ASSESSMENT OF AGRO-ECOLOGICAL DESCRIPTORS RESPONSIVE TO SOIL QUALITY AND CARBON SEQUESTRATION IN CONTINENTAL MEDITERRANEAN AGROECOSYSTEMS

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The increasing of atmospheric concentration of CO_2 in the last years has been mainly caused by anthropogenic activities such as fossil fuel burning and land use change. Soil biological degradation associated with the progressive decrease in soil organic matter (OM) and biomass C contents is an important factor leading to C emission from soil to the atmosphere, being closely linked to the loss of soil quality. Both recent European agroenvironmental policy focusing on conservation agriculture and the increased interest in the economical benefits of organic crops are requiring monitoring tools to assess the quantitative changes in the agrobiogeochemical functioning of soils. In this work, the aim was dual: i) selecting agro-ecological indices to assess the impact of conventional agriculture as regards organic agriculture in terms of soil quality, and ii) finding out soil descriptors to predict soils' potential C sequestration, related to the interest of properly-managed soils for alleviating the greenhouse effect.

Material and methods

Soil samples from conventional and organic farms in 20 representative farms from Segovia (Central Spain) were analysed for agro-ecological descriptors including chemical fertility status, OM (total concentration and degree of decomposition), mineralization rates, soil colour indices and nematode trophic groups. Organic farms performed crop rotations (barley-wheat-vetch) and used organic amendments (compost and manure), whereas conventional farms used mineral fertilizers. Multivariate non-linear statistical models were applied to classify the set of soil descriptors, so as to establish numerical taxonomy patterns between the soil samples set and the quantitative impact of soil use and management.

Results and discussion

The results obtained by multidimensional scaling applied to the matrix of normalized Euclidean distances between soil descriptors clearly showed independent trends that could be related either to the OM quality or its total quantity. The comparatively high OM concentration (soils behaving as potential C sinks) was associated with descriptors such as pH, P_2O_5, electric conductivity, exchangeable bases, iron-to-red ratio and total abundance of Enchytraeids, whereas other descriptors of soil quality such as the low content of free OM (labile OM pool) were associated with mineralization rates, ratio between soil colour brightness-to-soil C, total abundance of *Heterodera avenae* and CO_2 release for 0–3 day (stage I). Factorial discriminant analysis classified the above agro-ecological descriptors in terms of the response of soils to conventional or ecological agriculture (Fig. 1). In the former plots the soils showed high laboratory C mineralization rates, a comparatively high concentration of free OM and prevalence of phytoparasitic nematodes (*H. avenae*). In general, these soils showed a comparatively low α-biodiversity index.

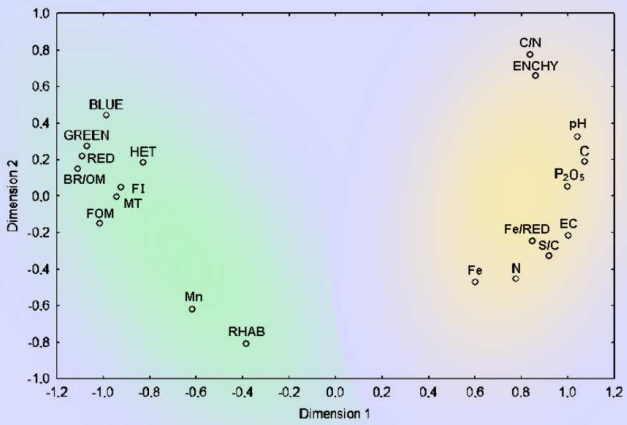

Figure 1. Non-linear mapping (Kruskal´s method) from a soil data matrix composed by the previously-selected soil descriptors: BR/OM: ratio between soil brightness-to-organic matter; EC: electrical conductivity; ENCHY: Enchytraeids; Fe/RED: red colour intensity-to-iron content, FI: carbon mineralization 0–3 day; FOM: free organic matter; HET: *Heterodera avenae*; MT: total mineralization rate; RED: red colour intensity; RHAB: rhabditids; S/C: bases-to-carbon ratio.

Some digital colour soil data processed as ratios of specific soil chemical data behaved as useful local agro-ecological descriptors of soil quality and moisture regime, such as *the ratio between soil brightness-to-OM*, which suggested high humification degree for ecological plots, *the red colour intensity-to-iron content*, probably responding to the soil oxidation degree, also related to seasonal water saturation, and the portion of the soil C concentration variance not fully explained by management factors.

Finally, the application of non-linear mapping (Kruskal´s method) to a soil data matrix including the previously-selected soil descriptors was useful for the quantitative agro-ecological reappraisal of a series of scenarios defined by different resilience and sustainability: whereas high changes in the overall soil properties were calculated in sites 8–16, 7–15 and 10-18, corresponding to polycultures vs. barley monocultures, the opposite situation, indicating that soil properties have not yet taken advantage of organic farming, was found in 9–17 (cereal vs. polyculture) sites (Fig. 2).

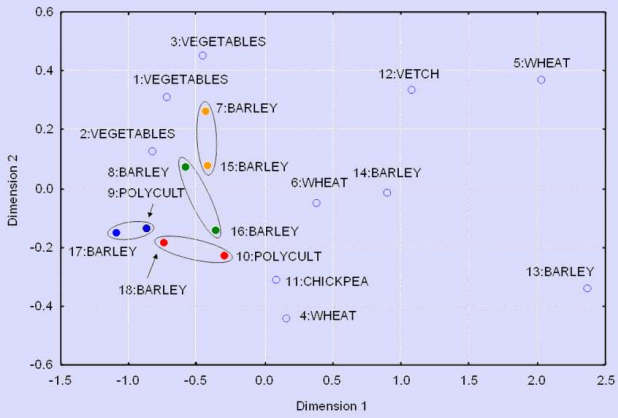

Figure 2. Non-linear mapping (Kruskal´s method) from the soil data matrix, indicated distance in the plane after the dimensional reduction.

Conclusions

The results suggest that total quality and quantity of OM are in general unrelated features and would require independent determination through suitable local descriptors in order to discuss the economical and environmental benefit of the management practices. Some digital soil colour data taken as ratios of specific soil chemical data (i.e., the ratio between soil brightness-to-OM and the red colour intensity-to-iron content) resulted valid agro-ecological descriptors of soil quality in terms of management. Factorial discriminant analysis classified soils in terms of conventional or organic agriculture, also depending on the response time after implementation of the corresponding practices (crop rotations and organic amendments). Finally, classifying soil samples by non-linear mapping after the previous screening of soil descriptors led to a quantitative agro-ecological assessment of the extent of the changes in the overall soil properties.

References

Kruskal, J. B. 1964. Psichometrika 29:1–27.