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Influence of Reduced Tillage and Green Manures on Weed Emergence and Yield in Organic Farming (TILMAN-ORG SESSION)

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Key words: *Avena sativa*, chisel, direct drilling, disc harrow, no-till, *Vicia sativa*

Abstract

If farmers want to use reduced tillage in organic agriculture, they often face great challenges in weed control. One goal of the European research project TILMAN ORG (www.tilman-org.net) was to develop a more efficient weed management and increased biodiversity through improved use of green manures in different systems of reduced tillage.

In a repeated one year trial on the research farm of University of Kassel the effects of different green manure species and different tillage systems on weed cover, density and biomass as well as yield of a subsequent main crop were examined. Sinapis alba, Trifolium resupinatum and Vicia sativa were tested as green manure species. Bare fallow served as control. After the green manures the main crop oat was sown in four different tillage systems: (1) plough, (2) chisel (2011/12) or disc harrow (2012/13), (3) mulching + drilling and (4) direct drilling.

In 2011/12, weed cover was generally low in the plough system compared to the other tillage systems. In the mulching + drilling- and direct drilling- systems V. sativa was able to suppress weeds considerably more efficiently than the other green manure treatments. The oat plots after the green manure species S. alba and T. resupinatum as well as the bare fallow had to be given up because weed pressure was too high. Instead, the oat yield in the mulching + drilling- and direct drilling treatments after green manure species V. sativa resulted in oat yields similar to the plough treatments. In the chisel system, oat yield in the V. sativa treatment was significantly higher than in the other green manure treatments. 2012/13 all mulching + drilling- and direct drilling- plots had to be given up because of too high weed pressure. In the disc harrow– system weed pressure differed not significantly from the plough system, but only green manure species V. sativa resulted in comparable oat yields.

Introduction

The control of unwanted wild plants is a challenge in organically managed agricultural systems under reduced tillage. If no plough shall be used, instruments for preventative weed management are mainly crop rotation and use of green manures, which may suppress weeds because of competitive power (Bàrberi 2002, Peigné *et al*. 2007, Shresta *et al*. 2001). One aim of this research project in the context of the European ERA-Net Core Organic II (www.tilman-org.net) was to develop an improved weed management in systems with reduced tillage through efficient use of green manures.

Material and methods

A repeated one year trial (2011/12 and 2012/13) was established on the experimental farm of University of Kassel, Domaene Frankenhausen (51.5 N; 9.4 E; 689 mm; 8.5ºC). The soil is a Haplic Luvisol (Ut4). The trial was designed as a two factorial (green manure and tillage) split plot with eight replicates in 2011/12 and four replicates in 2012/13. Eight replicates were needed because no adequate randomization could have been achieved otherwise due to the trial design. Before sowing the green manure the land was prepared with a chisel. The following leguminous and non-leguminous green manure species were sown in both years: *Sinapis alba*, *Trifolium resupinatum* and *Vicia sativa*. Bare fallow served as control. Before sowing the main crop oat four tillage systems were implemented: conventional tillage (plough) was compared to reduced tillage (chisel in 2012, disc harrow in 2013), mulching + drilling and direct drilling ("no-till"). The pre-crop in both years was winter wheat. The sowing dates of the green manures were 26.08.2011 and 22.08.2012. Sowing densities were 20 kg per hectare for *S. alba* as well as for *T. resupinatum*, and 105 kg per hectare for *V. sativa*. Sowing dates for the main crop oat (*Avena sativa* L., *cv*. Scorpion) were 10.04.2012 and

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22.04.2013. Sowing densities were 400 germinable grains in 2012 and 450 germinable grains in 2013. Weed assessments were done as follows (Table 1).

Table 1. Assessments of weeds

Investigation date	Parameters assessed	Number, type and placement of sampling areas
29.03.2012 / 08.04.2013 (= late stage of green manures)	Weed cover by species	One frame of 100 x 100 cm per plot
23.05.2012 / 21.05.2013 (= early stage of main crop oat)	Weed density by species	Four frames of ~31.6 x ~31.6 cm (= 1/10 m²) per plot
11.07.2012 / 16.07.2013 (= late stage of main crop oat)	Weed cover by species + Total weed biomass	One frame of 100 x 100 cm per plot (both on the same area)

Green manures were harvested on 17.11.2011 and 14.11.2012. A square of 1.5 m x 1.5 m (= 2.25 m²) per plot was harvested by hand. Harvest of main crop oat took place on 09.08.2012 and 12.08.2013. In 2012 two frames of 50 cm x 100 cm per plot were harvested by hand, in 2013 four frames of 50 cm x 100 cm. Total biomass yield, grain yield, panicles per m², thousand kernel weight and hectoliter weight were determined. Statistical parameters to describe the distribution of total weed density, total weed cover, total weed biomass, and yield, such as the mean and standard error were calculated. To check for the significance in differences in each parameter, an analysis of variance (ANOVA) was performed, followed by the Tukey-B test. All statistical analyses were done with SPSS-21.

Results

2012 there were no significant differences for weed cover in the green manures. In the main crop oat the results for weed cover showed significant differences for the factor tillage. The plough - system showed significantly lowest weed cover, whereas the direct drilling - system had the highest values. 2013 there were significant differences for weed cover in the green manures. Weed cover in the *V. sativa* plots was significantly the lowest, followed by the *S. alba* and *T. resupinatum* plots. The bare fallow plots had the highest weed cover. In the main crop oat weed cover was significantly lowest in the plough – system and highest in the direct drilling – system like in the previous year.

Regarding weed density the direct drilling- and the mulching + drilling - system had significantly less numerous but taller weeds than the chisel- and the plough – system in 2012. The plough system was showing the highest density. However, weeds were so tall in the direct drilling- and mulching + drilling - system that all plots beside “direct drilling x *V. sativa*” and “mulching + drilling x *V. sativa*” had to be given up. *V. sativa* was the only green manure species capable to suppress weeds to some extent under no-tillage. 2013 the mulching + drilling and direct drilling – system again had significantly less numerous but much taller weeds than the plough – system. In none of these plots the harvest of main crop oat could be carried out because they were overgrown by the weeds. This may be due to inferior green manure emergence, especially of *V. sativa*, compared to the previous year.

In 2012 the significantly highest weed biomass was found in the direct drilling - system (only *V. sativa* – treatment assessable). Ploughing had the lowest total weed biomass in all green manure treatments, while chiseling showed lower weed biomass under the *S. alba* and *V. sativa* green manure treatments. 2013 total weed biomass in the plough – system was low in all green manure treatments, while in the disc harrow – system it was lower in the *V. sativa*- and *S. alba* - treatments than in the *T. resupinatum*- and bare fallow – treatments.

V. sativa was the green manure treatment which gave the highest oat yield in both years. However, yields were acceptable in all plots (among 4 to 6 t/ha) except those that had to be neglected. 2012 Chisel x *V.*

sativa resulted in the significantly highest yields, plough x *S. alba* and chisel x *S. alba* in the lowest. 2013 there was a significant interaction for green manure x tillage. The treatment *V. sativa* x disc harrow was the only disc harrow treatment that gave no yield reduction when compared with the different plough treatments.

Discussion

The results show that in organic farming it is possible to achieve similar oat yields with reduced tillage like with conventional ploughing, if combined with a suitable green manure species, in this case *V. sativa*.

In this respect the positive findings of Wittwer *et al.* (2013) are confirmed, who had in a system with reduced tillage in the *V. sativa* – treatments yields similar to the plough – treatments.

In contrast to the reduced tillage systems the results of the treatments with "no-till" differed from 2012 to 2013. In the mulching and drilling and direct drilling systems, green manure species *V. sativa* showed a sufficient weed suppressing effect and resulted in proper yields 2012, but not 2013. This may be due to the inferior biomass production of the green manures in 2012/13 compared to 2011/12, especially of *V. sativa*.

Compared to the other green manure species in these two trials, *V. sativa* seems to be especially suitable to be combined with reduced tillage in organic farming.

The use of appropriate green manure species may lead to successful systems with reduced tillage in organic farming. The benefits especially for soil fertility, which reduced tillage may entail (Berner *et al.* 2008, Emmerling & Hampl 2002) let tillage without plough as often as possible appear worthwhile.

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