Original Scientific paper
10.7251/AGRENG2002107K
UDC 631.41

EVALUATION OF SOIL QUALITY PARAMETERS IN SILVOARABLE SYSTEMS

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ABSTRACT
Agroforestry is considered a sustainable cultivating methodology in comparison to intensified and one-dimension agriculture, resulting in higher yields, socio-economic benefits and environmental protection as well. The silvoarable systems constitute classification of the agroforestry systems that involve crops and trees in the same spatiotemporal scales. One of the most important benefits related to the productivity of silvoarable systems is the maintenance or improvement of soil quality. In the present study, qualitative characteristics of soils in traditional silvoarable systems in the area of Mouzaki, central Greece, were studied through the determination of basic soil parameters, including the organic matter content, total nitrogen, exchangeable potassium and available phosphorus. All systems under investigation were characterised as boundary hedgerows (livefences). The trees in the hedgerows may include mulberry, wild pear, wild walnut, and other wild tree types typical of the Mouzaki landscape, whereas the understorey crops were both arable and horticultural. Within the research areas, the effect of the trees on the concentration of the selected soil parameters was investigated. Soil samples were collected in all systems at two depths (0-30 and 30-60 cm) and at three distances from the selected trees, corresponding to half, twice, triple or quadruple the tree canopy width. The results of the research provided evidence of C sequestration in all soils under investigation, thus indicating the positive effect of agroforestry systems on the environment.

Keywords: *Traditional agroforestry systems, Silvoarable systems, Soil fertility, Organic matter, Macronutrients.*

INTRODUCTION
Agroforestry is a dynamic natural resource management system, which results in diversified and sustainable production via the integration of trees on farms and in the agricultural landscape, leading to social, economic and environmental benefits (FAO, 2015). The silvoarable systems constitute classification of the agroforestry systems that involve crops and trees in the same spatiotemporal scales. Agroforestry systems can deliver a wide range of ecosystem services and

environmental benefits, including biodiversity conservation, carbon sequestration, soil enrichment and water and air quality improvement (Jose, 2009). Soil conservation is one of the most important promises of agroforestry in temperate regions (Nair, 2011).

The role of trees is multiple, as on the one hand, they can offer products, such as timber, firewood, food for humans and animals, and on the other hand, services, such as soil protection from erosion, soil fertility, weed control, shading for animals and humans and habitat provision for wildlife (Schultz *et al.*, 1987). Trees may have several other positive effects on arable productivity, including among others, reduction of evaporative water losses by acting as windbreaks, lifting of drainage water to the upper soil horizons, reduction in crop transpiration through shading especially in arid areas, and protection against ground frosts in colder climates (Eichhorn *et al.*, 2006). Trees may also improve soil physical, chemical and biological properties through the addition of significant amount of above and belowground biomass and releasing and recycling nutrients in agroforestry systems (Eichhorn *et al.*, 2006; Nair, 2011).

Traditional agroforestry systems in Greece cover an estimated area of approximately 3 million hectares, or 23% of the whole country (Papanastasis *et al.*, 2009). Silvoarable systems show great diversity in Greece, as a large variety of combinations of trees and crops exist, and trees are either dispersed through the fields, or at margins, as boundary hedgerows (Eichhorn *et al.*, 2006). Most traditional agroforestry systems in Greece appear unorganized, rather as remnants (Vrahnakis *et al.*, 2014). The Municipality of Mouzaki in central Greece is one of the areas where traditional silvoarable systems are still maintained. However, they are gradually being abandoned in the upland, as a significant portion of the population moves to towns and cities in the lowland. On the other hand, in the lowland silvoarable systems tend to be replaced by crop monocultures, thereby decreasing soil and water quality and deteriorating landscape values (Vrahnakis *et al.*, 2016).

The aim of the present study was to evaluate qualitative characteristics of soils of traditional silvoarable systems in the area of Mouzaki through the determination of basic soil parameters, including organic matter content, total nitrogen, exchangeable potassium and available phosphorus.

MATERIALS AND METHODS

The study took place in three cultivated fields, located in the Municipality of Mouzaki, on the southwestern edge of the Thessalian plain, in central Greece, during the time period between June 2019 and February 2020. The fields under investigation are traditional smallholder silvoarable systems, in the form of boundary hedgerows (livefences).

The first field (Area 1) was located in the lowland, at an altitude of approximately 180 m. The understorey crop was vine, whereas the hedgerow included a variety of fruit tree species, such as wild figs, pear, and apple, and also mulberries. The other two fields were located in the upland, at an altitude of approximately 480 m. The second field (Area 2) was a young walnut orchard. At the time of sampling, the walnuts were 6 years of age. Walnuts planting distance was 10 x 10 m, with no intercropping. The hedgerow consisted predominantly of wild oaks and wild walnuts. In the third field (Area 3), the understorey crop was clover and the hedgerow included a mixture of wild trees, predominantly wild oak, walnut, and pear, and also blackberries.

The effect of the hedgerow trees on the concentration of selected soil parameters was investigated. In each field, three trees were selected on the same one side of the hedgerow. Mean canopy width were 7.9, 13.0 and 12.1 m for Areas 1, 2 and 3, respectively. For each one of the three trees, soil samples were collected along the line starting from the tree and directed vertically to the hedgerow, at three sampling points, corresponding to a distance of half, twice, triple or quadruple the tree canopy width (Figure 1). At each sampling point, soil samples were collected at the depths of 0-30 cm and 30-60 cm.

Soil samples were air-dried, ground, sieved (2 mm) and analyzed for texture (Bouyoucos method), concentration of organic matter (Walkley-Black method), total N (Kjeldahl method), exchangeable K (ammonium acetate method) and available P (Olsen method).

The data sets were analyzed using the statistical software SPSS version 26 (IBM Corp., Armonk, N.Y., USA). ANOVA was performed at a significance level of 0.05 and means were compared by Duncan test.

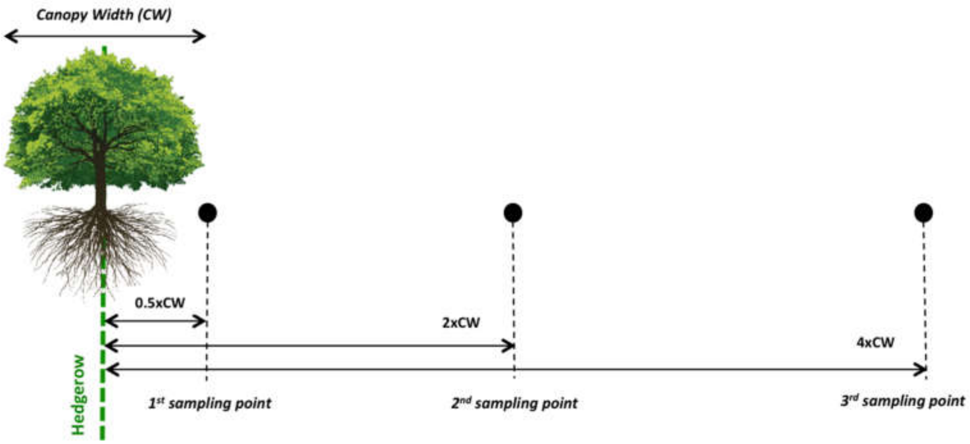

Figure 1. Schematic general layout of the soil sampling points per tree on the hedgerow.

RESULTS AND DISCUSSION

The soil texture of the first field in the lowland was clay loam in both the upper (0-30 cm) and lower (30-60 cm) layer. In the upland, both fields were of sandy clay loam texture, also in both layers.

All soil properties under investigation, i.e. organic matter content, total N, available P and extractable K, were found not to be significantly influenced by the distance of the sampling point from the tree row, in all three fields. Oelbermann and Voroney (2007) also found that after 13 years of alley cropping in a silvoarable system in Southern Canada, soil organic C and N pools did not differ significantly with distance from the tree row. Work by Gikas *et al.* (2016) in Northeastern Greece, also showed no statistically significant difference between distances from the tree row for Olsen P.

Soil organic matter content (OM) was significantly higher in the upper layer (0-30 cm) than in the lower layer (30-60 cm) (Figure 2), indicating accumulation of organic material in the upper horizon. The effect of depth on soil OM was particularly evident in the upland fields (Areas 2 and 3). The increase in soil organic matter content with elevation, can be explained by the change of climatic conditions with altitude (Ramesh *et al.*, 2019).

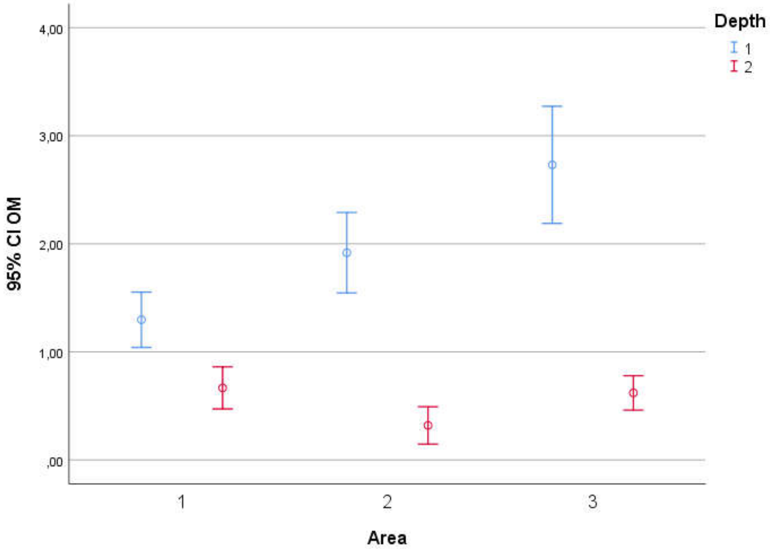

Figure 2. Mean and confidence interval 95% of soil organic matter content (%) for depths 1: 0-30 cm and 2: 30-60 cm from areas: 1, 2 and 3.

Soil total N followed the same trends with OM (Figure 3). The simultaneous increase in soil organic matter and N suggests organic C sequestration in the soil (Horwath and Kuzyakov, 2018), thus resulting in important environmental benefits.

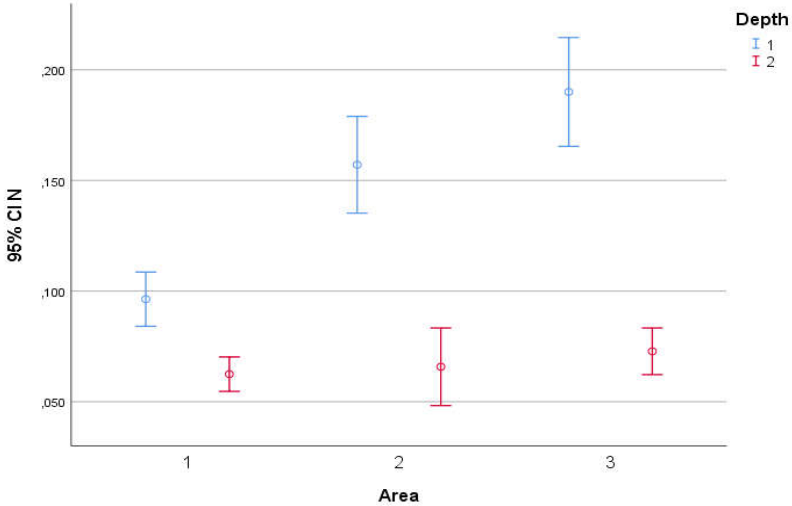

Figure 3. Mean and confidence interval 95% of soil total N (%) for depths 1: 0-30 cm and 2: 30-60 cm from areas: 1, 2 and 3.

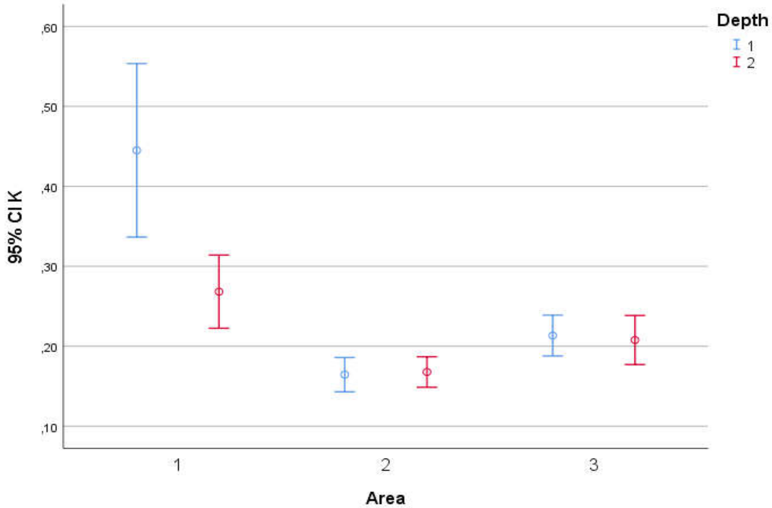

Figure 4. Mean and confidence interval 95% of soil exchangeable K ($cmol_c$ kg^{-1}) for depths 1: 0-30 cm and 2: 30-60 cm, from areas: 1, 2 and 3.

Soil exchangeable K was found to be low, in both the upper and lower layers, in both fields in the upland (Areas 2 and 3) (Figure 4). The field in the lowland (Area 1) showed higher concentration of exchangeable K in the upper layer, compared to the other two fields. Even in this later case, however, the soil exchangeable K content was a little higher than low. Soil available (Olsen) P content was found to be low in Area 2 in both depths under investigation (Figure 5). Medium content of soil available P was found in the lower layer of Area 1, whereas in the upper layer of Area 1 the soil available P content was high. In the case of Area 3, in the lower layer (30-60 cm), there was a trend for lower P concentration in the first sampling distance (0.5xCW), although the difference was not statistically significant. On average, soil available P in Area 3 was high.

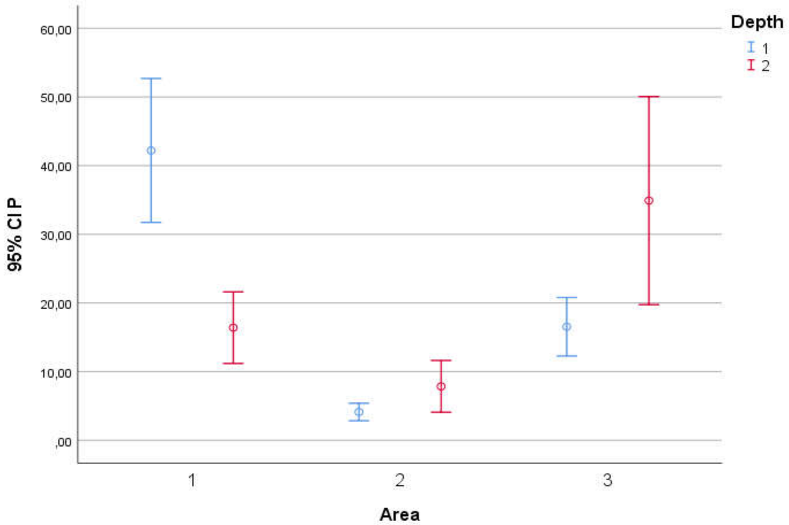

Figure 5. Mean and confidence interval 95% of soil available (Olsen) P (mg kg^{-1}) for depths 1: 0-30 cm and 2: 30-60 cm from areas: 1, 2 and 3.

CONCLUSION

Results showed that organic matter content, total N, available P and exchangeable K did not differ significantly with distance from the hedgerow trees row. Soil organic matter and total N were not evenly distributed through the soil profile. The largest organic matter and N pool occurred in the top 30 cm. This finding was particularly evident in the upland areas. The data provided evidence of C sequestration in the soils thus indicating significant environmental benefits. Soil exchangeable K was in general low. Soil available P content ranged from low to high, between the areas and sampling depths. The results favour the adoption of agroforestry in the plain area of Mouzaki, Greece; however detailed investigation to tree-specific effect of agroforestry on soil quality parameters is further needed.

ACKNOWLEDGEMENT

The present study is part of the project entitled “Perspective of Agroforestry in Thessaly region: A research on social, environmental and economic aspects to enhance farmer participation”. The project is funded by the General Secretariat for Research and Technology (GSRT) and the Hellenic Foundation for Research and Innovation (HFRI).

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