Environmental effectiveness of GAEC cross-compliance Standard 4.2 on biodiversity in set-aside management and economic evaluation of the competitiveness gap for farmers, part I

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Abstract

In 2005, the CAP reform introduced the principle of conditionality that enables the access to single payments for farmers only 'on condition' that a series of commitments, such as the Statutory Management Requirements (SMR) and Good Agricultural and Environmental Conditions (GAEC), are respected. In particular, the GAEC Standard 4.2 aims to ensure the proper management of the set-aside fields through specific agronomic practices consisting in mowing or equivalent operations in order to conserve and protect biodiversity. This is considered one of the main environmental challenges of the new CAP. In the present work, we report the results of a monitoring activity aimed at evaluating the effectiveness of the Standard 4.2 on soil biodiversity. Monitoring involved both soil microorganisms and soil arthropod fauna, representing the so-called 'invisible biodiversity', a key element for soil fertility and sustainability, as well as the ground-dwelling arthropods. Two different managements of set-aside, with and without mowing, were compared in three different areas in Italy: Caorle (VE), Fagna (FI), and Metaponto (MT). The results showed a slight but significant increase in biodiversity in the plots where mowing was applied.

Introduction

The regulation EC 1782/03 of the Common Agricultural Policy (CAP) reform introduced the principle of cross-compliance and defined the overall set of rules that farmers of the European Union have to comply with in order to access to the Single Farm Payment (SFP) scheme. Thus, SFP is not related to the type or the amount of the crop production but it depends on the cross-compliance with a series of 'acts' and 'Standards' which are defined Statutory Management Requirements (SMR) and Good Agricultural and Environmental Conditions (GAEC) (updated by Annexes II and III of Regulation EC 73/09). The term 'cross-compliance' indicates that the payment is conditional on compliance with the requirements.

Among the main environmental challenges faced up by the CAP, the protection of biodiversity within cultivated areas is one of the most important issues, especially with regard to soil conservation and sustainability. Indeed, the new CAP will put particular attention to the protection of natural resources also through the so-called process of 'greening' proposed by the CAP as a mandatory action for 2014-2020.

The GAEC Standard 4.2 'Managing set-aside land' (Objective 4, Maintenance Landscape and Habitat) aims to prevent the set-aside land abandonment. It established that the preservation of the set-aside productive potential should be guaranteed through mowing (or any equivalent practice) but without negatively altering soil fertility and biodiversity.

In fact, the set-aside fields serve as refuges and breeding areas for many animal species thanks to the presence of vegetation cover throughout the year. In addition, the management of set-aside fields could enhance the preservation of all those soil organisms specialized to the 'below-ground' life (e.g., bacteria, fungi, microarthropods, etc.) which represent an enormous reservoir of 'invisible' biodiversity and are essential for soil fertility and sustainability.

The main purpose of this study was to assess the effectiveness of the measure of the GAEC Standard 4.2 for the sustainability of soil biodiversity at different scales. Thus, we used several bioindicators, including micro-organisms (microflora), microarthropods (mesofauna) and ground-dwelling arthropods, to achieve quantitative assessment at different scales and, therefore, to provide management indications which take into account different ecological requirements.

Materials and methods

Experimental areas

The experimental fields of this study have been managed as set-aside from 2008, after having been previously used for cereal crops with different conventional rotations. The surveys were conducted in three farms located respectively in Northern, Central and Southern Italy (Figure 1). In Northern Italy the plots were located in Caorle (VE; 45° 37'51.21 "N-12° 58'10.29" E) in the 'Valle Vecchia' farm belonging to Veneto Agricoltura. This site is located in a lagoon at 1 m asl and the soil is classified as 'silty loam', in agreement with its texture. The traditional rotation is based on the alternation of corn and sorghum. In Central Italy, the monitoring plot is located in the CREA-ABP experimental field located in Fagna near Scarperia (FI, 43° 58'53.28 "N-11° 21'01.15" E), in a hilly area (253 m asl) characterized by clay texture. The rotation is quinquennial (wheat or barley one year, and alfalfa four years). In Southern Italy the experimental plot is located in the 'Pantanello' farm of the CREA-SSC in Metaponto (40° 23'12.13 "N-16° 47'40.08" E), situated in the plains (4 m asl) characterized by a soil texture classified as clay and silt; the rotation lasted four years and consisted of three years wheat and one year fallow.

The same experimental design was applied to compare three treatments for each site: i) Treated (F), where mowing operation was made in July avoiding the removal of the vegetation cover; ii) Non-treated (CF), plots without mowing; iii) Control (CTRL), plots characterized by the traditional rotation. The total area of the three plots in each site was about 1.5 ha (0.5 ha per plot) with an ecotonal belt on at least one side.

Soil sampling

Soil samples for the microbial and mesofaunal analyses were collected in September 2012 (after mowing) and in May 2013 (before mowing) in each study area in three different points of each plot, located at about 20 m, 40 m and 60 m from the ecotonal belt. A soil sample, of approximately 2 Kg, was collected from each point by means of a special corer devoted to the mesofauna sampling (a 10 cm cube). Soil samples were placed in a plastic bag and stored at 4°C until arrival to the laboratory. A sub-sample of about 50 g was prepared from each soil sample and stored at -20°C for the molecular analysis.

Sampling of ground-dwelling arthropods

In the same period the ground-dwelling arthropods were sampled in F, CF and CTRL plots of each monitoring area by using pitfalls, according to the methodology described in Biaggini *et al*. (2015). Three traps per treatment were placed and two samplings (lasting 14 days each) were performed before mowing (April-May) and after-mowing (September-October).

Microbiological analysis

Monitoring of microbial biodiversity was carried out through both molecular techniques, such as Denaturing Gradient Gel Electrophoresis (DGGE), and biochemical methods such as the assessment of soil respiration and microbial biomass.

Molecular analysis DGGE was performed on 16S rRNA genes as reported in Castaldini *et al*. (2005), after extraction of nucleic acids (DNA and RNA) using the Fast DNA SPIN Kit for soil (MP Biomedicals, OH, USA). In particular, we analyzed the region V6-V8 of 16S rRNA gene by PCR according to the procedure described by Felske *et al*. (1998). The DGGE analysis was performed on a 6% polyacrylamide gel (acrylamide / bis ratio, 37,5: 1), and under denaturing conditions (urea,

Figure 1. Location of the three farms where biodiversity was monitored.

7 M; 40% formamide with denaturing gradient from 42% to 58%), through the system INGENY phorU-2 (Ingeny, Netherlands).

Microbial respiration was conducted according to the 'static' method (Isermeyer, 1952), which consists in the determination of CO_2 released from the soil sample during incubation at 30°C in a closed system after 1, 2, 4, 7, 10, 14, 17, 21 and 28 days. For each soil sample, the basal respiration (C_{bas}) and cumulative respiration (C_{cum}) were determined and expressed as the amount of potentially mineralizable carbon (CO_2 mg kg^{-1} soil). The microbial biomass (C_{mic}) was determined according to the method described by Vance *et al*. (1987). The metabolic coefficient (qCO_2) and mineralization (qM) indices, commonly used as indicators of soil quality (Bloem *et al*., 2005), were also determined.

Edaphic microarthropod community analysis

Microarthropods were extracted from the soil samples using modified Berlese-Tullgren funnels following the Standard methodology (Parisi *et al*., 2005) and observed at the stereomicroscope. The edaphic microarthropods community was characterized using: i) individual abundance/m^2; ii) richness determined by counting the number of taxa; iii) Acarina and Collembola ratio (A/C) (Bachelier, 1986); (4) QBS-ar index according to Parisi *et al*., (2005). The index is based on the life-form approach and its values are the summa of EMI (Eco-Morphological Index) scores, ranging between 1 and 20 for each organism depending on its adaptation to the edaphic habitat.

Analysis of ground-dwelling arthropods biodiversity

All arthropods were determined at the order taxonomic level whereas beetles at the family level. For both indicators, and for each trap, the biodiversity index of Shannon-Wiener was assessed over the two sampling periods, pre- and post-mowing. In the present work, we descriptively report some of the diversity patterns observed for the ground-dwelling arthropod communities whereas for a thorough analysis of the possible effects of the Standard on these arthropods, please refer to Biaggini *et al*. (2015).

Statistics

Significant differences between the various soil managements and the bacterial and micro-arthropod communities were highlighted by using one-way analysis of variance (ANOVA), using PAST software (v.2.17c) (Hammer *et al*., 2001). When significant differences were found, ANOVA was followed by Duncan test with $P<0.05$. The principal component analysis (PCA), was also performed using a number of parameters (variables) that describe the biological characteristics of the soil: all the indicators of biodiversity (Shannon Index for arthropods, beetles and bacteria and the number of bacterial species as well), the indicators of soil biological quality (the A/C ratio between Acari and Collembola, the index QBS-ar) as well as the indicators of soil biological activity (C_{bas}, C_{cum}, C_{mic}, qCO_2, qM).

Competitiveness gap

In order to avoid the progressive abandonment of agricultural land, the Standard 4.2c imposes to prevent fires in drought conditions, to avoid the spread of weeds and to protect wildlife. For this purpose, soils are subjected to the implementation of agricultural practices consisting of mowing or similar operations, at least once a year.

To assess the competitiveness gap, the cost of mechanical operations was calculated by using the data originating from the monitoring activities carried out by the different operative units.

The work timing was assessed by adopting the recommendation of the *Associazione Italiana di Genio Rurale* (A.I.G.R.) IIIa R1 (Manfredi, 1971) that is based on the methodology of the *Commission Internationale de l'Organisation Scientifique du Travail en Agriculture* (C.I.O.S.T.A.). Field measurements have been calculated considering both the effective work time (TE) and the accessory time to turn back (TAV), which sum is the net total work time (TN). The hourly cost per hectare of machines and equipment was calculated using an analytical methodology (Biondi, 1999) and the technical standards of ASAE (2003a, 2003b).

The values regarding the farmer's salaries are an average of those indicated by the *Confederazione Italiana Agricoltori* for the specialized workers of level A, Area 1, in the different monitored provinces.

Monitoring results

Microbial diversity

Microbial biodiversity values are expressed through the Shannon diversity index (H') (Figure 2), based on the profiles DGGE (Denaturing Gradient Gel Electrophoresis). Molecular analysis showed no significant reduction in terms of bacterial biodiversity in the treated plots (F) in any of the three sites over the period 2012-2013. In contrast, the plots treated with mowing showed an increase, even if slight, of microbial biodiversity as compared to the untreated plots (CF): in Fagna and Caorle the increase was significant ($P=0.012$ and $P=0.038$, respectively). In general, however, biodiversity values of the plots characterized by conventional crop management (CTRL) are comparable to those of the thesis CF. Biochemical data showed that mowing, just after one year of monitoring, generally showed moderate effects on soil biological fertility (Table 1). In Fagna a significant increase in microbial biomass in the treated plots (as well as in CTRL, but not in CF) was observed during the post-mowing if compared to the pre-mowing. The values of organic carbon mineralization and microbial respiration seem to increase in the set-aside plots when compared to the conventional ones. In particular, the CF plots showed the largest increase. In Caorle a general decrease in the microbial activity occurred in the post-mowing while a simultaneous increase in microbial biomass was observed, especially in the arable land (CTRL). Beyond the seasonality effect, no significant differences between F and CF were highlighted.

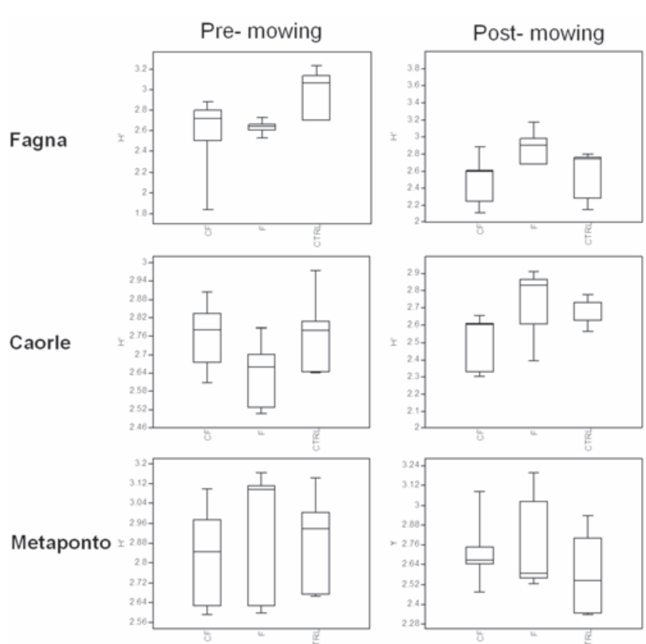

Figure 2. Boxplots reporting the mean values of the Shannon index (H') obtained through PCR-DGGE analysis and related to bacterial biodiversity observed in Caorle, Fagna e Metaponto in 2012-2013, either pre- mowing and post-mowing.

Finally, in Metaponto a general increase in both microbial activity and microbial biomass was observed. In terms of microbial respiration and mineralization of organic C the lowest values were detected in the arable plots (CTRL), whereas no significant differences were observed between F and CF. To be noticed that the values of a soil quality index such as the qCO_2, usually proportional to the stress level of the system, are generally higher in set-aside plots rather than in conventional ones. This is probably due to the increased availability of organic matter that is added to arable soils through the conventional fertilization and get stabilized as microbial biomass whereas the level of microbial activity and mineralization of organic matter decreases.

Mesofauna diversity

In all sites, the abundance of microarthropods/m^2 in F and CF was higher than in CTRL. The differences were significant only in Fagna with 2280, 1667 and 983 microarthropods/m^2 found in F, CF and CTRL, respectively. The highest abundance was observed in Caorle CF (9307 microarthropods/m^2) due to the presence of numerous *Solenopsis fugax* Latreille ants (Hymenoptera: Formicidae). In all sites, the highest number of taxa was found in F: the differences between F and CTRL were always significant (Figure 3). No differences were found between pre- and post-mowing, with the exception of Metaponto: the number of taxa decreased in the post-mowing period probably because of the severe summer drought.

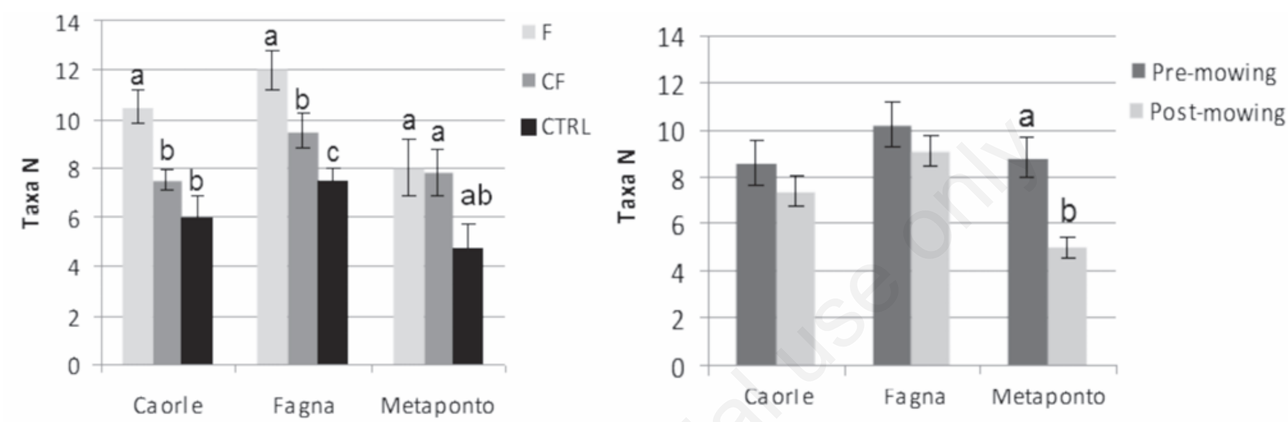

Figure 3. Number of soil microarthropod taxa in Caorle, Fagna and Metaponto sites during the monitoring period reported as: A) management; B) pre- and post-mowing.

Table 1. Indices of soil biological fertility of factual (F), counterfactual (CF) and control (CTRL) plots: basal respiration Cbas (mg C-CO_2/kg soil), cumulative respiration Ccum (mg C-CO_2/kg soil), C of microbial biomass (mg C/kg soil), mineralization quotient (%) and metabolic quotient (Cbas/Cmic*1000/24h).

		Cbas	Ccum	FAGNA qM	Cmic	qCO2
Pre-mowing	CF	8.66	412.53	6.63	209.88	5.23
	F	10.60	537.51	9.63	89.79	6.10
	CTRL	10.28	489.58	9.20	92.92	4.86
Post- mowing	CF	13.01	606.02	12.02	162.84	3.34
	F	10.33	444.71	9.48	129.54*	3.39
	CTRL	6.90*	296.12*	7.12	183.02*	1.69*
		Cbas	**Ccum**	**CAORLE qM**	**Cmic**	**qCO2**
Pre-mowing	CF	12.06	512.92	11.89	59.08	14.33
	F	17.93	745.18	14.30	37.80	19.75
	CTRL	12.86	538.13	13.37	24.97	34.95
Post- mowing	CF	8.39*	379.19*	8.01	116.66*	3.07*
	F	9.07*	422.85*	10.56*	133.38*	2.87*
	CTRL	5.52*	270.45*	5.11*	141.29*	1.66*
		Cbas	**Ccum**	**METAPONTO qM**	**Cmic**	**qCO2**
Pre-mowing	CF	9.76	512.60	7.20	80.00	5.45
	F	9.79	525.73	6.42	114.21	3.62
	CTRL	10.76	580.50	7.82	106.17	4.25
Post- mowing	CF	11.98	624.08*	5.59	268.22*	1.88*
	F	13.40*	711.83*	5.55*	235.58*	2.39*
	CTRL	7.14*	324.10*	4.52*	295.58*	1.01*

*Values significantly different between the pre-mowing and post-mowing at P<0.05.

Taxa distribution analysis highlighted marked differences among manegements: from the collected samples, 18 taxa were identified in the three sites and most of them were found in Fagna. Oribatida was the main order among mites. Concerning insects, Formicidae was the predominant family within Hymenoptera; Agromizidae and Cecidomiidae (phytofagous of cereal crops) within Diptera; Carabidae, Staphylinidae, Curculionidae, Crysomelidae, Scarabaeidae, Elateridae were the most common families of Coleoptera found after one year of monitoring.

Hymenoptera, Acarina and Collembola dominated in Caorle, but their abundance was different among managements (Figure 4). The CF thesis was distinguished by a lack of balance in the relative abundance of soil microarthropod taxa, due to the strong prevalence of Hymenoptera and, in particular, of the ant *S. fugax*. Acarina and Collembola dominated in Fagna and Metaponto. Moreover, Diplopoda, Isopoda and Symphyla increased their abundance in F and CF managements.

Microarthropods soil biological quality index, A/C ratio and QBS-ar, showed the highest values in F (Table 2). A/C ratios resulted lower than 1 only in Caorle CF and Fagna CTRL. The QBS-ar values were greater than 100 in all set-aside regimes (F and CF). The three conventional rotation (CTRL) registred different degrees of soil disturbance and their QBS-ar values ranged from 78 to 125.

Ground-dwelling arthropod diversity

Observing the values of the Shannon Index calculated on the ground-dwelling arthropod orders (Figure 5), the overall diversity in the treated plots (F) in the post-mowing period reaches the highest levels among those observed in the three monitored areas.

The same index calculated on the beetle families showed a more uniform patternbetween treatments and sampling periods. The treated plots showed values similar (in Caorle) or generally higher (in Fagna in the post-mowing period and in Metaponto) than to the non-treated and to the control ones. Detailed analyses regarding the ground-dwelling arthropods in relation to the possible effects of the Standard are reported in Biaggini *et al*. (2015).

PCA analysis

The principal component analysis (PCA) was performed separately for each of the three monitoring areas, taking into account all the surveyed variables.

In Fagna both arable and set-aside samples were very well distinguished along the first principal component (C1, X-axis) (Figure 6a). In general, samples from the arable plots showed higher microbial bio-

Table 2. Mean Acarina and Collembola ratio and QBS-ar of microarthropods (standard error) extracted from the soil samples collected from field replicates (n=3) in Caorle, Fagna and Metaponto.

	Acarina/Collembola	QBS-ar
Caorle		
Set-aside (mowed, F)	2.34 (1.25)	121.0 (10.28)
Set-aside (untreated, CF)	0.4 (0.16)	117.5 (9.17)
Conventional (control, CTRL)	1.3 (0.55)	87.0 (20.12)
Fagna		
Set-aside (mowed, F)	9.3 (3.12) [a]	175.5 (12.30) [a]
Set-aside (untreated, CF)	4.2 (0.98) [ab]	174.0 (6.26) [a]
Conventional (control, CTRL)	0.8 (0.14) [b]	125.0 (1.34) [b]
Metaponto		
Set-aside (mowed, F)	20.7 (8.01) [a]	134.5 (27.95)
Set-aside (untreated, CF)	12.7 (3.73) [ab]	125.0 (21.02)
Conventional (control, CTRL)	1.5(0.94) [b]	78.5 (7.38)

[a,b]Different letters indicate significant differences ($P<0.05$).

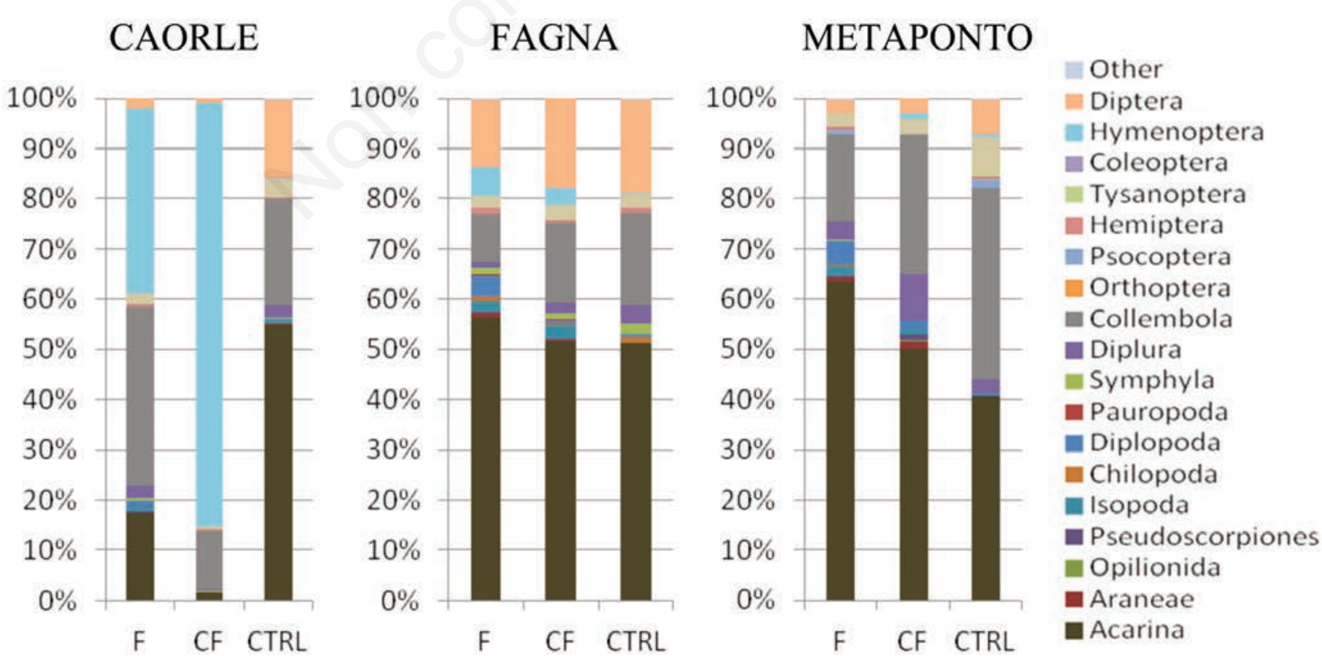

Figure 4. Relative abundance of soil microarthropod taxa per site in three different managements (F, mowing in July; CF, No mowing; CTRL, Conventional rotation).

mass and diversity of beetles, especially in autumn, while the set-aside samples showed higher microbial activity and biodiversity. The seasonal effect very clearly discriminated the samples along the second principal component (C2), reported along the y-axis: such effect was particularly evident for arable plots, and progressively less evident for the treated plots (F) and not mowed plots (CF). Soil samples showed a greater microbial diversity during spring (pre-mowing) as compared to the autumn (post-mowing) when, in contrast, higher values of QBS-ar, diversity of arthropods, microbial biomass, A/C ratio and microbial respiration were highlighted. Thus, the effect of Standard 4.2 was positive even if slightly.

In Caorle a strong seasonal effect on all plots was clearly highlighted along the first principal component (C1) (Figure 6b). Generally, both increased microbial activity and beetle diversity and QBS values (pre-mowing), as well as higher diversity of beetles and higher QBS values. In contrast, a higher microbial biomass was detected in autumn (post-mowing). The separation between control and set-aside samples was very well highlighted along the C2 axis, whereas no significant effect of mowing was observed. In particular, the control plot showed higher values of microbial and beetle diversity, whereas an increase in microbial activity, QBS and diversity of arthropods occurred in the set-aside plots. The effect of Standard 4.2 in Caorle was therefore negligible.

A strong seasonal effect was also detected in Metaponto for all plots (along the C1 axis) (Figure 6c). Generally, in spring (pre-mowing) greater microbial diversity, greater QBS-ar and mineralization of organic C were detected; in contrast, in autumn (post-mowing) an increased microbial biomass was observed. The separation of control and set-aside plots along the C2 axis was particularly evident. Especially set-aside samples showed higher values of microbial activity, A/C ratio, beetles and arthropod diversity than soils of the control plots where, in contrast, a slightly higher microbial diversity was detected. In the set-aside plots these features were more pronounced, after the mowing operation. Thus, the effect of the Standard 4.2 in Metaponto was slight but positive.

Competitiveness gap

In some cases during the mowing operation, a cutter bar instead of a rotary shredder was used. In both cases a PTO tractor is required to use them. The two machines provide different results: the cut bar only cuts the vegetation above the collar leaving the aerial part of the plant on the soil, whereas the rotary shredder produces a fragmentation of the vegetation which is released on the soil reduced into small fragments. Since the two processes also differ in working times and fuel consumption, the cost of mowing was calculated for both operating machines (Table 3). For each type of operation, the average cost and the values obtained by subtracting and adding the average Standard deviation were calculated and indicated in Table 3 as lower limit and upper limit, respectively.

Therefore the economic competitiveness gap coincides with the cost that the farmer has to support for mowing (Table 3); in average 33.40

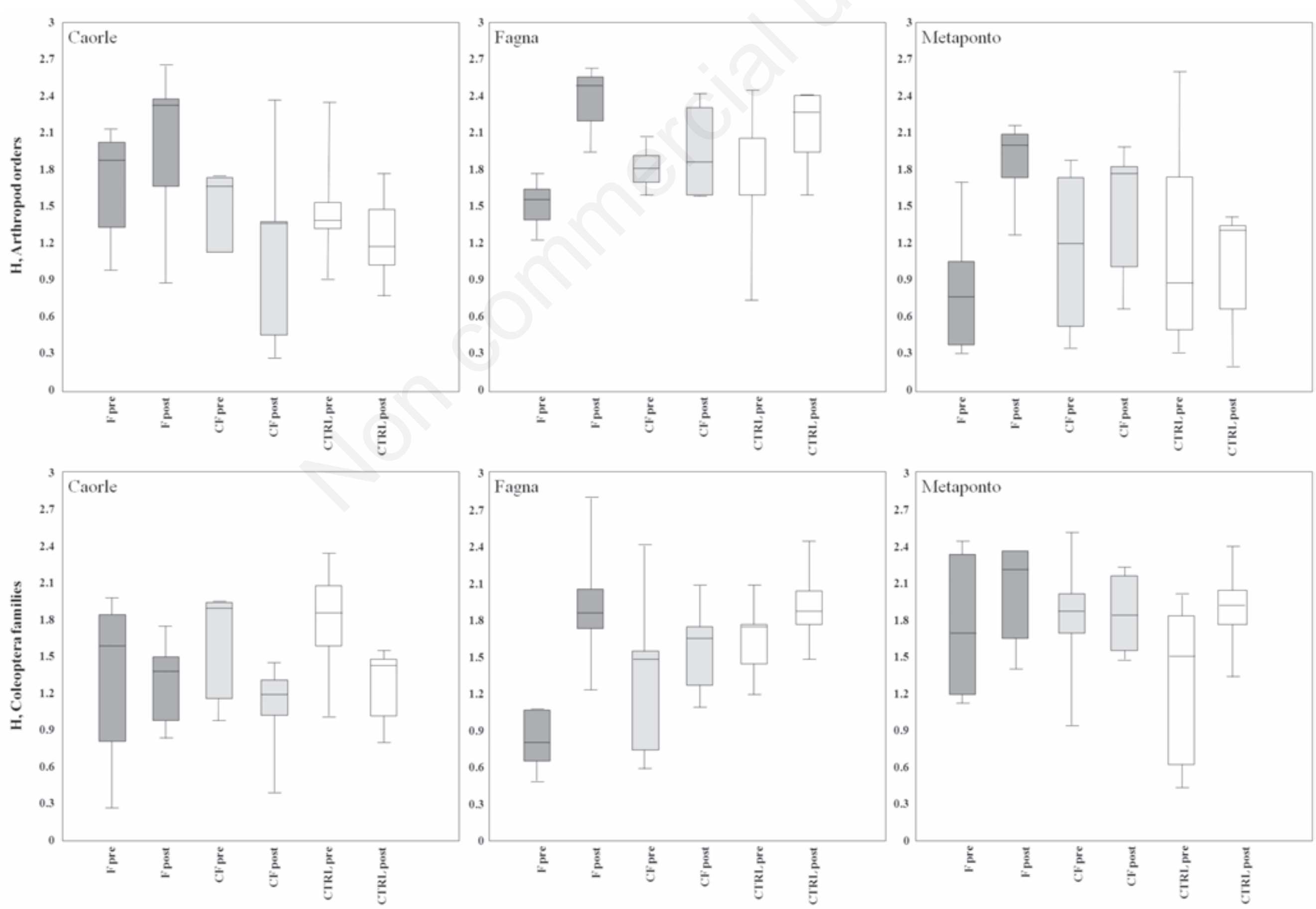

Figure 5. Values of the Shannon index (H) calculated for the ground-dwelling arthropod orders (above) and for the Coleoptera families (below) in the three monitored areas (F, factual; CF, counterfactual; CTRL, control), either pre- mowing (PRE) and post-mowing (POST). The boxplots represent the median, 25-75% quartiles and the extreme values.

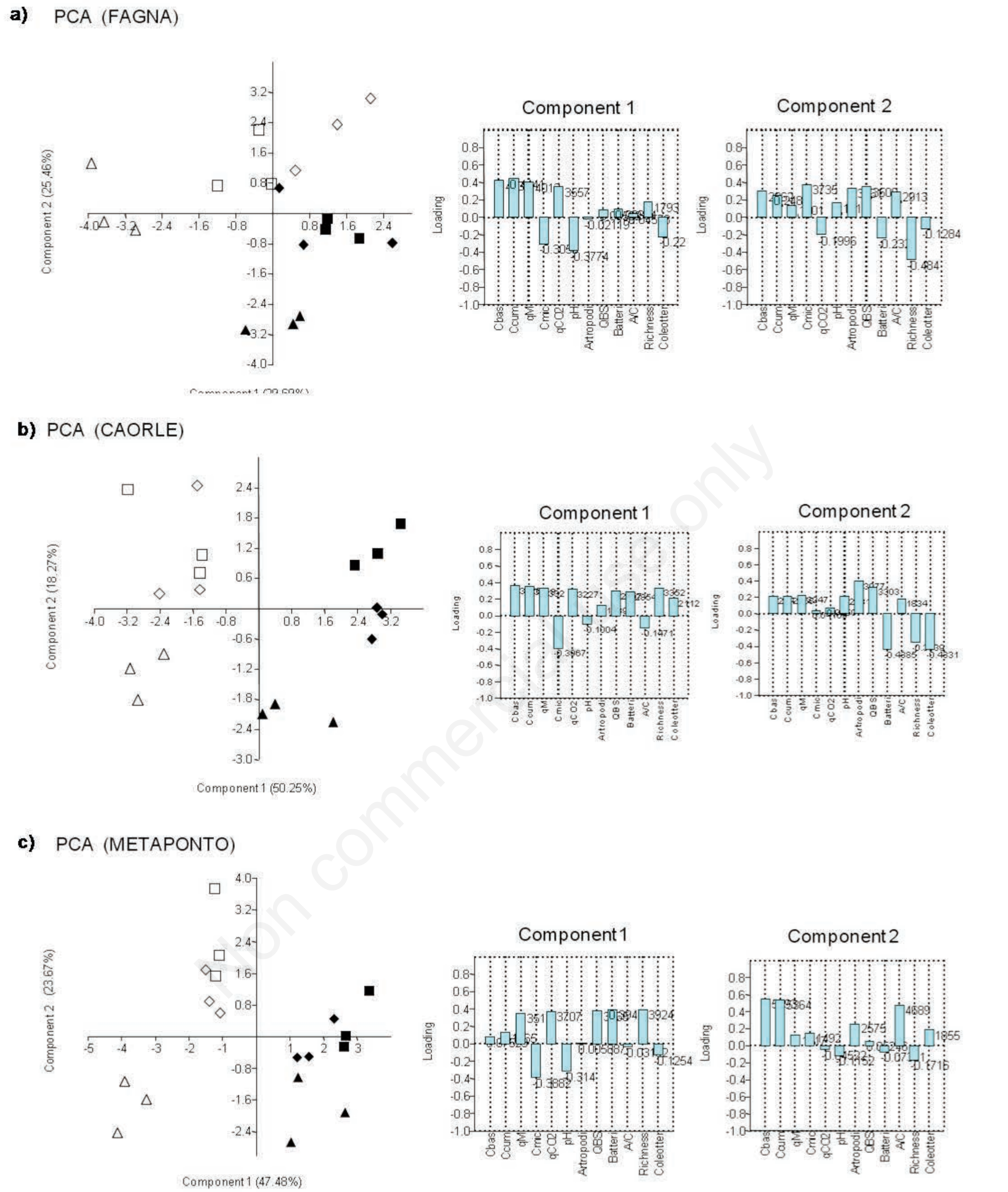

Figure 6. Principal Component Analysis (PCA) of the samples from Fagna, Caorle and Metaponto: △ , CTRL post mowing; ▲ , CTRL pre-mowing; □ , F post- mowing; ■ , F pre-mowing; ◇ , CF post-mowing; ◆ , pre- mowing. On the right the loading of each variables of the two considered components.

Table 3. Cost of mowing realized with two different types of machines, average fuel consumption and average CO_2 emission.

Equipment used for mowing operation	Lower limit (€ ha^{-1})	Average (€ ha^{-1})	Upper limit (€ ha^{-1})	Average fuel consumption (kg ha^{-1})	Average CO^2 emission (kg ha^{-1})
Cutter bar	27.27	33.40	39.52	6.30	19.96
Rotary shredder	45.83	67.05	88.27	13.59	43.09
Average value	36.55	50.22	63.89	9.94	31.52

€ ha^{-1} year^{-1} (range 27.27-39.52 € ha^{-1} year^{-1}) employing the cutter bar and € 67.05 ha^{-1} year^{-1} (range 45.83- 88.27 € ha^{-1} year^{-1}) employing a rotary shredder.

The average value of the economic competitiveness gap in case of compliance with the Standard, is 50.22 € ha^{-1} year^{-1} (ranges 36.55-63.89 € ha^{-1} year^{-1}). Consequently, the compliance with this Standard requires an increase in costs that represent an economic loss for the farmer. The realization of moving operation with the equipment described above, since it implies fuel consumption, causes an emission of 31.52 kg ha^{-1} of CO_2 in the atmosphere (Table 3).

Discussion and conclusions

The monitoring of the impact of mowing, as indicated by the Standard 4.2, conducted in Northern, Central and Southern Italy, has allowed to evaluate the effectiveness of this practice in very different areas, both in terms of agronomic management and pedoclimatic conditions. In general, the obtained data showed that the management of set-aside fields seems to be effective for both increasing biodiversity of microbial, edaphic and arthropod communities as well as for preserving soil biological quality.

Our results highlighted significant differences not only in terms the abundance, but also in the structure of bacterial, edaphic and ground-dwelling community, particularly between the set-aside and the conventional management. Our data showed that at microbial level the conventional management determined a greater efficiency in the use of the organic matter, enhancing the microbial biomass compared to the set-aside (both F and CF), as already observed at least in the short term (Hamer *et al*., 2008). However, mowing generally determined an increase in microbial diversity likely due the vegetal residues and roots left in the soil after mowing. Furthermore, a drastic decline of the labile organic matter availability provided by root exudates occurred just after mowing and it likely forced microorganisms to adapt and thrive under the new soil conditions.

A relative increase in emiedaphic and euedaphic mesofauna was observed in the set-aside plots.

The QBS-ar values exceeded 100 EMI in all set-aside regimes (F and CF) as previously reported for the natural areas (Menta *et al*. 2008; Ferrazzi *et al*. 2007; Parisi *et al*., 2005) and for the set-aside land use (Raglione *et al.*, 2011; Biaggini *et al.*, 2011). Few differences were observed between F and CF regimes. In general, F showed the greatest abundance and the highest presence of edaphic groups. Notably, CF has been characterized by the dominance of some groups, as observed for *S. fugax* ants in Caorle.

A five-year crop rotation in Fagna, based on wheat or barley (1-year) and alfalfa (4-year) determined the high QBS-ar values as observed for pasture by Menta *et al.* (2008). On the other hand, the degrading rotations used in Caorle (2-years) and Metaponto (4-years) provoked QBS-ar values lower than 100 EMI. In conclusion, the set-aside regime increases soil biological quality and fertility. Set-aside managed through mowing seems to be the best solution to preserve, biodiversity and to control weeds as well as limiting dominant groups.

The observed results may also explain the level of bacterial diversity found in CTRL plots which showed values comparable with the set-aside samples, especially for the CF. In fact, it is already known that the presence of alfalfa could lead to a selective increase in both the microbial biomass and diversity (Hartmann *et al*., 2009).

The supply of vegetal biomass to the soil after mowing could be likely considered as one of the main factors that determines the increase in ground-dwelling arthropods in all the three monitored areas, as already reported in literature (Thomas and Marshall, 1999). However, regarding beetles, this was observed only in Fagna. Using the *higher taxa* approach, and in particular focusing on the order level, in the F plots the arthropods showed a relatively high diversity level when compared to those observed in the other plots post-mowing (CF and CTRL) (Biaggini *et al*., 2015). In general mowing seems to affect positively species richness of some arthropod taxa, both at local as well as landscape level (Chambers and Samways, 1998; Braschler *et al*., 2009; Marini *et al*., 2009). Nevertheless, the timing of mowing should be planned taking into account the needs of a larger number of taxa such as grassland birds.

The PCA analysis highlighted two main points: i) a slight increase in the overall biodiversity due to the GAEC Standard 4.2; ii) a clear seasonal effect responsible for the observed differences in terms of biodiversity between pre- and post-mowing; iii) a clear difference between the set-aside and the conventional management.

In conclusion, any loss of biodiversity, regarding the monitored taxa, because of mowing was observed. Indeed, in some cases the management of the set-aside increased the soil biological quality and consequently its fertility. Therefore, among the different management of the set-aside fields, the F is not only agronomically preferable for the control of weeds, but it guarantees the presence of a higher biological emi/eu-edaphic diversity, reducing the risk of the dominance of more aggressive edaphic groups.

Finally, the results obtained in terms of biological quality and fertility of soils appeared even more relevant considering that they can be achieved at low cost. In fact, in the case of adherence to the commitments of the Standard 4.2 a modest increase in costs is due to the farmer. If the annual mowing treatment is performed with the use of an oscillating cutter bar the mean additional cost is equal to € 33.40 ha^{-1} year^{-1} whereas with the use of a rotary shredder the cost is equal to € 67.05 ha^{-1}-year^{-1}. The average values of CO_2 emissions will be respectively equal to 19.96 and 43.09 kg ha^{-1}.

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