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EFFICIENT PEST CONTROL IN OILSEED RAPE AND POSSIBILITIES FOR PROTECTING THE NATURAL POLLINATORS AND HONEY BEES

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Abstract

Oilseed rape is attacked by a number of pests, which could compromise the yield and quality of the produce. Losses caused by them could be reduced by applying a broad spectrum of pesticides (insecticides and fungicides) that often have a negative effect on the natural pollinators and honey bees.

Studies were carried out in the period 2010-2013 in the Training-and-Experimental Fields of the Agricultural University – Plovdiv and in industrial production areas in the regions of Pazardzhik and Plovdiv.

Phenological development of oilseed rape and the accompanying phytopathological and entomological problems enabled us to develop a plant protection model. The established critical period at the stages of buttoning – flowering – fruit set, includes the choice of applying the plant protection chemical and the time for realizing efficient control, combined with the possibilities for protecting the pollinators of oilseed rape.

Key words: oilseed rape, pests, chemical control, pollinators

Introduction

Oilseed rape is a crop with a long period of vegetation which starts in the beginning of September and lasts until June. This makes it necessary for the plant protection activities to encompass the autumn-spring period. The formation of the rosette in autumn is an important prerequisite for the successful wintering of the crop and its resistance to low temperatures. It has been proven that 50% of the yield is formed in autumn. The formed leaves shall be protected against diseases and pests.

Within the period stretching from the moment of growing to the formation of the rosette, damages are usually caused by the following pests: flea beetles of the *Phyllotreta* genus, cabbage stem flea beetles (*Psylliodes chrysocephala* L.*)*, red turnip beetles (*Entomoscelis adonidis* Pall) and coleseed sawflies (*Athalia rosae* L.) (Palagacheva and Dimitrov, 2011). In addition to the pests during the early vegetation period, serous damages are also caused by the fungal diseases blackleg (*Leptosphaeria maculans* (Desm.) Ces.& de Not.; *Phoma lingam* (Tode ex Fr.) Desm) and leaf spots (*Alternaria brassicae* (Berk.) Sacc.) (Encheva-Vasileva, 2006; Yu Chen, 2006; Tonev, 2008; Bankina, 2010).

In the early spring as the temperatures rise, the oilseed rape resumes its growth and forms a flowering stem. Throughout the entire vegetation period, it is inhabited by a large number of harmful and also useful insects. From the rosette phenophase to the stage of buttoning-flowering and fruit set, the following insects are detected: flea beetles of the *Phyllotreta* genus, cabbage stem flea beetles (*Psylliodes chrysocephala* L.*)*, pollen beetles - *Meligethes aeneus* F., beetles – *Tropinota hirta* Poda, cabbage stem weevils (*Ceutorhynchus quadridens* Panz.(*C.pallidactylus* Marsh.), cabbage seedpod weevils (*Ceutorhynchus assimilis* Payk.(*C.obstrictus* Marsh.), rape stem weevils (*Ceuthorynchus napi* L.) (Palagacheva and Dimitrov, 2011). The detected diseases are the following: blackleg (*L. maculans*; *Phoma lingam*), white mold (*S. sclerotiorum*), gray mold rot (*Botrytis cinerea* Persoon), leaf spots (*Alternaria brassicae* (Berk.) Sacc.), powdery mildew

(*Erysiphe cruciferarum* (Opiz ex L. Junell) (Encheva-Vasileva et al., 2006; Yu Chen and Fernando, 2006; Tonev et al., 2008; Bankina et al., 2010).

The protection of oilseed rape against pests is related to the execution of a number of activities which include the efficient completion of the overall fight and the protection of the natural pollinators and the bees as well. In autumn they are used for the purpose of limiting the scope of damage and improving the phytosanitary status of the crops and in the spring they are intended to protect the plants and provide good-quality high yield.

About 80% of the flowering plants are pollinated by bees and other useful types which constitute only 20% of all insects (Naydenov and Zaharinov, 2012). Based on the data provided by Food Agricultural Organization (FAO), out of 100 types of plants which provide 90% of the food worldwide, 71 are pollinated by bees. The effect of pollination is 20-25 times greater than the value of the obtained yield of honey.

Bees play an important role in the pollination of the oilseed rape, as a result of which we obtain a higher yield and good-quality seeds of this crop compared to the case when pollination is performed by the wind (Bommarco et al., 2012). In their studies Abrol et al. (2007) also emphasize the importance of bees among natural pollinators. The yield of rape and mustard seeds is doubled when pollination is done by the insects. Pollinators not only increase the yield of the crop but also contribute to the even and early formation of the pods.

The increased use of pesticides over the last few years significantly raised the mortality rate of the natural pollinators and the bees. In their studies Gill et al. (2012) have established that the use of neonicotinoids and pyrethroids has a negative influence on the large earth bumblebees, increases the mortality rate of the worker bees and considerably reduces the number of the offspring, which eventually leads to the death of the family. Neonicotinoids also affect the behaviour of the bees (Fischer et al., 2013). According to Henry et al. (2012), the contact with insignificant quantities of tiametoxam causes disorientation and inability of the bees to find the beehives.

The “empty beehive” syndrome and the introduced changes in the European legislation restricting the application of some neonicotinoids provide conditions for establishing plant protection models aimed at ensuring the effective protection of oilseed rape, the natural pollinators and the bees, which is the purpose of this survey.

Material and methods

The studies were conducted within the period 2010-2013 in the Training-and-Experimental Fields of the Agricultural University – Plovdiv and in the industrial production areas in the regions of Pazardzhik and Plovdiv. We conducted systemic observations on the emergence and the development of pests and diseases on the oilseed rape. The registering was implemented on the grounds of the common entomological and phytopathological methods – using an entomological net, sample lots, observations and visual inspections of the plants.

The index of diseases attack has been calculated using the formula of McKinney (Josefovich, 1956). The identification of the agents was performed using a macroscopic and a microscopic analysis.

The treatments of the crops were performed using preparations from the groups of the organophosphorus insecticides, the synthetic pyrethroids and oxadiazins. Their efficiency was observed by the 15th day after treatment.

Results and discussion

The conducted survey shows that the first pests in the rape agrocenosis during the cotyledon – rosette formation phenophase are the black cabbage flea beetles (*Phyllotreta atra* F.), the striped cabbage flea beetles (*Phyllotreta undulata* Kutsch.) and the cabbage flea beetles (*Psylliodes chrysocephala* L.). They are found in a mixed population. Out of all aforementioned types, the

cabbage stem flea beetle was proven to have the largest population – 2-3 insects/m^2 (Figure 1). The emergence of the adult insects in autumn coincided with the growing of the rape plants. The black cabbage flea beetle had permanent density during the three years of the experiment – 2 insects/m^2. Single insects of the striped cabbage flea beetles were found (1insect/m^2). Low numbers of red turnip beetles (*Enthomoscelis adonidis* Pall.) were detected is some areas planted with the crop around the city of Plovdiv. The coleseed sawfly (*Athalia rosae* L.) appeared in the periphery of the lots in small areas, especially in the region around the city of Plovdiv.

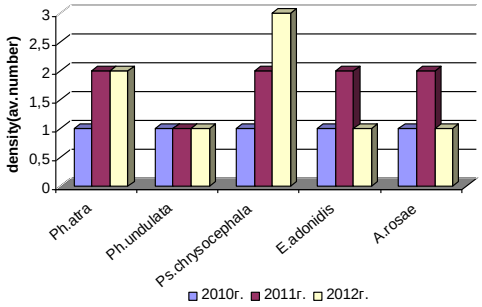

Figure 1. Species composition and density (insects/m^2) of the harmful entomofauna in the rape agrocenosis in autumn.

The first symptoms of the economically significant disease blackleg (*Phoma lingam)* over the years of observation were manifested at the end of October and in the beginning of November in the form of rounded white to grey spots with black pycnidia. The index of the disease attack ranged from 10,5% to 16,3% (Figure 2).

The resumption of the rape development in the spring started as the temperature rose to over 5^{o}C. The attack of the fungal disease blackleg was registered in the second ten days of April as the degree of development was 12,7 % in 2011, 17,5 % in 2012 and 35,5 % in 2013. In 2013 in the beginning of the vegetation period, we registered frequent rainfalls, which is a prerequisite for the more widespread development of the blackleg. During the second ten days of May, powdery mildew (*Erysiphe cruciferarum)* was detected on some individual plants in the form of spots with off-white powdery coating.

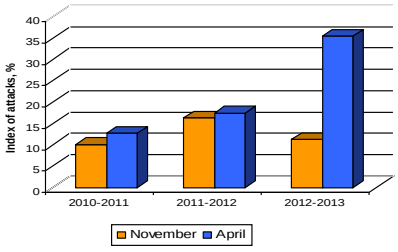

Figure 2. Index of the blackleg attack (*Phoma lingam)* on oilseed rape.

The first pests after the rise of the temperatures in the rape agrocenosis were the flea beetles and the cabbage stem flea beetles. Low density was registered - 1-2 insects/m^2. During the second half of April, with the rise of the temperatures we detected single insects of red cabbage bugs: the red cabbage bug (*Eurydema ornata* L.) and cabbage shild bug (*Eurydema oleraceum* L.). In some plants their density reached 1-2 insects/m^2 (Figure 3).

With the beginning of the buttoning and flowering stages, the following pests were detected: the pollen beetles (*Meligethes aeneus* F.), the beetles (*Tropinota hirta* Poda), the white-spotted rose beetles (*Oxytirea funesta* Poda). The type with the greatest economic importance is the pollen beetle

whose density was found to be the highest 3-7 insects/m^2. Out of the weevils, we detected the following types: cabbage stem weevils (*Ceutorhynchus quadridens* Panz.(*C.pallidactylus* Marsh.), rape stem weevils (*Ceutorhynchus napi* L.) and cabbage seedpod weevils (*Ceutorhynchus obstrictus* Marsh. (*C.assimilis*). We also found caterpillars of the large white butterfly (*Pieris brassicae* L.) and the small white butterfly (*Pieris rapae* L.). When the pods ripened as a result of the increase in humidity, even if the density was low (1-2 grades), the cabbage aphid (*Brevicoryne brassicae* L.) appeared annually.

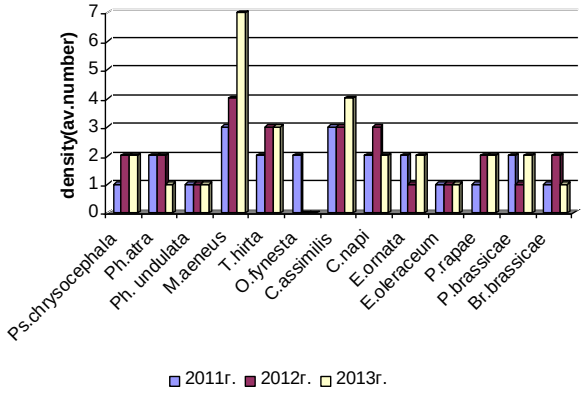

Figure 3. Species composition and density (insects/m^2) of the harmful entomofauna in the rape agrocenosis in spring.

Regarding the established entomofauna, the following types belong to the *Coleoptera* genus: flea beetles, cabbage stem flea beetles, red turnip beetles, pollen beetles, the weevils of the *Ceutorhynchus* genus, alleculid beetles and white-spotted rose beetles. The insects belonging to the *Hemiptera* genus, *Homoptera* subgenus, are the cabbage aphids; the insects belonging to the *Heteroptera* subgenus are the red cabbage bugs; the insects belonging to the *Hymenoptera* genus are the coleseed sawflies; the insects that belong to the *Lepidoptera* genus are the white cabbage butterflies and the small white butterflies.

The established species composition has a strict organotrophic specialization. The leaves feed the following insects: flea beetles, cabbage stem flea beetles, red turnip beetles, coleseed sawflies, red cabbage bugs, white cabbage butterflies, small white butterflies, cabbage aphids; the stem feeds the following insects: cabbage stem flea beetles, cabbage stem weevils, rape stem weevils; the flowers feed the following insects: pollen beetles, alleculid beetles, white-spotted rose beetles and the pods feed the cabbage seedpod weevils.

The dynamics of the population of the types results from the existing weather conditions and the phenological development of the oilseed rape (Figure 4).

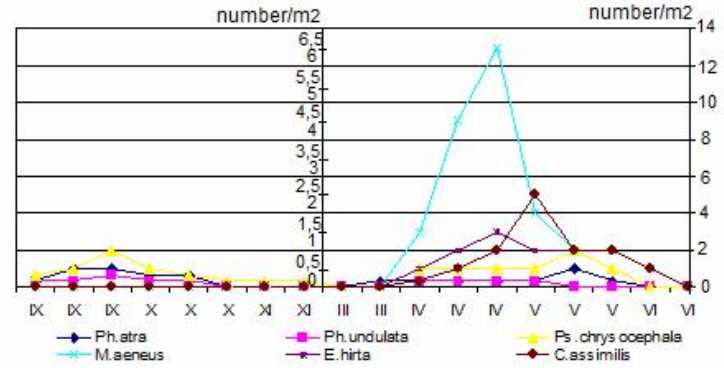

Figure 4. Dynamics of the density of the population of the main pests in the rape agrocenosis within the period 2010-2013.

During the autumn-winter period, the flea beetles of the *Phyllotreta* genus and the cabbage stem flea beetles dominated. The highest density was registered for the cabbage stem flea beetle – 1 insect/m^2. Its development lasted until November. The cabbage flea beetles *Ph.atra* and *Ph.undulata* had a smaller population as the highest values were registered at the end of September.

In the spring as the temperatures rose to over 5^{o}C, the oilseed rape started developing and the harmful and useful entomofauna started reproducing. The fleas appeared in March and their development lasted until June. Their number was the largest during the second ten days of May.

With the start of the buttoning phenophase, the density of the population of the pollen beetles dramatically increased. The type reached its peak of 13 insects/m^2 during the third ten days of April, which coincided with the emergence of the cabbage seedpod weevils. The wide spread of the weevils in the rape fields was detected during the mass flowering stage. The parallel development of both species resulted in competition for food and habitat, which caused the migration of the pollen beetles outside the planted areas.

In the beginning of April, the alleculid beetles appeared in the rape fields. The number of this species reached 1-2 insect/m^2 as the peak value of the density of the population was registered at the end of April.

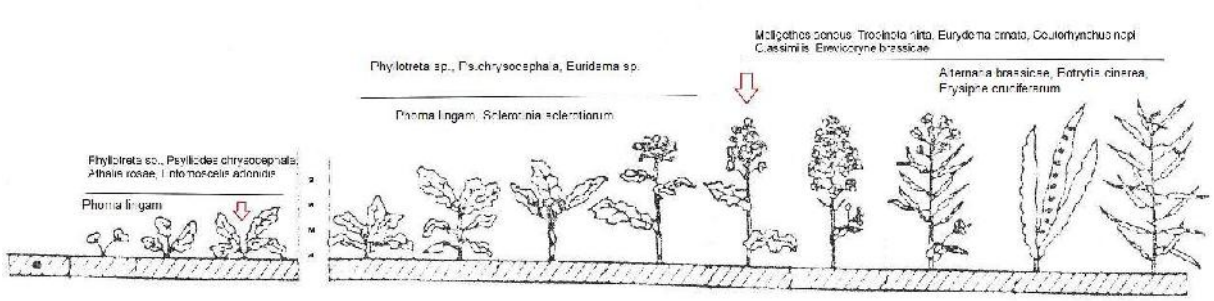

Figure 5. More important pests in the rape agrocenosis and appropriate periods of time to fight them

The fight against the pests on the rape plants starts in autumn when reaching the critical threshold of economic harmfulness: 2 insects/m^2 for the cabbage stem flea beetles, 2-3 insects/m^2 for the coleseed sawflies and 3-5 insects/m^2 for the flea beetles. The end of the calendar year and the forthcoming winter allow us to use preparations with a wider scope of activity and a long-term effect, such as: organophosphorus insecticides, (active substance chlorpyrifos-ethyl), synthetic pyrethroids (deltamethrin, alpha-cypermethrin, lambda cyhalothrin, cypermethrin + chlorpyrifos-ethyl, tau-fluvalinate) and neonicotinoids (active substance thiacloprid, thiacloprid + deltamethrin, Figure 5, Table 1).

In November and October there were favourable conditions (positive temperatures and high humidity) for the emergence and development of blackleg, leaf spots and powdery mildew. The systemic triazole fungicides show good effectiveness (active substance metkonazol, tebuconazole) (Table 1). When using them, they not only protect the crop from diseases, but also regulate the growth of the plants and prevent the risk of overgrowth.

In the spring, for the purpose of protecting the rape against blackleg, leaf spots, white mold, gray mold rot, powdery mildew and also for enhancing the resistance of plants against leaning, we apply treatment using the fungicides Caramba 60 EC (metkonazol) when the height of the plants reaches 23-35 cm and Folicur 250 EW (tebuconazole) during the buttoning phenophase. Under the conditions of frequent rainfalls and high relative humidity in the beginning of the flowering stage, fungicidal treatment shall be applied using Pictor SC (dimoxystrobin + boscalid) or Prosaro 250 EC (prothioconazole+ tebuconazole) in order to prevent the development of the white mold and the

gray mold rot, the blackleg and the leaf spots. These preparations are completely harmless for the bees when applied in accordance with their registration.

The successful completion of the fight against the pests on the rape during the spring is the factor that predetermines to the largest extent the successful protection of the cultivated crop and the useful entomofauna and also the pollinators in the rape agrocenosis. Among all other necessary activities, an important role is played by the monitoring approach that registers the dynamics in the density of the population.

Table 1 Approved pesticides for fighting pests in the rape agrocenosis

INSECTICIDE	**ACTIVE SUBSTANCE**	**CHEMICAL GROUP**
AVANT 150 EC	indoxacarb	oxadiazin
BISCAYA 240 OD	thiacloprid	neonicotinoid
PROTEUS 110 OD	thiacloprid + deltamethrin	neonicotinoid
CALYPSO 480 SC	thiacloprid	neonicotinoid
DEKA EK	deltametrin	synthetic pyrethroid
FASTAC NOV	alpha-cypermethrin	synthetic pyrethroid
KARATE ZEON	lambda cyhalothrin	synthetic pyrethroid
NURELLE D	cypermethrin+chlorpyrifos-ethyl	synthetic pyrethroid
MAVRIK 2F	tau-fluvalinate	synthetic pyrethroid
DURSBAN 4E	chlorpyrifos-ethyl	organophosphate
FUNGICIDE	**ACTIVE SUBSTANCE**	**CHEMICAL GROUP**
CARAMBA 60 EC	metkonazol	Triazole fungicide and growth regulator
ORIUS 25 EW	tebuconazole	Triazole fungicide
PICTOR SC	dimoxystrobin + boscalid	Two-component systemic fungicide
PROSARO 250 EC	prothioconazole+ tebuconazole	Triazole fungicide
FOLICUR 250 EW HORIZON	tebuconazole	Triazole fungicide

The weed known as wild mustard (*Sinapis arvensis*), which is suitable to be a host for flea beetles, alphides and pollen beetles, is regarded as an indicator of the phytosanitary status of the region. When the number of the pollen beetle is 2-4 insects/plant, there is a serious risk of its reproduction during the vegetation period, which necessitates conducting weekly examinations of the crops. After the examinations, it was established that the attack starts from the periphery (the pest chooses plants of a higher habitus) towards the inner areas of the crops and is related to the initial formation of buds. When the number reaches 1-2 insects/m for 15-20% of the attacked plants, it is necessary to apply treatment to the peripheral area of the crops that is 10-12 m wide, using preparations based on chlorpyrifos-ethyl. This enables us to limit the migration of the pollen beetle towards the inner area of the crops and also to preserve the natural pollinators and the bees whose density is still limited.

If it is necessary to apply a second treatment (during the “green-button” phenophase), we can use formulations that ensure high effectiveness for 5-6 days and have a repellent effect for about 7-8 days. This is the capacity of the insecticide Avant - 17 ml/dka (it belongs to the group of oxadiazins) in combination with the adhesive Codacide - 200 ml/dka.

In case of high density of the cabbage seedpod weevils and reproduction of the pollen beetles at the end of the flowering stage and the formation of the pods, the treatment is conducted using the preparation Biscaya, whose tolerance towards pollinators and bees has been proven.

Conclusion

As a result of the conducted survey, we can draw the following conclusions:

- The rape acts as a host for a number of diseases and pests. In autumn it is attacked by the following pests: the flea beetles of the *Phyllotreta* genus, the cabbage stem flea beetles (*Psylliodes chrysocephala* L.*)*, the red turnip beetles (*Entomoscelis adonidis* Pall). and the coleseed sawflies (*Athalia rosae* L.) and also by the following diseases: blackleg (dry stem rot) (*Leptosphaeria maculans* (Desm.) Ces.& de Not.; *Phoma lingam* (Tode ex Fr.) Desm) and leaf spots (*Alternaria brassicae* (Berk.) Sacc.). In the spring, the following pests develop on its plants: flea beetles of the *Phyllotreta* genus, the cabbage stem flea beetles (*Psylliodes chrysocephala* L.*)*, the pollen beetles - *Meligethes aeneus* F., the beetles – *Tropinota hirta* Poda, the cabbage stem weevils (*Ceutorhynchus quadridens* Panz.), the cabbage seedpod weevils (*Ceutorhynchus assimilis* Payk.(*C.obstrictus* Marsh.), the rape stem weevils (*Ceuthorynchus napi* L.). The diseases detected are: blackleg (*L. maculans*; *Phoma lingam*), white mold (*S. sclerotiorum*), gray mold rot (*Botrytis cinerea* Persoon), leaf spots (*Alternaria brassicae* (Berk.) Sacc.) and powdery mildew (*Erysiphe cruciferarum* (Opiz ex L. Junell).

- During the vegetation of the winter rape there are two critical periods as a result of the pest attacks – an autumn period covering the second half of September and the beginning of October when the plants are attacked by the flea beetles and the blackleg and a spring period – April (lengthening of the stem – buttoning) for the development of the blackleg, the white mold and the reproduction of the pollen beetles.

- The protection of the pollinators and the honey bees requires the application of minimal treatment of the crops that is related to the exact prognosis regarding the emergence and the development of the pollen beetle. By applying treatment to an area 10-12 m wide, using preparations based on chlorpyrifos-ethyl and if necessary treating the crops with the insecticide Avant 17ml/dka and the adhesive Codacide -200 ml/dka during the “green-button” stage, we can ensure an effective fight against the pollen beetle which has the slightest negative effect on the natural pollinators and the bees.

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