SOIL QUALITY IN RELATION TO SOIL MANAGEMENT AND PLANT COVER IN A SEMIARID MEDITERRANEAN ENVIRONMENT

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1.- INTRODUCTION

In the last years, research on soil degradation has been focused on the study of the called "soil quality indicators". Soil quality indicators refer to measurable soil attributes that influence the capacity of soil to perform crop production or environmental functions (Ashard, 2002). The selection of a minimum number of key indicators and their threshold values is actually one of the main objectives. In semiarid Mediterranean environments human induced changes in vegetation cover can accelerate soil degradation, in such an extent that it could be irreversible by originating desertification (Albaladejo et al., 1998). Shrubs and grasses occupy extensive areas in semiarid SE Spain, where there exists some controversy in relation to the convenience to afforest these zones. To study soil quality under the different vegetation cover could be an useful tool to help at decision-makers. Then, it would be necessary to look for an adequate set of soil quality indicators.

2.- OBJECTIVES

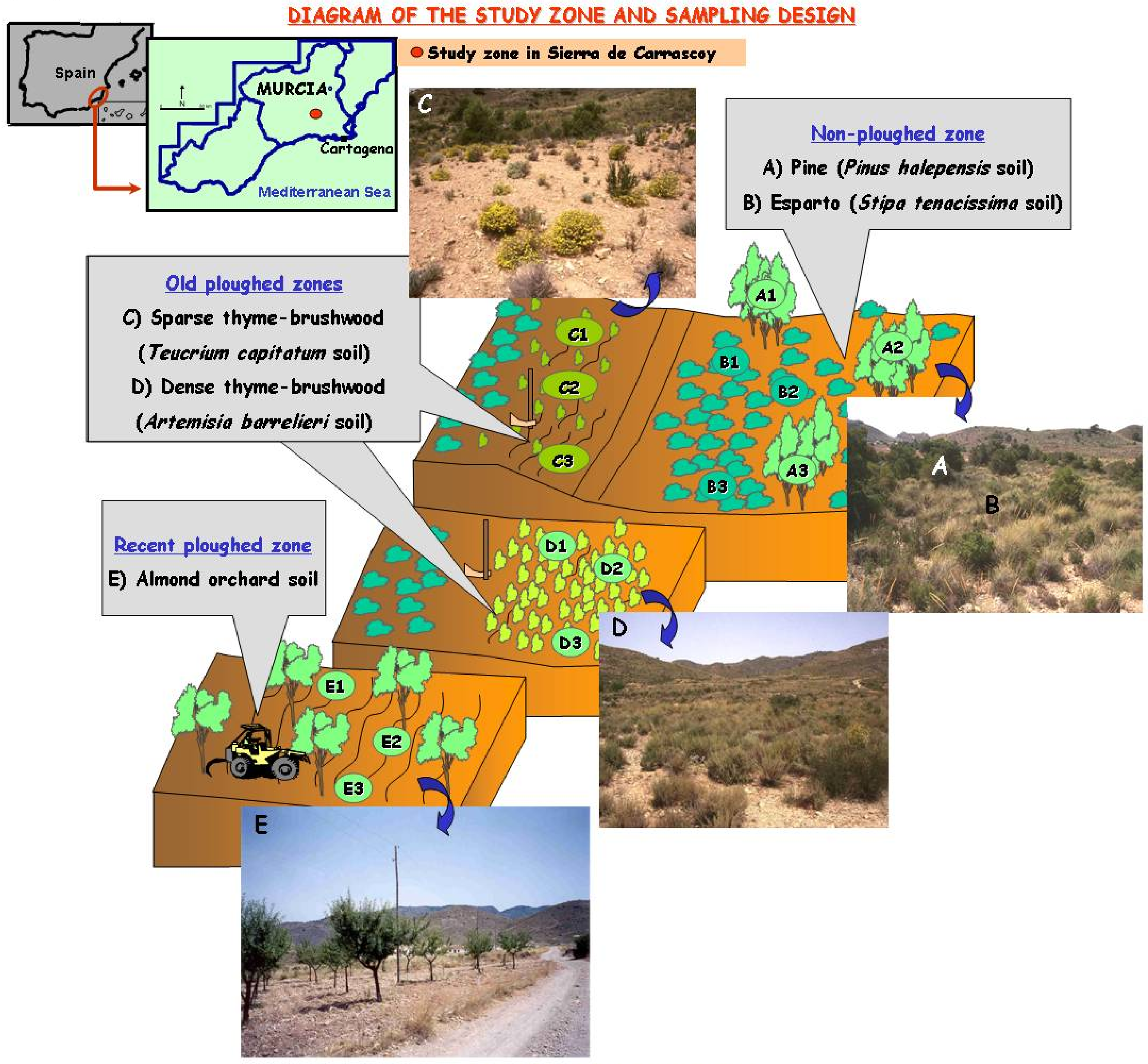
The aim of this study was to make a first approach to establish soil quality in a semiarid Mediterranean environment. The following conditions were studied: a) rizhospheric soil from four native plant species in non-ploughed and old ploughed zones; and b) rizhospheric soil from one species in a recently cultivated zone.

3.- MATERIAL AND METHODS

Three surface 20 cm soil samples were randomly taken from the rhizosphere of each plant species as follow. In non-ploughed zones the samples were taken in a) Pinus halepensis (pine) and b) Stipa tenacissima (esparto) soil; in old ploughed zones samples were taken in a) Teucrium capitatum soil from a sparse thyme - brushwood (tomillar) 20-30% cover and b) Artemisia barrelieri soil from a dense thyme - brushwood (60-70% cover); and in recently ploughed zones samples were taken from almond orchard soil. Each sample was composed by three randomly sub – samples. The sampling sites were distributed along transects (50 to 70 m long) following the slope gradient (one sample in the upper part, other in the middle part and another in the lower part). The study zone is located at 450 m above sea level (average slope of 6 – 8%). The climate is semiarid Mediterranean (mean annual rainfall 300 mm; mean annual temperature 17ºC; mean annual evapotranspiration 850 mm year-1). The most abundant soils in the zone are Haplic Calcisols (FAO, 1998) with loam and silty - loam texture (Faz, 1997).

Electrical conductivity (EC) and pH were measured in a soil:water 1:1 suspension. Total organic carbon (TOC) was determined by oxidation with $K_2Cr_2O_7$. The humic substances (HS) were extracted with 0.1 M $Na_4P_2O_7$, pH=9.8, in a solid:liquid ratio of 1:3. The fraction of fulvic acids (FA) was extracted after acidification of HS, pH=2, with H_2SO_4. Humic acids (HA) were obtained by difference between HS and FA. Water soluble carbon (WSC) was obtained by agitation (2 h at 600 cycles/min) in 1:3 soil:water suspension. Carbon from HS, FA and WSC was determined by wet oxidation with $K_2Cr_2O_7$ and measurement of the absorbance at 590 nm. Stability of soil structure was estimated by the mean weigh diameter (MWD). MWD was determined in 2-4 mm aggregates by fast wetting (MWDfw) and mechanical breakdown by shaking after pre-wetting (wet stirring, MWDws) according to Le Bissoniais (1996). EC, pH, TOC, FA, HA and WSC were analysed by duplicate and MWD by triplicate.

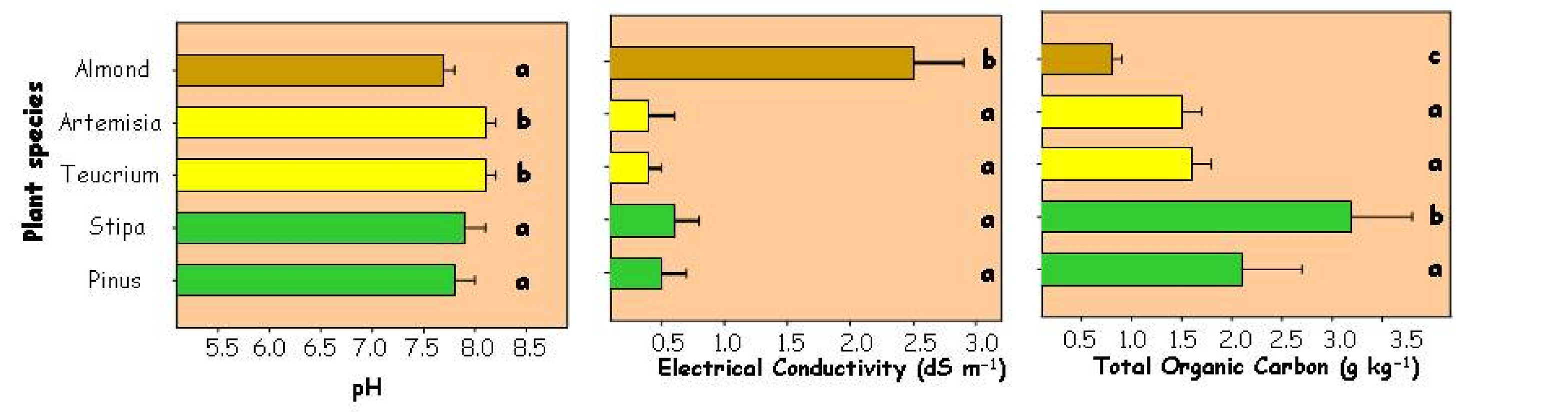
DIAGRAM OF THE STUDY ZONE AND SAMPLING DESIGN



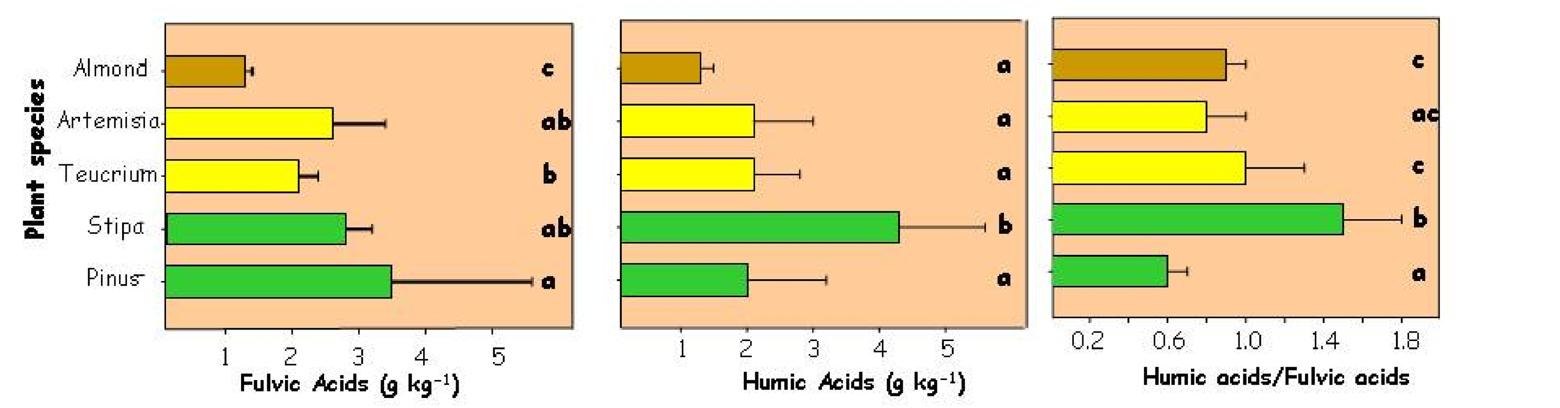
4.- RESULTS AND DISCUSSION

We did not study the same species in all the soil conditions, so we can not be sure of the combined effect of the management and species. However, after the abandonment of disturbed areas (such as those of the old agricultural uses) the recovering of the vegetation is difficult and several regressive plant communities appear, such as shrubs and thyme - brushwoods (Peinado et al, 1992). If we consider the existence of different species in old ploughed zones as a consequence of the soil disturbance, and these species influence soil characteristics in the root zone, we can infer a relation between land management and soil characteristics in the rizhosphere. In fact, the species studied were selected as representative of the different type of vegetation in each land management zone.

Significant differences in pH and EC were obtained between plant species (ANOVA, $p<0.001$). In spite of the statistical differences, the pH values were closed to 8.0 and their variations are not indicative of differences in soil quality. However, the EC values showed a degradative process by anthropic salinization in almond soil from the recently ploughed zone, probably due to the poor quality of irrigation water, the mineral fertilisation or both.



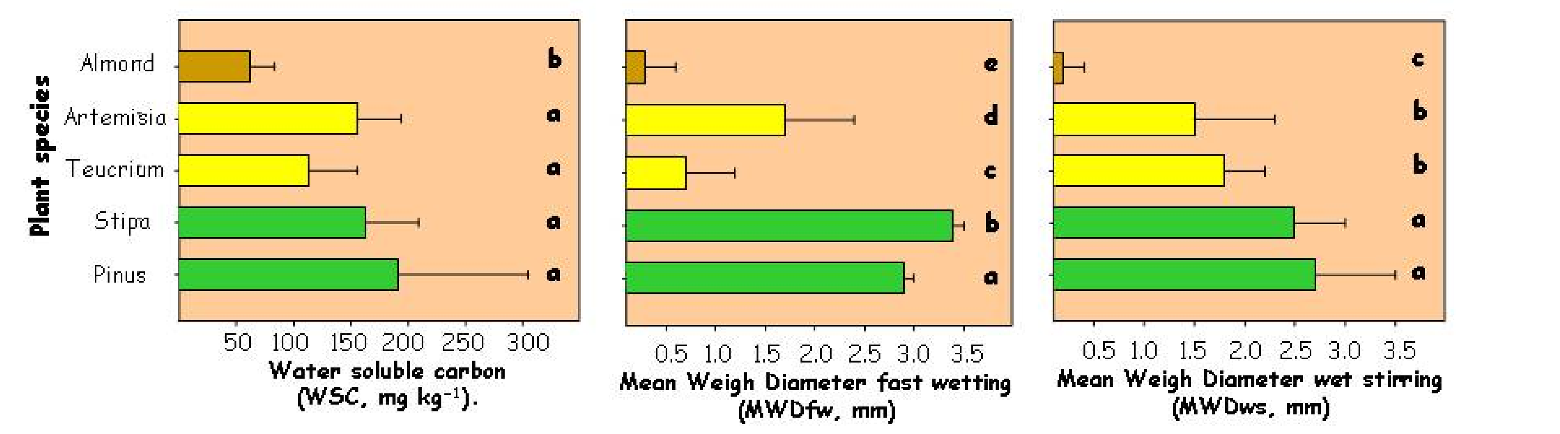
Total organic carbon was higher in rizhospheric soil from *Pinus* and *Stipa* (non-ploughed zones) than from *Teucrium* and *Artemisisa* (old ploughed zones), and it was higher in the latter than in almond soil (recently ploughed zone). FA and WSC did not show a pattern related to the species, except in the case of almond (recently ploughed soil had the lowest FA and WSC contents). HA was only significant different in *Stipa* soil, and WSC in almond soil. *Pinus* and *Stipa* soils showed a different pattern of humification with the highest labile compounds under pine (FA = 3.5 g kg^{-1} and WSC = 191 mg kg^{-1}) and the highest recalcitrant organic matter under *Stipa* (HA = 4.3 g kg^{-1}). These results can be due to the different origin and composition of fresh organic matter (from leaves decay in *Pinus* and from a dense root system in *Stipa*). The higher quantity of lipids in coniferous leaves than in grasses roots (Labrador, 1996) can make difficult polymerization and formation of HA in *Pinus* soil. Aranda et al. (2002) found similar tendencies when comparing soil from *Pinus* afforestation with soil from native shrubs.



The MWD values showed clear differences in soil structure between species. The highest MWD values were found in Pinus (2.9 and 2.7 mm) and Stipa soils (3.4 and 2.5 mm), both from the non-ploughed zone, and the lowest ones in almond soil (0.3 and 0.2 mm) from recently the ploughed. Teucrium and Artimisia soils (old ploughed) showed intermediate values. Fast wetting (the treatment that implies the highest energy, Le Bissoniais, 1996) best discriminated between plant species, and it indicated a better structure in Stipa soil than in Pinus soil and in Artemisia soil than Teucrium soil.

The relation between soil structure and organic carbon fractions was not clear. Teucrium and Artemisia soils had FA, HA and WSC similar to the content in soils from Pinus and Stipa soils. Several possibilities could contribute to the results obtained.

The high stability of the structure in Pinus soil would be favoured by the high quantity of fresh plant remains. The presence of this material in soils from thyme-brushwood is scarce. Puget et al. (2000) indicated that formation and stabilisation of macro aggregates is favoured by particulate organic matter (= plant debris). Fresh plants remains were scarce in Stipa soils, but the dense root system and the high quantity of HA can favour the structure. Lastly, although labile organic carbon is very important for the maintenance of soil structure, the microbial activity in the rhizosphere has been indicated as the main factor in soil aggregation (Caravaca et al., 2002). Since the root system is more developed under Pinus and Stipa than under Teucrium and Artemisia, a higher aggregate stability is expected, possibly as a consequence of a higher microbial activity.



5.- CONCLUSIONS

Among the soil characteristics analysed, EC, FA and aggregate stability better discriminated among the soil from the different species. TOC, HA and WSC seem to be good indicators of degradation in recently ploughed zones, but their variability did not permit accurately discriminate between different types of vegetation in zones actually non-ploughed. Due to the spatial and seasonal variability of the soil characteristics measured, and the possible influence of particular species in the characteristics of their rizhospheric soil, more data are needed in order to confirm the tendencies observed before selecting the best set of soil quality indicators in semiarid Mediterranean areas.

No evidences of degradation were found in *Stipa tenacissima* soil when comparing with *Pinus* soil. Moreover, soil under *Stipa* showed the highest total organic carbon content, the best humification and the strongest structure.

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