Predators as biological control agents in winter oilseed rape fields – results on predators from the EU-Project MASTER

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Introduction

The role of predators (mainly Carabidae, Staphylinidae and Araneae) as biological control agents of insect pests has been investigated in two different winter oilseed rape management systems. An ICM-system (ICM = Integrated Crop Management) with reduced soil cultivation and no insecticide applications has been compared with a Standard oilseed rape management system. This article presents a short overview of results achieved during 4 years within the EU-project MASTER (Integrated pest MAnagement STrategies incorporating bio-control for European oilseed Rape pests – QLK5-CT-2001-01447). For details regarding methods and further results see Williams et al. (2006).

Key predator species

Methods

Key predator species of oilseed rape field were identified by using the following sources: 1.Data from species lists in published papers or unpublished reports. 2. Data from the MASTER field trials. 3.Data from the MASTER lab trials (e.g. feeding trials; biochemical and/or microscopic analysis).

Results with dis cussion

In a europewide literature survey more than 160 taxa were recorded as (eu-) dominant and subdominant in oilseed rape fields. Carabidae dominate with more than 40 taxa (according to high no. of references), Staphylinidae with 30 dominant/subdominant taxa although Aleocharinae are usually not determined to species level; Araneae with 25 taxa; Diptera with 30 taxa. Other taxa mentioned in elder literature as for instance Silphidae (Coleoptera) or Centipedes (Chilopoda) are not more relevant in todays conventionally grown OSR fields. Thus, there is an enormous potential of predators who are able to contribute to pest regulation.

Spatio-temporal within field distribution of pest larvae and key predators

Methods

In the ICM and STN-system overall 49 sampling points were installed which consisted in a pitfall trap for epigaeic predators and a funnel trap for the pest larvae which drop down from the oilseed rape flower stands to pupate in the soil. In 20 of these trapping points an emergence trap was installed to control the emergence of the new pest generation. This trap design allows a SADIE analysis (Spatial Analysis of Distance IndicEs) by which associations or dissociations of pest and predator species can be proved.

Results with discussion

In the figure 1 areas with squares reflect high densities, areas with rhombuses low densities. Differences in abundances between the systems are quite obvious for both, the pest as well as the predator: In ICM we find areas of high densities and in STN those with low densities. Most striking however is that spatial distribution and abundance level of pest and predator fit quite well together so that a host–prey-relationship we are able to assume e.g from phenology and feeding trials actually are reflected also in the spatial distribution. Finally it could be clearly shown that the ICM system with no insecticides and reduced tillage enhances the populations of natural enemies in a way that population level of pests is considerably reduced. There are spatio-temporal associations between certain predator- and pest species. For several species pairs (e.g. *Poecilus cupreus / Dasineura brassicae; Tachyporus spp.-larvae* / *Meligethes aeneus-larvae*) these associations are significantly affected by the management system (table 1).

Consumption rates and feeding preferences of key species of carabids

Methods

Feeding trials were performed in round plastic dishes of ca. 10 cm in diameter and a height of ca. 3,5 cm, filled with a layer of a coal-plaster-mixture in a climate chamber holding 20°C, 80% r.h. and a long-day-rhythm of 16:8 hours. For each trial series and species, 20 specimens were tested simultaneously, if possible with a balanced proportion of sexes. Inside the dishes, a piece of bark was placed as a hiding shelter for the beetles (one beetle per dish) as well as a small, flat plastic plate

(diameter: 2,5 cm) for offering the prey larvae. Before each experimental series, each beetle starved for 48 hours.

Table 1: Spatio-temporal associations between *Dasineura brassicae*-larvae (Diptera: Cecidomyiidae) and several predator taxa during the total time of the experiment (TT) as well as during the periods when pod midge larvae of 1st and 2nd generation dropped to the soil.x= positive, 0 = negative spatio-temporal association

	Amara similata	Anchomenus dorsalis	Harpalus affinis	Poecilus cupreus	Pseudoophonus rufipes	Pterostichus macer	Araneae	Staphylinidae
TT				x	x		X	
1. generation			0	x	x		X	x
2.generation	x			0			X	

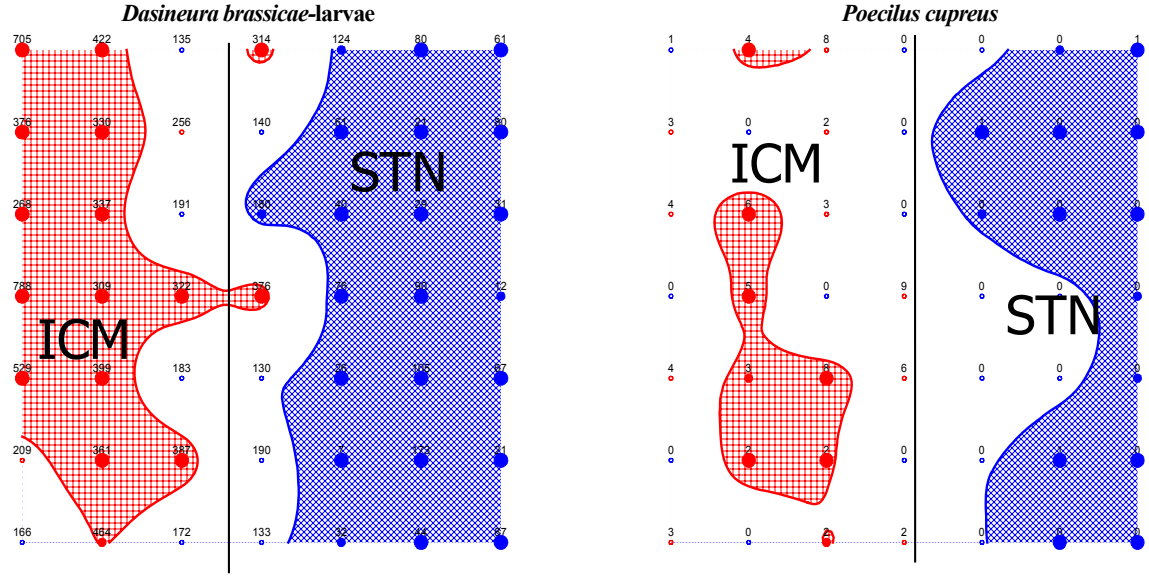

Fig. 1 Spatio-temporal distribution of *D.brassicae*-larvae (left), and 1. generation of *P. cupreus* (right) in the week of peak larval drop 2004

Results with discussion

Five species were identified as major key species and detailed assessed:

Amara similata: Feeding trials proved this species to be of considerable importance as predator of oilseed rape pest species larvae with comparable high feeding rates as the highly entomophagous *Poecilus cupreus*. *A. similata* seems to be an important predator with clear preference to *D. brassicae* whereas degree of entomophagy was less obvious when pollen-beetle- or weevil-larvae were offered simultaneously with oilseed rape seeds. Pods infected by *D. brassicae* were preferentially opened to feed on the larvae, thus, *A. similata* obviously has skills to detect *D. brassicae*- larvae from outside in pods which are still closed.

Poecilus cupreus: *P.cupreus* showed comparatively high consumption rates for each of the offered pest species larvae whereas seed consumption was nearly not traceable => *P. cupreus* is a very effective predator on all reachable dropping pest larvae on the soil surface by preferring bigger larvae to smaller ones.

Tachyporus hypnorum: *M. aeneus*-larvae are significantly preferred in comparison to *Brassica*-pod-midge- or other insect larvae. A predatory adaptation to *Meligethes*-larvae is strongly supported.

Pseudoophonus rufipes showed a balanced ratio between phytophagy and entomophagy. Oilseed rape seed consumption exceeds that of other partly granivorous species. Larvae of *C. palllidactylus* (and *C. napi*) are preferred in comparison to smaller larvae like *M. aeneus* and *D. brassicae* => *Pseudoophonus rufipes* is able to have an impact on pest species with larger larvae as e.g. *C. pallidactylus* and *C. napi.*

Harpalus affinis: Feeding habits, preferences and balanced ratio of entomo- and phytophagy resembles mainly the behaviour of *P. rufipes. Ceutorhynchus*-larvae are preferred to other pest larvae. However, daily feeding rates are significantly lower =>the impact on pest populations is considered as less important.

Molecular methods for pest DNA detection in predator gut

Methods

Predators *A. similata, P. cupreus, H. affinis, P. rufipes a*nd *P. melanarius* were frozen 24 hours after complete, rapid consumption of 5 or 10 pollen beetle larvae. Distinct, specific DNA proof was successful in most extractions of carabid specimens (80-90 %). No differences between consumption of 5 or 10 prey larvae could be detected.

Results with discussion

The appropriate CO1 gene of *M. aeneus* and *C. pallidactylus* were sequenced, aligned and analysed (collab. University of Cardiff) and appropriate primers designed. For cabbage stem weevil primers amplified a signal only on genus *Ceutorhynchus*

level. Appropriate primers were tested successfully on laboratory-fed carabids. A sufficient time span of prey DNA from predators digestive system was achieved with 28 h maximum. Testing 40 individuals of five key species (*P. cupreus, A. dorsalis, H. affinis, P. rufipes, A. similata*) sampled in the field, up to now only for *P. cupreus* a natural occurring consumption of the pest larvae could be proved

Microscopical gut analysis

Methods

50 individuals of the 5 key carabid species *A. similata, A. dorsalis*, *H. affinis, P. cupreus* and *P. rufipes*., collected in 2004 and 2005 during the weeks of main larval dropping and being frozen at –20° C, were investigated by gut dissection and detailed examination of the gut content with a microscope. Characteristic morphological features of the target pest species´ larvae have been chosen and evaluated for specific identification in the predators gut content: Mandibles and legs of pollen beetle larvae, mandibles, antennae and head capsule parts of stem weevil larvae, and finally spatulae from pod midge larvae.

Results with discussion

Characteristic morphological features of oilseed rape pests could be detected in the foregut of laboratory-fed key carabid species for a period of up to 12 hours after consumption. The consumption of *Dasineura brassicae*-larvae could be proved for *A. similata*. A consumption of *Meligethes aeneus*-larvae could be proved for ca. 25% of all dissected *P. cupreus.* In a lower no. of cases the consumption of *Ceutorhynchus*-larvae could be proved for *P. rufipes* and *H. affinis* as well as the consumption of pollen beetle larvae for *A. dorsalis* and *H. affinis*.

Horizontal webs of Linyphiid spiders

Methods

The horizontal webs of Linyphiid spiders were analysed in both systems by a) actual assessment: wire mesh pieces of 50×50 cm with a mesh width of 1 cm were randomly used to measure the size of Linyphiidae webs per area unit by counting filled wire meshes. b) permanent assessment:10 wire mesh pieces of 50 cm×50 cm with a mesh width of 0.5 cm have been mounted on the bare soil in each management system. The number of meshes filled with webs has been counted every 14 days during the growing season (BBCH 65-90)

Results with discussion

Within 4 years at least in 75% of all samples the density of horizontal webs was higher in ICM than in STN. The ICM-system seems to promote building of horizontal webs of Linyphiid-spiders. This is an indicator of their higher abundance in pitfall traps of ICM. As main factor reduced tillage could be identified.

Theridion impressum web densitiy

Methods

From 2002 to 2005 webs of *Th. impressum* were counted every two weeks in 6 areas of 3×3 m in each system during BBCH 65-90. 118 web samples were taken from ICM and the numbers and taxa of prey items were analysed.

Results with discussion

In 2/3 of all samples no. of *Theridion impressum* webs were higher in ICM, but in 4 years no significant differences to STN were recorded (except one week in 2004). *Th. impressum* seems to be most important as aphid (65% of all webs) and pod midge predator (40%) than as a predator of oilseed rape pest beetles. Moreover, beneficials as chrysopids, hover flies, rove beetles, ichneumonids, Braconid wasps were found frequently and numerous in the webs. Thus, importance of *Th. impressum* as bio-control agent in oilseed rape is doubtful.

Staphylinidae-larvae from oilseed rape flower stands as regulators of *Meligethes*-larvae

Methods

To assess the dropping of *Meligethes*-larvae and of rove beetle-larvae as their predators 21 funnel traps, consisting of a funnel (21 cm diameter) fixed onto a plastic bottle, were installed in each system. The bottles contained a 5% sodium acid solution, their edges were about 15 cm above soil level. The traps were emptied weekly between BBCH 65-97.

Results with discussion

In all 4 years of field experiments significantly higher abundances of Staphylinidae-larvae were recorded in the ICM–system in comparison to the STN-system. In both systems dropping of *Meligethes*-larvae reaches the peak in BBCH stage 69-71. For the Staphylinidae-larvae however significant differences regarding phenology are to be seen (peak of rove beetle larvae: ICM - BBCH 73-75; STN – BBCH 81-83). In ICM during peak of dropping of *Meligethes*-larvae a high abundance of rove beetle larvae (app. 1500 ind/m²×week) was recorded (relationship *Meligethes* to rove beetles = 1:16), in STN the peak abundance of rove beetle larvae occured fairly later than the peak of *Meligethes*-larvae dropping. Furthermore, the abundance in STN was rather low (50-200 ind/m²×week). In STN the hatching rate of the new generation of *Meligethes* was much higher than in ICM. This result was consistant for 3 years. It implies that the delay in phenological occurrence of the

rove beetle-larvae affects their efficiency in control of *Meligethes.*

Conclusions

The results from our research laboratory and field experiments indicate that there is a reziproke correlation between predator density and pest problems.

It could be shown:

- the ICM system leads during the time of pest attack and larval dropping to an increase of the numbers of ground beetles (Coleoptera: Carabidae) in oilseed rape as well as in the subsequent crop winter wheat. Thus, the ICM-system shows advantage to maintain biodiversity.
- in all years the activity densities of ground beetles and spiders were significantly higher in the ICM system.
- there are spatio-temporal associations between certain predator species and pest species which in most cases are clearly related to the management intensity.
- comparing the hatching rates of the new pest generation, differences between the ICM and STN systems (part. in respect to insecticide treatments) are not significant. This demonstrates the effectiveness of natural enemies and can be judged as a plus for the ICM-system in which no insecticides where applied.
- if a comparatively high no. of Staphylinidae-larvae occurs at the right time (coincidence with peak of *Meligethes*-larvae) and the abundance of *Meligethes*-larvae is comparatively low, the effect of predacious rove beetle larvae on *Meligethes* spp. population development is higher as that of insecticide applications. Thus, under certain circumstances Staphylinidae-larvae can replace insecticide treatments.
- Integrated crop management (ICM) seems to promote building of horizontal webs of Linyphiid-spiders and is an indicator of their higher abundance and presence in the field. As main factor reduced tillage could be identified.
- Thus, the Integrated Crop Management system ICM promotes predators by the following three key features:

1. Low/no insecticide use. 2. Reduced tillage (mulching). 3. Less distance to landscape structures like hedgerows, extensively managed field margins or fallows. Regardless of that there was a 10% - 20% higher yield in recorded in STN systems. In the average of 4 years a (ploughed) STN-system with reduced insecticide applications (2,0 insecticide applications in a more extensive STN system vs. 5,0 in a more intensive STN system) shows best yield. However, due to costs farmer reduce ploughing in oilseed rape anyhow, so a mixed system of ICM and STN would be most realistic and promising.

- Furthermore the following results with practical implications were achieved:
- Staphylinidae-larvae (*Tachyporus* spp.) are in connection with population development of *Meligethes* spp. an object for a phenological model within decision support systems.
- The reputation of *Amara similata* (Coleoptera: Carabidae) as more or less strictly phytophagous and non- relevant as predator could be clearly revised. *A. similata* seems to be an important predator with clear preference to *Dasineura brassicae*. *Amara similata* obviously has skills to detect *D. brassicae*-larvae from outside in pods which are still closed. This has implication on the practice as for example in France *Amara similata* was judged as pest as this species was seen climbing up the oilseed rape plant and feeding on pods and controlled with insecticides Now it is clear that they attack only pods infested by Brassica pod midge which loose their seeds anyway by splashing early through the toxin secretion of the pest larvae.

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