

Insect pests on winter oilseed rape studied by different catching methods

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Abstract. The distribution, species association and number of pest insects on winter oilseed rape of varieties ‘Wotan’ and ‘Express’ were studied in field experiments. Three catching methods were used: black plastic basins on the soil surface between plants, yellow flight traps filled with water at the height of the crop canopy and the shaking of plants above a plastic basin. The most abundant pest species was the pollen beetle, *Meligethes aeneus*, while the number of individuals from the species *M. virescens* in traps was much lesser. The other important group of pest insects were weevils *Ceutorrhynchus spp.*, the most common of which was the cabbage seed weevil, *C. assimilis*. Three species of flea beetles *Phyllotreta undulata*, *Ph. vittata* and *Ph. nemorum* were typical contents of traps during May. In the last decade of May, there was a large number of thrips (Thysanoptera, Tripidae) in traps.

Winter oilseed rape began to flower to some extent later, when pest insects of cruciferous plants had ended their hibernation. Therefore, the pests first inhabited weeds and already flowering plants, from where they later moved onto winter oilseed rape.

In the field of winter oil seed rape, chemical pest control with a pyrethroid, Fastac, did not significantly influence the abundance of pest insects. In the last decade of May, the total number of beetles in all test variants was relatively small, but, at the beginning of June, it increased almost to an equal extent. On the basis of flight traps, heavy damage of pods could be assumed, however, only a few larvae fell into traps on the soil surface, and virtually no damaged pods were detected. Thus the spraying with Fastac had no significant effects on the number of insects caught in traps.

Key words: winter oilseed rape, damage, insect pest distributions, pollen beetle, *Meligethes aeneus*, seed weevil, *Ceuthorrhynchus assimilis*

INTRODUCTION

Rape (*Brassica napus*) is known to be the oldest cultured plant, and it was grown in the Mediterranean countries already 4000 years ago. The homelands of rape are considered Holland and England, from where it spread to other European countries. In Estonia rape begun to be grown as a fodder culture, later as an oil culture, and its sowing area has been widened from year to year. In the year 2000, already 29,000 ha of rape was sown.

The spatial distribution and number of insects in rape fields is determined by several environmental and climatic factors, and agricultural technics (Free & Williams,

1979). Although the list of pests on winter oilseed rape is long, there are only a few species that cause serious damage. These are considered to be most of all pests damaging generative organs: the pollen beetle (*Meligethes aeneus*), seed weevil (*Ceutorrhynchus assimilis*) and pod midge (*Dasineura brassicae*) (Huges & Evans, 1999). The necessity of controlling these pests depends on a specific situation.

The aim of the present field experiments was to study the insect fauna on rape and determine the numbers of individuals found in traps during summer months but also estimate the effectiveness of chemical control on the abundance of pest insects. The gained data may be considered as a basis for estimating the effectiveness of chemical control performed on rape fields.

MATERIALS AND METHODS

Two varieties of winter rape cultivated in Germany were tested: 'Wotan' and 'Express'.

'Wotan' is a highly productive variety of medium height, with good lodging resistance and big seeds: the mass of 1,000 seeds being 5.08 g, oil content at least 42%. The variety has a very strong root system that ensures high resistance to drought and tolerance of most soil types. This is a late variety that flowers for a short time and ripens slowly.

'Express' is a productive variety with rapid autumnal development. The seeds are smaller to some degree than those of 'Wotan': the mass of 1000 seeds being 4.72 g, oil content 45%. In normal weather conditions it can endure both early and late sowing. The variety is resistant to winter conditions. In spring it starts developing early, and, therefore, also flowering earlier than 'Wotan'. The plants have short stems with good lodging resistance, seeds ripen early and can easily be harvested by a combine.

The field tested was founded in August 2001, sowing was performed at four different times, with weekly intervals: on 9, 16, 23 and 30 August. The observation of the distribution of insect pests by species and numbers was only a part of the complex experiment. For the observation, the variant sown on 16 August, where 150 seeds per one square metre had been calculated, was chosen. The field had earlier lain black-fallow. Seeds were sown in a north-south direction. The field was bordered by a gravel road from the north, a potato field from the east, a barley field from the south and, in the case of 'Wotan', a turnip rape (*Brassica rapa* ssp. *oleifera*) field, and, in the case of 'Express', a triticale field from the west. With both the varieties, observations were carried out in two variants: 0-variant, where no pesticides or mineral fertilisers were used, and the test variant, where the field was fertilised with complex granular combined fertiliser: Classic Brand 24-08-12, calculating 120 kg of the active substance agent of nitrogen per hectare. The fertiliser was applied on 25 April, when plants had already reached intensive growth of their vegetative mass. For insect pest control, the plants were sprayed on 9 and 18 May, by using Fastac, whose active substance agent is alpha-cypermethrine. The rate of active substance agent was calculated 0.15 l/ha.

According to literature data, both the varieties are tolerant of different sowing times, however, it found no full confirmation in the described experiments. With later sowing, on 30 August, the plants were growing sparsely, weeds began to suffocate rape, and no yield was gained. The strongest effects on plants were exerted by hibernation. Although the variant of the latest sowing germinated and sprouted very

well, the plants could not prepare themselves for the winter and remained small with a relatively weak root system. For a successful hibernation, plants have to be able to develop a dense rosette. Vernal frost heave damaged roots, and the plants perished. In other variants, the vernal growth of both the varieties was relatively modest, and, for that reason, the plants endured well slight night frost.

To study the spreading of insect pests, three different catching methods were employed.

1. Black plastic basins of 17 x 12 cm were placed on the soil surface between plants. These traps were placed with a purpose to elucidate the number of larvae of the pest descending into the soil for pupation.

2. Yellow flight traps of 30 x 30 cm filled with water were positioned on a metal pole at the height of the crop canopy. Species attracted by volatiles released by plants and flying above the plants in search of food, partners, or a place for oviposition, may be caught in these traps (Ferguson et al., 1991). The traps were emptied twice a week.

3. Shaking method was used, where in each variant the main inflorescences of 20 plants, chosen by means of a random selection, were shaken three times above a plastic basin. Thereafter fallen insects were counted and their species determined. By using the data of shaking catches, the pest control criteria of several insect species can be determined since this method enables the catching of such individuals who have already found true hosts for feeding and egg-laying. The investigations started on 8 May and ended before harvesting, on 24 July.

During the placement of the traps, the variety 'Wotan' had main and secondary inflorescences, flower buds visible but closed, which, according to the well-known Zadoks code for cereals, shows growth stage 55–57 (Lancashire et al., 1991). The variety 'Express' had reached flowering stage, and from 10% to 50% of flowers on the main raceme were open (growth stage 61–65). A nearby turnip rape field, situated at a distance of 10 metres, was in full flowering: 50% flowers on the main raceme were open, and older petals were falling (growth stage 65–66).

RESULTS

Pollen beetle, Meligethes aeneus, and M. virescens (Coleoptera, Nitidulidae)

The most hazardous pest of winter rape is the pollen beetle, *Meligethes aeneus* F. The number of other species of this genus, such as *M. viridescens* Sturm, is considerably smaller and does not cause any economic damage. The development and damage patterns caused by both the species are similar. Young beetles emerge from the soil after hibernation when temperature has risen above 10°C. The adults may feed on pollen and nectar of plants from a large number of plant families, however, they have specialised only in family Brassicaceae for oviposition (Fritzche, 1957). When temperature rises above 15°C, beetles move to a rape field. The pollen beetle prefers to lay eggs in buds of 2–3 mm in length (Nilsson, 1988). When flowers open, the larvae begin to feed on pollen, ovary and petals, and, as a result of heavier damage, flowers dry and fall, whereas slighter damage does not cause the falling of flowers but hinders the formation of pods (Williams & Free, 1978). Larvae and adults move from older flowers to younger ones and flower buds. The pollen beetle begin to inhabit rape field at the beginning of May, when buds are already big and the opening of the first

inflorescences of the main stem has started. This period is considered the most sensitive stage for beetles (Nilsson, 1988).

At the beginning of that time, however, the number of beetles in all our catches remained small (Fig. 1A,B and 3A,B). In tests samples taken simultaneously from a turnip rape field, where flowering was earlier, the number of pollen beetles was larger: 5–6 beetles per plant caught by shaking method.

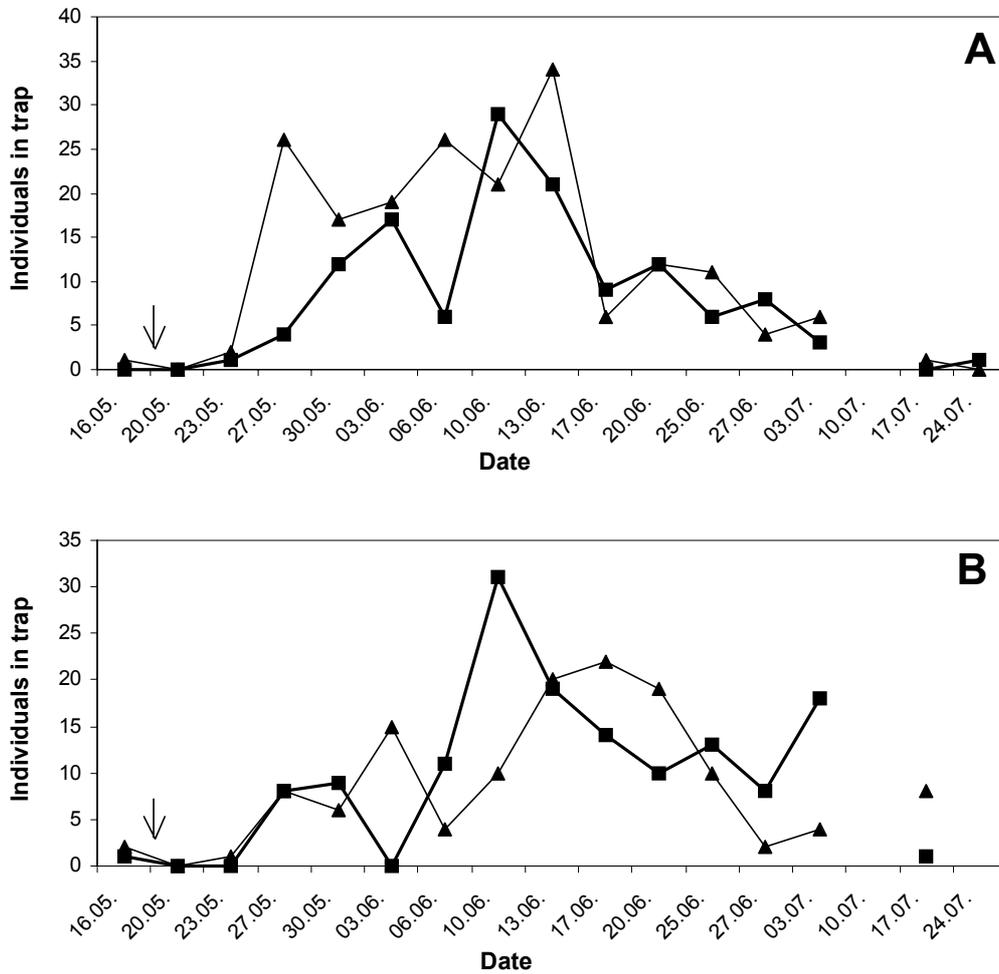


Fig. 1. Number of the individuals of pollen beetle, *Meligethes aeneus*, in yellow flight traps during the observation period in the control (▲), and after spraying with Fastac (■, arrow). Winter oilseed rape varieties ‘Wotan’ (A) and ‘Express’ (B).

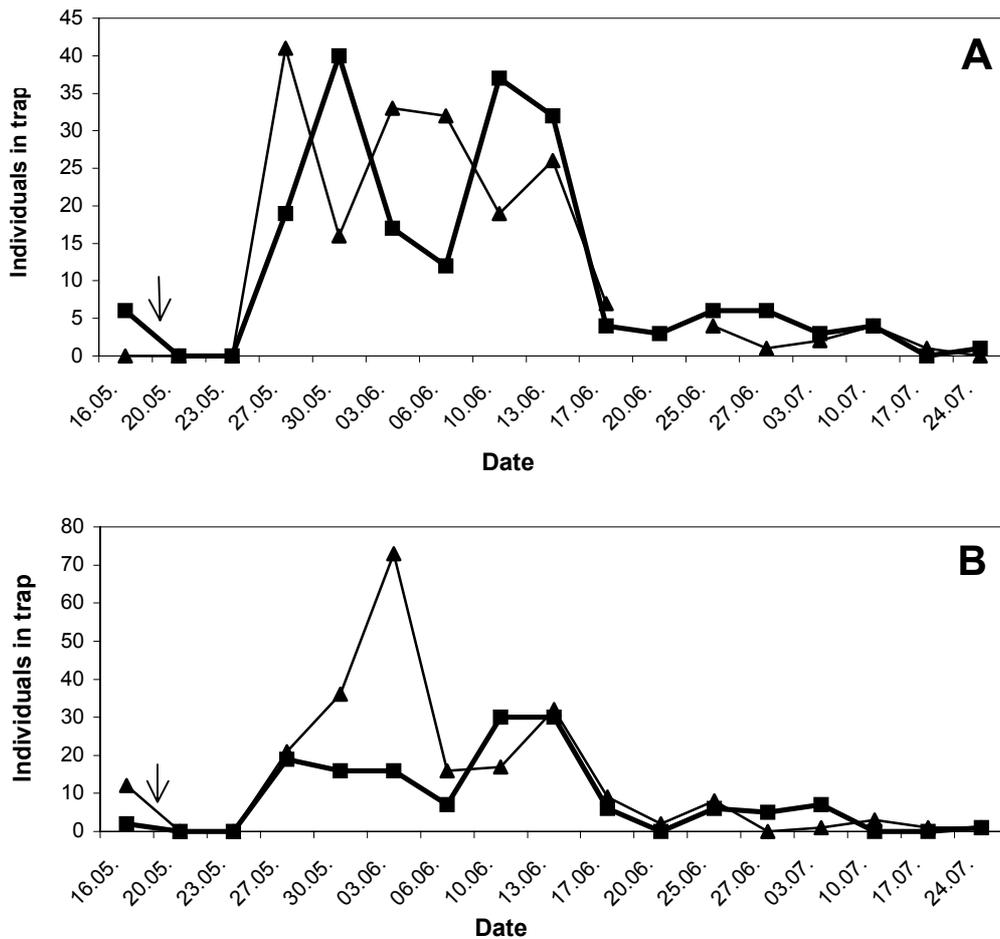


Fig. 2. Number of individuals of seed weevil, *Ceutorrynchus assimilis*, in yellow flight traps during the observation period in the control (▲), and after spraying with Fastac (■, arrow). Winter oilseed rape varieties ‘Wotan’ (A) and ‘Express’ (B).

A week after the second spraying, on 26 May, the number of beetles in all the variants started to increase. By that time, ‘Wotan’ had reached growth stage 57–61, i.e. approximately 10% of the main inflorescences had opened, and in secondary inflorescences petals were visible but flower buds were still closed. ‘Express’ had reached growth stage 63–64: over 30% of the main inflorescences had opened. At the same time, the neighbouring turnip rape field was about to finish flowering, 50% pods had reached final size (growth stage 69–75). In search of food and places for oviposition beetles moved onto oilseed rape plants. The active flight of beetles is indicated by a rapid growth in their numbers in yellow flight traps at the height of plant tops (Fig. 1A,B). In shaking no significant rise was noticed at that time (Fig. 3A,B) since beetles had not yet attached themselves to the oviposition sites.

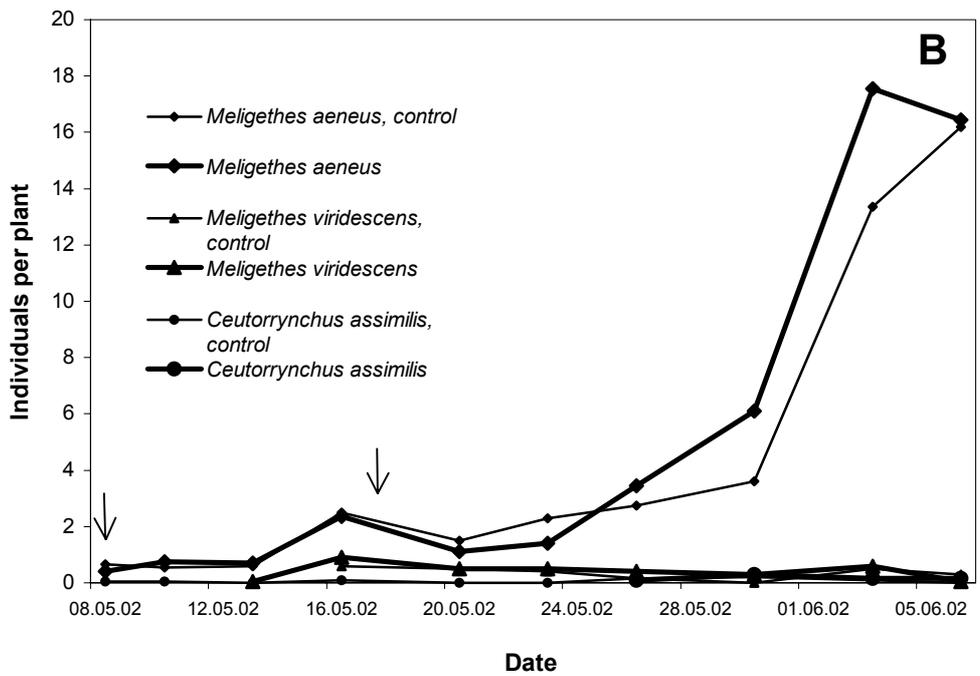
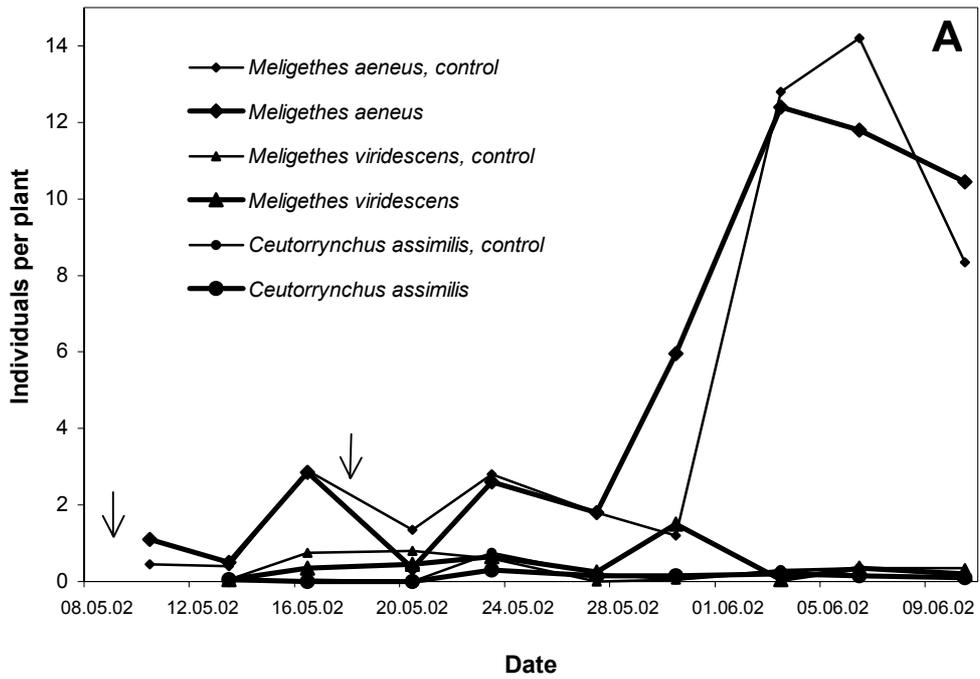


Fig. 3. Number of individuals of different beetle species captured by shaking method in vessel traps during the observation period in the control, and after spraying (arrow) with Fastac. Winter oilseed rape varieties 'Wotan' (A) and 'Express' (B).

It is difficult to estimate the effect of Fastac on pollen beetles. After the first spraying on 9 May, the total number of pests in all traps was still very small (Fig. 1A,B). Immediately after the second spraying (18 May), there occurred a decrease in the number of beetles in both the variants, whereas in the control and test there were no significant differences (Fig. 1A,B and 3A,B), which may have been caused by heavy rainfall and low nocturnal temperatures. When 'Express' was used, the number of pollen beetle remained smaller in catches by yellow basins than in the control as part of beetles perished as a result of spraying, and there followed no greater re-settling of beetles within a couple of weeks. There occurred abrupt fluctuations in the number of beetles on 'Wotan' in the part of the field that had undergone spraying. If on 5 June there were no beetles registered in yellow flight traps, a week later there were over 30 beetles in the catch, which demonstrated the active flight of beetles (Fig. 1A,B). Probably, the repellent effect of the toxicant had disappeared by that time.

The comparison of the varieties revealed that on leaving the field of turnip rape pollen beetles had preferred the field of 'Express'. Both the comparison of yellow basins and shaking catches shows a statistically reliable difference in the number of beetles in the catches of 'Express' and 'Wotan' (Fig. 1A,B and 3A,B). An obvious reason lies in the earlier development of 'Express' as it is known that adults prefer to feed on the stamens of already open flowers (Williams & Free, 1978).

At the beginning of June, when the flowering of oilseed rape was about to end, the number of beetles caught in yellow basins increased again (Fig. 1A,B) as in this period beetles were starting their migration in search of new food plants. In mid-June their number began to decrease in the field of 'Express' where flowering had been finished earlier, and, at the end of the first week of July, no beetles were found in traps. The flowering of 'Wotan' lasted longer, and the movement of pollen beetles also shifted to a later time, even in July they could be found in traps (Fig. 1A).

In all the variants, the number of beetles in shaking catches rose sharply at the beginning of June (Fig. 3A,B), which does not mean a rapid increase in their total number in the field but rather their accumulation on the last flowering branches chosen for shaking. When rape had ended flowering the beetles moved onto weeds growing on the edge of the field.

In black plastic basins, placed on the ground, there were seldom found few last instar larvae of pollen beetle who had ended feeding, which shows the low oviposition activity of beetles.

Meligethes viridescens appeared in the field a week later than the pollen beetle, and its number was very small during the whole observation period, less than one beetle per plant in a shaking catch (Fig. 3A,B). Catches with yellow flight traps included also only a few beetles.

Weevils, *Ceutorrhynchus* spp. (Coleoptera, Curculionidae)

The second more important group of pests on winter rape is weevils, the most common of which is the cabbage seed weevil, *C. assimilis*. The developmental cycle of the species has been widely studied (Dmoch, 1965; Williams, 1978). In spring, after emerging from their hibernation sites, beetles feed on wild cruciferous plants first, and, with the beginning of the flowering of winter oilseed rape, they move onto it.

The female of cabbage seed weevil makes an oviposition bite with her mouthparts, deposits one egg there and marks the place by a deterrent pheromone to

prevent a second egg-laying on the same spot. Young pods of 20–40 mm are preferred for oviposition, and a single female can lay 25–240 eggs during a season (Mudd et al., 1997; Kozłowski et al., 1983; Free & Williams, 1978). A newly hatched larvae pierces itself into a pod, scales and starts feeding on young seeds. A larvae consumes 5–6 seeds in a pod (Lerin, 87). The last instar larva leaves the pod and moves into the soil for pupation. Adult weevils die during June, a new generation of young beetles appear in July-August, feed on yet unripe pods, or move onto wild cruciferous plants to form an fatbody for hibernation (Alford et al., 1991). In August young beetles dig themselves into the soil in the same field, and a part of them migrate far away to other hibernation sites.

The cabbage seed weevil begin to colonise fields of winter oilseed rape at the outset of flowering. In the control variant with yellow flight traps, there were first beetles already in mid-May (Fig. 2A,B). However, the flying activity of beetles is greatly determined by climatic conditions; cool and rainy weather between 16 and 23 did not favour the flight of beetles, and catches in all variants were near zero. The maximum colonisation in the control variant of the field of 'Express' occurred on 27 May, and, in the variant with spraying, three days later. At that time the field was in full flowering, growth stage 63–65, and there were over 40 individuals per trap. In the field of 'Wotan' flowering and the maximum of flight of beetles occurred a week later. Although the peak of the catch on 3 June, 76 beetles per trap, exceeded nearly twice the maximum of the 'Express' catch (Fig. 2A,B), their number in 'Wotan' remained smaller during a longer period of time (Fig. 2A,B). The reason here was probably the earlier flowering of 'Express', because of which beetles from turnip rape and weeds settled in this field first. By mid-June, the number of beetles decreased rapidly in the fields of both the varieties: less than 5 beetles in a trap (Fig. 2A,B). At that time pods began to ripen, and lignified pods did not attract beetles anymore. A few individuals were flying above the field, and they could be found in traps until the harvesting of rape (Fig. 2A,B).

The first beetles in shaking catches were detected in mid-May but their number remained small both in sprayed variants and the control through the season, one beetle in a trap on the average (Fig. 3A,B). Shaking catches contained mainly egg-laying beetles. In the black plastic traps lying on the ground there were also a few larvae, which demonstrates the absence of correlation in the number of adults flying above the field and adults laying eggs in the field. The numbers of egg-laying beetles and those caught by flying traps did not coincide. The larvae of cabbage seed weevil were seldom found in black plastic traps on the ground. Actual damage is caused only by larvae since the feeding of adults may be compensated by the growth of a plant (Free & Williams, 1978; Lerin, 1987).

In addition, there occurred two other species of fam. Curculionidae: *Ceutorrhynchus pallidactylus* and *C. floralis*. *C. pallidactylus* feeds both on wild and cultural cruciferous plants. The female lays 2–8 eggs into the epidermis of a herbaceous stem or leaf. Larvae dig themselves into stems and leaf veins, and, as a result, stems break easily. The development of damaged plants stops, the leaves lose their turgor and fall. *C. floralis* feeds mainly on cruciferous weeds but often also on oilseed rape.

Both of these pests were rare in the field observed by us: only a few beetles were found in shaking catches and in yellow basins. With such small numbers, neither of the species damages rape seriously.

Flea beetles, Phyllotreta spp. (Coleoptera, Chrysomelidae)

Three species of the flea beetle were found. First individuals of *Phyllotreta undulata* Kutsch were caught into soil traps already at the beginning of May. The end of May was the peak in their abundance, when each trap contained 4–5 individuals on the average. In mid-June this species disappeared. A little later, at the end of May, there appeared *Ph. vittata*, and, by the end of the first week of June, *Ph. nemorum*, however, both the species were not abundant.

The adults of flea beetle feed on the leaves of cruciferous plants, larvae in the soil on plant roots. Although flea beetles are known as the most dangerous pests of cruciferous plants, they do not cause any significant damage on winter oilseed rape. By the time the pest appeared, plants had already formed rosettes and grown bigger. In some cases, beetles of the second generation may damage ripening pods (Gavlovski & Lamb, 2000), however, in the field observed by us there were no flea beetles in July.

Some individuals of *Phaedon cochleariae* (Chrysomelidae) were caught by yellow flight traps. The females of the species lay eggs into gnawed hollows in leaf veins, one at a time, hatched larvae feed on leaf surface, causing holes in leaves, and adults perforate leaves. In dry summers damage is slighter as the beetles are fond of humidity. *Ph. cochleariae* did not cause any damage on winter oilseed rape in the field we observed.

The apionid beetles (Apionidae, Coleoptera)

In mid-May three species of apionid beetles, *Apion apricans*, *A. aestivum* and *A. flavipens*, settled in the winter oilseed rape field. Although in some test samples of flight traps, their number was great, none of these species damages oilseed rape. Oilseed rape is not the host plant for *Apion* spp. They came from field boundaries and surrounding vegetation, primarily from papilionaceous plants.

Plant bugs (Hemiptera, Miridae) and shield bugs (Hemiptera, Pentatomidae)

A few individuals of plant bugs and shield bugs were detected in black plastic basins on the ground and in yellow flight traps at the height of plant tops, but these did not cause any perceptible damage to plants. Larvae and adults of bugs suck juice from plants, as a result of which light spots occur on leaves first, sucked cells dry and turn brown, later the leaves rip and are full of holes. The damage is more dangerous for younger plants as it affects normal metabolism, and plants become weak, which diminishes yield. Bugs appeared on winter oilseed rape only at the end of May, but posed no threat to the yield at that time.

Pod midge, Dasynura brassicae (Diptera, Cecidomyidae)

In mid-May a few adults of pod midge were found. These had been spread by winds after they had left their hibernation sites. In the odour zones of host plants, pod midges fly actively against the wind at the odour. The ovipositor of a pod midge is short and weak, which is why it can lay eggs only in previously damaged pods (Ferguson et al., 1995). The pod midge is closely connected with cabbage seed weevils and flea beetles, whose adults puncture the walls of pods, inside which adult gnats can later lay their eggs (Stechman & Shütte, 1978). Larvae of the pod midge feed on young seeds and walls of pods, and no fully valuable seeds can be obtained from the

damaged pods. Both in the test and control variants, the number of pod midges was very small, only a few adults appeared in the samples.

Other pest groups

In the last decade of May, shaking catches contained a large number of thrips (Thysanoptera, Thripidae), who inhabited inflorescences and sucked juices from petals. The effect of these pests on winter oilseed rape is not important as the greatest damage is caused by thrips on shoots.

At the beginning of June, several species of aphids (Homoptera, Aphidae) were found in yellow flight traps. If aphids start their damage at bud stage, it may bring about considerable yield loss, the falling of flowers that failed to open, and the deformation of pods. By the beginning of June, a great part of the plants had already developed pods, and aphids caused there no perceptible damage. Since in shaking catches there occurred only a few aphids, and, on observing the plants, clutches of the insects were not found, it can be supposed that the aphids fell into yellow basins occasionally, having been carried by wind from a cereal field located nearby.

In addition to pests, a flowering winter oilseed rape field attracts a plenty of pollinators, predators and parasitoids but these are not within the scope of this study.

DISCUSSION

Winter oilseed rape begins to flower to some extent later, when pests on cruciferous plants have ended their hibernation. Therefore they first inhabit weeds and already flowering cultural plants, from where they later move onto winter oilseed rape. The species may vary and the number of pests may fluctuate greatly in different fields, which is caused by several environmental factors, like the closeness of hibernation sites and the directions of prevailing winds (Ferguson, et al., 1999), vegetation surrounding the field, weather conditions, agrotechnics, etc. (Free & Williams, 1979).

During the formation of the insect fauna of the observed field, the following circumstances may play important roles:

1. Cruciferous cultures have been grown at the same place during many consecutive years, which creates possibilities for the accumulation of several species. For instance, the main pest of winter rape, the pollen beetle *Meligethes aeneus* is true to an area, and, in suitable feeding conditions, spends many years there (Nilsson, 1987).

2. A turnip rape field was situated next to the test field, and flowering there began earlier by attracting pests who had completed hibernation and fed on weeds. When turnip rape was ending flowering, winter oilseed rape was at the outset of flowering, and pests could settle there. The seed weevil respond well to the odour of cruciferous plants, when the source plant is at a distance of up to 20 m, followed by quick and direct flying onto new plants (Evans & Allen-Williams, 1993).

3. Although weeds were removed from the edges of the field, the plants of winter rape from later sowing, performed on 30 August 2001, remained sparse and weak. Wild plants belonging to different plant families and feeding a number of insect species grew there.

4. No chemical weed control has been carried out in the area for years, and only the test fields there have undergone selective insect pest control.

The list of species caught in the field of winter oilseed rape is long, however, most species in it are not able to cause noticeable damage on winter oilseed rape. By the time pests arrive, plants have grown sufficiently, and compensate the damage of several insects by intensified growth and formation of additional generative organs (Lerin et al., 1979; Dmoch, 1996). By the time flea beetles damaging leaves appeared, plants had already developed buds.

Although the number of pests fallen in traps is taken as a basis in determining pest control criteria and the planning of plant protection work, it cannot be always used for predicting yield loss. Damage caused by the cabbage seed weevil, *Ceutorrhynchus assimilis*, was substantially smaller than could be predicted by the number of adults found in our traps. Aggregation flight is characteristic of seed weevils, which is why the beetles were not evenly distributed in the field. Dmoch (1965) has discovered that males outnumber females in the populations of this pest as they display more flight activity and are thus more often caught in traps. On the basis of flight traps, heavy damage of pods could be assumed, however, only a few larvae fell into traps on the soil surface, and virtually no damaged pods were detected. Obviously glucosinolates protect oilseed rape from insects.

Damage caused by cabbage seed weevils may not be restricted to larvae destroying seeds. Feeding adults puncture young pods, and, in rainy weather, organisms producing fungal diseases may penetrate into pods and cause even greater damage (Dmoch, 1996). In the warm and dry summer of the present research no diseases of seeds were detected.

Damage caused by the pod midge, *Dasineura brassicae*, is directly connected with the cabbage seed weevil. The ovipositor of a pod midge is too short for laying eggs inside a pod, therefore it uses feeding holes made by cabbage seed weevils (Stechman & Schütte, 1978). In our test field, only seldom a few adults of the midge were found in some catches.

The species damaging generative organs, such as the pollen beetle, *Meligethes aeneus* are regarded as the most dangerous to winter rape, however, the use of insecticides against this beetle is considered economically sound only when at least 25% of pods are infected (Lerin, 1984). Oilseed rape plants have a great capacity to compensate for damage caused by pests. According to Williams & Free (1979), as many as 40% of buds could be removed from plants without causing any significant decrease in yield.

On the basis of the results of the present experiment, chemical pest control in the field of winter oilseed rape cannot be deemed purposeful. Nearly by the end of May, the total number of beetles in all the variants was small, but, at the beginning of June, it increased almost to an equal extent. One of the reasons may be the hidden lifestyle of beetles, because of which the effect of the toxicant may not fully be realised. A part of the beetles perish, many simply drop onto the soil while plants are moved, and, after some time, they can re-occupy the same plants. The second reason may be the too short distance between sprayed and unsprayed field patches, which provides beetles with an opportunity to move soon over to the sprayed areas.

According to the catch of our flight traps on the soil surface, the number of the larvae of pollen beetle remained small both in the sprayed and unsprayed variants; only a few larvae were found. Larvae may not hatch from all eggs laid by the females.

Sometimes, with warm weather, buds open before larvae of the beetles hatch. In this case, eggs may perish, and damage is smaller than predicted (Nilsson, 1987).

CONCLUSIONS

The damage caused by pollen beetles and seed weevils was considerably smaller than it could be expected according to the numbers of flying beetles caught. The field tests in the present investigation demonstrated that the chemical control of insect pests in the oilseed rape fields did not significantly influence the number of pest insects. A field of rape attracts not only pests but also pollinators, predators and parasitoids. Therefore chemical pest control is necessary only when the infestations are very heavy.

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