# Chapter 11
# Impact of Soil Tillage on Parasitoids of Oilseed Rape Pests

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**Abstract** Some of the parasitoids of important oilseed rape pests over-winter in the soil within the pupal chambers prepared by the host larva. Thus post-harvest soil tillage can have a great impact on the survival of these insects and the parasitization of oilseed rape pests the following year. Conventionally, soil tillage following harvest of oilseed rape was usually by ploughing but, more recently, methods of reduced tillage and direct drilling have become increasingly common. Experiments have shown that ploughing almost always reduces the number of parasitoids emerging the following year by 50% or more, while other kinds of tillage have a varying but lesser effect. Reduced, non-inversion tillage can be part of an integrated strategy to control insect pests in oilseed rape.

## 11.1 Introduction

Most of the parasitoids of the major insect pests of oilseed rape belong to the Hymenopteran family Ichneumonidae, subfamily Tersilochinae, but a few, mainly parasitoids of brassica pod midge, belong to the Chalcidoidea (Table 11.1); most develop during the larval stage of their hosts (see also Ulber et al. Chapter 2 this volume). The major part of the development and pupation of the parasitoid takes place in the soil chamber that the host prepares before pupation. The parasitoids hatch in the soil, but only the polyvoltine species e.g., *Omphale clypealis*, also leave the soil and eventually also the rape field that year. Univoltine species stay in the soil until the following spring, usually emerging when the oilseed rape of that year is at the appropriate stage for their hosts to be present. The fact that they stay in the soil after harvest of the oilseed rape crop, makes them vulnerable to post-harvest tillage and may be affected differently by different tillage, practised to establish the succeeding crop, usually cereals e.g., winter wheat or spring barley.

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**Table 11.1** Parasitoids of key oilseed rape pests that emerge from last year's rape field

| Pest | Parasitoid |
|---|---|
| | Family Ichneumonidae |
| *Psylliodes chrysocephala*<br>Cabbage stem flea beetle | *Tersilochus microgaster* (Szépligeti) |
| *Ceutorhynchus napi*<br>Rape stem weevil | *Tersilochus fulvipes* (Gravenhorst) |
| *Ceutorhynchus pallidactylus*<br>Cabbage stem weevil | *Tersilochus obscurator* Aubert |
| *Meligethes aeneus*<br>Pollen beetle | *Tersilochus heterocerus* Thomson<br>*Phradis morionellus* (Holmgren)<br>*Phradis interstitialis* (Thomson) |
| | Superfamily Chalcidoidea |
| *Dasineura brassicae*<br>Brassica pod midge | *Platygaster subuliformis* (Kieffer)<br>*Omphale clypealis* (Thomson) |

Most of these parasitoid species have no means of discriminating between a host already containing a parasitoid egg of the same or another parasitoid species and multiple oviposition is more the rule than the exception. Thus the number of parasitoids migrating into an oilseed rape field is important for the final parasitization level. As was shown by Jourdheuil (1960), the pattern of oviposition follows a Poisson distribution and the percentage of parasitized pest larvae is a curvilinear function of the quotient of parasitoid to host. A parasitization level in the pollen beetle (*Meligethes* sp.) of 50% needs 0.7 parasitoids for every host and a parasitisation level close to 100% would be possible only when there are more than three parasitoids for every host. Evidently, if soil tillage can influence the number of important parasitoids in the oilseed rape crop, this can be of great importance to the mortality of some of the more important insect pests and hence the need for chemical control or other control measures in subsequent years.

## 11.2 Tillage Systems

A couple of decades ago, soil tillage, following harvest of oilseed rape and before the sowing of winter or spring cereals, was usually by ploughing. However, methods of reduced tillage and direct drilling have recently become increasingly common, mainly due to the development of new machine concepts. Seeders with coulters (Fig. 11.1) that cut a furrow in the soil for the seed have, on many farms, replaced seeders with shoe coulters, the exception being when a seeder with a shoe coulter is used together with a rotary cultivator. In many areas, the soil structure after a winter oilseed rape crop is good enough to allow the establishment of winter wheat without ploughing and a much reduced tillage is often used.

Modern reduced-tillage seed drills perform tillage while preparing a seedbed for sowing. Disc coulters, clod crushers and pressing rollers are usually mounted on the

**Fig. 11.1** Seed drill coulter (Photo: C. Nilsson)

same machine as the drill and row spacing is about 0.12 m. The first experiments (1981–1983) that showed an effect of tillage on parasitoids (Nilsson 1985) were done with direct drills (Bettinson) that had a row spacing of 0.18 m and any impact on the soil was even less than that of present day direct drills.

In conventional tillage, the turning of the soil will put the pupal chambers at a depth of 15–25 cm, as the larvae pupate no deeper that 5 cm. Modern ploughs can work at any depth from 5 to 25 cm. Very shallow ploughing will hardly affect hibernating insects in the soil. The following harrowing, compaction and seed bed preparation will have more impact when ploughing has been less than 10 cm deep. At deeper ploughing, the insects are buried and can have problems working their way up to surface. Brassica pod midge can stay in the soil for several years (Nilsson et al. 2004) and will thus be ploughed up again the second and fourth autumn. The cocoons are spun encrusted with soil particles and will probably withstand different kinds of soil tillage quite well and so will the parasitoids within. The parasitoids will, as far as is known, not stay in the soil more than one winter and will have the same problem reaching the soil surface as other parasitoids, whereas the pod midge can survive for at least 5 years in the soil which increases its chances of survival.

In reduced tillage and tillage to prepare a seedbed after ploughing, a variety of other machines can be used, such as, different kinds of cultivators (tines), ducksfoot harrows, rotary harrows or disc harrows (Figs. 11.2 and 11.3). These machines break and sort soil aggregates. Rollers and cultipresses also compact the soil. Seeders for reduced tillage will also treat the soil partly in the same way. Pupal chambers can be broken and aggregates containing pupal chambers can be brought up to soil surface and dry out or be exposed to predators. It is not possible to foresee the effects in a specific situation. In Fig. 11.4 the resulting aggregate distribution from different machines in two fields in central Sweden, not far from each other, is shown (Arvidsson et al. 2004). As can be seen, the proportion of bigger aggregates can vary widely, more between fields than between machines. This investigation also shows that the soil water content, soil texture and type of machine are the most important parameters determining aggregate distribution and size.

**Fig. 11.2** Cultivator (Photo: C. Nilsson)

**Fig. 11.3** Ducksfoot cultivator (Photo: C. Nilsson)

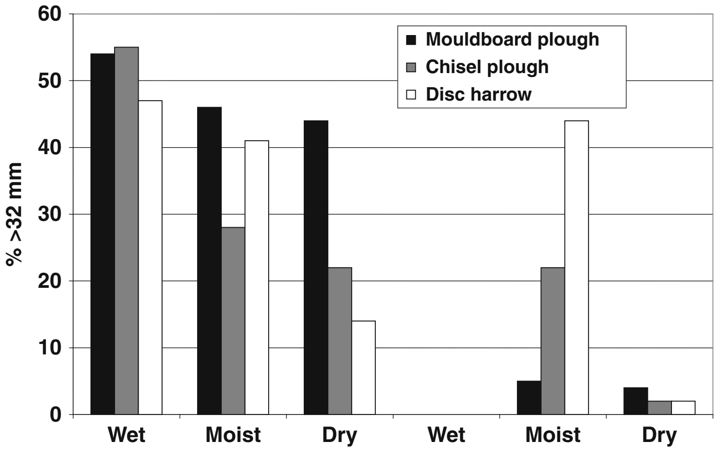


**Fig. 11.4** Proportion of aggregates > 32 mm after tillage with 3 different machines at wet, moist and dry soil conditions at two locations: *left*, Ultuna (30–44% clay) and *right*, Saby (14–25% clay), both near Uppsala in central Sweden

## 11.3 Effects of Tillage on Parasitoids

Experiments have been made in Sweden, Finland, Germany and UK during a 30-year period, with different machine systems. The first experiments in Sweden and Finland (Nilsson 1985, Hokkanen et al. 1988) showed that the over-wintering of parasitoids, mainly of pollen beetles, was about four times higher from fallow or when the winter wheat was sown with direct drill compared to ploughing or other forms of tillage (Table 11.2).

In the UK, a similar experiment, but with very low emergence of parasitoids was also done during 2005 (Ferguson et al. 2007). Here ploughing reduced emergence by an average of 30%, for some species more, whereas a shallow cultivation without

**Table 11.2** Numbers of pollen beetle parasitoids ($m^{-2}$) and the proportions (% relative to fallow) emerging from plots with different tillage systems. Comparisons followed by the same letter are not significantly different. Field experiments in Southern Sweden (Nilsson 1985) and Finland (Hokkanen et al. 1988)

| | Sweden | | | | | Finland | |
|---|---|---|---|---|---|---|---|
| | Fallow (no. $m^{-2}$) | Fallow | Direct drill (%) | Disc harrow (%) | Plough + harrow (%) | Fallow (%) | Plough + harrow (%) |
| *P. morionellus* | 6.9 | 100 a | 145 a | 26 b | 54 b | 100 c | 23 d |
| *T. heterocerus* | 28.2 | 100 | 77 | 19 | 18 | – | – |
| *P. interstitialis* | 10.8 | 100 | 127 | 24 | 17 | – | – |

**Table 11.3** Numbers of parasitoids ($m^{-2}$) and proportion (% relative to fallow) emerging from plots with different tillage systems. Comparisions followed by the same letter are not significantly different. Female parasitoids, males and a few *T. morionellus* are included in the sum. Field experiments from Weende, near Göttingen, Germany (Klingenberg and Ulber 1994)

| | Fallow (no. $m^{-2}$) | Fallow | Chisel plough 15 cm (%) | Ploughed 20 cm (%) | Ploughed + disc harrow 10 cm on stubble (%) |
|---|---|---|---|---|---|
| *T. microgaster* | 43 | 100 a | 12 b | 42 ab | 19 b |
| *T. obscurator* | 193 | 100 a | 42 a | 63 a | 34 a |
| *T. heterocerus* | 26 | 100 a | 81 ab | 60 b | 27 b |
| *P. interstitialis* | 25 | 100 a | 28 a | 48 a | 32 a |
| All Tersilochinae | 478 | 100 a | 40 b | 55 ab | 29 b |

**Table 11.4** Number of parasitoids $m^{-2}$ and proportion (% relative to direct drill) emerging from plots with different tillage systems. Numbers followed by the same letter are not significantly different. Field experiments in 1996 from Wendelsbreite (Nitzsche and Ulber 1998) and from Reinshof (Wahmhoff et al. 1999) near Göttingen, Germany

| | Direct drill (no. $m^{-2}$) | Direct drill | Chisel plough 8 cm (%) | Rotary harrow 5 cm (%) | Ploughed 25 cm (%) | Ploughed 25 cm + spade roller harrow 5 cm (%) |
|---|---|---|---|---|---|---|
| Wendelsbreite | | | | | | |
| *T. heterocerus* | 16.0 | 100 | 71 | 32 | 59 | 72 |
| *P. interstitialis* | 32.1 | 100 | 135 | 72 | 85 | 53 |
| All Tersilochinae | 48.1 | 100 a | 114 a | 59 b | 75 ab | 47 b |
| Reinshof | | | | | | |
| *T. obscurator* | 12.8 | 100 a | – | 144 a | 50 b | – |
| *T. heterocerus* | 11.0 | 100 a | – | 65 b | 9 c | – |
| *P. interstitialis* | 14.2 | 100 a | – | 50 b | 18 c | – |
| All Tersilochinae | 38.0 | 100 | – | 86 | 26 | – |

ploughing reduced the parasitoid populations less and was not significantly different from the emergence from fallow. Similar results were obtained in an experiment in Poland (Klukowski pers. comm.)

In Germany, several experiments (Tables 11.3 and 11.4) with different machines have also given a strong reduction of the emerging parasitoid population when ploughing was used, amplified by a stubble treatment after the harvest of the preceding crop. At this time in August, parasitoids start to develop into adults, but stay in their cocoons in the soil and are probably very sensitive to soil cultivation. The overall effect is 25 and up to 90% reduction of parasitoid numbers. In these experiments, the effects of a rotary harrow or a chisel plough are often as severe as ploughing, but, in the experiments shown in Table 11.4, especially that in Reinshof, the effects on the parasitoids are clearly less than those of ploughing.

These experiments show that direct drilling and reduced, non-inversion cultivation of soil after harvest of oilseed rape can be recommended to farmers as part of an integrated strategy to actively enhance parasitoid populations and thereby at least sometimes improve biological control of economically-important pests of oilseed rape. It is however not possible to predict the results of a specific tillage method in a specific situation. The use of this method to increase biological control would be much greater if we had a more detailed knowledge of which factors of post-harvest soil cultivation have the most significant impact on the winter survival and spring emergence of these parasitoids.

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