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Full Length Research Paper

Soil fertility status of selected citrus orchards in the Eastern, Central and Volta Regions of Ghana

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This study was initiated to evaluate the soil fertility status of selected citrus orchards in the Eastern, Central and Volta regions of Ghana. Soil (0 – 20 and 20 – 60 cm) and leaf samples were taken during the study period and their nutrient contents assessed. Results obtained indicated that Climatic conditions (rainfall and temperature) of the three regions are suitable for citrus production. Soil texture ranged from sandy clay loam in the Volta to clay loam in the Eastern and Central regions, however, their high sand contents of 44.00, 46.39 and 52.62 percent should be a matter of concern for nutrient losses through leaching and erosion. The EC within the two depths sampled for the three regions were below 4 dS/m and were therefore rated as non-saline. Mean top soil pH was slightly acidic (5.8) in the Eastern region but strongly acidic in the Central (4.7) and Volta (4.5) regions. Mean sub-soil pH was strongly acidic (< 5.0) for all the regions. Mean total nitrogen, available P and K contents within the two depths of the three regions were low. Organic carbon/matter contents were medium. Mean total exchangeable bases (TEB), exchangeable acidity, effective cation exchange capacity (ECEC) were low in these soils, whereas, their base saturation levels (%BS) were high. Leaf analytical results showed deficient N, Fe and Zn but high P, K Na and Mg levels for most of the sites in the three regions.

Key words: Citrus, primary nutrients, secondary nutrient, micronutrients, soil fertility, orchards.

INTRODUCTION

The Citrus fruits is not only important as a rich nutrition, flavour and tasty dietary sources but also a rich source of vitamins, minerals and dietary fibre (non-starch polysaccharides) that are essential for normal growth and development and overall nutritional well-being. Furthermore, they are endowed with other biologically active, non-nutrient compounds found in other plants (phyto-chemicals) that can also help to reduce the risk of many chronic diseases (Economos and Clay, 1998).

According to Economos and Clay (1998) citrus is a good source of vitamin C and is an essential nutrient source which includes both glycaemic and non glycaemic, carbohydrate (sugars and fibre), minerals such as potassium, folate, calcium, thiamin, niacin, vitamin B_6, phosphorus, magnesium, copper, riboflavin, pantothenic acid and a variety of photochemical. However, it contains no fat or sodium as well as no cholesterol. The average energy value of fresh citrus is also low (about 60 to 80 kcal), and can be very important for consumers concerned with excess body weight.

The Eastern, Central and Volta regions of Ghana, located within the semi-deciduous zone of Ghana are the three of the eight out of the ten political regions within which the crop is cultivated. These regions located within the semi-deciduous agro-climatic zone of Ghana are endowed with some of the most productive soils of the country. These soils are developed from rocks of the Birrimian system (middle Pre-Cambrian). Three major geological formations, namely, the phyllite, granite and

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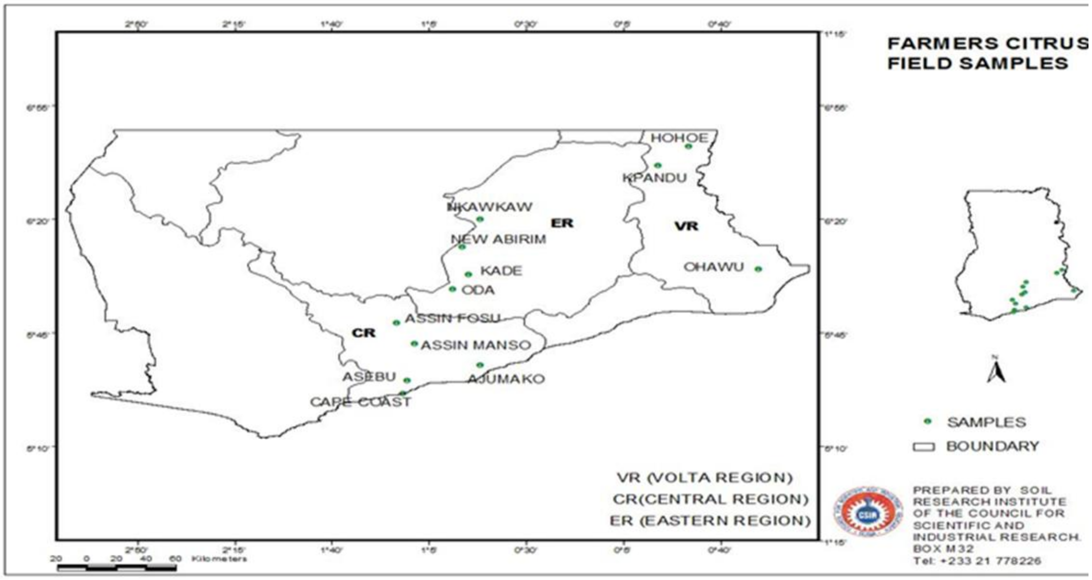


Figure 1. Selected citrus orchard sites in the Eastern (ER), Central (CR) and Volta (VR) regions.

tertiary sand have generally, influenced their formation and different characteristics. These major soils are classified under the FAO/UNESCO (1990). Soil classification system as Forest Ochrosols (Acrisols, Lixisols), Lithosols (Leptosols), Rubrisols (Luvisols) and Gleisols (Gleysols) which occur in limited areas as marginal soils in association with the Ochrosols (Adu, 1992).

The zone has a high bimodal rainfall distribution pattern (Dewdney and Timmer, 2009) with a mean ranging from 900 to 2500 mm that supports the cultivation of large scale plantation crops such as cocoa (Theobroma cacao), oil palm (Elaeis guineensis) and lemon (Citrus spp) as well as annual crops such as maize (Zea mays) cassava (Manihot utilissima) and plantain (Musa sapietum). The area has altitudes ranging from 0 – 2000m with temperatures of 5 – 40^0C.

The citrus spp generally, thrives on fertile, well drained, deep and loose loams (light to medium) with high water holding capacity. Soil pH range of 5 – 8 is suitable for a good citrus orchard yields. Excess water and salts are however, unsuitable for its growth and development. The crop has high nutrient demand and can remove about 100, 25 and 145 kg/ha N, P_2O_5 and K_2O kg/ha/growing cycle to produce 15 tons of fruits (Sys et al.,1993).

The production level of the citrus in the country is estimated at 50.450 t with an average yield of 35 Mt/ha (MOFA, 2010). Production is primarily for domestic consumption, but some are exported in the form of organic juice to Europe (Dewdney & Timmer, 2009). The main type and variety cultivated in Ghana is the sweet orange (*Citrus sinensis*), especially Late Valencia, budded unto rough lemon (Ofosu-Budu et al (2007). The Late Valencia is cultivated on over 5,000 ha of land mainly in the Kwabibirem district (Eastern Region) of the country. Other regions home to the citrus are the Greater Accra, Central, Ashanti, Western and Brong-Ahafo (MoFA, 2011).

The growth, yield and quality of citrus are influenced by environmental, edaphic and varieties. Climate is a major factor affecting citrus fruits (Nauer et al., 1972). Soil conditions are important in determining its yield and fruit quality (Tang and Tian, 1992) while the acid content is strongly influenced by the soil type in which the root stock is grown (Sam-Aggrey, 1973). Adequate supply of nutrients to the crop is essential for higher yield and nutrient concentrations of citrus (Embleton et al., 1973). Essential nutrient elements needed by the crop are nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca) and sulfur (S.). Ofosu-Budu (1998) reported of significant increase in yield due to increasing rates of fertilizer applied irrespective of the rootstock used. Furthermore, significant increases in yield and fruit quality in sweet oranges was observed when chemical fertilizer (Ofosu-Budu, 1998) and farmyard manures (Gathungu, 1975) were applied. Increasing demand for cropland has generally, forced farmers to cultivate on marginal lands that are prone to erosion (Bationo and Lompo, 1999). Notwithstanding the contribution of orange to the economy of Ghana and its nutritional values, there has recently been a decline in the production of the crop resulting in a reduction in foreign exchange earnings. The volume of exported orange, for instance, declined from 11,028 metric tonnes in 2009 to 10,729 metric tonnes in 2010. Its corresponding foreign exchange earnings also dropped from US$ 875,000 in 2009 to US$

Figure 2a. Mean rainfall. *Eastern region, Kade (Lat: 6.06N Long: 50 W. Alt. 137 m; Central region, Asebu (Lat: 5.13 N Long:1.13 W Alt: 76;Volta region, Ho (Lat: 6.36 N Long: 0.28 E Alt: 158m)* Sources: Ghana Meteorological Agency and MOFA 2010.

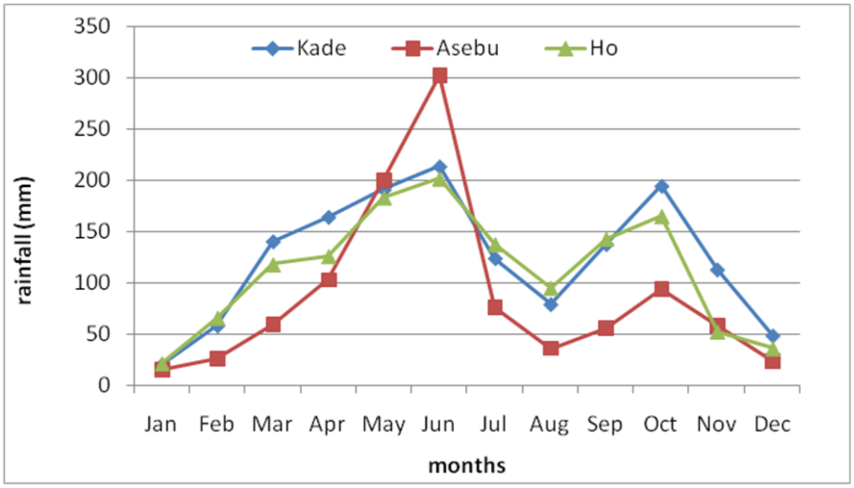
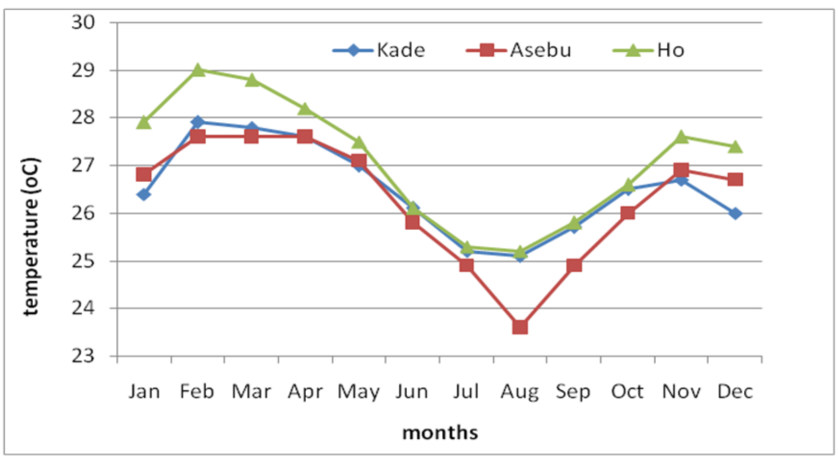


Figure 2b.Mean temperature. *Eastern region, Kade (Lat: 6.06N Long: 50 W. Alt. 137 m; Central region, Asebu (Lat: 5.13 N Long:1.13 W Alt: 76;Volta region, Ho (Lat: 6.36 N Long: 0.28 E Alt: 158m)* Sources: Ghana Meteorological Agency and MOFA 2010.



654,000 in 2010, representing 25.3% decline (MoFA, 2011). This decline in the production has been partly attributed to the degradation of the already inherently low fertile soils of the area, moisture stress, diseases and pest attacks (Ofosu-Budu, 2013).

Generally, the traditional farming systems in the country and the tropics as a whole have relied on the extended periods of fallow between cultivation periods to restore and maintain soil fertility. However, demographic growth and intensification of land use have further reduced or in many cases eliminated these fallow periods that were previously the main vehicle for generation of the fertility status most soils. The cultivation of sedentary crops like the citrus among others on a large scale has further aggravated the low fertility status of these soils (Ofori, 1998).

According to some researchers (Owusu-Bennoah et al., (2000), despite the agricultural potential and the general belief that the fertility status of soils within the semi-deciduous zone of the country are depleting and, hence, diminishing yields, only cursory and rather old data are available on them.

It was against this backdrop that the present study was initiated to assess the fertility status of the selected citrus orchards in the three selected regions and also to recommend the necessary nutrient management strategies for

Table 1. Physical properties of soils of selected citrus farms in the 3 major citrus growing regions.

Region	%Sand	%Silt	%Clay	Texture
Eastern	44.00b	25.58a	30.42b	Clay Loam
Central	46.39b	20.51a	33.10a	Clay Loam
Volta	52.62a	14.03b	33.35a	Sandy Clay Loam

Similar alphabets are not significantly different by Duncan's Multiple Range Test ($P < 5\%$).

sustainable growth and yields of the crop.

METHODOLOGY

The study was carried out in the Eastern (Nkawkaw, North Abirim, Kade and Oda), Central (Asebu, Assin Manso, Assin Fosu, Old Ebu, Chichiwere and Ajumako) and Volta (Abutia Kloe, Adofe, Tafi Atome and Ohawu), regions (Figure 1). Soil and reasonably matured leaf samples were taken from selected farmers' fields. The soils were sampled from the depths of 0 – 20 cm and 20 – 60 cm. Leaf samples were also taken from 20 selected trees, bulked, processed and analyzed at the Soil Research Institute, Accra Centre's laboratory. Parameters determined on the soil samples were texture, pH, Electrical Conductivity (EC), Total nitrogen (N), Available Phosphorus (P_2O_5), Available Potassium (K_2O), Organic carbon (OC)/matter (OM), Exchangeable cations such as potassium, calcium, magnesium and sodium, Exchangeable Acidity, Effective Cation Exchange Capacity (ECEC) and Base Saturation. Those for the leaves were nNtrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Iron (Fe) and Zinc (Zn).

Climatic (Temperature and Rainfall) data obtained from the Meteorological Agency of Ghana are contained in Figure 2a and b respectively. Both the 30 years mean annual rainfall and temperature showed a bimodal pattern of distribution. High temperatures preceded the major rainy season before the onset of the first rains in April. The climate of the area is humid tropical. The 30 years mean annual rainfall and temperature for the three regions are 1484.0, 1050.0 and 1339.9 mm and 26.5, 26.3 and 27.1 ^{0}C for the Eastern, Central and Volta regions respectively. The soil moisture regime is udic and the soil temperature regime is iso-hyperthermic (Van Wambeke, 1982).

Soil particle size analysis was determined by the pipette method as described by Gee and Bauder (1986). Soil reaction (pH) and Electrical Conductivity (EC) were measured in 1:2.5 soil: water suspension. Total Nitrogen was determined by the modified Kjeldahl method (Bremner, 1996). Available Phosphorus and Potassium contents in soils were extracted by Bray's P_1 solution and measured by a spectro-photometer (Bray and Kurtz, 1945). Organic Carbon was determined by the wet oxidation method of Walkley and Black (1934). Exchangeable Bases were extracted with 1.0 M ammonium acetate solution at pH 7.0. The Sodium and Potassium contents in the extracts were measured by flame photometry while Calcium and Magnesium in the same extract were determined by EDTA titration (Chapman and Pratt, 1961). Thomas (1982) method was used for the determination of Exchangeable Acidity. Effective Cation Exchange Capacity (ECEC) was calculated as the summation of the various exchangeable cations and total acidity (exchangeable Al^{3+} + H^{+}).

A representative reasonably matured leaf samples were also taken from newly flushed leaves of non-fruiting branches following the method of Obreza, (1990 & 1992). These were washed in mild detergent solution, thoroughly rinsed with pure water, dried at 80^{0}C and ashed in a mussel furnance and their N, P, K, Ca, Mg, Fe and Zn contents were determined by the appropriate standard analytical methods (Chapman and Pratt, 1961).

Soil and leaf interpretations were done following the Interpretation Guide of Marx et al., (1999) and Obreza et al., (2009 and 2010). The data obtained were analyzed by the StatView software. Means were separated using the Duncan Multiple Range Test at 5% level of significance.

RESULTS AND DISCUSSION

Physico-chemical soil properties (Soil texture, pH, EC and organic matter content)

Soil physical properties comprising of texture, water-holding capacity, organic matter content, soil pH, cation exchange capacity, and coatings on sand grains (Obreza, 2010) are important to nutrient management. Soil texture is basic to many other soil properties and serves as an indicator of water holding capacity, aeration and organic matter. It is defined as the relative proportion of sand, silt and clay in a mineral soil and influences the water holding capacity of the soil.

The textural classes of the soils from the three regions are containeed in Table 1. They ranged from sandy clay loam in the Volta to clay loam in the Eastern and Central regions. The percent sand content of these soils ranged from

Table 2a. Chemical properties of soils of selected citrus farms in the 3 major citrus growing regions.

Region	Depth (cm)	pH	EC (dS/m)	Total N (%)	Avail. P (mg/kg)	Avail. K (mg/kg)	% OC	% OM
Eastern	0 - 20	5.80a	0.52b	0.085a	40.89a	7.89a	1.7	2.92a
	20 - 60	4.86A	0.56B	0.072A	37.40A	6.44A	1.58	2.72A
Central	0 - 20	4.73a	1.87a	0.076b	28.12b	5.87b	1.63	2.80a
	20 - 60	3.95B	1.84A	0.063B	22.60B	5.56B	1.63	2.80A
Volta	0 - 20	4.48b	0.53b	0.074b	16.12c	4.78b	1.36	2.34a
	20 - 60	3.76B	0.52B	0.070A	13.4B	4.66C	1.22	2.10B

Similar alphabets are not significantly different by Duncan's Multiple Range Test (P < 5%). Alphabets in small and capitals are mean comparison for 0 – 20 and 20 – 60 cm respectively.

44.0% through 46.39 to 52.62 percent in the Eastern, Central and Volta regions soils respectively. Sand content in the Volta region soils are generally, significantly (*P = 5%)* higher than the other two regions. According to Obreza (2008) and Sys et al., (1993), Citrus prefer light to medium texture soils. The crop does better when drainage is less impeded and the presence of gravels or stones are few. Soil physical properties are therefore conducive for Citrus production in these regions. However, these soils are prone to nutrient leaching if adequate levels of organic matter and other vital plant nutrients elements are not maintained (Obreza 2008). Thus, it is very important to apply adequate organic and chemical fertilizers to maintain high fertility.

The pH values of soil suspension (1:2.5) of all representative top soils (0 – 20 cm) samples are mainly acidic (5.8) for the farms in the Eastern region but strongly acidic (< 5.0) for the farms in the Volta and Central regions (Tables 2a). pH is significantly high in the Eastern region than the other two regions. There are no significant differences between pH values in the Central and Volta regions .Mean subsoil pH for all the regions are however, strongly acid (< 5.0) in nature. They are also significantly higher in the Eastern soils than the Central and Volta regions. Sys et al., (1993) reported that citrus thrives best in soils having pH ranging from 5.0 to 8.2 with an optimum between 5.5 and 7.6. Soil pH generally, has significant influence on nutrient solubility and availability. The strong acidic conditions of these soils suggest that citrus yields will be negatively affected.

Soil pH levels in these regions must be improved through the application of either dolomitic or calcitic lime (Obreza, 2008). Excessive liming, however, can induce trace elements deficiencies. It has been documented that (Jenssen, 2010 and McKenzie, 2003) the most prominent nutritional disorder of plants grown in soils with more than 20% of hydrated lime is chlorosis due to elevated levels of bicarbonate concentration. High levels of bicarbonate can affect the uptake, translocation and utilization of iron, among other trace elements in the soil. Severe symptoms of lime-induced chlorosis are correlated not only with the levels of iron content in the leaves but also with severe inhibition of leaf growth and chloroplast development, which in turn results in the decrease in growth and yield of the crops.

The electrical conductivity (EC) values observed for these orchards (Table 2a) were below 4.dS/m within the two depths sampled in all the three regions and thus rated as non-saline. Furthermore, the EC is significantly (*P = 5%)* higher in the Central region soils than the other two. The results suggests that the soils are low (<2-4 dS m-1 at 25 0C) in electrolytes attributable to leaching by the high rainfall conditions in the three agro-eclogical zones. Such low EC values should be a matter of concerned so far as the maintenance of adequate levels of bases on sustainable basis for higher yields are concerned. Sys et al., (1993) also reported that, generally, no yield reductions should be expected if the EC of a citrus soil is less than 1.7 dS/m. At EC of 2,3dS/m 10% yield reduction must be expected. At 3.3, 4.8, and 8.0 dS/m yield reductions of 10, 25, 50 and 100% yield reductions can occur respectively. Higher EC values were comparatively observed in the Central region soils than the other two regions due to its proximity to the coast.

Soil chemical analytical data are rated as Very low, Low, Medium, High and Very high while Leaf data is rated Deficient, Low, Medium, High and Excess. Low test values imply that a crop will respond to fertilization with a particular nutrient in question. High soil test values indicate that the soil can supply all the needs, so no fertilizer is required. If the value is medium, then there is 50% chances of response to fertilization. The soil test value that separates predicted fertilizer response from non-response is called the critical or sufficiency soil test value (Obreza, 2008).

Mean total nitrogen content of the various orchards in the three regions (Table 2a) was low indicting high N response to fertilizer application. Total nitrogen is significantly (*P = 5%)* higher within the two depths sampled in the Eastern region than Central and Volta regions. However, differences between Central and Volta regions were not significant (*P = 5%).* For good citrus growth and yield the total nitrogen content of the soil

Table 2b. Cont.

Region	Depth (cm)	TEB (cmol(+)/kg)	Ex. K (cmol(+)/kg	Ex. Ca (cmol(+)/kg	Ex. Na (cmol(+)/kg)	Ex. Mg (cmol(+)/kg)	Ex. Acidity (cmol(+)/kg)	ECEC (cmol(+)/kg)	BS (%)
Eastern	0 - 20	2.09b	0.31a	0.78a	0.52b	0.48b	0.26a	2.35b	88.94b
	20 - 60	1.75B	0.19A	0.68AB	0.45C	0.43B	0.34A	2.09B	83.73B
Central	0 - 20	3.47a	0.19b	1.52a	0.90a	0.86a	0.14b	3.61a	96.12a
	20 - 60	3.65A	0.16A	1.41A	1.26A	0.82A	0.28AB	3.93A	92.88A
Volta	0 - 20	2.23b	0.37a	0.56b	0.88a	0.42b	0.24a	2.47b	90.28b
	20 - 60	1.75B	0.15A	0.44B	0.82B	0.34B	0.22B	1.97B	88.83AB

Similar alphabets are not significantly different by Duncan's Multiple Range Test ($P < 5\%$). Alphabets in small and capitals are mean comparison for 0 – 20 and 20 – 60 cm respectively.

must be within the range of 0.2 – 1.0 % (Marx et al., 1999). Hence, the low soil nitrogen content observed may be due to low N turn-over from organic matter sources such as low litter fall, uptake by crop, biological ammonification, nitrification and leaching under the high rainfall regimes in the three regions selected for the study. Therefore, the low nitrogen levels in these soils may be a contributing factor to the poor tree growth as well as appearance, fruit production and fruit quality observed during our field study as reported by Obreza, (2008). Sufficient N concentration in the citrus tree is necessary for maximum vegetation growth, flowering and fruit yield. Hence, nitrogen fertilizers must be applied to the crop in these orchards.

Mean available phosphorus levels in all orchards in the three regions were also low (Table 2a). It was significantly (*P = 5%)* higher within the two sampled depths in the Eastern than the Central and Volta regions. Differences between the Central and Volta regions were however, not significant (*P = 5%*). Citrus thrives best on soils with available phosphorus (P_2O_5) within the sufficiency range of 40 – 60 mg/kg (Obreza, 2008 and Marx et al., 1999). The plausible reasons for the low available P observed may be due to leaching of soluble and adsorbed forms of P through erosion and fixation as reported by Jenssen, (2010); Obreza, (2008) and McKenzie,(2003). Phosphorous is more available under acidic soil conditions. P fertilization is therefore needed for the crop on this soil.

Although Ghanaian soils are adequately furnished with potassium (Nye and Stephens, 1958), mean available K were low in these soils (Table 2a). It was significantly (P = 5%) higher within the 0 – 20 cm of the Eastern region soils than the Central and Volta regions. Generally, available potassium (K_2O) values between 175 to 280 mg/kg are generally, considered to be adequate for the growth and development of most tree crops (Obreza, 2006 and Marx et al., 1999). According to Saleem and Bertisson, (1978), available K varies with soil texture depending on the parent material and its degree of weathering. Clayey soils have higher available K contents than loamy and sandy soils. Therefore differences in available K observed between the three regions orchard could be attributed to the differences in soil texture as well as high K demand by the crop (Obreza, 2008 and Sys et al., 1993). Potassium fertilization is necessary in these orchards, however, excess levels must be avoided since fruit size will be adversely affected due to imbalanced leaf Ca and Mg (Mattos Jr. et al., 2004).

Mean organic carbon/matter content of the soils as contained in Table 2a were medium in both the 0 – 20 cm and 20 – 60 cm depths. It was highest in the Eastern region but differences observed between the three regions were not significant (*P = 5%*). This medium organic matter levels are bound to effectively improve upon soil structure and minimize nutrient losses through leaching and erosion. Organic materials are key component of nutrient recycling as well as a stable storehouse for plant nutrients. Nutrients associated with organic matter are not plant-available immediately but are slowly released as the material decomposed by soil microbes. The decomposition rate depends on the material's physical and chemical characteristics as well as climate (Obreza 2008). The warm and humid conditions in the three regions are ideal for decomposition and nutrient releases. There is therefore the need for prudent organic matter monitoring in these orchards and appropriate type and rates applied when levels decline.

Table 3.Leaf nutrient content of selected citrus farms in the 3 major citrus growing regions.

Region	N (%)	P (%)	K (%)	Na (%)	Ca (%)	Mg (%)	Fe (mg/kg)	Zn (mg/kg)
Eastern	1.01a	**0.11b**	4.50a	0.34b	2.82b	0.95a	22.00c	14.25a
Central	0.72b	**0.27a**	2.61b	0.66a	3.27a	0.53b	27.20a	14.88a
Volta	0.66b	**0.25a**	1.54b	0.38b	1.93c	0.33c	24.30b	13.57b

Similar alphabets are not significantly different by Duncan’s Multiple Range Test (P < 5%).

Whereas mean total exchangeable bases (TEB), exchangeable acidity, effective cation exchange capacity (ECEC) were low in these soils, their base saturation levels (%BS) were rather high (Table 2b). This indicates high adsorbed bases in the soils but poor releases to support growth and yield of the crop.

Total exchangeable bases (TEB) were generally, significantly (*P = 5%*) higher in both the 0 – 20 cm and 20 – 60 cm depths of the Central region soils than the Eastern and Volta regions. Whereas decrement in TEB were observed in the Eastern and Volta regions soils with increasing depths increments were rather observed in the Central regional soils with increasing depths. This can be explained by the increment in exchangeable Na in these soils with increasing depths probably due to leaching. Generally, with the exception of the Central region where exchangeable Na increased with increasing depths all other exchangeable cations generally, decreased with increasing depths.

Exchangeable K was generally rated as medium in the 0 – 20 cm of the Eastern and Volta region soils but low in the Central. Furthermore, they are significantly (*P = 5%)* higher in these soils than the Central region. No significant differences *(P = 5%*) were however observed between available K contents within the 20 – 40cm depths within of the three regions. This therefore accounts to some extent for the low available K observed in the Eastern and Volta regions.

Although exchangeable Ca, Na and Mg levels in the Central region were significantly (P = 5%) higher than the other two regions, levels observed in the three regions were generally very low. Calcite rather than dolomite should be used in liming these soils to replenish these nutrient elements.

The effective cation exchange capacity (ECEC) of the soils in the three regions were very low indicating poor soil fertility. The ECEC is a measure of the ability of the soil to hold positively charged nutrients against leaching. CEC is supplied by clay and organic matter and generally increases with increasing soil fertility Obreza, (2008). Calcium, potassium, magnesium and sodium are elements, which are lost with increasing acidity (Jenssen,2010 and McKenzie,2003). Furthermore, acidity can also induce deficiencies of micronutrients such as molybdenum, copper and boron, although a deficiency in the latter is more commonly seen in alkaline soils where over-liming has occurred. Other minor elements which may also be deficient due to low solubility in high pH includes manganese and iron, the deficiency of which produces a chlorotic condition. They further reported that, the best fertilizer use efficiency can be obtained for such low CEC soils by applying mobile nutrients like nitrogen (N) and K in splits.

The exchangeable acidity content of all the soils were very low. This is an indication that aluminum toxicity is not threatening at the moment despite the low pH observed. Therefore good soil management practices are necessary to prevent its occurrence in future.

Leaf: Leaf nutrient contents reflect nutrient accumulation and redistribution throughout the plant, so the deficiency or excess of an element in the soil is often reflected in the leaf (Obreza et al., 2008). Citrus stores significant amount of nutrient in its biomass, part of which is available for redistribution mainly to developing organs such as leaves and fruits (Mattos Jr. et al., 2003). Hence leaf analysis is a useful tool to complement the analysis of soil fertility and also to assess the nutritional balance of citrus plants. Moreover, in the case of N, where soil analytical methods lack consistency in diagnosis, leaf N analysis has been used as a criterion for evaluating its availability (Quaggio et al., 1998).

Leaf nitrogen (N), zinc (Zn) and iron (Fe) contents (Table 3) were deficient in all the three regions. Nitrogen was significantly (*P = 5%*) higher in the Eastern region’s orchard leaves than the Central and Volta regions. Higher and significant (P = 5%) leaf P levels were observed in the Central and Volta leaves than the Eastern. Similarly, leaf K, Na and Mg uptake were also very high. This implies higher foraging of these nutrients by the crop from soil resources. However calcium levels were low in the leaves of all the Eastern and Volta region orchards but optimum in the Central. This therefore goes to buttresses the earlier statement that calcitic rather than dolomitic lime should be applied in improving the pH levels of soils in these orchards.

CONCLUSION

It is clear from the study that the soil texture ranged from sandy clay loam in the Volta to clay loam in the Eastern and Central regions. pH of the orchards in the Eastern region were acidic (5.8) while those in the Central and and Volta regions were strongly acidic (< 5.0). The electrical conductivity (EC) values observed for these orchards were below 4.dS/m within the two sampled depths of all the three regions and are non-saline. Mean total nitrogen, available P and K contents of the orchards assessed are low indicting high responses to these plant nutrients upon fertilization. Oragnic matter contents were medium but the high sand content should be a course of concerned for nutrient losses through leaching. Mean total exchangeable bases (TEB), exchangeable acidity, effective cation exchange capacity (ECEC) are low in these soils, whereas, their base saturation levels (%BS) were high. This indicates poor soil fertility and nutrient releases for plant growth and good yields. Exchangeable Ca, Na and Mg levels in the three regions were generally very low.

Dolomitic lime rather than the calcitic should be used in liming these soils to replenish lost nutrient elements. Leaf analytical results showed N, Fe and Zn deficiencies but high P, K Na and Mg levels most of the sites in the three regions.

RECOMMENDATION

We recommend the application of N, P, K, Ca, Mg, Fe and Zn application to the orchards where they are limiting. Liming in the form of dolomite must be applied to improve pH and the genera fertility status of these soils. However the ideal rates of these fertilizers and lime to prevent excessive applications. Organic matter levels should be constantly monitored and corrected when the need arises.

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