Do living mulch based vegetable cropping systems yield similarly to the sole ones?

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Key words: organic farming, cauliflower, intercropping, yield quality, competition

Abstract

Ecological services may be exploited by use of living mulches in intercropping systems for production of vegetable crops. But may high yields be attained in intercropping systems for production of resource demanding crops such as cauliflower? In the frame of the InterVeg (Core Organic II) project, four field experiments were carried out in IT, SLO, DE and DK in order to study the effect of the living mulch introduction in cauliflower based cropping systems on crop yield and yield quality. The preliminary results, obtained after the first year project, showed yield and produces quality equal to those obtained in the sole cropping system if the system is properly managed (i.e. LM is late sown or its growth is controlled by root pruning).

Introduction

In living mulch (LM) systems a yielding crop is intercropped with one (or more) cover crop(s), introduced with the main aim to provide ecological services to the agro-ecosystem (Willey, 1990; Masiunas, 1998). While cover crop management is optimized to provide ecological services at field/farm level (i.e. weed, pest and diseases management contribution, pest control, nutrients leaching reduction, biodiversity conservation, etc.), competition between the yielding and the cover crop(s) should be managed in order to avoid yield losses (Hartwig and Ammon, 2002). Moreover, especially in cropping systems for vegetable production, yield quality detriment is also an issue. The *InterVeg* research project is studying the introduction of LM in vegetable crops in European environments. This paper reports the preliminary results obtained for cauliflower in four field experiments carried out during the first project year in IT, DK, SLO and DE. Yield and some selected yield quality parameters measured in living mulch and sole systems were compared to verify the hypothesis that the introduction and the proper management of living mulch do not reduce cauliflower yield and yield quality.

Material and methods

Experiment 1- Italy: the Experiment 1 was carried out at the Vegetable Research Unit of the Consiglio per la Ricerca e la Sperimentazione in Agricoltura (CRA-ORA) in Monsampolo del Tronto (AP), (latitude 42° 53' N, longitude 13° 48' E), along the coastal area of the Marche Region, Central Italy. In a strip plot experimental design with two factors (i.e. LM sowing time and crop cultivar) and three replicates, cauliflower (*Brassica oleracea* L. var. *botrytis*) was grown within August 2011 and January 2012 with Burr medic (*Medicago polimorpha* L. var *anglona*) used as living mulch. In this paper the effect of the first factor (LM sowing time) is discussed. Three treatments were compared: (i) control (no LM), (ii) living mulch early sowing (at cauliflower transplanting – es LM) and (iii) living mulch late sowing (three weeks delayed after cauliflower transplanting – ls LM).
Experiment 2 – Slovenia: the Experiment 2 was carried out at the University Agricultural Centre of the University of Maribor located in Pivola near Hoče (latitude 46°28′N, longitude 15°38′E), in Slovenia. In a randomized block experimental design with two factors (i.e. LM sowing time and crop cultivar) and three replicates, cauliflower was grown within June and October 2012 with white clover (*Trifolium repens* L.) as living mulch. In this paper the effect of the first factor (LM sowing time) is discussed. Three treatments were compared: (i) control (no LM), (ii) living mulch early sowing (at cauliflower transplanting – es LM) and (iii) living mulch late sowing (three weeks delayed after cauliflower transplanting - ls LM).
Experiment 3 – Denmark: the Experiment 3 was carried out at the Research Centre Aarslev, located at mid Funen (latitude 55°18´N, longitude 10°27´E) in Denmark. In a randomized block experimental design with three factors (i.e. LM presence, crop cultivar and N fertilization dose) and three replicates, cauliflower was

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grown within 31 May until harvest during the period 3-20 August 2012, and alternated with LM permanent strips according to a substitutive design (su LM), entailing a reduction of 1/3 of crop density. LM strips were root pruned at cauliflower transplanting. LM consisted of a overwintering mix of grass and legumes (*Trifolium repens* L., *Medicago lupulina* L. *Lolium perenne* L.). In this paper the effect of the first factor (LM presence) is discussed. Two treatments were compared, namely: (i) control (no LM) and (ii) living mulch (su LM).

Experiment 4 – Germany: the Experiment 4 was carried out at the Hessian State Estate Frankenhausen, located in Grebenstein (latitude 51°4'N, longitude 9°4'E), in Germany. In a randomized block experimental design with two factors (i.e. LM introduction strategy and crop cultivar) and three replicates, Cauliflower was grown within June and September 2012 intercropped with white clover (*Trifolium repens* L.). In this paper the effect of the first factor (LM introduction strategy) is discussed. Three treatments were compared, namely: (i) control (no LM), and (ii) living mulch introduced according to the additive approach (ad LM) and (iii) living mulch introduced according to the substitute approach (so LM), entailing a reduction of 1/3 of cauliflower density.

In all countries the no LM treatment was managed and weeded in accordance to the standard agronomic practices, commonly used by organic farmers in the area. In all the experiments, at cauliflower harvest total yield, marketable yield and size (diameter and weight of the cauliflower heads) were measured in accordance to local market standards.

Results

In the tables 1 to 4 the average values of cauliflower total yield, marketable yield, head diameter and weight are reported for the four experiments.

In the experiment 1 (IT, Table 1), the es LM treatment showed a significant reduction of all parameters compared to the control (no LM). This was due to the competition between the crop and the Burr medic since the beginning of the cauliflower cropping cycle. Also the presence of weeds (results not shown), which were not mechanically controlled and not suppressed by the LM, contributed to the reduction of crop yield and quality. On the other hand, the ls LM performed similarly to the no LM with regard to the marketable yield and head diameter. These findings were probably due to the reduced period of direct competition between cauliflower and LM.

Table 1 – Experiment 1 (IT)

Treatment	Total yield (Mkg ha^{-1})		Marketable yield (Mkg ha^{-1})		Head diameter (m)		Head weight (kg)	
no LM	21.2	a	19.4	A	0.135	a	0.62	a
es LM	6.1	c	4.0	B	0.054	b	0.21	c
ls LM	17.2	b	17.2	A	0.136	a	0.55	b

Note: no LM = sole crop system (control); es LM = LM additive system, sowing at cauliflower transplanting; ls LM = LM additive system, sowing delayed after cauliflower transplanting. The mean values in each column followed by a different letter are significantly different according to Duncan Multiple Range Test at the P≤0.05 probability level.

In the experiment 2 (SLO, Table 2), the cauliflower plants in the es LM strongly suffered from the competition by the LM and the weeds (not mechanically controlled, results not showed) and could not be harvested. As in the Italian experiment, the ls LM treatment yielded similarly to the control (no LM). Also the quality parameters measured showed lower but not statistically different values compared to the control.

Table 2 – Experiment 2 (SLO)

Treatment	Total yield (Mkg ha^{-1})	Marketable yield (Mkg ha^{-1})	Head diameter (m)	Head weight (kg)
no LM	28.8	11.9	0.126	0.74
es LM	-	-	-	-
ls LM	24.4	10.4	0.107	0.55

Note: no LM = sole crop system (control); es LM = LM additive system, sowing at cauliflower transplanting; ls LM = LM additive system, sowing delayed after cauliflower transplanting. The mean values in each column followed by a different letter are significantly different according to Duncan Multiple Range Test at the P≤0.05 probability level.

No significant differences for all the measured quality and quantity production parameters were observed between the two tested treatments in the Danish trial (Table 3). This was done after correction of the total yield and marketable yield values to take into account the reduced crop plant density in the substitutive system. These findings demonstrated that the introduction of opportunely managed permanent LM strips could be a valuable and feasible option for vegetable cropping system design and management.

Table 3 – Experiment 3 (DK)

Treatment	Total yield (Mkg ha^{-1})	Marketable yield (Mkg ha^{-1})	Head diameter (m)	Head weight (kg)
no LM	18.9	16.9	0.110	0.52
su LM	18.9*	17.0*	0.120	0.51

Note: * = results corrected to take into account the crop density difference between the compared systems; no LM = sole crop system (control); su LM = LM substitutive system; the mean values in each column followed by a different letter are significantly different according to LSD at the P≤0.05 probability level.

Table 4 – Experiment 4 (DE)

Treatment	Total yield (Mkg ha^{-1})		Marketable yield (Mkg ha^{-1})		Head diameter (m)	Head weight (kg)	
no LM	31.2	b	27.4		0.180	1.05	b
ad LM	33.6	b	26.5		0.190	1.14	b
su LM	38.3*	a	22.6*		0.190	1.29	a

Note: * = results corrected to take into account the crop density difference between the compared systems; no LM = sole crop system (control); ad LM = LM additive system; su LM = LM substitutive system; the mean values in each column followed by a different letter are significantly different according to Duncan Multiple Range Test at the P≤0.05 probability level.

No significant differences were found between the control (sole crop, no LM) and the additive LM treatment in experiment 4 (DE) (table 4). The substitutive LM system showed higher values for the total yield (if corrected to take into account the density difference to the control) and the head weight. The advantage of the substitutive system was probably determined by the lower number of cauliflower plants per area and the consequent lower intra species competition, which was apparently not made up by the inter species competition between the crop and the LM.
The bars in Fig. 1A represent the marketable yield percentage difference between the treatment (crop + LM) and its own control (sole crop, no LM system), measured in each experiment. Similarly, Fig. 1B shows the same for the head weight parameter. As far as marketable yield is concerned, not significant differences were observed in five cases out of seven, being the two cases with significant differences the es LM treatment in the Italian and the Slovenian experiments. In the same two treatments, head weight was

significantly lower. Conversely, the parameter showed a higher significant value in one case (experiment 4, DE, substitutive approach).

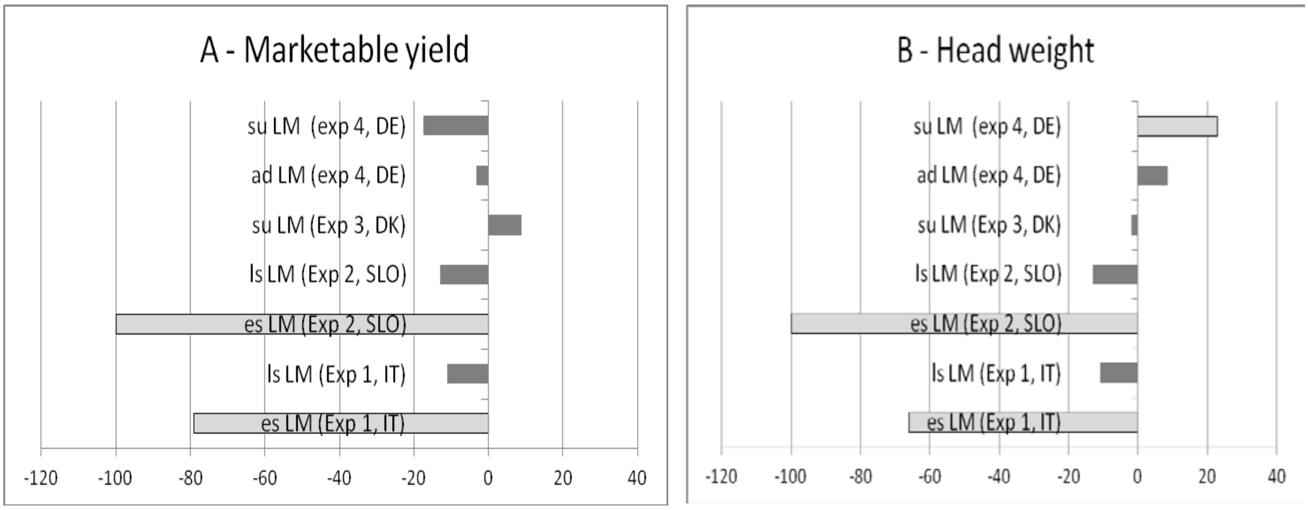

Figure 1. Marketable yield (A) and head weight (B) percentage difference between the treatment (crop + LM) and its own control (sole crop, no LM system). Note: light grey means significant differences between the treatment and its own control ($P \leq 0.05$); dark grey means no significant differences.

Conclusions

The results obtained indicated that the introduction of early sown LM (i.e. at crop transplanting) in cauliflower cropping systems reduces the yield and the yield quality. Conversely, if the LM was late sowed (i.e. 2 to 4 weeks after cauliflower transplanting, according to local conditions) no significant differences in yield and yield quality were observed. Moreover, our findings also indicated that the substitutive approach could be a valid agro-ecological approach if land area is not the main limiting factor in farming activities. The Danish experiment demonstrated that the introduction of opportunely managed permanent LM strips could be a feasible option for the design and management of vegetable intercropping systems. These results must be considered as preliminary, as they were obtained from a single year of field experiments.

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