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ARCHITECTURAL RESPONSES OF CASHEW TO INTERCROPPING AND NUTRITIONAL AMENDMENTS IN NIGERIAN GUINEA SAVANNA AGRO ECOLOGY

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ABSTRACT

Field experiment was conducted at Cocoa Research Institute of Nigeria sub-station Ochaja, to evaluate the impact of manure and intercrops on cashew tree growth, canopy development and yield. Treatments consisted of Bambara and Sesame intercrops and manuring using Cocoa pod husk (CPH) and NPK fertilizer applied at the rate of 0, 1,713kg and 400kg/ha respectively. The experiment was laid out in a split-split plot design with three replications and monitored within the two years of study. Data collected includes: Plant height, Stem girth and canopy North-South/East-West direction. These was used to calculate: crown diameter, canopy spread, canopy volume, canopy ground cover and canopy ground cover percentage. The results showed that the growth characters of Cashew were positively influenced by alley crops of Sesame and Bambara nut and manuring. Manuring with CPH exerted differences in the responses of cashew to alley crops, in particular, canopy development. Intercropping with a combination of bambara-sesame and the application of NPK fertilizer proved to have the highest Cashew growth development but showed no significant differences on the yield and yield attribute. The GGE biplot results identified the best intercrop system for each of the three-fertilizer type treatment. Within the two years of the experiment, Cashew development was not hampered by the introduction of the different intercropping systems.

Contribution/Originality: This study contributes to understanding compatibility of cashew with bambara-nut and sesame, generate information on the impacts of Canopy development on morphological and physiological traits associated with the productivity of these arable crops in Nigeria; and improved insight into the biophysical competitive interactions for growth resources.

1. INTRODUCTION

Cashew (*Anacardium occidentale* L.) plantation are usually established at varied spacing pattern. Amongst the most commonly used spacing pattern in Nigeria are: 6-meter x 6 meter (low spacing) and 9 meters' x 9 meters (wider spacing). Within two to five initial years of establishment Cashew canopy are yet unclosed. The moisture and nutrient resources of the plantation within this period are not optimally unutilized. Moreover, management expenses are usually incurred during the period, yet the spaces left unused can be productively and economically utilized.

Alley intercropping within rows of Cashew plants can recycle nutrients from the deeper layer of the soil and utilize other growth resources because the leaf canopy may not cover quickly [1, 2]. However, a successful cultivation

of Cashew with food crop intercropping system will depend on whether the food crops compete with the young Cashew plants for growth resources [1]. Other reports confirmed that these types of intercrops help to bridge the 'lag phase' and can also have direct advantages on the initial development of the tree crops [3]. Canopy development is a fundamental process in tree crops. From many reports [4-6], significant positive ccorrelations exists between tree growth and canopy size, stem diameter, canopy size and planting density. Tree canopy size is a function of individual tree's photosynthetic capacity. Moreover, the climate has modulating effect on tree canopy. It is noteworthy that the rate of canopy growth in Cashew determines how rapid the tree enters the economic production phase [7]. Cashew nut production gradually starts after three years of establishment and sole dependence on cashew production within the earlier years of establishment is unsustainable to the low-income farmers. Therefore, the involvement of other crops in a developing Cashew plantation is an economically viable programme leading to a productive utilization of the uncropped spaces before the canopy closes. This practice will enhance biodiversity, encourage positive interactions at the rhizosphere and reduce input requirements. The efficiency of resources use from the Cashew intercrop depends on the timing of the canopy closure. It is therefore imperative that intercropping Cashew plant with annual crops such as Bambara nut (*Vigna subterranea* (L.) Verdc.) And Sesame (*Sesamum indicum* L.) will provide a practice which will utilize the resources of land for production gain by the farmers in the Guinea savanna of Nigeria. In such intercropping system, the morphology and physiology of the impacts of each species in the system and the interaction among all the involved species can be monitor. While there could be competition in the rhizospere, natural nutrient improvement could be possible especially with Bambara nut, a Nitrogen-fixing legume. However, to forestall a sustainable system for optimum productivity from the intercropping system, nutrient amendments an organic and inorganic nutrient was equally incorporated in the present study. The present study therefore was proposed to understand compatibility of Cashew with some selected arable and identify how external nutrient amendment can enhance the growth, development and archi- canopy parameters of Cashew in the plantation.

2. MATERIALS AND METHODS

Experiments were conducted between 2013 and 2014 cropping seasons at the experimental plot of the Cocoa Research Institute of Nigeria (CRIN) Sub-Station, Ochaja (Latitude 7°46¹N - 7°52¹ and longitudes 6°38¹E – 6°48¹) Kogi State, Nigeria. The location is in the Southern Guinea Savanna Agro-ecological zone of Nigeria. The experiment was conducted within an already established three-year-old Cashew plantation. The established Cashew genotype in the plot was Jumbo which was planted 6m x 6m and replicated three times. One hundred and forty-four Cashew plants were involved in this experiment. The factors which comprised the treatments were three: five quarters of data measurements, three fertilizer types (Control, Cocoa Pod Husk manure applied at 0, 1,713kg/ha and NPK fertilizer applied at 400kg/ha) and four intercrop systems which were Cashew-sole, Cashew-Bambara nut, Cashew-Sesame and Cashew-Bambara nut-Sesame. The experiment was arranged in a Split-split plot design with periodic quarterly data measurements, the fertilizer type and intercrop systems as treatment factors occurring in the main and sub-plot and sub-sub plot respectively. Management practises were applied uniformly for all the treatments, for the cashew plants pruning and training was gone prior to the introduction of the intercrop. Data collection on plant height and trunk girth were at five intervals for 15 months within the two years of study. Data relating to canopy measurement includes: Crown diameter which was estimated as the mean values of diametric length of the ground space occupied by the cashew tree measured in two directions, the "North-South Spread" and "East- West Spread". Canopy spread (Cs), the multiplicative values of "North-South (NS), Spread and East-West (EW) Spread" was calculated as:

$$Cs = NS\ X\ EW \quad (1)$$

Where: Cs= canopy spread, NS= North-South spread diameter, EW= East-West spread diameter.

Canopy volume (CV) (m^3) was estimated following the equation given by Turell [8] as:

$$CV = 0.5236 \times H \times D \quad (2)$$

Where: CV = Canopy Volume (m^3), 0.5236 = a constant, H = Tree height, D = Tree diameter.

The ground coverage of cashew by the canopy was estimated following the procedure used by Tripathy, et al. [9] as:

$$\text{Radius of canopy (m)} = r2 = \frac{(D1 + D2)}{3} \quad (3)$$

Where: D1= Canopy spread in E-W direction (m), D2 = Canopy diameter in N-S direction (m), 3 = Number of replications. The Percentage ground coverage according to Tripathy, et al. [9].

$$\text{Ground coverage \% by canopy (m}^2\text{)} = \frac{Ground\ coverage\ by\ canopy(r)}{Actual\ area\ on\ the\ ground} \quad (4)$$

$$\text{Where: Actual ground cover = Plant Spacing (6m x 6m) / 10000} \quad (5)$$

All data were subjected to analysis of variance using [10]. Means of the three main effects were separated by honestly significant difference of Tukey. Moreover, variables with significant fertilizer type x Intercrop system interaction were partitioned by "which-won-where" option of the GGE biplot in GEA-R [11].

3. RESULTS AND DISCUSSION

From Table 1, all the variables were significant ($P \leq 0.001$) at the main plot except plant girth. However, significant ($P \leq 0.05$) differences existed for canopy volume, crown diameter, canopy spread and canopy radius at the sub plot treatment level. Moreover, only canopy North-South direction, crown diameter and canopy spread showed significance ($P \leq 0.05$) at the sub-sub plot treatment Table 1. In this study, fertilizer application and intercropping pattern supported the growth parameters of Cashew trees in the plantation. Similar results were reported by Chifflot, et al. [12] on nitrogen status of young wild cherry and hybrid walnut trees. More so among the various interactions, only the interaction between fertilizer type and intercrop type showed significance ($P \leq 0.05$) for stem girth, canopy volume, canopy East-West, North-South, crown diameter and canopy spread Table 1. Contrary to the above, the report of Figueirêdo, et al. [13] on a dwarf Cashew life cycle assessment, noted a decrease in need for mineral fertilization, hence, there would be need for fertilization modification to suit various soil types.

The results in this study showed that there was an increase in growth parameters measured at three months' interval after the introduction of the Bambara and Sesame intercrops. The developments of Cashew with respect to: canopy volume, canopy N-S direction, Crown diameter, canopy spread, canopy radius, canopy ground cover and percentage canopy ground cover had no competitive interactions with the intercrops. This seems to imply that Cashew trees may have benefited directly or indirectly from the understory crops in terms of nutrient capturing which were noticed at 3 - 6 months after the introduction of intercropping. In Table 2, at 3 months after sesame was sown into Cashew alley, there were no significant difference ($P<0.05$) among the Cashew plant height, girth and canopy East-West direction spread. However, the canopy volume, canopy North-South direction, crown diameter, canopy spread, canopy radius, canopy ground cover and canopy ground cover % significantly increased at $P < 0.05$ in the un-manure Cashew-Sesame plots Table 2. The trees had not closed the canopy, but it appears to have created a spread in terms of canopy development. According to Heywood [14], Cashew tree may grow up to as much as 15 meters tall and its roots may extend 20–60m from the trunks. Sesame on the other hand is beneficial to the soil, Tanja [15] noted that the incorporation of the Sesame in a crop rotation system improved tillage and reduced the presence of soil parasitic nematodes. The use of Bambara-Cashew intercrops and the application of CPH and NPK fertilizer enhanced the North-South canopy direction at 3-6 months after intercropping Table 3. At 9 months both treatments rates acted similarly expect for canopy volume and canopy East-west which was significantly higher ($P<0.05$) with the CPH manure treatment. At 12 months after the sowing of Bambara-Cashew intercrop and CPH into the cashew alley the canopy structure had significantly ($P<0.05$) higher values compare to the NPK and un-manure treatment plant; this continued consistently to the 15th months Table 3. Bambara is not a deep feeder of the soil nutrient. However, its beneficial contributions to the soil being a legume is by biological fixation of Nitrogen, according to Mkandawire [16]; Yakubu, et al. [17] stated in their report that Bambara groundnuts also fixes Phosphorus in the

soil. Encouraging the association of legumes with cashew plants was noted to reduce weed competition and hence herbicides usage, apart from increasing soil carbon, organic matter, and nutrient content [18].

The interactions between Cashew-Bambara and Sesame in Table 4 did not significantly influence the performances of Cashew, meaning that the response of each of the measured characters was independent of the interactions of the factors but the main effect of each. The effect of the intercrop in Cashew alley though not significant but not negative; Cashew growth and its canopy developments at 3, 6, 9, 12 and 15 months after intercropping continued in sequence consistently. Reason could be linked to the report of Jabbar, et al. [19] who stated that plants grow simultaneously with least competition whenever the two crops differ in height, canopy, adaptation, and growth habits. Apart from Canopy north-south direction at 3 and 15months, all Cashew growth parameters had a higher value under the CPH fertilizer treatment compared to NPK fertilizer treatments. Cashew architectural parameters at 9 and 12 months were similar, and responses was better in CPH Table 4 compare to NPK and control treatments.

The ten vegetative parameters Table 5 reflected the trend in the growth pattern of cashew. The significant ($P<0.05$) least values were in the earliest period of measurement (i.e. 3 Months after planting) while the highest significant ($P\leq0.05$) values of performance occurred at 12 months after planting Table 5. Addition of organic fertilizer (cocoa pod husk) or inorganic (NPK) level lead to the significant ($P\leq0.05$) increased in performance of seven traits except plant height, girth and canopy volume Table 5. Canopy East-West, North-South, crown diameter, canopy spread, canopy radius, ground cover and ground cover percentage had significant ($P\leq0.05$) increased performance when cashew was sown in sole and under an intercrop with Bambara nut and Sesame combination Table 5. It's worthy to note that the beneficial effect of manuring and other management practices in the interspaces of Cashew plants, like the application of CPH manure to sole Bambara and a combination of Bambara and Sesame plants in the Cashew alley improved the percentage canopy ground cover at the 15th month. This increases could be due to the Nitrogen fixing ability of Bambara which may have influenced the cashew tree vegetative growth. However, Contrary to the growth pattern observed in this study, the application of manure to the intercrops had no significant influence on cashew yield and its attribute as showed in Table 6 but a higher values of the study parameters was obtained when fertilizers was applied compare to the control. Similarly, Ratha and Swain [20] recorded highest growth and fruit number for mango based intercropping with French bean (*Phaseolus vulgaris* L.), followed by cowpea (*Vigna unguiculata*) plant. Pawar, et al. [21] equally obtained higher growth and yield attributes for mango when it was intercropped with soybean (*Glycine max*). The treatment of the fertilizer types as environments and the intercropping systems as genotypes in this study was deliberately necessary to be able to partition and understand the observed significance of the interaction of the two factors from the analysis of variance using the GGE biplot. The "which-won-where" option lead to the identification of the best intercrop system for each of the three levels of fertilizers. The "which-won-where" pattern of figuration in Figure 1 environment showed a trapezium with four sectors. Factors 1 and 2 gave 100% explanation of the interaction for girth. For the control environment, the vertex (best) treatment was in treatment 3, i.e. Cashew + Sesame. For CPH and NPK environment, Figure 1 their vertices treatments were in treatments 4 (Cashew-Bambara-Sesame) and 1 (Cashew-sole) respectively. A triangular "which-won-where" view was observed in the intercrop factors for Cashew canopy volume development Figure 2. However, the control environment was the same to what was observed in Figure 1, with its vertex treatment being in treatment 3 (i.e. Cashew + Sesame). The vertex treatments for CPH and NPK were shown in treatments 2 and 1 (i.e. Cashew-Bambara and Cashew sole) respectively Figure 2. In Figure 3 the "which-won-where" pattern of figuration showed a trapezium view for canopy East West direction and the control environment vertex treatments was seen in treatment 3 i.e. Cashew-Sesame. For CPH and NPK environment in Figure 3, their vertices were in treatments 4 at the North-South Canopy for the Cashew-Bambara-Sesame and treatment 1 (Cashew-sole) respectively and the impact shown in the control environment performance in this study was relatively poor. In Figure 4 the CPH and NPK environments and their vertices treatments were in treatments 2 (Cashew-Bambara). The two axes (1-Intercrop and 2 Environment) of the biplot explained 100% of the variance interactions of Canopy North-South direction Figure 4.

Table 1. Analysis of variance summary for Cashew growth characters and canopy structure.

Sources of Variation	DF	Mean Squares									
		Height	Girth	CanVol	CanEWD	CanNSD	CroDia	CanSp	CanRad	CanGCA	CanGCP
Replication	2	29.63***	1293.46	3814.55***	15.08***	14.76***	452.70***	1810.82***	23.29***	93.18***	120565.61***
Months	4	48.89***	3997.09	14421.04***	32.00***	38.87***	801.44***	3205.77***	179.93***	719.71***	931248.59***
Error (a)	8	0.12	121.66	472.59	0.33	0.29	14.21	56.83	0.83	3.32	4293.60
Fert. Type	2	2.21	348.29	685.03***	6.94	8.67	144.27*	577.06*	11.29***	45.17	58453.07
Months*Fert. Type	8	0.32	91.84	157.79	0.55	0.39	14.97	59.86	0.99	3.96	5126.88
Error (b)	20	1.11	221.53	239.62	0.64	0.27	13.13	52.54	0.788	3.15	4080.00
Crop Type	3	1.54	376.92	548.37	5.76	6.22***	108.61*	434.46*	8.21	32.83	42480.71
Months*Crop Type	12	0.35	133.31	82.77	0.18	0.33	6.44	25.75	0.43	1.70	2204.65
Fert. Type*Crop Type	6	3.36	656.29*	682.61**	5.87***	8.74***	128.13***	512.54***	8.03	32.11	41547.16
Months*Fert.Type*Crop Type	24	0.30	136.60	90.92	0.19	0.21	4.54	18.16	0.34	1.36	1758.73
Error (c)	12	0.78	257.97	249.91	1.41	1.06	22.84	91.35	1.86	6.34	8203.54
Mean		5.03	51.24	26.30	4.90	4.98	12.91	25.82	6.10	12.20	438.82
CV (%)		17.51	31.34	60.10	24.30	20.67	37.02	37.02	20.64	20.64	20.64

Note: Fert. – Fertilizer, CanVol – Canopy Volume, CanEWD – Canopy East-West direction, CanNSD – Canopy North-South direction, CRODIA – Crown Diameter, CanSP – Canopy spread, CanRad – Canopy Radius, CanGCA – Canopy Ground cover (m^2), CanGCP - Canopy Ground cover (%). CV- Coefficient of Variation; *, ** and *** - Significance at P = 0.05, 0.01 and 0.001.

Table 2. Interval responses of Cashew characters and canopy structure performances as influenced by different manuring in a Cashew-Sesame intercrop system.

Treatments	Height	Girth	CanVol	CanEWD	CanNSD	CroDia	CanSp	CanRad	CanGCA	CanGCP
3 Months after intercropping										
Un-manure	3.38a	44.33a	14.73a	4.07a	3.95a	8.10a	16.20a	2.67a	5.34a	192.13a
Cocoa Pod Husk	3.24a	36.83a	7.00b	3.39a	2.45b	4.02b	9.52b	1.95b	3.89b	139.97b
NPK	2.94a	34.17a	7.34ab	2.97a	3.22ab	4.76ab	8.05ab	2.06ab	4.12ab	148.32ab
6 Months after intercropping										
Un-manure	4.98a	51.17a	38.23a	5.51a	4.88a	13.65a	27.30a	7.14a	14.27a	513.31a
Cocoa Pod Husk	5.13a	39.00a	25.50a	4.88ab	3.81b	9.32b	20.94ab	6.14ab	12.29ab	442.05ab
NPK	4.74a	43.00a	26.18a	4.30b	4.77a	10.47ab	18.64b	5.89b	11.78b	423.86b
9 Months after intercropping										
Un-manure	5.37a	53.50a	45.35a	5.78a	5.37a	15.59a	31.17a	7.57a	15.13a	544.40a
Cocoa Pod Husk	5.44a	50.50a	33.04a	4.93a	4.52a	11.30a	22.59a	6.43a	12.86a	462.71a
NPK	5.24a	51.33a	35.08a	4.81a	5.22a	12.61a	25.22a	6.55a	13.11a	471.46a
12 Months after intercropping										
Un-manure	5.36b	59.50a	53.64a	5.96a	6.20a	18.65a	37.29a	8.02a	16.05a	577.18a
Cocoa Pod Husk	6.81a	55.67a	51.33a	5.46a	4.94a	13.81a	27.63a	7.11a	14.21a	511.15a
NPK	5.40a	54.83a	44.55a	5.35a	5.85a	15.60a	31.20a	7.30a	14.60a	525.34a
15 Months after intercropping										
Un-manure	5.88a	60.00a	1.89a	6.02a	6.35a	19.34a	38.68a	8.14a	16.28a	585.61a
Cocoa Pod Husk	7.55a	67.17a	2.62a	6.02a	5.73a	17.36a	34.72a	7.93a	15.86a	570.46a
NPK	6.28a	63.50a	2.09a	5.44a	6.42a	17.45a	34.89a	7.58a	15.15a	545.00a

Note: Means with the same letters (a,b,ab) along each column are not significantly different at 0.05 level of probability.
CanVol – Canopy Volume, CanEWD – Canopy East-West direction, CanNSD – Canopy North-South direction, CRODIA – Crown Diameter, CanSP – Canopy spread, CanRad – Canopy Radius, CanGCA – Canopy Ground cover (m^2), CanGCP - Canopy Ground cover (%).

Table 3. Interval responses of Cashew characters and canopy structure performances as influenced by different manuring in a Cashew-Bambara intercrop system.

Treatments	Height	Girth	CanVol	CanEWD	CanNSD	CroDia	CanSp	CanRad	CanGCA	CanGCP
3 Months after intercropping										
Un-manure	3.39a	30.67a	5.03a	2.32a	2.14b	2.57a	5.13a	1.49b	2.97b	106.99b
Cocoa Pod Husk	3.24a	37.33a	13.03a	3.41a	3.95a	7.07a	14.13a	2.45a	4.90a	176.38a
NPK	3.27a	37.17a	9.92a	3.31a	3.29a	5.52a	11.03a	2.20ab	4.40ab	158.23ab
6 Months after intercropping										
Un-manure	4.70a	39.17a	13.61a	3.56a	2.94b	5.31a	10.63a	4.54a	9.08a	326.62a
Cocoa Pod Husk	4.81a	47.00a	30.46a	4.28a	5.12a	11.58a	23.15a	5.98a	11.97a	430.42a
NPK	4.33a	47.00a	25.94a	4.65a	4.72a	11.03a	22.06a	6.22a	12.44a	447.44a
9 Months after intercropping										
Un-manure	5.33a	41.50a	17.85b	3.74b	3.37b	6.39b	12.77b	4.86b	9.72b	349.60b
Cocoa Pod Husk	5.07a	52.17a	44.08a	5.57a	5.51a	15.71a	31.41a	7.40a	14.80a	532.53a
NPK	4.78a	50.17a	30.30ab	4.76ab	4.87a	11.68a	31.41a	6.38a	12.76a	459.07a
12 Months after intercropping										
Un-manure	6.19a	50.33a	23.07b	3.86b	3.48b	6.84c	13.67c	5.02c	10.04c	361.19c
Cocoa Pod Husk	5.97a	61.67a	65.40a	6.08a	6.53a	20.13a	40.26a	8.25a	16.51a	593.84a
NPK	5.33a	51.83a	39.55b	4.91ab	5.57a	13.82b	27.64b	6.77b	13.54b	486.97b
15 Months after intercropping										
Un-manure	6.23a	52.00a	1.79a	3.99b	3.52b	7.23c	14.45c	5.16b	10.33b	371.46b
Cocoa Pod Husk	6.98a	62.33a	2.33a	6.39a	6.60a	21.46a	42.92a	8.59a	17.18a	618.07a
NPK	6.15a	53.67a	1.74a	5.278ab	5.67a	15.00b	29.99b	7.17a	14.34a	515.67a

Note: Means with the same letters(a,b,ab) along each column are not significantly different at 0.05 level of probability.
CanVol – Canopy Volume, CanEWD – Canopy East-West direction, CanNSD – Canopy North-South direction, CRODIA – Crown Diameter, CanSP – Canopy spread, CanRad – Canopy Radius, CanGCA – Canopy Ground cover (m^2), CanGCP - Canopy Ground cover (%).

Table 4. Interval responses of Cashew characters and canopy structure performances as influenced by different manuring in a Cashew-Sesame-Bambara intercrop system.

Treatments	Height	Girth	CanVol	CanEWD	CanNSD	CroDia	CanSp	CanRad	CanGCA	CanGCP
3 Months after intercropping										
Un-manure	2.73a	35.83a	11.80a	3.49a	3.52a	6.56a	13.12a	2.34a	4.67a	168.03a
Cocoa Pod Husk	3.67a	44.00a	13.89a	3.70a	3.68a	7.06a	14.11a	2.46a	4.92a	176.94a
NPK	2.98a	40.67a	10.49a	3.45a	3.77a	6.26a	12.51a	2.41a	4.81a	173.06a
6 Months after intercropping										
Un-manure	4.07a	42.67a	20.56a	3.91a	4.21a	8.51a	17.03a	5.31a	10.63a	382.2a
Cocoa Pod Husk	5.40a	45.83a	31.34a	4.95a	4.24a	10.76a	21.52a	6.36a	12.72a	457.7a
NPK	4.18a	48.17a	35.48a	4.59a	5.85a	13.53a	27.07a	6.54a	13.07a	470.2a
9 Months after intercropping										
Un-manure	4.54a	57.33a	38.94a	5.01a	5.42a	14.47a	28.93a	6.81a	13.63a	490.2a
Cocoa Pod Husk	5.54a	65.83a	40.66a	5.17a	5.15a	13.86a	27.72a	6.88a	13.76a	495.1a
NPK	5.00a	51.67a	44.93a	4.61a	6.46a	14.97a	29.94a	6.76a	13.51a	486.2a
12 Months after intercropping										
Un-manure	4.92a	61.00a	46.38a	5.40a	5.54a	15.90a	31.81a	7.25a	14.5a	521.4a
Cocoa Pod Husk	6.00a	71.33a	56.26a	6.07a	5.68a	17.87a	35.75a	7.96a	15.92a	572.5a
NPK	5.50a	55.00a	63.56a	5.21a	6.97a	18.37a	36.74a	7.54a	15.07a	542.2a
15 Months after intercropping										
Un-manure	4.97a	62.83	1.60a	5.57a	5.66a	16.74a	33.48a	7.46a	14.92a	536.5a
Cocoa Pod Husk	6.03a	77.83	2.44a	6.83a	6.70a	23.07a	46.13a	9.07a	18.13a	652.2a
NPK	5.99a	59.50	2.09a	5.89a	7.11a	21.20a	42.39a	8.26a	16.53a	594.6a

Note: Means with the same letters (a) along each column are not significantly different at 0.05 level of probability.
CanVol – Canopy Volume, CanEWD – Canopy East-West direction, CanNSD – Canopy North-South direction, CroDia – Crown Diameter, CanSP – Canopy spread, CanRad – Canopy Radius, CanGCA – Canopy Ground cover (m^2), CanGCP - Canopy Ground cover (%).

Table 5. Means performances of Cashew characters and canopy structures for the three main effects.

The main Effects	Height	Girth	CanVol	CanEWD	CanNSD	CroDia	CanSp	CanRad	CanGCA	CanGCP
	Months after inter cropping									
3 Months	3.18d	37.99d	10.40c	3.41c	3.36d	5.89d	11.77d	2.26d	4.51d	162.38d
6 Months	4.79c	44.58dc	29.46b	4.65b	4.67c	11.10c	22.20c	6.21c	12.41c	446.25c
9 Months	5.25bc	51.78bc	38.58b	5.06ab	5.17bc	13.42bc	26.84bc	6.79bc	13.58bc	488.33bc
12 Months	5.74ab	56.71ba	50.91a	5.51a	5.70ab	16.20ab	32.40ab	7.41ab	14.83ab	533.44ab
15 Months	6.21a	65.17a	12.16c	5.84a	6.00a	17.95a	35.89a	7.84a	15.67a	563.69a
Fertilizer Type										
Control	4.83a	48.48a	22.41a	4.52b	4.56b	11.12b	22.25b	5.60b	11.21b	403.18b
Cocoa Pod Husk	5.22a	52.40a	27.98a	5.19a	5.07a	13.93a	27.85a	6.41a	12.82a	461.28a
NPK	5.04a	52.86a	28.51a	4.96ab	5.30a	13.68a	27.36a	6.28a	12.57a	451.99a
Crop Type										
Sole Cashew	5.13a	51.78a	29.67a	5.26a	5.19a	14.14a	28.28a	6.51a	13.02a	468.17a
Cashew + Bambara	5.05a	47.60a	21.61a	4.40b	4.49b	10.75b	21.51b	5.50b	11.00b	395.63b
Cashew + Sesame	5.18a	50.97a	25.90a	4.99ab	4.91ab	12.80ab	25.60ab	6.17ab	12.33ab	443.53ab
Cashew + Sesame + Bambara	4.77a	54.63a	28.03a	4.92ab	5.33a	13.94a	27.88a	6.23a	12.45a	447.94a

Note: Means with the same letters(a,b,ab) along each column are not significantly different at 0.05 level of probability.
CanVol – Canopy Volume, CanEWD – Canopy East-West direction, CanNSD – Canopy North-South direction, CroDia – Crown Diameter, CanSP – Canopy spread, CanRad – Canopy Radius, CanGCA – Canopy Ground cover (m^2), CanGCP - Canopy Ground cover (%).

Table 6. Cashew yield and its components as influenced by intercropping and manuring.

Treatment	Number of nuts	Nut Weight (g)	Nut Length (mm)	Nut Width (mm)	Nut Thickness (Cm)	Nut Yield (kg/tree)
Fertilizer Types						
Control	219.98a	21.40a	1.24a	0.63a	4.58a	531.4a
NPK	275.67a	21.66a	1.62a	0.91a	7.46a	599.8a
Cocoa Pod Husk (CPH)	249.50a	21.47a	1.60a	0.79a	5.71a	535.9a
Crop Types						
Sole Cashew	262.7a	21.64a	1.20a	0.65a	2.83a	531.6a
Cashew + Bambara	171.6a	20.99a	1.81a	0.88a	8.36a	403.0a
Cashew + Sesame	295.8a	21.61a	1.78a	0.94a	8.58a	489.9a
Cashew+ Sesame +Bambara	263.6a	21.79a	1.15a	0.64a	3.90a	798.3a
Interaction effects						
Un manure (Um)						
Sole Cashew (Um)	247.33	21.17	0.56	0.3	2.67	475.45
Cashew + Bambara (Um)	285.33	21.5	2.29	1.07	10.4	985.53
Cashew + Sesame (Um)	291.33	21.8	2.41	1.19	11.13	606.27
Cashew+Sesame+Bambara(Um)	174	21.13	1.12	0.60	5.63	332.13
Cocoa pod husk (CPH)						
Cashew (CPH)	315.33	22.16	0.66	0.31	2.77	738.04
Cashew + Bambara (CPH)	94	20.57	1.25	0.57	6.03	88.61
Cashew + Sesame (CPH)	261.27	22.13	2.40	1.31	11.57	585.28
Cashew+Sesame+Bambara(CPH)	209.33	21.77	0.66	0.34	2.47	731.6
NPK						
Cashew (NPK)	225.33	21.6	2.38	1.34	3.07	381.4
Cashew + Bambara (NPK)	135.33	20.9	1.91	0.99	8.63	134.8
Cashew + Sesame (NPK)	334.67	20.9	0.55	0.32	3.03	278.27
Cashew+Sesame+Bambara(NPK)	407.33	22.47	1.66	0.97	3.6	1331.27

Note: Means with the same letters(a) along each column are not significantly different at 0.05 level of probability. CHP.Cocoa Pod husk.

For the four characters (girth, canopy volume, East-West canopy diameter and North-South canopy diameter) in Figures 1, 2, 3 and 4 whose fertilizer type x intercropping system were observed to be significant, the GGE biplot analysis consistently identified: sole Cashew for NPK fertilizer environment, Cashew-Bambara and Cashew-Bambara-Sesame for the Cocoa pod husk fertilized environment and Cashew-Sesame intercrop for the controlled (no fertilizer environment). It therefore means that, NPK is most preferable in sole cashew plots, soil with CPH nutritional amendment is preferred when the intercrop system is with Bambara alone and/or with Sesame. There are successful reports of specific genotype selection for specific environment using this method [22] for bread wheat; Aremu, et al. [23] for cowpea; Adewale, et al. [24] for African yam bean).

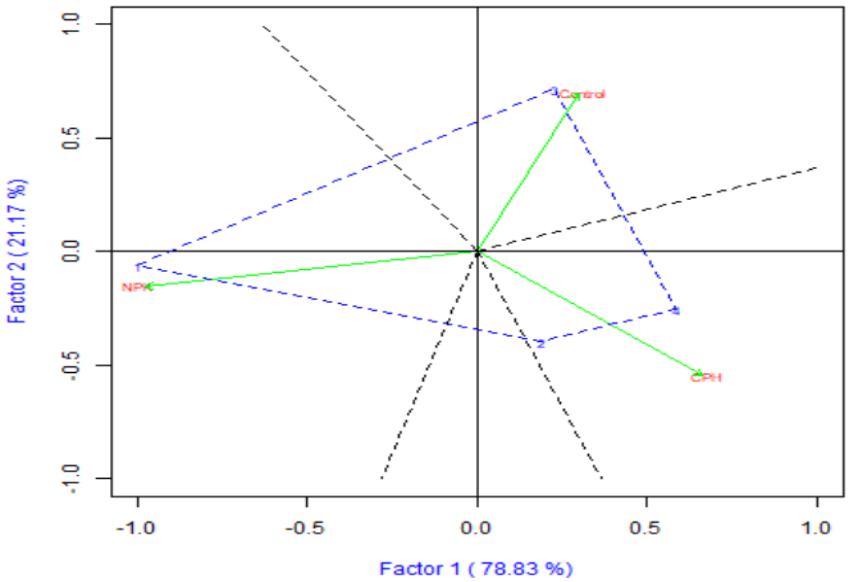

Figure 1. The polygon view of the intercrop systems by Fertilizer type interaction for girth.
†Note: 1 – Cashew-sole, 2 – Cashew-Bambara, 3 – Cashew-Sesame, 4 – Cashew-Bambara-Sesame.

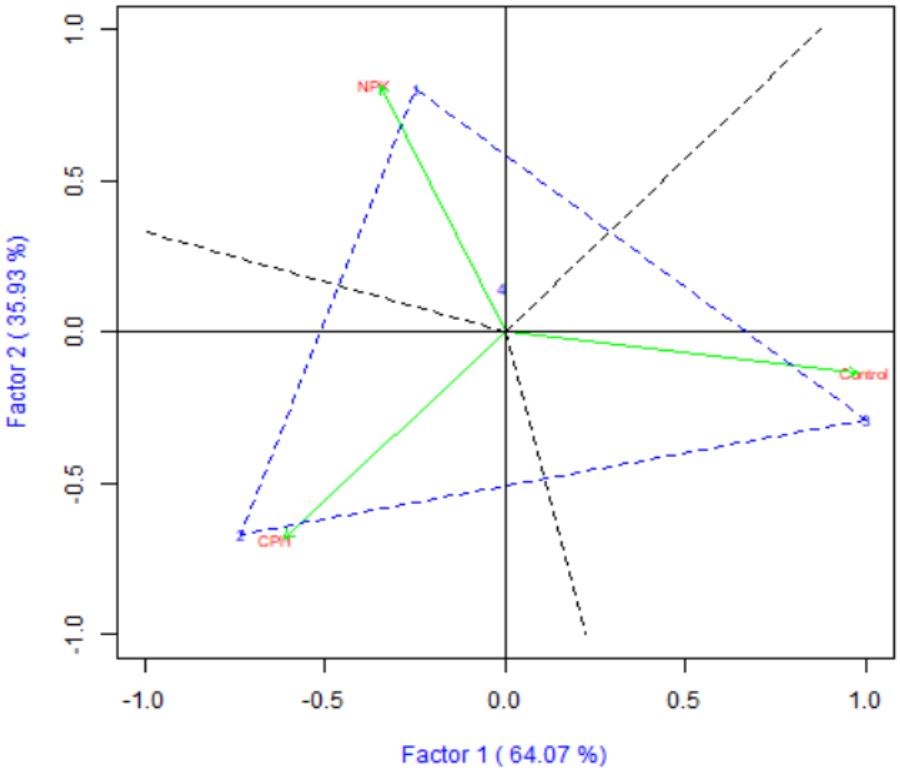

Figure 2. The polygon view of the intercrop systems by Fertilizer type interaction for canopy volume.
†Note: 1 – Cashew-sole, 2 Cashew-Bambara, 3 – Cashew-Sesame, 4 – Cashew-Bambara-Sesame

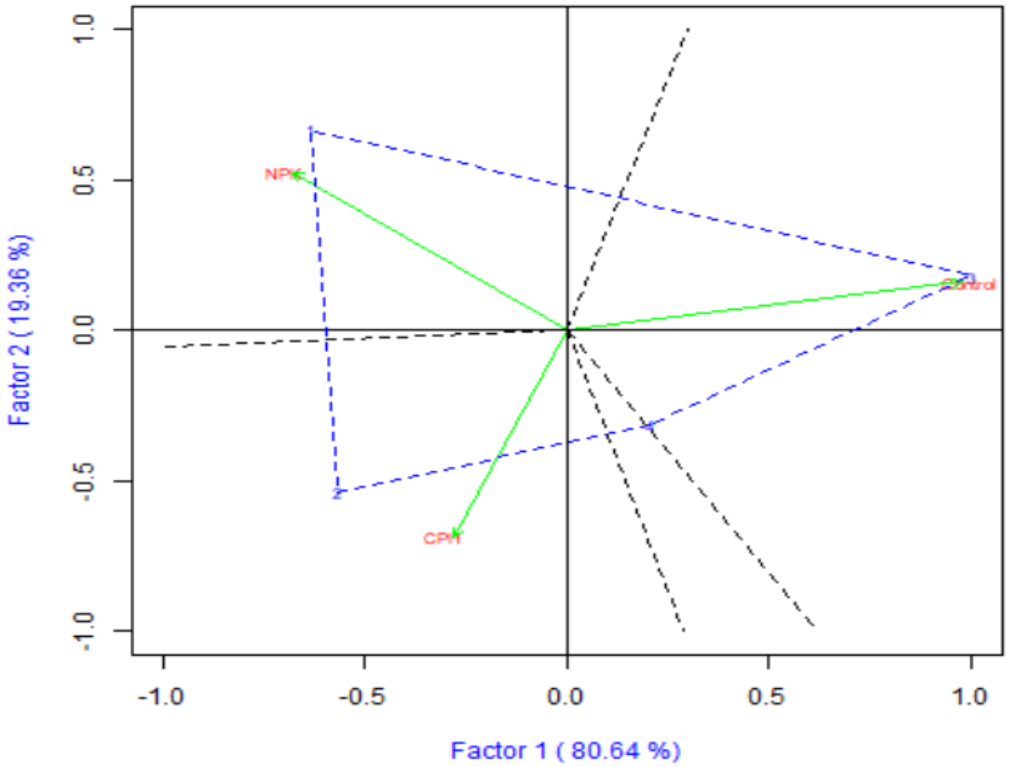

Figure 3. The polygon view of the intercrop systems by Fertilizer type interaction for canopy East West Diameter.
†**Note:** 1 – Cashew-sole, 2 – Cashew-Bambara, 3 – Cashew-Sesame, 4 – Cashew-Bambara-Sesame.

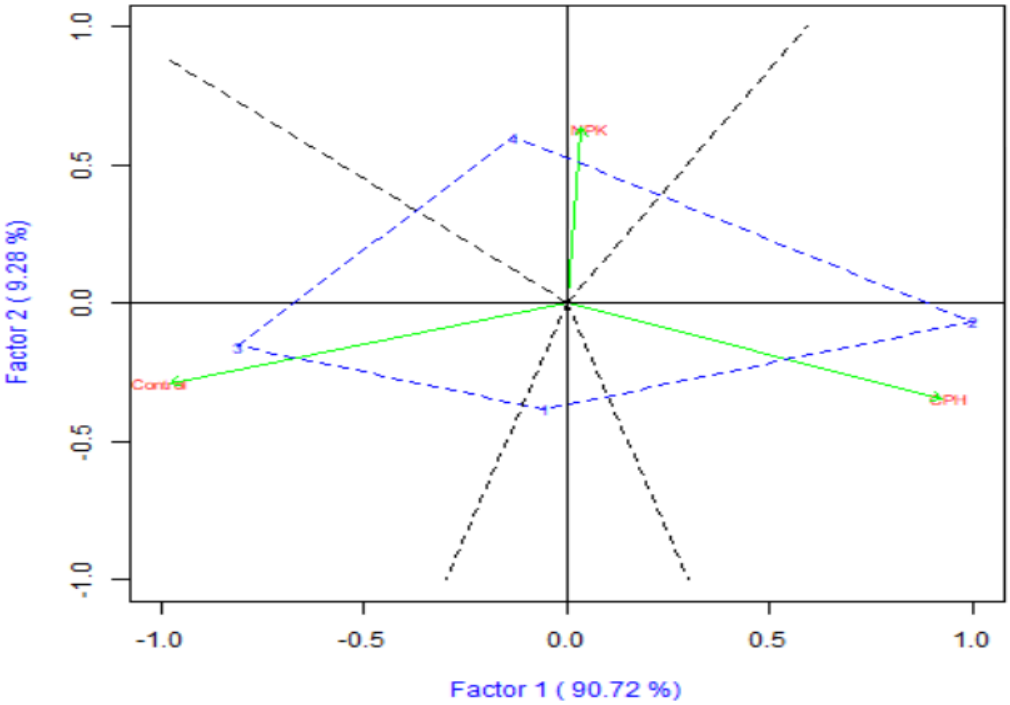

Figure 4. The polygon view of the intercrop systems by Fertilizer type interaction for canopy North South Direction.
Note: 1 – Cashew-sole, 2 – Cashew-Bambara, 3 – Cashew-Sesame, 4 – Cashew-Bambara-Sesame

The enhancement of the performance of cashew parameters under Cashew-Sesame intercrop in an unfertilized environment (control) observed in this study is unique. It is noteworthy that the practice of the incorporation of *Sesamun indicum* in Cashew plots is an aged practice by the farmers in Kogi state of Nigeria. However, the relationship of the two crops in the environment could be a remarkable investigation in the future. The choice of Cashew, Sesame

and Bambara in this study which are indigenous to Nigeria guinea savanna agro-ecology of Nigeria revealed the possibility of co-existence and positive eco-physiological interaction for optimum and productive utilization of land and nutrient resources. The interaction of these indigenous crops of the region with cashew was not negative to its growth and development because cashew tree has the ability to draw more resources due to its size. However, this system conserves the soil, provide food and income to the farmers during the initial period of establishment before Cashew canopy closes. Its worthy to note here that yield record of the cashew productivity as mentioned in this report was the beginning and the first year of fruit production.

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