Effect of living mulch on pest/beneficial interaction

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Key words: Cauliflower, arthropod fauna, *Pieris brassicae*, parasitization, bioindicators.

Abstract

The aim of this study was to evaluate the effect of cover crops on pest/beneficial dynamics and to test the potential of living mulch on enhancing biological control against insect pests. The research, carried out in the frame of the InterVeg (Core Organic II) project, involved four European countries: Germany, Slovenia, Denmark and Italy. Three crops were tested: cauliflower, leek and artichoke. The preliminary results obtained in Italy on cauliflower, indicated that the living mulch did not affect the infestation of the cabbage butterfly, Pieris brassicae, showing no detrimental effect of this technique on pest dynamics. A very high level of parasitization against cabbage butterfly was detected either in the living mulch crop (88%) and in the sole one (63%). Living mulch showed to increase the spider and rove beetle activity density, while the carabid activity density was slightly higher in the sole crop.

Introduction

Biodiversity and complexity are considered to be essential for the stability and balance of the living component of ecosystems (Pimentel 1961). According to these criteria, crop diversification is an agricultural strategy that can be used to manage insect populations; in fact susceptible plants may be supported by nearby non-host plants, reducing density of the host-plant and increasing the presence of natural enemies (Andow 1991).

Many studies showed that intercropping and living mulch (LM) can have positive impact on plant pests and diseases as well as weed control (Sans and Altieri 2005, Jones and Sieving 2006), although this trend cannot be considered a general rule, but evaluated on a case-by-case approach. For example, trials carried out by Hinds and Hooks (2013) in northeastern United States showed that the number of striped cucumber beetle (*Acalymma vittatum* F.), found on leaves of zucchini plants, was significantly lower in sunn hemp (*Crotalaria juncea* L.) interplanted plots compared to bare-ground treatment plots. In North America, soybean grown with alfalfa LM had an increase of natural enemies and showed a delay in *Aphis glycines* Matsumura establishment (Schmidt et al. 2007). A study on the population dynamics of whiteflies and aphids and their associated natural enemies was carried out in zucchini, to compare living and synthetic mulch; results showed that LM had consistently fewer adult whiteflies and aphids compared with the standard mulch treatments. LM treatments had higher natural enemy populations than synthetic mulch and bare-ground treatments (Frank and Liburd 2005).

The aim of our study was to evaluate the effect of cover crop – main crop intercropping on pest/beneficial dynamics and to test the potential living mulch on enhancing biological control against insect pests. The research, carried out in the frame of the InterVeg (Core Organic II) project, involved four European countries: Germany, Slovenia, Denmark and Italy. In each country, two main vegetable crops were considered: cauliflower (*Brassica oleracea* L. var. *botrytis*), common for all and leek (*Allium ampeloprasum* L.) for Germany, Slovenia and Denmark. Due to the different climate and market demand, in Italy leek was substituted by artichoke (*Cynara cardunculus* L.). In more detail, the first project year was aimed to identify the key pests for each of the studied trophic system (i.e. combination of main crop, living mulch and its arthropods community of each site) with the objective of successively transferring this knowledge to a larger scale at the second year of the study. Accordingly, in this paper the first year results obtained in Slovenia, Denmark and Italy are presented. Moreover, as case study, the results obtained in a larger scale experiment carried out on the Italian cauliflower trophic system are discussed, in order to have a comparison of the ecological services provided by each treatment (LM *vs* no LM, control treatment) in a pilot farm.

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Materials and methods

Small scale experiment - During the first year, in each country, an insect survey by visual observations was carried out at small scale (experimental site). The pest and beneficial data recorded on the different treatments (LM *vs* no LM) were pooled in order to have a general overview on the arthropod fauna. This choice was made because of the small size of the plots, which could cause a bias in the relative abundance of the insects between the treatments. In particular, one sampling per month was carried out, checking 5 organs (leaf or flower) per plant on 30 plants. A total amount of 150 sampling points, randomly selected, was checked every month during the cultivation period. In the case of Denmark, selective techniques as sticky yellow traps and Diptera eggs traps were added to the visual evaluation, to determine the presence of trips and flies. Moreover, in all the sites an evaluation of the damage caused by insect pests on the plants was carried out at harvest. The pest damage was recorded considering a relative score, defined by the severity of injuries suffered by plants. The scores of pest damage were 0 = absence; 1 = light; 2 = intermediate; 3 = heavy.

Large scale experiment - During the second project year, a larger scale experiment was carried out on the Italian cauliflower/annual medicago (*Medicago polimorpha* L. var *anglona*) trophic system in an organic farm (pilot farm) located in the Pescara province (Central Italy). A cauliflower plot with the annual *medicago* as LM was compared with the sole cauliflower crop. The size of each plot was 500 m² and the two plots were at a distance of 100 m in order to reduce the cross effect between the treatments. A total amount of 100 organs per treatment, randomly selected, was checked at every sampling, either in the LM and in the sole crop treatment. Presence/absence of the key pest was recorded. By this planning, one sampling every two weeks was carried out during the cultivation season, checking 5 organs (leaf or flower) per plant, on a total of 20 plants per treatment.
In order to quantify the effectiveness of biological control strategy against the key-pest in each treatment, the percentage of parasitisation was determined collecting a minimum sampling size of 15/20 larvae of the key pest per plot in each sampling. The sample of mature larvae was collected and dissected to check the presence/absence of parasitoid larvae inside it. Lastly, in order to have a complete overview of the fields, it was decided to investigate also the soil arthropod fauna, with the aim to compare the ecological sustainability among the treatments.

A minimum of 4 traps were placed in each treatment, in order to reach a density of one pit fall trap per 200 m^2. The traps were active for two weeks in each sampling. The content of the traps was transferred to the laboratory, and the number of Carabids, spiders and other soil bioindicator groups within each trap were counted.

Results

Small scale experiment - In Table 1 the results of the small scale monitoring are reported for each country. In Italy, the key-pests of cauliflower and artichoke were *Pieris brassicae* (L.) (large white or cabbage butterfly) and aphids, respectively. In Denmark, the dominant pest on cauliflower was the small white *Pieris rapae* (L.), while in Slovenia *Phyllotreta* spp. was most frequent.

Table 1- Key pest determined and percentage of infested leaves

Country	Cauliflower	Artichoke	Leek
Italy	*Pieris brassicae* 66.9%	Aphids 32.3%	-
Denmark	*Pieris rapae* 37.3%	-	Aphids 41.1% Trips 41.1%
Slovenia	*Phyllotreta spp.* 69.73%	-	No record

Large scale experiment - As far as the large scale experiment carried out in the pilot farm in Italy is concerned, the results showed that *P. brassicae* infestation, the key-pest of this crop in the Italian scenario, did not show any difference between the LM and the sole crop treatment (Chi-square test P>0.05) (Fig. 1).

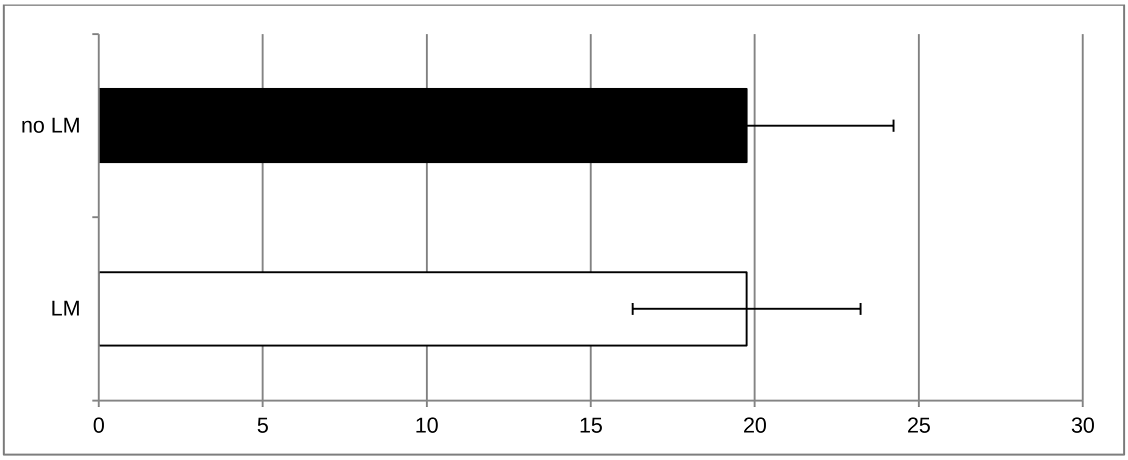

Figure 1 – Cumulative percentage of infested leaves by *P. brassicae* (bars indicate standard errors of binomial distribution).

Also, the percentage of parasitized larvae was higher in LM in comparison with the no LM, sole crop control treatment, even if this difference was not statistically different (Chi-square test, P=0.126) (Fig. 2). All the parasitized larvae were infested by *Cotesia* sp. (Hymenoptera Braconidae), a gregarious parasitoid which is a common biological control agent of this pest.

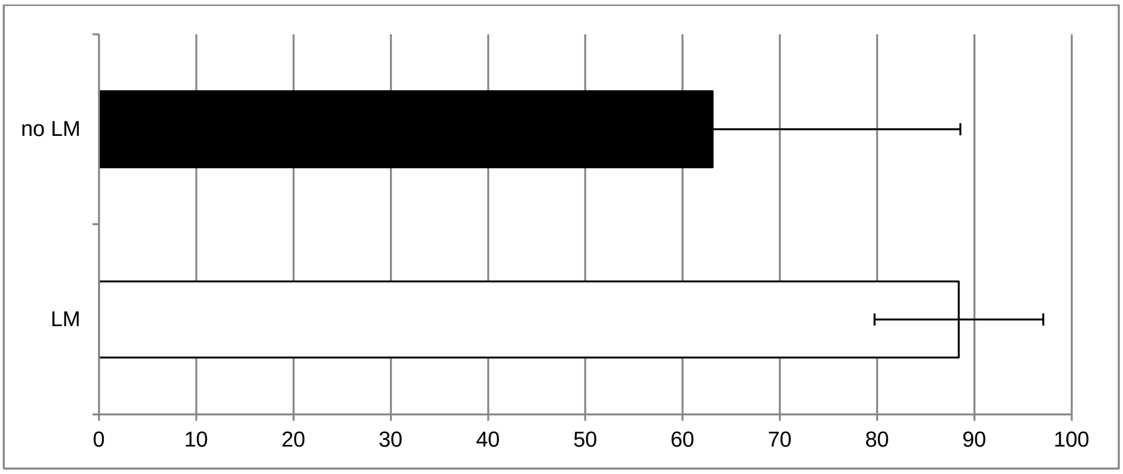

Figure 2 – Cumulative percentage of parasitized *P. brassicae* larvae (bars indicate standard errors of binomial distribution).

Concerning the soil bioindicators, an identification of the Carabidae to the species level is in progress, including a faunistic analysis of the trophic groups recorded in each treatment. The analysis in progress will state potential differences in species composition between the two treatments concerning the Carabidae. In Table 2 are reported the soil bioindicators divided in each trophic group. In general, all the groups showed similar activity densities in the two treatments, even if some slight differences was evinced (i.e Araneae or spiders and Staphylinidae or rove beetles density were higher on LM, and Collembola and Carabidae density were slightly higher on no LM).

Table 2: Bioindicators recorded per trap. The numbers show the mean activity density/per trap (±standard error)

	Carabidae	Araneae	Oniscidae	Staphylinidae	Collembola	Opilionidae
no LM	35.0±4.8	12.0±3.0	5.3±0.4	6.8±0.1	169.3±3.2	30.5±0.9
LM	22.5±2.3	22.5±4.7	4.5±0.4	25.8±2.2	136.8±6.8	27.0±5.3

Discussion

Small scale experiments were useful to focus each trophic system in the different countries, characterized by very different climatic and geographic situations. Moreover, the key-pest selection was a useful criterion to choose the suitable insect monitoring tool and the associated ecological services provided by beneficial fauna. For example, for the Italian scenario, the cabbage butterfly was selected as key-pest and the parasitization by the braconid *Cotesia* sp. was evaluated in order to determine if LM could affect biological control against the pest. The living mulch did not affect the infestation of *P. brassicae*, showing no detrimental effect of this technique on pest dynamics. A very high level of larval parasitization was detected in both treatments (Bryant et al. 2013); the percentage of parasitization was higher in LM (88%) *vs* no LM (63%). In general, a consistent regulatory capacity of the organic farm was detected in all the experiment. LM showed to increase the spider and rove beetle populations, while the carabid activity density was slightly higher in the no living mulch (Gill et al. 2011), although the low activity density of soil arthropod bioindicators in the autumnal season does not allow a definitive conclusion.

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