American Journal of Innovative Research and Applied Sciences.ISSN 2429-5396I www.american-jiras.com

ORIGINAL ARTICLE

CONTRIBUTION TO THE STUDY OF FERTILITY STATE OF AGRICULTURAL SOILS OF GAROUA 3 IN NORTHERN CAMEROON

| Arafat Gové [1,2*] | Michaël Zirted Jourmbi [1,3] | Alain Loabé Pahimi [1,4] | Daïrou Saïfoullah [1,3] | and | Jacques Housseni Djida [1,3] |

[1.] Institute of Agricultural Research for development (IRAD) | Multipurpose Station of Agricultural Research of Garoua | PO. Box 415 Garoua | Cameroon |
[2.] Departments of Earth Sciences | Faculty of Science | University of Ngaoundéré | P.O Box 454 Ngaoundéré | Cameroon |
[3.] Department of Biological Sciences | Faculty of Science | University of Ngaoundéré | PO. Box 454 Ngaoundéré | Cameroon |
[4.] Department of Environmental Sciences | National Advanced School of Ingineering | University of Maroua | Cameroon | P.O Box 46 Maroua |

| Received June 08, 2020 | | Accepted 28 June, 2020 | | Published July 08, 2020 | | ID Article | Arafat-Ref.2-ajira080620 |

ABSTRACT

Background: Soil fertility decrease is a major concern in global agriculture and particularly in tropical areas in general and particulary in the northen part of Cameroon where the population is growing faster than the food production. Garoua 3 subdivision is an important agricultural zone of Garoua in North region. It is intensely exploited for the production of various food products like corns, groundnuts and many other crops. This is the main cause of the decline of soil fertility in this area. **Objective:** determination of the fertility state of agricultural soils of Garoua 3 subdivision. **Methods:** Three villages were chosen and sixteen samples were collected per village by using an auger, and according to the type of speculation, then physico-chemical properties of each sample were analysed and compared with reference values of fertility. **Results:** pH and mineral particle size of all the samples varies slightly (Sandy loam and pH comprise between 6,2 and 6,8) except the one of Babla 1 where texture is claly. The soils of Djalingo 1 and 2 and Sanguere 1 have low organic matter content (<1%) and those of Sanguere 1 and Babla 1 and 2 have moderate and high organic matter. Available phosphorus is almost low everywhere except the soils of Babla 2 (27,76cmol/Kg) and Sanguere 2 which have value comprise in interval of normal value (10,32cmol/Kg). Soils of Sanguere 2, Djalingo 2 and Babla 2 shows the values situated out of the normative range of Ca^{2+}/Mg^{2+} ratio with respective values of 17; 13, 73; and 15,5 and soils of Sanguere 2, Djalingo 1 and 2, Babla 1 presents also the values out of normative range respectively 1,6; 1,45; 1,38 and 41,45. In all these localities, calcium remains the most dominant element with 72.2% of the exchangeable cations of all the soil. Babla1 registered he high value 6.56 meq /100g followed by the Babla2, 6.08 meq /100g and the lowest value of calcium were recorded to the Djalingo1 1.92 meq/100g. Concerning magnesium low value were registered in Sanguere2 0.152meq/100g. Where the high value is recorded to Babla1 4,56 meq/100g. Concerning the potassium, except Djalingo1 and the control which have registered a high value 0.25 meq/100g, the order rest have a same low value 0.11 meq/100g. The soil samples in Sanguere 2 have a low value of CEC 3.84 and the high is registrated in Babla1 60.8 cmol/Kg. The other ones have values comprise between 5 and 20 meq/100g. Whereas the high value of saturation rate is resgistrated in Sanguere1 soil samples 84,55 meq/100g and the low is obtained on the soil of Babla118.83. **Conclusion:** No sample has the optimal values for all the elements analysed and one can notice the low values of K^+ for all the samples, but normal pH for all.

Key words*: soil fertility, Garoua III, physicochemical properties, agriculture*

1. INTRODUCTION

Agriculture is one of the pillars of Cameroonian economy, it provides nearly 25% of total GDP, it occupies around 60% of active population and contributes to the growth of other economic sectors [1, 2]. In the northern regions of the country, the populations are 80% rural with very low literacy rate, so the main activity remains agriculture [3]. However, the yield of the main crops decreases each year and the vast majority of producers live below the poverty lines despite their multiple efforts due to land degradation [4]. Agriculture in sub-Saharan African countries in general is characterized by this low productivity due to the constant decline in soil fertility causes by climatic hazards (rain is rare and irregular), excessive use of chemical fertilizers, overgrazing, overexploitation of natural resources due to overpopulation and the disappearance of long fallows previous studies [5, 6, 7, 8]. The consequences include the disappearance of bushes and the scarcity of cultivable soils [7, 9]. The extent of this degradation varies according to the types of soil, the method of exploitation and the population dynamics (annual growth of up to 1.5%, population migrations) [10]. For more than a decade, there has been a decrease in agricultural productivity in the entire region of North Cameroon, particularly that of Garoua 3 which depends almost essentially on agriculture [11]. Garoua 3 subdivision is an important agricultural zone of Garoua in North region. It is intensely exploited for the production of various food products like vegetables, corn, groundnuts and many other crops. According to SODECOTON reports, there is a downward trend in yields of around 30% over 20 years, over 11 kg / ha / year in this area [12]. In addition, the doses and formulas of fertilizers vulgarized for certain crops developed for more than twenty years are no longer adapted to these soils because there would have been modifications in the chemical imbalances of the mineral elements of cultivated soils with the appearance of new deficiencies in the region, or a strengthening of those that already existed [12]. That is why it is therefore important to conduct a study to assess the fertility status of the various agricultural soils in this area, by studying the various major elements of fertility (total nitrogen, assimilable phosphorus, potassium, organic matter) present in these soils, the different ion balances (ion balances) and certain physical properties (pH, texture, etc.) in order to find notorious solutions for furthers restoration.

2. MATERIALS AND METHOD

2.1. Description of study site

The study is carried out in the Garoua III subdivision located in the North Region, Department of Benoue. It has an area of 432.5 km² (Figure 1). The commune is limited to the North by the Benoue river; to the south, east and west by Ngong commune. The climate is tropical, Sudanese type. It is characterized by a long dry season from October to April and a short rainy season from May to September. The average annual rainfall is about 1000 mm of water. Temperatures remain high with an average of 28 ° C and maximums reaching 40 to 45 ° C in March and April. The soils are ferruginous. The land is very deep with a sandy texture and good potential with alluvial land along the Benoue in flat land. Its population is estimated at 64,806 inhabitants is characterized by great ethnic wealth. The two main activities of the populations are agriculture which supports almost the entire population and breeding. The main food crops (maize, millet, rice) are the staple food. To these cereals are added peanuts, cassava, cowpeas, okra, tomatoes, soybeans, sesame seeds, and many other food crops. More than half of the production is intended for local consumption. The rest is carefully kept to wait for the lean season and to prepare the next agricultural season to be sold to resolve specific problems (health, education, etc.) PNDP (2011) [11].

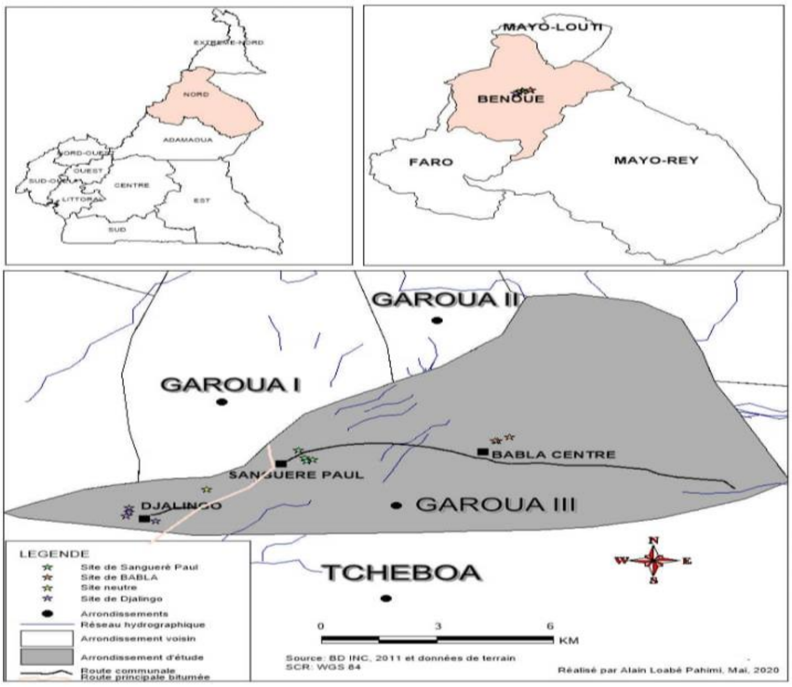

Figure 1: Map of study site.

2.2. Sampling method

The soil samples were taken between 0-20cm depth using a manual auger. On a quarter hectare plot, 15 to 20 core samples were taken along the two diagonals, approximately every 9 m. All the soil sampled is collected in a bucket and then well mixed. After that, 500g of this earth constituting a composite sample is recovered and bagged to carry out laboratory analyses.

2.3. Sampling plan

Three villages in this commune were chosen, Sanguere-Paul, Babla and Djalingo. The three villages chosen are the largest agricultural production areas in the commune, and they are the ones that have periodic markets (where there is trade in agricultural products). In each village, two agricultural speculations were targeted: maize and cotton (for the cases of Sanguere and Djalingo), corn and sorghum (for the case of Babla), eight composite samples were taken by speculation in each village (16 composite samples per village), so a total of 48 samples.

2.4. Physico-chemical analyses

The physico-chemical analyses were carried out at the Laboratory of Soil Analysis and Environmental Chemistry (LABASCE) of the Faculty of Agronomic Sciences (FASA) of Dschang (Cameroon) according to the international methods recommended by Pauwels et *al.*, (1992) [13]. The variables analyzed are: particles size analyses, pH, organic matter (MO), exchangeable bases (BE), cation exchange capacity (CEC), total nitrogen (Ntot) and phosphorus**.**

2.4.1. Particle size analyses

The different particle size fractions were determined by mechanical analysis according to the Robinson pipette method [14]. The procedure consisted in the elimination of organic matter by oxidation with hydrogen peroxide, of iron and aluminum sesquioxides by HCl, then the separation of sand by sieving under water with a 50 µm sieve. The clay + fine silt mixture is removed using a Robinson-Köhn pipette after dispersion of the colloidal suspension with sodium hexametaphosphate) [15].

2.4.2. pH

The pH-H20 (current acidity) of the soil was measured using a pH meter with a glass electrode 24 hours after mixing 10g of each soil sample in 25ml of distilled water. The pH-KCl (potential or total acidity) was measured 15 min after having introduced 10 g of each soil sample into 25 ml of 1N KCl solution [16].

2.4.3-Organic matter

The CO (%) was determined by the Walkley and Black method (1934) [17]. The organic carbon in the soil is oxidized by a solution of potassium dichromate ($K_2Cr_2O_7$) in excess, in a sulfuric medium. The excess of dichromate not reduced by the organic carbon is then titrated with a solution of ferrous sulphate (FeSO4.7H2O) in the presence of diphenylamine which turns from purple to green at the equivalence point. The rate of organic matter is determined by the formula:

$$\% \text{ OM} = \% \text{ CO} \times 1.724 \qquad \textbf{(1)}$$

2.4.4. Exchangeable bases, cation exchange capacity (CEC) at pH 7 and saturation rate

The determination of the contents of exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, Na^+) was carried out after extraction with 1N ammonium acetate at pH 7. Na and K were measured by flame spectrophotometry, while Ca^{2+} and Mg have were determined by complexometry with EDTA (ethylene diamine tetra acetate). The determination of the CEC at pH 7 is carried out after washing. The determination of the contents of exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, Na^+) was carried out after extraction with 1N ammonium acetate at pH 7. Na and K were measured by flame spectrophotometry, while Ca^{2+} and Mg have been determined by complexometry with EDTA (ethylene diamine tetra acetate). The determination of the CEC at pH 7 is carried out after washing with alcohol (90°C) in order to remove the saturated NH_4^+ solution. The determination of NH_4^+ is made by Kjeldahl distillation after quantitative desorption K^+.
The saturation rate of exchangeable bases (T) was obtained by the following formula:

$$V (\%) = (S/T)*100 \text{ where } S = \text{sum of bases exchangeable in meq/100 g} \qquad \textbf{(2)}$$

T = cation exchange capacity of the soil in meq/100 g.

2.4.5. Total nitrogen

The determination of the total nitrogen content was carried out according to the method of Kjeldahl [18]. It consists on complete mineralization of organic nitrogen with a mixture of concentrated sulfuric acid (H_2SO_4) and hot salicylic acid (350 ° C). The mineralize is distilled by steam entrainment, the distillate is then titrated with a solution of H_2SO_4 (0.01 N)/

$$N (g/kg) = (v-vo)*0.01*14/pe \qquad \textbf{(3)}$$

With

pe: test sample, volume of H_2SO_4 poured to neutralize nitrogen in the distillate
vo volume of the control.

2.4.6. Available phosphorus

The available phosphorus was determined by the Bray 2 method [19]. This method combines the extraction of phosphorus in an acid medium (HCl 0.1 M) with the complexation by ammonium fluoride (NH_4F 0.03 M) of Al3 + and Fe^{3+} ions linked to phosphorus. The dosage of phosphorus is determined by molybdenum blue colorimetry, based on the formation and reduction of a complex of phosphoric acid and molybdic acid by ascorbic acid. The spectrophotometer readings are taken at a wavelength of 665 nm.

2.5. Data analysis

The data collected from the field where subjected to the analysis with Excel package to obtain the means, Microsoft word for whriting the text; and Tridraw has used to determine soil class texture of soil samples.

3. RESULTS

3.1. pH

The pH-H_2O values ranged from 5.6 to 6.9; furthermore Djalingo 2 registered the high value compare to the Babla 2 which recorded the lowest value. Concerning ph –KCl the values are comprise within 4.2 to 5.8, meanwhile Babla 2 has a low values 4.2, whereas the high value is registered from Sanguere 1. The soil pH-H_2O of all study sites are between moderate acidic (5.6-6.0) to neutral (6.6-7.3) according to the PAP classification (1976) [20].

Table 1: The table presents the results of soil pH.

Ph	Djalingo 1	Djalingo 2	Sanguere 2	Babla 2	Sanguere1	Babla 1	Control soil
pH-H_2O (1 :2,5)	6.8	6.9	6.4	5.6	6.6	6.30	6.2
pH-KCl (1 :2,5)	5.3	5.5	5.3	4.2	5.8	5.31	5.0

3.2. Soil Texture

Table 2 presents the results of soil texture which derived to the percentage of particle size. Texture of all the soils studied outside of Babla 1 is sandy-loam (LS) type which is medium soils or loam. That of Babla 1 is clayly.

Table 2: The table presents the percentage of soil size particles and soil texture.

	Djalingo 1	Djalingo 2	Sanguere 2	Sanguere 1	Babla 2	Babla 1	Ctrl
Depth (cm)	20cm	20cm	20cm	20cm	20cm	20cm	20cm
Sand	79	72	77	75	76	13	81
Silt	11	16	10	11	8	32	7
Clay	10	12	13	14	16	55	12
Texture	LS	LS	LS	LS	LS	A	LS

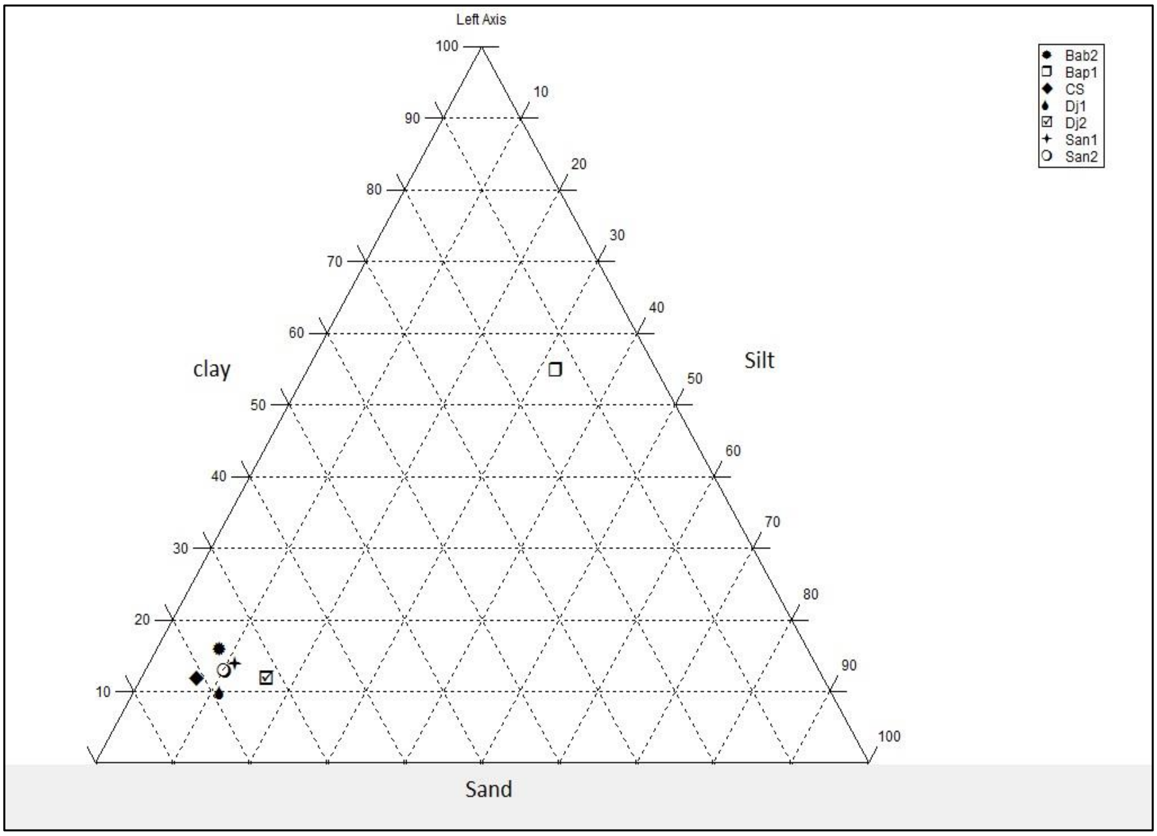

Figure 2: The figure presents the textural triangle.

3.3. Organic matter and total nitrogen

The results of soil Organic matter content analysis showed that the site of Djalingo 1; Djalingo 2 and Sanguere 2 have recorded lower value than the normative value (1%) ; whereas the organic matter content of sanguere 1 is lowly high to the normative value. The other site such as Babla 1; Babla 2 and control presented high value compare to the normative value. Regarding total nitrogen, the results show that the values are comprised within 0.23g/kg to 0.86g/kg. The high value is registered in the soil of Babla1 and the low value in Sanguere 2. In all of the soil sites, total nitrogen is fairly poor compare to the normative value. The results of C/N ratio showed that the values ranged from 1.3 in the Sanguere 1 soil to 3.2 corresponding to the control soil.

Table 3: Data of organique matter and total nitrogene.

Organic matter	Djalingo 1	Djalingo 2	Sanguere 1	Sanguere 2	Babla 1	Babla 2	Control
Organic Carbone (%)	0.57	0.48	0.69	0.30	2.26	2.02	1.36
Organic matter (%)	0.99	0.83	1.20	0.52	3.90	3.49	2.34
Total nitrogen (g/Kg)	0.30	0.30	0.33	0.23	0.86	0.65	0.42
C/N ratio	1.9	1.6	2.1	1.3	2.6	3.1	3.2

3.4. Exchangeable bases; available phosphorus, CEC and saturation rate.

Form the table (4) it is appear that In all these localities, calcium remains the most dominant element with 72.2% of the exchangeable cations of all the soil. Babla1 registered he high value 6.56 meq /100g followed by the Babla2, 6.08 meq /100g and the lowest value of calcium were recorded to the Djalingo1 1.92 meq/100g. Concerning magnesium low value were registered in Sanguere2, 0.152meq/100g. Where the high value is recorded to Babla1 4,56 meq/100g. Concerning the potassium, except Djalingo1 and the control which have registered a high value 0.25 meq/100g, the order rest have a same low value 0.11 meq/100g.

According to SYS (1976) when the ratios of calcium (Ca^{2+}) and magnesium (Mg^{2+}) give a value greater than one and less or equal to ten and or when the ratios of magnesium (Mg^{2+}) and potassium (K^{+}) give a value greater than three and less or equal to twenty ($1<Ca/Mg<10$ and $3<Mg/K<20$) [21]. In our results, one can see that the Sanguere 2, Djalingo 2 and Babla 2 soils have values outside the normative range of the Ca^{2+} / Mg^{2+} ratio with respective values 17; 13.73 and 15.2. The Mg / K ratio also shows that the soils of Sanguere 2, Djalingo 1 and 2 and Babla 1 have values outside the normative range (1.6; 1.45; 1.38 and 41.45 respectively).

The results show that available phosphorus values of these soil samples are included between the lowers and medium of normative values except the one of Babla 2 which has high value (27,76 cmol/Kg). Sanguere 1, Djalingo 1 and Djalingo 2 have low available phosphorus content with respectively values of 7,94 cmol/kg, 6,41 cmol/kg et 9,18 cmol/kg.

The soil samples in Sanguere 2 have a low value of CEC 3.84 and the high is registrated in Babla1 60.8 cmol/Kg. The other ones have values comprise between 5 and 20 meq/100g. Whereas the high value of saturation rate is resgistrated in Sanguere1 soil samples 84,55 meq/100g and the low is obtained on the soil of Babla1 18.83.

Table 4: Results of exchangeable cations, CEC and saturation rate.

Exchangeable bases	Djalingo 1	Djalingo 2	Sanguere 2	Babla 2	Sanguere 1	Babla 1	control
Calcium	1.92	2.72	2.088	6.08	5.6	6.56	2.32
Magnesium	0.4	0.16	0.152	0.4	1.2	4.56	0.8
'Potassium	0.25	0.11	0.11	0.11	0.11	0.11	0.25
Sodium	0.22	0.22	0.43	0.22	0.22	0.22	0.22
Sum of bases	2.79	3.21	2.78	6.81	7.13	11.45	3.59
CEC pH7 (meq/100g)	9.6	5.6	3.84	19.6	8.432	60.8	6
V (saturation rate)	29.06	57.32	72.39	34.74	84.55	18.83	59.83
Ca/Mg	4.8	17	13.73	15.2	4.67	1.43	2.9
Mg/K	1.6	1.45	1.38	3.63	10.9	41.45	3.2
K/Mg	0.62	0.68	0.72	0.27	0.09	0.024	0.31
Available Phosphorus	6.41	9.18	10.32	27.76	7.94	19.09	6.30

4. DISCUSSION

4.1. pH

The pH is an important element of the chemical composition of the soil which determines the availability of nutrients for plants and soil microorganisms [22, 23], it is also an indication of the general level of available chemical elements of soil. The pH of the soil is directly related to the exchangeable cations and anions. It plays an important role in the mechanism of retention or release of nutrients [24]. The pH-H_2O values obtained during this study show that they are moderately acidic to neutral, therefore suitable for agriculture according to Giguère (2002) [25]. The acidity of Babla2 which is vertisol is seems to be due to extensively agriculture exploitation added to regularly using of pesticides. Whereas the orther ones are washout ferruginous soils which are formed on sandstone formations that is why this soil have a high rate of sand, a low rate of exchangeable cations and the acidic pH.

4.2. Soil Texture

The Loamy sand texture of majority of soils sample analysed would certainly be linked to their pedogenetic nature, parental materials being of sandstone material. Babla1 soil is vertisol, that's why this soil has clayly texture. The LS considered according to the classification of APA (1976) [20] as soils with medium texture or even balanced texture. They are suitable for growing cassava, maize, peanuts, cowpeas, etc. [25, 26, 27, 28]. The soil of Babla 1, on the other hand, has a very fine texture (APA, 1976) [20].

4.3. Organic matter and total nitrogen

The soils of Djalingo 1; Djalingo 2 and Sanguere 2 have a low OM content; that of Sanguere 1 has an average organic matter content (1.20%) and finally those of Babla (1 and 2) and control soil have a high OM content. It also emerges from this study that the total nitrogen of all these soils is low compared to the optimal value (<1%) [20]. The low organic matter content at the Djalingo and Sanguere sites can be explained by the fact that the soils are exploited for several years without organic input or fallow (according to the testimony of farmers), that is why it is observed that the OM content of uncultivated soils (left fallow for more than 10 years) has a high content of OM (2.34%). Continued exploitation of the land without using suitable restoration and conservation techniques undoubtedly leads to total soil degradation [29, 30]. According to Hubert and Schaub (2011), organic matter plays a physical role in the soil for cohesion, structure, porosity, water retention or storage, etc [31]. It also plays a biological role in stimulating biological activity (earthworms, microbial biomass). Finally, it plays a chemical role in the nutrition of plants through actions of degradation, mineralization, etc. The ratio between carbon and nitrogen (C/N) is low (less than 20) for the case of Djalingo and Sanguere which can make according to Ballot et al., (2016) a slow or even difficult decomposition and does not allow good mineralization of organic matter [28]. The low OM content of these soils is an handicap for the dynamics of the soil ecosystem and remains a major factor in lowering agricultural productivity. The soils of Babla 1 have a high OM content, these soils are naturally different from those of other localities, and they are vertisols their property allows them to slowly mineralize the OM but also to retain the products of this mineralization as slow as it is. To this is added the phenomenon of pedoturbation (vertical movements) alternating swelling and shrinking of soil and favouring an almost equitable sharing of the OM over the entire profile. In another study carried out by Olina et *al*., (2008) in the same locality, the average of OM content, total nitrogen and the C/N ratio were respectively 1.27%, 0.49% and 15.59, a part of Babla 1 soils, all the others have lower values than the latter [12]. This proves that these lands are in perpetual degradation.

4.4. Exchangeable bases, available phosphorus CEC and saturation rate

In all these localities, calcium remains the most dominant element (with 72.2% of the exchangeable cations of all the soil samples with an average of 3.89 meq / 100g) followed by Magnesium. Despite its importance for the majority of plants, potassium shows low levels everywhere (average = 0; 15 meq/100g). Only the samples of Djalingo 1 have a normative value (0.25meq/100g) (reference threshold values: [32, 33, 22]) in K^+ compared to all the other soils which have lower values. There is a cationic equilibrium in a soil according to SYS (1976) when the ratios of calcium (Ca^{2+}) and magnesium (Mg^{2+}) give a value greater than one and less or equal to ten and or when the ratios of magnesium (Mg^{2+}) and potassium (K^+) give a value greater than three and less or equal to twenty (1<Ca/Mg<10 and 3<Mg/K<20). In our results, Sanguere 2, Djalingo 2 and Babla 2 soils have values outside the normative range of the Ca^{2+} / Mg^{2+} ratio with respective values 17; 13.73 and 15.2. The Mg / K ratio also shows that the soils of Sanguere 2, Djalingo 1 and 2 and Babla 1 have values outside the normative range (1.6; 1.45; 1.38 and 41.45 respectively). Too high K^+ / Mg^{2+} ratio in light soil causes a magnesium deficiency and therefore decreases yields, while in clay soils, a too low K^+/Mg^{2+} ratio slows the absorption rate of potassium, thereby limiting yields [33,27]. In our results, only the Sanguere1 and Babla 1 sites have a normal value of the K^+/Mg^{2+} ratio (between 0.05 and 0.1 as described by the above authors). Three sites have a low saturation rate: Djalingo 1 (29.06%), Babla 2 (34.74%) and Babla 1 (18.83%) and according to the interpretation of APA (1976) [20], these soils are moderately (Babla 2) and strongly (Djalingo 1 and Babla 1) leached. Apart from neutral soil, no other soil has a normal cationic equilibrium. The intense agricultural activities with the excessive use of chemical fertilizers and pesticides contribute to the cationic imbalance of the soils. The tropical ferruginous soils which cover a large part of northern Cameroon are reputed to be fragile, with a low level of fertility due to their very sandy texture and the sandstone nature of the original material [34]. Current cropping systems based on a cotton / cereal rotation without restitution of organic matter with tillage, result in a systematic decline in the level of soil fertility as soon as they are cultivated [35].

The results show that available phosphorus values of these soil samples are included between the lowers and medium of normative values except the soil of Babla 2 which has high value (27.76 cmol/Kg). Sanguere 1, Djalingo 1 and Djalingo 2 have low available phosphorus content with respectively values of 7.94 cmol/kg, 6.41 cmol/kg et 9.18 cmol/kg.

5. Conclusion

The main objective of this work consisted to determine the fertility state of agricultural soils of Garoua 3 subdivision. The results showed that except the soil samples in Babla 1 which has a clayly texture, pH and mineral particle size of all the samples varies slightly (Sandy loam and pH comprise between 6,2 and 6,8). The soils of Djalingo 1 and 2 and Sanguere 1 have low organic matter content (<1%) and those of Sanguere 1 and Babla 1 and 2 have moderate and high organic matter. Available phosphorus is almost low everywhere except the soils of Babla 2 (27,76cmol/Kg) and Sanguere 2 which have value comprise in interval of normal value (10,32cmol/Kg). In all these localities, calcium remains the most dominant element with 72.2% of the exchangeable cations of all the soil. Babla1 registered he high value 6.56 meq /100g followed by the Babla2, 6.08 meq /100g and the lowest value of calcium were recorded to the Djalingo1 1.92 meq/100g. Concerning magnesium low value were registered in Sanguere2, 0.152meq/100g. Where the high value is recorded to Babla1 4,56 meq/100g. Concerning the potassium, except Djalingo1 and the control which have registered a high value 0.25 meq/100g, the order rest have a same low value 0.11 meq/100g. All this soils has a low level of fertility and needed a eco-friendly technilogie to restore it. It is appear important to carry out a diachronic study to appreciate the level of decrease soil fertility and the impact of using organic and geological fertilizers for give back the lost elements.

6. REFERENCES

1. INS, 2015. Annuaire Statistique du Cameroun, édition 2015. Chapitre 14 : agriculture. Pp. 232-255. Available on : http://www.statistics-cameroon.org/news.php?id=345.

2. World Bank, 2014. Revue diagnostique des dépenses publiques de base dans le secteur agricole (2003-12). Rapport final. Pp.122. Available on : http://documents.worldbank.org/curated/en/285711467998789648/91835-REVISED-FRENCH-Box391503B-PUBLIC-Rapport-Revue-diagnostique-des-de-penses-publiques-du-secteur-agricole-version-31-mai-2014-2.pdf

3. AFD, 2018. Programme d'appui à la sécurisation et à la gestion intégrée des ressources agropastorales. Note de communication publique d'opération. CCM1272. Pp. 15. Available on : http://www.afd.fr/base-projets/consulterProjet.action?idProjet=CCM1272

4. Barbier B., Weber J., Dury S., Hamadou O., Seignobos C. 2003. Les enjeux du développement agricole dans le grand nord du Cameroun, 10 p. hal-00128885. Available on : https://hal.archives-ouvertes.fr/hal-00128885/document

5. Donfack P. & Seignobos C., 1996. Des plantes indicatrices dans un agrosystème incluant la jachère: les exemples des Peuls et des Guiziga du nord-Cameroun. Journ. d'agric. Trad. et de Bota. Appl., Vol. XXXVIII (1), pp. 231-250. Available on : https://www.documentation.ird.fr/hor/fdi:010011653

6. Worou S.K., 1998. Soils dominants du Togo. Corrélation avec la Base de référence mondiale. In Rapport sur les ressources en sol du monde 98. [En ligne]. Disponible sur le « *http: www.Fao.org/DOCREP/005/Y3948F/y3948f09.html #Top of page* ». Consulté le 23/05/2020. Available on : http://www.fao.org/tempref/docrep/fao/005/y3948f/y3948f05.pdf

7. Pallou M.O., 2011. Déterminants socio-économiques de la gestion paysanne des plantations d'Acacia senegal et de la production de la gomme arabique au Nord Cameroun. Thèse de doctorat PhD. TESC, Université de Toulouse. Pp. 274. Avalaible on : https://www.google.com/search?q=Palou+M.O.,+2011.+D%C3%A9terminants+socio-%C3%A9conomiques+de+la+gestion+paysanne+des+plantations+d%27Acacia+senegal+et+de+la+production+de+la+gomme+arabique+au+NordCameroun.+Th%C3%A8se+de+doctorat+PhD.+TESC,+Universit%C3%A9+de+Toulouse.+Pp.+274.&sa=X&ved=2ahUKEwibrIai9u_pAhVQCxoKHRk7DlYQ7xYoAHoECAkQAg&biw=360&bih=610

8. Saïdou A., Kossou D., Acakpo C., Richards P., Kuyper W.T., 2012. Effects of farmers' practices of fertilizer application and land use types on subsequent maize yield and nutrient uptake in Central Benin. *International Journal of Biological and Chemical Sciences*, 6(1): 363-376. Avalaible on : https://www.ajol.info/index.php/ijbcs/article/view/80508

9. Blay D., Bonkoungou E., Chamshama S. and Chikamai B., 2004. "Rehabilitation of Degraded Lands in Sub-Saharan Africa: Lessons Learned from Selected Case Studies," IUFRO-SPDC, FORNESSA, pp.2-5. Avalaible on : https://www.academia.edu/23014020/Scientific_Cooperation_Network_on_Climate_Change_Adaptation_in_Eastern_Africa

10. Seiny Boukar L., Floret Ch., Moukouri Kuoh H., Pontanier R., 1991. Dégradation des vertisols dans le Nord-Cameroun: modification du régime hydrique des terres et tentative de réhabilitation. Utilisation rationnelle de l'eau des petits bassins versants en zone aride. Ed. AUPELF·UREF. John Libbey Eurotext, Paris. 23, 287-294. Avalaible on : http://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers16-03/37004.pdf

11. PNDP, 2011. Plan de développement communal de Garoua 3. Commune de Garoua 3. Pp. 211. Avalaible on : https://www.pndp.org/documents/PCD_Garoua_3.pdf

12.Olina Bassala J.-P., M'Biandoun M., Ekorong J.A and Asfom P. 2008. Evolution de la fertilité des sols dans un système cotonniercéréales au Nord Cameroun: diagnostic et perspectives. TROPICULTURA, 26, 4, 240-245. Avalaible on : http://www.tropicultura.org/text/v26n4/240.pdf

13. Pauwels J. M., van Ranst E., M. Verloo, and MvondoZe A., 1992. Manuel de Laboratoire de pédologie. Publications Agricoles N° 28. Bruxelles: AGCD. Avalaible on : https://biblio.ugent.be/publication/223183

14. Afnor, 2004. Détermination de la distribution granulométrique des particules du sol (NF X 31 107). In: Evaluation de la qualité des sols. Volume 1: Méthodes d'analyse chimique. Afnor (Ed.). Paris. Avalaible on : https://tel.archives-ouvertes.fr/tel-00396553/document

15. Ebanga, M., Moujouopou, M., Sipa, A., Delavet, G., Bikay. L., et N. Edibi. 1982. Physiques Terminales C.D. E. Programme Camerounais. Les Classiques Africaines. Avalaible on : https://www.leslibraires.fr/livre/1407776-physique-premieres-c-d-e-programme-camerouna--josette-ebanga-mose-mounjouopou-abraham-sipa-les-classiques-africains

16. Mc Lean E.O, 1982. pH and lime requirements. In: Page, A.L. et al. (Eds.), Methods of Soil Analysis, Part 2, second ed., Agronomy, vol. 9 Soil Society of America, Madison, WI, pp: 199–244. Avalaible on : http://www.sciepub.com/reference/150407

17. Walkley A., Black C. A., **1934.** An examination of the Degtjareff method for determining soil organic matter and a proposal modification of the chromic acid titration method. Soil Science, Vol. 37, p. 29-38. Avalaible on : https://journals.lww.com/soilsci/citation/1934/01000/an_examination_of_the_degtjareff_method_for.3.aspx

18. Bremner, J.M. and Mulvaney, C.S, 1982. Total Nitrogen. In: Buxton, D.R., Ed., Methods of Soil Analysis, Part 2, American Society of Agronomy Inc. and SSSA Inc., Madison, 595-624. Available on : https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=181829

19. Bray R.H., and Kurtz L.T., 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Sci. 59:39-45. Avalaible on : https://journals.lww.com/soilsci/Citation/1945/01000/Determination_of_Total,_Organic,_and_A
20. APA, 1976. Principes de classification et d'évaluation des terres pour la République du Bénin 36 p.p. Avalaible on : https://www.preventionweb.net/files/61025_ben149187.pdf
21. Sys C., Ranst Van E., Debaveye J., Beernaert F., 1993. Land evaluation, part III crop requirements, Agricultural publications N°7, General Administration for Development Cooperation. Place du Champ de mars 5 bté 57-1050 Brussels Belgium, pp.67-147. Avalaible on : https://biblio.ugent.be/publication/233235
22. Doucet, R., 2006. Le climat et les sols agricoles. ed. Berger, Eastman, Québec, xv, 443. Avalaible on : https://www.abebooks.fr/climat-sols-Agricoles-Doucet-Roger-%C3%89ditions/1318799682/bd
23. Borah K.K., Bhuyan B., Sarma H.P., 2010. Lead, arsenic, fluoride, and iron contamination of drinking water in the tea garden belt of Darrang district, Assam, India. Environmental monitoring and assessment 169, 347-352. Avalaible on : https://link.springer.com/article/10.1007/s10661-009-1176-2
24. Farah H et al., 1979. pH effect in the adsorption of heavy metal ions by clays CHem''. Geol, vol 25, 317-326pp. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5790784/
25. Giguère, R., 2002. Botanique et horticulture dans les jardins du Québec : guide 2002. Éditions Multi. Mondes, société des amis du Jardin Van den Hende, 245. 289-440- 263 Avalaible on : http://www.cef-cfr.ca/uploads/Membres/Comm.BotaniqueJBL.pdf.
26. Buol S., Southard R., Graham R., McDaniel P., 2011a. Morphology and Composition of soils. soil Genesis and Classification, Sixth Edition, 35-87. Avalaible on : https://www.academia.edu/40089206/SOIL_GENESIS_AND_CLASSIFICATION_SIXTH_EDITION
27. Pypers, P., Sanginga, J.-M., Kasereka, B., **Walangululu M., Vanlauwe B., 2011**. Increased productivity through integrated soil fertility management in cassava–legume intercropping systems in the highlands of Sud-Kivu, DR Congo. Field Crops Research 120, 76-85. Avalaible on : https://ees.kuleuven.be/africa-in-profile/dig-deeper/forest-zone/Casava legume%20intercropping%20Sud-Kivu%20DRC.pdf
28. Ballot C. S. A., Mawussi G., Atakpama W., Moita-Nassy M., Yangakola T. M., Zinga I., Silla S., Kpérkouma W., Dercon G., Komlan B. And Koffi A., **2016**. Caractérisation physico-chimique des sols en vue de l'amélioration de la productivité du manioc (*Manihot esculenta Crantz*) dans la région de Damara au centre-sud de Centrafrique. Agronomie Africaine 28 (1): 9 - 23 . Avalaible on : https://www.ajol.info/index.php/aga/article/view/164135
29. Lal R., 1976. Soil erosion on alfisol in Western Nigeria. Geoderma, 16, pp. 363-441 Avalaible on : https://www.sciencedirect.com/science/article/pii/0016706176900033
30. Azontonde H. A., 1993. Dégradation et restauration des Terres de barre (sols ferralitiques faiblement désaturés argilosableux) au Bénin. La gestion conservatoire de l'eau, de la biomasse et de la fertilité des sols (GCES), Cahiers ORSTOM, Série. Pédologie, vol., 28 n° 2, pp. 217–226. Avalaible on : http://horizon.documentation.ird.fr/exl-doc/pleins_textes/cahiers/PTP/10009093.PDF
31. Hubert, G., Schaub, C., 2011. La fertilisants des sols. L'importance de la matière organique. Chambre d'Agriculture, BasRhin. Service Environnement-Innovation, 46. Avalaible on : https://agriculture-de-conservation.com/La-fertilite-des-sols-l-importance.html
32. Howeler R.H., 1996. Diagnosis of nutritional disorders and soil fertility maintenance of cassava. Tropical tuber Crops: Problems, Prospects and Future Strategies. Oxford and IBH Publishing Co., New Delhi, India, 181-193. Holer https://espace.library.uq.edu.au/view/UQ:397208/s41815029_final_thesis.pdf.
33. Giroux, M., Audesse, P., 2004. Comparaison de deux méthodes de détermination des teneurs en carbone organique, en azote total et du rapport C/N de divers amendements organiques et engrais de ferme. Agrosol 15, 107-110. Avalaible on : https://www.irda.qc.ca/assets/documents/Publications/documents/giroux-audesse-2004_article_methodes_dosage_c_n_amend_org.pdf
33. Brabant P. and Gavaud M., 1985. "Les Sols et Ressources en Terres du Nord-Cameroun. Carte et Notice Explicative No. 103," MESRES-IRA, Yaoundé, ORSTOM, Paris. Avalaible on : https://scirp.org/reference/referencespapers.aspx?referenceid=1074879
35. Vallee G., M'Biandoun M. & Forest F., 1996. Semi-direct dans l'aménagement de Sanguere-Djalingo (Cameroun). Cahiers Agricultures, 1996, vol 5, pp. 161-169. Avalaible on : http://agritrop.cirad.fr/388900/

AUTHORSHIP CRITERIA: Alain LOABE P. and Arafat G. has defined the thème of ressearch. The sampling protocole and the field work were carried out by all the authors. The writing has been done by Arafat G. at 50%, and by Michaël ZIRTED J at 30%, Alain LOABE P. at 20%. The proofreading was done by SAÏFOULLAH DAÏROU and Jacques HOUSSENI D.

CONFLICTS OF INTEREST: The authors affirm that there is not conflits of interest between them.

Cite this article: Arafat Gové, Michaël Zirted Jourmbi, Alain Loabe Pahimi, Daïrou Saïfoullah, and Jacques Housseni Djida s. CONTRIBUTION TO THE STUDY OF FERTILITY STATE OF AGRICULTURAL SOILS OF GAROUA 3 IN NORTHERN CAMEROON. *Am. J. innov. res. appl. sci.* 2020; 11(1): 05-12.