Characterization of almond orchards to assess soil fertility and organic matter dynamics to improve soil conditions by using organic amendments

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Abstract
The characterisation of soils in almond orchards from SE Spain has been carried out to assess fertility and organic matter content to improve soil properties by posterior use of organic amendments. The experimental area was divided into 14 plots. Samples of surface and subsurface were taken to analyse soil pH and electrical conductivity (EC), soil organic carbon (SOC), total nitrogen (N_t), calcium carbonate, bioavailable metals and available nutrients. The results highlight the low content of organic matter in the studied plots. The content in calcium carbonates and the alkaline pH make the nutrients partially unavailable for the crop. The application of organic amendments is one of the best solutions to improve soil quality and fertility. This procedure is not only a way of fertilization but a way of reusing a pig farm residue that is difficult to manage, pig slurry, thus fulfilling international guidelines of sustainable development.

Key Words
Soil properties, nutrients, organic fertilization, soil organic carbon

Introduction

In the Mediterranean Basin of Spain, almond trees have been cultivated for centuries (Zornoza *et al.,* 2009), Murcia (SE Spain) is one of the principal regions in almond production, as almond orchards require warm climate. This crop tolerates the lack of water and requires alkaline or neutral soils. To reach a good production of almond, keeping soil fertility, is needed so that nutrients are available for the plant. Inorganic fertilization has been carried out for years, although fertilization using organic amendments such us pig slurry and manure has also been introduced, which adds to the soil important contents of organic matter and nitrogen. This is important for the correct fertilization of soils and also improves its condition and structure. In fact, nutrient release increased more with organic amendment than with inorganic fertilizers (Goyal, 1998; Daudén *et al*., 2004). In this sense, in order to determine the proper dose of organic fertilizers to apply to the soil, and the nutritional necessities of the crop, it is necessary to characterize orchards soil. The results obtained are essential to fulfil the soil requirements for improved almond production.

Materials and methods

The study site is located in the village of La Aljorra, belonging to the municipality of Cartagena in the Murcia Region (SE Spain). The experimental area is an almond orchard of 8064 m^2. The climate of the area is semiarid Mediterranean with mean annual temperature of 18ºC and mean annual rainfall of 275 mm. A total of 14 plots (12 m x 30 m) were designed in the field so that sampling was representative of the surface area of the orchards. Plots are named alphabetically from A to N. The aim of this division in plots was to compare in the future the use of different organics amendments in order to determine the optimum dose for the necessities of soils and crops. The soil is a Typic Haplocalcid with clay loam to loam texture.

Soil sampling was made in September 2008. Three samples were taken per plot at two depths (0-15 cm, 15-30 cm depth). Soil pH and electrical conductivity (EC) were measured in deionised water (1:1 and 1:5 w/v, respectively). Soil organic carbon (SOC) and total nitrogen (N_t) were determined according to Duchaufour (1970). Calcium carbonate was assessed by the Bernard calcimeter (Porta, 1986). Bioavailable metals and available nutrients were extracted with DTPA and ammonium acetate, respectively, and measured using an atomic absorption spectrophotometer (AAnalyst 800, Perkin Elmer).

Results and discussion

As we can see on Figure 1, values of SOC ranged from 0.55 % to 1.80%, similar to the results obtained by Zornoza *et al*. (2009) in almond orchards in the province of Alicante, SE Spain, with similar soils and climatic conditions.

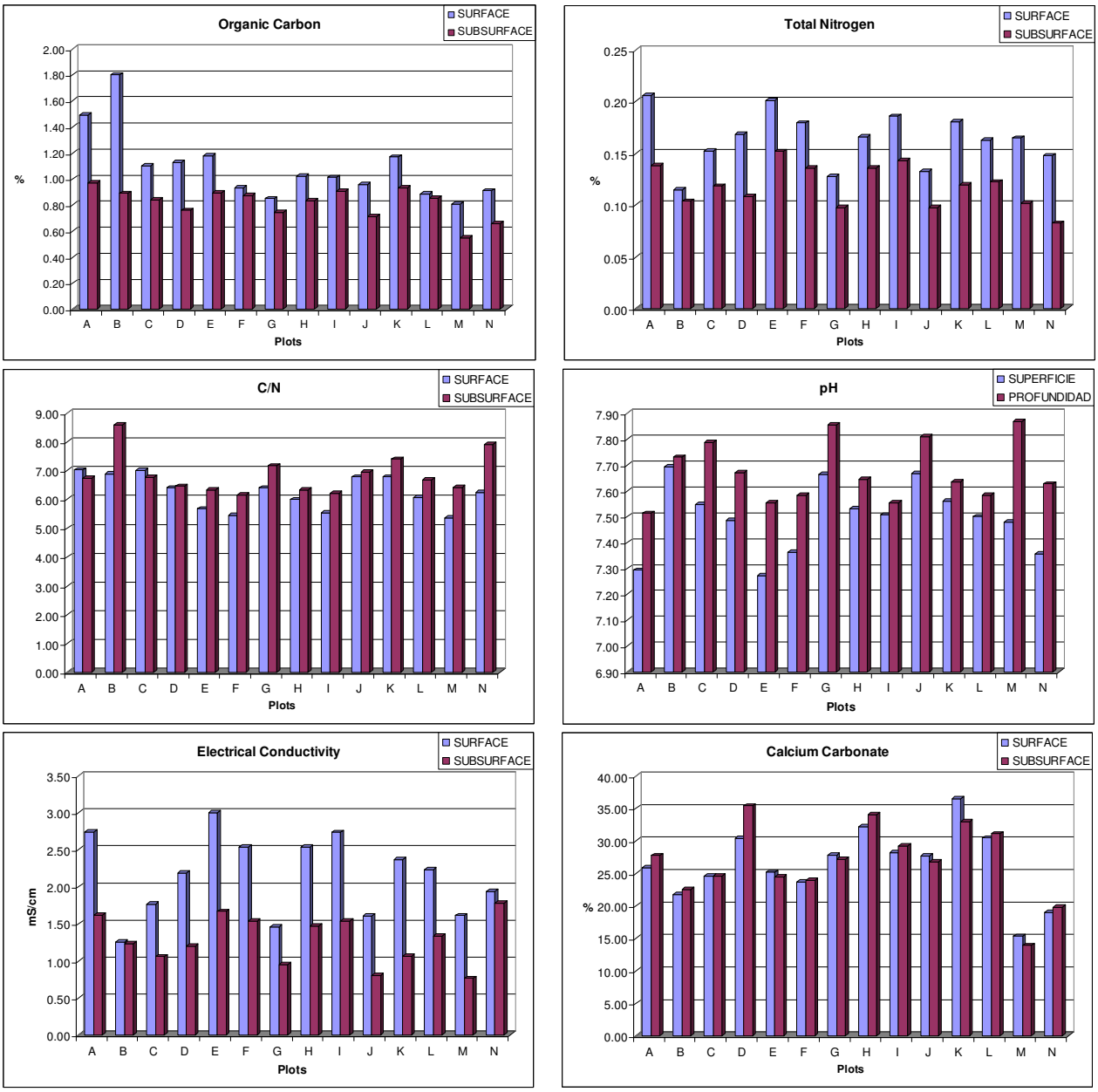

Figure 1. Physico-chemical characteristics of the different plots studied. Values are the mean (n=3).

Thus, we can consider that the soil organic matter content in the studied orchard is low. With regards to N_t, results show that percentages were quite high, considering these soils as medium for total nitrogen (Urbano, 1995). Therefore, we obtain C/N ratio quite low, what means that soil tends to the mineralization of organic matter and has a low to medium fertility, besides the organic rate could be increased by adding great amounts of organic matter to the soil (Cobertera 1993).

Values of pH and electrical conductivity indicate that we have moderately alkaline and slightly saline soils. This can be due to the use of irrigation water with high levels of salts. The content of calcium carbonate varies from 15% to 36% which are considered as normal to high values (Porta *et al*., 1999). The content of available micronutrients required for plant nutrition was quite low (Figures 2 and 3). In this type of soils, the level of carbonates and alkaline pH favour the immobilization of most nutrients, especially Fe.

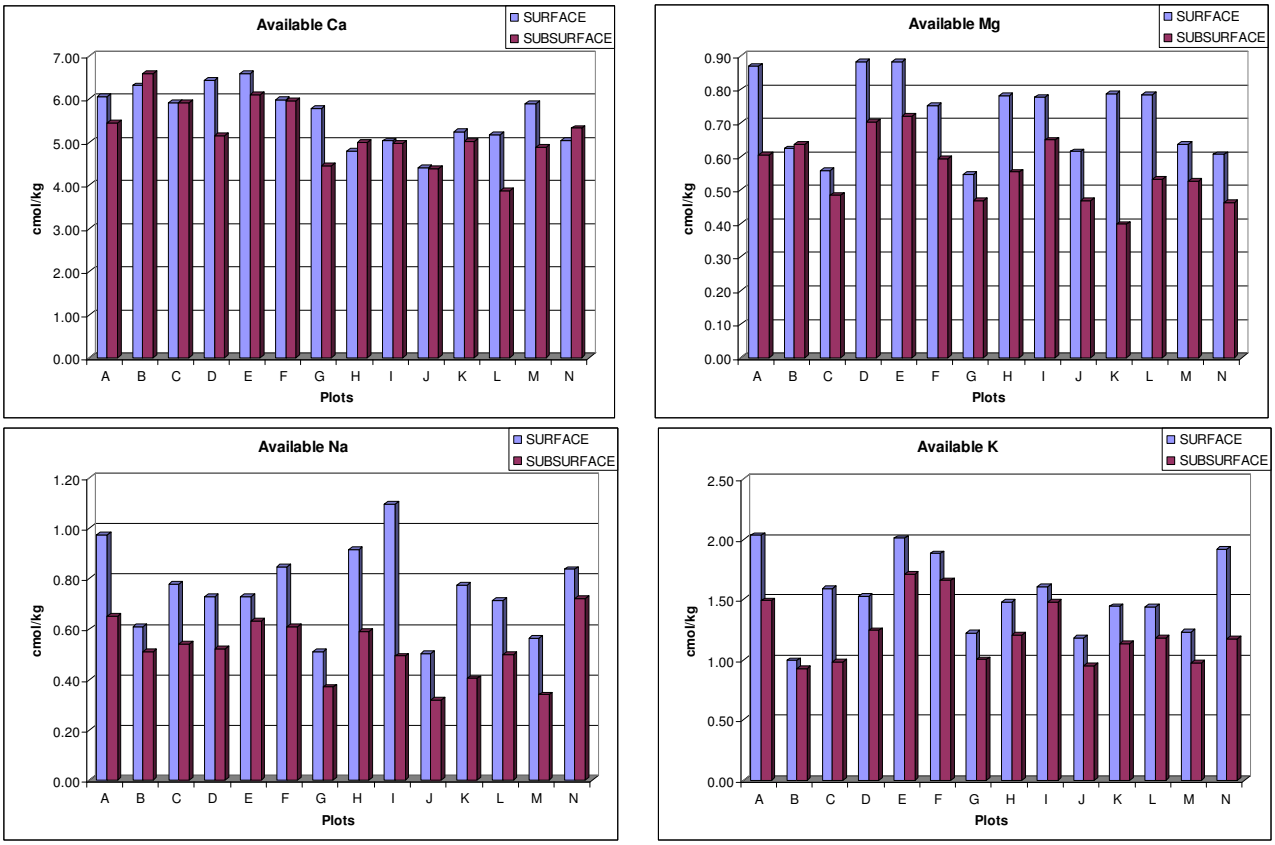

Figure 2. Bioavailable nutrients part 1. Values are mean (n=3).

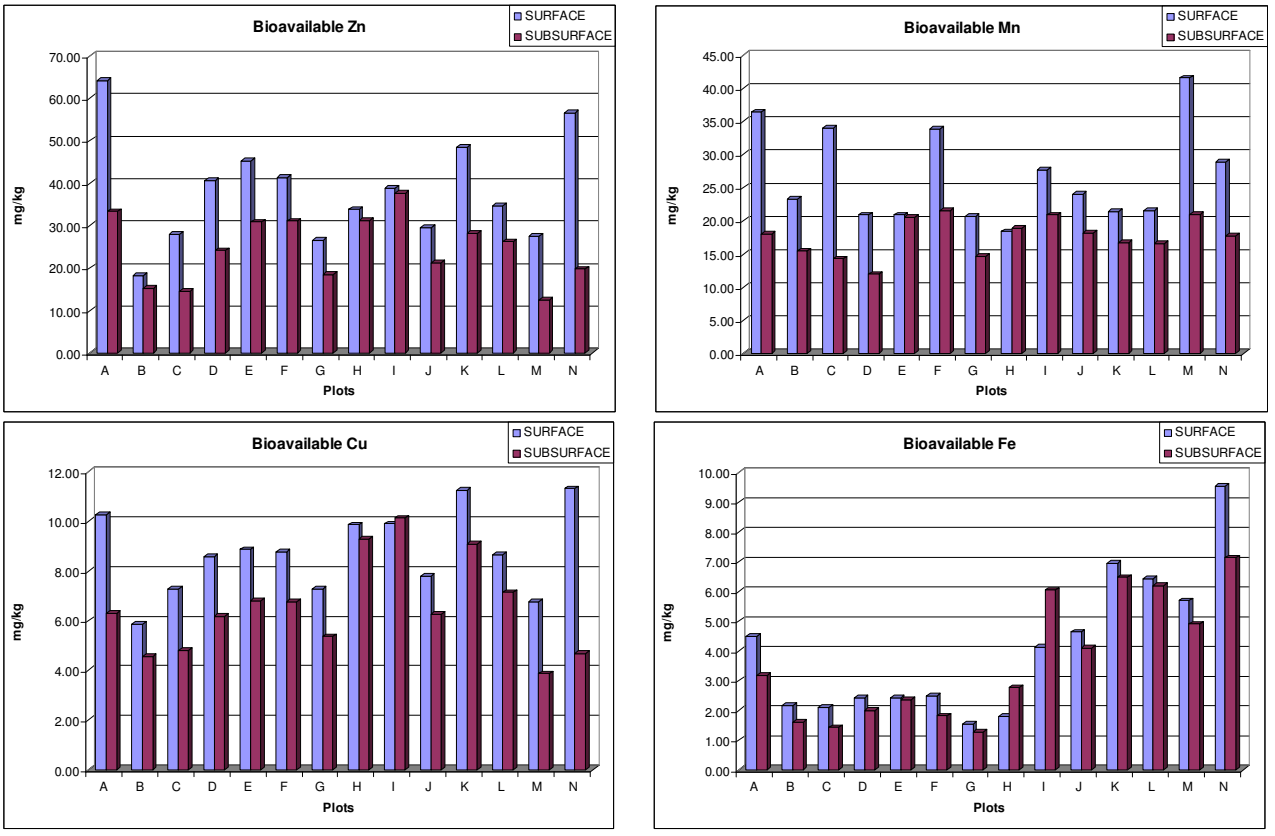

Figure 3. Bioavailable nutrients part 2. Values are mean (n=3).

Conclusion

The studied soils have some deficiencies in most properties required to support optimum production of the almond orchards. The content soil organic carbon is quite low, as well as the C/N ratio, There is a necessity to apply organic matter in order to improve soil conditions. The content in calcium carbonate and the alkaline pH of the soils immobilises nutrients so that the plant is not able to suitably assimilate them. The application of organic amendments such us pig slurry and manure, would add important quantities of organic carbon to the soil, which will enrich the soil continuously releasing nutrients at appropriate rates, favouring microbial activity and improving crop productivity. Contrary to inorganic fertilization, organic amendments would add higher quantities of organic matter. The use of these fertilizers is a way of utilising a residue generated in great amounts by farmers and which is very difficult to manage. This practice provides the basis of a sustainable procedure.

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