SOC sequestration in a 4 year conventional and conservative rotation

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THEME 2

INTRODUCTION

Estimation method

SOC sequestration estimation is decisive in a Life Cycle Assessment that covers an agricultural phase. However, the limited availability of data often does not allow the application of SOC dynamics simulation models in daily or monthly steps. The aim of this work was to implement a physically based, simplified computational model, to provide guidance on how to increase the SOC sequestration in the top-soil horizon (0-30 cm), taking into account both site-specific characters and the cropping system. The Hénin-Dupuis model provided the conceptual basis, by estimations of the constants (k1 and k2).

Fig. 1: The Hénin-Dupuis model

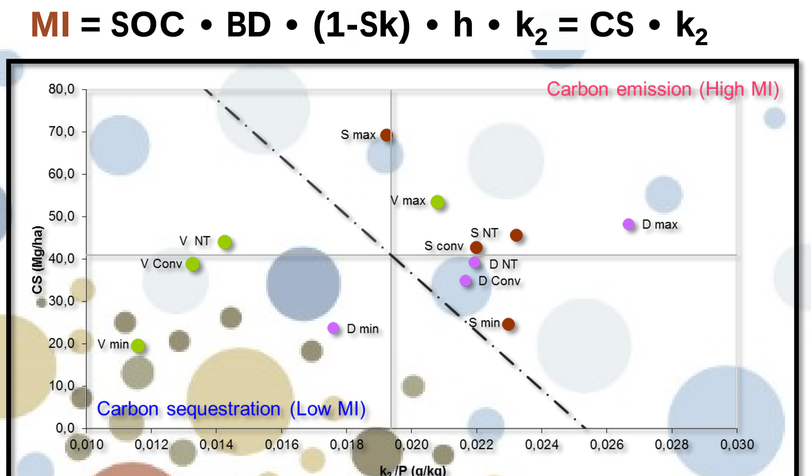
Specific residual biomass, agricultural practices (P) (i.e. tillage, irrigation and organic fertilizers), site mean annual air temperature (T), SOC, bulk density (BD), coarse materials (Sk), clay content (A) and total carbonates (CaCo3) were considered.

Tab. 1: Values of adopted k1 and biological stability index (BSI)
BSI • OM = k1 • M
OM stand for Organic Matter, M stand for Raw Organic Matter

	Zea mays	*Glycine max*	*Triticum aestivum*	*Brassica napus*	*Sorghum vulgare*	*Hordeum vulgare*	*Vicia sativa*	*Roots*	Digestate
BSI	0.13	0.11	0.06	0.16	0.04	0.11	0.08	0.16-0.18	0.36
k1	0.12	0.10	0.06	0.12	0.03	0.09	0.07	0.15	0.26

$$k_2 = P \cdot \frac{1200 \cdot 0{,}2 \cdot (T-5)}{(200 + A) \cdot (200 + 0{,}3 \cdot CaCO_3)}$$

$$MI = SOC \cdot BD \cdot (1\text{-}Sk) \cdot h \cdot k_2 = CS \cdot k_2$$



Graph 1: K2/P characterising soils at the start of simulation

The amount of SOC potentially mineralized each year per volume unit was estimated, by the mineralization index (MI), characterising soils with high and low MI..

OBJECTIVES

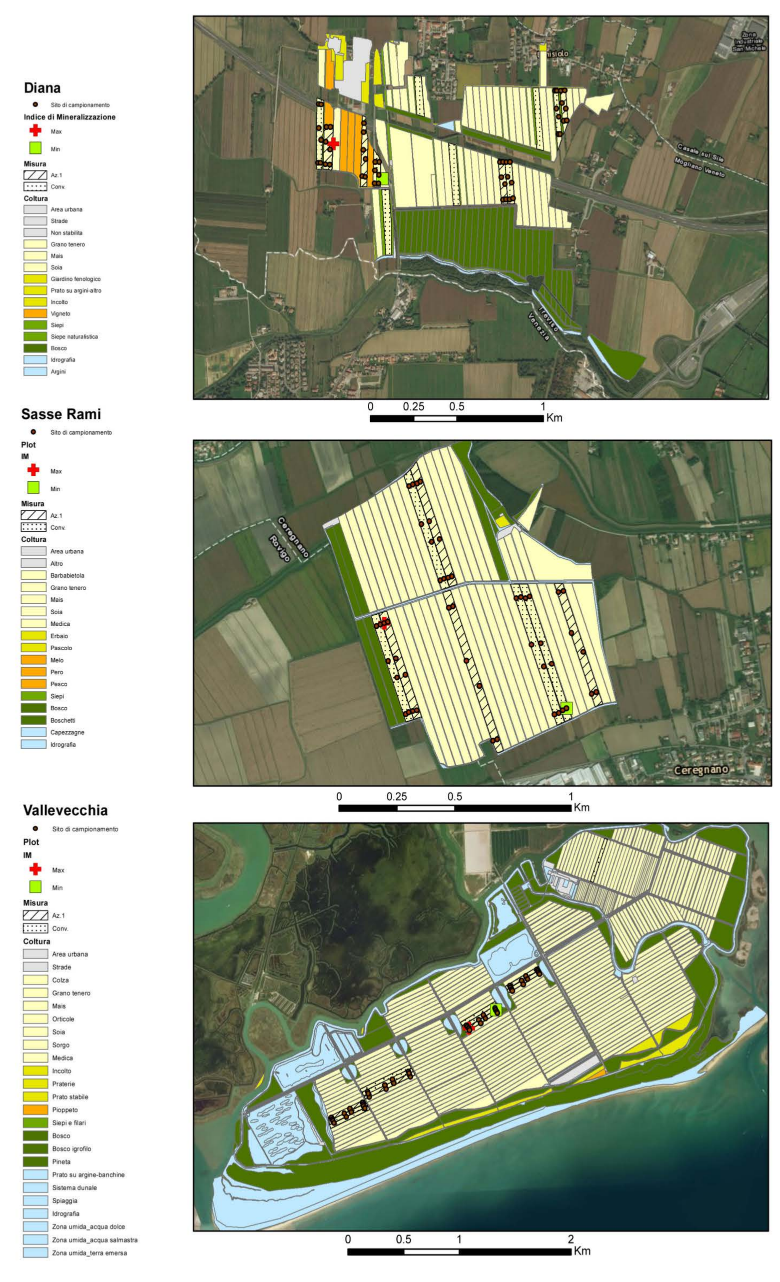


Fig. 2: Extract of the ArcGis project: Sampling sites, maximum and minimum MI, arable lands (white), permanent grassland (yellow), tree crops (orange), hedge and wood (green) and natural areas (blue)

Cropping systems

In 3 Veneto Agricoltura experimental farms, a three-year monitoring has been conducted. It involved the collection of a 564 georeferenced sampling sites data set related to 32 plots of about 1.5 hectares each.

The sod seeding four-year rotation involved the use of cover-crops (in red) :

- 1st y: *Zea mays* L. cv korimbos;
- 2nd y: *Hordeum vulgare* L. + *Vicia sativa* L. - *Glycine max* (L.) cv Demetra;
- 3rd y: *Triticum aestivum* L. cv Aubusson - *Sorghum bicolor*
- 4th year *Brassica napus* L. cv Excalibur - *Sorghum bicolor*
- 5th y *H. vulgare* + *V. sativa* - *Z. mays* ... The Conventional had the same rotation without cover crops.

Tab. 2 Amounts of organic material incorporated in soil. Crop residues do not include roots.

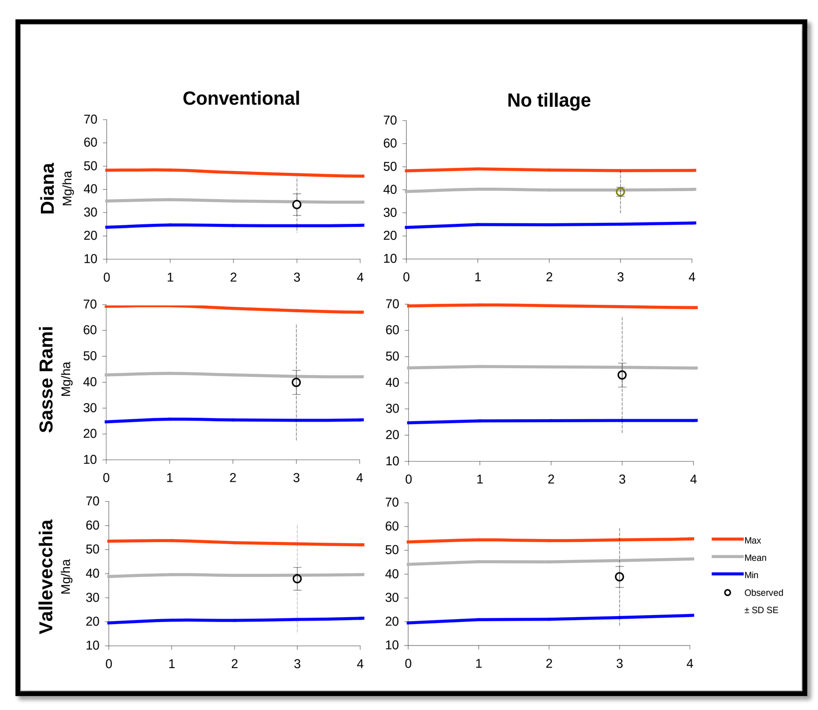
Mg/ha (dry matter)	*Zea mays*	*Glycine max*	*Triticum aestivum*	*Brassica napus*	*Sorghum vulgare*	*Hordeum vulgare*	*Vicia sativa*
Conventional							
Diana							
crop residues	16.96	2.31	5.70	6.97			
roots	2.28	0.49	2.36	1.17			
Sasse Rami							
crop residues	18.19	4.51	6.41	7.82			
roots	3.51	0.71	2.15	1.97			
Vallevecchia							
crop residues	13.17	2.90	9.27	8.30			
roots	4.53	0.54	3.76	1.36			
No tillage							
Diana							
crop residues	17.76	1.58	4.74	6.13	1.93	0.53	0.054
roots	2.05	0.38	1.48	1.10	0.79	0.12	0.008
Sasse Rami							
crop residues	11.15	4.90	4.91	1.78	1.51	0.43	0.075
roots	2.78	0.68	1.29	0.71	0.23	0.31	0.014
Vallevecchia							
crop residues	17.10	2.52	8.23	9.14	3.64	0.35	0.026
roots	3.28	0.53	3.63	1.31	1.02	0.31	0.005
Digestate	7.6	0	5.6	4.5			

Three scenarios have been compared:

- Conventional intensive management;
- Full replacement of mineral nitrogen with digestate from energy crops and industrial products;
- No tillage with cover crops

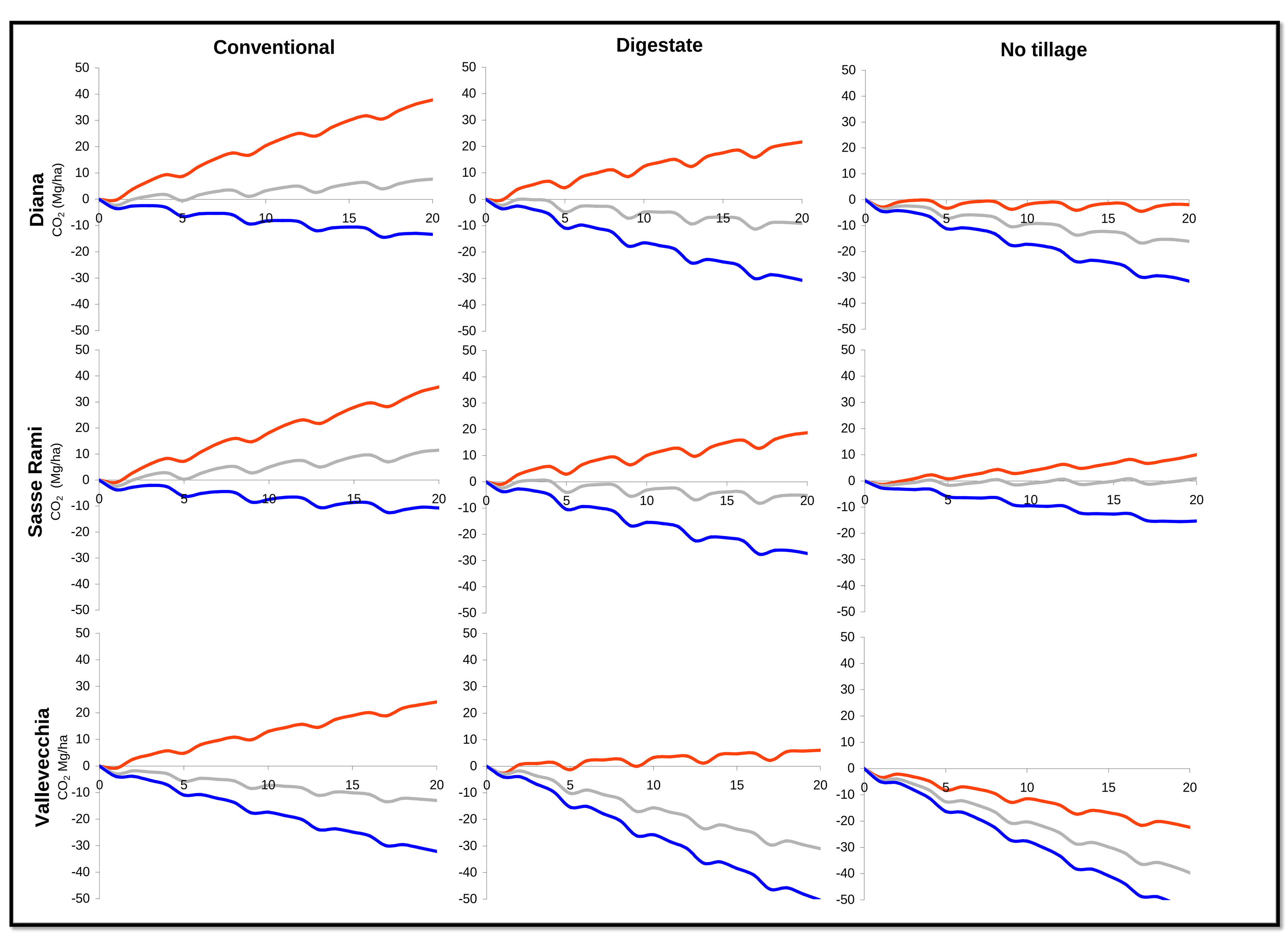
MAIN RESULTS

The model ran on soils with mean characters for each farm and each scenario and validated on SOC measured values in 2012, 2013 and 2014. Outputs were compared with those of 2006 IPCC model. The time interval of 3 years resulted inexcessively reduced relation of data variability.



Graph 2: Predicted and observed Carbon stock (CS). Bars: standard error (full) and standard deviation (dashed)

While the estimates of the soil carbon stock (that take into account BD) after 4 years, is more accurate, an exception is given by Vallevecchia farm (particularly in no tillage plots) where the clay fraction also contains carbonate rocks (dolomite and calcite).



Graph 3: SOC sequestration estimation (<0) or the emissive character (> 0) of soils with maximum, medium and minimum mineralization potential in the different scenarios

The protection of the mineralization induced by carbonates seems overestimated by the model, suggesting a possible adjustment.

In soil with minimum MI full crop residues incorporation allows for carbon stock sequestration.

On mean soils, conventional farming scenarios show low emissions, while conservative ones show carbon sequestration. Sod seeding and cover crops seem to reach slightly higher sequestration and lower variability between different sites than digestate, replacing N applied with mineral fertilization.

CONCLUSION

The model quantifies site-specific C sequestration or depletion, useful to provide guidance to the objective of the 4 ‰ yearly SOC increase proposed by the Climate Change Conference, Paris 2015. Furthermore, it could be used to assess the effect of different management practices (different organic fertilization or agro-forestry) on carbon stock changes.