International Journal of Research Studies in Agricultural Sciences (IJRSAS)
Volume 1, Issue 4, August 2015, PP 25-31
ISSN 2454–6224
www.arcjournals.org

Growth Performance and Nutrient Uptake of *Coffea Canephora* Prierre Ex. Froehner Grown in Contrasting Soils

Ayegboyin, K. O.[A], Famaye, A. O.[A], Akinrinde E. A[B]., Adejobi, K. B.[A]

Akanbi, O. S. O. [A]

[A] Agronomy and Soils Division, Cocoa Research Institute of Nigeria, Ibadan
[B] Department of Agronomy, University of Ibadan, Nigeria
kayodeolufemi@yahoo.com

Abstract: *An experiment was carried to study effect of soil type (virgin forest and cultivated land) and depth (0-15cm and 15-30cm) as well as application of fertilizers on the performance of Robusta coffee at Cocoa Research of Nigeria, Ibadan. Data on the agronomic parameters (plant height, stem girth, number of leaves, leaf areas and canopy spread) showed that coffee plants grown on top soils were significantly higher (P = 0.05) than those on their sub soils. While the dry matter accumulation and nutrient contents of the plants also reveal no significant differences between treatments of topsoil of virgin forest and cultivated land.*

Keywords: *Coffee, Soil type, Soil depth, Soil amendment.*

1. INTRODUCTION

Coffee is a major export product in some African countries like Uganda, Burundi, Rwanda, Kenya and Ethiopia. Globally, over 25 million people are directly involved in coffee production while the international coffee trade has about 500 million people in its management, from cultivation to the final product for consumption. About 70% of the total world production comes from the smallholding farmers who cultivate less than 10 ha per person.

Among some 100 species of the *Coffea* genus, only *C. arabica* L. (arabica coffee) and *C. canephora* Pierre ex A. Froehner (robusta coffee) are economically important worldwide and represent about 99% of world total bean production. While Arabica coffee accounts for about 64% of coffee produced, C. *canephora* is a relatively new commercial crop but with a great potential for genetic improvement. Robusta coffee trees are usually less vigorous and productive than Arabica trees. In Nigeria, Robusta coffee constitutes around 96% of the country's total coffee beans production (Omolaja, 2009). Adamawa, Abia, Taraba, Plateau, Cross River, Delta, Edo, Kogi, Ondo, Oyo, Ekiti, Ogun and Osun are the 13 states where coffee is currently grown in Nigeria (Ibiremo et al., 2013).

Cultivation of Robusta coffee, like most tree crops in Nigeria, is mainly through raising of seedlings and or cuttings/clonal materials in the nursery. Early propagation of coffee, among other conditions to be met, involves filling the seedlings bags with top soils collected within 0-15cm of the surface of virgin forest soil (Ofori-Frimpong et al., 2002). Increasing pressure on land due to higher population density and urban development however, has made the availability of virgin forest soil much more difficult by the day (Obatolu et al., 2000). Being faced with the two-dimensional problems of declining per capita production and progressive deterioration of its environment (Hassan et al., 2013), Nigeria needs to adopt a production system that is environmentally, economic and socially sustainable (Bello and Adekunle, 2013).

Maintenance of soil organic matter is the basis of sustainable crop production in tropics, particularly in Nigeria (Oladipupo et al., 2005), therefore, for optimum growth and increase productivity, coffee plants require water and adequate nutrients even at the nursery stage. Application of both organic and inorganic fertilizers should supply the necessary nutrients in the required amounts and as at when necessary. This, to a large extend, depends on the soil condition, inherent soil fertility status and history of the soil (Ngaruiya, 1995). In Nigeria, application of NPK fertilizer in *C. canephora* increased the uptake of some other essential nutrient elements like Ca, Mg, Mn, Cu and S in the soil (Ojeniyi, 1981) while the use of organic fertilizers, due to very important roles they play both in the

soil and plants, is recommended in coffee production. Application of some organic fertilizer helps tremendously to improve the activity of the soil micro-organisms, soil structure, aeration and water penetration. Also, soil temperature fluctuations were drastically reduced in coffee farms through application of organic fertilizers in Kenya (Ngaruiya, 1995).

In Cocoa Research Institute of Nigeria (CRIN), Ibadan, due to unavailability of virgin forest, top soil of virgin forest is usually bought from outside and then transported to CRIN Central Nursery whenever coffee seedlings and/or clonal materials are to be raised. Aside the fact that a lot of money is expended on this activity, it is laborious, time consuming while the authenticity of such top soil is difficult to ascertain. This study was conducted to evaluate the performance of C. *canephora* seedlings raised on soil collected from different soil types, depths and amendments.

2. MATERIALS AND METHODS

The study was carried out in CRIN between July 2013 and February 2014. It was a factorial combination of two soil types (virgin forest and cultivated land), two soil depths (top-oil and sub-soil), three treatments (soil amendment with organic fertilizer Pacesetter Grade B, soil amended with NPK 2:1:1 inorganic fertilizer and soil with no amendment), two destructive harvests (at 15^{th} and 27^{th} week after sowing and three replications. The total number of 72 coffee seedlings was used for this trial was laid out in Completely Randomised Design and the soils used were from Alfisol of Olorunda Series.

The forest land used had never been cultivated while the cultivated land had been previously used to grow maize, yam, cocoyam, cassava and vegetables. The cultivated land was left fallow for about six months before its top and sub soils were collected for this experiment. Top soil was collected 0-15cm of the soil surface while sub soil was collected at 15-30cm. Two types of fertilisers, the locally made organic fertiliser, Pacesetter grade B and inorganic fertiliser NPK grade 2:1:1, were separately added at an equal rate of 60kgN ha^{-1}, 30kgP_2O_5 ha^{-1} and 30kgK_2O ha^{-1}, in two equal split applications within the 13^{th} and 17^{th} weeks after sowing.

The coffee seeds were first de-pulped and pre-germinated before transferring them into 35cm by 25cm black polythene bags, which were already perforated at the base and filled with 5kg of 2mm-sieved soil samples. The soils were either amended with specific type of fertiliser or were allowed to produce crop with their native nutrients alone and used as control.

Data were collected on the agronomic growth parameters: plant height, girth, number of leaves, leaf area and canopy spread. While measurement of plant height, stem diameter, numbers of leaves as well as number of branches were determined non-destructively, the leaf area was done destructively within 24 hours of plant detachment by an AM300 portable leaf area machine (ADC Bio Scientific Ltd). At the end of 27 weeks of growth, seedling leaves were destructively sampled to determine their N, P and K uptake after their fresh and dry shoots and roots had been weighed. Total N was analysed by colorimetric method proposed by Baethgen and Alley (1989), P was determined by vanadomolybdophosphoric colometric method at 430nm while total K was determined by the flame photometer method (Lachica et al 1973). Genstat (VSN International Limited) 13^{th} edition was used to statistically analysed data using analysis of variance and significant means were determined by least significant difference (LSD) at P = 0.05 value.

3. RESULTS AND DISCUSSION

The clay and silt contents of the experimental soils (Table 1) was sufficient to hold enough water for coffee growth (Ipinmoroti et al., 2009) while the nutrients N, P and K were marginal in all the experimental soils used (Cambrony, 1992). These provide avenues for plants absorption of artificial N, P or K that were used to amend the soils.

Table1. *Some physicochemical properties of the experimental soils*

Soil type	pH (H_2O)	Organic C (gKg^{-1})	Total N (gKg^{-1})	Available P ($mgKg^{-1}$)	Exchangeable cations ($CmolKg^{-1}$)		
					K	Mg	Ca
Virgin Forest (top soil)	6.61	27.3	5.4	45.6	0.17	0.25	12.9
Virgin forest (sub soil)	5.60	11.2	3.8	38.01	0.09	0.16	10.2
Cultivated soil (top soil)	6.7	25.7	5.5	44.75	0.14	0.2	13.9
Cultivated soil (sub soil)	5.8	14.62	3.2	44.57	0.08	0.12	9.6

The height of coffee seedlings (Table 2) showed that coffee seedlings produced from cultivated land topsoil amended with NPK was significantly higher than those of virgin forest without amendment (Rep 1). However, coffee seedlings on top soil of both forest and cultivated land were significantly higher (P = 0.05) than their counterparts on the corresponding sub soils. Similarly, results of other non-destructively agronomic parameters like stem girth (Table 3) and number of leaves (Table 4) showed that seedlings from top soils performed significantly better than those on their sub soils in all treatments and soil types. Similar trends were noticed on the fresh and dry weights of the seedlings (Table 5). The leaf area and canopy spread of the plants (Figs. 1and 2) showed that top soil of cultivated land amended with NPK was significantly better than control but no significant differences between top soil of virgin forest and cultivated land without amendment. The N, P and K content among coffee seedlings (Table 6) showed that plants treated with NPK inorganic fertilizer had the highest mean than those treated with P organic fertilizer and control. This might be a result of faster availability of inorganic fertilizer to the crop than organic. While, topsoil gave significantly higher nutrient content than the subsoil, the differences on the two top soils were not significant.

Table2. *Mean plant height of coffee seedlings at 27th week under various soil types and amendments*

Soil type	Treatment	Replicate 1	Replicate 2	Replicate 3
Virgin forest (top soil)	P	77.6	80.1	70.7
	NPK	70.1	75.3	68.2
	NA	69.2	78.3	67.4
Virgin forest (sub soil)	P	50.5	51.0	45.5
	NPK	52.5	50.3	50.9
	NA	45.2	45.5	44.4
Cultivated soil (top soil)	P	75.3	80.6	79.9
	NPK	79.2	75.9	76.2
	NA	73.1	71.1	79.0
Cultivated soil (sub soil)	AP	49.1	44.4	49.7
	NPK	51.2	47.0	43.4
	NA	44.2	42.9	49.0
Mean		61.4	61.9	56.7
LSD (P = 0.05)		8.8	8.2	8.9

Table3. *Mean of the stem girth (cm) of seedlings at 27th week under various soil types and amendments*

Soil type	Amendment	Replicate 1	Replicate 2	Replicate 3
Virgin forest (top soil)	P	1.12	1.06	1.09
	NPK	1.13	1.91	1.06
	NA	1.03	0.9	0.99
Virgin forest (sub soil)	P	0.49	0.42	0.48
	NPK	0.49	0.50	0.59
	NA	0.46	0.42	0.40
Cultivated soil (top soil)	P	1.01	0.89	1.19
	NPK	1.04	0.97	1.20
	NA	0.98	0.85	0.87
Cultivated soil (sub soil)	P	0.46	0.47	0.49
	NPK	0.49	0.50	0.56
	NA	0.40	0.41	0.50
Mean		0.76	0.69	0.79
LSD (P = 0.05)		0.18	0.32	0.54

Legends:

P = Amended with Pacesetter grade B (Organic fertiliser)

NPK = Amended with NPK 2:1:1 (Inorganic fertiliser)

NA = No amendment

Table4. *Mean number of leaves of seedlings at 27th week after sowing under various soil types and amendments*

Soil type	Treatment	Replicate 1	Replicate 2	Replicate 3
Virgin forest (top soil)	AP	32.3	31.1	30
	NPK	32.5	33.9	31.7
	Not applicable	30.6	31.8	30.1
Virgin forest (sub soil)	AP	27.7	27.5	23.3
	NPK	27.2	28.3	25.5
	Not applicable	25.0	25.5	22.2
Cultivated soil (top soil)	AP	30.4	30.6	30.9
	NPK	32.2	30.9	32.9
	Not applicable	30.9	30.1	31.2
Cultivated soil (sub soil)	AP	25.8	24.4	23.1
	NPK	25.8	25.0	23.7
	Not applicable	24.0	23.4	22.5
Mean		28.5	28.4	27.3
LSD (P = 0.05)		2.5	2.8	2.8

Legends:

P = Amended with Pacesetter grade B (Organic fertiliser)

NPK = Amended with NPK 2:1:1 (Inorganic fertiliser)

NA = No amendment

Table5. *Mean total fresh and dry weights of coffee seedlings at 27 weeks after sowing under various soil types and amendments*

Soil type	Treatment	Fresh weight (g)	Dry weight (g)	Water content (g)
Virgin forest (top soil)	P	77.8	46.3	31.5
	NPK	87.3	48.9	38.4
	NA	79.0	39.8	39.2
Virgin forest (sub soil)	P	46.7	27.3	19.4
	NPK	47.2	27.9	19.3
	NA	40.1	28.2	11.9
Cultivated land (top soil)	P	80.3	50.1	30.2
	NPK	81.7	52.9	28.8
	NA	78	46.1	31.9
Cultivated land (sub soil)	P	45.4	20.2	25.2
	NPK	45.9	21.5	24.4
	NA	39.8	23.2	16.6
Mean		62.5	36	26.4
LSD (P = 0.05)		9.6	6.5	10.2

Table6. *Nutrient uptake of the seedlings after 27 weeks after sowing under various soil types and amendments*

Soil type	Treatment	N (gKg^{-1})	P ($mgKg^{-1}$)	K ($molKg^{-1}$)
Virgin forest (top soil)	P	1.15	0.071	0.21
	NPK	1.25	0.091	0.18
	NA	1.19	0.082	0.17
Virgin forest (sub soil)	P	0.62	0.041	0.12
	NPK	0.56	0.043	0.13
	NA	0.45	0.05	0.13
Cultivated land (top soil)	P	1.19	0.083	0.19
	NPK	1.19	0.076	0.19
	NA	1.18	0.08	0.18
Cultivated land (sub soil)	P	0.74	0.05	0.12
	NPK	0.62	0.06	0.11
	NA	0.45	0.05	0.12
Mean		0.88	0.065	0.15
LSD (P = 0.05)		0.28	0.022	0.04

Legends:

P = Amended with Pacesetter grade B (Organic fertiliser)

NPK = Amended with NPK 2:1:1 (Inorganic fertiliser)

NA = No amendment

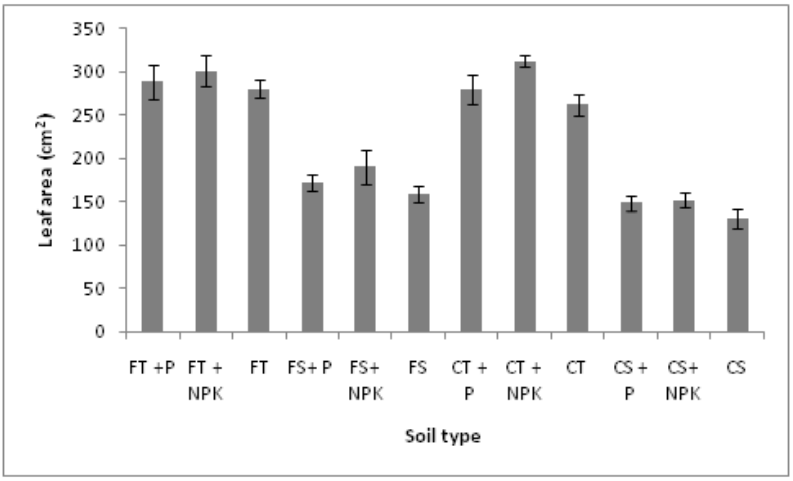

Fig1. *Leaf area of the coffee seedlings at 27th week after sowing under various soil types and amendments. Bars show standard error.*

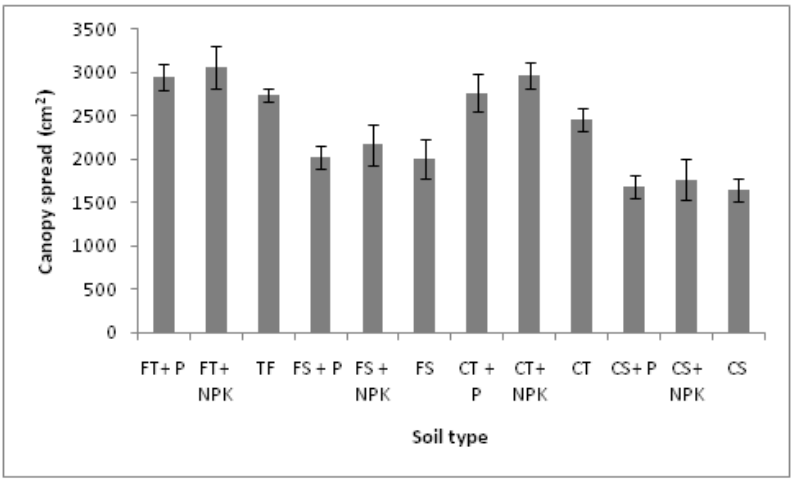

Fig2. *Canopy spread of coffee seedlings at 27th week after sowing under various soil types and amendments. Bars show standard error.*

Legends

FT = Virgin forest Topsoil

FS = Virgin forest Subsoil

CT = Cultivated land Topsoil

CS = Cultivated land Subsoil

+P = Amended with organic fertilizer

+NPK = Amended with inorganic fertilizer

Addition of fertilizer to the soils produced some advantages over the control (no amendment) on the growth performance and nutrient contents of the coffee seedlings. While the performance of seedling were statistically higher (P = 0.05) than those on the sub soil, there were no statistically differences among the treatments within the top soils irrespective of the type of soil used in the experiment.

4. CONCLUSION

It was evident that top soils, whether from virgin forest or cultivated land, without additional fertiliser have the same potential for raising Robusta coffee seedlings. However, it is necessary that such cultivated land should be left fallow for some period of time before it could be used. Where top soil was collected from land that did not have up till 6 months fallow period, we recommend top dressing of with either NPK 2:1:1 or Pacesetter grade B fertilizers 60kgN ha^{-1}, 30kgP_2O_5 ha^{-1} and 30kgK_2O ha^{-1} as early as 4 weeks after sowing to enhance seedling growth when topsoil from heavily cultivated land is used.

ACKNOWLEDGEMENT

The authors are grateful to the Executive Director/Chief Executive Officer of Cocoa research Institute of Nigeria, Professor Malachy Akoroda for the permission to publish this work.

REFERENCES

[1] OMOLAJA, S. S., Caffeine phenol and protein contents of thirty seven clones of Nigerian Robusta coffee (Coffea canephora Pierre ex. Froehner). Journal of Applied Horticulture Malaysia, 11(2)**,** 30-34 (2009).

[2] IBIREMO, O. S., AKANBI, O. S. O., OLOYEDE, A. A., ADEBOWALE, L. A. & ADEYEMI, E. A., Evaluation of NPK fertilizer formulations on the growth and dry matter yield of coffee seedlings. Nigeria Journal of Soil Science, 23(1)**,** 22-26 (2013).

[3] OFORI-FRIMPONG, K., AFRITA, A. A. & APPIAH, M. R., Growth and nutrient uptake of some cocoa seedlings varieties grown in contrasting soil. Ghana Jnl. Agric. Sci., 32**,** 41-48 (2002).

[4] OBATOLU, C. R., ADEYEMI, A. A. & IBIREMO, O. S., Agronomy of the production of cocoa, kola, coffee, cashew and tea in Nigeria. Agronomy in Nigeria, Uni.of Ibadan.**,** 117-122 (2000).

[5] HASSAN, M., SADDIQ, A. M. & IBRAHIM, M., Fertility evaluation of some soils in Adamawa State, Nigeria. Nigerian Journal of Soil Science, 23(1)**,** 110-113 (2013).

[6] BELLO, W. B. & ADEKUNLE, I. O., Evaluation of integrated applicaion of urea and animal manures. Nigerian Journal of Soil Science, 23(1)**,** 52-55 (2013).

[7] OLADIPUPO, O. G., ADUAYI, E. A. & OLAYINKA, A., Effects of organic amendments on microbial activity, N and P mineralization in an alfisol Environmental Management Journal, 2**,** 30-40 (2005).

[8] NGARUIYA, J. K., Fertilizer application in Coffee. Kenya Coffee: November 1995, 60**,** 2113-2115 (1995).

[9] OJENIYI, S. O. (1981) Soils and Nutritional Requirements of Coffee: Studies on the characteristics of suitable coffee soils and nutrients status of coffee groves. Annual Report of the Cocoa Research Institute of Nigeria, Ibadan (1981).

[10] IPINMOROTI, R. R., IREMIREN, G. O. & OLUBAMIWA, O., Utilization of Cocoa pod husk and NPK as nutriemt sources for growth and dry matter yield of Kola (Cola nitida) seedlings in the greenhouse, Conference proceding, 16th International Cocoa Conference. Grand hyatt Hotel, Bali, Indonesia (2009).

[11] CAMBRONY, H. R., The Tropical Agriculturist 13, CTA Publication ,1992.

AUTHORS' BIOGRAPHY

Dr Kayode Olufemi Ayegboyin, was born on 21 May 1975. He attended the University of Ibadan, Ibadan, Nigeria, where he obtained B.Sc. (Hons) in Agriculture in 1997 and MSc in Crop Science in 2004. He later proceeded on scholarship to the University of Reading, Reading, United Kingdom where he obtained PhD in Plant Sciences in 2012. He started his career with Cocoa Research Institute of Nigeria, Ibadan as a Research Officer Grade 2 in January 2002 and presently a Principal Research Officer with the Institute. He has many research publications in some reputable journals and currently a fellow of the International Institute of Tropical Agriculture, Ibadan. Dr Ayegboyin is also the present Head of Station, Cocoa Research Institute of Nigeria, Ajassor Substation, Cross River State, Nigeria and married with two lovely children. *kayodeolufemi@yahoo.com*

Dr Amos O. Famaye, was born in September 1960. He attended the University of Ibadan, Ibadan, Nigeria where he obtained B.Sc. (Hons) in Agronomy in 1987, MSc (Crop Science) in 1992 and PhD in 2000. He started his career with Cocoa Research Institute of Nigeria as a Research Officer Grade1 in 1993 and rose through the cadres to the position of a Director. He is the current Director, Production and Substations, with the Institute. He also has many research publications on coffee, cocoa, kola and tea in various reputable international journals and married with five children. *amos2010@yahoo.com*

Professor **Ezekiel Akinkunmi Akinrinde**, attended the University of Ibadan, Ibadan, Nigeria where he obtained B.Sc., MSc and PhD. He worked as a Lecturer at Oyo State College of Education where he rose to the rank of Chief Lecturer before joining the Agronomy Department of his alma mater, the University of Ibadan, Ibadan, Nigeria in 1997 as a Senior Lecturer. He is an icon in Soil and Plant Nutrition and became a Professor with the University of Ibadan in 2005. He has close to 90 research publications in many reputable academic journals on many annual and perennial crops of Africa. Apart from his success in academic, Professor Akinrinde has also held many non-academic appointments and married with children. *akinkinrinde@yahoo.com*

Dr Kayode Babtunde Adejobi, was born on 29 September 1969 to a royal family in Orile-Owu town of Osun State, Nigeria. He attended the Federal University of Technology, Akure, Ondo State, Nigeria where he obtained his B.Sc. MSc and PhD. He started his career with Cocoa Research Institute of Nigeria as a Research Officer Grade 1 in 2006 and presently a Senior Research Officer. He has 11 research publications in some peer-review reputable international journals. Dr Adejobi is married with children. *jobikayode@gmial.com*

Mr Olorunfemi S.O. Akanbi, was born on 20 March 1977. He obtained a Higher National Diploma (HND) in Agriculture before joining Cocoa Research Institute of Nigeria, Ibadan as an Agricultural Superintendent in 2008. He later proceeded to the Federal University of Technology, Akure, Ondo State, Nigeria for his post-Graduate Diploma (PGD) programme and upon obtaining his MSc in the Department of Crop and Pest Management of the same University, Mr Akanbi was converted to a Research Officer 1 with Cocoa Research Institute of Nigeria and currently rounding-up his PhD programme at the Federal University of Technology, Akure, Nigeria. He is also married with children.

akanbioso2008@gmail.com