ACCUMULATION AND VERTICAL DISPLACEMENT OF NUTRIENTS AT IRRIGATED FRUIT GROWING AREAS

ACÚMULO E DESLOCAMENTO VERTICAL DE NUTRIENTES EM ÁREAS DE FRUTICULTURA IRRIGADA

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ABSTRACT

The application of soluble fertilizers without planning burdens agricultural production and leads to soil salinization, a very evident problem in irrigated agriculture in the semiarid region. The soil management practices used in grape and mango cultivation are the main responsible for the loss of nutrients by leaching and soil salinization in the São Francisco submedium' Valley. The objective of the work was to quantify the accumulation and vertical displacement of nutrients in 0-20, 20-40, 40-60, 60-80 and 80-100 cm layers of cultivated and native areas. The study was carried out in the municipality of Petrolina/PE, in 43 areas with different cultivated grapevine, mango and Caatinga crops in the São Francisco submedium' Valley. pH, EC, OM, P, K^+, Ca^{++} and M^{++} were evaluated at different depths. The movement of nutrients, especially P, was favored by the continuous application of high fertilizer doses as well as by the sandy texture of the soils studied. The high levels of nutrients observed in the areas cultivated with grapevine suggest an adjustment in the recommended fertilizer doses, aiming at the reduction of environmental impacts and fertilizer losses.

KEYWORDS: Holding capacity, Chemical fertilizers, leaching, Transport of nutrients.

RESUMO

A aplicação de adubos solúveis sem planejamento onera a produção agrícola e conduz à salinização dos solos, problema muito evidente na agricultura irrigada do semiárido. As práticas de manejo de solo utilizadas no cultivo de uva e manga são as principais responsáveis pela perda de nutrientes por lixiviação e salinização do solo do Vale do Submédio do São Francisco. O objetivo do trabalho foi quantificar o acúmulo e o deslocamento vertical de nutrientes nas camadas de 0-20, 20-40, 40-60, 60-80 e 80-100 cm de áreas cultivadas e nativa. O estudo foi realizado no município de Petrolina/PE, em 43 áreas com diferentes cultivos de videira, mangueira e Caatinga no Vale do Submédio do São Francisco. Foram avaliados pH, CE, MO, P, K^+, Ca^{++} e Mg^{++} em diferentes profundidades. O movimento dos nutrientes, principalmente do P, foi favorecido pela aplicação contínua de doses elevadas de adubos bem como pela textura arenosa dos solos estudados. Os altos teores de nutrientes observados, nas áreas cultivadas com videira, sugerem um ajuste nas doses de fertilizantes recomendadas, visando redução de impactos ambientais e perdas de fertilizantes.

PALAVRAS-CHAVE: Capacidade de retenção, Fertilizantes químicos, Lixiviação, Transporte de nutrientes

INTRODUCTION

The São Francisco submedium Valley is located in the semi-arid region of the Brazilian Northeast, where the largest center of irrigated fruit farming in Brazil is concentrated. A very important economic activity for having favorable climatic conditions and for having water and technology for agricultural management. However, the soils of this region have very low levels of organic matter (OM), phosphorus, and are generally sandy[1].

The removal of the natural vegetation of the Caatinga to introduce cultivation with vines and mango trees can increase the impact of agricultural activity[2]. Once that fruit farming in the dipole, has favored the emergence of relevant problems in the production areas, among many stand out the disorderly application of soluble fertilizers, culminating in the burden of production, salinization of soils and contamination of water resources.

The diagnosis of intensive mango and grapevine production areas in the São Francisco submedium' Valley, in relation to the accumulation and loss of nutrients in the soil, is of an emergency character, in the search for sustainability and optimization of the crops.

Several studies deal with the vertical migration of ions in the soil profile[3-4]. Nutrient losses by vertical displacement in the soil profile, intensified by excessive applications, can be significant, especially those of higher mobility in the soil, since overdoses are motivated by the economic vigor of crops[5-6], with grapevine and mango being the main ones for the region in focus.

In view of this, considering the intensive agricultural system and the limitations of the soils of the São Francisco valley, it becomes relevant evaluate changes in soil fertility, consequently contributing to environmental sustainability, with the purpose of rationalize the use of inputs. The objective of this work was to quantify the accumulation and vertical displacement of nutrients in 0-20, 20-40, 40-60, 60-80 and 80-100 cm layers of cultivated and native areas.

MATERIAL AND METHODS

The work was performed in the irrigated perimeter of the Senador Nilo Coelho' Project (PSNC), in the city of Petrolina -PE (09º 09' S, 40º O and 365.5m altitude). According to the Köeppen classification, the climate of the region is classified as type Bswh, with an average annual temperature of 26.4°C and irregular rainfall.

To identify the accumulation and displacement of nutrients in the soil profile, 222 composite samples were collected, at depths 0-20, 20-40, 40-60, 60-80, and 80-100 cm, in 43 areas with different cultivated, grapevine (*Vitis*), mango (*Mangifera indica*), and Caatinga (native tree shrub vegetation).

The soil was classified as Quartzipsamments and Psamments, with soil texture that varied from sandy to loamy-sandy soil. In the areas under cultivation fertigation was used, with drip and micro sprinkler systems.

The soil samples were forwarded to the soil and plant analysis laboratory of IF Sertão - PE. Campus Petrolina rural zone; they were air dried and passed through a 2 mm sieve; in these composite soil samples, pH in water (1:2,5) were determined and by the saturated paste extract method the Electrical Conductivity (EC), according to the methods of [7]. The quantification of Organic Matter (OM) made from the combustion process with heating at 600°C, obtaining the value by the difference between the mass of oven-dried soil and the mass of the residue obtained after incineration in muffle.

The Phosphorus (P) and Potassium (K^+) levels, extractable with Mehlich-1 were quantified by colorimetry and flame photometry, respectively[7]. The Calcium (Ca^{++}) and Magnesium (Mg^{++}) changeable were extracted with KCl 1 mol L^{-1} and quantified by atomic absorption spectrophotometry according to the methodology proposed by[7].

The results of the soil analyses were submitted to variance analysis using the statistical software Sisvar 5.3[8] and the means were compared using Tukey's test at 5% probability.

RESULTS AND DISCUSSION

At depths of 0-20, 20-40 and 40-60cm, the pH values in the vine and mango areas did not show significant difference (Figure 1A), however, both differed from the Caatinga' area (0-20 and 20-40cm). A decrease was observed in the layers 60-80, 80-100 cm in the mango areas, which may be associated with the reduction of Ca^{++} and Mg^{++} levels (Figure 3A and B).

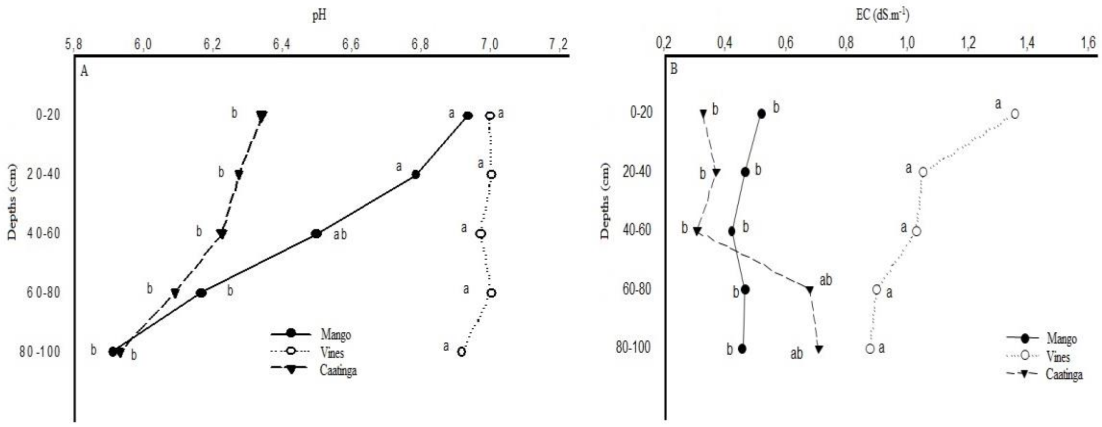
In general, the soil pH of all treatments was within the ideal range for nutrient absorption by plants, ranging from 5.9 to 7.0[9]. Frequent agricultural practices such as fertilization and surface irrigation tend to form a surface gradient of concentration, causing variability in soil pH indices, as a result of the increase in exchangeable bases[7], moreover, the addition of OM routinely can provide a significant increase in pH[3].

The EC in the soil cultivated with grapevine at a depth of 0-20 cm was 1.35 $dS.m^{-1}$ corresponding to 2.6 and 4.1 times more than that found in the area cultivated with mango and caatinga, respectively. However, the levels in the areas cultivated with mango did not differ from those found in the caatinga areas.

At depths of 20-40 and 40-60 cm, the average EC in the vine areas was 1.4 $dS.m^{-1}$, approximately twice as high as those found in the mango areas and three times higher than those found in the caatinga. At the depths of 60-80 and 80-100 cm, the vine showed significant difference only in relation to the mango. Throughout all soil depths analyzed, the EC of the mango areas did not differ significantly in relation to the caatinga (Figure 1B).

The high EC in the superficial layer in areas cultivated with grapevines is associated with the increase of soil bases, via fertilization or fertigation, since grapevines produce two or more annual harvests. According to[1], the increase in OM content (Figure 2A) throughout the crop cycle, also contributes largely to the EC of soils, due to its mineralization. Thus, approaching levels of salts not tolerable by the crop.

Figure 1. pH (A) and EC (B) of the soil at depths 0-20, 20-40, 40-60, 60-80 and 80-100cm in areas cultivated with vines, mango and caatinga. Means with the same letter do not differ by the Tukey test at 5% probability.



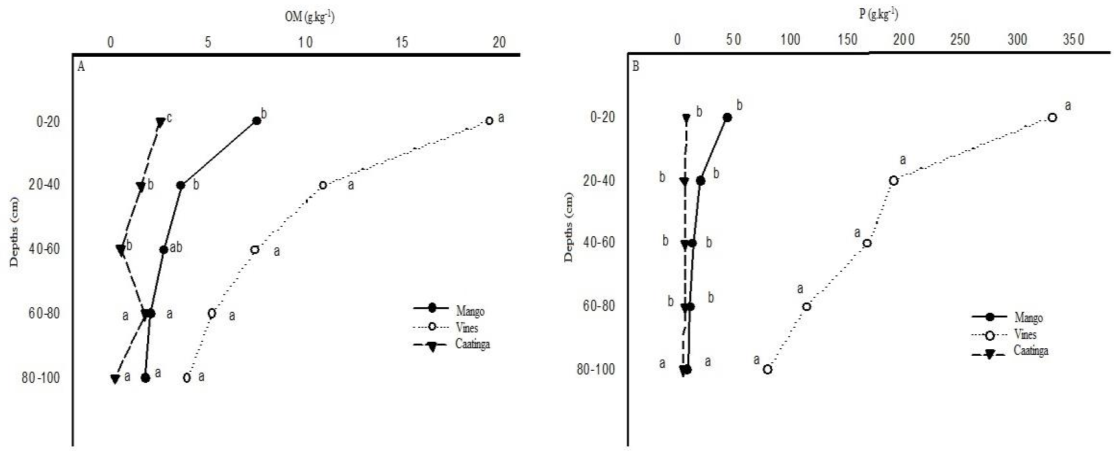
The OM in the areas cultivated with grapevine differed significantly, being higher than the areas with mango and caatinga, at depths of 0-20 and 20-40 cm, with average values of 19.45 and 10.82 g kg^{-1}, respectively, with an increase of 2.6 (0-20) and 3 (20-40) times in relation to the areas with mango (Figure 2A).

At depths 40-60 cm, the cultivation of grapevines and mangoes did not differ among themselves. At depths 60-80 and 80-100 cm there was no significant difference between cropping systems, results that corroborate those of[4], who obtained no difference between depths 40-60 and 1.00-1.20 cm, in tillage and cerrado areas.

This difference in OM level between the areas of vines and the others is configured by the fact that the culture receives, on average, 30 L of manure and 6 kg of sugarcane bagasse per plant each cycle, this provides the accumulation of OM, besides that the sugarcane bagasse has high C/N ratio, evidencing a greater resistance to decomposition[10-11].

At depths 0-20, 20-40, 40-60 and 60-80 cm, the P content in areas with vines differed from the others, indicating vertical displacement of available P (Figure 2B). Soils with characteristics close to the parent material and sandy (Quartzipsamments and Psamments), the vertical displacement of P is intense, as a result of the low capacity of adsorption[3]. According to[12], there is displacement of P in both inorganic and organic forms.

Figure 2. OM (A) and P (B) content of soil at depths 0-20, 20-40, 40-60, 60-80 and 80-100 cm in areas cultivated with vines, mango and caatinga. Means with the same letter do not differ by the Tukey test at 5% probability.

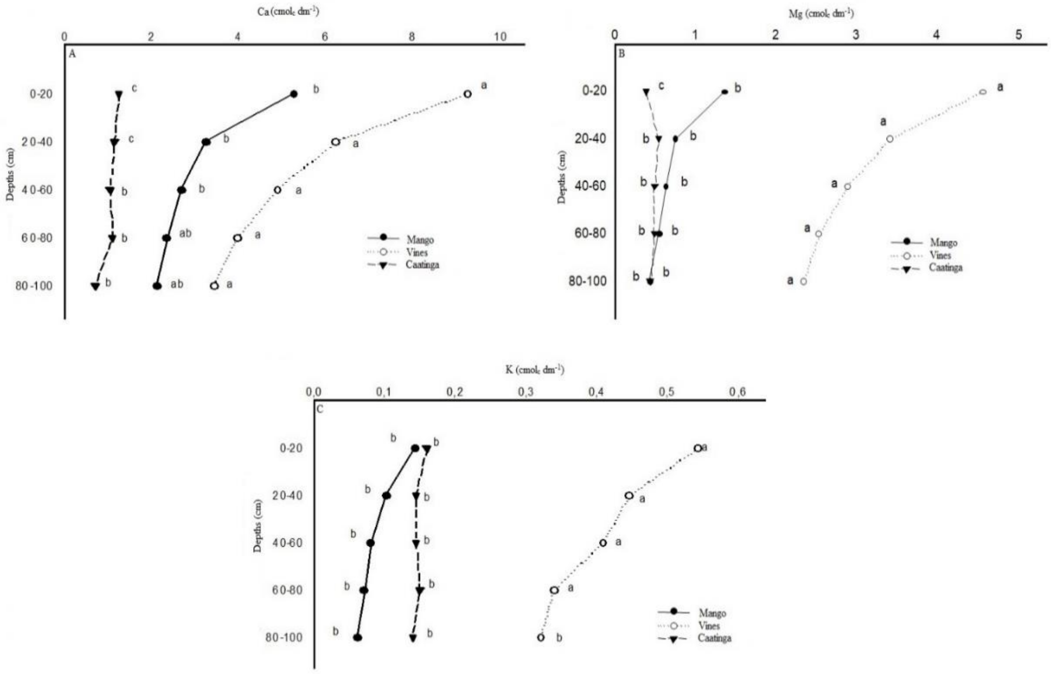


Ca^{++} and Mg^{++} showed similar movements along the depths (Figure 3A and B) in the vineyards, differing from the others. However, the at the depths of 60-80 and 80-100cm the Ca there was no significant difference between the crops. According to[1], this migration in the soil profile of Ca^{++} and Mg^{++} to deeper layers is due to the low retention capacity, due to the sandy texture of the soil, leaving the cations free in solution. According to[12], depending on the state of decomposition of plant residues on the soil surface, organic complexation can also occur, i.e., formation of water-soluble organic compounds, moving along the profile.

In general, semi-arid soils are less developed, with low levels of iron and aluminum oxides, less acidic, and very high levels of Ca^{++}, thus enabling the formation of ionic pairs with part of the P, precipitating as calcium phosphate (P-Ca), since it forms crystals that are unavailable for plant uptake[13-14].

Higher levels of exchangeable Mg^{++} (Figure 3B) were identified at depth in the vine areas, when compared to the others. These results may be associated with its higher hydrated ionic radius and lower electronegativity, consequently leading to a lower retention in the exchange complex, allowing for greater movement in the profile[15].

Figure 3. Ca^{++} (A), Mg^{++} (B) and K^{+}(C) contents of the soil at depths 0-20, 20-40, 40-60, 60-80 and 80-100 cm in areas cultivated with vines, mango and caatinga. Means with the same letter do not differ by the Tukey test at 5% probability



The areas cultivated with vines differed at all depths. According to[6], the water flux, soil density and the low interaction of K^{+} with soil charges cause variations in the increase of exchangeable K^+ contents at depth. This fact was observed by[4], as the rainfall promoted the leaching of the nutrient to deeper soil layers.

In general, K^+ fertilization promotes a significant increase in K^+ content at all depths, being one of the nutrients most required by grapevines[1], acting to regulate the osmotic potential of cells, activating enzymes involved in respiration and photosynthesis, regulating nutrient translocation, and assisting in carbohydrate transport and storage[6].

CONCLUSIONS

Despite receiving lower amounts of fertilizers, the mango areas still presented high levels of nutrients, especially in the superficial layer, indicative of the practice of disorganized fertilization in the region.

Phosphate fertilization could be suspended for a few cycles without harming the grape crop, since very high levels of phosphorus were found in the soil.

The movement of nutrients, especially P, was favored by the continuous application of high doses of fertilizer as well as by the sandy texture of the soils studied.

The high nutrient contents observed in the grapevine areas suggest an adjustment in the recommended fertilizer doses, aiming at reducing production costs and environmental impacts.

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