

Agro-ecological Service Crops with roller crimper termination enhance ground-dwelling predator communities and pest regulation

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Abstract

The dependence on tillage in organic agriculture has raised questions regarding soil management in organic systems. Recently, Agro-ecological Service Crops (ASC) and roller crimper (RC) technology have attracted attention in organic farming circles. ASC are sown before cash crops to provide benefits for agro-ecosystem services. RC permits the creation of a mulch on the soil surface consisting of ASC plant material with no need for tillage. Studies carried out in the USA, Canada and Latin America on RC reveal some of the potential benefits and drawbacks of this technology. However, only a few such studies have taken place in European agroecosystems. The objective of the SoilVeg project (ERA-Net CORE Organic Plus) is to study RC under European environmental and agronomic conditions. This paper shows how sowing ASC before autumn-winter cash crops and the termination strategy affect (i) the abundance of soil arthropods and (ii) the diversity of both pest and beneficial insects in Italy and Spain.

Introduction

Preserving soil fertility and health – and the organisms it contains – is one of the fundamental principles of organic farming as defined by IFOAM (2014). However, organic management often depends on soil disturbance for weed control, green manure incorporation and seedbed preparation, which may have negative effects on soil organisms and their trophic networks (Roger-Estrade *et al.* 2010).

The use of roller crimper (RC) as an alternative to tillage has attracted a great deal of attention amongst European scientists. Several studies have shown the potential of RC combined with the use of agro-ecological service crops (ASC) to control weeds, decrease soil erosion, and reduce the use of labour and fossil energy consumption (Canali *et al.* 2013, Altieri *et al.* 2011). Nevertheless, certain drawbacks have also been observed (Altieri *et al.* 2011) and to date few RC studies have been performed in European agroecosystems.

The European project SoilVeg (ERA-Net CORE Organic Plus) involves 14 institutions in nine countries and aims to study the effectiveness of RC under different scenarios, i.e. different combinations of crops, soils and climatic conditions. This project aims to verify the hypothesis that the use of ASC and termination by RC (1) maintains the

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productivity and quality of organic vegetable crops, (2) improves agronomic and environmental soil quality, (3) reduces the consumption of fossil fuels, and (4) helps to create a suppressive environment for pests, diseases and weeds. In this study, we focused on the fourth of these objectives in an experiment performed simultaneously in Italy and Spain. Our aim was to study how the sowing of an ASC before autumn-winter cash crops and the termination strategy, i.e. the incorporation of ASC as green manure (GM) vs. the use of RC, affect the ground-dwelling arthropod assemblages and, in particular, communities of the natural enemies of aphids.

Material and methods

Site and experimental design

In winter 2015, experiments were carried out in Spain in the Gallecs Area of Natural Rural Interest (Barcelona) (41° 33' 42.8" N 2°12' 7.6" E) and in Italy at Metaponto (CRA-SCA ASM) (Matera) (40° 23' 00.0" N 16° 48' 26.1" E). In Spain, the ASC mixture consisted of 50% *Vigna unguiculata* and 50% *Sorghum bicolor*, while in Italy four different combinations of *V. unguiculata*, *Pennisetum glaucum* and *Raphanus sativus* were used. ASCs were terminated with either RC or GM before the sowing of the cash crop. In Italy the cash crop was cauliflower, while in Spain it was cabbage. In Spain a control treatment based on keeping the soil bare without any plant cover (hereafter BS) was also established.

Data collection

In all the experiments pit-fall traps and standard practices were used to investigate the soil arthropod fauna (Döring and Kromp 2003). Each pit-fall station consisted of two pit-fall traps connected to a 10-cm-high and 1-m-long Plexiglas barrier. Traps were filled with propylenglycol (40 %). In Spain, eight samplings were carried out every fortnight, while in Italy four samplings were carried out every three weeks. In the laboratory, the most relevant taxa were counted in each sample.

Aphid colonies were assessed visually and separated into four infestation categories: class 0 (no aphids), class 1 (presence of a few aphids), class 2 (small colonies) and class 3 (large colonies). Aphid infestation was expressed as weighted percentage (%). In Spain, a total of 15 leaves per plot were assessed, three leaves per plant from five randomly selected cabbages. Aphidophagous predators such as hoverfly larvae, lady bugs and predatory bugs were also recorded from the same leaves. Aphid mummies were collected in order to identify the parasitoid species.

The same sampling protocol was performed in Italy, with the exception of the number of leaves sampled per plot (30, three leaves per plant on 10 randomly selected plants).

Statistical analyses

In Spain, the effects of the ASC termination technique on soil arthropods, aphids, parasitoids and aerial predators were analysed using a one-way ANOVA with three treatments (BS, RC and GM) and four repetitions per treatment. Post-hoc comparisons were performed using a Tukey test.

In Italy, the experiment was planned using a randomized block design with four replicates in which the sources of variations were the termination technique (two levels, RC-GM) and ASC mix (four levels). Data were analysed using a two-way ANOVA and were log- or square-root-transformed to meet the requirements of normality and homoscedasticity.

Results

Ground-dwelling arthropods

In Spain, the most abundant group was beetles (59.92%), followed by spiders (16.73%), earwigs (11.55%) and crickets (11.80%). The ANOVA showed significant differences between treatments for the activity density of spiders ($F = 5.80$, $df = 2$, $p < 0.05$), beetles ($F = 15.01$, $df = 2$, $p < 0.01$) and crickets ($F = 6.25$, $df=2$, $p < 0.05$) (Figure 1. A). No significant differences were found for earwigs. Spider and beetle abundances benefited from RC treatments, while cricket abundances were greater in BS plots.

In Italy, springtails were the most abundant group (68.6%), followed by isopods (24.1%), ground beetles (3%), spiders (2.9%) and rove beetles (1.2%). Ground and rove beetles and isopods were more abundant in roller crimper (RC) plots than in green manure (GM) plots (Figure 1. B). Springtails showed no differences between the different termination techniques.

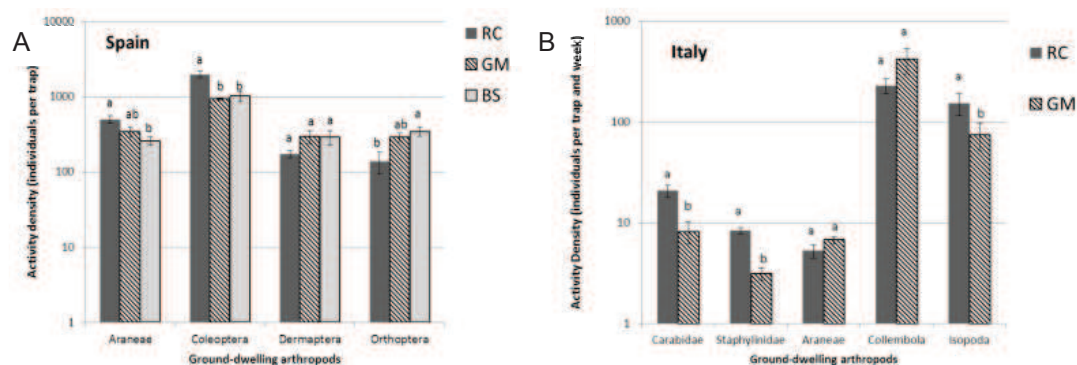


Figure 1. Activity density (individuals per trap) (mean \pm standard error) of the most abundant ground-dwelling arthropod orders. A - Spain; B - Italy. In each order, treatments with the same letter were not significantly different at $P \leq 0.05$ (Tukey test).

Aphids, aphid mummies, parasitoids and aphidophagous predators

In Spain, aphid infestation varied between treatments ($F = 4.41$, $df = 2$, $p < 0.05$) and RC plots suffered less aphid infestation than BS treatment plots (Figure 2. A). However, there were no differences between RC and GM plots.

The abundance of aphidophagous predators was influenced by the soil treatment ($F = 4.48$, $df = 2$, $p < 0.05$) and there were greater abundances of these communities in BS plots than in GM plots; no differences were found between GM and RC plots (Figure 2. A). The abundance of aphid primary parasitoids varied according to treatment ($F = 6.57$, $df = 2$, $p < 0.05$) and there was a greater abundance of parasitoids in BS plots than in RC plots (Figure 2. A).

In Italy, aphid infestation was higher in GM than in RC plots on the third sampling date; no differences between termination techniques were found for the remaining sampling dates. The density of mummies was higher in GM than in RC plots on the fourth sampling date (Figure 2. B).

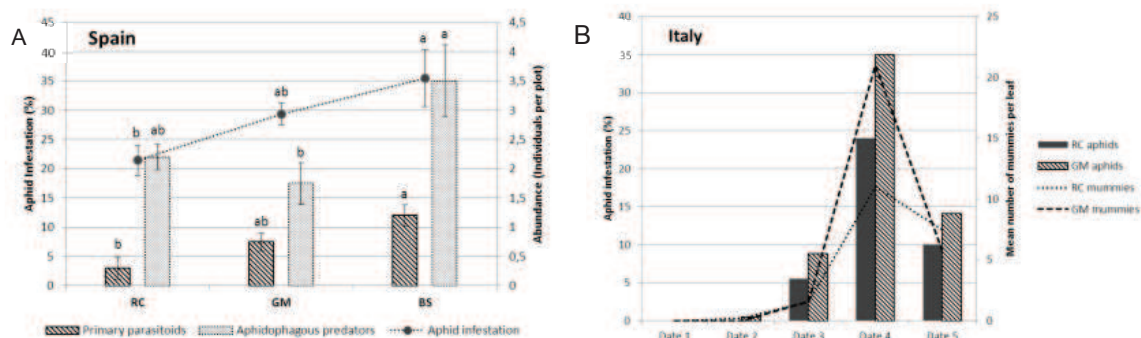


Figure 2. A – Aphid infestation (expressed as weighted percentage %), primary parasitoids and aphidophagous predator abundances per plot under each treatment (mean \pm standard error) in Spain. For each order, treatments with the same letter were not significantly different at $P \leq 0.05$ (Tukey test). B - Trends in aphid infestations (expressed as weighted percentage %) and mummy occurrence for each treatment during the sampling season in Italy.

Discussion

The hypothesis that RC would help suppress pests was supported in both countries by the enhancing of ground-dwelling aphid-predator communities. In Italy in particular, ground and rove beetles greatly benefited from RC termination in comparison with GM, whereas in Spain spiders were the group that most benefited from the RC treatment. In Spain, the abundance of aphidophagous predators was mainly determined by the abundance of their potential prey items. Consequently, a greater abundance of aphids in the BS treatment led to higher predator abundances. In Italy, canopy infestation was very low under both treatments and higher aphid infestation was only recorded in green manure plots on one sampling date. Aphids were effectively controlled by parasitoids, their most abundant natural enemies on cabbages. The abundance of parasitoids appears to be closely associated with the abundance of *Brassica* aphids in both countries, which may account for the aggregation response to the prey (Pareja et al., 2008).

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