement of synthetic pesticides by biorational substances allowed preserving many species of beneficial insects at the level, providing the further protection of the orchard by biological means. In addition, the protective

forest belts in the neighbourhood of the orchards, which did not undergo any chemical treatments, served as a natural source of the natural entomophages, favouring the fast growth of the population of predators in adjacent orchards.

CONCLUSIONS

The obtained data attest that the replacement of the synthetic pesticides by biorational substances in the integrated protection systems of plum and peach trees does not decrease the effectiveness of protective measures. The reduction of the chemical treatments, as well as the presence of the forest belts that did not undergo treatment, favours the accumulation of biota and increases the ensuring of crops with predators, mainly Coccinellidae, Chrysopidae, and Syrphidae.

ACKNOWLEDGEMENTS

The authors thank to Vasiliy Voineac, Doctor habilitat of Agriculture, Elena Iordosopol, Doctor of Biology, Diurici Galina and Iakimchuk Alla, research assistants, for their help when working with the species of Coccinellidae, Chrysopidae and Syrphidae. We also express our gratitude to the reviewers that work together with the Editorial Board of the Journal "Oltenia. Studii şi comunicări. Ştiinţele Naturii" for their useful discussions and constructive suggestions.

REFERENCES

ADASHKEVICH B. P. 1975. Entomophages of wreckers of vegetable cultures [Text]: *Aphidophageous:* [scientific works] / B. P. Adashkevich; Vsesoyuz. All-Union academy of Agricultural Sciences of V. I. Lenin, All-Union research Institute of biological methods of plants protection. M.: Kolos, 191 pp. [In Russian].

ANDREYEV A. V. 1982. *Aphids of plum gardens of Moldova.* Kishinev: Institute of zoology and physiology, Abstract of the candidate of science. 22 pp. [In Russian].

ASPÖCK H., ASPÖCK U., HÖLZEN H. 1980. *Die Neuropteren Europas*. Goecke and Evers, Krefeld. **1**. 495 pp.

BLACKMAN R. L. & EASTOP V. F. 2000. *Aphids on the World's Crops.* An Identification Guide (second edition). J. Wiley & Sons. Chichester. 466 pp.

BROWN P. M. J., THOMAS C.E., LOMBAERT E., JEFFRIES D.L., ESTOUP A., HANDLEY L. L. 2011. *The global spread of Harmonia axyridis (Coleoptera: Coccinellidae): distribution, dispersal and routes of invasion.* BioControl: Editor-in-Chief: Eric Wajnberg. **56**: 623-641.

DOLJENKO V. I. 2004. Metodiceskie ukazania po registrationnym ispytaniam insecticidov, acaricidov, moliuscotidv i rodentodov v seliskom hozeaistve. S-Peterburg: *RASHN VNIIZR IZZR*. 363 pp. [In Russian].

DOSPEHOV B. A. 1979. *Metodika polevogo opyta*. Moskva: Kolos. 338 pp. [In Russian].

DUNAYEV E. A. 1997. *Methods of ekologo-entomological researches.* M.: Mosgor SUN. 44 pp. [In Russian].

GATYNA EMILIA. 1989. *Diseases and wreckers of plum in Moldova.* Shtiintsa. Kishinev. 204 pp.

GONTARENCO A. G. & BICHINA T. N. 1983. *Predators and parasites of pests of a garden*. Shtiinta. Kishinev. 192 pp. [In Russian].

HRAMOV A. 2013. *God's Asian cows won Europe by means of the biological weapon*. Published on 17.V.2013. http://www.infox.ru/science/animal/2013/05/17/Bozhi_korovki_aziaty.phtml. [In Russian].

IAZLOVETCHII I. & VICTORIA SUMENCOVA. 2013. *New invasive species in the Republic of Moldova: Multicolored Asian Ladybird Harmonia axyris Palas (Coleoptera: Coccinellidae).* VIII International Conference of Zoologists. Actual Problems of Protection and sustainable use of the animal world diversity. Chisinau. Book of Abstract: 136-137.

IZHEVSKIY S. S. 2005. *Coccinellidae*. Protection and quarantine of plants: Editor-in-Chief: Mckenzie Ehc, PhD, Senior Plant Pathologist, LandCare Research, New Zealand. **2**. 65 pp. [In Russian].

KLECHKOVSKIY JU. E. 2005. *Shidna plodojorka*. K.: Kolobig. 86 pp. [In Ukrainian].

MILLER G. L. & FOOTTIT R. G. 2009. *The taxonomy of crop pests: The aphids.* Insect Biodiversity: Science and Society, 1st edition. Edited by R. Foottit and P. Adler. Blackwell Publishing. 465 pp.

NARTSHUK E. P. 2003. *Key to Families of Diptera (Insecta) of the Fauna of Russian and Adjacent Countries*. Proceedings of the Zoological Institute. RAS. S-Pt. red. Asanovich T.A. **294**. 251 pp. [In Russian].

ORLOVA-BIENKOWSKAJA M. JA. 2013. *The dangerous invasive harlequin ladybird Harmonia axyridis (Pallas, 1773) (Coleoptera, Coccinellidae) in European Russia*. Russian Journal of Biological Invasions. Editor-in-Chief: Yury Y. Dgebuadze. **1**: 75-82. [In Russian].

RUSSU A. *Moldova - in new gardens.* 2009. Newspaper Kishinev observer. Iss. **17**. 07.05.2009. http://www.ko.md/main/view_article.php?issue_date=2009-05-07&issue_id=1119&PHPSESSID=tznpgglk.[In Russian].

SHAPOSHNIKOV G. H. 1964. *Suborder Aphidinea - aphids*. Determinant of insects of the European part of the USSR: edition of Bey-Biyenko G. Ya. M.– L.: Science, **1**. 587 pp. [In Russian].

UKRAINSKY A. S. 2013. The multicoloured Asian lady beetle Harmonia axyridis Pall. (Coleoptera, Coccinellidae) in North Caucasus. *Russia*. *Euroasian Entomological Journal*. Editor-in-Chief: Glupov V.V., ISAJ SO RAS. **12**(1): 35–38. [In Russian].

VANEK G., KORCHAGIN V., TER-SIMONEAN L. 1989. *Atlas of diseases and wreckers fruit and berry crops and grapes*. M. : Agropromizdat. 333 pp. [In Russian].

VERESHCHAGINA VALENTINA & VERESHCHAGIN B. V. 1966. *Aphids of the stone fruits and fruit breeds of Moldova and their diagnostics*. Works of Moldavian Scientific research institute of gardening, wine growing and winemaking (edition Talitsky V. I.). Kishinev: *Kartya Moldovenyaske*. **13**: 39-52. [In Russian].

VERESHCHAGIN B. V. & ANDREYEV A. V. 1981. *Aphids (Homoptera, Aphidoidea), damaging plum in Moldova*. News of academy of Sciences of MSSR (edition to Lupashk M. F.), Kishinev: Shtiintsa. **5**: 36-41. [In Russian].

VOINEAC V. 2003. *Mijloace biologice în protecţia integrată a plantelor*. Chişinău: ACSA. 48 pp.

VOINEAC V. & MUSLEH M. 2013. *Protecţia integrate a prunului*. Mater. Simp.naţional „Biotehnologii avansate – realizări şi perspective". Chişinău: S.n., Tipogr. „Print Caro". 182 pp.

ZAHARENCO A. B. & KRIVOHATSKIY V. A. 1993. Neuropterans (Neuropteren) European part of the former USSR. *The Kharkov Entomological Society Gazette*. Editor-in-Chief: Ye. N. Beletsky. **1**(2): 34-83. [In Russian].

*** 2002. *Îndrumări metodice pentru testarea produselor chimice şi biologice de protecţie a plantelor de dăunători, boli şi buruieni în RM*. Centrul de Stat pentru atest. produs. chimice şi biol. de prot. şi stimulare a creşterii plantelor. Chişinău: Tipografia Centrală. 286 pp.

*** 2012. *Registrul de stat al produselor de uz fitosanitar şi al fertilizanţilor, permise pentru utilizare în Republica Moldova*. Chişinău: S.n. (Î.S.F.E.-P. "Tipografia Centrală". 312 pp.

*** 2008. *Regulament (CE) NR. 889/2008 al comisiei din 5 septembrie 2008 de stabilire a normelor de aplicare a Regulamentului (CE) nr. 834/2007 al Consiliului privind producţia ecologică şi etichetarea produselor ecologice în ceea ce priveşte producţia ecologică, etichetarea şi controlul*. 18.9.2008. RO Jurnalul Oficial al Uniunii Europene. L 250/1-84.

Elisoveţcaia Dina, Shleahtich Vladimir, Mohammed Musleh Cristman Dina
Institute of Genetics, Physiology and the Plant Protection of Academy of Science of Moldova
Chisinau, Republic of Moldova.
E-mail: dina.elis.s@gmail.com

Received: March 30, 2014
Accepted: May 9, 2014