Environmental effectiveness of GAEC cross-compliance standard 1.1c 'Maintenance of farm channel networks and field convexity' and economic evaluation of the competitiveness gap for farmers

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Paolo Bazzoffi: coordinator of the MO.NA.CO. project and of the Operative Unit CREA-ABP: text writing, methodological monitoring setup, contribution to survey of competitiveness gap. Silvia Carnevale: field surveys and laboratory analyses, contribution to competitiveness gap survey in Fagna. Andrea Rocchini: field surveys and laboratory analyses, contribution to competitiveness gap survey in Fagna. Marco Fedrizzi: Coordinator of the Operative Unit CREA-ING: Methodological approach of monitoring the competitiveness gap, application of the survey methodology for monitoring working times and farm machinery costs, data processing for the evaluation of the competitiveness gap and CO_2 emissions. Giulio Sperandio, Mauro Pagano, Mirko Guerrieri e Daniele Puri: Methodological approach of monitoring the competitiveness gap, application of the survey methodology for monitoring working times and farm machinery costs, data processing for the evaluation of the competitiveness gap and CO2 emissions. Marisanna Speroni: Coordinator of the Operative Unit CREA-FLC. Lamberto Borrelli: field surveys, contribution to competitiveness gap survey, data processing and report writing.

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Abstract

This paper shows the results of the monitoring carried out in three farms of the project MO.NA.CO. in order to verify the effectiveness of the cross-compliance standard 1.1c which obliges the farmer to the 'Maintenance of farm channel networks and field convexity' in order to ensure its efficiency and functionality in draining water. It was also examined the competitiveness gap induced to the agricultural enterprise by the application of the standard, that is to say the additional costs borne by the beneficiary of the single payment determined by cleaning farm collector channels.

Effectiveness was determined by evaluating the degradation of soil structure at the end of winter, on flat fields sown in autumn with winter wheat, in the two cases: a) Factual (channels along the field edges not clogged and no waterlogging present on the cultivated soil); b) Counterfactual (channels clogged and waterlogging present on the cultivated soil).

The monitoring confirmed a positive effect of the adoption of this standard on predisposing soil to the ideal conditions for the maintenance of the structure. Despite the statistical evidence found, it must be said that the change in the surface roughness factor was so small as not to take any practical significance in order to affirm that the functional maintenance of collectors channels have been effective in reducing erosion. Overall, the soils were unstructured and crusted at the end of the observation period.

Indexes Ic_{li}, NTU, and DS show a structural fragility from medium to high for soils of the three monitoring farms. This explains the lack of appreciable differences in the soil roughness parameter, especially in relation to heavy rains and long waterlogging periods in the cropping years of monitoring. The competitiveness gap induced by the application of this standard, amounted to 19.89±€ 6.35 ha^{-1} $year^{-1}$. Atmospheric emission of CO_2, was equal to 14.53±6.62 kg ha^{-1} $year^{-1}$. It is considered important to point out that at the present Annex II: 'Rules of cross-compliance' of Regulation (EU) No. 1306/2013 includes a BCAA not taking into account the environmental threats determined by waterlogging in cultivated land to soil, crops and to atmosphere, due to the possible production of greenhouse gases. As regards the infringement criteria to the standard it is suggested the introduction of the verification of the presence of convexity on cultivated fields in the plain.

Introduction

The cross-compliance Standard 1.1 (commitment c) aimed at achieving the objective No.1: SOIL EROSION: 'Protect soil through appropriate measures' is enclosed in the Rule 1: 'Measures for Soil Protection' of the decree on Cross-compliance No. 30125/2009 and following, until the recent decree No. 180 of January 23, 2015 issued by the Italian Ministry of Agriculture.

This standard, which until 2005 was made compulsory by MiPAAF[1] decree for each arable, obliges the farmer to the 'Maintenance of farm channel networks placed at the field margins and field convexity' in order to ensure its efficiency and functionality in draining water.

Until Ministrerial Decree No. 13286/2007 on cross-compliance, this standard was oriented to achieve the objectives set out in Annex IV of the EC Reg. 1782/03. That is the attainment of the environmental objective No. 3: 'Soil structure: Maintain the structure of soil through appropriate measures. 'The standard was made mandatory as part of the Standard 3.1 entitled 'Protection of soil structure (...).' Subsequently, with the MiPAAF decree on Cross-compliance No. 30125/2009, issued after the 'Health Check of the CAP[2], this Standard has been aimed at achieving a different environmental objective, namely to protect the soil from erosion. The last cross-compliance MiPAAF decree No.180 of January 23, 2015 placed this commitment in Annex 1: SECTOR ENVIRONMENT: Climate change and good soil agricultural condition; MAIN THEME: Soil and carbon stocks; GAEC 5: Minimum land management that meets specific conditions to limit erosion. This commitment has the same wording both of the one included in the above Norm 3.1 and in the standard 1.1c of the MiPAAF decree No. 30125/2009.

The change of environmental goal for this standard and its still not optimal finalization in the decree 180/15 is justifiable by considering that Annex II of Regulation (EU) No. 1306/2013 does not include a GAEC rule that takes into account the environmental threat determined by waterlogging in cultivated land. Thus in the decree No. 180/2015 the legislator included this commitment under letter 'c' of the GAEC 5 'Minimum land management that meets specific conditions to limit erosion', believing that in GAEC 5 it was possible to find the best compromise, among all other GAECs, with regard to the environmental objective to be attributed to this commitment. To support the need to better define a GAEC that takes into account waterlogging it must be considered that it determines the degradation of the soil structure, crop yield decrease, root asphyxia and damage to the atmosphere, because of possible increase in N_2O emissions due to denitrification (Allen *et al.*, 2010) and CH_4 emissions, already observable after 7-14 days from waterlogging beginning (Angel *et al.*, 2011; Fenner *et al.*, 2011).

After this necessary clarification it must be said that the effectiveness of the standard 1.1c of MiPAAF decree 30125/2009 was evaluated, in this monitoring, in relation to the environmental objective described in the decree, that is the objective: 'Soil erosion: Protect soil through appropriate measures.' Reading the text that describes this commitment, we understand that the main environmental parameter to be monitored is the conservation of soil structure as correlated to soil erodibility and erosion. As known, a resistant soil structure increases the resistance to erosion (Renard *et al.*, 1997; Cogo *et al.*, 1984). Anyway it must be observed that the standard 1.1c obliges the recipient of direct payments to the maintenance both of farm channel networks and field convexity (Figures 1 and 2).

Also from the text of the decree it is clear that the target land for the application of the Standard 1.1c are those in the plains. Indeed, the decree n. 30125/2009 and also the decree n.180 / 2015 do not specify for the Standard for 1.1c, as is the case for the Standard 1.1a (temporary ditches), that: 'this commitment must be applied to sloping land affected by soil erosion detectable by the presence of rills and where no land set-up systems for soil and water conservation are applied'. Furthermore, also Circular AGEA 2014 Prot. No. ACIU.2014.529 determines the infringement for this standard 1.1c as follows: 'Infringement to this Norm happens when the following non-compliance with commitments applicable to the farm are detected: [...] 1.1.4. absence of maintenance of the hydraulic channel networks, with the simultaneous presence of waterlogging' (Figure 2). No doubt, that legislation allows us to locate in the plain lands the prevailing agricultural context for the application of the standard 1.1c. In fact, the maintenance of field convexity is indicated by the standard between the actions to be taken and it, as well known, is an agronomic practice typical for the plain, finalised to ensure that the 'effective soil depth,[3] is compatible with the success of crops. It is therefore considered important that the presence of soil convexity is included within the criteria of determination of the infringement for this standard. Since the lowering of the water table determined by soil convexity, with the consequent disappearance of stagnant surface water, can take quite a long time (2 to 3 days) after the last rain, it is important to wait for a reasonable time lapse, at least 7 days after the last rain, before certifying the presence of waterlogging on fields.

Field convexity: basics and elements to define the infringement

In order to provide relevant information to the appropriate definition of the infringement concerning field convexity it is important to recall some basic concepts.

Realization of surface field convexity represents an important complement to all land setting for soil conservation in the plain where subsurface pipe drainage is not realized. Field convexity has the aim to prevent the formation of stagnant surface water by helping its outflow towards the ditches positioned along the edges of fields. Without field convexity collector ditches could not effectively perform their function of draining water.

To achieve a convex surface of the land repeated fill ploughing during the years are executed. The same result can be obtained by bulldozers or levelling machinery (Figure 3). The slope of field pitches is modest, in the range of 1-3% (minimum in very permeable soils, maximum in clay soils) but sufficient to prevent the stagnation of water in fine-textured soils with low-permeability (http://it.wikipedia.org/wiki/Baulatura).

Typically, the difference of elevation between the edge of the field along the ditch side and the top elevation in the middle of field is 30-40 cm for land settings adopted in Southern Italy; 60-80 cm in land settings of Emilia and 150 cm in the Paduan countryside. These values can be referred to define criteria for infringement.

[1] Ministry of Agricultural, Food and Forestry Policies.

[2] On 20th November 2008 the EU agriculture ministers reached a political agreement on the 'Health Check' of the Common Agricultural Policy (CAP). The 'Health check' introduced a number of changes to the EU rules for the Single Payment Scheme (SPS) and other direct aid schemes.

[3] Effective soil depth: minimum thickness of the surface soil layer, free from percolation water, necessary for the normal development of plants. It derives from the lowering of the surface aquifer and it is the distance between the soil surface and the top level of the water table in the farthest point from drainage channels after a fairly long period (2 to 3 days) since last rain.

State of the art

In a previous publication on the effectiveness of the Standard 1.1c (Bazzoffi and Nieddu, 2011) the positive effect of the adoption of this standard on predisposing soil to the ideal conditions for the maintenance of the structure has been highlighted.

Particularly relevant are the results of a laboratory study conducted on the effect of the duration of waterlogging on soil structural stability and the results of some previous research from which it appeared that a good drainage of water has the following positive effects: 1) reduces the risk of dispersion of microaggregates in the clay and silt domain responsible for the formation of surface crust; 2) decreases in the risk of decay of the soil structure due to freeze-thaw cycles during winter.

Materials and methods

Location of monitoring sites

The monitoring of standard 1.1c has been performed in three experimental farms (Figure 4):

1. Monitoring farm CREA-ABP, Fagna (Scarperia, FI), Research Centre for Agrobiology and Pedology, Firenze
2. Monitoring farm CREA-FLC, Baroncina (Lodi), Research Centre for Fodder Crop and Dairy Productions, Lodi
3. Monitoring farm Veneto Agricoltura, Vallevecchia (Caorle, VE), Regional Agency for the Agricultural, forestry and agri-food sector, Legnaro (PD)

Figure 1. Waterlogging in a plain of Padua countryside.

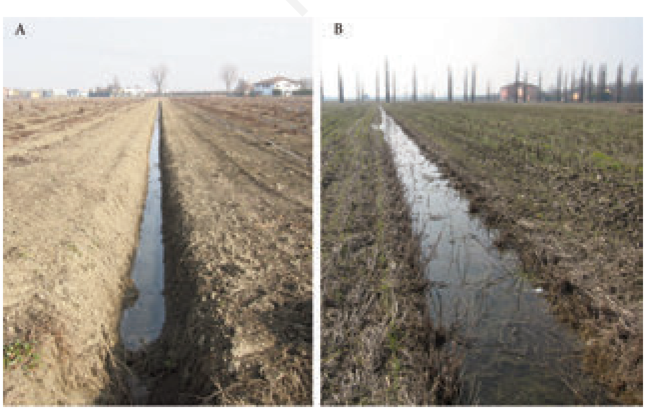

Figure 2. The Standard 1.1c commits to the maintenance of the farm channel network . (A) channel maintained properly and (B) channel invaded by herbaceous vegetation which does not ensure an effective drainage of water from the fields.

Environmental parameter detection method: soil roughness

To assess the environmental effectiveness of the Standard 1.1c, it was chosen the environmental parameter 'soil structure', measured by the surface roughness or cloddiness. In fact, roughness of the soil surface influences soil erosion both directly (Cogo *et al.*, 1984) by decreasing the speed of runoff and by reducing its transport capacity and indirectly by acting on the effectiveness of crop residues in protecting soil.

In the present monitoring the model RUSLE (Renard *et al.*, 1997) has been taken into account, in it a component of the Cover Factor and management of soil 'C' is the subfactor Sr = surface roughness of the soil.

In the present monitoring we considered the RUSLE model (Renard *et al.*, 1997) in which a component of the soil 'Cover and management

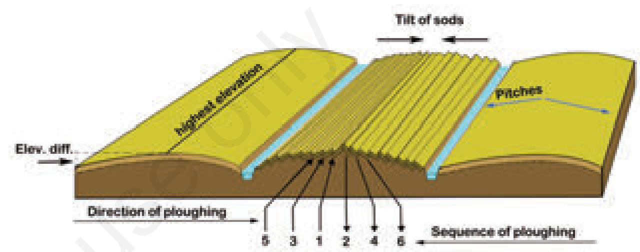

Figure 3. Realization of field convexity through 'working to fill only' and elevation difference to be evaluated in the field to define criteria of infringement. Re-edited image, taken from http://en.wikipedia.org/wiki/Ridge_and_furrow.

Figure 4. Location of the monitoring sites.

Factor' (C) is the subfactor Sr = surface roughness of the soil.

The subfactor Sr is defined as the standard deviation of soil surface elevations cleared from the changes of the surface due to local slope or not random depressions (tracks left by the tractor, oriented incisions made by the man, *etc*.).

A high surface roughness increases the infiltration and decreases the degree of soil sealing determined by raindrop impact (Sumner and Stewart, 1992). On the contrary, a finely granular or even pulverized soil by excessive tillage is prone to seal quickly, with surface crust formation and consequently low infiltration rates and runoff generation.

The subfactor Sr (dimensionless) is calculated by using the following expression:

$$S_r = e^{[-0.026(\mathrm{RR}-6.1)]} \qquad \text{(eq. 1)}$$

where RR is the surface roughness (Random Roughness in mm) and 6.1 mm is the standard reference roughness.

Values of the subfactor roughness lower than 1 are obtained when the surface roughness of the site-specific condition is greater than 6.1 mm, while values higher than 1 are obtained when the site-specific surface roughness is lower than 6.1 mm. The value of the subfactor Sr can vary from about 1.2 for a perfectly smooth surface to less than 0.3 for a very cloddy soil.

The RR (random roughness), the best known index of roughness, in the final drafting of Currence and Lovely (1970) is expressed as the standard deviation of the relative heights of the surface profile sampled according to a regular step or grid:

$$\mathrm{RR} = \sqrt{\sum_{i=1}^{n} (Y_i - \mu_y)/n} \qquad \text{(eq. 2)}$$

where: n is the number of relative sampled heights; $_y$, the arithmetic mean of sampled heights; Y_i the value of each relative eight in the profile (transect).

As said before, to calculate RR (dimensionally a length, L) it is necessary to proceed to a preliminary elimination of non-linear or linear trends that may be present on the entire profile. In the present monitoring the surface roughness of the soil was determined by the index of tortuosity (Boiffin, 1984), defined as the ratio between the total contour length of a surface section of soil along a transect and its projection perpendicular to the plane (Figure 5). In the MO.NA.CO. project the tortuosity index has been detected with the chain method (Bertuzzi *et al.*, 1990), that uses a 100 cm-long 'roller chain' (bicycle chain). In practice the chain is placed on the soil surface and adapted to clods morphology, then the effective length in a straight line between the two ends of the chain is measured (length of chain placed on soil) (Figure 6). The survey is performed on 10 transects perpendicular to the tillage working direction and 10 sections along working direction.

By using the chain method the tortuosity index T is calculated with the following equation:

$$T = \frac{\text{100 cm(length of chain stretched)}}{\text{X cm (effective length in a straight line between the two ends)}}$$

The tortuosity index (T) was converted into the corresponding value of random roughness (RR) through the regression equation (6), with $R^2 = 0.88$, obtained by placing RR as the dependent variable and T as the independent variable on a dataset of 179 observations and processing with the MRIC software (Borselli, 1998) as many surface soil profiles obtained in different previous researches made by CREA-ABP (the equation is valid only for values of RR≤0.3 cm). The summary of the regression is reported in Table 1, while the chart with the expected and observed values in shown in Figure 7.

$$\mathrm{RR\ (cm)} = 89.7117 - 89.6805\ T + 222.1443\ \mathrm{Log}_{10}\ T \qquad \text{(eq. 4)}$$

From the values of tortuosity (T) the corresponding values of Random Roughness were obtained (RR). These values, transformed into mm, allowed to calculate the subfactor Sr using the equation (1).

Methodology for the calculation of environmental parameters susceptibility to crusting and fragility of soil the structure in relation to waterlogging

To evaluate soil susceptibility to crusting, three estimation indices were used: 1) the crusting sensitivity index (Ic_{li}) on the manual: 'Methods of evaluation of soils and lands' (Calzolari *et al.*, 2006) and simplified by Bazzoffi and Pellegrini in this study through a re-elaboration of original data; 2) the NTUratio index (Nephelometric Turbidity Units) (Pellegrini *et al.*, 2005) and 3) the DS index that expresses the fragility of the structure caused by waterlogging (Bazzoffi and Nieddu, 2011).

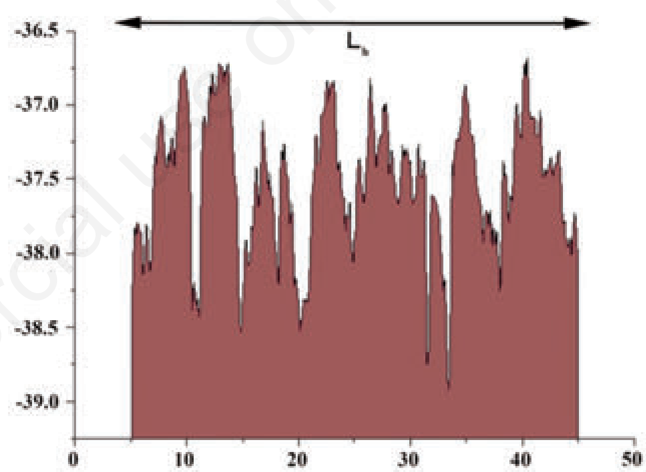

Figure 5. Soil surface transect to calculate the index of tortuosity T.

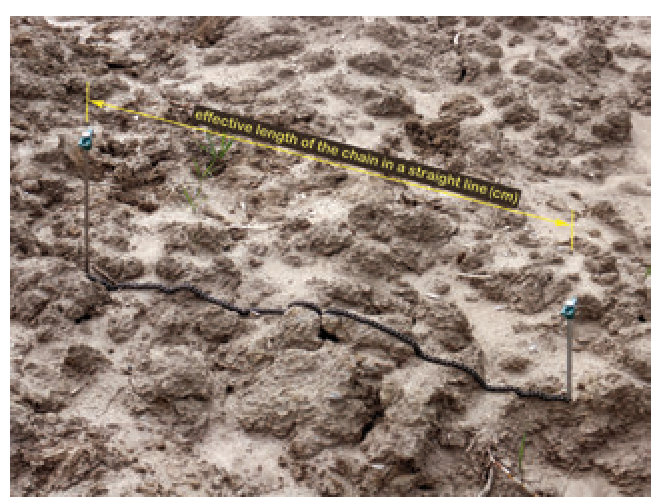

Figure 6. Measurement of the tortuosity index with the chain method. Example of survey of a transect.

Table 1. Regression summary for the variable Random Roughness (RR).

R^2= 0,876 F(2,176)=624.47 P<0.0000 St. Err. of est.: 0.0237

	Beta	Std Err. of Beta	B	St. Err. of B	t(176)	P
Intercept			89.712	9.878	9.082	0.000
Log_{10} T	21.329	2.2506	222.144	23.435	9.479	0.000
T	-20.426	2.2506	-89.681	9.879	-9.078	0.000

Crusting sensitivity index (Ic_{Li})

The orginal Ic index is shown in Equation 5, while the risk classes are reported in Table 2.

$$Ic = (1.5Zf + 0.5Zc)/(C+10\ OM) \quad \text{(eq. 5)}$$

where:
Zf = % fine silt
Zc = % coarse silt
C = % clay
OM = % organic matter

The simplified **Ic_{Li}** index (where it is considered the total silt, Li, instead of the two fractions: coarse silt and fine silt) used in this study is calculated by the following equation:

$$Ic_{Li} = Li/(C+10\ OM) \quad \text{(eq. 6)}$$

where:
Li=(-0.0734 + 1.126 % total silt)
C = % clay
OM = % organic matter

The simplification equation, whose summary is shown in Table 3, is the following:

$$Li = (-0.0734 + 1.126\ \%\ \text{total silt}) \quad \text{(eq. 7)}$$

The expected and observed values of the variable Li with the regression model are shown in Figure 8.

Soil crusting sensitivity index (NTU_{ratio} estimated)

With this index the structure decay was evaluated indirectly through aggregate stability tests performed through the turbidimetric method (Dexter and Czyz, 2000) that measures in NTU (Nephelometric Turbidity Unit) the turbidity of a dispersion of soil in water after stirring.

The index used in this monitoring is as follows:

$$NTU_{ratio} = NTU_{1h}/NTU_{18h} \quad \text{(eq. 8)}$$

where NTU_{1hand} NTU_{18h} represent turbidity values after 1 h and 18 h of stirring (NTU g-1 L-1), the latter corresponding to the maximum amount of dispersible clay.

Soil structural Stability measurements using this method were carried out on 19 soils (different respect grain size distribution and / or organic carbon content), in order to check how the NTU ratio index varies in function of these two parameters. From data processing it has been possible to formulate the following model for estimating NTU:

$$NTU_{ratio\ estimated} = 0.6844 + (0.00134 \cdot (\%\ silt)) + (-0.42014 \cdot \log_{10}(\%\ organic\ matter)) \quad \text{(eq. 9)}$$

Table 2. Classes of risk of soil crusting according to the Ic index.

Ic	Crusting risk
<1.2	Low
1.2-1.6	Moderate
>1.6	High

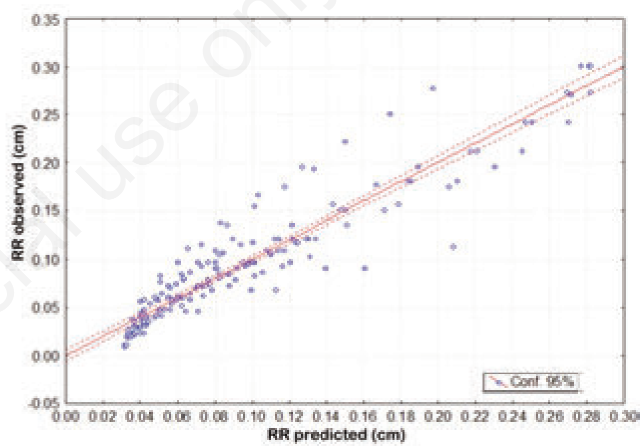

Figure 7. Expected and observed RR values with the regression model (eq. 6).

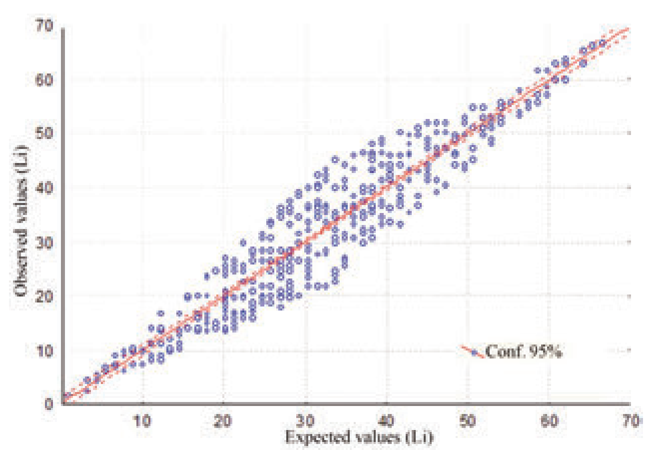

Figure 8. Expected and observed values of the variable Li with the regression model.

Table 4 shows the Regression summary. The expected and observed values of the variable NTU_{ratio} with the regression model are shown in Figure 9.

Through Table 5 it is possible to assign the crusting-risk class from the estimated value of NTU_{ratio}

DS index of soil structural fragility determined by waterlogging

Bazzoffi and Nieddu (2011) developed an index to define the disaggregation of soil structure determined by wetting-drying cycles.

The percentage of disaggregation DS is a function of the number of wetting-drying cycles and the percentage of clay + silt, according to equation (10)

$$DS = 37.0078 + \frac{130549.02}{x^2} - 0.0041 \cdot y^3 \quad \text{(eq. 10)}$$

Table 6 shows the risk classes of soil disaggregation according to DS index.

Monitoring site: Fagna farm

General features

The farm (Figure 10) is located at Fagna (Scarperia, province of Florence), the WGS84 coordinates of the farm centroid company are: N 43° 58' 53.35"; E 11° 20' 57.27". The average elevation is 247.6 m asl. The soils evolved on the Pleistocene (Villafranchiano) lacustrine clay and silt deposits; floods and in the (Holocene) sand and gravel alluvial deposits.

The soils are moderately deep, with clay to clay loam texture, with strong vertic characters, very calcareous, from weakly to strongly alkaline, rather poorly drained. They are classified as fine Typic Udorthents (Soil Survey Staff, 2014). The dominant clay minerals are: illite, kaolinite and halloisite.

Table 7 shows the morphological and chemical characteristics of the monitoring plots (surface soil horizon 0-20 cm). Rainfalls observed during the monitoring period are shown in Figure 11.

Description of monitoring in the Fagna farm

The compared theses were two:

FACTUAL-TREATMENT: cleaning and maintenance of the collector channel to keep it in perfect functionality. The cleaning of the channel was performed by a passage with single-wheel rotary ditcher to

Table 5. Soil crusting risk classes according to the estimated value of NTUratio.

$NTU_{ratio\ estimated}$	Soil crusting risk
<0.48	Low
0.48-0.63	Moderate
>0.63	High

Table 6. Soil disaggregation risk classes according to different values of the DS index.

Percent soil disaggregation DS	Fragility of soil structure determined by waterlogging
0-20	Low
21-50	Moderate
51-100	High

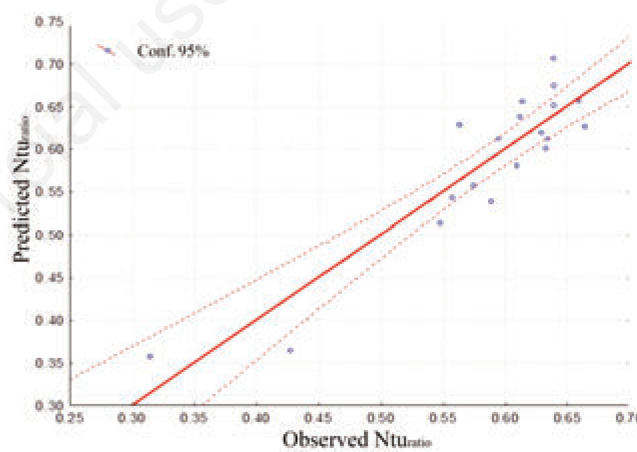

Figure 9. Observed and predicted values of the variable NTU_{ratio} through the regression model.

Table 3. Regression summary for the variable Li.

$R^2 = 0.89$, $F(1,398)=3090,1$; $P<0.0000$; St. Err. of est.: 4.8932

	Beta	Std. Err. of Beta	B	St. Err. of B	t(398)	P
Intercept			-0.0734	0.632	-0.117	0.907
Total silt	0.9417	0.017	1.126	0.0203	55.589	0.000

Table 4. Regression summary for the variable NTU_{ratio} estimated.

$R^2 = 0,83$; $F(2,16)=39.202$; $P<0.000$; St. Err. of est. 0.041

	Beta	Std. Err. of Beta	B	St. Err. of B	t(16)	P
Intercept			0.6844	0.0604	11.3277	0.0000
Total silt %	0.1203	0.1033	0.0013	0.0011	1.1642	0.2614
$\log_{10}$ (Org.matter.%)	-0.9140	0.1033	-0.4201	0.0475	-8.8460	0.0000

clean the grassy-shrubby vegetation.

COUNTERFACTUAL-TREATMENT: collector channel in the absence of maintenance and kept in condition of functional degradation (silted and clogged by herbaceous-shrubby vegetation).

Surveys carried out

Surveyed parameters: Surface roughness of soil, on 21st March 2013 and on 28th March 2014 and agronomic evaluation of fields condition by means of qualitative judgment (pPreserved, sufficiently preserved, degraded, very degraded).

Economic competitiveness gap

The measurement of working time and fuel consumption for the Standard 1.1c has been done in the factual thesis during the cleaning operation of channels. CO_2 emissions related to fuel consumption for cleaning channel were derived from the amount of fuel used.

Monitoring site: Baroncina Farm

General features

The Baroncina farm (Figure 12) is located near Lodi. The WGS84 coordinates of the farm centroid are: N 45° 17' 32.97"; E 9° 29' 54.45". The average elevation of the farm is 73 m asl.

The monitoring sites are located in two fields neighbouring with the farm as shown in Figure 12.

The farm is located on fluvioglacial sandy gravel river flood deposit. Soils are classified as Ultic Haplustalfs (Soil Survey Staff, 2014) with sandy loam texture. The substrate is located at a depth varying from 132 to 150 cm.

The monitoring plots have the morphological characteristics and chemical properties (surface horizon 0-20 cm) reported in Table 8.

Rainfalls observed during the monitoring period are shown in Figure 13.

Description of the monitoring in the Baroncina farm

The compared theses were two:

FACTUAL-TREATMENT: cleaning and maintenance of the collector channel to keep it in perfect functionality. The cleaning of the channel was performed by a passage with a 18-knife brush cutter.

COUNTERFACTUAL-TREATMENT: collector channel in the absence of maintenance and kept in condition of functional degradation (clogged by herbaceous-shrubby vegetation).

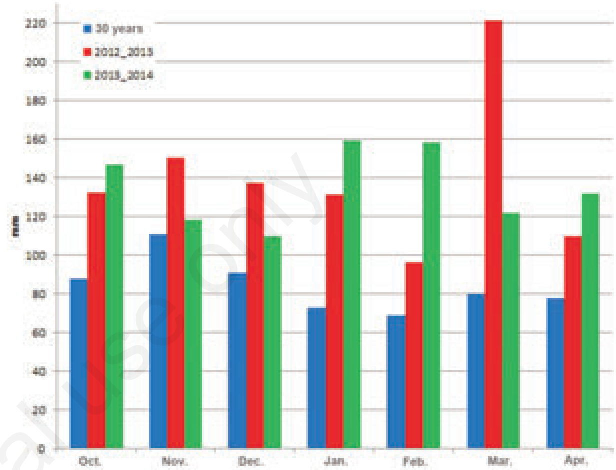

Figure 11. Fagna farm. Monthly rainfall during the monitoring period and average rainfall in thirty years.

Figure 10. Fagna farm (CREA-ABP) and location of the monitoring plots for Standard 1.1c.

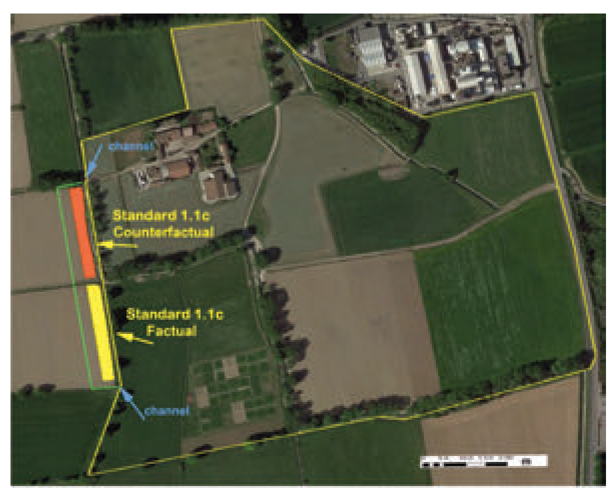

Figure 12. Baroncina farm (CREA-FLC) and location of the monitoring plots for the Standard 1.1c.

Table 7. Characteristics of soil in the monitoring plots for standard 1.1c at Fagna.

	Gravel, >2000 µm (%)	Total sand, 53-2000 µm (%)	Silt, 20-53 µm (%)	Clay, 2 µm (%)	pH (1:2.5) H_2O	$CaCO_3$ (%)	Organic matter (%)
Factual	0	19.79	35.65	44.428.11	15.01	1.81	
Counterfactual	0	13.88	42.05	40.318.32	21.42	1.86	

Surveys carried out

Surveyed parameters: Surface roughness of soil, on 1st March 2012 and on 20th March 2013. On 25th March 2014 the agronomic evaluation of fields condition by means of qualitative judgment (preserved, sufficiently preserved, degraded, very degraded) was done.

Monitoring site: Vallevecchia farm

General features

The Experimental Farm Vallevecchia (Figure 14) is located in the municipality of Caorle (Venice). The WGS84 coordinates of the farm centroid are: N 45° 37' 45.49"; E 12° 57' 20.92". The average elevation of the farm is 0-1 m above sea level.

The farm is located in the coastal dunes and sandy calcareous-dolomitic coastal formations. The soils of Vallevecchia are Entisuoli classified as Gleyic Fluvic Cambisols (Soil Survey Staff, 2014) and have a strong tendency to form surface crust.

The weather conditions during the period: autumn 2012-spring 2013 was dominated by sequences of intense and numerous rainfall events. The total rainfall of 2013 at Vallevecchia was more than 300 mm above the average, especially in the months of March and April. Thus, determining predisposing conditions for waterlogging. The monitoring plots have the morphological characteristics and chemical properties (surface horizon 0-20 cm) reported in Table 9. Rainfalls observed during the monitoring period are shown in Figure 15.

Description of the monitoring in the Vallevecchia farm

The compared theses were two:

FACTUAL-TREATMENT: cleaning and maintenance of the collector channel to keep it in perfect functionality.

COUNTERFACTUAL-TREATMENT: collector channel in the absence of maintenance and kept in condition of functional degradation.

Surveys carried out

Surveyed parameters: Surface roughness of soil, on 29th March 2013, 8th May 2013, 16th January 2014, and on 28th March 2014 and agronomic evaluation of fields condition by means of qualitative judgment (Preserved, sufficiently preserved, degraded, very degraded) was done.

To set up the monitoring plots 'factual' and 'counterfactual' the following operations were executed: In November 2012 the cleaning of the master channel and secondary channels was done in the 'factual' part of farm. The 'counterfactual treatment was obtained without cleaning the master channel and secondary channels. It was also decided to accentuate the situation of bad water draining by blocking the flow of water through the realization of a small earth barrier within the master channel.

Results of monitoring

Table 10 and Figure 16 show the average of the measured values of the tortuosity index (T) in the three farms in relation to the two treatments: Factual (collector channel cleaned) and Counterfactual (collector channel clogged). Table 4 shows the Duncan test of mean separation from which it is demonstrated that in the Fagna farm soil roughness in the factual treatment resulted significantly higher, 5.9% more than the counterfactual. In the Vallevecchia farm the mean difference (Factual minus Counterfactual) was 2.6% without reaching statistical significance, while in the Baroncina farm no differences between the theses were detected.

In Table 11 the significance tests for the tortuosity index (T), thesis Factual *vs*. Counterfactual of the three farms is shown. Considering all of the three farms together the factual treatments show an average index T significantly superior to counterfactual (Table 12 and Figure 17). The mean separation with the Duncan test shows that the mean value of the index T for the factual treatment is significantly higher,

Table 8. Characteristics of soil in the monitoring plots for Standard 1.1c at Baroncina.

Monitoring site	Gravel, >2000 µm (%)	Total sand, 53-2000 µm (%)	Silt, 20-53 µm (%)	Clay, 2 µm (%)	pH (1:2.5) H_2O	$CaCO_3$ (%)	Organic matter (%)
Factual and Counterfactual	0	54.10	38.21	8.11	6.0	0	2.11

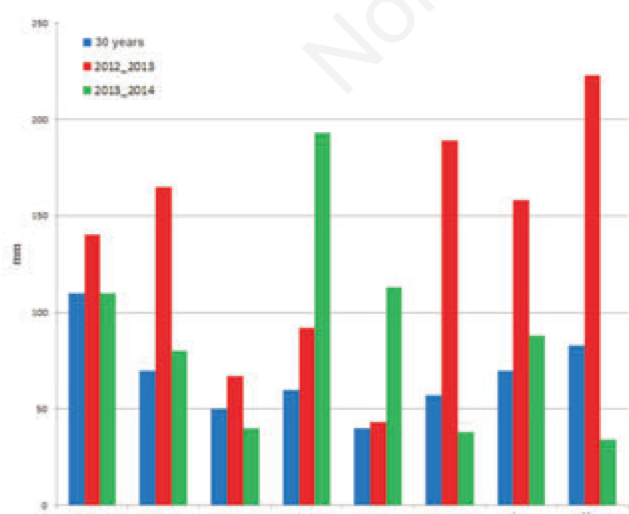

Figure 13. Baroncina farm. Monthly rainfall during the monitoring period and average rainfall in thirty years.

Figure 14. Vallevecchia farm (Veneto Agricoltura) and location of monitoring plots for the Standard 1.1c.

2.7% more than the counterfactual treatment.

Despite the statistical evidence found, it must be said that the change in surface roughness factor (T) and RR factor (derived from T) in favour of factual treatment is so small as not to take any practical significance in order to affirm that the functional maintenance of channels has been effective. The same can be said about the subfactor Sr of the equation (1) whose change in favour of the reduction of soil erosion is so small as to be irrelevant. Overall, soils resulted destructured and crusted at the end of the observation period.

The indices Ic_{li}, NTU, and DS show a structural fragility of soil classified from medium to high for the three farms soils. This explains the lack of agronomical appreciable differences of the soil roughness parameter, in relation to heavy rains and long lasting waterlogging periods occurred in the cropping years of monitoring. Table 13 shows the overall judgment of structural fragility of soil in relation to waterlogging soil and the risk of crusting for soils of the monitoring farms based on the indices Ic_L, NTU and DS. In addition to measures of surface roughness, qualitative agronomic judgment of fields conditions at times of measurements were made (Table 14 and Figure 18). These observations evidence that waterlogging events were quite frequent in the months of monitoring, because of the very heavy rains much higher in quantity than long-term averages. That is because farm channel network could not effectively drain excess water, even in factual treatments.

Competitiveness gap for the Standard 1.1c – Maintenance of farm channel networks

To assess the competitiveness gap the cost of machining was calculated using data from field surveys carried out during the course of farming operations.

For each type of operation, by using the project database, the average cost has been calculated (Table 15). In addition, the values obtained by subtracting and adding to the mean value the standard deviation (indicated in Table 15 as highest and lowest machining cost limits) were calculated. The monitoring of the competitiveness gap for these standards was carried out on plots planted with wheat. For calculating the economic balance for this crop, a simplification was adopted: input costs and revenues from the sale of the grain were disregarded. That was possible because they did not affect the competitiveness gap, as

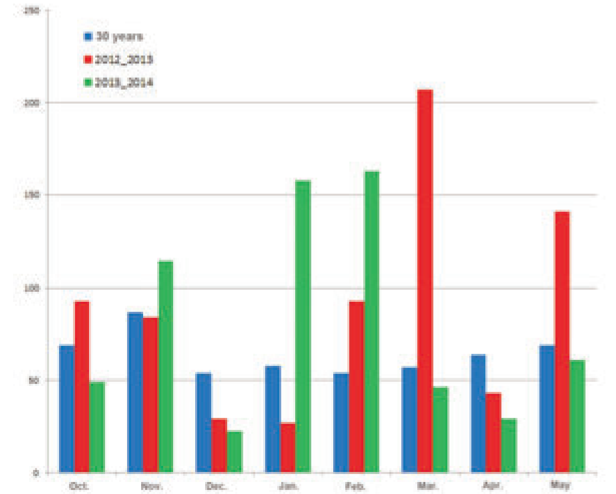

Figure 15. Vallevecchia farm. Monthly rainfall during the monitoring period and average rainfall in thirty years.

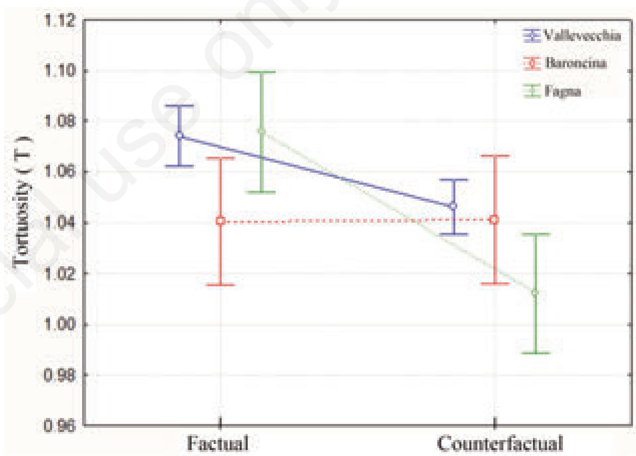

Figure 16. Mean values of the tortuosity index (T); Factual *vs* Counterfactual separately on the 3 farms. Vertical bars show ±95% confidence.

Table 9. Characteristics of soil in the monitoring plots for Standard 1.1c at Vallevecchia.

	Gravel, >2000 μm (%)	Total sand, 53-2000 μm (%)	Silt, 20-53 μm (%)	Clay, 2 μm (%)	pH (1:2.5) H_2O	$CaCO_3$ (%)	Organic matter (%)
Factual and Counterfactual	0	18.1	51.4	30.5	7.9	62.02	1.62

Table 10. Differences of factor T (tortuosity and derived indices RR and Sr) in the three monitoring farms in relation to the Factual and Counterfactual treatments.

Homogeneous groups, alfa = 0.05 Error: MS between groups= 0.0029, d.f. = 250.00

Farms	Factual Counterfactual	Tortuosity (T)	Duncan Test Mean separation			Roughness RR	Sub factor Sr
Fagna	CF	1.012	****			0.107	1.139
Baroncina	F	1.040	****	****		0.229	1.104
Baroncina	CF	1.041	****	****		0.231	1.103
Vallevecchia	CF	1.046		****	****	0.245	1.099
Vallevecchia	F	1.074			****	0.282	1.089
Fagna	F	1.076			****	0.282	1.089

they were identical in the two conditions (factual and counterfactual). It was taken as a reference the land setting for soil conservation widespread in some areas of the Po Valley (said Ferrara scheme), where farmland drainage permanent channels are parallel to each other and distant about 33 meters on average. Therefore it can be assumed that in one hectare of land, of a square shape, 3 collectors 100 m long each are present. This corresponds to a total length of 300 m ha^{-1} (Bazzoffi *et al.*, 2011). It was calculated the difference between the total costs for mechanical working both for factual (adherence to the commitments of the standard) and counterfactual conditions (non-adherence to the commitments). The competitiveness gap amounted to 19.89±6.35 € ha^{-1} $year^{-1}$. Atmospheric CO_2 emissions due to fuel consumption amounted to 14.5 ±6.62 kg ha^{-1} $year^{-1}$.

Conclusions

The monitoring confirmed a positive effect of the maintenance of the channel network on preparing soil to the maintenance of structure.

In the Fagna farm soil roughness was 5.9% higher in the treatment factual than in the counterfactual. In the Vallevecchia farm that difference was 2.6% while in Baroncina farm no differences between the theses were detected.

Despite the statistical evidence found, it must be said that the change in the surface roughness factor (T) and the derived Sr factor of RUSLE model (to estimate erosion) is so small as not to take any practical significance in order to assert that the functional maintenance of collector channels have been effective.

Overall, soils resulted destructured and crusted at the end of the observation period.

The indices Ic_{li}, NTU, and DS show a fragility of soil structure from medium to high for soils of the three monitored farms. This explains the lack of agronomically appreciable differences in the parameter soil roughness, due to heavy rains and long lasting periods of waterlogging occurred in the crop years of monitoring.

In addition to measures of surface roughness qualitative assessments of the conditions of the fields were carried out at times of meas-

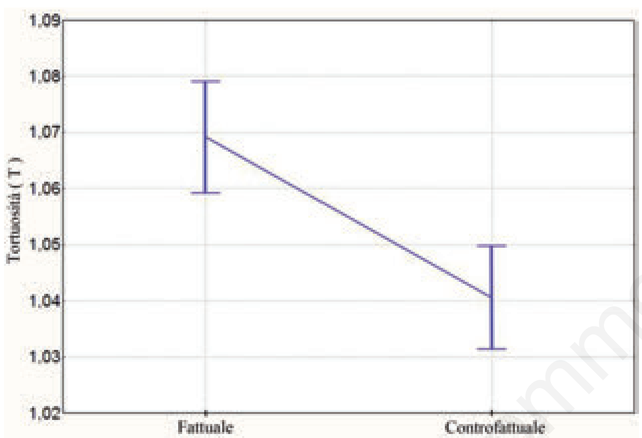

Figure 17. Significance tests for the tortuosity index (T); Factual vs. Counterfactual on the 3 farms as a whole. Vertical bars show ± 95% confidence.

Figure 18. Evidence of structure degradation and crust formation in the Fagna farm.

Table 11. Significance test for the tortuosity index (T), thesis Factual vs Counterfactual for the 3 farms.

	SS	d.f.	MS	F	P
Intercept	169.334	1	169.33	58333.78	0.000000
Location	0.017	2	0.0083	2.86	0.058883
Thesis (F *vs.* CF)	0.035	1	0.035	12.08	0.000600
Location*Thesis	0.020	2	0.010	3.44	0.033720
Error	0.726	250	0.003		

d.f., degree of freedom.

Table 12. T factor differences (tortuosity and derived indices RR and Sr) for the whole three monitoring farms in relation to the Factual and Counterfactual treatments.

Homogeneous groups, alfa=0.05 Error: MS between groups = 0.003, d.f. = 254.0

Treatment	Tortuosity (T)	Duncan Test mean separation		Roughness RR	Sub factor Sr
CF	1,041	****		0,230	1,165
F	1,069		****	0,281	1,163

urements. It was noticed that waterlogging events were frequent in the months of monitoring because of abundant rains, much higher in quantity than long-term averages. That is because farm channel network could not effectively drain excess water, even in factual treatments. The competitiveness gap due to the adoption of this standard amounted to 19.89±6.35 € ha^{-1} year^{-1} in terms of working costs. Atmospheric CO_2 emissions due to fuel consumption amounted to 14.5 ±6.62 kg ha^{-1} year^{-1}.

It is considered important to point out that at the present Annex II: 'Rules of conditionality' of Regulation (EU) No. 1306/2013 do not includes a BCAA taking into account the environmental threat determined by waterlogging in cultivated lands, the potential prejudice to

Table 13. Overall judgment of structural fragility of soil and the risk of crusting for soils of the monitoring farms.

Monitoring site	Input parameters for models Total sand (%)	Total silt L (%)	Clay (%)	Org. matter (%)	Risk indices Ic_{Li}	NTU	DS	Overall judgment on the fragility of soil structure and risk of crusting
Fagna	13.88	42.05	40.31	1.86	0.80 (L)	0.63 M)	56.25 (H)	Medium
Baroncina	54.1	38.21	8.11	2.11	1.47 (M)	0.60 (M)	97.85 (H)	Medium to high
Vallevecchia	18.1	51.4	30.5	1.62	1.24 (M)	0.67 (H)	56.47 (H)	Mostly high

L, low; M, medium; H, high (risk classes).

Table 14. Qualitative assessment of the state of the fields at the time of surface roughness surveys.

Farm	Season	F/CF	Judgment of soil surface condition	Waterlogging ponds
Baroncina	Winter 2012	F	Degraded with presence of soil crust	Present
	Winter 2012	CF	Degraded with presence of soil crust	Present
	Winter 2013	F	Degraded with presence of soil crust	Several
	Winter 2013	CF	Degraded with presence of soil crust	Several
	Spring 2014	F	Clods sufficiently conserved	Absent
	Spring 2014	CF	Clods sufficiently conserved	Absent
Fagna	Spring 2013	F	Clods sufficiently conserved	Absent
	Spring 2013	CF	Degraded with presence of soil crust	Several
	Spring 2014	F	Clods sufficiently conserved	Present
	Spring 2014	CF	Degraded with presence of soil crust	Several
Vallevecchia	Winter 2012	F	Degraded with presence of soil crust	Several
	Winter 2012	CF	Degraded with presence of soil crust	Several
	winter 2013	F	Degraded with presence of soil crust	several
	winter 2013	CF	Degraded with presence of soil crust	several
	spring 2014	F	Degraded with presence of soil crust	present
	spring 2014	CF	Degraded with presence of soil crust	present

Table 15. Competitiveness gap for the cultivation of wheat determined by the average values of machining. Upper and lower limits obtained by adding and subtracting the standard deviation to the mean value of the individual machining costs.

Machining operations	Lowest limit of working cost (€ ha^{-1} y^{-1})		Mean value of working cost (€ ha^{-1} y^{-1})		Highest limit of working cost (€ ha^{-1} y^{-1})	
	In adoption of cross compliance rules	Not in adoption of cross compliance rules	In adoption of cross compliance rules	Not in adoption of cross compliance rules	In adoption of cross compliance rules	Not in adoption of cross compliance rules
Ploughing	139.51	139.51	210.17	210.17	280.82	280.82
Harrowing	28.04	28.04	50.08	50.08	72.12	72.12
Fertilization	3.50	3.50	6.86	6.86	10.21	10.21
Sowing	24.93	24.93	39.01	39.01	53.08	53.08
Rolling	16.02	16.02	19.32	19.32	22.62	22.62
Weeding	4.87	4.87	6.78	6.78	8.68	8.68
Combine harvesting	93.98	93.98	126.64	126.64	159.29	159.29
Maintenance of channels	13.54		19.89	26.24		
Total cost of agricultural machining	324.40	310.86	478.73	458.84	633.06	606.82
Competitiveness gap (€ ha^{-1} y^{-1})	13.54		19.89		26.24	

soil, crops and the atmosphere, due to the possible production of greenhouse gases. Thus the legislature has done well to put in the cross-compliance decree n. 180/2015 the commitment under letter 'c' included in the GAEC 5- Minimum land management that meets specific conditions to limit erosion. The presence of the GAEC commitment 5 (c) is identical to the Standard 1.1c of the MiPAAF decree 30125/2009 allowed not to neglect the environmental importance of waterlogging, although the obvious shortcomings detected in that Annex II of Regulation (EU) 1306/2013 has forced the legislator to finalize the commitment to limit erosion according to GAEC 5. Evidently, this finality is irrational from the point of environmental threats to counteract through the commitment (c) of GAEC 5, which are very different and inconsistent with the environmental threat represented by soil erosion. As regards the criteria of infringement to this standard it is suggested the introduction of the verification of the presence of convexity in the fields of the plain. Typically, the difference of elevation between the edge of the field along the ditch side and the top elevation in the middle of field is 30-40 cm for land settings adopted in Southern Italy; 60-80 cm in land settings of Emilia and 150 cm in the Paduan countryside. These values can be referred to define criteria for infringement. In addition to that, since the lowering of the water table determined by field convexity, with the subsequent disappearance of stagnant water, may take quite a long period (2 to 3 days) after the last rain, it is important to wait for a reasonable time lapse, at least 7 days after the last rain, before certifying the presence of waterlogging on fields

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