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Does the irrigated mango cultivation in the semiarid change the Physical and chemical attributes of the soil?

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Abstract

The replacement of native vegetation by crops may result in changes in the chemical and physical attributes of the soil, preventing the sustainability of the agricultural production. Therefore, the aim of this study was to evaluate, in two consecutive years (2014 and 2015), the effect of irrigated mango cultivation in some physical and chemical attributes of the soil in relation to Caatinga in Petrolina-PE, Brazil. In areas under irrigated mango (under the canopy region and the row spacing) and Caatinga (taken as reference), soil samples were collected at the 0-10 and 10-20 cm depths. The chemical and physical analyzes were performed, and were calculated bases sum (BS), cations exchangeable capacity (CEC) and base saturation (V, %). The irrigate mango cultivation (canopy region) increased the macronutrients content (P, K, Ca and Mg), BS and V (%) for both evaluated years at the 0-10 and 10-20 cm depths. In soil under irrigated mango cultivation (under the canopy region and in the row spacing), the macronutrient contents presented a stochastic pattern in the years of 2014 and 2015. The change of land use, from Caatinga to irrigated mango cultivation, does not induce a negative impact in the soil chemical attributes under the adopted management conditions.

Keywords: fruticulture, soil management, *Mangifera indica* L., land use

Introduction

The submedium San Francisco Valley situated in the Brazilian northeastern is known worldwide by the quality and quantity of its produced fruits. Among the main cultivated fruits it can be highlighted mango that presents high added value in the most varied marketing centers.

Therefore, the implantation of crops in areas previously occupied by native vegetation may cause changes in properties and processes of chemical, physical and biological orders, which are dependent on the soil's conditions, weather, crop species and on the crop practice used (Arcoverde, et al., 2015).

In consequence, the inadequate use of the soil with inappropriate management techniques can motivate loss of soil quality and, consequently, reduction of the crop yield (Bogunovic et al., 2018).

According to Aguiar Netto et al. (2017), some irrigate perimeters in the Brazilian northeastern have presented soil physical and chemical degradation problems. This way, the knowledge about changes suffered in the soil's attributes may infer an adequate management to minimize soil's degradation.

Many studies have been carried out expecting to find solutions to an effective management of crops (Wadt & Silva; Politi et al.,

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2013; Silva et al., 2013) and this way reduce soil's degradation keeping its sustainability.

Additionally, it is known that soil's properties, principally the chemical ones, are dynamic and may vary over time (Chaudhuri et al., 2015) and that changes are related mainly to variations in the land use and management practices adopted (Jiang et al., 2008).

Although economic importance of mango market in Brazil, especially in the region of the Submedium San Francisco Valley, little is known about the consequences of the Caatinga vegetation's replacement for the irrigated mango cultivation may cause on soil's attributes over time. This study aimed to evaluate, in two consecutive years (2014 e 2015), the consequences of irrigated mango cultivation in some physical and chemical soil's attributes in relation to Caatinga in Petrolina-PE.

Materials and methods

The study was performed in an area located on the farm: Desenvolvimento Agricola do Nordeste - DAN situated in the irrigated perimeter Nilo Coelho, Petrolina city, Pernambuco state.

The region is characterized as Caatinga biome and situated under the geographical coordinates latitude 9°23'11,83'' S and longitude 40°41'24,55'' W, with a medium elevation of 411 m. The climate of the region is Bsh' (semiarid), according to the climate classification of Köppen, with a low rainfall during all year (400 to 800 mm). The rainfall at times of soil sampling is shown in table 4.

Rainfall (mm)												
Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
-	-	-	-	-	6,8	13,6	4,6	0,4	0	25,6	155	206
Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
28,6	37,5	56,7	179,8	1,6	1,3	26,3	2,4	7,2	0	0	47,9	389,3
Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
12,0	34,6	27,1	78,2	0,8	2,4	-	-	-	-	-	-	155,1

Source: Agrometeorological station of Petrolina- INMET – Nacional institute of meteorology – Petrolina city, Pernambuco state.

The soil is classified as Psamment presenting textural sandy class, with medium contents of 934,0, 14,0 and 52,0 g kg^{-1} of sand, silt and clay, respectively.

The soil's samples were collected in two consecutive years, (January, 2014 and 2015), in two areas from the Desenvolvimento Agrícola do Nordeste farm, one of them with an eight years old irrigated mango orchard (under the canopy region and in the row spacing) and another one with native vegetation (Caatinga hypoxerophytic, referential area), located approximately 10 m from each other and under the same class of soil. Previously, the area with irrigated mango was occupied with Caatinga, until 2006. After its removal, the soil was prepared (plowing and harrowing) for mango planting. Then, soil's pH was corrected with dolomitic limestone (Effective calcium carbonate equivalent = 80%), to elevate pH to 5.5-6.0. using the method of bases saturation (Ribeiro, 1999). The pH's soil correction when necessary, was also performed annually, after every production cycle. The crop (cv. Kent) was planted in 8,0 x 6,0 m spacing where was added goat manure (20 L planting $hole^{-1}$) and planting fertilization (P, K, S), with medium values of 500 g $plant^{-1}$ of simple superphosphate, 80 g plant $^{-1}$ of potassium chloride (KCl), and 18 kg ha^{-1} of Sulphur. Annually, were performed side dressing fertilization 120 kg ha^{-1} of urea e 150 kg ha^{-1} of KCl and micronutrients (B, Zn), with medium doses of 2g $pant^{-1}$ of boron and 5 g plant $^{-1}$ of zinc, to attend the nutritional demand of the crop.

For fructification fertilization with expected production of 40 t ha^{-1}, were applied 500 g $plant^{-1}$ of simple superphosphate and 2,0 kg $plant^{-1}$ of KCl. Annually is added 20 L $plant^{-1}$ of goat manure in the canopy region (crown projection). The irrigation system used is located (micro sprinkler), with a medium water flow of the splinker of 50 L h $^{-1,}$ looking to attend the plant's hydric demand. The irrigation management was performed based on the crop's evapotranspiration (ETc mm), determined by the multiplication of the reference evapotranspiration (ETo, mm) and the crop coefficient (kc), according to Soares et al. (2006). The mango flowering induction is always done with calcium nitrate and potassium nitrate applying. The canopy region and the row spacing were always kept without weed by the manual and mechanical weeding. After the harvest, annually is performed a pruning keeping the organic residues on the canopy region.

This work is composed of three treatments (irrigated mango canopy region and irrigated mango row spacing), disposed of split-blocks desing, with ten repetitions (10 georeferenced points). In areas under irrigated mango (canopy region and row spacing) and in the Caatinga area were collected soil samples at the layers of 0-20 and 10-20 cm depth. Emphasizing that in the irrigated mango area were collected 10 samples of soil on canopy region (crown projection area) and row spacing (4,0 m from the tree trunk). In the area under Caatinga was collected a subsample in the middle of the georeferenced point and another two within a radius of 1 m from the georeferenced point. By that, were collected three simple samples from each depth to obtain a composite sample.

After collected, the soil's samples were transported to the soil's chemistry and physics laboratory of the Federal University of the San Francisco Valley where they were open air dried, had the clods broken up, homogenized and sieved (2,0 mm) to obtain fine earth air dried (FEAD). Also were collected soil's undisturbed samples (using a 98,17 cm³ cylinder) on the mentioned layers and all the treatments.

For the physical analysis were determined soil texture (pipette method) soil bulk density (Bd), clay dispersed in water (CDW), flocculation degree (FD) and total soil porosity, according to the methodology proposed by Donagema et al. (2011).

From the disturbed samples were determined the pH values (H_2O), potential acidity (H+Al), electrical conductivity in the saturation extract (SE) P, K and Na contents [extracted with Mehlich-1 and determined in spectrophotometer (P) and fire photometer (k^+, and NA^+)]; Ca^{2+}, Mg^{2+} and Al^{3+} [extracted with KCL 1,0 mol L and determined in spectrophotometer of atomic absorption (Ca^{2+} and Mg^{2+}) and by the titration method (Al^{3+})]. All the chemical analyzes were performed according to the methodology proposed by Donagema et al. (2011). Posteriorly were calculated the sum of bases (SB), cations exchange capacity (CEC) and bases saturation percentage (V).

The data normality hypotheses were verified by the Shapiro-Wilk test. The obtained data were analyzed by the t teste (α= 5% probability) for independent samples which were made comparisons between Caatinga and irrigated mango canopy region and Caatinga and irrigated mango row spacing, to each depth and evaluated year. It was performed a hierarchic grouping analyze in standardized data from averages from each kind of soil use in each collect period evaluated using the completed link method with euclidian distance. The link distance was expressed as (Dlink/Dmax) x 100, which represents the standardized quotient between the link distances to a particular case divided by the maximum link distance. In the definition of group numbers in the dendrograms was drown the fenon line (Cutting line) in the Euclidian distance average standardized corresponding to the highest leap found in the grouping steps.

Results and discussion

Soil Physical attributes

The year of 2014

The irrigated mango cultivation (canopy region) did not cause any significant difference in the soil bulk density values (BD), flocculation degree (FD) and clay dispersed in water (CDW) when compared to Caatinga at the layers of 0-10 and 10-0 cm depth. (Figures 1A, 1B, 1E, 1G, 1H). In contrast, for the total porosity variable (TP), in the year of 2014, was verified a significant difference only at the layer of 0-10 cm depth, with greater value to the irrigated mango (canopy region) (42,32%) in relation to Caatinga (39,61%) (Figure 1C).

This behavior might be associated, eventually, to the management adopted in the crop implantation (soil preparing), the maintenance of the pruning residues and, or, greater soil exploration by the mango roots resulting in greater soil aggregation and,

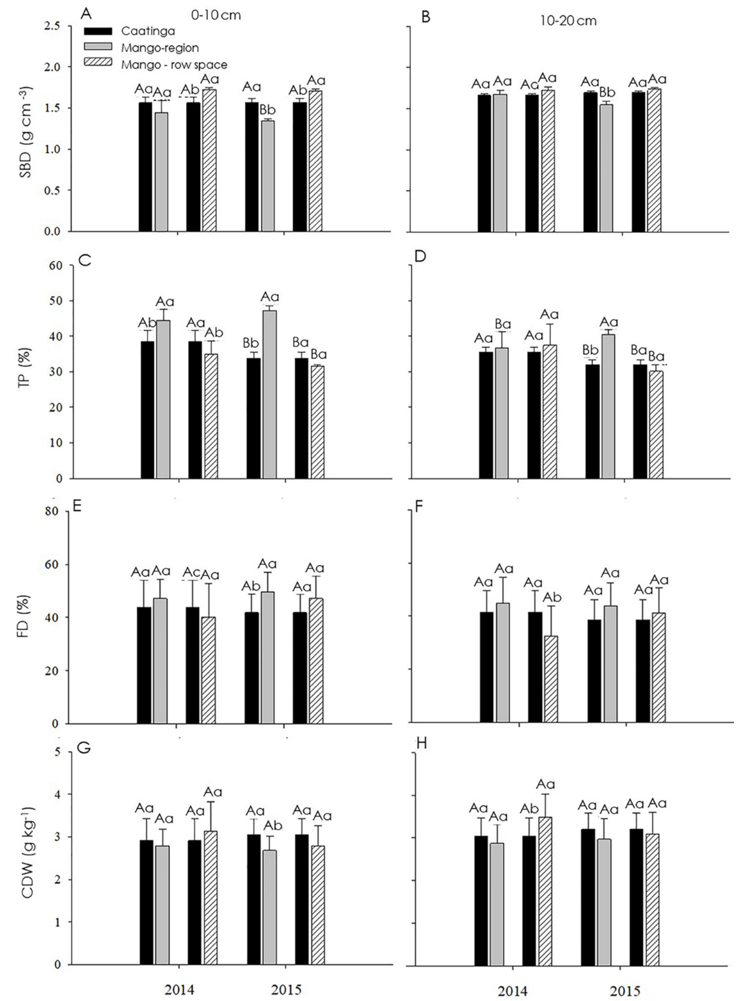

Figure 1. Soil bulk density (A;B), total porosity (C;D), flocculation degree (E;F) and clay dispersed in water (G;H) at the 0-10 and 10-20 cm layers of soils under irrigated mango cultivation (canopy region and row spacing) and Caatiga for the years of 2014 and 2015. Columns followed by the same lower case between the uses and capital letter between years do not differentiate by student's t test (P>0,05). The bars represent the average's standard deviation .

consequently, greater soil porosity. This effect is more evidenced in the top soil what is expected since there is no incorporation of organic residues on surfaces in areas of fruit production.

The soil limit bulk density is that one referred to the value witch the soil macroporosity is equal to 10%, may vary according to the soil's texture.

As suggested by Stolf et al. (2011), the value of the soil's limit bulk density (SLD) might be estimated using the sand content (SLD = 1.275 + 0,456 sand in $kg\ kg^{-1}$). Therefore, to the soil of the present study (Sand = 0,93 $kg\ kg^{-1}$) the SLD is of 1,70 $g\ cm^{-3}$. This way, to the year of 2014 the average values of BD in the mango cultivation (canopy region) and Caatinga are under the critic value in both studied layers (Figure 1A and 1B), indicating that macroporosity is greater than 10%, while the average value for the crop (row spacing) is above the limit density (Figure 1A e 1B), indicating that the water drainage and soil's oxygenation might not be adequated to the plant.

The Tp average was above 35%, what characterize the management practices adopted in the study areas as practices that do not compromise the physical structure of the soil. The comparisons between soils from native vegetation and cultivated areas, in the majority of cases, it can be observed significant decrease of Tp in the managed soils, mainly in relation to that ones with dense forest, as verified by Vasconcelos et al. (2014) and Oliveira et al. (2015 a). In Caatinga areas, can be observed maintenance or improvement of the soil physical quality when there is the replacement of the native vegetation by determined agricultural use, as indicate the obtain data in this research (figure 1) and by Correa et al. (2010).

Comparing the soil collected in the row spacing of irrigated mango with soil under Caatinga, it can be observed that there was not difference in FD and CDW values at the layer of 0-10 cm depth, and in the BD and Tp values at the layer of 10-20 cm depth (figures 1B, 1D, 1E, 1G). In the soil top soil under irrigated mango (row spacing), the BD (1,72 g cm^{-3}) was greater than the BD of the area under Caatinga. As a consequence, the Tp values were lower than those found for Caatinga soil in the same sampled layer.

The FD was greater in Caatinga area in relation to the crop row spacing at the layer of 10-20 cm depth (figure 1F), consequently the CDW showed lower values in Caatinga (figure 1 H).

This way, techniques that enable BD decrease and, consequently, the porosity and aggregates stability increase, must be continuously used in the row spacing. Some areas under different use systems evaluated by Silva et al. (2015) showed that BD is decreased when the organic cultivation or in conversion to organic is implemented, being indicative, possibly, of the greatest contribution of soil's organic matter, increasing microbial activity and improving the particles aggregation. Therefore, it is appropriated to suggest the adopted practices in the canopy region (as maintenance of the pruning residues from the crop) must be expanded to the row spacing of irrigated mango cultivation, just like occurred in alley cropping systems. (Meirelles & Souza, 2015).

The year of 2015

The soil under row spacing of the irrigated mango did not difference statistically for Tp, FD and CDW at the layers of 0-10 and 10-20 cm depth. Following this same tendency, in the crop canopy region, the FD and the CDW did not show statistic differences at the layer 10-20 cm depth (figure 1F and 1H).

On another hand, the irrigated mango cultivation (canopy region) resulted in lower values of BD when compared to Caatinga at the layers of 0-10 and 10-20 cm depth, respectively. Similar to the previous year, in the year of 2015 the average values of the soil bulk density were greater than the critical value (BD= 1,70 g cm^{-3}), only in the irrigated mango cultivation (row spacing) in both studied layers (Figure 1A and 1B). The Tp showed greater in the crop canopy reagion in relation to caatinga in both studied layers. (Figure 1E and 1F).

Uses comparisons between the years of 2014 and 2015 for the soil's physical attributes

In general, was noticed just a few differences on the physical attributes values comparing the studied years. A hypothesis is related to the short period of evaluation so it can be noticed significant modifications in the soil's physical attributes.

However, was possible to verify that the soil bulk density decreasing in the crop canopy region from 2014 to 2015. The temporal comparative analyses of the crop use in the sampled period (2014 and 2015) allow to determinate alterations in BD. In the crop canopy reagion there was a decrease from 1,50 and 1,67 g cm^{-3} in 2014 to 1,32 and 1,54 g cm^{-3} in 2015, at the layers of 0-10 and 10-20 cm depth, respectively (Figures 1A and 1B). These alterations are justified as a function of the addition, in each production cycle, of liquid biofertilizer by fertigation and maintenance of the residues on the soil surface in the crop canopy region. As time went by, the soil bulk density under systems that do not modify the soil tends to decrease because, in part, to the increase of organic matter on the surface layer, that performs improving the soil aggregation. (Tommea et al., 1998).

Grouping analysis of the soil attributes

It is extremely important to clearly indentificate if the possible alterations in the soil's physical attributes according to the type of managemant adopted are really capable of distinguishing such areas (under crop) from those under native vegetation. So, it is observed, at the layers of 0-10 cm depth, greater similarity between samples collected in the same year, independent of the type of use (Figure 2A).

Whereas the surface layer, it was possible to observe that there was greater similarity between samples collected under crop (CCR-2015 and CCR-2014) and between samples under native vegetation (C-2015 and C-2014) (Figure 2B).

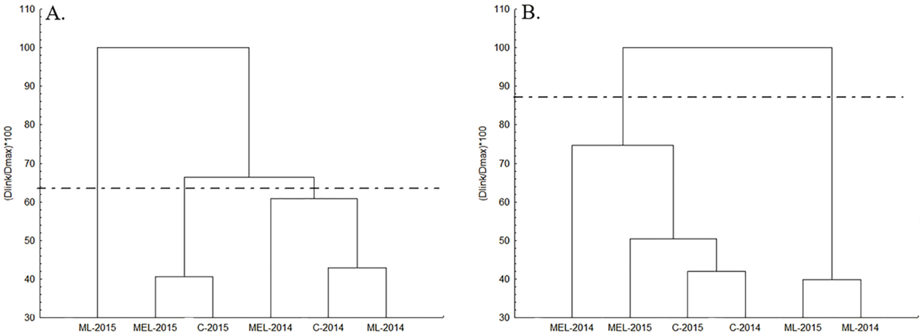

Figure 2. Dendograms resulted from grouping analysis of the soil's physical variables at the 0-10 (A) and 10-20 cm (B) deepths. *C-2015 (Caatinga 2015); C-2014 (Caatinga 2014); CRS-2015 (Crop row spacing 2015); CRS-2014 (Crop row spacing 2014); CCR-2015 (Crop canopy reagion 2015); CCR-2014 (Crop canopy reagion 2014).

This differentiation of grouping between the soil's layers evaluated suggests that there is and influence of the management in soil's physical properties from one year to another, specially on the surface layer, where, particularly, there is maintenance of the crop prunning residues and, or, greater soi'l exploration by the crop roots, what helps to increase soil's aggregation and porosity.

Soil chemical attributes

The year of 2014

The soil under irrigated mango (Canopy reagion) showed greater contents of phosphor (P), calcium (Ca^{2+}), magnesium (Mg^{2+}), and potassium (K^{+}) in relation to soil under Caatinga at the layers of 0-10 and 10-20 cm depth (Figure 3A and 3H).

There was a similar behavior noticed in P and Mg^{2+} when irrigated mango (Canopy region) was compared to Caatinga. The soil under irrigated mango (Canopy region) also showed greater K^{+} content in relation to soil under Caatinga at the layer of 0-10 cm depth, just like Mg^{2+} in both evaluated layers. The available P contents observed in soil under Caatinga at the layers of 0-10 and 10-20 cm depth (Figure 3A and 1B).

Observing the nutrient levels tables to recommend fertilization for the irrigated mango cultivation in the submedium San Francisco area, the available P contents observed in soil were classified as high at the layers of 0-10 and 10-20 cm depth, being above the critical level estabilished for the crop (40 mg dm^{-3}) for the Pernambuco state (Silva et al., 2004).

The K^{+} contents in soil under irrigated mango are classified as low (Silva et al., 2004) at the layers of 0-10 and 10-20 cm depth. The greater contents of K^{+}, Ca^{2+} and Mg^{2+} in soil under irrigated mango are justified by the accomplishment of pH corrections and soil fertilization, replacing exported nutrients by crop and, or, loss by leaching. In Caatinga, the low contents are explained, in part, due to the greater proportion of the nutrient is located in vegetation, from the natural low fertility of the quartz sandy neosol and from the low nutrients cycling offered by the semiarid region climate.

The potential acidity values (H+Al) varied between the different types of use, with greater values observed in the crop at the layer of 0-10 cm depth (Figure 4A). Opposite result was noticed at the layer of 10-20 cm depth.

There was no difference in the exchangeable acidity (Al^{3+}) and pH between soils under different types of use evaluated at the layers of 0-10 and 10-20 cm depth (Figure 4C to 4F). Some differences were observed to the electrical conductivity (EC) comparing Caatinga to irrigated mango (Canopy region or row spacing) In both evaluated layers, however, the absolute values are low, staying between 0,48 and 0,65 dS m^{-1} . Considering that the submedium

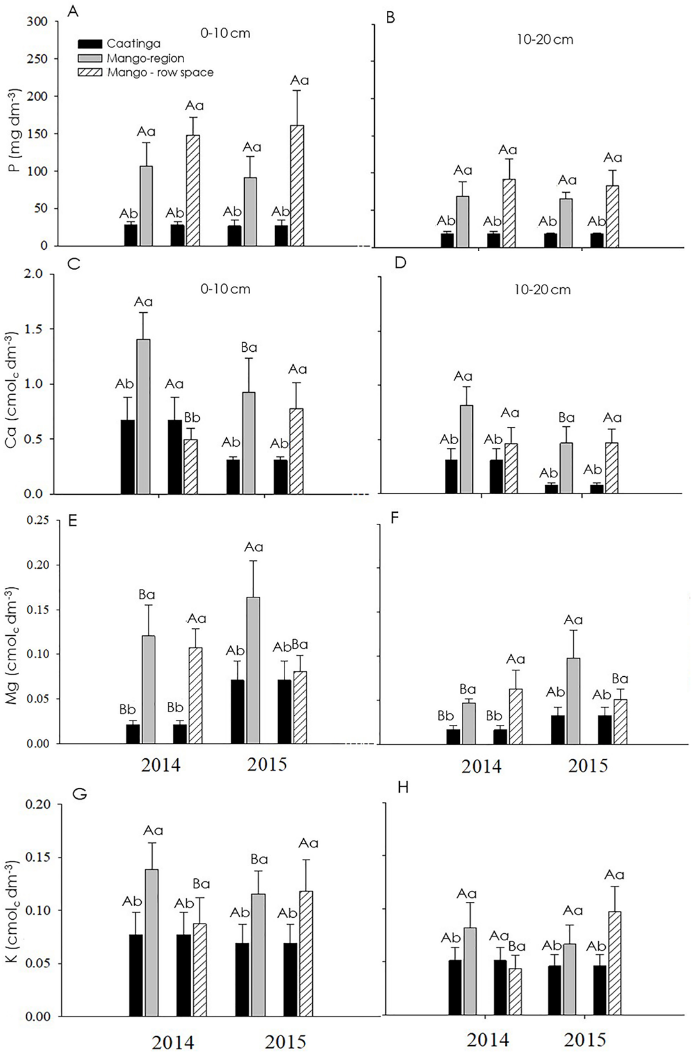

Figure 3. Phosphor contents (A;B), calcium (C;D), magnesium (E;F) and potassium (G;H) at the layers of 0-10 and 10-20 cm depth under irrigated mango cultivation (canopy reagion and row spacing) and caatinga to the years of 2014 and 2015. Columns followed by the same lower case between the uses and capital between years do not differentiate by the Student's T test (P>0,05). The bars represent the average standard deviation.

San Francisco valley region is in a semiarid climate area, where the evapotranspiration rates exceed the precipitation ones, the EC plays an important role in the salinity monitoring during and in between the crop production cycle.

The pH results are near to the optimum range to the crop development (Embrapa, 2015). Corrêa et al., (2009), studying sandy soils in semiarid, it was observed greater pH values in irrigated mango cultivation area in relation to the area of Caatinga. The pH values of 5,5-6,0 contribute to macro e micronutrients disponibility, and collaborate to the Al^{3+} transformation to other complex forms (Spera et al., 2014), not toxic to plants.

The soil under irrigated mango cultivation (Canopy region) showed greater values of the sum of bases (SB) and bases saturation (V) in relation to soil under Caatinga, to the layers of 0-10 and 10-20 cm depth (Figure 5). The soil under irrigated mango (row spacing) also showed greater values of SB and V in relation to soil under Caatinga at the layers of 0-10 and 10-20 cm depth (Figure 5).

The nutrients contribution through the production fertilization favour the greater values of SB and V (%) in soil under irrigated mango in relation to soil under Caatinga. According to Corrêa et al. (2009), the corvertion from native vegetation to crop favour greater values of SB and V values due to liming and fertilization performed. The CEC values were greater in soils

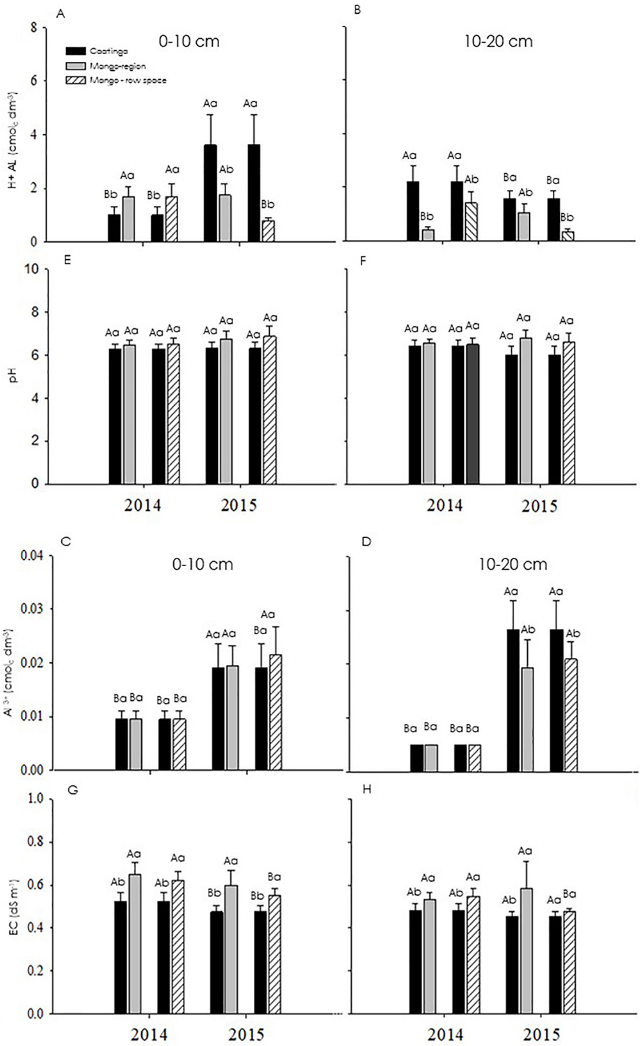

Figure 4. Potential acidity (A;B), exchangeable acidity (C;D), pH (E;F) and electrical conductivity (G;H) at the layers of 0-10 and 10-20 cm depth under irrigated mango cultivation (Canopy region and row spacing) and Caatinga for the years of 2014 and 2015. Columns followed by the same lower case between uses and capital between years do not differ by the Student's T test (P>0,05). The bars represent the average's standard deviation.

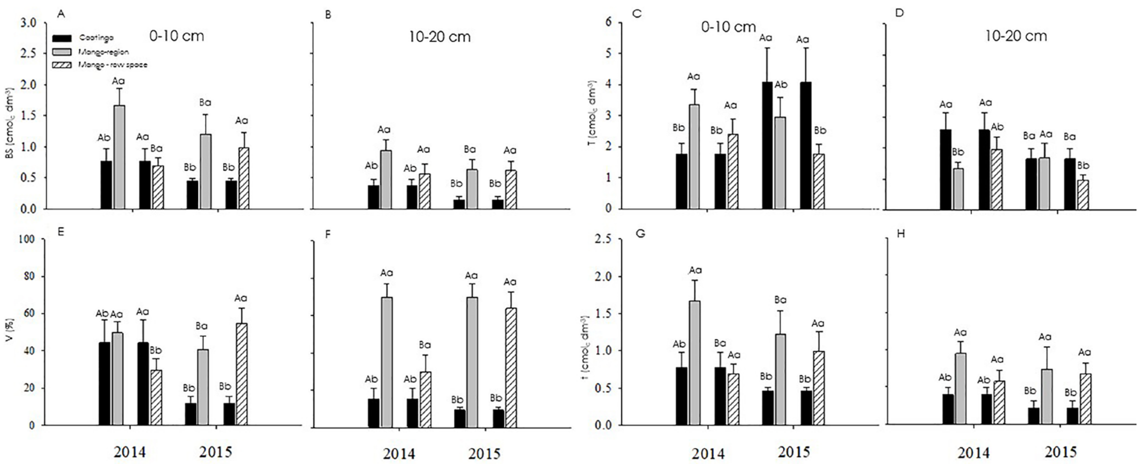

Figure 5. Sum of bases (A;B), potential cations exchange capacity-CEC (C;D), bases saturation (E;F) and effective CEC (G;H) at the layers of 0-10 and 10-20 cm depth under irrigated mango cultivation (Canopy region and row spacing) and Caatinga to the years of 2014 and 2015. Columns followed by the same lower case between uses and capital between years do not differ by the student's T test (P>0,05). The bars present the average standard deviation.

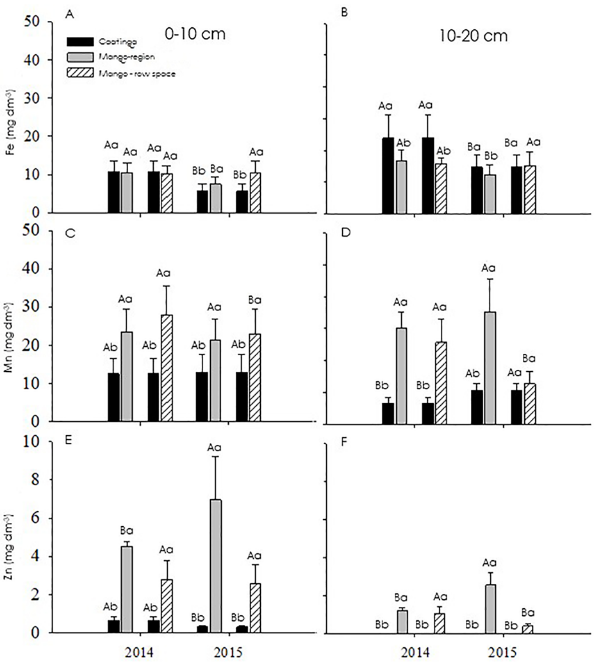

Figure 6. Iron (A;B), manganese (C;D) and zinc (E;F) contents at the layers of 0-10 and 10-20 cm depth in soils under irrigated mango cultivation (Canopy region and row spacing) and Caatinga for the years of 2014 and 2015. Columns followed by the same lower case between uses and capital between years do not differ by the student's T test (P>0,05). The bars represent the average standard deviation.

under irrigated mango on surface layer than in the other treatments. Opposite behavior was observed at the layer of 10-20 cm depth (Figure 5D).

Whereas the effective CEC (t), exeception of similaty of crop canopy region and Caatinga, the soil under irrigated mango showed greater t value.

Such as macronutrients, was verified that in a general way the micronutrients contents were greater in crop areas, especially those in the canopy region. The manganese (Mn^{2+}) and zinc (Zn^{2+}) contents were greater at the layers of 0-10 and 10-20 cm depth under irrigated mango in relation to soil under Caatinga (Figure 6C to 6F). The Fe^{2+} contents were classified as low to medium, according to Ribeiro et al. (1999)..

Higher values of micronutrients in soil under irrigated mango are justified by the technological level adopted, with micronutrients fertilization, replacing the exported contents by the crop. The Mn^{2+} and Zn^{2+} contents observed at the layer of 0-10 cm depth under irrigated mango were classified as high (Mn^{2+} > 12 mg dm^{-3} and Zn^{2+} > 2,2 mg dm^{-3}), according to Ribeiro et al. (1999). The reduced contents of micronutrients in soil under Caatinga are justified, in part, by the Psamment natural low fertility.

The year of 2015

In the year of 2015, the soil under irrigated mango (Canopy region and row spacing) showed P, Ca^{2+}, Mg^{2+}, and K^{+} greater than those found for soil under Caatinga at the layers of 0-10 and 10-20 cm depth (Figure 3).

In figure 4 is possible to observe that the different uses evaluation considering the values of H+Al, Al^{3+}, pH and EC followed the same behaviour from the previous year, as exception of the values of H+Al at the layer of 0-10 cm depth and Al^{3+} at the layer of 10-20 cm depth, witch contents were greater in Caatinga.

The SB, T, V (%) and t values showed significant differences between the irrigated mango cultivation area and Caatinga (Figure 5A to 5F). The soil under irrigated mango (Canopy region and row spacing) showed SB, V and t values greater than those found in Caatinga at the layers of 0-10 and 10-20 cm depth. On the other hand, the soil under irrigated mango (Canopy region and row spacing) showed T values lower than those found for Caatinga at the 10 cm initial depth (Figure 5C).

For micronutrients, the soil under irrigated mango (Canopy region and row spacing) showed Fe^{2+}, Mn^{2+} and Zn^{2+} contents greater than the values in the soil under Caatinga in both soil evaluated layers, expected for Fe^{2+} content at the layer of 0-10 cm depth (Figure 6).

Comparisons of uses between the years of 2014 and 2015 for the soil chemical attributes

A few alterations in the nutrients contents were observed in the area of Caatinga from the year of 2014 to 2015. These results are expected since in natural and stabilized environments the nutrients cycling is found in balance, because there is not crop exportation.

The soil under irrigated mango cultivation showed significant differeces between both years. Similar to the one found by Oliveira et al. (2015b) that studied the heavy metal and micronutrients variation in an area of vine under three irrigation strategies in Petrolina-PE, witch the nutrients contents in irrigated mango canopy reagion and row spacing showed sthocastic standard between the studied years (Figures 3 and 4).

It can be observed that the irrigated mango cultivation (canopy region) resulted in a decrease of 34,0 and 43,2% in the Ca^{2+} contents at the layers of 0-10 and 10-20 cm depth, respectively. A similar behavior was noticed for the K^{+} contents and V(%) values at the layer of 0-10 cm depth. The irrigated mango cultivation (canopy region) also resulted in a decrease in the SB values at the layers of 0-10 and 10-20 cm depth. On the other hand, for the Mg^{2+} contents, it can be observed that the irrigated mango cultivation (canopy region) increased 41,7% at the layer of 0-10 cm depth and 100% at the layer of 10-20 cm depth. The irrigated mango cultivation (canopy region) also resulted in an increase of 100% in Al^{3+} contents at the layers of 0-10 and 10-20 cm depth (figgure 4C and 4D) and 23,70% in the T values at the layer of 0-10 cm depth (Figure 5D).

According to Ribeiro et al. (1999), the T values observed in this study are classified as low (1,61-4,30 $cmol_c$ dm^{-3}), indicating that the soil has a little capacity to retain cations in an exchangeable form. Thus, chemical fertilizations must be performed in a fragmented way to reduce the nutrients loss by leaching, or, still, make use of low liberation fertilizers or less soluble ones (Duarte et al., 2013; Frazão et al., 2014). The low T values observed are justified by the low clay amount (5,2%) in quartzsandy neosol. In addition to the greatest amount of the coarse fractions of the soil, that deduct less density of negative charges (CEC), is possible that a good part of the CEC must be originated from minerals of variable charges, as indicate Cunha et al. (2014) studying the origin of negative charges in soils of reference from the Pernambuco state.

In this conditions the low CEC values, decrease cations retention, which induces the necessity of using management practices that can enable the plant's incremental nutrients availability and decreasing loss by leaching, as indicate Mendel et al. (2015).

The irrigated mango cultivation (row spacing) resulted in an increase of 56% in the Ca^{2+} content at the layer of 0-10 cm depth and, 33,3 and 150% in the K^{+} contents at the layers of 0-10 and 10-20 cm depth, respectively. Similar behavior was observed to Al^{3+} in both soils evaluated layers, and for the SB and V (%) in the first 10 cm depth.

The irrigated mango cultivation (row spacing) resulted in a decrease of 27,3 and 16,7% in the Mg^{2+} contents at the layers of 0-10 and 10-20 cm depth, respectively. In this same collect area there was a decrease of 54,1 and 78,8%; 11,3 and 14,53% in the H+Al and EC at the layers of 0-10 and 10-20 cm depth, respectively.

Differently, of what was observed in mango canopy region, the plant necessary nutrients in greater amount did not decrease in row spacing region, because, even though the root system reaches the row spacing region and nutrients absorbed in this region, this absorption is considered smaller in comparison to canopy region.

For the micronutrients contents, compared to the years of 2014 and 2015, it can be observed that the irrigated mango cultivation (canopy region) resulted in a decrease in the Fe^{2+} contents and increase in the Zn^{2+} contents at the layers of 0-10 and 10-20 cm depth, respectively.

In this study two agricultural years were analyzed and the time interval may be considered small. Although, the results in this study show that might occur changes in the soil attributes in a short time. Such timeless changes are of great importance to determinate the fertilization recommendations.

Therefore, this study shows the importance of knowing the temporal evolution in the soil attributes in order to build fertility historic of the soil of a determined agricultural area to make a decision about its management.

Grouping analysis of soil chemical attributes

Through the grouping analysis for the chemical attributes of the soil (Figure 7) was possible to observe that was formed two groups with relative distance below 65% at the layer of 0-10 cm depth (Figure 7) and two groups with 48 and 64% of relative distance at the layer of 10-20 cm depth (Figure 7B).

In the top soil (0-10 cm) there is greater proximity between Caatinga soils collected in 2014 and 2015 (Figure 7). As well as greater proximity between the irrigated mango soils, mainly for samples collected in the same year (MRS-2015: MCR-2015 and MRS-2014: MCR-2014). In the layer of 10-20 cm depth, there was good proximity between MCR-2015 and MRS-2014 and MRS-2015 and MCR-2014.

By means of grouping analysis, it can be observed the greater relation between soils under native vegetation, such as those under irrigated mango cultivation. Freitas et al. (2014) also observed the greater similarity between soils that suffered greater external interference such as sugarcane cultivation and reforested area, making a clear division between this group (Sugarcane and reforested area) and the group under native vegetation.

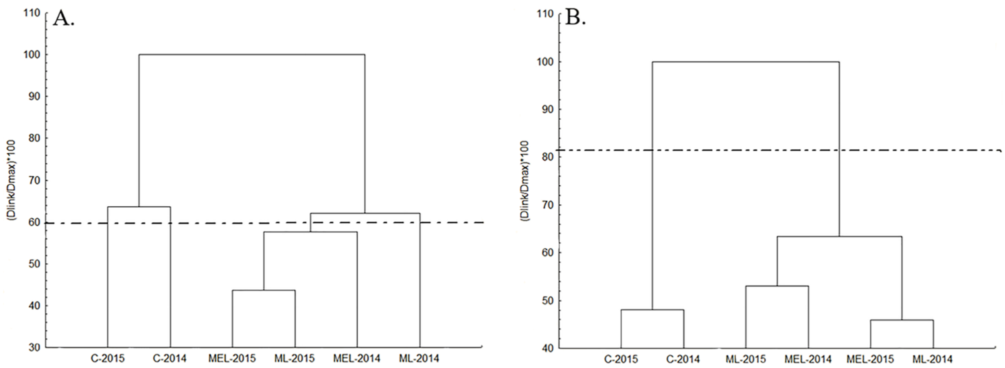

Figure 7. Dendrograms resulted from grouping analysis of the soil chemical variables at the layers of 0-10 (A) and 10-20 (B) cm depth. *C-2015 (Caatinga 2015); C-2014 (Caatinga 2014); MRS (Mango row spacing 2015); MRS-2014 (Mango row spacing 2014); MCR (Mango canopy region 2015); MCR-2014 (Mango canopy region 2014).

Conclusions

The irrigated mango cultivation (canopy region and row spacing), in the area previously occupied by Caatinga, promotes just a few alterations in the soil physical attributes in both evaluated years.

For both evaluated years, the irrigated mango cultivation (canopy region and row spacing), in the area previously occupied by Caatinga, promotes in a general way increase in the macronutrients contents.

The macronutrients contents in soil under irrigated mango canopy region and row spacing showed a stochastic pattern between the year of 2014 and 2015.

There is a clear distinction between the soils in the area of Caatinga and under irrigated mango in relation to chemical attributes, which establish good relation between soils under irrigated mango, in any collecting periods, such as good similarity of soils under Caatinga in both evaluated years.

The changes in the soil use, considering the adopted management, do not cause negative impacts in the soil chemical attributes.

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