International Journal of Plant Breeding and Crop Science IJPBCS
Vol. 6(2), pp. 536-542, June, 2019. © www.premierpublishers.org, ISSN: 2167-0449

Research Article

Stability in Tea {*Camellia sinensis* (L.) O. Kuntze} Genotypes Using GGE Bi-plot Analysis in Nigeria

***[1]Olaniyi O.O., [2]Kehinde O.B., [3]Ayo Vaughan M.A., [4]Atayese M.O., [5]Muyiwa A.A., [6]Adenuga O.O., [7]Aremu C.O., and [8]Oloyede A.A.**

[1,5,6,8]Cocoa Research Institute of Nigeria, Ibadan PMB 5244, Ibadan, Nigeria
[2,3,4]Federal university of Agriculture Abeokuta PMB 2240, Abeokuta, Nigeria
[7]Landmark University, Omu Aran, PMB 1001 Omu Aran, Nigeria

Tea [*Camellia sinensis (L.) O. Kuntze*] is one of the oldest non-alcoholic beverage plants in the world. Its cultivation is however restricted to upland ecology occasioned by unfavourable environmental conditions in Nigeria. Thirty-four tea genotypes from Cocoa Research Institute of Nigeria were evaluated for stability of agronomic performance in three agro-ecologies in Nigeria viz: Ibadan (rain forest), Mambilla (mountain forest), and Mayoselbe (woodland forest). Performance was measured using quantitative traits. Genotype main effect and genotype by environment interaction (GGE) analysis was employed in the evaluation. Highly significant effects of genotype, environment and genotype x environment interaction were observed for all the characters studied except internode length and leave length (p<0.01). The G X E analysis showed the stability of NGC18, C143 and C357 across environments. Genotypes NGC 40, NGC19 and NGC15 adapted to Ibadan environment while NGC46 and NGC8 adapted to Mambilla environment. Therefore, genotypes NGC18, C143 and C357 could be grown in any of the three environments. Genotypes NGC 40, NGC19 and NGC15 could be grown in Ibadan while NGC46 and NGC8 are better grown in Mambilla for optimum production of tea.

Keywords: Adaptability, Genotype x Environment Interaction, Quantitative traits, and Agro-ecologies

INTRODUCTION

Tea [*Camellia sinensis* (L). O. Kuntze],an evergreen, perennial, cross pollinated plant belongs to the family Theacea and originated from South East Asia at the point of intersection between Irrawady river and South West of China(Wright (1959).Tea cultivation began in china about 2000 years ago (Li 1983), and was introduced to Nigeria for cultivation in 1972. Cultivation in large quantities was restricted to Mambilla plateau due to some environmental phenomena. Genotype by environment interaction in tea posed a problem between phenotype and genotype values resulting in inconsistent performance in different environment. This has greatly been responsible for low production in tea in Nigeria. To increase tea production, there is need to extend cultivation to the lowland ecologies of Nigeria. Evaluation of available germplasm for yield and stability of performance is the stand-point for successful increase in production. This is because genotypes exhibit different levels of phenotypic expression under different environmental conditions resulting in inconsistent performance of genotypes under varying environmental conditions. This was defined as genotype x environmental (G x E) interaction (Dixon and Nukenine, 2000) G x E is a phenomenon that explains certain difficulty in breeding programmes since no genotype is consistently superior in all environments. Therefore, evaluating genotypes in different environments to arrive at a reasonably reliable result leads to increase in the cost of breeding work. In such situations, a plant breeder may look for genotypes that perform relatively consistently across test environments, stable or broadly adapted or choose specific genotypes that are adapted to different environments. Several statistical models have been used to study and interpret G x E interaction (Gauch and Zobel, 1996). Many of these concepts vary from the Francis and

***Corresponding Author:** Olayinka O. Olaniyi; Cocoa Research Institute of Nigeria, Ibadan PMB 5244, Ibadan, Nigeria. **Email:** yinkamoji@yahoo.com

Kannenberg's (1978) coefficient of variability (CV) to Finlay and Wilkinson's (1963) regression coefficient had been discussed (Lin, *et al.,*1986). The additive main effects and multiplicative interaction (AMMI) model of Gauch and Zobel 1996, is one of the most recent stability analytical tools which has been described as being efficient in determining the most stable and high yielding genotypes in a multi – environment trial than these other earlier methods. Yet, it has its own limitations as recognized by Yan and Kang, (2003).

The GGE biplot methodology [Genotype main effect (G), plus genotype by environment interaction (GE)] of Yan and Hunt (2001) is a recent addition to the tools for analyzing multi – environment trials. Many authors have acknowledged it to be very efficient. GGE biplot showed that both genotypes and environments occur on the same bi-plot in a graphic form, and inferences about their interactions can be made.

In this study therefore, GGE biplot methodology was used to analyze of yield data of 34 tea genotypes in three environments to identify high yielding, stable and adapted genotypes.

MATERIALS AND METHODS

Thirty-four genotypes of tea were obtained from the germplasm of Cocoa Research Institute of Nigeria in Mambilla, Taraba State (Table 1).

Table 1: List of the 34 tea genotypes used.

S/N	Genotype	Source	Origin	S/N	Genotype	Source	Origin	S/N	Genotype	Source	Origin
1	NGC12	CRIN	China	**13**	NGC32	CRIN	China	**25**	NGC53	CRIN	China
2	NGC13	CRIN	China	**14**	NGC37	CRIN	China	**26**	NGC54	CRIN	China
3	NGC15	CRIN	China	**15**	NGC38	CRIN	China	**27**	NGC55	CRIN	China
4	NGC17	CRIN	China	**16**	NGC40	CRIN	China	**28**	NGC6	CRIN	China
5	NGC18	CRIN	China	**17**	NGC41	CRIN	China	**29**	NGC8	CRIN	China
6	NGC22	CRIN	China	**18**	NGC42	CRIN	China	**30**	NGC19	CRIN	China
7	NGC23	CRIN	China	**19**	NGC46	CRIN	China	**31**	NGC45	CRIN	China
8	NGC24	CRIN	China	**20**	NGC47	CRIN	China	**32**	C143	CRIN	Kenya
9	NGC25	CRIN	China	**21**	NGC48	CRIN	China	**33**	C318	CRIN	Kenya
10	NGC26	CRIN	China	**22**	NGC49	CRIN	China	**34**	C357	CRIN	Kenya
11	NGC27	CRIN	China	**23**	NGC50	CRIN	China				
12	NGC29	CRIN	China	**24**	NGC51	CRIN	China				

CRIN = Cocoa Research Institute of Nigeria
NGC = New Germplasm Clone

Location of the experiment

The experiments were conducted during the 2014 – 2016 growing seasons in 3 agro-ecologies, which include Cocoa Research Institute of Nigeria headquarters Onigambari (7º12ʹ N; 3º51ʹ E), Ibadan (1), Cocoa Research Institute of Nigeria sub-station Kusuku (6º43ʹ N; 11º15ʹ E) Mambilla, Taraba State (2) and Cocoa Research Institute of Nigeria Experimental Station Mayoselbe (6º55ʹ N; 11º13ʹ E) Taraba State (3). The altitudes of Kusuku Mambilla, Ibadan and Mayoselbe are 1600 m, 230 m and 457 m above sea level, respectively. The rainfall pattern in Ibadan is usually bimodal while that of Mambilla and Mayoselbe are unimodal. More information on climatic condition of locations is presented in Table 2. The land area was cleared manually. All the 34 tea genotypes were planted in each environment. The cuttings of the 34 genotypes were raised in the nursery and transplanted to the field. The experiments were laid out in a Randomized Complete Block Design with 3 replications. Spacing of 0.6 m x 1.0 m within and between rows with 12 plants per plot with plot size of 7.2 m^2 were used making the total land area in each location to be 870.4 m^2

Maintenance: Weeding and other cultural maintenance practices were done as and when necessary.

Data collection

Data were collected on 9 plants per plot in 3 months interval for 2 years 2015 and 2016 using meter rule, vernier caliper and electronic weighing balance according to Bioversity International descriptor for tea. The average were determined and used to run the anova.
The quantitative characters measured are presented in Table 3.

Data collected were analyzed using statistical analysis software 9.1.1 (SAS, 1999). Combined analysis of variance across the three tested environments were performed on plot means for all characters to establish significant differences within the experimental factors-genotypes, environment, block and genotype x environment.

Means were separated using Duncan Multiple Range Test (Duncan, 1955) at 5% probability level ($P \leq 0.05$).

Table 2: Weather data for the three locations: Mambilla, Ibadan and Mayoselbe for the year 2016

Month	Temp.(ºC) Ibadan	RF(mm) Ibadan	R.H(%) Ibadan	Temp.((ºC) Mayolsebe	RF(mm) Mayoselbe	R.H (%) Mayoselbe	Temp. (ºC) Mambilla	RF(mm) Mambilla	R.H(%) Mambilla
Jan	22.50	5.70	60.00	24.50	0.00	33	18.33	0.00	2
Feb	23.45	31.20	62.55	28.00	2.00	26	19.72	1.00	5
March	24.50	112.80	78.25	28.50	15.00	31	21.38	3.12	40
April	24.13	73.30	71.70	29.00	133.00	53	21.38	5.2	90
May	23.06	177.20	72.10	27.00	214.00	67	19.72	6.51	98
June	20.12	222.40	75.95	27.50	227.00	72	18.05	7.31	97
July	19.93	163.10	86.00	27.50	251.00	74	17.78	9.02	95
August	24.85	112.90	84.00	27.50	263.00	76	17.78	10.3	95
Sept.	21.65	329.30	70.00	27.00	333.00	78	18.45	9.8	96
Oct.	24.37	303.60	77.00	27.50	273.00	76	18.33	7.33	96
November	25.15	1.50	78.50	26.00	55.00	55	18.44	3.12	50
December	24.86	0.00	77.15	23.50	0.00	39	24.72	0.00	5

Table 3. Quantitative characters measured and mode of measurement

S/N	Character	Mode of measurement
1.	Internodes length (cm)	Measured with meter rule between 3rd and 4th nodes
2.	Length of mature leaf (cm)	Measured with meter rule from leaf base to the apex
3.	Width of mature leaf (cm)	Measured with meter rule at the middle of the leaf
4.	Plant height (cm)	Measured from ground level to the tip of the plant
5.	No of branches	Recorded by counting number of branches
6.	Shoot weight (g)	Measured using electric weighing balance
7.	Stem diameter	Measured at the ground level with vernier calliper
8.	Number of leaves	Recorded by counting number of leaves
9.	Number of flower buds	Recorded by counting number of flower buds

GGE - biplot Model

$$Y_{ij} = \mu + \beta_j + g_{i1}e_{1j} + g_{i2}e_{2j} + \varepsilon_{ij}$$

Where
Y_{ij} *is the mean yield of genotype i inenvironment j*
μ is the grand mean
β *is the mean yield of all the genotypes in environment j*
$g_{i1}e_{1j}$ and $g_{i2}e_{2j}$ are PC1 and PC2 scores for genotype i in environment j, respectively.
ε_{ij} is the residual associated with genotype i in environment j (Solonechnyi *et al.*, 2015).

RESULTS

The combined analysis of variance (ANOVA) of 34 tea genotypes in 3 environments is presented in Table 4. Genotype effect was significant for all the characters measured except for IL (1.28) and LL (17.64). The environment component had significant effect on for all the characters at 99% probability level. The block effect was significant for PH, NL, NB, SD and yield/plant. The effect of replication was not significant for all the traits measured. There was significant interaction between genotypes and environments for all the traits except for IL and LL.

The effect of 3 different agro-ecological zones on the performance of 34 tea genotypes is shown in Table 5. Mambilla agro-ecology had the tallest plants (76.92 cm) followed by Ibadan (67.11 cm) and the least height was observed in Mayoselbe (58.10 cm) and significantly different from each other. Similar results were observed for number of leaves (199.65, 139.63 and 92.17 leaves for Mambilla, Ibadan and Mayoselbe respectively). The numbers of branches were higher in Ibadan (27.88) followed by Mambilla (17.06) and the least was observed in Mayoselbe (9.5) and were statistically different from one another. Also, average of 13.74 harvestable points was recorded for Ibadan. Mambilla had 6.42 harvestable points while Mayoselbe had 5.74 harvestable points and were significantly different from each other. The highest values for IL (3.61 cm) and (LL 9.41 cm) were observed in Mambilla and the least were observed in Mayoselbe for IL (2.98 cm) and (LL 7.59 cm) respectively and were significantly different from each other. There was no significant difference between Mambilla and Ibadan for LL with values of 3.48 cm and 3.54 cm respectively. The highest value of NFB was observed in Ibadan (17.48a) and the least was recorded in Mambilla and statistically different from each other. The highest yield was recorded in Ibadan (5.27g) and the least was observed in Mambilla (3.13g) and statistically different from each other.

Figure 1 also defined the accessions that performed best in the various locations. The polygon drawn to join genotype G9, G8, G14 and G20 which are the genotype located farthest from the origin of the biplot and perpendicular to the sides of the polygon. (In this case hexagon) effectively divided the biplot into four sections; the G9 vertex sector, the G1 sector, G5 vertex sector and G34 vertex sector, according to (Yan and Kang, 2003).

Table 4: Mean squares of agronomic characters evaluated in thirty-four genotypes of tea across 3 Environments (Average of 2 years)

Sources of variation	Df	PH (cm)	NL	NB	HP	SD (mm)	IL (cm)	LL (cm)	LB (cm)	NFB	Yield (g)/plant
Replicate	2	69.37	1482.04	59.30	10.12	4.99	0.22	37.72	0.81	184.52	3.10
Genotype	33	2668.78**	25836.89**	357.22**	111.75**	56.08**	1.28	17.64	2.42**	808.85**	98.82**
Environment	2	22154.45**	738245.67**	18559.61**	2134.66**	938.72**	27.11**	154.31**	9.04**	3829.59**	240.40**
Block	2	1324.06*	159113.08**	355.14*	42.89	35.90*	0.57	21.08	0.72	12.19	59.69**
GXL	66	1135.24**	14074.85**	260.88**	66.61**	31.99**	1.90	16.99	1.65**	853.64**	52.29**
Residual	198	427.42	5887.49	101.02	18.67	12.07	1.91	14.79	0.50	91.45	11.03

**,* = Significant at P≤0.01 and P≥ 0.05 respectively; CV= coefficient of variation
Plant Height (PH), Number of Leaf (NL), Number of Branches (NB), Stem Diameter (SD), Harvestable points (HP), Internode Length (IL), Leaf Length (LL), Leaf Breadth (LB), Number of Flower Buds (NFB), and Yield/plant

Table 5: Environmental effect on the performance of 34 tea genotypes in 3 agro ecological zones in Nigeria (Average of 2 years)

Environment	PH(cm)	NL	NB	HP	SD(mm)	IL(cm)	LL(cm)	LB(cm)	NFB	Yield/plt.(g)
Mambilla	76.92a	199.65a	17.06b	6.42b	14.64a	3.61a	9.41a	3.48a	8.62c	3.13c
Ibadan	67.11b	139.63b	27.88a	13.74a	10.87c	3.10b	8.27b	3.54a	17.48a	5.27a
Mayoselbe	58.10c	92.17c	9.55c	5.74c	14.00b	2.98b	7.59b	3.04b	10.61b	4.62b

Means with the same letter along the column are not significantly different at 5% level of probability using DMRT
Plant Height (PH), Number of Leaf (NL), Number of Branches (NB), Harvestable Points (HP) Stem Diameter (SD), Internodes Length (IL), Leaf Length (LL), Leaf Breadth (LB), Number of Flower Bud (NFB) and Yield/plant

This G20, G9, G8, G14, G13, 26 and G18 were outstanding in Ibadan environment, while genotype G1, G21, G22 and G2 were outstanding in Mayolselbe. Genotypes G23, G5, G11, G16, G29, G17 and G4 did not seem to perform very well in any of the environment.

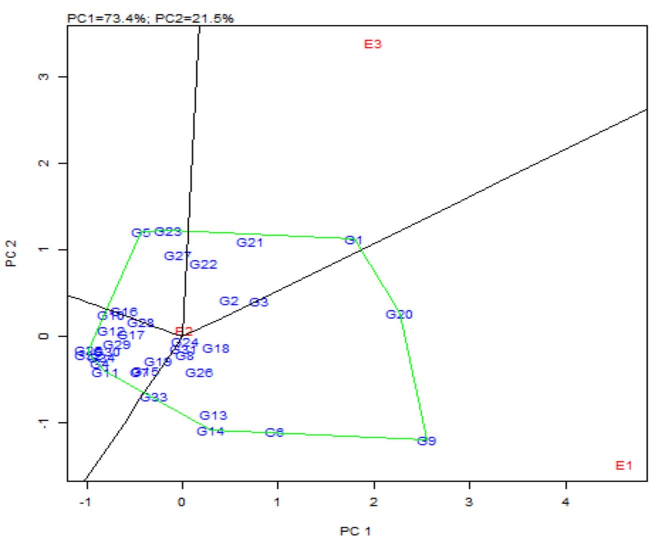

Figure 1: Which-genotype-won-where of best for which environment

Note: C143=G1, C318=G2, C357=G3, NGC12=G4, NGC13=G5, NGC15=G6, NGC17=G7, NGC18=G8, NGC19=G9, NGC22=G10, NGC23=G11, NGC24=G12, NGC25=G13, NGC26=G14, NGC27=G15, NGC29=G16, NGC32=G17, NGC37=G18, NGC38=G19, NGC40=G20, NGC41=G21, NGC42=G22, NGC45=G23, NGC46=G24, NGC47=G25, NGC48=G26, NGC49=G27, NGC50=G28, NGC51=G29, NGC53=G30, NGC54=G31, NGC55=G32, NGC6=G33, NGC8=G34.

Figure 2 represents the averages tester coordination view, showing the performance of the genotypes across the environments and their stability. The small circle near G8 is representing point of ideal genotypes. The line connecting the bi plot origin and the circle is referred to as the average tester axis based on their mean performance; the genotypes are ranked along the average tester axis with the arrow pointing towards genotypes with greater values. Based on this G9 was ranked first, followed by G6 while the least performed genotype was G34. A doubled arrowed line also divided the bi -plot into two, separating genotypes that performed above average from those that performed below average.

However, G9 was ranked first followed by G6 and G20 having longer projections parallel to the double arrowed line were more variable in performance (yield) and therefore less stable across the environment, while G1, G2 and G8 were more stable having shorter projections.

Figure 3 described GGE Bi plot – Environment view for yield/plant. The bi plot shows the position of the environment. E2 line Mambilla located at the origin of the bi plot was the ideal environment while E3 (Mayoselbe) and E1 (Ibadan) deviated from the origin point. Therefore, Mambilla represent the best environment for tea production in Nigeria while Ibadan is the most discriminate environment and Mayoselbe was the most representative. Figure 4 shows the response of the tested genotype to varying environment under consideration G9, and G20 were found in the same concentric circle and G9 had the highest yield in Environment 1 (E1).

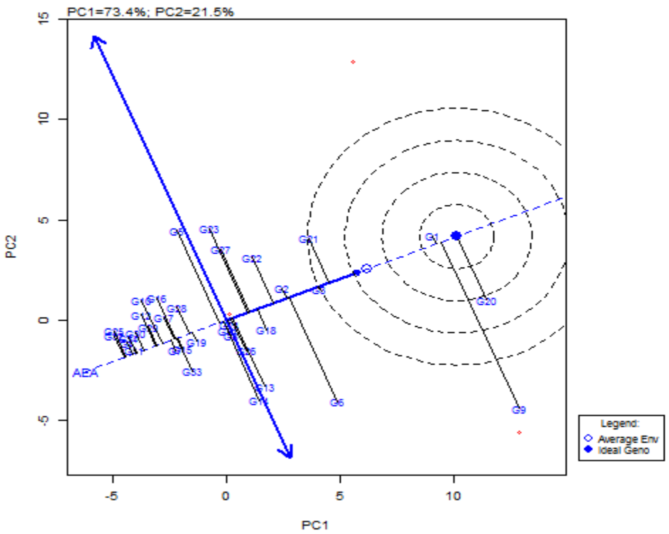

Figure: 2 GGE Biplot of mean performance and stability of 34 tea genotypes across the test environments

Note:C143=G1, C318=G2, C357=G3, NGC12=G4, NGC13=G5, NGC15=G6, NGC17=G7, NGC18=G8, NGC19=G9, NGC22=G10, NGC23=G11 ,NGC24=G12, NGC25=G13, NGC26=G14, NGC27=G15, NGC29=G16, NGC32=G17, NGC37=G18, NGC38=G19, NGC40=G20, NGC41=G21, NGC42=G22, NGC45=G23, NGC46=G24, NGC47=G25, NGC48=G26, NGC49=G27, NGC50=G28, NGC51=G29, NGC53=G30, NGC54=G31, NGC55=G32, NGC6=G33, NGC8=G34.

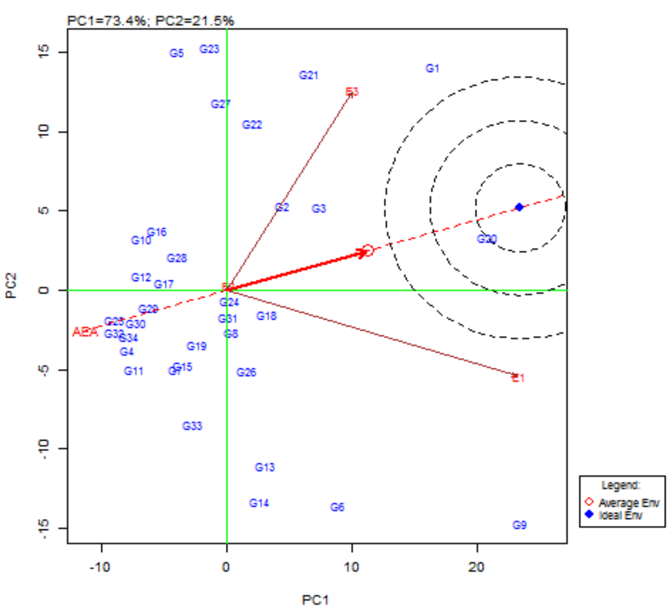

Figure 3:GGE biplot of the discriminating power versus representativeness of test environments in tea

Note:C143=G1, C318=G2, C357=G3, NGC12=G4, NGC13=G5, NGC15=G6, NGC17=G7, NGC18=G8, NGC19=G9, NGC22=G10, NGC23=G11 ,NGC24=G12, NGC25=G13, NGC26=G14, NGC27=G15, NGC29=G16, NGC32=G17, NGC37=G18, NGC38=G19, NGC40=G20, NGC41=G21, NGC42=G22, NGC45=G23, NGC46=G24, NGC47=G25, NGC48=G26, NGC49=G27, NGC50=G28, NGC51=G29, NGC53=G30, NGC54=G31, NGC55=G32, NGC6=G33, NGC8=G34.

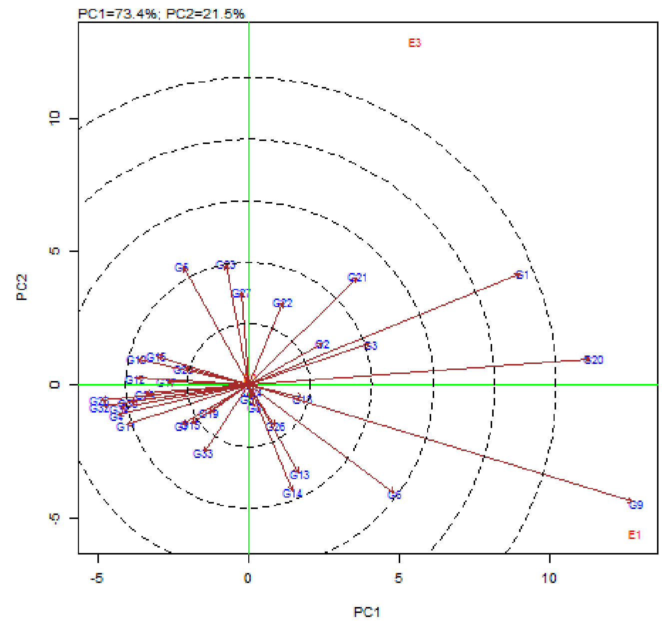

Figure 4: GGE biplot for genotype view of 34 tea genotypes in 3 environments.

Note:C143=G1, C318=G2, C357=G3, NGC12=G4, NGC13=G5, NGC15=G6, NGC17=G7, NGC18=G8, NGC19=G9, NGC22=G10, NGC23=G11 ,NGC24=G12, NGC25=G13, NGC26=G14, NGC27=G15, NGC29=G16, NGC32=G17, NGC37=G18, NGC38=G19, NGC40=G20, NGC41=G21, NGC42=G22, NGC45=G23, NGC46=G24, NGC47=G25, NGC48=G26, NGC49=G27, NGC50=G28, NGC51=G29, NGC53=G30, NGC54=G31, NGC55=G32, NGC6=G33, NGC8=G34.

DISCUSSION AND CONCLUSION

The highly significant genotypes x environment interaction (GEI) for yield and yield attributed traits in this study justified the need to partition the interaction to determine specific adaptation, the yield potential and stability of the genotype, and to investigate the best core test environments in the various mega-environments. Kamila *et al.* (2016) stated that GEI is only problematic for plant breeders when there are changes in performance of varieties in different environments (Crossover Interactions). Simmonds (1991) observed it as an opportunity not a problem to note the difference between a good variety and an ideal variety through specific adaptation.

The performance of the genotypes in this study helps to sum up that GGE biplot analysis is a plant breeding tool that helps to visualize relationships among genotypes and environments, identify target breeding environments and to choose representative testing sites in these environments. It is also useful to select varieties with good adaptation and to identify key agro-climatic factors, disease and insect pest and physiological traits that determine adaptation to environments (Yan and Tinker, 2005; Yan *et al*, 2000; Setimela *et. al,* 2007) GGE biplot was used in this study to partition the genotypes x environment interaction.

Stability analysis is an important and efficient tool for plant breeders. It helps to identify and select the most stable, high performing genotypes that are best suited under a given set of environmental conditions. This suggests that a given crop species or cultivar can be successfully planted in an agro-climatic region depending on its adaptability and yield stability. Adaptability refers to a good performance of a genotype in a specific agro-climatic condition while yield stability is the ability of a genotype to avoid substantial fluctuating in yield over a range of environmental condition (Heinrich *et al.,* 1983). The current multi-location studies showed variation in the performance of 34 tea genotypes from one environment to another. C143, NGC18, C357 and C318 were among the best high yielding genotypes and most stable across all the tested environments suggesting that these genotypes were suitable for the agro-climatic regions evaluated in this study. NGC40, NGC19 and NGC15 adapted well to Ibadan environment therefore recommended for cultivation around this agro ecology, while NGC 46 and NGC 8 adapted to Kusuku Mambilla environment and is therefore recommended for Mambilla agro ecology. Mambilla environment represent the best environment (ideal environment) for tea production in Nigeria while Ibadan is the most discriminate environment and Mayoselbe was the most representative.

REFERENCES

Dixon, A.G.O. and E.N. Nukenine, Genotype × environment interaction and optimum resource allocation for yield and yield components of cassava. *Afr. Crop Sci. J*., 2000. 8: 1-10.

Duucan, Di, Multiple range and multiple F-test *Biometrics.* 1955. 11:42

Finlay K.W. and Wilkinson G.N. The Analysis of Adaptation in a Plant Breeding Programme. Aust. *J. Agricultural Research* 1963.14, 742 – 754.

Francis, T.R and L.W. Kannenberg Genotype grouping and stability measurement. Can. *J. Plant Sci*. (1978).58: 1029-1034.

Gauch H.G. and Zobel R.W. AMMI Analysis of Yield Trials. Chap. 4. 1996.P 85-122 in: Kang M.S.; Gauch H.G., Eds, Genotype-by-Environment Interaction. *CRC Press Boca Raton, Florida*, USA

Heinrich, G.M., Francis C.A. and Eastin, J.D. Stability of sorghum yield components across diverse environment. *Crop Science* 1983. 23; 209-212.

Kamila N., Atina L., Wierlawska P., and Jan B. Genotype by environment interaction for seed yield in rapseed (Brassica napus L.) using additive main effects and multiplicative interaction model. *Euphitical* 2016. vol 208 issue 1 pp 187-194.

Li, H.L. The domestication of plants in China: ecological considerations. In: the origin of Chinese Civilization. (Eds.): D.N. Keightley. *University of California press.* 1983.

Lin C.S., Binns, M.R. and Lefkovitch, L.P. Stability Analysis, Where do we stand? *Crop Science* 1986. 26: 894-900.

Setimela, P.S., Vivek, B., Banzigr, Mm, Crossa, J. And Maideni, F. Evaluation of early to medium maturing open pollinated maize varieties in SADC model. *Field Crop research* 2007.103: 151-169.

Simmonds, N.W. Selection for local adaptation in a plant breeding programme. *Theoretical and Applied Genetics* 1991.83: 363-367.

Solonechnyi L., Vasko N., Naumov A., Solonechnaya O., Vezhenina O., Bandareva O., and Logvinenko Y. GGE biplot analisis of genotype by environment interaction of spring barley varieties. *Journal of Zemdirbyste-Agriculture,* 2015.vol. 102 No. 4 p. 431-436

Statistical Analysis System (SAS). Statistical Methods, SAS Institute Inc. Cavy North Carolina. (1999),

Wright. Nomenclature and classification of tea plant. *Nature,* (1959) 183: 1726-1728.

Yan W. And Hunt L.A. Interaction of Genotype X interaction for winter wheat yield in Ontario. *Crop Science* 2001 41; 19-25

Yan W. and Kang M.S. GGE Biplot Analysis. A geographical tools for Breeders, *Geneticists and Agronomists CRC press LLC. Boca Roton, Florida*. 2003.Pg 271.

Yan W., Hunt, L.A., Sheng, Q and Szlavnics, Z. Cultivar Evaluation and Mega Environment investigation based on GGE Biplot. *Crop Science* 2000 40: 597-605

Yan, W. And Tinker, N.A. An integrated biplot analysis system for display, interpreting, and exploring genotype x environment interaction. *Crop Science* 2005. 45: 1004-1016.

Zobel R.W., Wright M.J., and Gaugh Staistical analysis of a yield trial. *Agronomy Journal* 1988.80; 388-393.

Accepted 11 June 2019

Citation: Olaniyi OO, Kehinde OB, Ayo Vaughan MA, Atayese MO, Muyiwa AA, Adenuga OO, Aremu CO, Oloyede AA (2019). Stability in Tea {*Camellia sinensis* (L.) O. Kuntze} Genotypes Using GGE Bi-plot Analysis in Nigeria. International Journal of Plant Breeding and Crop Science, 6(2): 536-542.