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Effects of Vegetation Parameters on Soil in the Cross River Rain forest Succession Phases, South-South Nigeria

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ABSTRACT

The Cross River Rainforest belt being the only remaining typical tropical rainforest is dwindling very fast. This forest is mainly found in Akamkpa and Boki Local Government Areas of Cross River State. In spite of this, deforestation through indiscriminate logging, infrastructural development, plantation agriculture alongside land grabbing has led to the loss and degradation of forest biodiversity. The paper seeks to examine the influence exerted by vegetation components on the soils of the Cross River tropical rainforest. Soil samples were collected in the quadrat laid on each succession shape at 10cm-15cm for surface soil and 15cm-30cm for sub-surface. A total of 50 soil samples were collected at both surface and sub-surface levels. Therefore, in consideration of the interrelationship behavior in successional phases between vegetation and soil, an increase in sub soil exchangeable calcium brings about an increase in tree size of vegetation. Invariably, the size of tree/shrub species was affected with an increase in sub soil exchangeable calcium too. Similarly, from multiple regression analysis (MRA), result also showed that DBH or tree size has a significant effect on sub soil exchangeable calcium. Hence, vegetation parameter affects soils in the Cross River Rainforest, Nigeria.Afforestation, reforestation and forest ecosystem restoration should be encouraged.

Key words: Vegetation parameters, soil properties, Cross River rainforest, successional phases, Nigeria.

INTRODUCTION

In the Cross River Rainforest belt being the only remaining typical tropical rainforest is dwindling very fast. This forest is mainly found in Akamkpa and Boki Local Government Areas of Cross River State. In spite of this, deforestation via indiscriminate logging, infrastructural development, plantation agriculture alongside land grabbing has lead to loss and degradation of forest biodiversity. This increased in forest loss has given rise to the emergence of wanton disturbances leading to secession in the area thereby creating different forest succession phases in the Cross River tropical rainforest of Akamkpa.In the light of the aforementioned, the inhabitants of the rainforest bearing communities in Akamkpa Local Government Area are mainly farmers (agrarian communities). This people still practice cultured and rudimentary agricultural practices which in turn brings about the widespread of destruction of foliage forest cover vis-à-vis soil nutrient loss. With the supposed soil nutrient losses and decline in crop yield, the bush fallow system of agriculture is adopted to regain and restore soil fertility overtime(**Aweto, A**.). However, the abandonment of degraded forest areas overtime thus bring forth sequential changes that affects vegetation structure and floristic composition from the beginning of the fallow period to the final re-establishment of the forest attributes that were initially existingconstitutes secondary ecological succession (**Aweto, A, 1981**); (**Botkin, D. B. & Keller, E. A, 1998**).

In the same vein, (**Singh, J. S; Singh, S. P. & Gupta, S. R., 2008**) had viewed secondary succession as the gradual changes and or takeover of a particular area by species composition and processes of communities that replaces one another thereby leading terminal stable community which is in equilibrium with environmental conditions. Secondary succession has also been posited as a process that is driven by an event be it natural or man-made that has the capability of modifying the already existing established ecosystem to a smaller populations thereby posing a lot of impact on soils, biota and ecosystem interactions (**Cook W. M et al., 2005**);(**Van der Kamp, J., Yessir, I. &Burrman, P.2009**).Vegetation and soil have been seen to have symbiotic relationship. This is as a result of the fact that wherever vegetation is found, soil is also found. This is further buttressed by the works of (**Bradshaw, M. & Weaver, R., 1995**); (**Nebel, B. J., 1981**) as they stated that while soils provide nutrient, support for plant growth, vegetation in turn protects the soil from erosion, fertility loss and maintenance of basic attributes. However, in the Cross River rainforest region of Akamkpa, vegetation has contributed to the increase in diversity organic carbon and nitrogen due to dense foliage cover, increase in litter and crown cover especially in the primary forest region and fallow genealogical cycle that is of forest generation (**Offiong, R. A. et al., 2015**); (**Iwara, A. I. et al., 2014**); (**Offiong, R. A., Bisong, F. E. & Ekpe, A. I., 2014**);(**Offiong, R. A., et al., 2013**); (**Offiong, R. A &Iwara, A. I., 2012**). Therefore, it is against this background that the paper seeks to examine the influence exerted by vegetation components on the soils of the Cross River tropical rainforest. This therefore, will serve as a referral to scientist and forest ecologist who are interested in forest restoration in providing relevant information on the vegetation-soil relationship in the study area. The vegetation data that was obtained were mainly floristic and structural variables such as: height, basal area, basal, cover, crown cover, diameter at breast height (DBH), composition, diversity, evenness and species diversity alongside the even numbers.

MATERIALS AND METHOD

Study area: The study area is the Oban group rainforest ecosystem located between longitude 8^{0}060ʾ0”E and 8^{0}50ʾ20”E and latitude 5^{0}00’0”N and 5^{0}57ʾ20”N. Hence, data for the study was collected in Neghe community which is geographically located between longitude 8^{0}3630”E and 8^{0}20ʾ10”E and latitude 5^{0}20’0”N and 5^{0}13ʾ30”N. Data was collected using the direct field observation, measurement and enumeration of vegetation data. The vegetation data was collected from the established quadrats with the various succession phases namely forbs (<2years); young fallow (≥3≤7 years); mature fallow (≥8≤15 years); secondary climax (≥ 16 ≥ 25 years), while the primary climax was > 25 years old. The vegetation data that was obtained were mainly floristic and structural variables such as: height, basal area, basal, cover, crown cover, diameter at breast height (DBH), composition, diversity, evenness and species diversity alongside the even numbers.

Crown cover (CC) = $\frac{crown\ of\ intercepted\ tree/shrub x 100}{\text{length of tape used (30m)}}$; Basal cover (BC) = $\frac{number\ of\ intercepted\ tree/shrub x 100}{\text{length of tape used (30m)}}$; Basal area (BA) = π (D.$\frac{2}{2}$); Where $\pi = pie\ (3.143)\ and\ D = diameter\ at\ breast\ height\ (DBH)$; Height (H): the trigonometry method was used.

Further, soil samples were collected in the quadrat laid on each succession shape at 10cm-15cm for surface soil and 15cm-30cm for sub-surface. A total of 50 soil samples were collected at both surface and sub-surface levels. This means that 10 samples were collected in each phase which was generally five in number. On the other hand, the collected soil samples were taken to the laboratory for analysis of physic-chemical properties. Organic carbon was determined by (**Walkey, A. J. & Black, I. A., 1934**)Kjeldahl method by (**Breamner, J. M. &Malvauney, C. S., 1982**) was also used in the determination of Nitrogen while Phosphorus was determined using (**Bray, R. H. & Kurtz, L.T., 1945**) method. The exchangeable bases and soil cation, exchange capacity were determined by leaching soils with 1M neutral ammonium acetate to obtain the leacheates. The (**Bouyoucous, G. J., 1962**) hydrometer method was used in analyzing the textural class (particle size composition). Lastly, the glass electrode tectonic digital, PH meter (model 511) with a soil moisture ratio of 1:2 was used in the determination of the soil PH.

RESULTS AND DISCUSSION

This section of the study presents the results of Principal Component Analysis (PCA), Canonical correlation Analysis (CCA) and Multiple Regression Analysis (MRA) of the vegetation and soil parameters in the succession and fallow cycles. PCA was used to reduce the vegetation-soil data set in order to identify basic and exploratory variables; CCA was employed to investigate the linear combinations of the predictor (vegetation) and criterion (soil) variables, the essence was to examine their interrelationships; while MRA was used to examine the effect/influence a set of predictor variables had on a set of criterion variables. This enabled significant vegetation parameter(s) that influenced changes in soil properties to be established. This was down through the aid of computer software called statistical analysis for science (SAS) 9.0

PCA was performed for ten vegetation parameters in order to identify critical vegetation factors as well as define the vegetation structure. Component loadings (correlation coefficients) and the variances (eigenvalues) for the various vegetation parameters were computed; however, based on the rule of thumb that only components with eigenvalues > 1 would be extracted, only one component out of ten vegetation parameters was extracted. For interpretation and understanding of the components, only variables with correlation coefficients>0.3 were extracted. Table 1 shows results of the principal component matrix of vegetation parameters with eigenvalues ≥ 1; it showed that six (6) vegetation parameters loaded heavily on component 1, the parameters/variables included Diameter at Breast Height (DBH) or tree size (0.331), basal cover (0.330), tree height (0.324); species diversity (0.323); basal area (0.320); mean no. of trees (0.303) and species evenness (0.310). This component exemplified vegetation richness and it accounted for 9.02 of the total eigenvalue loading and 90% variance in the vegetation data set. Nevertheless, among these vegetation parameters that loaded on this component, the variable-defining coefficient (that is vegetation variables with the highest component loading or correlation coefficients) was tree size otherwise referred to as DBH. These implied that among the vegetation parameters that were on this component, tree size or DBH was the most significant followed closely by basal cover.

Table 1: Components matrix of vegetation parameters in succession

Vegetation Parameters	Principal Components 1
Tree Density	0.297
Mean No. of Trees	0.303
Species Diversity	0.323
Species Evenness	0.310
Species Composition	0.322
Basal Cover	0.330
Crown Cover	0.230
DBH	0.331
Basal Area	0.320
Tree Height	0.324
Eigenvalues	9.017
% Variance	0.902
Cumulative Exp.	0.902

Source: Field work, 2010

PCA was performed for 30 soil properties in order to reduce and identify critical soil factors in the soil data structure. Out of the thirty soil properties, three components with eigenvalues >1 were extracted, these three extracted principal components accounted for 100% of the variation in the overall soil properties (Table 2). In other words, out of the thirty soil properties imputed, only components (variables) were extracted as basic and uncorrelated soil variables. The result showed that based on the component loading (correlation coefficients) threshold of >0.23, five soil properties loaded on component 1, which included subsoil exchangeable calcium (0.237); topsoil moisture content (-0.236); topsoil available phosphorus (0.236); subsoil exchangeable magnesium (0.236) and subsoil available phosphorus (0.236). This component accounted for 17.454 of the total variance and 58% (0.58) of the variation in the data set.

In component 2, three soil properties loaded heavily, they included electrical conductivity (-0.321); organic carbon (0.305) and total nitrogen (0.314). These components exemplified organic and it accounted for 8.997 of the total eigenvalue loading as well as 30% (0.30) variation in the soil properties. Whereas, two soil properties loaded heavily on component three, which included top soil exchangeable potassium (0.520) and subsoil moisture content (0.346); this component accounted for 3.55 of the total eigenvalues and 12% (0.12) of the variation in the overall soil data set. However, among these soil properties that loaded on the three extracted principal components, the variable defining coefficients (.i.e. soil variables with the highest component loadings or correlation coefficients) were subsoil exchangeable calcium, topsoil electrical conductivity and topsoil exchangeable potassium.

Table 2: PCA result on soil properties in the succession phase

Soil Properties	Principal Components		
	1	2	3
Sand Content Surface	0.122	0.269	0.159
Silt Content Surface	0.205	0.170	-0.059
Clay Content Surface	-0.193	0.178	-0.130
Porosity Surface	-0.126	0.271	0.132
Moisture Surface	-0.236	-0.048	0.037
Organic Carbon Surface	-0.082	0.266	0.263
Total Nitrogen Surface	-0.084	0.286	0.199
Exchangeable Ca Surface	0.234	-0.057	-0.055
Exchangeable Mg Surface	-0.230	-0.056	0.115
Exchangeable Na Surface	-0.174	-0.228	-0.007
Exchangeable Potassium Surface	0.011	-0.067	0.520
CEC Surface	0.212	-0.136	-0.113
Av Phosphorus Surface	0.236	-0.015	-0.088
pH Surface	0.230	0.052	-0.118
EC Surface	0.050	-0.321	0.087
Sand Content Subsurface	0.182	-0.154	0.244
Silt Content Subsurface	-0.092	0.263	-0.254
Clay Content Subsurfac	-0.222	-0.034	-0.193
Porosity Subsurface	0.181	0.143	-0.263
Moisture Content Subsurface	-0.176	-0.058	0.346
Organic C Subsurface	0.084	0.305	0.104
Total Nitrogen Subsurface	0.056	0.314	0.126
Exchangeable Ca Subsurface	0.237	0.009	0.072
Exchangeable Mg Subsurface	0.236	0.054	0.017
Exchangeable Na Subsurface	-0.106	-0.294	-0.086
Exchangeable K Subsurface	0.222	0.034	0.193
CEC Subsurface	0.229	0.094	-0.037
Av Phosphorus Subsurface	0.236	-0.010	-0.074
pH Subsurface	0.209	-0.154	0.078
EC Subsurface	0.190	0.130	0.247
Eigenvalues	17.454	8.997	3.550
% Variance	0.582	0.300	0.118
Cumulative Explanation	0.582	0.882	1.000

Source: Field work, 2010

Canonical correlation analysis of vegetation-soil interrelationships in the succession phase

In this section, canonical correlation analysis was performed to examine the relationships between the vegetation parameters as a set of predictors and the soil properties as a set of criterion variables. In this regards, canonical correlation according to (**Aweto, A. O., 1981c**) and (**Veldman, D. J., 1967**) is a multivariate statistical approach that examines the way in which two multivariate measures are related and the strength and nature of these relationships. The canonical variates are pairs of maximally correlated linear combinations of predictor and criterion variables. Table 3 depicts result of the canonical correlation analysis; since only one component was extracted when PCA was performed on the vegetation parameters, one canonical variate was therefore extracted and it was identified by vegetation-soil variates >0.9. However, the only canonical variate (linear combination of the two variables-predictor and criterion) extracted by the model implied that there was a perfect negative relationship tree size (DBH) and subsoil exchangeable calcium.

This therefore showed that DBH and subsoil exchangeable calcium were negatively related (exhibit an inverse relationship). Therefore, in that an increase in one would result in a corresponding decrease in the other. In addition, the canonical correlation coefficient between these variables displayed a high positive relationship (0.96), and the relationship was significant as 10% significance level. The standardized canonical coefficients (canonical weighs) in Table 3showed that the first canonical variable for the vegetation parameter was a weighted sum of the variable DBH (1.00); this canonical weight implied that an increase in DBH across the succession stages would result in the increase of subsoil calcium concentration; in the same manner, the canonical weights (the standardized canonical coefficients) show that the first canonical variable for the soil properties was a weighted sum of the variables subsoil exchangeable calcium (-1.02); topsoil electrical conductivity (0.07) and topsoil exchangeable potassium, with emphasis on subsoil exchangeable calcium. The coefficient for the variable EC is near 0; therefore, successional fallow vegetation with increase in subsoil exchangeable calcium would affect the DBH or tree size of vegetation. Invariably, the size of tree/shrub species was affected with an increase in subsoil exchangeable calcium.

Table 3: Results of canonical correlation analysis of the vegetation-soil interrelationships in the succession phase

Parameters	**Canonical Variates** 1	**Canonical Weights**
Vegetation Parameters		
DBH	1.00	1.00
Soil Properties		
Subsoil Exchangeable Calcium	-0.99	-1.02
Topsoil Exchangeable K	-0.10	0.07
Topsoil Electrical Conductivity	-0.04	0.07
Canonical Correlation Coefficient	0.96	
Adjusted Can. Corr. Coefficient	0.95	
F-ratio	4.02**	

****Significant at 10% significance level**

Source: Field work, 2010

Multiple regression analysis of vegetation-soil in the succession phase

Based on the variable-defining coefficients extracted by PCA in the vegetation-soil variables, these identified components (.i.e. tree size or DBH for vegetation and subsoil exchangeable calcium, topsoil exchangeable potassium and electrical conductivity for soil properties) were used as explanatory variables and thereafter regressed on the independent variables to yield reduced rank equations to examine the effect of vegetation variable on soil properties. Since only one vegetation variable was extracted, it was regressed on the three extracted significant soil properties.

Effect of DBH on subsoil exchangeable calcium

The multiple regression analysis (MRA) was used to test the effect of predictor variable (DBH or Tree Size) on the criterion variable (subsoil exchangeable calcium). The mathematical equation representing this association is defined as: $Y = a + b_1X_1 + \ldots e$……………………………….eqn (1)

Where: Y = Subsoil Exchangeable Calcium (SEC), a = Y- intercept, b_1 = Regression Coefficient, X_1= Diameter at Breast Height (DBH), e = Residual or Error Term

Table 4: Multiple regression result of dbh-exchangeable potassium

Parameters	Coefficients	Std Error	T-test
Intercept	3.502	0.294	11.92**
DBH	-0.354	0.063	-5.60**
Diagnostic			
F-ratio	31.31		
Adj. R^2	0.88		
Error Term	0.32		
R^2	0.91		
Probability	0.05		

**Significant at 0.05 significance level

Source: Field work, 2010

Data from the table 4 was inputted into equation 1 as follows: SEC= 3.502 – 0.354DBH…………eqn 2

The result in the table above shows that 88% of the variation in the criterion variable (SEC) was accounted for by the predictor variable (DBH). The F-ratio ratio implied that DBH had significant influence on SEC ($p<0.05$). Also, the low residual or error term (0.32) showed the model was a good fit in explaining the effect that the predictor variable had on the criterion variable. The effect of DBH on subsoil exchangeable calcium showed a significant effect, though negative ($p<0.05$). In essence, as DBH increased, the concentration of subsoil exchangeable calcium reduced in a corresponding ratio.

Effect of dbh on topsoil exchangeable potassium

The multiple regression analysis (MRA) was used to test the effect of predictor variable (DBH or Tree Size) on the criterion variable (topsoil exchangeable potassium). The mathematical equation representing this association is defined as: $Y = a + b_1X_1 + \ldots e$…………………………………eqn (3)

Where: Y = Topsoil Exchangeable Potassium (TEK), a = Y- intercept, b_1 = Regression Coefficient, X_1= Diameter at Breast Height (DBH), e = Residual or Error Term

Table 5: **Multiple regression result of dbh-exchangeable potassium**

Parameters	Coefficients	Std Error	T-test
Intercept	0.092	0.028	3.35**
DBH	-0.001	0.006	-0.17*
Diagnostic			
F-ratio	0.03		
Adj. R^2	-0.32		
Error Term	0.03		
Probability	0.05		

**Significant at 5% significance level; *Insignificant at 5% significance level

Source: Field work, 2010

Data from the table 5 was inputted into equation 3 as follows: EK= 0.092 - 0.001DBH…………..eqn 4

The result in the table above shows that 32% of the variation in the criterion variable (TEK) was accounted for by the predictor variable (DBH). The F-ratio ratio implied that DBH had no significant influence on TEK (p>0.05). Also, the low residual or error term (0.03) showed the model was a good fit in explaining the effect that the predictor variable had on the criterion variable. The effect of DBH on topsoil exchangeable potassium showed insignificant effect (p>0.05); and it indicated that as DBH increased, the concentration of subsoil exchangeable calcium reduced as well.

Effect of dbh on topsoil electrical conductivity

The multiple regression analysis (MRA) was also used to test the effect of predictor variable (DBH or Tree Size) on the criterion variable (electrical conductivity). The mathematical equation representing this association is defined as:

$Y = a + b_1X_1 + \ldots e$…………………………………eqn (5)

Where: Y = Topsoil Electrical Conductivity (TEC), a = Y- intercept, b_1 = Regression Coefficient, X_1= Diameter at Breast Height (DBH), e = Residual or Error Term

Table 6: Multiple regression result of dbh-exchangeable potassium

Parameters	Coefficients	Std Error	T-test
Intercept	0.361	0.170	2.13*
DBH	-0.002	0.067	-0.16*
Diagnostic			
F-ratio	0.00		
Adj. R^2	-0.33		
Error Term	0.18		
R^2	0.0012		

*Insignificant at 5% significance level

Source: Field work, 2010

Data from the table 6 was inputted into equation 5 as follows:

EC = 0.361 - 0.002BC………………………………………..eqn 6

The result in the table 6 shows that 33% of the variation in the criterion variable (TEC) was accounted for by the predictor variable (DBH). Like the formal, the F-ratio ratio implied that DBH had no significant influence on TEC ($p>0.05$). Also, the low residual or error term (0.18) showed the model was a good fit in explaining the effect that the predictor variable had on the criterion variable. In general, when the variations accounted for by the predictor variables are compared, it becomes glaring that the basic vegetation and soil variables across the successional fallow communities are DBH and Subsoil Exchangeable Calcium (SEC). The MRA results between DBH and TEK as well as TEC and SEC making inference from their coefficient of variation (Adjusted R Square) and t-values corroborate the findings of the canonical correlation analysis (CCA) which showed a perfect negative relationship between DBH and SEC and a weak positive relationship between DBH and TEC/TEK. In conclusion, the MRA result indicated that DBH or tree size had a significant effect on subsoil exchangeable calcium. Therefore, the H^o was rejected, while the Hypothesis three H^i accepted.

CONCLUSION AND RECOMMENDATIONS

In the Cross River tropical rainforest which the Oban group rainforest is part thereof has five succession phases which were the forbs area, young fallow, mature fallow, secondary climax and primary climax. From the analysis carried out, DBH was the major extracted vegetation parameters that affected soil properties such as; sub soil exchangeable calcium, top soil electrical conductivity and top soil exchangeable potassium. Therefore, in consideration of the interrelationship behavior in successional phases, it is clearly seen with an increase in sub soil exchangeable calcium that affects tree size of vegetation. Invariably, the size of tree/shrub species was affected with an increase in sub soil exchangeable calcium. Similarly, from multiple regression analysis (MRA), result also shown that DBH or tree size has a significant effect on sub soil exchangeable calcium. Hence, vegetation parameter affects soils in the Cross River Rainforest of Nigeria. Therefore, the vegetation of the area should be maintained. Again, the inhabitants of the area should be made to adopt alternative means of livelihood sustainability. This will therefore continue to allow existing vegetation to remain. Again, afforestation, reforestation and forest ecosystem restoration should be encouraged.

REFERENCES

1. Aweto, A. O. “Total nitrogen status of soils under bush fallow in the forest zone of south – WesternNigerian”. Soil Science 32: 639 – 642. (1981).
2. Botkin, D. B. and Keller, E. A. “Environmental Science: Earth as a Living Planet”. New York, JohnWiley and Sons Inc. (1998).
3. Singh, J. S; Singh, S.P. and Gupta, S.R. “Ecology, Environment and Resource Conservation”. New Delhi, Anamaya Publishers. (2008).
4. Cook, W.M., Bryan, J. Y., Foster, L., Holt, R. D. and Patrick, L. B..“Secondary Succession in anExperimentally Fragmented Landscape: Community Patterns across Space and Time”. Ecology, 86(5):1267-1279. (2005)
5. Van der Kamp, J., Yessir, I. and Burrman, P. ‘’Soil carbon change upon secondary succession inImperata Grassland (East Kalimantan, Indonesia)”. Geoderma 149(1-2): 76-83. (2009).
6. Bradshaw, M. and Weaver, R. “Foundation of Play”. Geography. New York, M. C. Brown. (1995).
7. Nebel, B. J. “Environmental Science 2nd edition”. Prentice-Hall, New Jersey. (1981).
8. Offiong, R.. A., Iwara, A. I., Umoh, N. E. & Ekpe, I.A. “Effect of Secondary Succession on the Changes in Soil Physiochemical Properties in the Cross River Rainforest, Nigeria”. Journal of emerging trends in economics and management sciences (JETEMES) 6 (3):209-213. (2015).
9. Iwara, A. I., Offiong, R. A., Njar, G. N., &Ogundele F.O. “An assessment of herbaceous Species Diversity, Density and Cover in Agoi-Ekpo, Cross River State, Nigeria”. International Journal 0f biological sciences (IJBS), 01 (1) 21-29. (2014).
10. Offiong, R. A., Bisong, F. E. & Ekpe, I. A. “Effects of vegetation change on soil properties in the Cross River Rainforest Fallow Genalogical Cycles, South- Southern Nigeria”. Research Journal in Engineering and Applied Science, 3 (4):267-273. (2014).
11. Offiong, R.A., Bisong F.E., Iwara, A.I., & Ekpe, I.A. “Effect of fallow Genealogy on Vegetation Characteristics in the Cross River Rainforest, South-Southern Nigeria”. SWISS Journal of Applied Sciences, 2 (7):52-61. (2013).
12. Offiong, R.A., and Iwara, A.I. “Quantifying the Stock of Soil Organic Carbon Using Multiple Regression Model in a fallow vegetation, Southern Nigeria”. Ethiopian Journal of Environmental Studies and Management, 5 (2): 166-17. (2012).
13. Walkey, A. J and Black, I. A.“Estimation of soil organic carbon by the chromic acid titration method”.Soil Science 37, 29-38. (1934).
14. Breamner, J. M and Malvauney, C. S Total Nitrogen; In: A, L. Page, R.H Miller and D.R Keeny, (Eds). “Methods of soil analysis”. American Society of Agronomy and Soil Science, Madison, PP 1119-1123. (1982).
15. Bray, R. H. and Kurtz, L. T. “Determination of Total, Organic and Available Forms of Phosphorousin Soils”. Soil Science 5:39-45. (1945).
16. Bouyoucous G. J.“Hydrometer method improved for making particle size analysis of soils”. Agronomy journal 54, 464-465. (1962).
17. Aweto, A. O. “Secondary succession and soil fertility Restoration in south Western Nigeria”. Journal of Ecology 69: 957 – 963. (1981c)
18. Veldman, D. J. “Fortan Programming for the BehaviourialSceinces”. Holt, Renihart& Winston,Chicago”. (1967).