

Research Article

Soybean insect pests: A review of Ukrainian and world data

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Soya – is the main albuminous and oily crop of the world agriculture. It takes an important place in the structure of crops, grain, fodder and food balance. This is a strategic crop in solving the global food problem that is why it is grown on all continents in the main agricultural regions of our planet. In recent years soya has no competitors by the rates of crops growth and production volumes. Though Ukraine takes the first place in Europe by area of soya cultivation, its yield still does not correspond to potential possibilities. One of the factors which limit potential productivity is pests. Soybean protection from them is an important and relevant component for getting stably high yields and raising the quality of seeds simultaneously. Especially effective it has been monitoring in recent years as a result of an increase of sown areas and yield due to implementation of intensive technologies for soya cultivation. However, it should be taken into account that many species of harmful insects damage soya at all stages of ontogenesis, at the same time the loss of yield can make 30–40%. Harmful insect species from the following series have been discovered on soya crops in the Eastern Forest-Steppe of Ukraine: Orthoptera, Homoptera, Hemiptera, Thysanoptera, Coleoptera and Lepidoptera.

Key words: Soya; Pests; Insects; Species composition; Habitat; Protection

Introduction

One of the obstacles in obtaining soybean high yields can become harmful entomofauna, which remains studied not enough for the Forest-Steppe of Ukraine. Along with the expansion of this crop sowing areas the species composition of pests and their significance gradually increases. Most of them are polyphagous. In the favorable for development years pests can destroy up to 90% of yield. It's known, that harmful arthropods, which damage soybean can greatly decrease yield, influence the quality of seeding material, harm the grain during the storage, therefore the study of forming peculiarities of harmful entomofauna of soybean farm ecosystems is relevant. There is no common theory that explains the forming of entomological communities in agroecosystems of agricultural crops. It is known that each species in the conditions of its existence is inherent an optimal population density, which is hereditarily conditioned, and the deviation from which negatively affects the rates of reproduction and vital activity of individuals. An important factor is the potential of reproduction, as it determines the number, and hence the harmfulness and economic significance of the species.

Methods

In order to determine the dominant species of soybean pests which may have economic significance over 50 literature sources have been analyzed as for past and contemporary condition of soybean production in the world and the structure of

entomological community of soybean agricultural habitat. After that, in 2018 on the base of the generally accepted methods the research of soybean harmful entomofauna on the fields in the Experimental Field "Experimental Farming Elitne" of V.Ya.Yuriev Institute of Plant Cultivation of National Academy of Science of Ukraine was started.

Results and Discussion

Analysis of literature sources indicates about the differences in species composition of pests on soybean. There are more than 500 potentially harmful species in the world fauna (Fedotov, 1999). In the whole world, approximately 380 species of harmful insects collected on soybean are described (Luckmann, 1971). The biggest number of them was found in the countries of the Asian Region. In Japan, for example, on soybean can be found 220 species of insects, 30 of them cause significant crop losses (Kobayashi, 1970). The greatest harm is caused by *Nezara viridula* L., *Leguminivora glicinivorella* Mats., *Etiella zinckenella* Tr. and *Matsumura phaseoli* Mats. (Atsushi, 1984; Le Viet Dung 1983).

Fletcher (1922) was one of the first who discovered 9 soybean pests in India. About 85 species of insects, which belong to six different rows of insects and ticks on soybean, were described in the state of Madhya Pradesh by an entomologist Gangrade (1962), and Saxena (1972) registered in the same state only 32 insects. In the early 1970s of the 20 century during the beginning of soybean growing in India, as a crop, only about ten small pests-insects were noticed, meanwhile in 1997 this number increased to an alarming figure of 270, except for 1 tick, 2 millipedes, 10 vertebrates and 1 snail (Singh, 1999). More than 65 insects damage soybean from the cotyledon to the stage of harvesting in Indian state of Karnataka (Rai et al., 1973; Adimani, 1976; Thippaiah, 1997). Among them *Melanagromyza sojae* Zehntner and *Aproaerema modicella* Deventer, cause 100% damage and a decrease in yield by 20–30% (Singh & Singh, 1990).

The harmfulness of *M. sojae* Zehntner increased sharply in the third decade of August and the damage increased from 72.0 to 98.9 in the first decade of September (Singh & Singh, 1990a). According to some scientists' data (Berg, 1995) *M. sojae* Zehntner, as a rule, damages soybean throughout the season. At first, the damage is insignificant, reaches its maximum in 5-8 week after sowing, and decreases by the end of the season. The entomologist Patil (2002) has found out that the damage from *M. sojae* Zehntner was high in the states of Jahmandi (14.80%) and Mudhol (14.45%) the district of Bagaltok, Gokak (16/20%), Raibag (16/30%) and Atana (14.45) in the district of Belgaum (Karnaka State). In the same state of Rai (1973) as registered 24 species of insects that feed on soybean, including the maximum damage was done by larvae of *Lamprosoma indicata* F., *Stomopteryx subsecivella* Zeller and *Diacrisia obliqua*, another scientist Adimani (1976) near Dharvad has described 59 species of insects, that belong to 6 rows.

In Thailand 17 species of insects were found on the soybean crops, among which *M. sojae* Zehntner dominates. When grown in mixed crops of corn, the same pests are found on it, their harmfulness also does not change. Soybean cultivation in a monoculture leads to an increase in the number of pests compared to conventional crop rotation (Yoshimeki, 1986). In tropical and subtropical Asia and the Pacific Ocean *M. sojae* Zehntner is also a dangerous soybean pest. Imago lays eggs on the leaves; larva after feeding on the leaves penetrates into the trunk of the plant, makes passes and pupates (Vander Goot, 1930). The damage is not visually noticeable on the plant. They can be seen only after the dissection of a stem. As a result of infection of soybean crops with *M. sojae* Zehntner can lead to damage to about 100% of plants and a significant reduction in yield (Talecar & Chen, 1983).

Survey of soybean crops and researches of *M. sojae* Zehntner were carried out on the island of Kusu (Japan) (Suenaga, 1953). This pest is widespread and causes great harm to all legumes. Studies have shown that *M. sojae* Zehntner occurs from May to October. During the dissection of a soybean stem, it turned out that larvae appeared in June in small quantity. During the sowing of soybean at the end of May, in June, no damage was found. During the sowing in early June, the plants had 100% damage to the stems. 4 generations are developed for a year. In North-East China and in Korea *Epilachna vigintiomaculata* Motsh and *Laspeyresia glycinivorella* Mats are widespread on soybean, which more than 80% reduce grain yield (Avoy, 1979; Binh Nguyen, 1988). In such countries as Vietnam, Thailand and China the most harmful and widespread is *M. Sojae*, which damages up to 90% of soybean plants (Yoshimeki, 1986). In Indonesia the scientists note that *Etiella hobsoni* Butler destroys up to 80% of soya beans (Atsushi, 1984; Atsushi, 1986; Atsushi, 1987).

Soybean has become widely spread in America, in such countries as Mexico, Brazil, Argentina, USA (Avoy, 1979). In the USA soybean by the sowing area occupies the third place after wheat and corn. In the state of Arkansas (USA) 267 species of pests were registered on soybean fields (Tugwell et al., 1973). Insect damage has increased significantly in recent years because of increased sowing areas (Schillinger, 1976). A large number of insects is found on soybean here, among which the most dangerous is *Helicoverpa (=Heliothis) zea* (Boddie), which mainly damages soya beans and leaves in some southern countries.

Each caterpillar can damage 6-8 beans during the vegetation period (Rukovishnikov, 1978). Seeds are also damaged by *Leguminivora glycinivorella* (Obraztsov) and *Etiella zinckenella* Tr. (Kobayashi, 1980). Also great damage is caused by *Helicoverpa armigera* Hb, among beetles - *Epilachna varivestis* Mulsant. Leaves, flowers, young beans are being damaged (Funderburk, 1983). Nodules on the soybean roots are destroyed by larvae of flies *Rivellia quadnifasciata* Macquart from Platystomatidae family. Cotyledons in the soil and sprouts in cold springs are damaged by larvae of *Hylemya platura* Moig. Significant spread on soybean got bugs *Acrosternum hilare* Say, *Nezara viridula* L. and *Euschistus servus* Say, both adult individuals and larvae. They suck out the juice and damage all parts of the plants. Damage to underdeveloped seeds leads to significant changes in the chemical composition of soybean oil, the content of palmitic, stearic and oleic acids increases, and linolenic and linoleic decreases. Sowing qualities of seeds become worse (Reynard, 1976).

In some states of Brazil caterpillars of *Anticarsia gemmatilis* (Hüb) make up 80% of the total quantity of caterpillars, which feed on soybean leaves (Tadd, 1976). Bugs damage the beans in the period of grain formation, one of them is the bug *Nezara viridula* L., its part makes up 60-68% of the total number of bugs on soybean crops (Jones, 1978), in connection with it the percentage of grains which was damaged by this species is up to 70%, *Piezodorus guildini* Westwood – 25%, by other species – 5% (Ramachandran, 1992). In Argentina, the damage to seeds by bugs is 100%. The most vulnerable plants to damage by sucking pests in the phase of beans setting. During this period, 10 bugs registered per m² caused 100% damage to beans (Vaishamayan, 1980). In Egypt *Spodoptera littoralis* Boisduval does a great damage (Azab et al., 2001). Its caterpillars can damage more than 90 economically important plants, the main ones are soybean, cotton and others. For the last 25 years, an intensive use of pesticides against this *Spodoptera littoralis* Boisduval has led to resistance to insecticides treatments that are registered in the country

(Aydin & Gurkan, 2006). In European countries, there are their differences in species composition of pests and their spread. So in Serbia 23 species of insect have been discovered. Caterpillars of *Etiella zinckenella* Tr. do the biggest damage (Simova, 1988). Lately *Vanessa cardui* L. has been doing a great damage to soybean crops. Analysis of literature sources allowed determining known outbreaks of a *Vanessa cardui* L. reproduction, which are registered in Europe – 1973, 1996, 2001 and 2005 years. In 1996 millions of *Vanessa cardui* L. appeared in Great Britain. In 2005 was observed the maximum outbreak of *Vanessa cardui* L. in history. The maximum movement of an insect was noted in sight of about three individuals per second (<https://butterflyconservation.org/search?query=Vanessa+cardui>). This pest is spread throughout the world. Mass reproduction on the coast of Northern Africa and the far parts of the Sahara, causes the migration of *Vanessa cardui* L. Flying over the Mediterranean Sea, butterflies settle throughout Europe, and the eastern part of migrants, flying in transit Asia Minor, reaches the coast of the Caucasus (<https://1838.life/news/vanessa-cardui-iz-afriki-poselilas-na-sochinskoy-poberezhe/>). Butterflies of this species move in flocks and overcome up to 500 km per day, using passing airflows. In Europe, a new generation emerges over the summer. For a long time, scientists did not know if these insects come back in autumn to Africa, where their parents were born. In 2012 a group of radar entomology of the British agricultural research center Rothamsted Research confirmed, that the autumn migration really exists. Only to the South butterflies fly at a big altitude, so they are rarely seen (https://polit.ru/news/2017/10/06/ps_vanessa_cardui/). In 2019, mass flying of *Vanessa cardui* L. was noticed throughout the world. A great number was observed in Central Asia, namely in Uzbekistan and Tajikistan. The last outbreak of *Vanessa cardui* L. was observed 5-6 years ago (<https://www.fergana.agency/news/107561/>). There is also evidence that a large number of these insects were seen in southern California. Scientists believe that such a mass flying has not been observed since 2005, when about a billion of *Vanessa cardui* L. flew over the region. *Vanessa cardui* L. flies with a speed of up to 40 km/h without stops. The flocks are so big that they are counted as birds flocks (<https://oko-planet.su/pogoda/news/pogoda/484944-v-kalifornii-massovoe-nashestvie-babochek.html>). In March 2019 in Israel one of the biggest migration of this species was recorded. Especially many of these butterflies are in the coastal areas of Central and Northern part of the country, as well as in the Arava Desert. The previous mass migration of *Vanessa cardui* L. was recorded in 2014, but at that time they were ten times less. According to scientists calculations, in March of the same year from 700 million to 1 billion of *Vanessa cardui* L. flew over Israel toward Cyprus, Turkey and Southern parts of Europe. During the flying butterflies feed on nectar (<https://tass.ru/obschestvo/6248978>). The mass migration of *Vanessa cardui* L. did not pass by Russia. There are data that many butterflies settled on the coast of Sochi and such a big quantity was not observed earlier (<https://1838.life/news/vanessa-cardui-iz-afriki-poselilas-na-sochinskoy-poberezhe/>). In Ukraine in 2019, there is also a great number of butterflies of this species. Bilyavsky Yu.V. was engaged in researches of *Vanessa cardui* L. in Ukraine. In his article he represented the observation data for 2002-2009 years, was engaged in spread monitoring of this insect (Bilyavsky, 2010). Fokin A.V. was looking for the reasons for the mass appearance of *Vanessa cardui* L. in Ukraine. In his opinion, the mass appearance of the pest in 2009 in Ukraine is connected with butterflies migration from the South-Western region (Italy, Romania, Greece, Albania, Turkey) in the North-Eastern direction (Fokin, 2010). Russian scientists A.N.Frolov and M.I.Saulych have made an area of *Etiella zinckenella* Tr. prevalence and zone of its harmfulness, within which was defined the zone of average harmfulness (South of Ukraine, Krasnodar and Stavropol Krai, Rostov region, Lower Volga region), where yield losses of pulse on average can be 5-6%; the zone of low harmfulness, where yield losses, as a rule, are below the 5% limit, in European part of the Former USSR occupies the territory of pulse cultivation, in Asian part – the territory of soybean cultivation with an average temperature of July not lower than 20°C. Researches, which were carried out in Germany, show that great damage to crops is done by caterpillars of *Spodoptera litura* F. and *Thysanoplusia orichalcea* F. (Babu, 1979). In the South-East of France, where soybean is grown relatively recently, depending on the conditions the most harmful is *Tetranychus turkestanii* (Ugarov & Nikolskii) (Blane, 1988). In Latvia, there are not many phytophagous on soybean, about 20 species. The most harmful is *Heliothis armigera* Hüb. (Singh, 1973). In Turkey, 18 species of insects and 1 species of tick were noticed on soybean. The most widely spread are *Tetranychus urticae* CL Koch., *Nezara viridula* L., *Spodoptera exigua* Hub., *Autographa gamma* L., *Heliothis armigera* Hub., and *Vanessa cardui* L. (Zumreoglu, 1987). At the beginning of 90-s in the North Caucasus O.M. Shabalta and Thi Chat Nguen discovered 54 species of soybean photophagous, 20 of them are included in the list of soybean pests of Krasnodar Krai for the first time. From 54 known insects the most numerous are Lepidoptera – 20 species, Hemipterous – 12 species, Coleopterous – 8 species, Orthoptera – 7 species, Homopterous and Thysanoptera – 7 species. Besides, one species of tick was found (Shabalta, 1993; Shabalta, 1995; Shabalta, 1997). About 60 species of photophagous are registered in soybean crops, which is cultivated in the South-East of Kazakhstan on large areas. Among these insects, visible harm is done by *Tetranychus turkestanicus* Ug. et Nik., *Aphis fabae* Sc., *Aphis gossypii* Glov., *Cicadella viridis* L., *Psammotettix striatus* L., *Lygus pratensis* L., *Adelphocoris lineolatus* G., *Polymerus cognatus* F., *Graphosoma lineatum* L., *Thrips tabaci* Lind., *Agrotis segetum* Schiff., *Discestra trifolii* Hufn., *Heliothis virescens* Huf. and other insects. The time of intensive nutrition of photophagous coincides with critical periods in the life of plants, that along with other unfavorable conditions has a negative impact on productivity (Kuznecova, 1979). According to A.I. Mishchenko data in conditions of the Far Eastern Region 78 species of insects were described, 45 of which were found for the first time (Mishchenko, 1957). The most spread pests are Lepidoptera – 48 species (60% of harmful fauna). Ticks by the number of species are significantly inferior to Lepidoptera (9 species or 11.5%). This tendency concerns to beetles (8 species or 10%), Orthoptera (7 species or 10%). The part of other representatives of other rows (Homopterous Rhynchota, Thysanoptera and Diptera) does not exceed 10% (Kulikova, 1971). As early as in 2000 in the Priamurye nearly 100 species of arthropods were found, which can cause damage to soybean crops. The most spread pests are: *Luperodes menetriesi* Fald. – wide polyphage, which is typical for the Far-Eastern fauna and damages cotyledon, stem and leaves; *Loxostege stricticalis* L. – polyphagous pest; *Laspeyresia glycinivorella* Mats. – damages beans (Mashenko, 2005). E.V. Litvinenko in 1999–2002 years carried out the research on the specification of species composition of soybean pests in Krasnodar Krai. In general, the author identified 207 species of insects and 2 species of ticks, including 98 species of phytophagous which damage soybean (Litvinenko, 2001) In the conditions of Ukraine 68 harmful species were determined, among which the most dangerous are *Delia platura* (Meigen), *Sitona lineatus*, *Loxostege stricticalis* L., *Etiella zinckenella* Tr., *Heliothis dipsacea*, *Tetranychus urticae* Koch. and Elateridae. This description of soybean photophagous is given in O.A.Grykun's works in 1976 (Grikun, 1981). Later, in 1983, the list of entomofauna expanded to 72 species, which belong to 10 genera and 39 families and three classes – insects, ticks and slugs. As of 2009, year it contains 114 species of arthropods (Grikun, 2011). Analysis of species composition of pests on soybean crops from Experimental Field "Experimental Farming Elite", V.Ya.Yuriev Institute of Plant Cultivation of National Academy of Science of Ukraine in 2018 indicates that in systematical relation the biggest quantity of harmful species belongs to the rows of Hemiptera and Coleoptera – 30% of the total number of phytophagous insects. Lepidoptera belongs to the third largest group of species

(25%). Less numerous representatives are Orthoptera, Thysanoptera and Homoptera, which made up 5% (each) of the total number of pests (Figure 1 and Table 1).



Figure 1. Taxonomic structure of harmful soybean entomological complex in the Eastern Forest-Steppe of Ukraine.

Table 1. Species composition of soybean polyphagous insects in the Eastern Forest-Steppe of Ukraine.

Row	Family	Species	Specialization	Frequency of occurrence	
Orthoptera	Tettigoniidae	<i>Tettigonia viridissima</i> L.	P	C	
Homoptera	Cicadellidae	<i>Stictocephala bubalus</i> F.	P	C	
Hemiptera	Miridae	<i>Lygus pratensis</i> L.	P	D	
		<i>Lygus rugulipennis</i> Popp.	P	SD	
		<i>Adelphocoris lineolatus</i> Goeze.	P	Д	
	Pentatomidae	<i>Dolycoris baccarum</i> L.	P	SD	
		<i>Piezodorus lituratus</i> F.	P	D	
		<i>Palomena viridissima</i> Poda.	P	C	
		<i>Thrips tabaci</i> Lind.	P	C	
	Thysanoptera	Thripidae	<i>Thrips tabaci</i> Lind.	P	C
	Coleoptera	Elateridae	<i>Agriotes obscurus</i> L.	P	C
			<i>Sitona lineatus</i> L.	S	D
Curculionidae		<i>Sitona crinitus</i> Hrbst.	S	D	
		<i>Tychius quinquepunctatus</i> L.	S	C	
		<i>Psalidium maxillosum</i> D.	P	D	
		<i>Tanymecus palliatus</i> F.	P	C	
Lepidoptera	Noctuidae	<i>Autographa gamma</i> L.	P	C	
		<i>Chloridea viriplaca</i> Hfn.	P	C	
		<i>Etiella zinckenella</i> Tr.	S	C	
	Phycitida	<i>Etiella zinckenella</i> Tr.	S	C	
	Pyraustidae	<i>Margaritia sticticalis</i> L.	P	C	
	Nymphalidae	<i>Vanessa cardui</i> L.	P	R	

Note: P – Polyphagous; S – Specialized Species; D – Dominant (more than 5.0% of the total number); SD – Subdominant (2.0-5.0%); C – Constant; (0.5-2.0%); R – Rare (less than 0.5%)

Conclusion

The analysis of literature sources shows that soybean is cultivated throughout the world in different countries of the world. Species composition of phytophagous of this crop is very diverse. With the expansion of soybean crops new pests appear and accumulate in agroecosystem of the crop. The number of species of pests is increasing every year, due to the adaptation of many

phytophagous of local biocenosis to feed on soybean, which is caused by the expansion of sowing areas under this crop. Therefore, in order to control, it is necessary further observation of species composition of insects in soybean agroecosystem. In the course of a critical analysis of literature sources, we have noticed nearly the total absence of data on the species composition of soybean pests in the Eastern Forest-Steppe of Ukraine. Dominant species of pests, their biology, ecology and seasonal dynamics of quantity are not determined, and as a result, there are no reasonable recommendations as for protection measures against them. From this, it can be made a conclusion of the relevance of carrying out of researches in the Eastern Forest-Steppe of Ukraine and undeniable novelty of the obtained data. During experiments, we have identified pests, which belong to six rows. Generally, 20 species were counted. No excess of economic threshold of harmfulness was observed. Soybean plants are damaged at all stages of development, but the most vulnerable are in phenophases of sprouting, laying of generative organs, grain formation and grain ripening. Accounting on the surface of the soil and on plants is carried out throughout the active life of insects.

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