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REVIEW ARTICLE

Rape pollen beetle: Range, bioecological features, harmfulness and protection measures: Review

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In the course of the literature critical analysis the authors paid special attention to the morphological, biological and ecological features of the rape pollen beetle, both in Ukraine and abroad; the authors came to the conclusion that despite the considerable number of literary sources devoted to the rape pollen beetle, there is still a number of its biological and ecological features which are in close connection with the protection measures for controlling it and these measures have not yet been completely clarified. The data obtained by the entomologists from different countries regarding the harmfulness of the rape pollen beetle and its economic importance are quite controversial and also need experimental confirmation.

Keywords: Rape pollen beetle, morphology, biology, ecology, harmfulness, economic threshold of harmfulness, integrated protection.

Introduction

The rape pollen beetle (Meligethes aeneus Fabricius, 1775) is one of the most dangerous pests on Brassicaceae crops in all areas of their cultivation, as it can damage plants during the budding and flowering phases (Snizhok, 2007; Shpaar, 2007; Yakovlyev, 2007; Sekun et al., 2008; Chirkov & Moskalenko, 2009; Snizhok, 2009; Gordyeyeva, 2010 a; Gordyeyeva, 2010 b; Yevtushenko & Stankevych, 2010; Yevtushenko & Stankevych, 2011; Stankevych, 2011a).

The rape pollen beetle is widespread throughout Ukraine, annually causing significant damage to plantations and reducing seed yields (Kasyanov, 2011). The species range covers the entire Europe, the Caucasus, Asia Minor, and North Africa (Vasilev, 1987), but as to Central Asia, it is only found in Turkmenistan (Fig. 1) (Pavlovskij, 1941). N.A. Filippov (Filippov, 1978) pointed out that the rape pollen beetle was the most dangerous pest on Brassicaceae crops in Moldova. D. Shpaar (Shpaar, 2007) reported that the rape pollen beetle was the most dangerous pest on Brassicaceae crops in Germany, Poland and France.

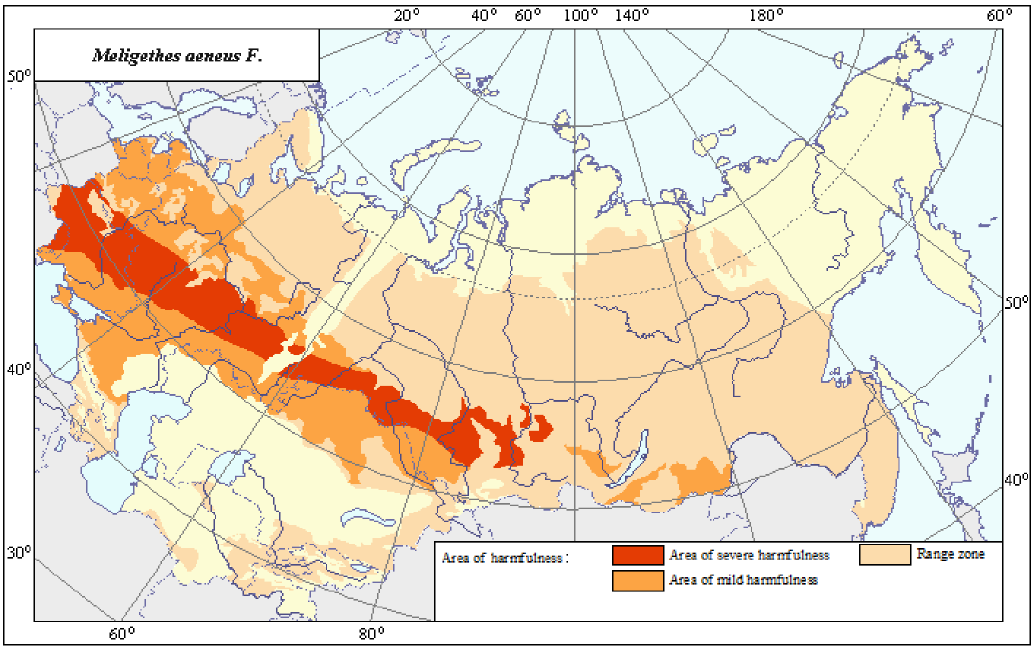

Fig. 1. Range zone and areas of harmfulness of the rape pollen beetle.

It should be noted that the rape pollen beetle is not new to our country; it was mentioned as a pest both of rapeseed and of other Brassicaceae crops as early as in 1845 (O vrednyh nasekomyh, 1845) and its morphology, biology and ecology were described in detail the 19th century publications (Bramson, 1881; Keppen, 1882; Iversen, 1883; Lindeman, 1866; Blomejer, 1901). N.N. Plavilshikov (Plavilshikov, 1994) defined the taxonomic status of the rape pollen beetle as follows: Class Insects-*Insecta* Leach, 1815; Subclass Winged Insects or Higher Insects-*Pterygota* Gegenbaur, 1878; Infraclass Neopterans-*Neoptera* Martynov, 1923; Division Holometabolic Insects-*Holometabola;* Hyperorder Coleopteroids-Coleopteroidea; Order Coleopterans-*Coleoptera* Linnaeus, 1758; Suborder Omnivorous Beetles-*Polyphaga* Emery, 1886; Family Sap Beetwles-*Nitidulidae* Latreille, 1802; Genus *Meligethes* Fabricius, 1775.

Materials and Methods

The authors analyzed 157 literary and electronic sources from the late 19th to the 21st century. During the analysis, special attention was paid to the morphological, biological and ecological features rape pollen beetle in Ukraine and abroad. The data on the harmfulness of the rape pollen beetle and its economic significance are especially analyzed. In the course of the analysis special attention was paid to the methods and ways of controlling the rape pollen beetle in Ukraine and abroad. The protective measures were considered in such directions as agro-technical, physic and mechanical, chemical, biological, biotechnical and selective and genetic ones. Each of them is noteworthy and has both a number of disadvantages and indisputable advantages in comparison with other methods.

Results and Discussion

Morphology, biological and ecological features and harmfulness of the rape pollen beetle

The imago is 1.5-2.7 mm in size; its body is flat, elongated, black with a green or blue metallic sheen (Fig. 2A); the antenna are relatively short, with a three-segmented club; the legs are short and dark; the anterior legs are rarely reddish-brown; the anterior tibiae are finely serrated (Gerasimov & Osnickaya, 1961; Shapilo, 1986; Kasyanov, 2011). The body top is densely dotted; the gaps between the dots are not larger than the dots themselves.

The egg size is 0.3 mm; the egg is white, smooth, elongated-oval (Gerasimov & Osnickaya, 1961; Ivanov et al., 1985; Iskakov & Krasnikova, 1991). The grub is 3.5-4 mm in size, worm-like, with three pairs of brown-black legs, pale gray, covered with small black warts; the head is brown (Fig. 2B) (Gerasimov & Osnickaya, 1961; Abramik et al., 2010). The pupa is 3 mm in size, free, flattened-ovoid, waxy-white; it turns yellow prior to the imago emergence and then becomes completely dark (Vasilev, 1988).

Fig. 2. Rape pollen beetle: **A**-imago; **B**-grub.

Training, research and production center *doslidne pole (experimental field)* of vv dokuchaev khnau (2011)

In Ukraine, sexually immature beetles overwinter on the soil surface under fallen leaves or under plant remains on the edge of forests, in gardens and parks. Beetles get out of overwintering housings in the second half of April-early in May (Bardin, 2000). It was published (Gar & Melnikova, 1986) that the main triggers for overwintering beetles to get out were the air temperature of 8.6 (± 0.6)°C and soil warming at a depth of 5 cm to 8.7 (± 0.8)°C. Mass swarming occurs at 13.8–14.6°C; however, other scientists give the following temperatures: 10.1–11.3°C (Gerasimov & Osnickaya, 1961; Gurova, 1963) and 10.7°C, with the sum of effective temperatures of 94.1–119.1°C (Snizhok, 2009).

Several researchers (Gerasimov & Osnickaya, 1961; Laba, 2006; Gordyeyeva, 2010 a; Gordyeyeva, 2010 b; Yeshenko, 2010; Pisarenko & Gordyeyeva, 2010) reported that beetles first inhabited flowers of dandelion, buttercup, winter cress, and later appear on flowers of fruit trees (cherry-trees, apple-trees, etc.). We observed (Stankevych, 2011a; Yevtushenko & Stankevich, 2012; Stankevych, 2012f; Stankevych, 2012h) that after leaving wintering housings the rape pollen beetle additionally fed on dandelion, buttercup, small tumbleweed mustard, flixweed, field mustard, and winter cress. As E.A. Ivancova (Ivancova, 2010) described, the additional feeding lasts 12–15 days in the rape pollen beetle. Beetles appear on domestic Brassicaceae plants with the first green buds (Kulik & Shvecova, 1940; Lugovskij, 2011), which is mentioned by the vast majority of scientists, however, V.V. Stefanovskij (Stefanovskij & Majstrenko, 1990). noted that plants got inhabited as inflorescences formed. This period coincides with the first half of May. Beetles feed on the inner parts of flowers (pistils, stamens, pollen, petals). Damaged buds turn yellow and drop. Feeding mainly on pollen of full-blown flowers, the rape pollen beetle is less harmful, if anthesis is even and rapid. However, upon mass swarming, beetles can inflict significant damage during anthesis (Shapilo, 1986; Vlasenko, 1997; Krut', 2003).

As B.A. Gerasimov (Gerasimov & Osnickaya, 1961) noted, when the crop was damaged in the budding phase (10 beetles per 100 buds), the yield loss was 72.5%, but when the crop was damaged during anthesis (10 beetles per 100 flowers), the yield loss was 35.9%. When flowers were slightly damaged, they did not fall off and distorted curved pods developed. However, L.M. Ovchinnikova (Ovchinnikova, 1971) and V.N. Voskresenskaya (Voskresenskaya, 1973) reported that, when the crop was infested in the budding phase with a population density of 5 beetles and 10 beetles per plant, the yield decreased by 1.0-16.7% and 2.5-20.5%, respectively. If beetles infested plants during anthesis, even the population density of 15-20 beetles per plant led to no decrease in the yield and even a gain in the yield of 3.66 ± 0.12% to 7.00 ± 0.12% was observed. This is attributed to the fact that the rape pollen beetle acts as a pollinator (to some extent) during the anthesis. Nevertheless, with an increase in the population density to 30 beetles per plant, the yield was reduced by 2.66 ± 0.11%. L.V. Sorochinskij (Sorochinskij, 1988) published data that at a population density of 70 beetles per plant, the yield loss amounted to 82%. Бернд Хонемайєр from the University of Rostock (Germany) reported that at the rape pollen beetle population density of 1.5 beetles/plant during anthesis, the yield decreased by 22.2%, at 5.5 beetles/plant-by 55.5%, and at 11 beetles/plant-by 66.4% (Krut, 2003). The degree of the rape pollen beetle–induced damage to plants is also associated with Alternaria affection of rapeseed plants. Pathogens use beetle-damaged flowers to penetrate the plant (Sytnyk, 1997). In Germany, the economic threshold of harmfulness (ETH) (Kirch & Basedow, 2008) for the rape pollen beetle is currently 2 beetles/plant, but it is being discussed that this parameter may be changed to by 5-6 or even 8-10 beetles/plant. In Austria, the rape pollen beetle ETH is 6 beetles per plant on winter rape and 2 beetles per plant on spring rape (Szith, 2009). In Norway (Andersen, Kjos, Nordhus & Johansen, 2008), the ETH is 1-2 beetles per plant in the budding phase.

M.V. Krut' (Krut', 2003) pointed out that The ETH was 0.5-1.0 beetles/plant during the flower bud formation, 2.0 beetles/plant 14 days before anthesis, and 2.5–3.0 beetles/plant prior to anthesis. At the Institute of Cruciferous Crops of NAASU, the ETH for the rape pollen beetle was defined as follows: 1 beetle per plant during the bud formation, 2-3 beetles per plant in the phase of enlarged buds, and 5-6 beetles per plant at the anthesis onset (Abramyk et al., 2010; Gordyeyeva, 2010a; Gordyeyeva, 2010b). The beetle population density is particularly high in areas adjacent to afforestation belts and shrubs.

It is interesting that I.V. Kozhanchikov (Kozhanchikov, 1929) and N.L. Saharov (Saharov, 1934) emphasized that the presence of the rape pollen beetle in no way prevented the Brassicaceae seed plants from giving high yields of seeds.

After 12–15 days (usually during the third 10 days of May), females lay eggs in buds that have not yet bloomed with stamens. According to different references, the female lays from 1 to 10 eggs in one bud (Gerasimov & Osnickaya, 1961; Osmolovskij, 1972; Ivanov et al., 1985; Milashenko & Abramov, 1989; Iskakov & Krasnikova, 1991; Leisker, 2007; Ivancova, 2010). The total number of eggs laid by 1 female is 40–50 eggs (Maksimov, 1990). Four–twelve days later, depending on the temperature, grubs that live in buds and flowers, feeding on pollen, hatch (Gerasimov & Osnickaya, 1961; Gurova, 1963; Bardin, 2000). Different researchers reported various duration of the embryonic period: from 4 to 14 days (Gorodnij, 1970; Ovchinnikova, 1971).

Only with a dense infestation of flowers, grubs can significantly damage them (Gerasimov & Osnickaya, 1961). G.Ye. Osmolovskij (Osmolovskij, 1972) published data that grubs inflicted significant damage only at a population density of 3 or more grubs per flower. However, Ya.P. Bardin (Bardin, 2000), L.I. Bud'ko (Bud'ko, Rovba & Shaganov, 2008) and Ye.A. Ivancova (Ivancova, 2010) believed that grubs of the rape pollen beetle could cause significant damage. Ya.P. Bardin (Bardin, 2000) reported that several grubs could feed simultaneously on some flowers, moving from flower to flower, from plant to plant, and completely destroying the inflorescence. V.V. Markov (Markov, 2006) and L.I. Bud'ko (Bud'ko, Rovba & Shaganov, 2008) published data that grubs also intensively fed on young pods. With mass emergence, grubs of the rape pollen beetle reduce seed yields and often completely destroy seeds. However, the Swiss researcher F. Hani (Hani, 1988) thought that grubs feeding on flower pollen did not do any harm to plants.

Grubs live 10–30 days, then they mine into the soil (Orobchenko, 1959; Gerasimov & Osnickaya, 1961; Milashenko & Abramov, 1989; Bardin, 2000) to a depth of 1.5–5.0 cm (different researchers reported different figures) and pupate (Maksimov, 1990; Abramik et al., 2010). The pupal stage lasts 10 to 16 days. In late May-early June, young beetles of a new generation emerge and also feed on flowers of different plants. Around the end of July, when Brassicaceae oil crops ripen, the new generation of beetles fly to overwintering housings (Orobchenko, 1959; Milashenko & Abramov, 1989).

G.Ye. Osmolovskij (Osmolovskij, 1972) reported that in the northern regions of Russia the rape pollen beetle had one generation per year, while in the central and southern regions-two or three generations. Ye.A. Ivancova (Ivancova, 2010) reported that in the Volga region the rape pollen beetle gave 1-3 generations per year. R.Ya. Kuznecova (Kuznecova, 1975) pointed out that in the northern regions of Russia the rape pollen beetle had one generation per year, while in the southern regions it gave 2-3 generations. In Sweden and Norway (Andersen, Kjos, Nordhus & Johansen, 2008; Wivstad, 2010), the pest produces one generation per year. The vast majority of researchers believed that in Ukraine the rape pollen beetle gave two generations (Gurova, 1963; Gorodnij, 1970), but G.M. Kovalchuk (Kovalchuk, 1987) thought that only one. V.P. Orobchenko (Orobchenko, 1959) published data about 3-4 generations. A. Podkopayev (Podkopayev, 1933) also wrote that the rape pollen beetle gave several generations per year. V.P. Fedorenko (Fedorenko et al., 2008) emphasized that in Ukraine the rape pollen beetle gave 1-2 generations per year. Z.I. Gurova (Gurova, 1963) wrote that in the eastern forest-steppe of Ukraine the full development cycle of the first generation of the rape pollen beetle took 36–42 days, and of the second generation-26-29 days. The maximum use of its natural enemies is an important factor limiting the rape pollen beetle numbers.

According to F. Keppen data (Keppen, 1882), the scarlet malachite beetle *Malachius aeneus* eats *M. aeneus* grubs and wasps of the genus *Microgaster* parasitize in grubs. The endoparasite *Diospilus capito* Nees (Hymenoptera: Braconidae) parasitizes in *M. aeneus* grubs (Ovchinnikova & Voskresenskaya, 1972; Voskresenskaya, 1973).

In Germany, major main natural enemies of the rape pollen beetle are the parasitoid *Phradis morionellus* (family Ichneumonidae), which develops in *M. aeneus* grubs and pupae, and nematodes of the genera *Steinernema* and *Heterorhabditis*, which infest up to 10% of *M. aeneus* pupae in the soil (Brust, 1991; Nitzsche & Ulber, 1998; Nielsen & Philipsen, 2005; Susurluk, 2005; Ehlers, R.-U. (2006). In Switzerland, the natural enemies of *M. aeneus* grubs are parasitic wasp of the genera *Isurgus* and Diospilus, and the imago number is regulated by the microsporidium *Nosema meligethi* I. et R. (Lipa & Hokkanen, 1991).

Protection against the rape pollen beetle

Information on protection against the rape pollen beetle has been known since the mid-1800s. Beetles were recommended to be collected with sweep-nets or shaken in bags early in the morning or in cloudy weather (Bramson, 1881; Keppen, 1882; Iversen, 1883; Blomejer, 1901). In the 1930s, there were recommendations to sprinkle plants with calcium orthoarsenate, sodium fluorosilicate or anabadust, to spray with copper acetoarsenite and barium chlorate at the budding onset and to repeat spraying twice or three times with an interval of 6-7 days, to shake beetles in a bucket of water with a little kerosene on the water surface (Podkopayev, 1933;

Shyogolev, Znamenskij & Bej-Bienko, 1937). In the 1940s, shaking plants in the morning was recommended to protect against *M. aeneus* imagoes. During the budding phase, but always prior to anthesis, twice or three-time sprinkling with calcium orthoarsenate or sodium fluorosilicate with talc in a ratio of 1:6 and anabadust was applied. It was also reported that in experiments of the Novosibirsk Plant Protection Station good results were obtained from spraying with a pyrethrum extract (Moric-Romanova, Berezhkov & Davydov, 1941). In the 1950s-1960s, several researchers (Zambin, Turaev & Shumilenko, 1953; Orobchenko, 1959; Gerasimov & Osnickaya, 1961) recommended twice or three-time sprinkling plants with pesticide dusts such as dichlorodiphenyltrichloroethane (DDT), hexachlorane, sodium fluorosilicate, calcium orthoarsenate, anabadust or metaphos in the budding phase; there are also data that in other countries insecticide toxaphene, which, like DDT and hexachlorane, is an organochlorine compound, but as the author stated, was much safer for bees, was used. In the 1970s, sprinkling plants with hexachlorane or metaphos, or with a mixture thereof was recommended (Gorodnij, 1970).

In 1974, A.A. Moskalyova (Moskalyova, 1974) for the first time presented data on the effectiveness of microbial products such as Entobacterin with a titer of 30 billion spores of *Bacillus turingiensis var galloriae*, Dendrobacillin with a titer of 20 billion spores of *Bacillus turingiensis var dendim titer*, Boverin with a titer of 6 billion spores *Beauveria bassiana (Bals) vuil* to control the rape pollen beetle numbers. These agents were used alone or in mixtures with chlorophos. The mortality of beetles from biological products amounted to 45%, and from mixtures with chlorophos-to 93%.

In 1973, as part of a research project, to protect against the rape pollen beetle at a population density of 20 insects/plant, plants were twice sprayed with malathion, azinphosmethyl, phosalone or with hexachlorocyclohexanes (HCH) during the budding phase (Rape seed production, 1973). V. Teuteberg (Teuteberg, 1973) in Germany recommended to carry out 1-2 sprayings with chlorfenvinphos prior to anthesis and 4-5 treatments with HCH during anthesis. In Czechoslovakia (Vilinskiy, 1974), plants were sprinkled with toxaphene at the anthesis onset. A.A. Moskalyova (Moskalyova, 1974), to control the rape pollen beetle numbers, also recommended a number of organophosphorus compounds such as dichlorvos, cartap hydrochloride, tetrachlorvinphos, diazinon, dimethoate, phosphamide, phosalone, and cyanox, the effectiveness of which ranged 28 to 100%, as well as a biological product, Bitoxibacillin (BTB-202), with a titer of 40 billion disputes, the efficiency of which was 100%.

A.A. Gortlevskij (Gortlevskij & Makeeva, 1983) recommended spraying with thiodan at a population density of 6–8 insects/plant in the budding phase. O.A. Ivanov (Ivanov et al., 1985) recommended spraying with chlorophos, thiodan, dichlorvos, malathion, or with phosphamide at a population density of 2–3 insects/plant before budding and with 1% suspension of Bitoxybacillin before anthesis P.I. Zajcev (Zajcev, 1987) indicated that the effectiveness of fenvalerate was 90% and of metaphos-70-80%. V.T. Piven (Piven, 1988) recommended protecting plants against the rape pollen beetle by spraying with thiodan or fenvalerate in the budding phase A.P. Tuzlukova (Tuzlukova, 1987) published data on a high effectiveness of organophosphorus insecticides (metaphos, phoxim, pirimiphos-methyl) in mixtures with trace elements (boron and molybdenum) in the control of the rape pollen beetle.

In the early 1990s, V.V. Stefanovskij (Stefanovskij & Majstrenko, 1990), to protect plants against the rape pollen beetle, recommended spraying with insecticides such as pirimiphos-methyl, permethrin, phoxim, phosalone, malathion, methylparathion, fenvalerate and cypermethrin in the budding phase and adding dimethoate or etaphos to the soil simultaneously with sowing. N.G. Vlasenko (Vlasenko & Kulagin, 1993) recommended trap crops as a method of controlling the rap pollen beetle numbers, i.e. about 10% of the planned cultivation area is allocated for a trap crop. According to his data, this way is used to protect spring rape against the rape pollen beetle in Finland. Spring rape itself, but sown a week earlier than the main crop, acts as a trap crop. N.G. Vlasenko (Vlasenko & Kulagin, 1993) used winter cress, mustard and oil radish as trap crops in Siberia.

The white turnip is used as a trap crop in Switzerland (Buchi, 1990).

Recently, the range of insecticides recommended for the protection of Brassicaceae oil crops against the rape pollen beetle has been so widened that there is no need to dwell on each agent. Several researchers recommended spraying with one of the permitted insecticides to protect plants in the budding phase (Chehov, 2001; Chervonenko, Tereshenko & Ishenko, 2003; Laba, 2006; Lazar et al., 2006; Gordyeyeva, 2007a; Gordyeyeva, 2007b; Sahnenko, 2007; Shpaar, 2007; Zhuravskij & Sekun, 2007; Fedorenko et al., 2008; Sytnyk, 2008; Mazur et al., 2009; Snizhok, 2009; Abramyk et al., 2010; Ivancova, 2010; Krasilovec, 2010; Yeshenko et al, 2010; Kasyanov, 2011; Kyforuk et al., 2011).

As per the List of Pesticides and Agrochemicals Approved for Use in Ukraine, in 2020, 88 insecticides were recommended to be sprayed on Brassicaceae oil crops to protect them against the rape pollen beetle during the growing period; of them, 36 insecticides (40.9%) are synthetic pyrethroids, 19 insecticides (21.6%)-neonicotinoids, 5 insecticides (5.7%)-organophosphorus compounds, 1 insecticides (1.1%)-pyridinecarboxylides, and 27 insecticides (30.7%) are combined products.

When regulating the rape pollen beetle numbers, vegetating plants are sprayed with permitted insecticides before anthesis to prevent mass extermination of bees (Bardin, 2000; Stankevych, Teslina & Ozhga, 2010; Stankevych, 2010; Stankevich & Fedorenko, 2011; Stankevych, 2012f; Stankevych, 2012h). The need to expand the range of insecticides to control the rape pollen beetle numbers arises from the fact that this beetle rapidly becomes resistant to pyrethroids, which are now widely used worldwide to protect rapeseed. In addition, pyrethroids lose their insecticidal properties after a long exposure to temperatures above 25°C and direct sunlight. This was menthioned by D. Shpaar (Shpaar, 2007) as early as in 2007. According to his data, in 2004 in Germany, the resistance of the pest to pyrethroids was 10%, in 2005-20%, and in 2006-as high as 50% and in most areas the yield losses amounted to 70-80%. After that, neonicotinoids and new organophosphorus compounds were mandatorily included in the protection algorithm, and the next year the phytosanitary situation improved. Moreover, organophosphorus compounds appeared to be more effective than neonicotinoids (Burghause & Schackmann, 2006; Heimbach, Thieme & Mulle, 2006). In 2005, at a meeting of a special commission on insect resistance to synthetic pyrethroids in Germany (Fachausschuss Pflanzenschutzmittelresistenz, 2005), data on the effectiveness of some agents against the rape pollen beetle were presented. For example, the highest mortality of beetles was recorded with beta-cyfluthrin application (40-92%), while lambda-cyhalothrin only killed 8-77% of beetles. In addition, it was reported that beetles that had become resistant to pyrethroids overwintered much better and left overwintering houses much earlier than it had been expected. The genetic mechanism of developing resistance to synthetic pyrethroids in the rape pollen beetle was studied in Sweden and described in detail in J. Pernestal publication (Pernestal, 2009). Since in Sweden, starting from the 1980s, only pyrethroids were used to control the rape pollen beetle numbers, in 2009, there was not a single synthetic pyrethroid insecticide left on the pesticide market that would be effective in controlling the pest. To date, the rape pollen beetle numbers are limited to insecticides belonging to other chemical groups (Sundgren et al., 2008). In 2007 in Norway, it was noted that synthetic pyrethroids almost did not regulate the rape pollen beetle numbers, because due to their continuous long-term use, beetles had developed cross-resistance to these insecticides (Andersen, Kjos, Nordhus & Johansen, 2008), and today, to control this pest, neonicotinoid insecticide Biscaya (24% oil dispersion) is used. However, it is not advisable to use only this insecticide, as resistance to it may also develop (Andersen, Kjos, Nordhus & Johansen, 2008). In Switzerland, the most promising trend in controlling the rape pollen beetle numbers is the cultivation of resistant rapeseed varieties, including genetically modified ones (Ammann & Vogel, 1999), and, in Germany, the cultivation of trap crops is important (Hirthe, 2010; Hirthe & Jakobs, 2010; Michel. & Hirthe, 2010).

Conclusion

The analysis of the literary data indicates that despite the considerable number of the literary sources devoted to the rape pollen beetle, there is still a number of its biological and ecological features which are in close connection with the protection measures for controlling it and these measures have not yet been completely clarified. Modern systems of plant protection, consist in developing and implementing the integrated measures that preserve the crops from the harmful organisms while being the safest for the environment, animals and humans. The transition to such integrated systems involves the application of a biological method of pest control, reducing the number of pesticide treatments, the ability to use the preparations of selective action together with the entomophages, etc. An important reserve in this program is the activation and use of natural resources of the beneficial insects (parasitoids and predators) which limit the number of harmful insect-phytophages.

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