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Do different field bordering elements affect cabbage seed weevil damage and its parasitism rate differently in winter oilseed rape?

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Abstract: The cabbage seed weevil, *Ceutorhynchus obstrictus*, is an important oilseed rape crop pest in Europe. Its abundance is usually managed by synthetic insecticides that can be harmful to neutral and beneficial organisms, including parasitoids, occurring in the agricultural fields. Parasitoids can play an important role in the control of the population size of seed weevils. This experiment was conducted to see if and how different field bordering element types affect cabbage seed weevil infestation and parasitism rate in conventionally grown winter oilseed rape crops. The percentage of damaged pods was low (between 8.5% and 10.9%), but even with such low pest abundance the parasitism rate was sufficient for efficient biocontrol; varying between 55.5% and 68%.

Key words: *Ceutorhynchus obstrictus*, field margins, conservation biological control

Introduction

The cabbage seed weevil *Ceutorhynchus obstrictus* Marsham (Coleoptera: Curculionidae) is a significant brassicaceous oilseed crop pest in Europe and North America (Dosdall *et al*., 2001; Alford *et al*., 2003). Adult weevils feed on oilseed rape plants on two separate occasions during the season, but the main yield loss is caused by larval feeding inside the pods on developing seeds (Doucette, 1947; Free *et al*., 1983; Buntin, 1999). In the spring, emerged adults feed on buds and flowers of early flowering brassicaceous plants (Doucette, 1947) and invade winter oilseed rape during the bud and/or early flowering stage (Williams & Free, 1978), where they continue feeding, then mate and females lay their eggs, one or two at a time inside pods that are at least 2 mm in diameter (Doucette, 1947; Dmoch, 1965).

In Europe parasitoids play an important role in the population regulation of the cabbage seed weevil (Williams, 2003; Veromann *et al*., 2011; Kovács *et al*., 2013), however in most oilseed rape growing areas, control measures currently rely on synthetic pyrethroid insecticides applied as foliar sprays (Williams, 2003), which are effective but at the same time create a harmful environment for beneficial organisms. The over use of pesticides threatens the efficacy of biological control by killing natural enemies of pests. When natural regulatory processes are reduced, insecticide applications have to be increased in order to keep pests under control (Pickett *et al*., 1995), which might lessen the economic competitiveness of the crop. Additionally, the resistance of *C. obstrictus* to tau-fluvalinate, etofenproxand and lambda-cyhalothrin recorded in Germany (Heimbach & Müller, 2013) shows the importance of avoiding unjustified pesticide use to lessen the likelihood of pesticide resistance development. Hence, alternative management strategies should be favoured. Creating and maintaining alternative habitats for beneficial insects has to be a key task in pest management.

Non-cultivated field margins serve as hibernation sites and offer food sources for adult weevils, supporting their survival, especially if the vegetation is botanically related to the main crop (Altieri, 1999). On the other hand, these sites also provide regulating ecosystem services by maintaining a habitat for the natural enemies of many pests via providing a modulate microclimate (Rahim *et al*., 1991), overwintering habitat, food resources (Jervis *et al*., 1993), source of alternative prey, all of which results in higher densities of predators and parasitoids (Lys *et al*., 1994; Sutherland *et al*., 2001).

The aim of this study was to measure and compare cabbage seed weevil infestation and parasitism rate in oilseed rape fields bordered by different non-crop habitat types.

Material and methods

Study area

The study was carried out on commercial winter oilseed rape crops in 2013, Tartu County, Estonia. Four different commonly occurring landscape element types were selected: herbaceous areal, woody areal, herbaceous linear and woody linear. The dimensions of areal elements were at least 60 x 60 meters while the width of linear elements did not exceed 12.5 meters and the length was at least 150 meters. At the sampling point the study crop was directly bordered by one landscape element and the minimum distance to a different element was at least 200 meters. There were 54 sampling points; 19 on winter oilseed rape crops bordered by herbaceous areal elements, 11 by woody areal, 15 by herbaceous linear and 9 by woody linear elements.

Sampling method

The cabbage seed weevil damage and parasitism rate was assessed at the ripening stage of oilseed rape (BBCH 83-85) (Lancashire *et al*., 1991). Pod samples were collected from two different distances per sampling point, 2 and 20 meters from the field margin. At each distance 10 pods (5 pods from the main raceme and 5 pods from the third raceme) from 5 randomly selected plants were collected, 100 pods per sampling point. Collected pods were incubated for four weeks in emergence traps (described in detail in Dosdall *et al*., 2006; Dosdall & Kott, 2006; Veromann *et al*., 2011; Kovács *et al*., 2013) after which time the emerged larvae and parasitoids were counted. Pods were examined and dissected and all exit-holes and weevil or parasitoid remains were noted. The rate of damaged pods and parasitism rate was calculated per plant.

Statistical analyses

The effect of field bordering elements on the damage and parasitism rate were analysed using a generalized linear model with normal distribution and identity-link function. The differences between treatments were studied using the same analysis but with Bonferroni correction. Statistical analyses were carried out using STATISTICA 12 (Statsoft Inc. USA, 2014).

Results and discussion

Generally, the damage rate caused by seed weevils was low in all studied winter oilseed rape fields and approximated 10%. In our study, the bordering landscape element type of the oilseed rape crop had no effect on the damage rate caused by *C. obstrictus* ($\chi^2 = 2.40$, df = 3, p = 0.49). The damage rate was similar on all crops regardless their bordering landscape elements (Figure 1) probably due to the low average damage rate (9.9% ± 0.6%). However, despite the low damage rate, parasitism rate was high in all studied fields and exceeded 50%, although the crop bordering element type had no effect on the parasitism rate ($\chi^2 = 3.25$, df = 3, p = 0.35). The highest parasitism rate was recorded from crops bordered with herbaceous linear elements (68% ± 5.3%) and lowest on locations where oilseed rape was bordered with woody elements: 55.7% (± 7.4%) of *C. obstrictus* was parasitized next to woody linear elements and 55.5% (± 5.9%) next to woody areal elements (Figure 1). Although not statistically significantly different, a somewhat lower parasitism rate in oilseed rape crops adjacent to woody landscape elements might indicate difficulties in the host finding of parasitoids.

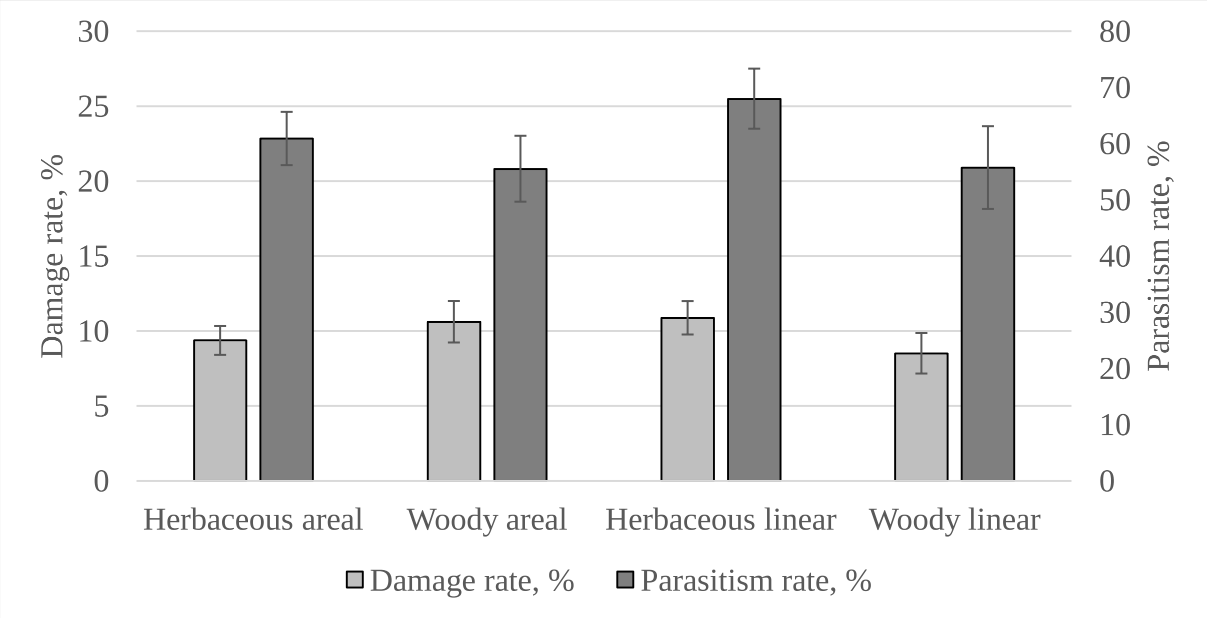

Figure 1. The mean (± SE) percentage of damaged winter oilseed rape pods caused by *Ceutorhynchus obstrictus* and its larval parasitism rates on crops adjacent to different landscape elements in Tartu County, Estonia, 2013.

Like other parasitoids, species attacking *C. obstrictus* use volatile cues emitted by host plants (Turlings *et al*., 1991; McCall *et al*., 1993; De Moraes & Mescher, 1998; Dicke, 1999); parasitoids of brassicaceous pests may use in addition isiothiocyanates, specific volatile organic compounds emitted by plants of this family, to locate and recognize host plants (Bartlet *et al*., 1993; Alford *et al*., 2003; Schiestl, 2010; Williams & Cook, 2010). Both oilseed rape pests and their parasitoids fly upwind towards the scent of host plants (Williams *et al*., 2007). As the dispersal of volatile compounds is directly linked to physical barriers, woody elements (forests and hedgerows) suppress wind and therefore decrease the dispersal of odours indirectly affecting the host finding success of parasitoids. The odour plumes and their dispersal is known to differ in forests and open landscapes (Murlis *et al*., 2000) and likely affect the dispersal of both pests and parasitoids. As pests only need to locate the crop they are in a better position compared to parasitoids, which first need to locate the crop and then the host within that habitat (Vinson, 1998) which might explain the equal damage rate between different crop bordering elements. Despite the lack of significant differences among parasitism rate, the average parasitism rate per sampling point type varied up to 5%, which suggests that parasitoids might be more affected by landscape composition than pests. However, the parasitism rate in all studied fields surpassed the level of effective pest control (32% according to Hawkins & Cornell, 1994) and we can conclude that in Estonia they can effectively control the population size of seed weevils.

In future studies it would be important to determine if and how much different field margins affect the damage rate and parasitism rate of this pest by comparing fields bordered by non-crop habitats with fields bordered directly by another crop field.

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