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Environmental effectiveness of GAEC cross-compliance Standard 4.1 (b, c) 'Protection of permanent pasture land' and economic evaluation of the competitiveness gap for farmers

Mauro Salis,[1] Lucia Sepe,[2] Rosa Francaviglia,[3] Marco Fedrizzi,[4] Paolo Bazzoffi,[5] Salvatore Claps,[2] Maurizio Pitzalis,[1] Michele Lilliu,[1] Paola Ruda,[1] Emilio Sabia,[2] Annarita Bruno,[2] Domenico Rufrano,[2] Maria Teresa Dell'Abate,[3] Alberto Alianello,[3] Marco Veloccia,[3] Olimpia Masetti,[3] Gianluca Renzi,[3] Roberto Fanigliulo,[4] Mauro Pagano,[4] Giulio Sperandio,[4] Mirko Guerrieri,[4] Daniele Puri,[4] Antonio Melchiorre Carroni[1]

[1]CREA-AAM Council for Agricultural Research and Economics, Research Unit for Agro-pastoral Systems in Mediterranean Environment, Sanluri, Medio Campidano (VS)
[2]CREA-ZOE Council for Agricultural Research and Economics, Research Unit for Extensive Animal Husbandry, Bella (PZ)
[3]CREA-RPS Council for Agricultural Research and Economics, Research Centre for Soil-Plant System studies, Roma
[4]CREA-ING Council for Agricultural Research and Economics, Research Unit for Agricultural Engineering, Monterotondo (RM)
[5]CREA-ABP Council for Agricultural Research and Economics, Agrobiology and Pedology Research Centre, Firenze, Italy

Corresponding author: Mauro Salis
E-mail: msalis@uniss.it

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CREA-ABP: Paolo Bazzoffi, MO.NA.CO. Project coordinator
CREA-ING: Marco Fedrizzi, coordinator OU, organization and competitiveness gap surveys. Giulio Sperandio, Roberto Fanigliulo, Mauro Pagano, collaboration in organization and competitiveness gap surveys, data processing, report. Mirko Guerrieri, Daniele Puri collaboration in surveys, data processing, report.
CREA-RPS: Rosa Francaviglia, coordination OU, coordination of soil analyses, data processing, results, writing report. Maria Teresa Dell'Abate, results, report. Alberto Alianello, Marco Veloccia, Olimpia Masetti and Gianluca Renzi, chemical, biochemical and biological soil analyses.
CREA-ZOE: Salvatore Claps, coordination OU, competitiveness gap surveys, data processing, report. Lucia Sepe, organization, botanical and competitiveness gap surveys, data processing, report. Emilio Sabia, botanical surveys, soil samplings, data processing, report. Annarita Bruno, herbage analyses. Domenico Rufrano, herd management, competitiveness gap surveys.

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Abstract

The paper presents the main results of the monitoring on the effectiveness of the cross-compliance Standard 4.1 'Permanent pasture protection: lett. b, c' carried out in two case studies within the MO.NA.CO. Project. Soil, botanical, productive and economic (competitiveness gap) parameters have been monitored. In the short term, the Standard 4.1 showed its effectiveness on soil quality, biomass productivity and competitiveness gap in both case studies. Botanical parameters showed differing results, therefore their generalization is not applicable to the heterogeneity of the pasture land Italian system. Shallow soil tillage could be suggested, every 40-50 years, when an appropriate soil organic matter content and the absence of runoff phenomena occur.

Introduction

Most pasture lands in Europe represent habitat where plants and animal species are considered depending directly or indirectly on grazing use. Some pasture land vegetation types, linked to grazing use, can host some endemic rarities (Caballero *et al.*, 2009). The characteristics of a permanent herbage layer on pastures leads to a higher biodiversity and soil protection compared to other agricultural land uses. McNeely *et al.* (1995) observed that land use changes reduced the biodiversity of permanent pastures. Habitat degradation following the changes in land use is connected with a worsening of soil structure and biological quality, mainly due to tillage and loss of biodiversity (Van Eekeren *et al.*, 2008). By the end of the 19^{th} and the beginning of the 20^{th} century new developments in agricultural technology caused a marked decline in permanent pastures (Ellenberg, 1996), but Mac Sharry's reform in 1992 and then Agenda 2000 introduced a different policy, based on the maintenance of low input and more sustainable agriculture. Restoration of habitats after the conversion from intensive agricultural systems often does not recover completely the original habitat (Poschlod *et al.*, 2005). The Regulation (EC) 1782/03 introduced for the first time the concept of Cross-compliance, where direct payments are available for farmers only if they meet certain environmental requirements (Good Agricultural Environmental Conditions - GAEC) (Ruda *et al.*, 2011). To avoid the habitats deterioration, Standard 4.1 prescribes for all permanent pastures: a) the prohibition to reduce permanent pasture areas in accordance with Art. 4 Reg. (EC) 1122/09 and subsequent amendments; b) the prohibition to convert into arable crops those permanent pastures included in the list of the Sites of Community Importance, special areas of conservation and special protection areas, identified in accordance with Directives 92/43/EEC and 2009/147/EC, unless otherwise required by the competent authorities of management; c) the prohibition to till the soil, with the exception of agricultural practices related to the renewal and/or thickening of the sward, and to the management of drainage water. Permanent pasture conversion into arable crops is an important issue for the concomitant effects of environmental degradation, alteration of biogeochemical cycles and emissions of greenhouse gases. The scientific literature agrees on the negative effects on soil organic carbon which shows a decreasing trend in the change in the use of pastures, with losses related to the type and intensification level of the crop. On average, soil organic carbon (SOC) decreases by 25-30% as a result of the conversion to arable land; there is an exponential trend in the early years, while later the organic carbon stabilizes towards a new equilibrium condition. Celik (2005) reported a SOC loss of 49% after 12 years from the change in the use use of a permanent pasture to arable land in the Mediterranean Turkey. Guo and Gifford (2002) found that the greatest losses of organic carbon after the same conversion were found after 30-50 years, and with annual rainfall of 400-500 mm. Qiu *et al.* (2012) reported SOC losses of 57-61% after 27 years from the change in the use of a pasture to arable land in a semi-arid environment. The aim of this monitoring was to verify, in two case studies, the effectiveness of the Standard 4.1 of Cross-compliance.

Materials and methods

Two case-studies have been monitored in Italy, in two experimental farms afferent to the CREA, (Figure 1). A private farm in Siligo, in agreement with the Research Unit for Agro-pastoral Systems in Mediterranean Environment (CREA-AAM, in Sanluri), and the experimental farm of the Research Unit for Extensive Animal Husbandry in Bella (CREA-ZOE), corresponding to two Italian areas representative of sheep grazing system: the Southern Apennines and the Sardinian hill.

Sites description and monitoring design

Siligo (SS) – CREA-AAM

Canu's farm is located in Siligo (SS), North of Sardinia Region (40° 35' 15" N, 8° 43' 27" E), in a hilly area, 255 m asl. The farm is located in a typical pastoral area, with permanent pastures (grazed by Sarda sheep) and grass meadows. The farm lands have been used as permanent pasture for 20 years, and show a slight slope (about 3%). In autumn 2012 three natural permanent pasture areas were identified (length 80 metres, width 15 metres). The areas have been attributed the following conditions: i) Factual plot (F): natural pasture grazed by sheep; ii) Counterfactual plot 1 (CF1): yearly ploughed and harrowed; iii) Counterfactual plot 2 (CF2): land use change: ploughed and harrowed, and sowed for annual forage production (oat, with seed density 200 Kg/ha). No tillage was adopted in F plot. In autumn 2013, CF1 and CF2 plots were ploughed and harrowed, but no sowing was done in CF2 plot.

Bella (PZ) – CREA-ZOE

ZOE farm is located in Bella-Muro (PZ), Southern Apennines, (40°42' N, 15°32' E), in a hilly area, 350 m asl), with a slight slope (3%). The soil is of alluvial origin, has a clay-loam texture and a medium depth. The area has been used as natural pasture for 20 years (grazed by goats). In October 2011 three homogeneous areas have been identified (length 142 metres; width 35 metres; about 5,000 m^2). The following conditions have been attributed to the areas: i) Factual plot (F): natural pasture grazed by sheep with stocking rate 2.6 LU/ha; ii) Counterfactual plot 1 (CF1): one-time ploughed and harrowed; iii) Counterfactual plot 2 (CF2): land use change: ploughed and harrowed, sowed for annual forage production (oat-vetch with density 160 and 60 kg/ha, ratio 80/30). In late summer 2012 and 2013, in CF2 plot ploughing and harrowing were done while only in 2013 the oat-vetch mix was sown (160 and 60 kg/ha) (not in 2012 due to climate problems).

Monitored parameters

The following parameters have been considered for the monitoring:

Figure 1. Location of ZOE and AAM monitoring sites.

i) Soil organic matter and biological fertility; ii) Botanical bio-diversity; iii) Biomass production; iv) Herbage quality; v) Competitiveness gap.

Soil organic matter and biological fertility

Soil organic matter content (OM) is commonly determined indirectly multiplying the total soil organic carbon concentration (TOC) by the Van Bemmelen conversion coefficient (1.724) reported by Jackson (1965). Therefore, in this work the soil organic carbon was considered. Regarding the biological fertility (IBF), six key parameters have been considered (Benedetti *et al.,* 2006; Benedetti e Mocali, 2008; Francaviglia *et al.,* 2015): total soil organic matter (SO), microbial biomass carbon (Cmic) (Vance *et al.*, 1987), basal respiration (Cbas) and cumulated respiration (Ccum) (Isermayer, 1952), metabolic quotient (qCO_2), given by (Cbas/Cmic)/24*100 (Anderson and Domsch, 1990; 1993), mineralization quotient (qM), expressed as Ccum/TOC*100 (Dommergues, 1960).

<u>CREA-AAM.</u> Soil samplings were carried out at 0-30 cm of depth (three replicates in each plot), in 2012 before tillage, in 2013 and 2014 (end of monitoring).

<u>CREA-ZOE.</u> Soils have been sampled at the beginning of monitoring (November 2011 and March 2012), in October 2013 and at the end of the monitoring (January 2015) at two depths (0-20 and 20-40 cm) (three replicates in each plot).

Botanical biodiversity

The floristic surveys were performed by visual assessment of the crop coverage and the present families, divided into Grasses, Legumes, Others, palatable and unpalatable plants, degradation species (thorny, bushy species and trees), and bare soil (inverse of coverage index) (only in F and CF1 plots).

Biomass production

In both sites, the dry matter (DM) production per ha was evaluated by mowing 1 square meter of vegetation in 2-3 homogeneous areas, at the beginning and at the end of the grazing season, and determination of DM percentage.

Herbage quality

At ZOE farm, a replicated sub-sample of herbage was taken from F and CF1 plots, and used for the following qualitative determinations: Crude Protein (CP), Crude Fibre (CF) (Martillotti *et al.*, 1987) and its fractions Neutral Deterged Fibre (NDF), Acid Deterged Fibre (ADF), Acid Deterged Lignin (ADL) (Van Soest *et al.*, 1991), Ethereal extract (EE), Ash.

Competitiveness gap

To determine the competitiveness gap induced by the application of this standard, the direct and indirect costs paid by the farmer were taken into account. The cost of mechanical farming operations was calculated by using the data monitored by the two Operative Units during the farming operations. The data processing allowed the definition of working time for each process (Manfredi, 1971). The measurements were carried out in the farms on the effective work time (ET) and to the accessory turning time (ATV), which give together the net working time (NT). The calculation of unitary surface cost for each farming operation was carried out using the ASAE (2003) and Biondi (1999) methods. Concerning the remuneration of farm workers the average of the values fixed by Italian Agriculture Confederation (as regulated in the national collective agreement in force for the qualification of super specialized worker, level A, Area 1) was used. The farmer who does not apply for the grant, can consider necessary the ploughing of the pasture

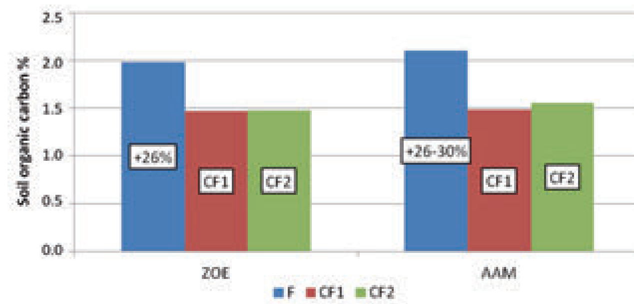

Figure 2. Soil organic carbon at the two monitoring sites.

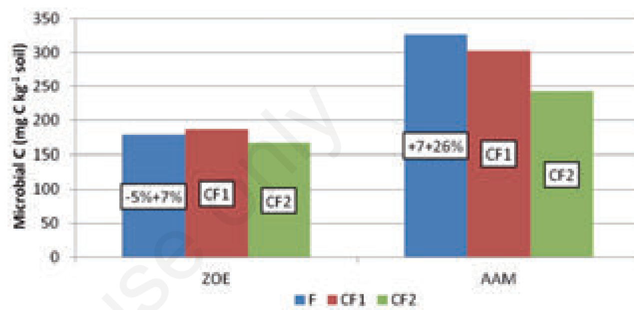

Figure 3. Soil microbial biomass carbon at the two monitoring sites.

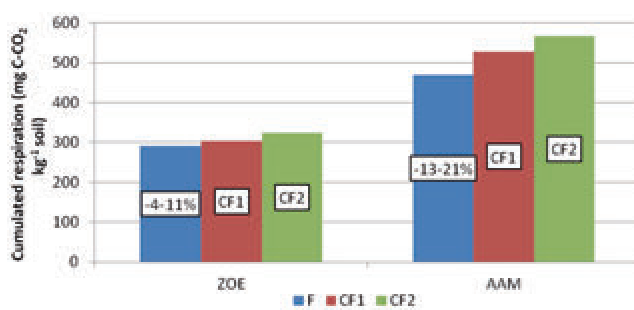

Figure 4. Cumulated soil respiration at the two monitoring sites.

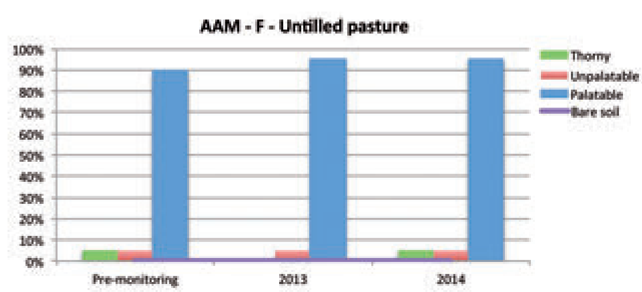

Figure 5. Variation of botanical composition during monitoring in F area in AAM farm.

(CF1) or a change in the use from pasture to grassland for hay production (CF2). In the first hypothesis, after ploughing, a significant reduction of biomass production occurs, and consequently the farmer needs to integrate the diet of the flock, choosing between two alternatives: purchase of hay (CF1a) or rent of grazing areas (CF1b). In the hypothesis of a change of land use (CF2), it is considered that the farmer carries out all the cultural operations necessary for the crop cycle of a vetch and oat mix.

Results

Soil organic matter and biological fertility

CREA-AAM. At the end of the monitoring period, soil organic carbon content was 2.11, 1.48 e 1.56% in the F, CF1 e CF2 plots respectively. The effectiveness in the untilled plot F in comparison with counterfactual plots CF1 and CF2, given by (F-CF)/F*100, was positive and equal to +26 and +30% respectively (Figure 2). Among the biological fertility parameters, the microbial biomass carbon (Cmic) showed as average the highest values in the untilled pasture. The effectiveness in the untilled plot F in comparison with CF1 and CF2 plots was +11 and +22% (Figure 3). The cumulated respiration (Figure 4) was always lower in F plot in comparison with CF1 and CF2 plots (-13 and -21%, respectively).

CREA-ZOE. At the end of the monitoring period, soil organic carbon content was 1.99, 1.47 and 1.48% in the F, CF1 e CF2 plots respectively. The effectiveness in the untilled plot F in comparison with counterfactual plots, given by (F-CF)/F*100, was positive and equal to +26 (Figure 2). Among the biological fertility parameters, the microbial biomass carbon (Cmic) showed slightly higher values in the untilled pasture only in comparison with CF2 plot. The effectiveness in the untilled plot F was -5 and +7% (Figure 3). The cumulated respiration (Figure 4) was lower in F plot in comparison with CF1 and CF2 plots (-4 and -11%, respectively).

Overall the Standard has proved effective in maintaining soil organic matter. In fact at the end of the monitoring, the differences between F plot and CF1 and CF2 plots were positive in both sites (+26 and +30%). Among the biological fertility parameters, the microbial biomass carbon has proved more sensitive to land use changes.

Botanical biodiversity

CREA-AAM. The spring monitoring of pasture botanical composition was carried out in F and CF1 plots. Along the years, flora composition did not show significant variations in untilled plot F (Figure 5). The Palatable species always ranged between 90 and 95% (about 60% Grasses and 20-30% Legumes). Unpalatable and Thorny species never exceeded 5% each, and the sward coverage was quite total. During the pre-monitoring period (Figure 6) the botanical composition and the coverage in CF1 plot was similar to F plot. In the spring after the first ploughing and harrowing, the percentage of Palatable species in CF1 plot was much lower (60%), with a decrease in Legume from 30 to 10%. Unpalatable species increased from 5 to 30%, and the sward coverage decreased from 100% to 60%, probably due to the incorporation (by ploughing) of the seeds of annual species produced in the previous. In the second year (2014) bare soil decreased: probably a percentage of the hard seeds not germinated and incorporated the previous year, were brought to the surface with ploughing and found the proper conditions to germinate.

CREA-ZOE. As in AAM, the spring monitoring of botanical composition of pasture occurred only in the F and CF1 plots. Over the years, flora composition did not show significant variations in the untilled plot F (Figure 7). The Palatable species always ranged between 70 and

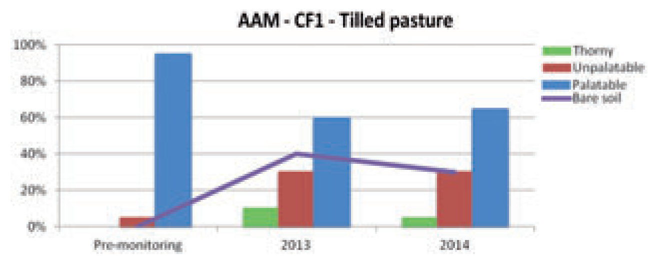

Figure 6. Variation of botanical composition during monitoring in CF1 area in AAM farm.

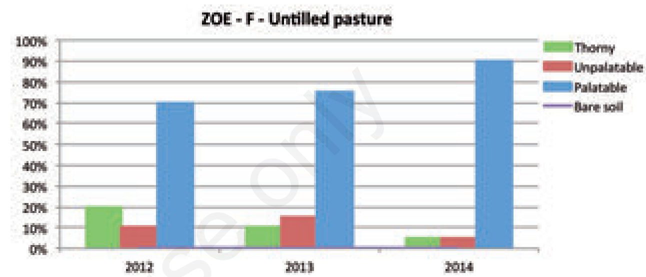

Figure 7. Variation of botanical composition during monitoring in F area in ZOE farm.

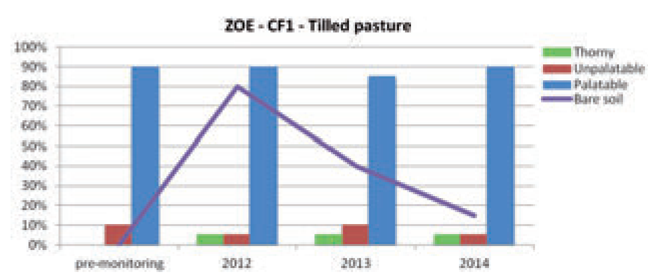

Figure 8. Variation of botanical composition during monitoring in CF1 area in ZOE farm.

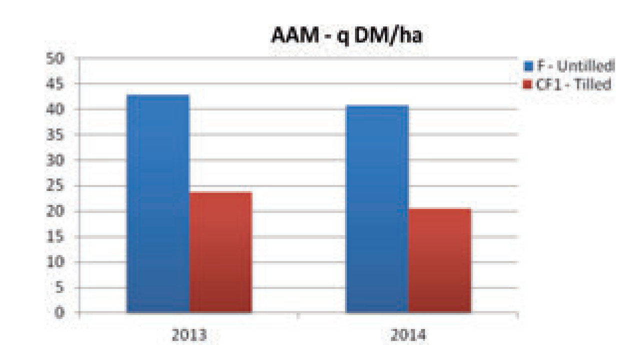

Figure 9. Herbage yield (q DM/ha) in AAM farm.

90% (about 60% Grasses and 20-30% Legumes) and Unpalatable species never exceeded 15%. The sward coverage was always 100%. In autumn 2011 (pre-monitoring), the flora composition in CF1 plot was slightly different from F plot, evidencing the high variability of natural pastures, even at such a small scale. In CF1 plot (Figure 8) bare soil was 15%, Grasses/Legumes/Other species had a ratio 30:30:40, and no Thorny species were present. In the spring after the first ploughing and harrowing, the percentage of Palatable species in CF1 plot was much lower (50%), with a decrease of Legumes from 30% to <1%. The Unpalatable coverage increased from 5% to 50%. In spring 2012 bare soil was about 80% (due to the incorporation by ploughing of the seeds of annual species produced the previous year, and the disruption of cespitose plants of perennial grasses), decreased to 50% in November 2012, and remained at 15% in 2014. The stagnation species had more chance to develop due to the decrease in competition of grasses and legumes. In the following two years the coverage of Unpalatable and stagnation species decreased, Palatable species increased, and bare soil percentage decreased to 5%, but without recovering the same botanical composition before the tillage. In 2012 the sward coverage in CF2 plot was 100%. In the second year, adverse weather conditions did not allow the sowing, and spontaneous flora developed. As a consequence, in 2014 hay production was low (absence of oat, and weeds as about 80%).

The Standard 4.1 showed contrasting effectiveness in the two sites. In Sardinia, tillage produced significant variations in ratios among the species; in Southern Apennines the ratios among Palatable, Unpalatable and Thorny species did not change during the monitoring.

Biomass production

CREA-AAM. Dry matter production of biomass (Figure 9) was constant over the two years in each plot (F and CF1); while in the untilled plot production resulted higher than 40 q/ha, in the tilled plot the production was always between 20:25 q/ha.

CREA-ZOE. Dry matter production of biomass (Figure 10) has been constant over the two years in the untilled pasture F (about 35 q/ha). In the tilled plot CF1, production was 8 q/ha in the first year after ploughing, and 15 q/ha in the 2013. In 2014, dry matter production reached 42 q/ha in the F plot, while in CF1 it reached about 36 q/ha.

The Standard has proved effective at both sites since tillage caused a clear reduction in the production of dry matter in both cases.

Herbage quality analyses

Results from ZOE farm (Figure 11) showed an irregular trend in crude protein content in the three years of monitoring. As average values were higher in the tilled plot, characterized by a better nutritional profile due to the development of a new pasture micro-ecosystem. In the factual plot F, the crude fibre content appeared closely linked to the climatic trend. In the counterfactual plot CF1, the crude fibre content did not show significant variations in the first two years; furthermore the lowest average content of crude fibre and lignin is justifiable with the progressive setting up of young plants. These observations could not be exhaustive, due to the short monitoring period that is not adequate to consider an area as stable under natural permanent pasture (at least 5 years).

Competitiveness gap

Regarding CF1a hypothesis, for the mechanized farming operations, the farmer must pay a total cost of € 2998.44 ha^{-1}. It has been hypothesized that the ploughing of the pasture land could be repeated after 20, 30, 40 or 50 years: in relation to the length of interval, the average annual cost decreases from € 220.63 to € 139.58 ha^{-1} $year^{-1}$. With reference to the CF1b hypothesis, in order to provide feed to the flock during spring-

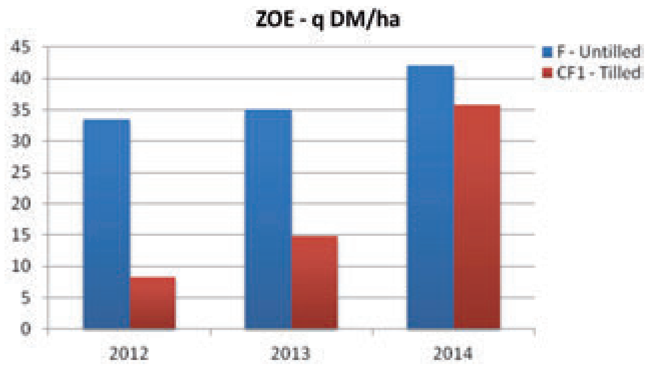

Figure 10. Herbage yield in ZOE farm.

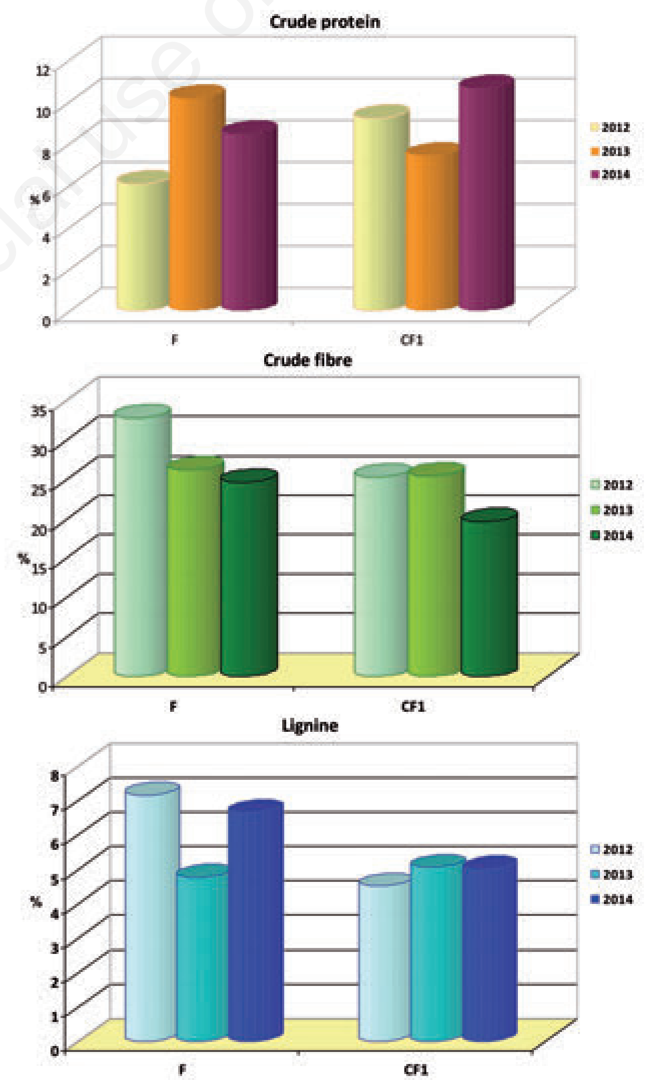

Figure 11. Crude protein, crude fibre and lignin (Acid Deterged Lignin) content in herbage (F and CF1 areas) during monitoring study in ZOE farm.

summer of the first four years, the breeder would have to increase the grazing area through renting contracts. A calculation was simulated considering renting of grazing areas, to meet the feed requirements of each year, bearing in mind the progressive increase in production of natural pasture. As annual rent, the amount of € 60 ha^{-1} was considered. Also in this case the costs have been referred to intervals of 20, 30, 40 or 50 years; the average annual cost paid by the farmer varies from € 26.62 to € 16.84 ha^{-1} $year^{-1}$. As for the hypothesis CF2, all farming operations for the production of vetch-oats hay were monitored, with the exception of fertilization, considered unnecessary. The input costs consisted in the purchase of the vetch (€ 22.00 ha^{-1}) and oats seed (€ 30.69 ha^{-1}). According to the sale of hay produced, there was no monetary value available in the official local market to refer to, and was estimated as average price of € 85.00 t^{-1}, while the production of hay amounted to 2.04 t ha^{-1}. Due to the low productivity of pasture converted to annual grassland, the considered change of soil use is highly economically disadvantageous. In fact, from the monitoring data, the gross operating margin amounted to –411.49 € ha^{-1} $year^{-1}$ and ranged from –552.26 € to –270.72 € ha^{-1} $year^{-1}$. Under these conditions, the economic competitiveness gap calculated as difference between the gross operating margin in compliance (F) and not in compliance (CF1 and CF2) with the standard, would be even more disadvantageous for this last hypothesis. Finally, the compliance with the standard always led to an indirect economic advantage for the hypothetic farmer because, in doing so, he would avoid the economic loss resulting from a negative gross operative margin.

Conclusions

Standard 4.1 showed a high effectiveness in maintaining soil organic carbon content: in both monitoring sites, the soil organic carbon values in the untilled pasture resulted always higher in comparison with the counterfactual plots. Concerning the biological fertility parameters, the factual plot showed a higher effectiveness, only for microbial biomass carbon. These parameters need further scientific investigation in a longer period. The short term monitoring showed the Standard effectiveness also for the productive and economic parameters. To renew permanent pastures, in case of pasture exhaustion but in the absence of run-off and with a proper soil organic matter content, a shallow tillage could be suggested once every 40-50 years: in this way the probability to restore the sward in 4-5 years, avoiding a significant habitat deterioration, is high. Contrasting results have been obtained in the two sites regarding the flora biodiversity, therefore their generalization is not applicable to the heterogeneity of the Italian pasture land systems. Further studies are required to evaluate the effectiveness of the Standard 4.1 in the long period and in other different pasture land systems.

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