INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

ANALYSIS OF THE SOILS SUPPORTING *CRYPTOLEPIS SANGUINOLENTA* (LINDL.) SCHTR. HARVESTED FROM DIFFERENT LOCATIONS IN THE EASTERN REGION OF GHANA

Y. Ameyaw
P. O. Box 25, Biology Education Department, Faculty of Science Education, University of Education, Winneba – C/R.

ABSTRACT
A survey was conducted on the soils supporting *Cryptolepis sanguinolenta* (Lindl.) Schtr. harvested from the environs of three sampling locations, namely; Abonse, Mamfe and Pepease in the Eastern Region of Ghana. The research was to determine intraspecific variation in some of the edaphic factors supporting the plant species, *C. sanguinolenta*. A linear statistical model, SPSS 16.0 was fitted to the dataset to determine whether variations do exist. The results showed that the Topsoil characteristics including soil pH were significantly different in the three locations.

KEYWORDS: Edaphic factors, soil pH,

INTRODUCTION

Habitat differences within populations of an ecotype of a species could lead to edaphic ecotypes hence a wide distribution range of a species could probably be composed of a large number of physiologically distinct populations (Milne, 1947). According to him, each of the populations closely adapted to a narrow range of edaphic conditions rather than to phenotypic plasticity of the same genotype. Okali, Hall and Lawson (1973) in a much-related study also noted that thicket clumps of *C. anisata* appear to be limited to deep soils that are dark in colour, rich in clay content and are of higher acidity than the areas of the surrounding grassland vegetation. According to Nyle and Weil (1996), soil colours provide some indication of soil mineralogy.

Turesson (1925 and 1930), Gregor (1938), Clausen and Hiesey (1940) and Clausen and Hiesey (1958) have done extensive work on plant responses to climatic or edaphic factors. According to Lawson (1966), soil factors are important in giving local variation to the plants in a particular habitat. Thus, soil differences are reflected in differences in the vegetation therefore vegetation normally shows some form of zonation. Elkington (1986) also reported on the genetic adaptation within plant species in relation to variation in the soil environment but not much of his works have been applied to intraspecific classification. Edaphic environments are known to commonly vary in a complex and mosaic structural pattern with attached complex variation pattern in morphological adaptation (Pandeya, Puri and Singh, 1968; Snaydon, 1973 and Elkington, 1986).

Pandeya *et al*. (1968) observed that biological and chemical properties of a soil are affected greatly by their physical properties and that favourable physical properties of a soil to a plant adaptation sometimes compensate to a great extent to the deficiency in chemical properties.

According to Etherington (1982) soil texture indirectly affects the nutrients status of a soil, as the clay fraction is the main source of many plant nutrients. He further observed that soil texture directly influences soil-water relationships, aeration and permeability through its relationship with inter-particle pore space.

Brady (1990) and Richards (1996) noted that in most localities with high precipitation, soil acidity is very common because of the leaching of appreciable quantities of exchangeable base-forming cations from the surface layers of the soil whereas alkaline soils occur in areas where there is considerable high degree of saturation of base-forming cations.

Nielsen (1965) observed that in West Africa soil pH is not an important factor when it comes to plant growth as compared to those in the temperate regions. Soil pH influences the growth of agronomic plants, which depends on specific pH regimes. Soil pH was noted to be controlled by many factors such as leaching, erosion, etc (Nielsen, 1965)). It has been observed by Lawson (1966) that plant growth depends on the presence of a sufficient quantity of mineral nutrients based on a suitable texture and adequate air as well as water. In an earlier studies by Nye (1954), it was concluded that mineral nutrients such as nitrogen, phosphorus, potassium, calcium, sulphur, magnesium, iron, copper, boron, manganese, zinc, etc are always required in varying quantities for plant growth.

Griffin (2002) found that organic matter releases many plant nutrients as it is broken down in the soil, including nitrogen (N), phosphorus (P) and sulfur (S) needed for plant growth. Again, he noted that organic matter loosens the soil, which increases the amount of pore space, which has several important effects.

Lawson (1985) observed that the total amount of nutrients in the soil exceeds that of the vegetation and is true for such mineral elements such as nitrogen, calcium and magnesium

but phosphorus is somehow present in equal proportions in both the soil and the vegetation. Hall and Swaine (1976) in a similar studies confirmed that such soils have low pH, poor saturation of cation exchange complex, low total exchangeable bases and low concentrations of available phosphorus and total nitrogen.

According to Ewer, Hall and Mitchelmore (1981) the pH of a soil depends on the proportion of the cation exchange capacity (CEC), which depends on the hydrogen ions present. Sandy soils in areas that experience high rainfall tend to have low pH. Ewer *et al*. (1981) concluded that certain elements: Fe, B, Mn and P have been noted to be present as insoluble compounds tends to be deficient at high pH values whereas at low pH, Fe and Al tend to be relatively soluble and mobile.

As stated by Kimmins (1987), the development of a vegetation of any habitat relies on at least the physical nature of the soil more especially on the moisture regime, pH and the levels of available mineral elements, with particular reference to nitrogen, phosphorus, potassium, calcium and magnesium. Therefore, this research is to analysis the soils supporting *C. sanguinolenta* (Lindl.) Schtr. harvested from three locations, namely; Pepease, Mamfe and Abonse in the Eastern Region of Ghana.

MATERIALS AND METHODS

Soil samples used in the study were collected from the environs of Pepease, Mamfe and Abonse in the Eastern Region of Ghana. The three settlements are located in the Kwahu South and Akuapem North Districts of the Region. The two districts lie between latitude $5^0$30'N and $7^0$30'N

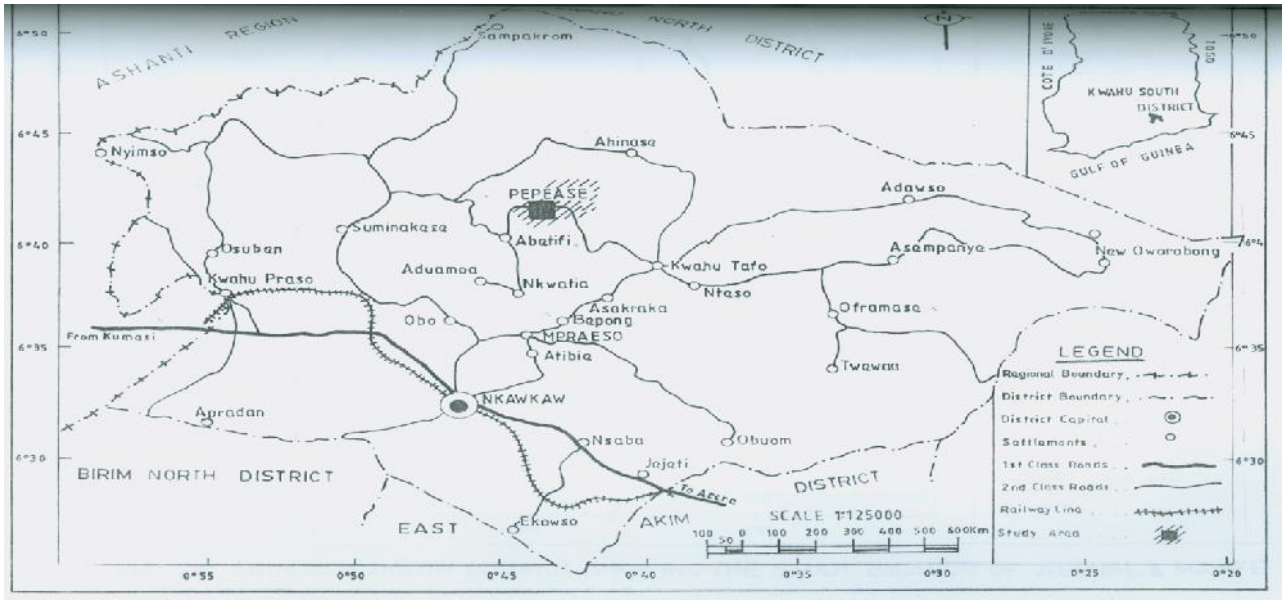

FIGURE 1a: Kwahu South District showing the study location of Pepease

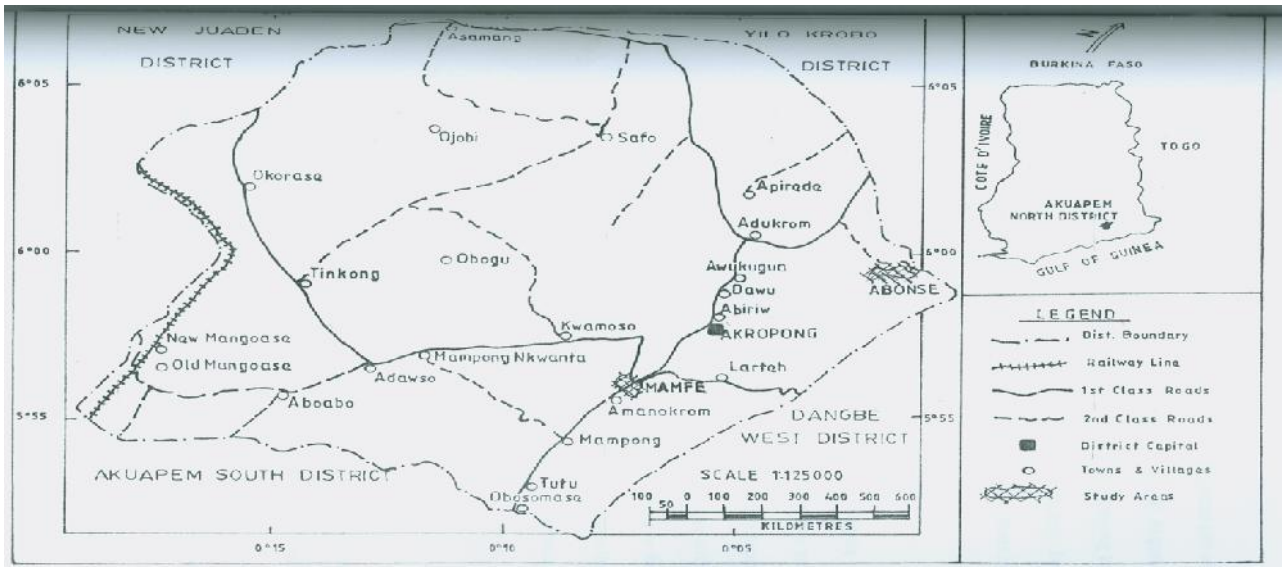

FIGURE 1b: Akuapem North District showing the study location of Abonse and Mamfe

and longitude $0^0$30'W and $1^0$30'W. Kwahu South District covers an area of 5.306 acres (Fig. 1a) while Akuapem North District also covers 6.79 acres of the land surface of Ghana (Fig. 1b).

At each location (viz: Pepease, Mamfe and Abonse), soil samples were taken around plants within 5cm radius, which have been tagged for study. The soil samples were taken in March, June, September and December 2003. On each occasion, the samples were analysed for pH, available phosphorus, total nitrogen, organic carbon, organic matter and particle size.

Assessment of soil pH

In determining pH, the method developed by IITA (1985) was followed. Ten grammes of soil were weighed into a centrifuge tube and 25ml of distilled water added. The content of the tube was intermittently stirred with a glass rod for 30 minutes. The pH was read using the pH-meter (WP 9418).

Determination of Available Phosphorus

Available phosphorus was determined using the method developed by IITA (1985). One gramme of soil was weighed into a centrifuge tube and 7ml Bray No. 1 solution added. Bray No. 1 solution was prepared by adding 15ml of 1M of ammonium flouride to 25ml of 0.5M of hydroflouride in 460ml of distilled water. The dissolved soil was filtered through Whatman No. 1 filter paper. Two millilitres of the soil extract was pipetted into a 25ml volumetric flask and 10ml of distilled water added. Four millilitres of colour forming reagent (comprising ammonium molybdate, potassium antimony tartarate, Sulphuric acid and ascorbic acid) was added and made up to volume with distilled water. The colour was allowed to develop for 15 minutes and the phosphorus content was determined on a spectrophotometer at a wavelength of 882nm. Standard phosphorus solutions were prepared and colours were developed. The absorbance of the samples and standards was determined. A standard curve was plotted and the concentration of phosphorus in the samples was extrapolated from the standard curve.

Determination of Total Nitrogen

Total nitrogen was determined by Kjeldahl oxidation method (Anderson and Ingram, 1989). A sample soil weighing 0.2g was digested at 360^OC for 2 hours in a mixture of selenium powder, lithium sulphate, hydrogen peroxide and concentrated sulphuric acid. The digested mixture was steam-distilled. The distillate was titrated with 1/140M of Hydrochloric acid to a pink end-point using a microburette. The titre (T) was recorded, and the formula below was used to calculate the total nitrogen:

$$\text{Total Nitrogen (\%)} = \frac{T}{W} \times 0.04\%$$

Where: W = weight of soil sample

T = Concentration of the titre

Determination of Organic Carbon

The Walkley-Black method adopted by IITA (1985) was used in determining organic carbon. One gramme of soil weighed into a conical flask and 10ml of normal potassium dichromate solution added. The mixture was stirred gently to disperse soil particles. Twenty milliliters of concentrated sulphuric acid was then added. The flask and its contents were swirled gently to ensure thorough mixing of the soil and the reagents. The flask and its contents were left to stand for 30 minutes and 200ml of distilled water was added followed by 0.2g of sodium flouride. This was titrated against ferric hydroxide using 1 ml of diphenylamine as an indicator. The titration was carried out until the colour changed from blue to green. The percentage organic carbon was calculated using the formula given below:

$$\text{\% Organic Carbon} = \frac{(B - S) \times \text{Normality of } Fe^{++} \times 0.003 \times 100}{W \times 7} \times 100$$

Where:

B = Blank titration

S = Sample titration

W = Weight of soil samples

0.003 = 12/4000 = milliequivalent weight of carbon (gms)

100/77 = the factor of converting the carbon actually oxidized to total carbon and 100 is the factor to change from decimal fraction to per cent.

Determination of Organic Matter

The same procedure above for the determination of organic carbon was repeated for the determination of organic matter content. The result obtained was multiplied by the factor 1.724 to give the organic matter content. The assumption is that soil organic matter contains 58% of carbon, therefore, the use of the factor 100/58 = 1.724. Therefore, the percentage organic matter is given as: % Organic Matter (OM) = % Organic Carbon x 1.724

Determination of Particle Size

Bouyoucos (!962) method was used to determine the soil particle size. Hundred millilitres of 5% Sodium hexametaphosphate (Calgon) solution was added to 40g air-dried soil and containers corked. The mixture was then agitated on an electric shaker for 24 hours. The suspension was transferred to a graduated sedimentation cylinder and stirred until a uniform suspension was obtained. The sand portion was then dried and weighed.

Statistical analysis

The SPSS 16.0, Minitab 13.32 and MSstats were fitted to the dataset to determine whether there was any variation in the soils supporting *C. sanguinolenta* collected from the three different sampling locations. The variables used in the analysis wwere topsoil characteristics. The Duncan's Multiple Range Test and T-test were applied to assess the level of significant differences between the variables and locations. Correlation functions were conducted to ordinate relationships between variables.

RESULTS

Table 1 gives detailed information on some of the topsoil characteristics of the soils obtained from the different locations. Some of the topsoil characteristics of the soils under consideration are pH, available phosphorus, organic carbon, organic matter, total nitrogen and textural class.

TABLE 1: Some topsoil characteristics of the soils

Site	pH	Available Phosphorus (µg/g)	Organic Carbon (%)	Organic Matter (%)	Total Nitrogen	Sand (%)	Clay (%)	Silt (%)	Textural Class
P_3 (Mar)	4.12 h ± 0.008	2.53 h ± 0.014	1.10 fg ± 0.001)	1.89 ef ± 0.028	0.10 ef ± 0.003	57.0	37.12	5.88	Sandy clay loam
P_6 (June)	6.63 b ± 0.005	6.41 b ± 0.005	2.34 b ± 0.007	4.03 b ± 0.010	0.23 a ± 0.003	42.76	38.08	19.16	Sandy clay loam
P_9 (Sept.)	6.87 a ± 0.007	1.44 h ± 0.007	2.26 g ± 0.007	3.88 f ± 0.071	0.22 ab ± 0.003	42.14	38.8	18.06	Sandy clay loam
P_{12} (Dec.)	6.37 c ± 0.005	5.54 b ± 0.009	1.83 b ±0.028	3.15 b ± 0.040	0.20 b ± 0.003	48.38	37.70	13.92	Sandy clay loam
M_3 ((Mar.)	3.70 k ± 0.005	2.87 c ±0.012	1.48 a ± 0.004	2.54 a ± 0.023	0.13 cd ± 0.003	71.6	18.78	9.62	Sandy loam
M_6 (Jun)	4.47 d ± 0.009	6.16 g ± 0.009	1.11 c ± 0.002	1.93 c ± 0.038	0.11 def ± 0.003	79.0	14.0	7.0	Sandy loam
M_9 (Sep)	4.30 f ± 0.005	2.34 e ± 0.009	1.00 cd ± 0.001	1.73 cd ± 0.031	0.09 f ± 0.002	78.48	13.98	7.54	Sandy loam
M_{12} (Dec.)	4.34 e ± 0.007	5.72 f ± 0.012	1.33 de ± 0.003	2.29 d ± 0.033	0.12 de ± 0.003	75.12	16.26	8.62	Sandy loam
A_3 (Mar.)	4.05 j ± 0.009	2.75 i ± 0.009	1.14 a ± 0.002	1.97 a ± 0.007	0.11 def ± 0.003	68.0	21.24	10.76	Sandy clay loam
A_6 (June)	4.25 g ± 0.005	6.88 d ± 0.013	1.69 fg ± 0.004	2.92 ef ± 0.059	0.15 c ± 0.003	62.24	27.24	10.36	Sandy clay loam
A_9 (Sept.)	4.10 i ± 0.005	4.43 g ± 0.007	1.30 efg ± 0.003	2.25 ef ± 0.007	0.13 cd ± 0.003	71.26	20.84	7.90	Sandy clay loam
A_{12} (Dec.)	4.34 e ± 0.009	7.47 a ± 0.005	1.23 def ± 0.002	2.12 de ± 0.035	0.11 def ± 0.003	71.74	16.28	11.98	Sandy loam

Legends:

P_3 : 1st quarter collection of soil in March 2003 from Pepease.
M_3 : 1st quarter collection of soil in March 2003 from Mamfe.
A_3 : 1st quarter collection of soil in March 2003 from Abonse.
P_6 : 2nd quarter collection of soil in March 2003 from Pepease.
M_6 : 2nd quarter collection of soil in March 2003 from Mamfe.
A_6 : 2nd quarter collection of soil in March 2003 from Abonse.
P_9 : 3rd quarter collection of soil in March 2003 from Pepease.
M_9 : 3rd quarter collection of soil in March 2003 from Mamfe.
A_6 : 3rd quarter collection of soil in March 2003 from Abonse.
P_{12} : 4th quarter collection of soil in March 2003 from Pepease.
M_{12} : 4th quarter collection of soil in March 2003 from Mamfe.
A_{12} : 4th quarter collection of soil in March 2003 from Abonse.
Figures followed by the same letter in the same column do not differ significantly ($P \leq 0.05$).

pH of the soils

The pH of the soils recorded at Pepease for the four quarters was significantly different in all cases (Table 2) at the 0.05 probability level; $p \leq 0.05$. The pH values recorded within the year at Mamfe were significantly different, $p \leq 0.05$ (Table 2). Also, the pH values recorded within the year at Abonse were significantly different, $p \leq 0.05$ (Table 2). The soil pH for both Mamfe (3.70 – 4.34) and Abonse (4.05 – 4.34) are acidic while that of Pepease (6.37 – 6.63) is close to neutral (Table 1).

TABLE 2: Analysis of variance for pH of the scale

K Value	Source	Degrees of freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	1	0.0000	0.000	0.8813	
2	Factor A	11	27.835	2.530	66.7.6818	0.0000
-3	Error	11	0.004	0.0001		
	Total	23	27.839			

Co efficient of variance: 0.41%

Available phosphorus in the soils

The available phosphorus in the soils recorded for the four quarters were not significantly different from one another in most cases even at the 5% level of probability (Table 3). There were significant differences in the values of available phosphorus obtained from Pepease during the first and second quarters and between the third and fourth quarters but no significant differences were recorded between the second and fourth quarters and first/third quarters (Table 1) even at the 5% level of probability. Again, there were significant differences in the values of the available phosphorus in the soils obtained from Mamfe within the year (Table 1) at the following probability level: $p \leq 0.05$ (Table 3). Also, there were significant differences in the values of available phosphorus obtained from Abonse within the year (Table 1) at 5% probability. The available phosphorus for the three locations ranges between 2.53 – 5.54µg/g for Pepease; 2.87 – 5.72 µg/g for Mamfe and 2.75 – 7.47 µg/g also for Abonse (Table 1).

TABLE 3: Analysis of variance for available phosphorus of the soils

K Value	Source	Degrees of freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	1	0.005	0.005	0.5486	
2	Factor A	11	94.141	8.558	974.7148	0.0000
-3	Error	11	0.097	0.009		
	Total	23	94.243			

Co-efficient of Variation: 2.06%

Organic carbon in the soils

Significant differences in the values of organic carbon content in the soils obtained from the locations are presented in Table 4. There was significant difference in the values of the organic carbon content between the first two quarters (March and June) and the last two quarters (September and December) at Pepease. But the organic carbon content values were not significant between June/ September and September/December at Mamfe. Again there was significant difference in the values of the organic carbon content between the first quarter (March) and the remaining three quarters (June to December) at Abonse (Table 1). The organic carbon of Pepease, Mamfe and Abonse occurred in the order of 1.00 – 1.83%, 1.33 – 1.14% and 1.14 – 1.23% respectively (Table 1).

TABLE 4: Analysis of variance for organic carbon of the soils

K Value	Source	Degrees of freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	1	0.001	0.001	0.2488	
2	Factor A	11	4.487	0.408	84.2610	0.0000
-3	Error	11	0.053	0.005		
	Total	23	4.541			

Coefficient of Variation: 4.06%

Organic matter in the soils

The organic matter content of the soils obtained from the locations for the four quarters was significantly different ($p \leq 0.05$) in most cases (Table 5). There was significant difference in the values of the organic matter content between the first two quarters (March and June) and the last two quarters (September and December) at Pepease. But the values of the organic matter content were not significant between June/ September and September/December at Mamfe. Again, there was significant difference in the values of the organic matter content between the first quarter (March) and the remaining three quarters (June to December) at Abonse (Table 1). The organic matter for the three locations namely: Pepease, Mamfe and Abonse were 1.80 – 3.14%, 2.29 – 2.54% and 1.97 – 2.12% respectively (Table 1).

TABLE 5: Analysis of variance for organic matter of the soils

K Value	Source	Degrees of freedom	Sum of squares	Mean square	F Value	Prob
1	Replication	1	0.015	0.015	1.0924	0.3184
2	Factor A	11	13.248	1.204	90.7143	0.0000
-3	Error	11	0.146	0.013		
	Total	23				

Coefficient of variation: 4.51%

Total nitrogen in the soils

The total nitrogen of the soils obtained from the locations for the four quarters was significantly different ($p \leq 0.05$) in most cases (Table 6). There was significant difference in the values of the total nitrogen content between the first quarter (March) and the remaining three quarters (June to December) at Pepease. The same pattern was observed at Mamfe. Again, there was significant difference in the values of the organic matter content between the first quarter (March) and the remaining three quarters (June to December) at Abonse (Table 1). Soils from Pepease had a total nitrogen content ranging between 0.10 – 0.19%, while that of Mamfe ranged between 0.12 – 0.13% and that of Abonse was between 0.10 – 0.11%.

TABLE 6: Analysis of variance for the total nitrogen of the soils

K Value	Source	Degrees of freedom	Sum of squares	Mean square	F Value	Prob
1	Replication	1	0.001	0.001	18.5263	0.0012
2	Factor A	11	0.048	0.004	76.2368	0.0000
-3	Error	11	0.001	0.0001		
	Total	23				

Coefficient of Variation: 5.39%

Textural class of the soils

The textural class of soils from the three locations were sandy clay loam (57.0%, 37.12%, 5.88%) for Pepease, whereas that of soils from Mamfe was found to be sandy loam (71.6%, 18.78%, 9.62%) and the soils from Abonse was also sandy clay loam (68.0%, 21.24%, 10.76%) (Table 1).

DISCUSSION

The pH values of the soils from the study sites were significantly variable (Table 2). The soils of Pepease, Mamfe and Abonse were acidic in nature while that of Pepease was near neutral (Table 2). The acidic nature of the soils might have been caused by leaching, erosion, crop uptake of basic cations, example calcium, (Ca^{2+}); magnesium (Mg^{2+}); potassium (K^{+}) besides decay of plant residues and plant root exudates, which serve as channels of the increasing in soil acidity. Moreover, a common source of acidity of the soils might have resulted from H^{+} ions that were released because of the presence of high levels of aluminum (Al^{3+}) in the soils. Earlier reports on the varying acidic nature of soils linked to the above mentioned attributes have been made by Richards (1996) and Brady (1990).

Available phosphorus in the soils was significantly different from each other as presented in Table 1 and Table 3. The varying difference could be attributed to the significant difference in the pH and organic matter of the soils of the different locations. Thus acidic soils cause phosphorus (P) to form insoluble compounds with aluminum and iron; and lower soil pH allows P to be more available for plant uptake. Moreover, organic matter contributes to the release of many plant nutrients, including nitrogen (N), phosphorus (P) and sulfur (S) as it is broken down in the soil. Similar roles by the soil pH and organic matter of soils have been reported in other soils by Griffin (2002), Richards (1996) and Brady (1990).

The organic carbon, organic matter and nitrogen of the soils were significantly different in their respective locations (Tables 4, 5 & 6). The organic carbon and organic matter of the soils with the former normally deduced from the latter could be the possible factors in bringing about variations in the soil micronutrients as well as the pH of the soils. Similar reports by Griffin (2002) has confirmed the functional roles of organic matter in the release of many plant nutrients, including nitrogen (N), phosphorus (P) and sulfur (S) as it is broken down in the soil and serves as one of two sources of cation exchange capacity (CEC) in the soils. The CEC represents the sites in the soil that can hold positively charged nutrients for example, calcium (Ca++), magnesium (Mg+) and potassium (K+). Increasing the CEC of the soil to hold more nutrients and release them for plant growth. The CEC is directly related to organic matter.

Two textural classes, sandy loam and sandy clay loam were observed in the soils of the different study locations (Table 2) and these are known to affect the soil nutrients status such as the micronutrients, for example, available phosphorus, nitrogen and organic matter. These might have accumulated from the weathering of rock materials and the decomposition of plant materials by microbes, which normally contribute to texture determination. Etherington (1982) and Lawson (1966) have similarly reported on the importance of soil texture in determining the nutrient status, soil - water relationship, aeration and permeability of a soil.

CONCLUSION

The soils contained the basic soil nutrients and soil pH in varying concentrations for the plant growth. Two textural classes were observed as sandy loam and sandy clay loam, which were, all important factors in improving the soil mineralogy of the different study locations. These could be seen in the endowment of the locations with a wide variety of plant species.

ACKNOWLEDGEMENT

The author thanks the Staff of the Rector Unit of the Ghana Atomic Commission for their support.

REFERENCES

Anderson, J. M. and Ingram, J. S. (1989) Tropical soil biology and Fertility. A handbook of methods. CAB International, Wallingford.

Bouyoucos, G. J. (1967) Hydrometer method for making particle size analysis of soil. *J. Agron.*, **54**: 464 – 465.

Brady, N.C. (1990) The nature and properties of soils, 10th Ed. Macmillan Publishing Company, New York, p. 243 – 246.

Clausen, J., and Hiesey, W.M. (1958) Experimental Studies on the nature of species IV. Genetic Structure of ecological races. Carnegie Inst. Wash. Publ., **615**: 1 – 312.

Clausen, J., Keck, D.D. and Hiesey, W.M. (1940) Experimental Studies on the nature of species. I. Effect of varied environments on western North American plants. *Carnegie Inst. Wash. Publ*., **520**: 1 – 452.

Elkington, T.T. (1986) Patterns of variation in wild plants in relation to selection pressures and infraspecific categories. In: Styles, B.T. (ed.) *Infraspecific Classification of Wild and Cultivated Plants*. Clarendon Press, Oxford, p. 33 – 52.

Etherington, J.R. (1982) Environment and Plant Ecology. 2nd ed. John Wiley, New York.

Ewer, D. W., Hall, J. B. and Mitchelmore, J. (1981) Ecological Biology, *Teacher's guide* 1. Longman Group Ltd. Essex. England.

Gregor, J.W. (1938) Experimental taxonomy, II. In Radford, A.E. Dickson, W.C., Massey, J.R. and Bell, C.R. (eds.), Vascular Plant Systematics. Harper and Row, New York, p. 485 – 500.

Griffin, T. (2002) Know Your Soil – Soil organic matter, University of Maine, U. S. A, Co-operative Extension Bulletin, No. 2288.

Hall, J.B. and Swaine, M.D. (1976) Classification and ecology of closed canopy forest in Ghana. *Journal of Ecology*, **64**: 913 – 951.

IITA (International Institute of Tropical Agriculture) (1985) *Laboratory manuel of selected methods for soil and plant analysis*. Ibadan, Nigeria.

Kimmins, J.P. (1987) Forest Ecology. Macmillan Publishing Company, New York.

Lawson, G.W. (1985) Plant life in West Africa. Ghana Universities Press, Accra.

Lawson, G.W. 1966. Plant life in West Africa. Oxford University Press, London.

Milne, G. (1947) A soil reconnaissance journey through parts of Tanganyika territory, December,1935 to February, 1936. *J. Ecol*., **35**: 192 – 265.

Nielsen, N.C. (1965) Introduction to the Flowering Plants of West Africa. University Press, London.

Nye P. H. (1954) Recent progress in work on the fertility of West African soils, *J. West African Science Assn.*, **1**: 18 – 25.

Nyle, C.B. and Weil, R.R. (1996) The Nature and Properties of Soils. Prentice – Hall, Inc., New Jersey, **3**: 99.

Okali, D.U., Hall, J.B. and Lawson, G.W. 1973. Root distribution under a thicket clump on the Accra Plains, Ghana: its relevance to clump localization and Water relations. *J. Ecol*., **61**: 439 – 454.

Pandeya, S.C., Puri, G.S. and Singh, J.S. (1968) Research Methods in Plant Ecology. Asia Publishing House, Bombay.

Richards, P.W. (1996)The Tropical Rainforest: an ecological study. 2nd Ed. Cambridge University Press, Cambridge, p. 251.

Snaydon, R. W. (1973) Ecological factors, Genetic variation and Speciation in plants. In: Heywood, V. H. (ed.) *Taxonomy and Ecology*. Academic Press, London, p. 1 – 29.

Turesson, G. (1925) The plant species in relation to habitat and climate, Hereditas, **6**: 147 – 236.

Turesson, G. (1930) The selective of climate upon the plant species, Hereditas, **14**: 99 – 152.