ADAPTATION AND GROWTH PERFORMANCE OF TEA PLANTS *(CAMELIA SINENSIS* (L)O. KUNTZE) IN OBUDU HILLS,CROSS RIVER STATE

ABSTRACT

Young seedlings of five tea clones under cultivation (318, 236, 68, BB35, and 143) and five from the germplasm), were collected from the Kakara Highland tea Plantations, Mambila Plateau, Taraba State. Seedlings were planted in fifty sample boxes to enable the seedlings to be established first before transplanting to the field. After the establishment, they were transported to ObuduHills for investigation. The experiment was laid out in a randomized complete block design (RBCD) with 3 replications. Data collected on morphological traits were subjected to an analysis of variance (ANOVA) test. Multivariate analysis such as principal component analysis (PCA), hierarchical cluster analysis and correlation analysis were used to estimate genetic diversity between the tea plant clones. The result showed that the tea clones survived the first two months after transplanting. However, subsequently, the percentage of survival was reduced. Results from the morphological studies revealed that the accessions differed significantly ($p>0.001$) in all evaluated traits except for leaf width and dry biomass. Three principal components were identified based on eigenvalues; the first principal component contributed 44.18% of the total variation with an eigenvalue of 3.977, the second principal component accounted for 24.36% with total eigenvalue of 2.193 while PC3 accounted for 15.345% of the total variation with eigenvalue of 1.381. Cluster analysis showed that the evaluated tea clones were grouped into two main clusters containing sub-clusters. The high genetic diversity identified in *Camellia sinensis*clone in the study will serve as a guide in breeding, genetic improvement, utilization and conservation of this important nutritional and medicinal plant species.

Keywords: *Camellia sinensis*, Tea, Kakara, Obudu hills

1.1 INTRODUCTION

Tea plant *Camellia sinensis* (L) O. Kuntze, is an economic crop with significant importance (Xia *et al.,* 2017). They are species of evergreen shrubs in a flowering plant family (Theaceae). The leaves are used in tea production. Tea is the second most popular non-alcoholic beverage in the world not only for its rich flavor and taste, but also for its therapeutic benefits (Wei *et al.,* 2011). Tea plant was the first documented tree crop in China and has a long history of cultivation particularly, in Yunnan and Sichuan provinces (Kingdom-Ward, 1950; Yu, 1986). Following domestication and economic utilization of the tea plant in China, it was introduced to other countries in Asia through the SilkTrade Road and Horse Road (Lu *et al.*,2016) and was thought to have subsequently been introduced to Africa by Western Missionaries and imperialists (Matheson and Bovill, 1950; Eden, 1976). Thetea plant is grown in Asia, Africa, and South Africa (Edirisinghe *et al.*,2018) where it is cultivated in tropical and subtropical climates, especially in areas with at least 127cm (50 inches) of rainfall a year. There are two main varieties grown today*: Camellia sinensis var. sinensis* and *Camellia var. Assamica*. The tea plant is heterogeneous because of its high inbreeding depression and long periods of allogamy.

Regarding chemical composition, tea contains tannin, alkaloids, flavonols, proteins, amino acids, aroma-producing volatile substances, enzymes, vitamins, mineral compounds, and microelements (Omalaja, 2005).Tea contains some major nutrients, which are carbohydrate (16.15%), calcium (2.60%), copper (2.11%), phosphorus (1.43%), and potassium (1.38%). Many of the beneficial effects of tea are due to the flavonoids it contains. These flavonoids belong to a group of chemicals with strong antioxidant properties.Therefore,analyzing the genetic variability using morphological descriptors to differentiate the clones has become imperative for the breeding and improvement of tea plants.

MATERIALS AND METHODS

Location and sample collection

Young seedlings of ten tea clones,five obtained from the nursery of the clones currently under cultivation (318,236,68,BB35, and 143), and 5 from the germplasm were collected from the Kakara Highland Tea Plantations,MambilaPlateau,and TarabaState. The clones were raised in fifty sample boxes. This was to enabletheestablishment of the seedlingsbeforetransportation and subsequently, for transplanting to the field at the tea plantation in Taraba State.After the establishment,they were transported to ObuduHills for transplanting.

Soil analysis

Top soils (3-5cm deep) were collected from different locations in the plantation andObudu sites for analysis. The soil samples were analyzed for physical-chemical properties.

Transplanting of established seedlings experimental design

A plot of land measuring 50m by 50m was used for the experiment. Ten ridges were prepared for the transplanting of the seedlings.Each clone was replicated 3 times and was given a totalof 135 stands of tea seedlings. During transplanting, the seedlings were carefully uprooted with the soil to avoid damage. On the ridge, a hole was made where each uprooted seedling was placed and covered gently.The experiment was laid out in a randomized complete block design (RCBD)with 3 replications.

Morphological characterization of tea clones

The morphological descriptors used for data analyses were based on the outcomes of previous studies conducted on tea by Guansekaran*et al.* (2001) and Piyasundara*et al.*(2006). The parametric descriptors include leaf length, leaf width, leaf area, shoot length, internode length as well as biomass yield. The leaf area was calculated using the following formula according to Kim *et al.* (2007) and Yang *et al.* (2012):

Leaf area (cm^2) = Leaf length X Leaf width X (0.74).

Data analysis

All data collected were subjected to analysis of variance (ANOVA). Means were separated using the Least Significant Difference (LSD) test at 5% confidence interval. Correlation analysis was conducted to establish the association of traits. All analyses were carried out using Predictive Analytical Software (PASW) Version 20, Principal Component Analysis or (PCA), and cluster analysis was carried out using SPSS software version 20.0.

RESULTS AND DISCUSSION

Weather statistics of Kakara Tea Plantation, Taraba State, and Obudu Hills, Cross River State.

Meteorological information showed that the total rainfall in Kakara Tea Plantation and ObuduHills was 170.10 and 42000mm, total wet days, were 23 and 26.2 while total sunshine was 5 and 3hours respectively. Additionally, maximum humidity was 90.80% and 80.00% with maximum and minimum temperatures of 27°C and 7°C and 26°C and 4°C, respectively (Table 1).

Soil analysis of Kakara Tea Plantation and ObuduHills

The results of soil analysis of Kakara tea plantation and ObuduHills are presented in Fig. 1. Results showed that the soil of Kakara Tea plantation has 85.6% sand, 13.0% silt, 1.4% clay, and 13.0% organic carbon while soil from ObuduHills was made up of 80.6% sand and, 14.0% silt, 5.4% clay, and 13.2% organic carbon.

The soil pH from Kakara Tea plantation was 6.0 while that of ObuduHills was 5.9. Available phosphorus was 844.9 and 1203.6 mg/Kg, Sodium 10.0 and 9.45mg/kg, Potassium 6.15 and 10.32cmol, Calcium 7.8 and 11.6 cmol/kg, Magnesium was 6.8 and 6.0 cmol/kg, hydrogen ions was 0.72 and 0.36cmol/kg while aluminum ions were 0.4 and 0.41 cmol/kg respectively. ECEC was 31.87 and 38.13cmol/kg, nitrogen 0.53% and 0.57%, and base saturation was 96.4% and 98.5% for soil samples from Kakara tea plantation and Obudu, Hills, respectively (Fig. 3).

TABLE 1
Weather statistics of Kakara Tea plant plantation, Mambila Plateau, Sarduna Local Government Area, Taraba State andbecheve,ObuduHills, Cross River State.

S/N	Weather parameter	Kakara Tea plant plantation	ObuduHills
1	Latitude	06° 50” 40” N	06° 25’ N 6.4167°N
2	Longitude	11° 67” 49” E	09° 22’ E 9.36617°E
3	Altitude	1,464 MSL (Meters above sea level)	1600M
4	Total Rainfall	170.10mm	4,200 mm (between April to November)
5	Total wet days	23 days	26.2 days
6	Total sunshine	5hrs	NA
7	Relative Humidity	90.80%	NA
8	Maximum Temperature	27°C	26°C
9	Minimum temperature	7°C	4°C
10	Soil Temperature	22°C	NA
11	Average vapour pressure	24°C	NA
12	Dew point	20°C	NA
13	Average wind speed	2.6km/hr	NA
14	Wind direction	South-West	North

Source: Weather statistics, 2021

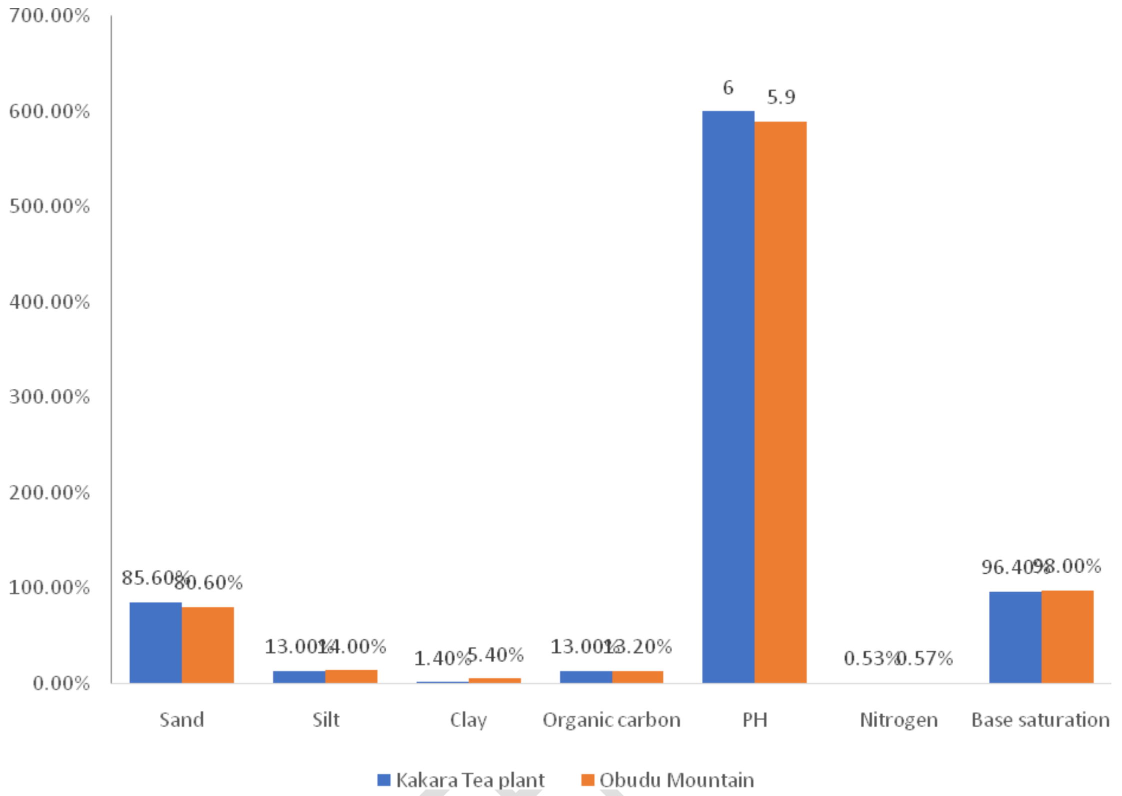

Fig 1. Soil analysis of Kakara tea plantation and ObuduHills (The number of samples has not been included. Where is the standard deviation? and explain properly)

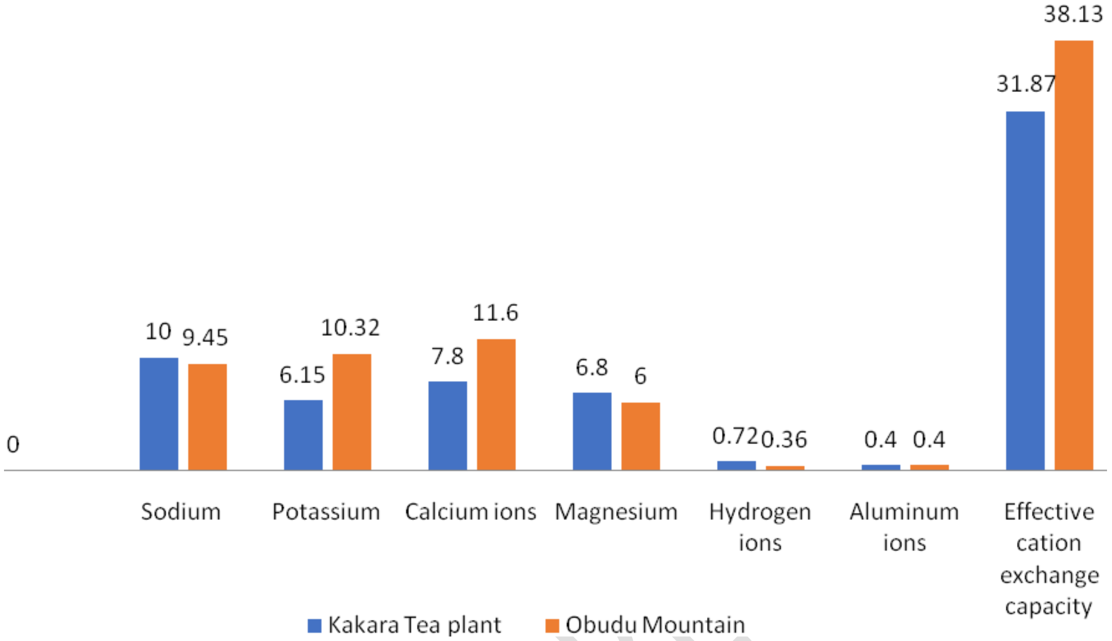

Fig 2. Growth performance of Kakara tea plantation (The number of samples has not been included. Where is the standard deviation? and explain properly)

Growth performance of ten clones of tea plants

Results from the Agronomic traits showed that there were significant differences (P< 0.05) in the plant height, number of leaves, number of branches, leaf area, leaf length, and internode length, while leaf width and dry biomass weight did not differ significantly (P>0.05) among the tea clones (Table 3).

Mean plant height ranged from 12.32± 1.65cm in clone 7 to 19:11± 1.08cm in clone 10, leaf area of plants ranged from 67.04± 7.52 in clone 1 to 34.68± 5.60cm^2 in clone 6, while the number of branches per plant varied from 6.00± 1.00 in clones 6 to 2.60± 0.89 in clone 2. Clone 2 had the highest number of leaves per plant (7.60± 1.4), while clone 6 recorded the least number of leaves per plant (3.60± 0.54).

Internodes length was highest in clone 4 (6.26±0.73cm) and least in clone 7 (4.41±0.45cm) while the percentage survival was highest for clone 9 80.80±3.63% and lowest in clone 4 (30.80±0.83%). Mean dry biomass of tea plants ranged from 0.12g in clone 6 to 0.7g in clone 5, the leaf length of plants varied from 12.90±1.21cm in clone 1 to 9.16±1.76cm in clone 4, while the mean leaf width ranged from 5.20±0.46m^2 in clone 1 to 4.00±0.94m^2 for clone 4

Table 2. Morphological attributes, percentage survival and dry biomass of ten clones of Tea plants grown in ObuduHills

Cultivates/Clones	PH (cm)	NL	NB	LA (m^2)	LL(cm)	LW (m)	IL(cm)	LB (g)
318	16.24±2.99	5.70±0.44	3.40±0.54	67.04±2.52	12.90±1.21	5.20±0.46	6.10±0.23	0.08±0.00
236	14.54±0.46	7.00±1.14	2.60±0.89	57.03±1.82	11.90±0.50	4.78±0.47	5.80±0.88	0.08±0.00
68	18.00±0.72	6.80±1.14	4.80±0.23	50.53±1.20	11.30±1.58	4.40±0.96	5.16±0.27	0.09±0.00
BB35	16.25±0.82	4.60±0.20	2.80±0.83	37.66±0.70	9.16±1.76	4.00±0.94	6.26±0.73	0.08±0.00
143	17.52±0.41	4.80±0.83	4.60±0.89	55.64±2.96	11.70±0.66	4.76±0.20	5.00±0.52	0.07±0.00
Clone6	17.33±2.22	4.20±0.54	6.00±1.00	44.90±5.60	10.28±1.91	4.34±0.38	5.58±0.49	0.12±0.00
Clone7	12.32±1.65	6.40±0.54	3.20±0.23	51.81±8.38	11.36±0.67	4.56±0.71	5.44±0.45	0.05±0.00
Clone8	17.83±2.47	3.80±0.44	6.00±1.00	53.57±8.01	11.30±1.19	4.74±0.41	4.92±0.76	0.07±0.00
Clone9	14.59±1.32	6.00±0.89	2.80±0.04	52.85±7.19	11.02±1.04	4.82±0.46	4.86±0.40	0.08±0.00
Clone10	19.11±1.08	3.80±0.44	6.20±0.32	52.07±6.01	10.96±1.82	4.70±0.55	5.54±0.46	0.09±0.00
$LSD_{5\%}$	2.04	I.07	0.92	10.74	1.42	NS	0.61	NS

PH=Plant height, NL=Numbers of leaves, NB=Numbers of branches, LA=Leaf area, LL=Leaf length, LW=Leaf width, IL=Internode length, PS=Percentage survival and BD= Biomass of dry weight.

Principal component analysis of growth traits in tea clones

The components were identified based on eigenvalues. The first principal component (PCI) contributed 44.19% of total variation with a total eigenvalue of 3.977. Principal component (PC2) accounted for 24.37% with a total eigenvalue of 2.193 while PC3 accounted for 15.35% of the total variation with an eigenvalue value of 1.381.Commonalities were higher for leaf area 0.988, leaf length 0.949, and leaf width 0.927, respectively.

In PCI, the number of leaves shows the highest contribution with a loading value of 0.819, followed by leaf area 0.810, leaf width 0.677, and leaf length 0.748. For PC_2, leaf weight had the highest loading value of 0.684 as the highest contributing trait. This is followed by the number of branches with a loading value of 0.621; leaf length 0.619 and plant height 0.606.

Hierarchical cluster analysis of growth traits in tea clones

Two clusters were generated from the hierarchical cluster using the Ipads method. Cluster I is made up of tea clones that are currently under cultivation, clone (318, 68, BB35, and 143) while cluster 2 has 6 tea clones including clone 2 (236), which is under cultivation. Others in the cluster were obtained from the germplasm. There were sub-clusters from the main clusters. For instance, in cluster I, clone 4 (143) was in a separate cluster, which was also the trend in cluster 2 where clone 6 was found alone (Fig. 3).

TABLE 3

Principal component analysis of nine morphological attributes of ten clones of Tea plant grown onObudu Hills.

Traits	Cummunalitie	PC1	PC2	PC3
Plant height	0.833	-0.659	0.606	-0.174
No. of leaves	0.772	0.819	-0.257	0.188
No. of branches	0.861	-0.615	0.621	0.311
Leaf area	0.988	0.810	0.513	-0.261
Leaf length	0.949	0.748	0.619	-0.073
Leaf width	0.927	0.677	0.684	-0.029
Internode length	0.726	0-.585	0.316	-0.534
Dry biomass	0.579	-0.690	0.255	0.195
Eigen values		3.977	2.193	1.381
Percentage variation		45.187	24.367	15.345
Cumulative percentage variation		44.187	68.554	83.900

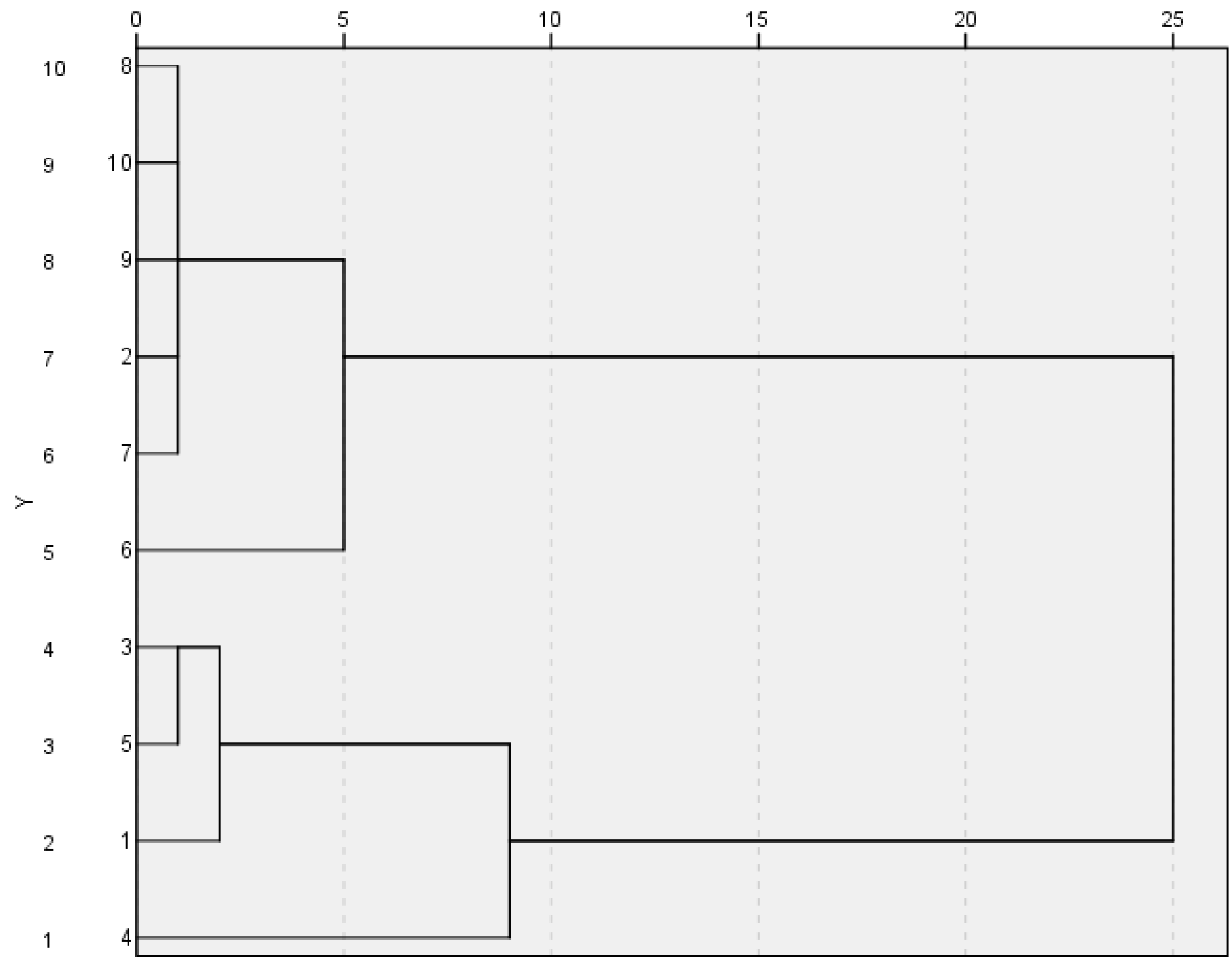

Fig. 3:Dendrogram for morphological attributes of ten clones of Tea plants grown on ObuduHills.

1=Clone1 (318), 2=Clone2 (236), 3=Clone3 (68), 4=Clone4 (BB35), 5=Clone5 (143), 6=Clone6, 7=Clone7, 8=Clone8, 9=Clone9 and 10=Clone10

Discussion

Clonal identification and characterization are traditionally based on morphological descriptors such as plant shape, stem width, leaf shape, etc(Lai, 2001; Koriet*et al.*, 2013).Though morphological traits are associated with drawbacks such as the influence of the environment on traits expressions, epistatic interactions as well as pleiotropic effects, its applicability in evaluating genetic diversity cannot be over-emphasized (Koriret*et al.*,2013).Mean values for morphological attributes were therefore further subjected to PCA in order to confirm the existence of genetic diversity among the evaluated tea plant clones. PCA results generated using mean values of morphological characters showed that three components were identified based on eigenvalues. The eigenvalues for the three principal components in the present report were greater than one, indicating that those traits formed in the PCs significantly contributed to the variations existing in the evaluated genotypes of the tea plant studied. According to the eigen vectors of the three PCs number of leaves, leaf area, leaf width, and leaf length significantly contributed to the total variations in PCI, leaf width, number of branches, leaf length, and plant height made significant contributions to the total variations in PC2 while percentage survival and internode length were the only traits that contributed significantly to the total variations in PC3. Of the 9 characters studied, dry biomass did not significantly contribute to the variations.Data from morphological traits also suggest that some accessions in each group possess unique variations and they could be used as character identification necessary to differentiate the tea accessions.

Conclusion

The study revealed that phenotypic characters such as plant height, number of branches, number of leaves, internode length, leaf length, leaf area can be used to distinguish tea plants. Therefore, information on morphological diversity should also be useful for future breeding programmes as well as for proper conservation of genetic diversity in the adapted germplasm.

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