Organic farming systems benefit biodiversity and natural pest regulation in white cabbage

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Natural regulation of cabbage root flies works well in experimental organic cropping systems of white cabbage. Low input and complex organic systems benefit functional biodiversity by providing good living conditions to several groups of natural enemies. Intercropped green manure benefits large predators while small predatory beetles favour low input organic systems with bare soil between crop rows.

The experimental organic farming system

Organic farming systems include enhancement of the natural regulation of insect pests. The organic farmer has little choice as conventional chemical pesticides are prohibited. In high value crops such as vegetables only low levels of crop damage is tolerated. Therefore, organic vegetable cropping systems must provide good living conditions for natural enemies (predators, parasitoids and insect pathogens) and rely on efficient natural regulation mechanisms.

In the ICROFS project VegQure (www.vegqure.elr.dk) vegetables (white cabbage, carrots, onions and lettuce) were grown under four different farming regimes:

- C1: Conventional vegetable cropping system (conventionally farmed control)
- O1: Organic farming in compliance with Danish regulations, dependent on external input
- O2: Organic farming with low input, green manure and nutrient cycling
- O3: Organic farming with low input, green manure, nutrient cycling and intercropping between crop rows

The O3 system is unique by adding structural diversity to the cropping system. This is done by leaving strips of the green manure from the previous year as intercrop between crop rows. The three organic cropping systems therefore range from simple to complex with decreasing reliance on external input.

In VegQure we have over several years studied the effects of these four farming systems on populations of selected pest insects and ground living predators in the experimental plots with white cabbage. This focus enables us to study the outcome of natural regulations of pests over time and evaluate how each farming system provides living conditions for natural enemies.

Farming system	May 2007	May 2008
C1	25-30	25-30
O1	5-10	25-30
O2	5-10	10-15
O3	>70	50

Table 1. Percent traps with large ground predator species in experimental plots with white cabbage

Regulation of cabbage root flies

During three field seasons, 2007, 2008 and 2009 we monitored the population dynamics of one of the major pests in white cabbage, the cabbage root fly (Delia radicum). In Denmark, the root fly generally has two generations per year. Eggs of the first generation are laid at the time when cabbage seedlings are planted while second generation flies lay their eggs in July-August. We monitored the eggs present in soil samples collected around the plants in 2007 - 2009.

In all years, the numbers of eggs per cabbage plant for first generation flies were relatively stable (15-20 eggs per plant) except for system O3. Here, levels decreased to one third compared to the other three systems over these three years. For the second generation, most eggs were laid in system O3 in 2007 (185 eggs per plant), in 2008 there were no differences in egg numbers between the systems (80-90 eggs per plant), and in 2009 significantly fewer eggs were laid in system O3 (35 eggs per plant). Overall, the numbers of eggs laid per plant decreased over the three year period by a factor 1.7 per year, but most prominently so in O3 with a factor 2.3 decrease in egg numbers per year.

Larvae hatching from the eggs live in the soil and feed on the cabbage roots. Pupation also occurs in the soil; offspring of first generation flies will emerge as second generation flies in July and their offspring mostly overwinter in the soil around the food plant.

The overall numbers of overwintering pupae of root flies decreased in the experimental plots over the study period, but we found two to three times as many overwintering pupae in system C1 compared to the three organic systems. As no more eggs were laid here than in the organic systems, we conclude that survival and resulting pupation success in C1 was higher than in the organic systems. Thus, natural regulation mechanisms function better in the three organic systems than in the conventional C1 system. One factor accounting for the differences in cabbage root fly survival could be predation by natural enemies.

Farming systems affect natural enemy diversity

It is known that ground dwelling predatory beetles consume significant proportions of fly eggs just after the eggs are laid. We therefore trapped predators that were active on the soil surface while the flies laid their eggs in 2007 and 2008. Trapping was done by placing pit-falls in between the cabbage rows. The egg predators are small species less than 8 mm in length, and they can access cracks and

Photo 1: Organically farmed plots with cabbages planted between intercrop rows of previous year's green manure showed high benefit for large ground dwelling predators.

Photo 2: Ground dwelling predators were monitored in experimental cabbage plots by pit-fall trapping. A trap is placed in the foreground of the picture.

Photo 3: The low input organic system O2 where white cabbage was grown in bare soil plots showed highest abundance of small predatory beetles which are known to consume cabbage root fly eggs.

Photo 4 (left): Cabbage with intercropped strips of green manure in the organic system O3 showed the most significant decrease in egg laying by cabbage root flies over the three year study period. Egg numbers were estimated from soil samples collected around the cabbage plant.

crevices in the soil where the fly eggs are located.

Two to four times as many potential egg predators were caught in system O2 compared to the three other systems during first generation fly activity of both 2007 and 2008. This trend continued in 2008 during second generation flight too (Fig. 1).

Small predatory beetles show increased activity in organic system free of external input, but only in plots with bare soil between crop rows as in O2. The beetles are likely to contribute to an improved regulation of cabbage root flies. However, system O3 - which only differ structurally from O2 by intercropping - did not benefit small beetle activity.

Natural enemies other than small predatory beetles are also affected by the four farming systems. We trapped small money spiders (family Linyphiidae) and larger generalist predators - ground beetles (family Carabidae) and hunting spiders (family Lycosidae) - in the cabbage plots in 2007 and 2008. Both groups responded to the farming systems, but in surprisingly different ways.

Practically no money spiders were present in the cabbage crop in May, but the numbers increased drastically in the organic systems compared to C1 in July (Fig. 2). Three to four times more spiders were trapped in the organic systems than in the conventional C1 in July 2008. The trends actually reflect the increasing level of complexity and thus assumed sustainability of the four farming systems by O1<O2<O3. Money spiders are predators of aphids which also attack cabbage.

Ground beetles and hunting spiders also responded to the farming systems. These predators are normally associated with complex habitats usually absent in arable farmland. Effects were evident in May when significantly more traps contained species of these natural enemies in O3 as compared to the other systems (Table 1). Early in the season, the intercrop in O3 therefore adds faunal elements to the arable farmland.

The organic systems O2 and O3 show similar levels of natural regulation of cabbage root flies but benefit the activity of natural enemies differently. Organic cabbage cropping with low input give no more problems with cabbage root flies than high input systems such as O1. However, O2 benefits the predators associated with fly egg predation while the complexity of O3 benefits predator diversity in general.

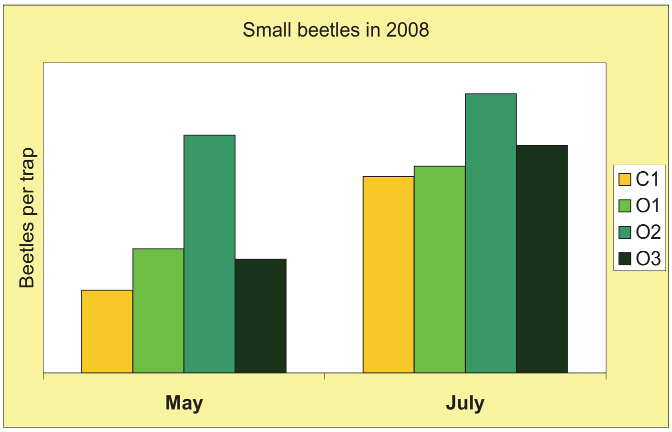

Figure 1
Small (<8 mm) predatory beetles consume the eggs of the cabbage root fly. Small beetle activity was highest in the low input organic system O2

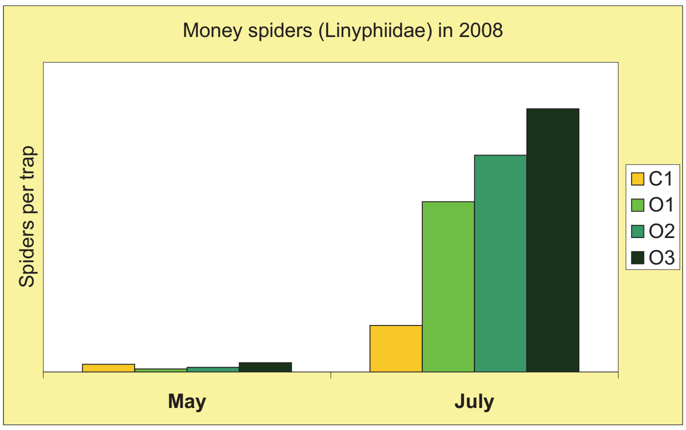

Figure 2
Small money spiders were much more abundant in the three organic systems, O1, O2 and O3, compared to the conventional system C1 in July 2008. These spiders mostly consume aphids.

Read more
You can find more information about the DARCOF III research project VegQure on the webpage:

www.icrofs.org/Pages/Research/darcofIII_vegqure.html

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