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Harmfulness of *Rhinoncus sibiricus* Faust on Crops of *Fagopyrum esculentum* Moench in Primorsky Krai of Russia

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Abstract The article presents monitoring results of spreading and harmfulness of *Rhinoncus sibiricus* in Primorsky krai. There was evaluated efficiency of chemical and biological preparations for *Rhinoncus sibiricus* control. The most biological efficiency under the treatment of chemical preparations was 93,5%, -biological preparations -92,9%. Maximum yield was achieved under the treatment of Kinmix 1,42 t/ha and Phytoverm 1,35 t/ha. It was defined that in the conditions of the region the optimal sowing term for buckwheat is period from June 20 till July 1. The best predecessor is perennial grasses that maintain the most yield and decrease damage *Rhinoncus sibiricus* of the plants.

Keywords Buckwheat, *Rhinoncus Sibiricus,* Harmfulness, Chemical and Biological Preparations

1. Introduction

Weevils subfamily of Ceutorhynchinae damages a lot of agricultural crops (Balciunas, Korotyaev, 2007). B Buckwheat is currently being studied and used as a pollen and nectar source to increase natural enemy numbers to control crop pests in New Zealand (Berndt, Wratten, Hassan, 2002). In the second half of XX and in XXI centuries a great amount of species subfamily of *Ceutorhynchinae* was introduced from Euroasia into Canada, USA and Australia for control of imported weeds. Thus weed *Myriophyllum spicatum* in USA was brought into the North America, probably in 1940-s. Some districts of Rod-Island, New York, New Jersey, Michigan, Minnesota and Washigton became the most infested with weeds (Couch, Nelson, 1985; Creed, Sheldon, 1993; 1994). Weevil *Euhrychiopsis lecontei* (Dietz) from subfamily *of Ceutorhynchinae* eating absolutely *Myriophyllum spicatum,* is an effective protective means against it (Newman, Borman, Castro, 1997;Solarz, Newman, 1996, 2001). Besides, study of the weevil biology, their effect upon the potential weeds, not only as the part of the nature diversity, but also as a valuable resource of the plants protection system, is an important task.

In Primorsky krai *Rhinoncus sibiricus* Faust makes great damage for sowings of *Fagopyrum esculentum* Moench during the whole vegetative period. The first results of harmfulness of *Rhinoncus sibiricus* Faust in the Far East of Russia were presented in the work of Mishchenko (1940), Safiullina (1959) mentioned it as a dangerous vermin in 1952-1957. It is spread on the territory of Russia from Tyva to the Far East (Amur oblast, Primorsky krai, southern part of Khabarovsky krai, Sakhalin and Kurile Isls). It is also well-known abroad: in Japan (Hokkaido, Honshu, Sikoku, Ryukyu); in China (Shansi, Taiwan) and in Mongolia. (KўÏo, Morimoto, 1960; Hayashi et. al., 1994; Anonymous, 1994; Korotyaev, 1980; 1997; Hong Ki- Jeong et. al.,2000; Hong K.-J., Korotyaev, 2002). The most harmful are beetles and larvae. The beetles appear at the end of May-beginning of June and begin eating first on the shoots of drops of *F. esculentum* and weeds of *Polygonaceae* Juss. family. The first period of harmfulness of *Rhinoncus sibiricus* starts when the shoots appear. The beetles gnaw out holes on the leaves thus decreasing the area of the assimilate surface. In some years damaged by the beetles leaves reaches 100% thus the part of shoots dies. The beetle harmfulness increases in non-favorable conditions for growth and development of the crop, under low moisture of the soil. As a result the number of died shoots increase. The second period of harmfulness of the beetle appears when the worm of *Rhinoncus sibiricus* embedded in the stem, boring through it, thus disrupting the vascular-conducting system. The larvae damage very much the first node. This can cause curvature of the stem, lodging and even break (Kuznetsova et. al., 2012). The damaged plants do not secrete nectar and do not give high-grade grains. According to our data harmful activity of *Rhinoncus sibiricus* is able to decrease yield of *F. esculentum* by 30-50 % (Kuznetsova, Klykov, 2012).

The goal of this work is to carry out monitoring of distribution and harmfulness of *Rhinoncus sibiricus* in Primorsky krai, to study biologic peculiarities and to define factors, influencing upon damage of *F. esculentum*.

2. Materials and Methods

The study was carried out in the experimental field of Primorsky Scientific Research Institute of Agriculture of Russian Academy of Agricultural Sciences on the brown-meadow whitened soils and in the Far Eastern Scientific Research Institute for Plant Protection of Russian Academy of Agricultural Sciences. In the experiment they used the following chemical preparations:

- from the group of phosphorus organic – Aktellic, emulsion concentrate (500g/l) -1 l/ha; Fufanon, emulsion concentrate (570g/l) -1 l/ha;
- pyrethroids –Kinmix, emulsion concentrate (50g/l) -0,3 l/ha; Karate, emulsion concentrate (50g/l) -0,1 l/ha;
- neonicotinoids – Aktara, water-dispersive (250g/kg) -0,07 kg/ha; Konfidor, water-soluble concentrate (200 g/l) – 0,15 l/ha; Kruyzer, (350 g/l) -0,7 l/ha. There were also used preparations from avermectin complex– Fitoverm, emulsion concentrate (10 g/l) -0,5 l/ha and Fitoverm M, emulsion concentrate (2 g/l) -2,5 l/ha; Batsikol, liquid (Bacillus thuringiansis)- 20 l/ha; Boverin, liquid (Beauveria bassiana, titre 60 million. spores/ml) – 20 l/ha. These preparations were not registered on buckwheat. Plants under control were treated with water. Preparation Kruyzer was used for the seeds treatment three days before sowing. Spraying of F. esculentum sowings with the preparations was carried out in the period of active feeding of the beetles on the stage of shootings – the first true leave. The working solutions were sprayed with the help of knapsack syringe in the morning. Account of plants injured by Rhinoncus sibiricus was carried out before treatment, on the seventh day after the solution treatment on the stage of mass flowering and before harvesting the crop. The preparations efficiency was evaluated according to the injured leaves and stems in percentage. Efficiency of the predecessor's effect upon the buckwheat plants damage by Rhinoncus sibiricus was studied in the experiment with the following complex of plants: Glycine max (L.)Merr. For green fertilizer; Avena sativa L. for green fertilizer; Avena sativa L. with plowing of stubble remains, straw and straw +N20; Glycine max (L.)Merr. with plowing of stubble remains, straw and straw +N20; Trifolium pretense L. for seeds.counted area of the plots was 60 m2, three replications. Sowing norm for buckwheat is 2 million of germinating seeds per 1 hectare. The route study of the production sowings of F. esculentum (variety Izumrud) was carried in 2007-2012 in the main grain sowing agro-climatic zones in Primorsky krai: steppe zone (Ussuriysky district, Octyabrsky, Pogranichny, Khankaysky, Khorolsky), forest-steppe zone (Mikhailovsky district, Chernigovsky, Lesozavodsky, Kirovsky), southern taiga zone (Anuchinsky district).

Evaluation of *Rhinoncus sibiricus* damage of *F. esculentum* leaves was carried out on shoots. The worm damage of *F. esculentum* stems was evaluated on the stage of flowering and ripening. The plants damage of the vermin was evaluated on 20 plants according to methods (Potyemkina, Kuznetsova, 2008).

3. Results and Discussion

In 2007-2012 the Far Eastern Scientific Research Institute for Plant Protection carried out the rout study of sowings of *F. esculentum* for *Rhinoncus sibiricus* damage in different agro-climatic zones of Primorsky krai. As a result of monitoring there were determined differences in *Rhinoncus sibiricus* damage of *F. esculentum* which depend on cultivation district and conditions of the year. On average for the study years the most *Rhinoncus sibiricus* damage of the plants was found in steppe zone and the least damage – in the southern taiga zone. It should be mentioned that the most favorable conditions for *F. esculentum* cultivation are in the southern taiga zone (*Rhinoncus sibiricus* damage of the plants was the least in limits of 42,0-89,0%). An average regional least percentage of the damage was observed in 2010, 2011 and 2012 (table 1).

Study of *Rhinoncus sibiricus* biology was not carried in Primorsky krai before. Thus we studied biology and phenology of the vermin. Starting from May till September we carried out observation of the *Rhinoncus sibiricus* development in natural conditions.

On the bases of received data we described phenology and biology of the vermin. We defined the time of *Rhinoncus sibiricus* appearance and its development from one stage to another. The beetle has dark grey colour. The body length is 2,5-3,5 mm (Figure 1).

Figure 1. Rhinoncus sibiricus and damaged leave of F. esculentum

Table 1. Rhinoncus sibiricus Faust damage of F. esculentum plants in Primorsky krai

Natural-climatic zone, district	Damage of stems on the stage of ripening, %						
	2007	2008	2009	2010	2011	2012	2007-2012
Steppe zone, Ussuriysky, Oktyabrsky, Pogranichny, Khankaisky, Khorolsky	85,0	98,0	92,5	75,0	70,0	65,0	81,0
Forest-steppe zone, Mikhailovsky Chernigovsky, Lesozavodsky, Kirovsky	75,0	81,0	100,0	69,0	65,0	58,0	74,7
Southern Taiga Anuchinsky	66,0	86,0	89,0	42,0	50,0	55,0	64,7
Average in the krai	75,0	88,0	94,0	63,0	62,0	59,0	73,5

There is a spot on the beetle body in front of the suture top. Rostrum reaches the mid-chest. In the upper part of the rostrum there are attached to club-shaped cranked feelers. The males have 8-segmented feelers, males -7segmented feelers. The beetles have big eyes directed forward. Mouth is well developed. Upper wings are of incorrect oval form and hard. The back and front parts of the notum are in the same horizontal level (Potyemkina et. al., 2008).

The lower wings of the beetles are membranous. Hind coxae do not cut through the first epigastrium, trochanters are small, ordinary ones. The females have ordinary shanks cut on the outer edge in front of the top. The males have spurs on the middle and back shanks. The male has an abdomen with five depressed segments but the female has six segments of prominent shape. There is an ovipositor on the edge of the abdomen. It was defined that the beetles awakening time after wintering depends on the spring coming terms: in early and warm springs – in the middle of May, in long cold springs – at the beginning or middle of June.

In the conditions of Primorsky krai the beetle's emergence in 2008, 2011, and 2012 was noticed at the end of May. After coming out from wintering the females undergo the period of additional feeding. They eat leaves of weeds till the time when buckwheat shoots appear. When buckwheat shoots appear the beetles move on them and eat first the cotyledon leaves, then true leaves. The beetles pairing and oviposition start in the second and third decade of June and lasts till the middle of September. The females lay 5-40 eggs into the side nodes and on the buckwheat leaves. While laying eggs the female with jaws cuts epidermis then turns and sticks its ovipositor into the incision. The place of laying eggs is easy to recognize watching the brown rim of the holes, made by the worm perforating the stem wall. The eggs are oval of milky white colour. The stage of development from the egg till worm takes 7-10 days. It was defined that the worms after birth from eggs intrude into the hollow part of the side nodes. The worms of different age were found in the stems of buckwheat plants. The worms live and eat in the stem of buckwheat (fig. 2). They eat inner soft tissue of the stem, concentrating in the nodes, and leave brown powdery excrements. The stem is damaged from the first till the sixth nodes, but the most suffering is the first node and crookedness takes place here.

Stems damaged by the worms are observed from the first till the fifth and the sixth nodes. We noticed that the worms move vermiform in the stem. They move from the bottom to the upper part of the plant stem. At the same time they make 4-6 holes in the stem. At a big density of beetles on $1m^2$ some larvae immediately damage the stem. There can eat 1-4 larvae in one stem. Larva in buckwheat stem was found in the third decade of July. At the end of August the number of larvae is sharply reduced, fnd at the beginning of September there were no larvae in the stems of buckwheat.

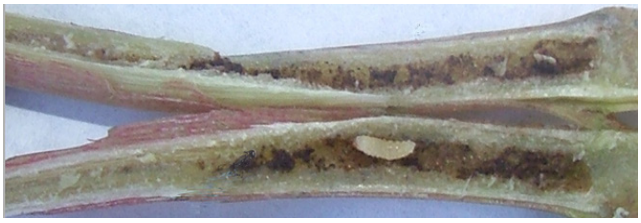

Figure 2. Larva of Rhinoncus sibiricus Faust

It was defined that the larva live and develop about a month in the *F. esculentum* stem. Then pupation occurs, as a rule, in the soil 5-10 cm deep or in the stem. The larva makes itself soft white cocoon. The beetle, appeared in 1-2 days has grey colour which becomes quickly dark and starts to eat buckwheat leaves. During the whole period we noticed that *Rhinoncus sibiricus* Faust are met on *F. esculentum* from shooting till harvesting time. A big amount of beetles was observed from the second half of June till August. The adult insects can fly well. Mass flight of beetles *Rhinoncus sibiricus* occurs in sunny days under heating of air till 20^oC and higher. On a fine sunny day they settle down on the upper side of *F. esculentum* leaves. In wet, windy and cold weather they hide in flowers, leaf axils and under clods of soil. Greyly colour of the beetles masks them well enough. Beetles of the current year eat coarsen leaves and go into the soil for wintering with underdeveloped ovaries and testicles. Thus next spring they need additional feeding. It explains primary damage of buckwheat made by *Rhinoncus sibiricus*. At the end of September when day and night temperatures fall down the adult insects go into soil for wintering. Thus one generation of the vermin develops in Primorsky krai. Our data are proved by researches of Safiullina (1959). The study showed that *Rhinoncus sibiricus* damage more in the early sowing than in the later ones (Table 2).

Table 2. Rhinoncus sibiricus damage of F. esculentum plants depending on the sowing term

Sowing term	The plant height, cm	The level branch number		The plant damage, %	Yield, t/ha
		1 level	2 level		
June, 1	91,5*/91,9**	2,5/2,5	0,7/0,8	92,5	1,2/1,4
June, 10	92,5/96,0	2,3/2,5	0,7/0,8	87,8	1,3/1,5
June, 20	97,1/99,5	3,0/3,0	0,9/1,1	75,0	1,4/1,8
July, 1	96,1/98,5	2,7/2,9	0,8/1,3	69,2	1,2/1,6
July, 10	91,5/95,0	2,5/2,5	0,7/0,8	67,7	1,1/1,4
LSD (5%)	6,2	0,1	0,1	8,6	0,1

* damaged plants; ** non-damaged plants. Significant difference (P<0.05)

Table 3. Usage efficiency of chemical and biological preparations on F. esculentum

Treatments	Biological efficiency, %	Yield, t/ha	Yield increase, t/ha
Control	-	0,97	-
Aktellik, emulsion concentrate (500 g/l) - 1 l/ha	82,2	1,10	0,13
Fufanon, emulsion concentrate (570 g/l) - 1 l/ha	77,5	1,00	0,03
Kinmix, emulsion concentrate (50 g/l) - 0,3 l/ha	93,5	1,42	0,45
karate, emulsion concentrate (50 g/l) - 0,1 l/ha	92,0	1,29	0,32
Aktara, water dispersion granule (250 g/kg) - 0,07 kg/ha	91,5	1,26	0,29
Konfidor, water-soluble concentrate (200 g/l) - 0,15 l/ha	84,4	1,08	0,11
Phytoverm, emulsion concentrate (10 g/l) - 0,5 l/ha	88,2	1,35	0,38
Phytoverm M, emulsion concentrate (2 g/l) - 2,5 l/ha	92,9	1,31	0,34
Batsikol – 20 l/ha	73,0	1,10	0,13
Boverin – 20 l/ha	84,7	1,20	0,23
Kruiser, suspension concentrate (350 g/l) – 0,7 l/ha	77,3	1,09	0,12
LSD (5%)	-	0,1	-

Significant difference (P<0.05)

The stem damage in the maturity stage varied from 67,7% till 92,5%. The most yield of non-damaged *F. esculentum* plants was received in sowings of June 20 and July1 (by 17-29% higher), than of damaged plants. At this period there are favorable conditions for growth and development of the plants. It promotes getting high yield of the crop. Proper organization of land use and crop rotation help to prevent massive colonization of crop pests. Such measures usually provide satisfactory phytosanitary condition of crops and reduce the need for using the pesticides.

While searching the predecessors' influence upon buckwheat plants resistance to *Rhinoncus sibiricus*, it was determined that the most stem damage of *F. esculentum* (75,0 %) was after soybean sowing [6]. While using perennial grasses and clover as a predecessor, there was found the least *Rhinoncus sibiricus* damage of the plants. The increase of the crop was accordingly 0,6 and 0,5 t/ha. Carried study for evaluation of chemical and biological preparations in order to decrease of *Rhinoncus sibiricus* damage, showed different biological efficiency (Table 3).

Thus after the chemical preparations treatment the most biological efficiency was 93,5% (Kinmix), the least – 77,5% (Fufanon). Usage of biological preparations also allowed getting good biological efficiency about 92,9% while treating by Fitoverm M. Tested protecting means increased buckwheat yield from 0,03 till 0,45 t/ha. Search work proved that the higher increase of yield was observed under treatment of Fitoverm M and Fitoverm 1% emulsion concentrate (from 0,34 till 0,38 t/ha), from chemicals – Kinmix (0,45 t/ha).

4. Conclusion

In the conditions of Primorsky krai *Rhinoncus sibiricus* is the most dangerous vermin (yield of buckwheat decreases by 17-40%). In *Rhinoncus sibiricus* protection of buckwheat the most important is a high cultivation technology of the crop.

The main cause of the sowings' damage by the vermin and low yield of the crop is poor agrotechnics. Decrease of the plants damage was observed in buckwheat sowing from June 20 till July 10. The best predecessor for *F. esculentum* providing the highest yield (till 2,2 t/ha) and decrease of *Rhinoncus sibiricus* damage in the conditions of the region are perennial grasses of long term usage (3-4 years). Usage of chemical and biological preparations in vermin control with beetles and larva of *Rhinoncus sibiricus* promoted decrease of the vermin harmfulness. Usage of chemical methods of the vermin protection means is dangerous for insects-fertilizers. Thus treatment of damaged shootings should be finished before buckwheat blooming, before bees start to fly in the buckwheat field. Not less importance in *Rhinoncus sibiricus* protection has coating of the seeds with the powder of biological and chemical preparations. Usage of them in *Rhinoncus sibiricus* protection promoted decrease of the vermin damage by 45%. Biological preparation Phitoverm M. showed the most biological efficiency during shooting period. Usage of biological preparations is the most harmless method for dicrease of *Rhinoncus sibiricus* damage. Thus, this protection method can be widely used in future.

Study of effect of biological and chemical protection of buckwheat against *Rhinoncus sibiricus* was not carried before except against weeds. That's why we solved the task to study different chemical and biological preparations against *Rhinoncus sibiricus* on buckwheat.

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