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Environmental effectiveness of GAEC cross-compliance Standard 2.2 'Maintaining the level of soil organic matter through crop rotation' and economic evaluation of the competitiveness gap for farmers

Lamberto Borrelli,[1] Roberta Farina,[2] Antonio Melchiorre Carroni,[3] Paola Ruda,[3] Mauro Salis,[3] Paolo Bazzoffi,[4] Silvia Carnevale,[4] Andrea Rocchini,[4] Nino Virzì,[5] Francesco Intrigliolo,[5] Massimo Palumbo,[5] Michele Cambrea,[5] Alfio Platania,[5] Fabiola Sciacca,[5] Stefania Licciardello,[5] Antonio Troccoli,[6] Mario Russo,[6] Marisanna Speroni,[1] Giovanni Cabassi,[1] Luigi Degano,[1] Roberto Fuccella,[1] Rosa Francaviglia,[2] Ulderico Neri,[2] Margherita Falcucci,[2] Giampiero Simonetti,[2] Olimpia Masetti,[2] Gianluca Renzi,[2] Domenico Ventrella,[7] Vittorio Alessandro Vonella,[7] Luisa Giglio,[7] Francesco Fornaro,[7] Rita Leogrande,[7] Carolina Vitti,[7] Marcello Mastrangelo,[7] Francesco Montemurro,[8] Angelo Fiore,[8] Mariangela Diacono,[8] Lorenzo Furlan,[9] Francesca Chiarini,[9] Francesco Fracasso,[9] Erica Sartori,[9] Antonio Barbieri,[9] Francesco Fagotto,[9] Marco Fedrizzi,[10] Giulio Sperandio,[10] Mauro Pagano,[10] Roberto Fanigliulo,[10] Mirko Guerrieri,[10] Daniele Puri,[10] Michele Colauzzi[11]

[1]CREA-FLC, Council for Agricultural Research and Economics, Research Centre for Fodder Crop and Dairy Productions, Lodi; [2]CREA-RPS, Council for Agricultural Research and Economics, Research Centre for the Soil-Plant System, Roma; [3]CREA-AAM, Council for Agricultural Research and Economics, Research Unit for Agro-pastoral Systems in Mediterranean Environment, Sanluri (VS); [4]CREA-ABP, Council for Agricultural Research and Economics, Research Centre for Agro-biology and Pedology, Firenze; [5]CREA-ACM, Council for Agricultural Research and Economics, Research Center for the Citrus crops and the Mediterranean, Acireale (CT); [6]CREA-CER, Council for Agricultural Research and Economics, Research Centre for Cereal Crops, Foggia; [7]CREA-SCA, Council for Agricultural Research and Economics, Research Unit for Cropping Systems in Dry Environments, Bari; [8]CREA-SSC, Council for Agricultural Research and Economics, Research Unit for the Study of Cropping Systems, Metaponto (MT); [9]Veneto Agricoltura, Regional Agency for the agricultural, forestry and agri-food sector, Legnaro (PD); [10]CREA-ING, Council for Agricultural Research and Economics, Research Unit for Agricultural Engineering, Monterotondo (RM); [11]Freelancer, Italy

Corresponding author: Lamberto Borrelli
E-mail: lamberto.borrelli@crea.gov.it

Data processing and text writing: Lamberto Borrelli and Roberta Farina.

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Abstract

Within the Project MO.NA.CO was evaluated the Environmental effectiveness of GAEC cross-compliance standard 2.2 'Maintaining the level of soil organic matter through crop rotation' and economic evaluation of the competitiveness gap for farmers who support or not the cross-compliance regime. The monitoring was performed in nine experimental farms of the Council for Agricultural Research and Economics (CREA) distributed throughout Italy and with different soil and climatic conditions. Were also evaluated the soil organic matter and some yield parameters, in a cereal monocropping (treatment counterfactual) and a two-year rotation cereal-legume or forage (treatment factual). The two-years application of the standard 'crop rotations' has produced contrasting results with regards to the storage of soil organic matter through crop rotation and these were not sufficient to demonstrate a statistically significant effect of treatment in any of the farms considered in monitoring, only in those farms subjected to more years of monitoring was recorded only a slight effect of the standard as a trend. The variations of organic matter in soils in response to changes in the culture technique or in the management of the soil may have long lag times and two years of time are not sufficient to demonstrate the dynamics of SOM associated with the treatment, also in consideration of the large inter annual variability recorded in different monitored sites.

Introduction

Soil organic matter (SOM) is the sum of the organic components that are found in soil and on its surface, with the exclusion of the living plant biomass. Its quantity in the soil is closely related to the nutrient cycles and, in particular, to that of the carbon, its most abundant component. The soil organic C (SOC), with its 2344 billion tons of organic C (Stockmann *et al.*, 2013), represents the largest terrestrial reserve of carbon (C), thus small changes in soil C stock could result in large emissions of CO_2 to the atmosphere (Luo *et al.*, 2010).

The SOM plays a series of biological structural and chemical-physical functions into the soil, influencing in a decisive way the availability and the movement of the mineral elements and of exogenous compounds that reach the ground. The SOM favours the formation and preservation of soil structure, the creation of stable complexes with clays, increases the water holding capacity in sandy soils, prevents the formation of impermeable layers and crusting in loamy soils, reduces compaction and risk of soil erosion, contributes positively to the cation exchange capacity of the soil; and represents the nutrient source for the microorganisms of the soil, increasing activity and promoting biodiversity, and, as a result of mineralization, releases nutrients into the soil. The organic matter is also responsible for the process of absorption and/or inactivation of anthropogenic substances (heavy metals, herbicides, etc.), preventing also from soil leaching.

The limits of organic C content to avoid the negative effects on soil quality, depends on the soil texture as can be seen from Table 1. The more is the clay content, the more organic matter is required to permit

Table 1. Soil and climate characteristics of the monitoring farms and crop rotation implemented.

Farm	Site	Climate	Soil type	Soil texture (%)	pH	Crop rotation F	Crop rotation CF
AAM	Sanluri Lat 39.52116° Lon 8.859392°	R=450mm T=18°C	Typic Fluvaquents	Sa=43 Si=26 Cl=31	8	I Berseem clover II Wheat	I Wheat II Wheat
ABP	Fagna Lat 43.98321° Lon 11.3441°	R =1024mm T=13.4°C	Typic Udorthent	Sa=24 Si=60 Cl=16	7.8	I Fieldbean II Corn	I Corn II Corn
ACM	Acireale Lat 37.54172° Lon 14.58462°	R =450 mm T=17.0 °C	Vertisol	Sa= 14.3 Si= 38.3 Cl=47.5	8.5	I Berseem clover II Wheat	I Wheat II Wheat
CER	Foggia Lat 41.46337° Lon 15.49671°	R =526 T=15.8°C	Chromic Calcixerert	Sa=19.5 Si=31.1 Cl=49.4	8.3	I Fieldbean II Wheat	I Wheat II Wheat
FLC_1	Lodi Lat 45.30304° Lon 9.514188°	R =800 mm T=12.5°C	Typic Haplustalf	Sa=67 Si=20.7 Cl=12	6.2	I Forage II Corn	I Corn II Corn
FLC_2	Lodi Lat 45.23105° Lon 9.423971°	R =800 mm T=12.5°C	Typic Haplustalf	Sa=68 Si=18 Cl=14	5.6	I Soybean II Corn	I Corn II Corn
RPS	Monterotondo Lat 42.09786° Lon 12.63737°	R =800 mm T=15.2°C	Entic Lithic Haploxeroll	Sa=33 Si=45 Cl=21	6.9	I Fieldbean II Wheat	I Wheat II Wheat
SCA	Foggia Lat 41.4496° Lon 15.50266°	R =526 T=15.8°	Chromic Haploxerert	Sa=19.5 Si=31.1 Cl=49.4	8.3	I Chickpea II Wheat	I Wheat II Wheat
SSC	Metaponto Lat 40.38296° Lon 16.80883°	R =500 mm T=16°C	Typic Epiaquerts	Sa=19 Si=39 Cl=42	7.8	I Fieldbean II Wheat	I Wheat II Wheat
VEAGR	Caorle Lat 45.64036° Lon 12.95414°	R =970 mm T=13.7°C	Calcari-Gleyc Fluvisols	Sa=18.1 Si=51.4 Cl=30.5	7.8	I Soybean II Corn	I Corn II Corn

normal soil functions to be performed (Sequi and De Nobili, 2000).

All above considered soil organic matter represents the most important factor for agricultural soil fertility. In Europe, the information concerning soil organic C content, is still lacking, except for some database integrated with climate, topography and land use (European Commission, 2006). A thorough understanding and accurate assessment of SOM (or organic carbon) level is quite difficult because it is strongly influenced by climatic conditions, the management practices of the soil and by human activities. For these reasons, the SOM monitoring should be performed at least every ten years.

The content of SOM is the result of a budget whose active voices are represented by inputs of organic substance, mainly of vegetable origin or source of exogenous organic fertilization, while the outputs are represented by all the losses that may occur, from the oxidative activity of microorganisms (CO_2 or DOC = dissolved organic C) or, in submerged soils, for reducing the activity that leads to the formation of methane. Both members of this budget are greatly influenced by cropping systems and soil and crop management.

Among the crops that have a beneficial effect on soil C, special attention is given to forage, and pastures, for their effects on the structure, chemical-physical and biological properties of the soil (Haussmann, 1986). The literature on this subject is very wide. The long term experiment of Rothamsted in England has clearly shown particularly high growth rates of SOM induced by permanent grassland in the first 20-30 years, then they decreased slowly in subsequent years until they reached the equilibrium in a period of 150-200 years (Russell, 1982). The same experiences indicate a strong reduction in soil organic C (-45%) when the soil management contemplates the transition from an old pasture to continuous arable crops. These results indicate that changes in the content of SOM occur in a relatively long term. In fact, the rotation of including three years of alfalfa, followed by arable crops does not make significant changes to the content of SOM, either if it follows an arable crop or a pasture. However the meadows in the short term has a positive effect on aggregate stability (Toderi, 1991). In a study of management of set-aside land, Borrelli and Tomasoni (2007) found, in three years from the start of the trial, an 8% reduction in SOM in the case of a non-food crop (sunflower) and no decrease with the use of a cover-crop.

With regard to Standard 2.2 (crop rotation), the scientific debate on the effectiveness of the only effect of rotation on the level of organic matter is discordant and is still ongoing. West and Post (2002) by analyzing the global data obtained in 67 experiments found that the increase in the complexity of the rotation led to a small accumulation of C (15 ± 11 g C m-2 yr^{-1}). Rotations with alfalfa (*Medicago sativa* L.), vetch (*Vicia sativa* L.) (Masri and Ryan, 2006), wheat, sunflower (Lopez-Bellido *et al*., 2010) adopted under the conditions of the Mediterranean climate have produced significant increases in soil organic matter in comparison with wheat in monoculture and wheat-fallow rotation. Aref and Wander (1998) have determined, at the Morrow Plots trial of the Illinois University, in 90 years, a cumulative loss of C equal to 26.5% in a monoculture of grain maize, to 18.9% in a two-year rotation maize - oats and 14.1% in a three-year rotation of corn - oats - clover. In Veneto region (sub-humid climate), only the meadows and complex rotations were able to maintain the level of SOM compared to monoculture (Morari *et al*., 2006). In Apulia region wheat-forage crops rotations recover the content of organic carbon and total nitrogen in topsoil and increase the performance of seed production and quality of kernel (Martiniello, 2011).

The changes in the way we conduct agricultural activity occurred in recent decades, resulting from genetic progress, chemical, mechanical and technological innovations, have produced, particularly in the areas most suiTable for agriculture in terms of soil and climate, high intensification of agriculture that has led to a considerable increase in productivity. As a side effect, there has been the abandonment of long crop rotation in favor of simpler and intensive systems, a choice that could have a negative impact in the medium and long term soil productivity and fertility, as well as entail the risk of water pollution due to the higher fertilization levels (mineral and manure). In fact, since the eighties, EU support to the crops (cereals and protein crops such as soybeans) has conducted many farmers to abandon their livestock to devote themselves solely to the cultivation of arable crops, emphasizing the phenomenon of the extremely simplified cropping systems, factors that had always guaranteed the maintenance of soil fertility and soil organic matter content. Therefore, the result of this crisis was on the one hand the excessive concentration of animals on some farms and on the other hand the increase in agricultural enterprises, without breeding, dedicated to the monoculture of cereals and forced to make substantial use of chemical fertilizers to counteract the reduction in C inputs to soil. It follows that also the agronomic fertility, the content of organic matter, and the quality of the soils from the standpoint of physical, chemical, biological, plant health and ecological aspects were affected.

The project MO.NA.CO. has established a network of experimental farms on a national scale with the specific task of monitoring the effects and effectiveness of the Standards of cross compliance to the environmental problem for which each standard was conceived (see REGULATION (EC) No. 73/2009 Annex III) and meeting the specification of the Italian Ministry of Agriculture in order to *monitor and evaluate* the effects of the environment protection actions transferred by the CAP to the National Agricultural Policy.

In this case the main objective was to assess the degree of effectiveness of objective 2 Standard 2.2 concerning the measures for the maintenance of organic matter through crop rotation.

Materials and methods

Monitoring plan

In order to evaluate the effectiveness of rotations for the maintenance of organic matter in Italian soils, in 2011 a project was started for monitoring at field scale, including several CREA- (Council for Agricultural Research and Economics) center and research units as well as other research organizations, characterized by different climatic conditions and distributed in the entire Italian territory including the islands.

The monitoring of the Standard 2.2 was carried out in nine experimental farms (Figure 1):

1. Monitoring farm CREA-AAM (AAM), Research Unit for Agro-pastoral Systems in Mediterranean Environment, Podere 'Ortigara', Sanluri Stato (VS);
2. Monitoring farm CREA-ABP (ABP), Research Center for Agro-biology and Pedology, Fagna, Scarperia (FI);
3. Monitoring farm CREA-ACM (ACM), Research Center for the Citrus crops and the Mediterranean, Acireale (CT)
4. Monitoring farm CREA-CER (CER), Research Center for Cereal Crops, Località Manfredini (FG);
5. Monitoring farms CREA-FLC, Research Center for Fodder Crop and Dairy Productions, Lodi (FLC_1), and S. Angelo Lodigiano (LO) (FLC_2);
6. Monitoring farm CREA-RPS (RPS), Research Center for the Soil-Plant System, Tormancina (RM);
7. Monitoring farm CREA-SCA (SCA), Research Unit for Cropping Systems in Dry Environments, Podere 124, Foggia;
8. Monitoring farm CREA-SSC (SSC), Research Unit for the Study of Cropping Systems, Campo7, Metaponto (MT);
9. Monitoring farm Vallevecchia" Veneto Agricoltura, Caorle (VE).

In each experimental farm two fields, with adequate and homogeneous dimensions, for pedological and principal soil characteristics, cropping history (land use), were set up:

A - factual (F): where the standard was applied (two years rotation cereal-leguminous)

B - counterfactual (CF) without application of the standard (i.e., monocropping of cereals).

In order to be able to compare the results also in different environments, we have identified the following minimum common factors:

i) Crops: use of winter cereals in southern and central Italy farms, and spring and summer cereals for the northern areas, in rotation with a legume forage for factual treatment opposed to monocropping for treatment counterfactual.

ii) Soil management: tillage and all cultural practices (fertilization, weeding, pesticide treatments, irrigation, *etc*.) were those conventional and ordinary applied in the monitoring area.

At the start of monitoring period the initial conditions of soils in each farm and each field were assessed.

Sampling and determinations

In each plot three soil samples to a depth of 30-40 cm (depending on depth of tillage operation) were collected and sent to laboratory analysis for the determination of the nitrogen and Total Organic Carbon (TOC) content, microbial carbon (Cmic), basal respiration (CBAs), cumulative respiration (Ccum), metabolic quotient (qCO_2), mineralization quotient (qM) and index of biological fertility (IBF). For the analytical methods description and the meaning of the parameters refer to the publication 'Metodologie per la determinazione dei parametri chimici, biochimici e microbiologici del suolo' (Francaviglia *et al*., 2015). The index of biological fertility was calculated. Samplings were carried out at the beginning of the monitoring and at the end of each crop cycle or after harvesting.

In order to evaluate the effect of rotation on productivity performance, we measured, in three sampling areas of about 10 m^2, the emergence of the plants, the number of weeds and the yield. To assess the quality of yield we assessed the weight of 1000 seeds, the test weight, harvest index and the protein content.

Monitoring sites

In Figure 1 are reported the locations of the sampling areas. Table 1 shows the characteristics of climatic and soil medium businesses, and rotations implemented.

Data analysis

Statistical analyses were performed with the software StatSoft ver. 7.0. The comparison of the data was made by using the methodology ANOVA with three factors: site, treatment and year. For each selected indicator, the judgment of effectiveness of the standard is expressed with the following classification (classes of merit): A= high efficacy/effectiveness; B = inconsistent; C = not effective. The letter A is given when the factual is always improved with respect to the factual against a number of sites between 100% and >50%, while if the factual improves the soil in a number of farms between 50% and 0% or is always pejorative is attributed respectively the letter B and C.

Monitoring results

The indicator for the standard 2.2 is represented by the organic matter content, calculated by the soil C content which is determined by chemical analysis.

Figure 2 shows the values of organic carbon (OC) referring to the first and second year of monitoring, that shows the great heterogeneity of the values of OC. The soils of AAM, FLC and SSC, have OC content rather low, particularly in relation to the predominantly nature silt and silty-clayed of soils. In the other sites the OC content can be considered acceptable, according to the classification given in Table 2. During monitoring the values of C varied from one year to another; Table 3 shows the values of % change compared to the first year of OC.

Figure 1. Location of monitoring farms of MO.NA.CO. project.

Table 2. Evaluation of the equipment of organic matter on the basis of the USDA textural classes. Adapted from Sequi and De Nobili, 2000.

	Soil textural classes USDA		
Equipment	Sand Loamy-sand Sandy-loam	Loam Sandy-clay-loam Silt-loam Sandy-clay Silt	Clay Clay-loam Silty-clay Silty-clay-loam
	Organic carbon (g/kg)		
Low	Less than 7	Less than 8	Less than 10
Normal	7 to 9	8 to 12	10 to 15
Good	9 to 12	12 to 17	15 to 22
Very good	More than 12	More than 17	More than 22

USDA, United States Department of Agriculture.

Taking the average of the two treatments, the content of organic C decreased from the first to the second year in 6 out of 10 sites, AAM, ABP, CER, RPS, SCA, FLC_1 and VEAGR ($P<0.05$), the site SSC remained almost constant and websites ACM and FLC_2, in which the content of C grew considerably in the second year (an average of 21 and 33% compared to baseline). Regarding the latter two sites the statistical analysis showed no significant differences, probably because of the large variability in the data. However, variations of OC are not attributable to the application of the Standard 2.2, not significant in most cases, rather to the variability of climate very different over the years of experimentation. In the AAM website, where experimentation has been performing for three years, treatment F has a higher content of C compared with CF ($P<0.001$). However, in the three years of experimentation there has been a continuous decrease in C, up to 11% for the third year ($P<0.05$) compared to the initial level. In detail, in the soils of the sites CER and SCA (with very similar climatic characteristics) the reduction in organic C was significant ($P<0.05$) with an average of 26 and 7%, respectively. Also in these situations the change is due only to the effect of the year, while there is no effect due to the rotation. The soil of RPS showed average reductions of 28% ($P<0.05$). In general, the two contrasting treatments have very similar values of C, equal to 10.92 and 10.75 g/kg soil for CF and F respectively.

In order to be able to evaluate the effect of rotation, net of initial differences of the two experimental plots F and CF and seasonal effect, the following formula was applied:

$$\text{Delta C (F-CF)} = [((C_{fin}F - C_{iniz}F)/C_{iniz}F)-((C_{fin}CF - C_{iniz}CF)/C_{ini}CF)]*100$$

The results are shown in Figure 3.

As can be seen the greater percentage change in negative is found for VEAGR, where the treatment factual shows a capacity to retain OC which is approximately 21% lower compared to the CF. Similarly for FLC_1 and CREA- RPS factual treatment is less efficient against factual in reducing losses of OC. ACM is the site where the efficiency of the treatment factual in OC sequestration is greater, treatment F is more powerful, although only 4.6% compared to the CF treatment.

In order to investigate in more detail the dynamics of OC, C microbial (Cmic) basal respiration Cbas), cumulative respiration (Ccum), metabolic quotient (qCO_2), quotient of mineralization (qM), and Index of Biological Fertility (IBF) in soils were determined. Values are given in Table 4.

As for soil organic C level, all biological parameters of the soil show a great variability linked to the sites rather than treatments.

Only for AAM and RPS farms, for which both initial and final data were available, we summarized the changes of microbial biomass (Figure 4), and variations in the basal respiration (Cbas), respiration cumulative (Ccum) and the qCO_2 (Figure 5).

For both sites, the percentage change of microbial C was significantly affected by treatment at AAM registering an increase of 7% in the treatment CF and 34% in the treatment F, whereas in the case of RPS CF treatment led to a decrease in the parameter by about 14% compared with an increase of approximately 45% in the treatment F.

Figure 5 shows how the effect of treatment rotations is different in amplitude depending on the parameter considered and the site. At the AAM site treatment F resulted in a decrease in both Ccum and qCO_2 and a slight increase in Cbas. Similarly to the AAM site, F at RPS site the parameters Cbas and Ccum have had the same trend while qCO2 showed a negative trend. At both sites, the analyzed parameters increased at the end of the treatment and to a greater extent at the RPS site, with the exception of the parameter Ccum at RPS.

Finally, the relative changes of the Index of Biological Fertility (IBF), shown in Figure 6, were always positive, with the exception of treatment in CF at RPS site. The biological fertility has increased in both

Table 3. Percentage change of organic carbon in the monitoring farm.

Farm	P value	CF	F	Average
AAM	*	-0.11	-0.11	-0.11
ABP	*	-0.18	-0.10	-0.14
ACM	*	-0.02	0.46	0.21
CER	*	-0.25	-0.27	-0.26
FLC_1	*	0.31	0.35	0.33
FLC_2	*	0.23	0.10	0.16
RPS	*	-0.16	-0.06	-0.28
SCA	*	-0.10	-0.05	-0.07
SSC	ns	0.02	0.02	0.02
VEAGR	*	-0.19	-0.40	-0.30

CF, counterfactual; F, factual; *significant at P=0.05; ns, not significant.

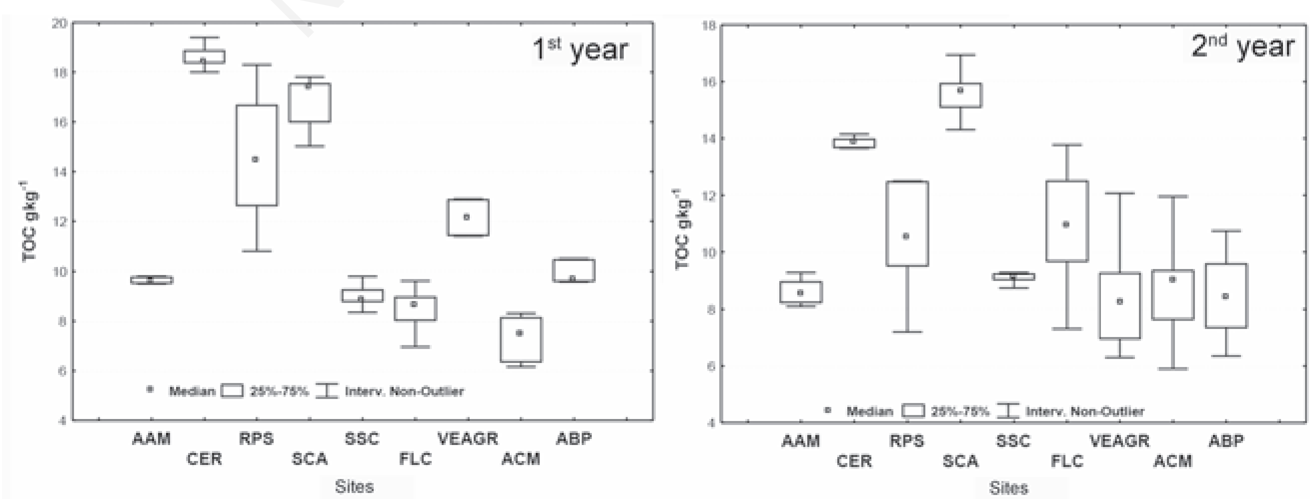

Figure 2. Contents of total organic carbon (TOC) at the beginning and at the end of the monitoring in different websites.

treatments, it was higher in the case of the application of the standard 2.2 (rotation) compared to the counterfactual (monoculture).

The effect of the two treatments F and CF was tested also in relation to production performance. As the Table 5 shows, in general, all parameters analysed are not affected by the treatments except the yield for the site ACM, of Harvest index for sites FLC_2 and FLC_1 in 2013 and for the weight of 1000 seed for the site SCA in 2013.

Economic evaluation of the competitiveness gap for farmers

Methodology

The standard states that continuous cereal cropping cannot be longer than five years. Therefore the cereal farmer that adheres to the commitments of the Standard, after five years of continuous cereal cropping must practice a catch crop and therefore, with reference to territorial characteristics, we have hypothesized two models of crop rotation:

1. corn and soybean crop rotation practiced in northern Italy, which entails, in compliance with this standard (factual), the practice of corn crop for five years and its replacement with a catch crop, such as soybean, in the sixth year. By way of comparison, in case of failure to comply with the standard (counterfactual), it is assumed to practice a continuous corn cropping for six consecutive years;
2. wheat and field bean crop rotation practiced in southern Italy, which entails, in compliance with this standard (factual), the practice of the durum or common wheat crop for five years and its replacement with a catch crop, such as field bean, in the sixth year. By way of comparison, in case of failure to comply with the standard (counterfactual), it is assumed to practice a continuous durum or common wheat cropping for six consecutive years.

Monitored farms crops have been practiced as mentioned above. To assess the competitiveness gap, we used data from the monitoring of farming operations. Thanks to the processing of the acquired information, it was possible to assess the necessary working time for every mechanical operation, in accordance with the recommendation of the

Table 4. Soil biological parameters.

Farm	Treatment	Parameters Cmic (mg/kg ±SE)		RBas (mg/kg ±SE)		Rcum (mg/kg ±SE)		qCO_2 (mg/kg ±SE)		qM (% ±SE)		IBF
AAM	CF	167.0	22.7	6.78	0.52	226.5	13.5	0.19	0.04	2.51	0.18	15
	F	158.0	17.6	7.58	0.22	247.3	17.0	0.22	0.03	2.48	0.16	16
Average		162.5	13.8	7.18	0.30	236.9	10.8	0.20	0.02	2.50	0.11	
CER	CF	195.1	1.0	7.25	0.97	242.3	7.3	0.16	0.01	1.27	0.04	18
	F	252.5	32.8	8.05	0.59	431.8	78.0	0.14	0.03	2.25	0.34	20
Average		223.8	23.3	7.65	0.54	337.0	54.9	0.15	0.02	1.76	0.27	
FLC_1	CF	96.3	0.2	5.57	0.25	176.3	3.7	0.26	0.05	2.12	0.07	14
	F	102.0	10.0	4.74	0.55	174.7	4.7	0.19	0.02	2.11	0.12	14
Average		99.2	9.5	5.15	0.33	175.5	2.7	0.23	0.03	2.12	0.06	
RPS	CF	303.0	25.4	6.95	2.09	194.7	29.0	0.10	0.03	1.41	0.19	18
	F	222.0	32.6	5.22	0.33	175.8	17.5	0.11	0.01	1.77	0.35	17
Average		262.5	23.2	6.08	1.04	185.3	16.4	0.10	0.02	1.59	0.20	
SCA	CF	272.7	20.8	6.42	0.64	313.3	11.8	0.11	0.01	1.76	0.09	20
	F	219.4	37.6	7.05	1.00	312.3	19.9	0.16	0.02	2.04	0.04	18
Average		246.1	21.0	6.73	0.58	312.8	11.1	0.13	0.01	1.90	0.06	
	CF	214.8	19.6	6.64	0.54	235.9	13.0	0.16	0.02	1.86	0.13	17
	F	190.6	16.5	6.56	0.37	259.7	20.7	0.16	0.01	2.13	0.13	17
Average		202.7	12.8	6.60	0.35	247.8	13.2	0.16	0.01	1.99	0.09	

Cmic, microbial carbon; CBas, basal respiration; Ccum, cumulative respiration; qCO2, metabolic quotient; qM, quotient of mineralization; IBF, biological index of fertility; CF, counterfactual; F, factual.

Table 5. Average yield, Harvest index, test weight and the weight of 1000 seeds of the sites included in the monitoring and significance related to the treatments in each location.

Thesis			Yield (t/ha at 13%)			Harvest index			Test weight (kg/hL)			Weight 1000 seeds (g)			Crude proteins (%)		
Farm	Year	Crop	CF	F	P	CF	F	P	CF	F	P	CF	F	P	CF	F	P
ACM	2013	Wheat	2.09	3.30	*	0.46	0.46	ns	77.1	79.3	ns	57.6	62.4	ns	11.5	11.9	ns
CER	2013	Wheat	3.58	4.14	ns	0.42	0.44	ns	84.8	84.1	ns	47.1	53.3	ns	13.1	11.9	ns
FLC_1	2012	Corn	9.47	11.59	ns	0.45	0.47	ns	78.3	77.1	ns	393	390	ns	7.33	7.43	ns
FLC_1	2013	Corn	7.89	9.35	ns	0.43	0.51	*	76.7	77.1	ns	341	370	ns	8.77	8.7	ns
FLC_2	2013	Corn	16.78	14.77	ns	0.55	0.50	*	76.5	76.8	ns	342	331	ns	8.89	8.67	ns
RPS	2014	Wheat	3.00	2.26	ns	0.40	0.31	ns	72.7	73.6	ns	42	35.3	ns			
SCA	2013	Wheat	5.74	5.47	ns	0.26	0.27	ns	81.8	82.7	ns	38	42	*	15.8	15.4	ns
VEAGR	2013	Corn	6.99	6.85	ns				60.9	67.4	ns						

CF, counterfactual; F, factual; *significant at P=0.05; ns, not significant.

Associazione Italiana di Genio Rurale (A.I.G.R.) III^a R1 (Manfredi, 1971) that considers the methodology of Commission Internationale de l'Organisation Scientifique du Travail en Agriculture (C.I.O.S.T.A.). The surveys carried out in the field have been related to the actual working time (TE) and to the turning accessory time (TAV), whose sum is the net working time (TN). In order to assess the hourly cost of the machines and equipment, it was necessary to determine the cost per hectare of the agricultural operations by means of an analytical methodology (Biondi, 1981) and technical standards to which it refers (ASAE, 2003a, 2003b). The data relating to the remuneration of farm labour, used in the above method, is the average of the values fixed by the Confederazione Italiana Agricoltori in the national collective labour agreement in force, for the qualification of super specialized worker, A level, Area 1, concerning the monitored provinces. The data of cereals and soybean technical input costs were obtained by the Centro Ricerche Produzioni Vegetali (CRPV, 2014), and data of field bean were obtained by the Piano di Sviluppo Rurale 2007-2013 della Regione Sardegna (Regione Sardegna, 2014). The average sales of durum and common wheat grain in the last 12 months were obtained by the Istituto di Servizi per il Mercato agricolo Alimentare (ISMEA, 2014), and the price of the field bean was obtained from price lists published by the Camere di Commercio Industria Agricoltura e Artigianato (Table 6) (CCIAA Arezzo, 2014; CCIAA Brescia, 2014; CCIAA Forlì-Cesena, 2014). The production data were recorded by monitoring. In the case of soybean, since the duration of the project did not allow to repeat the monitoring in different areas and years, the monitored productions were significantly lower than the average national production due to adverse climatic conditions. Since these data strongly influence the balance, for soybean crops we have preferred to use data from the *Istituto Nazionale di Statistica* (ISTAT, 2014) (Table 7).

The gross operative margin of cultivation was calculated for each crop by means of the difference between total revenue and total costs directly related to the production. The corn and soybean require irrigation, therefore the cost of water supply was added to the balance of these cultures. Corn requires to be irrigated three times a year and soybean only once. Table 8 shows in detail all the items related to the costs and revenues of the crops considered. The cumulative competitiveness gap (€ ha^{-1}), has been calculated through the difference between the cumulative gross operative margin both in case of compliance and non-compliance with this standard. This calculation was carried out considering six cases of sexennial crop rotation, in each of which the leguminous is cultivated in a different year. In such way, it was considered the randomness of the occurrence of the crop rotation during the six-year period. Gross operative margins obtained were discounted with the financial function NPV (Net Present Value). In order to obtain the annual value of the competitiveness gap, expressed in € ha^{-1} year^{-1}, the financial formula was applied to the NPV to calculate the constant annual instalments. For each type of cultural operation we calculated the average value of the cost and the values obtained by adding and subtracting the average standard deviation which are indicated in the Table as upper limit and lower limit respectively. The results vary depending on the models of crop rotation considered (Table 9). Regarding southern Italy, in case of common wheat and field bean crop rotation, with reference to the calculations performed with the average values of mechanized cultural operations, the annual competitiveness gap shows values ranging from -12.71 to -15.47 € ha^{-1} year^{-1}, or in case of durum wheat and field bean crop rotation, values are significantly higher and range from -37.05 to -45.08 € ha^{-1} year^{-1}. In northern Italy, for the corn and soybean crop rotation, the annual competitiveness gap shows values ranging from -9.77 to -11.88 € ha^{-1} year^{-1}. A similar trend can be observed with reference to the calculations performed with upper limit and lower limit.

Table 6. Average prices; data from ISMEA, 2014; CCIAA Arezzo, 2014; CCIAA Brescia, 2014; CCIAA Forlì-Cesena, 2014).

Average prices	(€ t^{-1})
Durum wheat grain	261.25
Common wheat grain	209.77
Corn grain	188.88
Soybean	440.65
Field bean	278.33

Table 7. Yield of the crops.

Crops	Production (13% moisture) (t ha^{-1})
Durum wheat grain	5.05
Common wheat grain	5.52
Corn grain	8.64
Soybean	2.82
Field bean	3.46

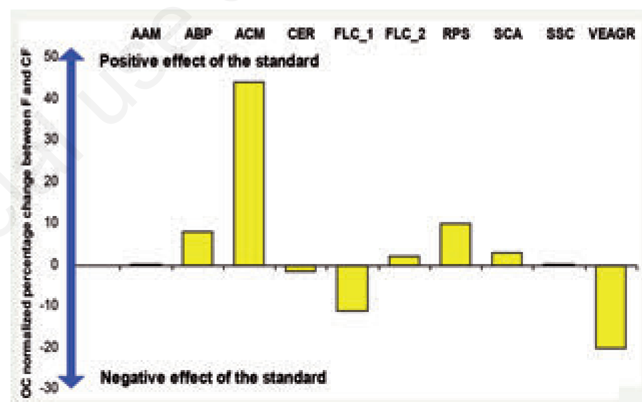

Figure 3. Organic carbon (OC) normalized percentage change between factual (F) and counterfactual (CF) treatments.

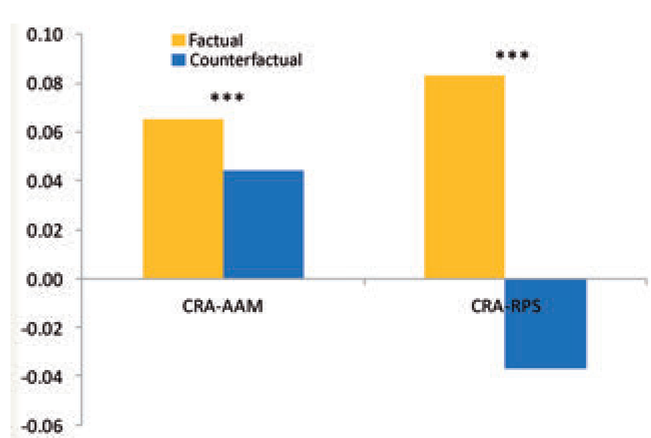

Figure 4. Percentage change from baseline of the microbial biomass in the two treatments for the two farms AAM and RPS. ***Significant at P=0.001.

Discussion and conclusions

The variations of soil organic matter in soils in response to changes in cultivation technique or land management can have quite long time to show up. In this case, after two years from the application of the standard 'rotations' the results are contrasting and not sufficient to demonstrate a statistically significant effect of the treatment, except for AAM, where, however, the treatment was applied for three years. Also the great variability of the two years probably confounded the possible effects of rotations.

In AAM, the only site where monitoring has been ongoing for three

Table 8. Annual crop balance calculated with the average values of mechanized cultural operations.

Balance items	Common wheat (€ ha^{-1} year^{-1})	Field bean (€ ha^{-1} year^{-1})	Durum wheat (€ ha^{-1} year^{-1})	Corn (€ ha^{-1} year^{-1})	Soybean (€ ha^{-1} year^{-1})
Ploughing	210.17	210.17	210.17	210.17	210.17
Harrowing	50.08	50.08	50.08	50.08	50.08
Fertilization	6.86	6.86	6.86	6.86	6.86
Sowing	39.01	39.01	39.01	39.01	39.01
Soil rolling	19.32	19.32	19.32	19.32	19.32
Weed control	6.78	6.78	6.78	6.78	6.78
Irrigation	-	-	-	184.67	61.56
Hoeing	-	-	-	-	55.74
Combine harvesting	126.64	138.00	126.64	170.98	142.50
Total cost of mechanized cultural operations	458.84	470.21	458.84	687.85	592.00
Technical input cost	529.00	229.40	529.00	715.00	768.33
Total revenue	1157.46	784.90	1318.88	1631.50	1524.20
Gross operative margin	169.62	85.29	331.04	228.64	163.87

Table 9. Annual values of the competitiveness gap (€ ha^{-1} year^{-1}), lower limit, average and upper limit for each crop rotation.

Year of leguminous cultivation	Annual values of the competitiveness gap - Southern Italy Common wheat field bean crop rotation (€ ha^{-1} year^{-1})			Southern Italy Durum wheat field bean crop rotation (€ ha^{-1} year^{-1})			Northern Italy Corn-soybean crop rotation (€ ha^{-1} year^{-1})		
	Lower limit	Average	Upper limit	Lower limit	Average	Upper limit	Lower limit	Average	Upper limit
6th year	-17.64	-12.71	-7.79	-41.97	-37.05	-32.13	-17.29	-9.77	-2.24
5th year	-18.34	-13.22	-8.10	-43.65	-38.53	-33.41	-17.98	-10.16	-2.33
4th year	-19.08	-13.75	-8.43	-45.40	-40.07	-34.75	-18.70	-10.56	-2.43
3rd year	-19.84	-14.30	-8.76	-47.21	-41.68	-36.14	-19.45	-10.98	-2.52
2nd year	-20.63	-14.87	-9.11	-49.10	-43.34	-37.58	-20.22	-11.42	-2.62
1st year	-21.46	-15.47	-9.48	-51.07	-45.08	-39.09	-21.03	-11.88	-2.73

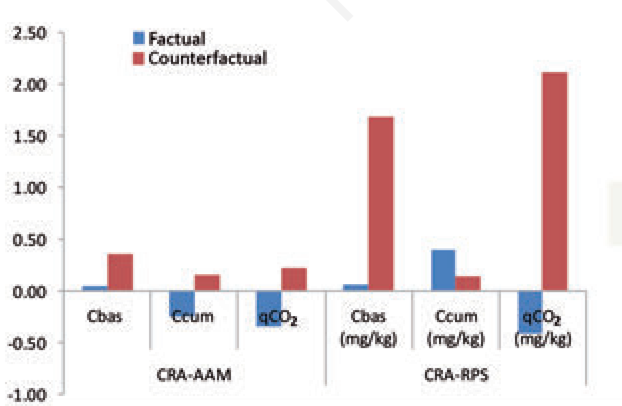

Figure 5. Relative changes of the biological parameters basal respiration (CBAs), breathing cumulative (Ccum) and metabolic quotient (qCO_2).

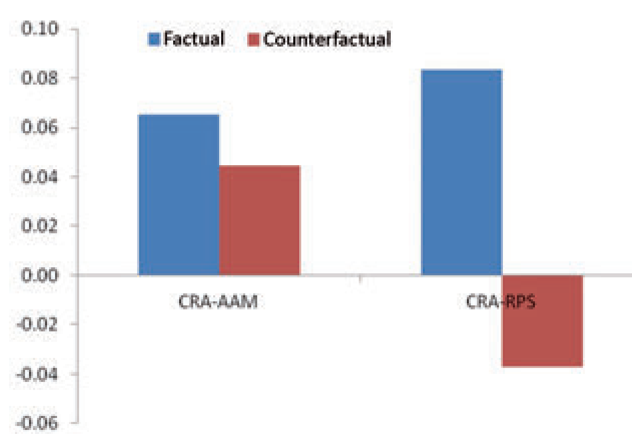

Figure 6. Relative change of the Index of Biological Fertility (IBF).

years, showed a significant effect F and CF, although the standardization of the same data - relative change of the final value compared to the initial value - showed an effectiveness of the Standard 2.2 of only 0.3%, but indicative of the fact that the treatment F has an effect on soil OC dynamics.

However the results must not lead to the conclusion that the indicator 'organic matter', proposed for the evaluation of the Standard 2.2, is not suitable to describe synthetically the effect of treatment. Instead it is more correct to say that in view of the medium-long term necessary to show significant changes in the OC, two years of time are definitely not sufficient to demonstrate a dynamic SOC associated with the treatment, also taking into account the large interannual variability recorded at the different sites monitored. As regards other possible parameters involved in the dynamics of the soil OC, in particular the microbiological ones, there were only two sites in which initial and final determinations are present: AAM and RPS.

Although these early data show that the microbial biomass, compared to the SOM, appears to be a more dynamic indicator able to early indicate possible changes in the content of organic C, examples are too limited to draw conclusions. Long term monitoring of soil parameters is needed to cover knowledge gaps and answer the question; if Standard 2.2 is effective in reducing SOM losses and increase SOM sequestration. Regarding the economic evaluation of the competitiveness gap for farmers, the practice of six-year crop rotation, compared to continuous cereals cropping, according to the assumptions indicated, always causes a negative annual competitiveness gap, which represents a modest economic loss caused by a reduction of gross operative margin for the farmer that complies with the standard.

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