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Field Performance Evaluation of Tea (*Camellia sinensis* L.) to the Application of Different Organic Wastes under Southwest Nigeria

S. A. Adeosun[1*] and A. O. Togun[2]

[1]*Agronomy Section, Cocoa Research Institute of Nigeria, P.M.B. 5244, Ibadan, Nigeria.*
[2]*Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Authors SAA and AOT designed the study. Author SAA performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AOT managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To assess the field establishment of two tea cultivars under Cocoa Pod Husk (CPH) and Poultry Manure (PM).
Study Design: Randomized complete block design arranged in Split-plots (cultivars as main plots and organic amendments as sub-plots) with four replications.
Place and Duration of Study: Cocoa Research Institute of Nigeria stations in Ibadan and Owena, Southwest Nigeria between May 2016 and November 2017 (Rainy and dry seasons of 2016; Rainy season of 2017).
Methodology: Milled CPH and cured PM were applied each at the rates of 150 and 300 kg Nha^{-1} to established C143 and C318 tea cultivars on the field; unfertilized tea cultivars served as control. Data on number of leaves, number of branches, leaf area, plant height and stem diameter were collected on monthly basis; while dry matter was assessed at 15 months after transplanting. The data were analyzed with ANOVA and correlation at $\alpha_{.05.}$

**Corresponding author: E-mail: seunfunmi1999@gmail.com;*

Results: The C143 performed better than C318 and 150 kg Nha^{-1} of CPH and PM enhanced the vegetative growth and dry matter of tea better than 300 kg Nha^{-1} in Ibadan and Owena. Cultivar 143 was significantly (P=0.05) better than cultivar 318 in number of leaves, number of branches and stem diameter in Ibadan; and in number of leaves and leaf area in Owena. CPH at 150 kg Nha^{-1} increased number of leaves, number of branches, leaf area, plant height and total dry matter by 135.11, 88.19, 346.12, 65.33 and 428.11% at Ibadan; and by 349.09, 245.41, 376.89, 80.89 and 231.49% at Owena, compared to control. On the interaction, tea cultivar 143 that received 150 kg Nha^{-1} CPH produced significantly (P=0.05) higher number of leaves, leaf area and total dry matter at Ibadan and Owena. Leaf area was positively correlated with number of leaves (r=0.87) in Ibadan and stem diameter (r=0.80) in Owena.

Conclusion: CPH at 150 kg Nha^{-1} enhanced the growth and dry matter content of C143 tea established on the field in Ibadan and Owena, and is therefore recommended for tea cultivation in Southwest of Nigeria.

Keywords: Tea cultivars; cocoa pod husk; poultry manure; vegetative growth; dry matter.

1. INTRODUCTION

Tea (*Camellia sinensis* [L.] O. Kuntze) has gained much popularity worldwide due to the nutritional and health benefits obtainable from the consumption of its beverage. Tea beverage is a good source of antioxidants, especially epigallocatechin galate (EGCG) which helps to prevent oral diseases, renal failure and cancer [1] and theanine, an amino acid found in tea [2]. However, poor soil fertility is a major abiotic limiting factor in its production in many tropical regions of the world, especially in Nigeria, where soils under tea cultivation and adaptability trials are poor in fertility when compared to soils of other tea producing regions of the world [3]. Some of the effects of poor soil fertility in tea include poor productivity, reduced synthesis and accumulation of its quality components, poor seedling establishment, poor yield and retarded growth of apical meristem [4,5]. Poor soil fertility has caused as much as 80% reduction in economic yield of tea on Mambilla highland in Nigeria [6].

Introduction of inorganic fertilizers to farmers seemed to proffer temporal relieve from adverse effects of poor soil fertility. Inorganic fertilizers had been distributed to farmers at subsidized rate. However, apart from the fact that the subsidy channel was complicated [7] and unsustainable, excessive use of inorganic fertilizer has deleterious effects on the ecosystem [8]. Over dependence on the use of inorganic fertilizers has been implicated in the pollution of underground water and soil acidification [8]. The poor affordability, scarcity, delay in supply and harmful effects that result from the excessive use of inorganic fertilizers have made search for better and environmentally safe alternative inevitable. This alternative has been found in organic fertilizers.

Application of organic fertilizers in crop production has produced a lot of outstanding results. Apart from being safe to handle [9], organic fertilizers have been rated high in promoting crop growth, improving soil physical, chemical and biological properties, releasing plant nutrients slowly to meet tea plant nutritional needs and enhancing tea yield [10,11,12, 13,14,15]. The yield of tea was enhanced when grown under organic fertilizers in China [14] and on Mambilla highland [16]. Moreover, the quality of tea beverage is enhanced when tea is grown under organic fertilizers [17]. [18] found out that increased in yield and chlorophyll content of tea leaves was attributed to applied organic fertilizers.

Many agricultural by-products that could be regarded as organic farm wastes have been formulated into organic fertilizers. The application of these farm wastes to the soil for crop production has been reported to produce outstanding results [19, 20]. Kola pod husk based organomineral fertilizer enhanced the growth and yield of Amaranths [21]. Cocoa pod husk, cocoa pod husk ash and cocoa pod compost have been reported to enhance the growth of cacao [1, 22], cucumber [23] and kola seedlings [24]. Applied coffee husk improved cashew seedling growth [25]. Poultry manure and siam weed enhanced the seedling growth of tea on Mambilla highland in Nigeria [14]. Besides their use as organic fertilizers, these farm wastes that could have been otherwise disposed of also have the potential of additional revenue generation to the farmers [20]. However, there is scanty information on the use of organic farm wastes on field establishment of tea in Southwest Nigeria.

Therefore, this trial was aimed to assess the effects of applied organic farm wastes (cocoa pod husk and poultry manure) on the field establishment of tea plant in Ibadan and Owena, areas of Southwest Nigeria.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

This field experiment was carried out in Cocoa Research Institute of Nigeria (CRIN) stations in Ibadan (Latitude 07 10'E and Longitude 03 52'E; Tropical rain forest belt) and Owena (Latitude 07°N and longitude 05°7'E; Humid rain forest belt), Southwest Nigeria. The locations have two distinct main seasons: rainy season and dry season. The rainy season is characterized by heavy rains, humid atmosphere and cloudy sky; while the features of the dry season include little or no rainfall, hot and scorching sun with very low relative humidity. At Ibadan, ~~The~~ average maximum and minimum temperature are 27.0°C and 19.8°C, respectively; while relative humidity varies from 89% during rainy season to 57% during dry season [26]. At Owena, relative humidity varies from 89% during raining season to 76% during dry season; while average maximum and minimum temperature are 29.9°C and 20.7°C, respectively [27].

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2.2. Treatments and Experimental Design

In this experiment two tea cultivars (143 and 318) and two organic wastes (poultry and milled cocoa husk) were evaluated in two factorial combination during the Rainy season of 2016. The poultry manure and cocoa husk in 150 and 300 kg N ha^{-1} rates were combined with the two tea cultivars. In addition, no any organic fertilizer for both tea cultivars were considered as control treatments. This provided about eight treatment combinations and two control treatments. The research was conducted in randomized complete block design arranged in Split-plots with four replications; while the cultivars and organic fertilizers served as main and sub plots respectively.

2.3 Planting Materials, Nursery and Field Preparation

Tea stem cuttings of cultivars 143 and 318 were obtained from CRIN, Mambilla station, Nigeria. The cuttings were set and raised in polythene pots in the nursery for 12 months before being transplanted on field. A suitable site was selected in each experimental location. The land was cleared of all vegetation and the trees felled manually. The cleared field was laid out into blocks and stands for tea plats were marked out at a spacing of 100x60 cm.

2.4. Soil Sampling and Analysis

The soil samples from 0-30cm were taken from the five cores of experimental site using soil auger. Then the soil samples were composited as one sample for analysis. The soils were taken to Soil Laboratory of Agronomy Department of University of Ibadan Nigeria for analysis of soil physical and chemical properties using standard procedures.

2.5 Preparation and Analysis of Organic Fertilizers

Cocoa Pod husk (CPH) and Poultry Manure (PM) were used as organic fertilizers. Fresh CPH was collected from the Fermentary Unit of CRIN Ibadan. The cocoa pods were sun-dried for four weeks, and milled into powder with milling machine. The poultry manure was collected from poultry house and allowed to cure for 4 weeks. Both CPH and PM were assayed in the laboratory of Department of Animal Science, University of Ibadan Nigeria for their nutrient contents.

The pH was determined by pH meter, organic matter by ashing method. After acid digestion, calcium and potassium were read on Flame Photometer, magnesium and iron on Atomic Absorption Spectrophotometer (AAS); Phosphorus was read on Spectrometer; while Total nitrogen was determined with Microkjedahl methods [28].

2.6. Transplanting and Field Management

After 12 months in the nursery, the young tea plants at 30 cm height and 11 leaves stage were transplanted on the prepared field by carefully removing them from the polythene bags, placing the tea roots with a ball of earth in the already dug planting holes and covering the roots with the soil that was dug out. The dimension of the planting holes was 20x20x25 cm. The tea plants were transplanted at a spacing of 100x60 cm. After two months of transplanting (2 MAT) organic fertilizer treatments were applied to the established tea plants by placing the fertilizer in ring form round the newly transplanted tea plants. The treatments: cocoa pod husk at 150 kg Nha^{-1} (CPH_{150}) (0.6 kg of milled CPH per stand) and 300 kg Nha^{-1} (CPH_{300}) (1.2 kg of milled CPH per stand); poultry manure at 150 kg Nha^{-1} (PM_{150}) (0.5 kg of poultry manure per stand) and 300 kg Nha^{-1} (PM_{300}) (1.0 kg of poultry manure per stand) were randomly applied to the tea plants; while control plants received no fertilizer.

2.7 Data Collection and Analysis

Data collection were started after three months of transplanting (MAT) and continued on monthly basis. At each sampling, the following morphological parameters were measured on two preselected tea plants per treatment: number of leaves, number of branches, leaf area, plant height and stem diameter. Number of leaves and number of branches were determined by visual count. Leaf area (cm^2) was determined by measuring the length (mid-rib) and width of the 5^{th} and 6^{th} leaves from the apex of each plant. The area of the leaves (Length x Width) was multiplied by a predetermined Leaf Area Factor of 6.1 giving the actual area of each leaf. Leaf area per plant was determined from the product of the average area of the leaves and the number of leaves per plant. Plant height (cm) was measured with meter rule from the soil surface to plant apex and stem diameter (cm) by using digital veneer calipers at 4 cm height of the stem. At 15 MAT two plants per treatment were carefully uprooted. They were partitioned into root, stem and leaves. The fresh weight of the plant parts was measured. The plant parts were oven dried at 70°C for 48 hours and their dry weight was measured. The fresh and dry weights of the plant samples were measured with Electronic Compact Scale Model BL5002. All the collected data were subjected to analysis of variance (ANOVA) and Pearson correlation analysis using STAR software [29] and the significant means were separated with Tukey's Honest Significant Difference (HSD) Test (P=.05).

3. RESULTS AND DISCUSSION

3.1 Soil Chemical and Physical Properties

The result for pre-cropping physical and chemical properties of the soils used for the field trial showed variation in Ibadan and Owena experimental sites. The soil pH values of 7.4 and 6.2 at Ibadan and Owena indicates a slightly alkaline and slightly acidic conditions respectively. The slightly acidic soil of Owena falls within the range of 4.5 – 6.5 considered suitable for optimum tea production [30]. The N values of 23.1g/kg and 15.6g/kg for Ibadan and Owena respectively are higher than the critical value of 3.4 g/kg for soils under tea production [31]. Similarly, P values of 14.90 and 10.40 mg/kg for Ibadan and Owena respectively are higher than 10.0 mg/kg considered optimum for tree crops [32]. However, K (0.32 cmol/kg), Ca (0.15 cmol/kg) and Mg (0.10 cmol/kg) contents for Ibadan, and K (0.29 cmol/kg), Ca (0.17 cmol/kg) and Mg (0.13 cmol/kg) contents for Owena fall below the critical values of 1.0, 8.0 and 0.80 cmol/kg for K, Ca and Mg respectively; while 27.98 and 16.89% Organic carbon for Ibadan and Owena respectively is considered too low for tea production [30]; hence the need for addition of organic fertilizer to the soils. Besides, the low K in the soils could impede N absorption making it less available for the tea plants [30]. This suggests the need for incorporation of fertilizer to the soil for sustainable tea production. The N, P, K and Mn values of 23.10 $mgkg^{-1}$, 14.93 $mgkg^{-1}$, 0.32 $cmolkg^{-1}$ and 0.11 $cmolkg^{-1}$, respectively of Ibadan are higher than those of Owena (15.60 $mgkg^{-1}$ N, 10.40 $mgkg^{-1}$ P, 0.29 $mgkg^{-1}$K and 0.11 $cmolkg^{-1}$ Mn). However, Owena soil contained higher values for Ca (0.17 $cmolkg^{-1}$), Mg (0.13 $cmolkg^{-1}$), and CEC (1.01) as against Ibadan values of 0.15 $cmolkg^{-1}$, 0.10 $cmolkg^{-1}$, and 0.90 for the same properties, respectively. The soils of the two locations could be classified as sandy-loam as the sand, silt and clay of 140.00, 800.00 and 60.00 g kg^{-1}soil respectively was obtained in Ibadan; while Owena soil was made of 120.00 g kg^{-1} sand, 822.00 g kg^{-1} silt and 58.00 g kg^{-1} clay. The higher CEC and lower pH of Owena soil might be responsible for the better performance of tea. This might explain why tea had better vegetative growth and dry matter yield in Owena than Ibadan. Tea has been reported to thrive better in slightly acidic soil [33].

3.2 Characteristics of Organic Fertilizers

As shown in Table 2, the nutrients content, physical and chemical properties of the organic fertilizer materials used in the field trial. Poultry manure was higher than cocoa pod husk in all chemical properties except C/N and Fe content which provided about 10.44 and 169.57 $mgkg^{-1}$, respectively which were higher than 9.56 and 128.6 $mgkg^{-1}$ in poultry manure. Poultry manure N (1.96%), P (0.99%), K (1.37%), Ca (2.86%) and Mg (0.26%) were higher than 1.4%, 0.41%, 0.726%, 0.24% and 0.25% for cocoa pod husk N, P, K, Ca and Mg, respectively. Similarly, poultry manure was richer in micro nutrients: 33.15

$mgkg^{-1}$, 15.7 $mgkg^{-1}$ and 6.1 $mgkg^{-1}$ for Mn, Zn and Cu respectively for PM as against 32.30 $mgkg^{-1}$, 15.2 $mgkg^{-1}$ and 4.3 $mgkg^{-1}$ for the same nutrients in CPH. The %OM (Organic matter) and pH of cocoa pod husk were 41.15 and 7.2, respectively, while that of poultry manure were 68.34 and 8.3, respectively.

It is apparent that poultry manure was superior to cocoa pod husk in nutrient contents. The protein component of poultry feeds might explain the cause of the higher N and other mineral contents of the poultry manure [4]. This also corroborates the findings of [14]. The lower nutrient content of CPH explains the consequence of most cocoa farmers not applying fertilizers on their farms [19]. The lower nutrients content in CPH indicates that more quantity would be required to compensate for the lower nutrients in the soil.

3.3 Effects of Organic Fertilizers and Tea Cultivars on Number of Leaves

The two tea cultivars are significantly (P=.05) different in their number of leaves at Ibadan and Owena (Table 3). At Ibadan cultivar 143 increased in number of leaves from 28.62 at 3MAT to 107.45 at 12 MAT as against cultivar 318 which increased from 24.90 number of leaves at 3MAT to 54.83 at 12 MAT. The different rates of the organic fertilizers were significantly (P=.05) different in enhancing leaf growth of tea plants in both locations. The 150 kg Nha^{-1} of CPH and PM was consistently better than 300 kg Nha^{-1}. Although all the fertilizer rates were better than the control, CPH at 150 kg Nha^{-1} produced the highest number of leaves – 34.19, 54.75, 84.25 and 125.38 at 3, 6, 9 and 12 MAT respectively. In the same trend at Owena, CPH at 150 kg Nha^{-1} produced the highest number of leaves – 29.00, 46.19, 76.06 and 193.36 at 3, 6, 9 and 12 MAT respectively.

The superior leaf growth of C143 might be due to its genetic and morphological characteristics as well as its ability to thrive under harsh tropical climate. It has been previously adjudged as high yielding, drought tolerant, more adaptable to the lowland and more vigorous in growth than C318 [34]; [35]. The positive response of tea plants to the application of the organic materials attests to the fact that when soil is amended with organic fertilizers in form of farm wastes, the soil nutrient status and the availability of such nutrients for crop use are enhanced. This corroborates [36,10,13,14] who submitted that organic manures increased the growth and yield of water melon and tea.

3.4 Effects of Organic Fertilizers and Tea Cultivars on Number of Branches

Cultivar 143 was significantly ((P=.05)) superior to 318 in their number of branches (Table 4). The 150 kg Nha^{-1} CPH consistently enhanced the best branch initiation in tea plants as it produced the highest number of branches – 6.94, 12.19, 15.81 and 20.08 at 3, 6, 9 and 12 MAT respectively. In the same trend at Owena, CPH at 150 kg Nha^{-1} enhanced the highest number of branches – 6.81, 11.50, 17.88 and 30.88 at 3, 6, 9 and 12 MAT respectively.

Table 1. Pre-cropping physical and chemical properties of soils used in Ibadan and Owena

Soil properties	Ibadan	Owena
pH (H_2O) 1:1	7.4	6.2
Exchangeable cations (cmol kg^{-1} soil)		
K^+	0.32	0.29
Ca^{2+}	0.15	0.17
Mg^{2+}	0.10	0.13
OC (%)	27.98	16.89
Total N (g kg^{-1})	23.10	15.60
Average P (g kg^{-1})	14.90	10.40
Exchangeable micronutrients (cmol kg^{-1} soil)		
Mn^{2+}	0.11	0.11
Al^+	0.12	0.11
H^+	0.04	0.10
CEC	0.90	1.01
Particle size analyses (g kg^{-1})		
Sand	140.00	120.00
Silt	800.00	822.00
Clay	60.00	58.00
Textural class	Sand-loam	Sand-loam

Table 2. Chemical properties of the organic farm wastes used

Properties	Cocoa pod husk	Poultry manure
~~Ph~~ pH	7.2	8.3
%K	0.73	1.37
%Ca	0.24	2.86
%Mg	0.25	0.26
%OM	41.15	68.34
%N	1.4	1.96
%P	0.41	0.99
C/N	10.44	9.56
Mn (mgkg^{-1})	32.30	33.15
Iron (mgkg^{-1})	169.57	128.6
Zinc(mgkg^{-1})	15.2	15.7

The superior branch initiation in C143 might be due to its genetic and morphological characteristics. It has been previously adjudged as more vigorous in growth than C318 [34,35] The positive response of tea plants to the application of the organic materials attests to the fact that organic fertilizers in form of farm wastes enhances the availability of plant nutrients for crop use [36,10,13,14].

3.5 Effects of Organic Fertilizers and Tea Cultivars on Leaf Area

The two tea cultivars are significantly (P=.05) different in their leaf area at Ibadan and Owena (Table 5). At Ibadan, cultivar 143 increased in leaf area from 1055.72 at 3MAT to 3581.02 at 12 MAT as against cultivar 318 which increased from 1053.92 leaf area respectively at 3MAT to 1917.56 at 12 MAT. The different rates of the organic fertilizers were significantly (P=.05) different in enhancing the leaf area of tea plants in both locations. The 150 kg Nha^{-1} of CPH consistently enhanced better growth of tea plants than 300 kg Nha^{-1} as it caused the highest leaf area – 1548.38, 1777.75, 2554.08 and 4595.30 cm^2 at 3, 6, 9 and 12 MAT respectively. In the same trend at Owena, CPH at 150 kg Nha^{-1} produced the highest leaf area – 911.18, 1963.77, 3003.14 and 6318.58 cm^2 at 3, 6, 9 and 12 MAT respectively. This confirms the findings of [37] that the optimum nutrient requirement for tea growth was 150 kg Nha^{-1}, 30 kg Pha^{-1} and 30 kg Kha^{-1}. The higher effectiveness of CPH might be due to its lower pH and higher concentration of other essential nutrients that resulted from its higher quantity applied, compared to PM. The CPH contained lower nitrogen than PM. In order to achieve 150 kg Nha^{-1} of CPH, it was applied in higher quantity than PM. This better effectiveness of CPH is consistent with the results of better performance of cucumber [23], *cacao* [22, 38]; kola seedlings [24] and tea in nursery [14] under its application.

The two tea cultivars responded to the fertilizer rates differently in their leaf area in the two locations (Table 5). However, the interactions of fertilizer rates with cultivars were significantly (P=.05) different at Ibadan (12MAT) and at Owena (6-12MAT). Cultivar 143 was better than 318 under all the fertilizer rates. At Ibadan, interaction of C143 with150 kg Nha^{-1} CPH produced the highest leaf area (1693.02, 2116.23, 2922.83 and 6295.15 cm^2 at 3, 6, 9, 12 MAT respectively). The same trend was observed in Owena as the interaction of C143 with 150 kg Nha^{-1} CPH enhanced the highest leaf area throughout the sampling periods. This result implies that efficiency of the fertilizers in enhancing the accumulation of dry matter was higher in C143 plants than in C318. The reported higher adaptability to lowland and better vigor for growth [34,35] might explain the higher efficiency of the applied fertilizers in cultivar 143 compared to 318.

3.6 Effects of Organic Fertilizers and Tea Cultivars on Plant Height

Table 6 reveals that cultivar 143 was taller than cultivar 318 especially from 9-12MAT at Ibadan. The same trend was observed in Owena except 3-6MAT when the stem of C318 was taller than that of C143. The different rates of the organic fertilizers were significantly (P=.05) different in enhancing the plant height of tea plants in both locations. Tea plants fertilized with 150 kg Nha^{-1} of CPH and PM consistently grew taller than those fertilized with 300 kg Nha^{-1}. Tea plants under 150 kg Nha^{-1} CPH possessed the highest plant height – 51.22, 63.66, 76.01 and 82.02 cm at 3, 6, 9 and 12 MAT respectively. In the same trend at Owena, CPH at 150 kg Nha^{-1} produced the highest plant height – 53.02, 64.35, 63.83 and 94.28 cm at 3, 6, 9 and 12 MAT respectively. The superior performance of cultivar 143 especially under 150 kg Nha^{-1} CPH is the evidence of better genetic and morphological superiority over C318 as reported by [34].

Table 3. Effects of cultivars and organic farm wastes (OFW) on number of leaves of tea plants in Ibadan and Owena

Treatments	Ibadan				Owena			
Cultivars	**3MAT**	**6MAT**	**9MAT**	**12MAT**	**3MAT**	**6 MAT**	**9 MAT**	**12MAT**
C143	28.62a	45.55a	72.33a	107.45a	24.73a	38.98a	76.47a	151.35a
C318	24.90a	34.80a	47.98b	54.83b	19.68b	27.77b	45.31b	59.52b
OFW								
CPH_{150}	34.19a	54.75a	84.25a	125.38a	29.00a	46.19a	76.06a	193.38a
CPH_{300}	23.31a	34.44bc	51.25ab	66.44b	17.19c	34.25ab	65.03a	91.75bc
PM_{150}	25.69a	37.06bc	71.25a	91.19ab	24.44ab	37.75ab	73.94a	121.88b
PM_{300}	30.12a	46.00ab	59.38ab	69.38b	22.69abc	30.25bc	45.84b	77.12bc
Control	20.50	28.62b	34.62b	53.31b	17.69bc	18.44c	43.59	43.06c
OFW x Cultivars								
CPH_{150} x C143	38.88a	69.88a	104.25a	156.75a	30.88a	62.50a	104.69a	311.00a
C318	29.50a	39.63b	64.25a	95.00b	27.13a	29.88b	47.44b	75.75b
CPH_{300} x C143	21.00a	36.13a	56.88a	77.13a	22.13a	44.00a	83.25a	125.00a
C318	25.63a	32.75a	45.63a	55.75a	12.25a	24.50b	46.81b	58.50b
PM_{150} x C143	30.00a	47.75a	100.41a	147.75a	27.50a	36.13a	82.38a	169.50a
C318	21.38a	26.38a	41.75b	34.63b	21.38a	39.38a	65.50b	74.25b
PM_{300} x C143	27.88a	49.63a	70.25a	92.00a	24.50a	32.25a	52.38a	92.00a
C318	32.38a	42.38	48.50a	46.75b	20.88a	28.25a	39.31b	62.25b
Control x C143	25.38a	24.38a	29.50a	63.63a	18.63a	20.00a	59.68a	59.25a
C318	15.63a	32.88a	39.75a	43.00a	16.75a	16.88a	27.50b	26.88b
Mean	26.76	40.17	60.15	81.14	22.20	33.38	60.89	105.44
CV (%)	43.93	30.71	36.22	48.28	27.71	20.86	49.37	12.29

Means followed by same letters are significantly different in same treatments along a column by HSD (P=.05)
CPH_{150} = Cocoa pod husk at 150 kg Nha^{-1}; CPH_{300} = Cocoa pod husk at 300 kg Nha^{-1}; PM_{150} = Poultry manure at 150 kg Nha^{-1}; PM_{300} = Poultry manure at 300 kg Nha^{-1}; MAT= Months after transplanting

Table 4. Effects of cultivars and organic farm wastes (OFW) on number of branches of tea plants in Ibadan and Owena

Treatments		Ibadan				Owena			
Cultivars		**3MAT**	**6MAT**	**9MAT**	**12MAT**	**3MAT**	**6 MAT**	**9 MAT**	**12MAT**
C143		5.65a	9.72a	13.45a	17.52a	4.98a	8.15a	14.36a	22.18a
C318		4.83a	10.34a	13.38a	12.91b	4.13a	7.87a	12.11a	16.63a
OFW									
CPH_{150}		6.94a	12.19a	15.81a	20.08a	6.81a	11.50a	17.88a	30.88a
CPH_{300}		4.75a	9.29bc	11.81a	13.88a	4.38bc	8.50b	11.94bc	16.19bc
PM_{150}		5.13a	10.81ab	14.75a	16.56a	4.69b	9.31ab	13.56ab	22.12b
PM_{300}		5.58a	10.75ab	15.00a	14.88a	4.25bc	7.38b	15.16ab	18.88b
Control		4.00a	7.12c	9.44a	10.67a	2.62c	3.38c	7.66c	8.94c
OFW x Cultivars									
CPH_{150} x	C143	7.62a	11.63a	17.00a	19.50a	7.75a	14.50a	23.56a	41.75a
	C318	6.25a	12.75a	14.63a	20.67a	5.88a	8.50b	12.19b	20.00b
CPH_{300} x	C143	5.25a	7.75a	12.00a	13.13a	6.25a	8.75a	11.88a	18.88a
	C318	4.25a	10.83a	11.63a	14.63a	2.50b	8.25a	12.00a	13.50a
PM_{150} x	C143	5.38a	12.50a	18.50a	24.50a	5.00a	7.88b	15.75a	24.50a
	C318	4.88a	9.13a	11.00a	8.63b	4.38a	10.75a	11.38a	19.75a
PM_{300} x	C143	5.75a	10.50a	12.75a	17.63a	4.50a	6.75a	13.13a	15.25a
	C318	5.00a	11.00a	17.25a	12.13a	4.00a	8.00a	17.19a	22.50a
Control x	C143	4.23a	6.25a	6.50a	12.83a	1.38b	2.87a	7.51a	10.50a
	C318	3.75a	8.00a	12.38a	8.50a	3.88a	3.87a	7.81a	7.38a
Mean		5.24	10.03	13.36	15.21	4.55	8.01	13.24	19.40
CV (%)		68.28	40.94	62.62	24.36	20.16	25.75	28.33	29.84

Means followed by same letters are significantly different in same treatments along a column by HSD (P=.05)
CPH_{150} = Cocoa pod husk at 150 kg Nha^{-1}; CPH_{300} = Cocoa pod husk at 300 kg Nha^{-1}; PM_{150} = Poultry manure at 150 kg Nha^{-1}; PM_{300} = Poultry manure at 300 kg Nha^{-1}; MAT= Months after transplanting

3.7 Effects of Organic Fertilizers and Tea Cultivars on Stem Diameter

Table 7 reveals that cultivar 143 had thicker stem than cultivar 318 especially from 9-12MAT. The same trend was observed in Owena as the stem diameter of cultivar 143 were higher than that of cultivar 318 throughout the sampling periods except 3-6MAT when the stem of C318 was thicker than that of C143. The different rates of the organic fertilizers were significantly (P=.05) different in enhancing the plant height of tea plants in both locations. The 150 kg Nha^{-1} of CPH and PM consistently enhanced higher height of tea plants than 300 kg Nha^{-1} in both locations. This is consistent with [35] who posited that cultivar 143 performed better than 318 in vegetative growth; and with [37] who found out that tea performed optimally under 150 kg Nha^{-1} fertilization.

3.8 Effects of Organic Fertilizers and Tea Cultivars on Dry Matter of Tea

Table 8 shows that cultivar 143 was superior to 318 significantly (P=.05) in the accumulation of photo assimilate. The total dry matter of C143 (95.04 and 110.31 $plant^{-1}$at Ibadan and Owena respectively) is significantly (P=.05) higher than that of C318 (42.04 and 52.22 $plant^{-1}$ at Ibadan and Owena respectively). Similarly, 150 kg Nha^{-1} CPH enhanced significantly (P=.05) higher RDW (Root dry weight), SDW (Stem dry weight) and LDW (Leaf dry weight) compared to other fertilizer rates and the control. CPH at 150 kg Nha^{-1} increased the total dry matter by 84.21, 286.65, 109.24 and 428.11% at Ibadan; and at Owena by 82.22, 40.84, 183.69 and 231.49% compared to 300 kg Nha^{-1} CPH, 150 kg Nha^{-1} PM, 300 kg Nha^{-1} PM and control respectively. Moreover, 150 kg Nha^{-1} rate of CPH and PM was better than their 300 kg Nha^{-1} in enhancing dry matter accumulation especially at Owena. Similarly, the interactions of the different fertilizer rates with the two tea cultivars was significantly (P=.05) different in dry matter accumulation. The effectiveness of the fertilizers in enhancing the accumulation of dry matter was higher in C143 plants than in C318. The highest dry matter at Ibadan (213.67 g/plant) and Owena (216.59 g/plant) was observed under the interaction of 150 kg Nha^{-1} CPH with cultivar 143. The reported better adaptability to lowland and better vigor for growth [34, 35] might explain the higher efficiency of the applied fertilizers in cultivar 143 compared to 318.

Table 5. Effects of cultivars and organic farm wastes (OFW) on leaf area (cm^2) of tea plants in Ibadan and Owena

Treatments	Ibadan				Owena			
Cultivars	**3MAT**	**6MAT**	**9MAT**	**12MAT**	**3MAT**	**6 MAT**	**9 MAT**	**12MAT**
C143	1055.72a	1436.96a	1802.61a	3581.02a	683.85a	1419.67a	2529.78a	4436.72a
C318	1053.92a	1210.40a	1253.87a	1917.56a	608.50a	1063.42a	1844.88a	2382.04b
OFW								
CPH_{150}	1548.38a	1777.75a	2554.08a	4595.30a	911.18a	1963.77a	3003.14a	6318.58a
CPH_{300}	1164.35a	1293.55ab	1320.23bc	2697.55b	494.75bc	1201.19b	1842.91bc	3307.43b
PM_{150}	1042.16a	1382.62a	2089.55ab	2774.56ab	704.01ab	1230.33b	2996.66a	3686.78b
PM_{300}	1058.52a	1430.77a	1145.09c	2649.01b	767.69ab	1216.21b	2087.30b	2409.16b
Control	460.68b	733.70b	532.24c	1030.05b	353.24c	596.24c	1006.65c	1324.96b
OFW x Cultivars								
CPH_{150} x C143	1693.02a	2116.23a	2922.83a	6295.15a	850.99a	2712.67a	4342.07a	9615.75a
C318	1403.75a	1439.27a	2185.34a	2895.46b	971.38a	1214.87b	1664.21b	3021.41b
CPH_{300} x C143	1199.84a	1313.46a	1423.27a	3153.02	575.53a	1440.51a	2091.27a	4257.62a
C318	1128.85a	1273.65a	1217.19a	2242.09	413.96a	961.87b	1594.04a	2357.23a
PM_{150} x C143	1041.07a	1526.09a	2652.49a	3814.37a	787.45a	1184.04a	3231.48a	4363.76a
C318	1043.25a	1239.16a	1526.52a	1734.74b	620.58a	1276.62a	2761.86a	3009.80a
PM_{300} x C143	888.48a	1452.14a	1383.06a	3598.88a	867.44a	1134.44a	1699.15b	2461.79a
C318	1228.57a	1409.39a	907.12a	1699.13b	971.38a	1297.98a	2475.46a	2356.53a
Control x C143	456.19a	776.85a	631.41a	1043.71a	337.86a	626.72a	1284.44a	1484.69a
C318	465.18a	690.55a	433.07a	1016.40a	368.63a	565.74a	728.85a	1165.24a
Mean	1054.82	1323.68	1528.24	2749.29	646.17	1241.55	2187.33	3409.38
CV (%)	53.74	42.72	50.07	64.44	38.82	24.91	12.66	52.40

Means followed by same letters are significantly different in same treatments along a column by HSD (P=.05)

CPH_{150} = Cocoa pod husk at 150 kg Nha^{-1}; CPH_{300} = Cocoa pod husk at 300 kg Nha^{-1} PM_{150} = Poultry manure at 150 kg Nha^{-1}; PM_{300} = Poultry manure at 300 kg Nha^{-1}; MAT= Months after transplanting

Table 6. Effects of cultivars and organic farm wastes (OFW) on plant height (cm) of tea plants in Ibadan and Owena

Treatments		Ibadan				Owena			
Cultivars		**3MAT**	**6MAT**	**9MAT**	**12MAT**	**3MAT**	**6 MAT**	**9 MAT**	**12MAT**
C143		44.62a	52.54a	67.88a	72.90a	38.45b	48.34a	57.09a	75.10a
C318		45.85a	55.18a	64.94a	66.93a	48.25a	52.47a	56.88a	65.97a
OFW									
CPH_{150}		51.22ab	63.66a	76.01a	82.02a	53.02a	64.35a	63.83a	94.28a
CPH_{300}		51.44a	60.53a	76.17a	75.43a	35.86a	47.01b	50.58a	73.81ab
PM_{150}		41.29a	55.61a	65.42ab	75.80a	49.06a	50.02b	56.75a	73.07ab
PM_{300}		47.58a	51.03ab	67.94a	66.71a	43.84a	49.35b	58.94a	59.36b
Control		34.60b	38.45b	46.52b	49.61a	34.98a	41.28b	54.82a	52.12b
***OFWx Cultivars**									
CPH_{150} x	C143	49.75	64.15	79.28	91.31	49.13	61.13	71.16	108.94
	C318	52.69	63.18	72.74	72.73	56.91	67.60	56.50	79.63
CPH_{300} x	C143	46.69	56.60	76.62	72.19	29.21	42.90	47.88	77.63
	C318	56.25	64.46	75.73	78.68	42.50	51.13	53.29	70.00
PM_{150} x	C143	45.86	54.49	69.67	91.83	44.63	41.18	54.59	81.61
	C318	36.71	56.72	61.18	59.76	53.50	58.88	58.92	64.53
PM_{300} x	C143	46.73	47.04	68.90	71.13	37.81	51.58	51.38	58.30
	C318	48.44	55.03	66.98	62.30	49.86	47.13	66.51	60.43
Control x	C143	34.05	40.40	44.95	38.06	31.50	44.95	60.45	49.00
	C318	35.15	36.50	48.10	61.16	38.46	37.61	49.20	55.25
Mean		45.23	53.86	66.41	69.91	43.35	50.41	56.98	70.53
CV (%)		24.95	25.23	31.22	36.56	21.77	24.75	22.71	31.53

Means followed by same letters are significantly different in same treatments along a column by HSD (P=.05); CPH_{150} = Cocoa pod husk at 150 kg Nha^{-1}; CPH_{300} = Cocoa pod husk at 300 kg Nha^{-1} PM_{150} = Poultry manure at 150 kg Nha^{-1}; PM_{300} = Poultry manure at 300 kg Nha^{-1}CPH = Cocoa pod husk; PM = Poultry manure; MAT= Months after transplanting

** = The interactions are not significantly different (P=0.05)*

3.9 Pearson Correlation between the Growth Parameters of Tea Plants

It is apparent in Table 9 that the vegetative growth parameters were positively correlated in the two locations. At Ibadan, number of leaves was positively correlated with number of branches, leaf area, plant height and stem diameter. The strongest relationship existed between number of leaves and leaf area (r=0.87***); plant height and leaf area (r=0.86***) as well as number of leaf and number of branches (r=0.84***). This signifies that the higher the number of leaves, the higher the leaf area and number of branches and vice versa; and the higher the plant height, the higher the leaf area. Stem diameter was positively but weakly correlated with number of leaves (r=0.36**), leaf area (r=0.37**) and number of branches (r=0.32**) while its correlation coefficient with plant height was not significant (P>0.05). However, at Owena, the strongest correlation existed between stem diameter and leaf area (r=0.80***), number of branches and number of leaves (r=0.79***) as well as number of leaves and leaf area (r=0.78***); while the weakest correlation at P<0.01 was between plant height and number of branches (r=0.41***), number of leaves (r=0.50***) and stem diameter (r=0.57***). The relationships between tea vegetative parts imply that number of leaves and leaf area have higher positive influence on other vegetative parts; and level of growth of other parts also determines their growth. This might be as a result of their photosynthetic capacity. The leaf is the most important photosynthetic site of the plant with preponderance of chlorophylls. Hence, its number and surface area have positive correlation with photosynthetic rate which in turn determines the plant growth rate. This corroborates the findings of [39] who reported that number of leaves and leaf area of rooted tea cuttings were positively correlated with their other morphological parameters.

Table 7. Effects of cultivars and organic farm wastes (OFW) on stem diameter (cm) of tea plants in Ibadan and Owena

Treatments		Ibadan				Owena			
Cultivars		**3MAT**	**6MAT**	**9MAT**	**12MAT**	**3MAT**	**6 MAT**	**9 MAT**	**12MAT**
C143		0.54a	0.67a	0.73a	1.35a	0.55a	0.60a	0.74a	0.89a
C318		0.62a	0.67a	0.71a	0.83b	0.57a	0.63a	0.71a	0.78a
OFW									
CPH_{150}		0.64a	0.79a	0.81a	1.20a	0.61a	0.71a	0.80a	1.03a
CPH_{300}		0.65a	0.71ab	0.73a	1.16a	0.52ab	0.62ab	0.76ab	0.89ab
PM_{150}		0.53a	0.63bc	0.73a	1.16a	0.57a	0.61b	0.73abc	0.88ab
PM_{300}		0.62a	0.71ab	0.69a	1.30a	0.64a	0.62bc	0.69bc	0.79b
Control		0.48a	0.51c	0.62	0.62b	0.45b	0.51c	0.64c	0.59c
OFW x Cultivars									
CPH_{150} x	C143	0.59a	0.85a	0.89a	1.69a	0.61a	0.70a	0.84a	1.24a
	C318	0.69a	0.74a	0.74a	0.72b	0.62a	0.71a	0.75a	8.13a
CPH_{300} x	C143	0.53a	0.65a	0.65a	1.52a	0.55a	0.64a	0.78a	9.14a
	C318	0.77a	0.77a	0.81a	0.80b	0.50a	0.61a	0.74a	8.64a
PM_{150} x	C143	0.56a	0.68a	0.81a	1.42a	0.53a	0.55a	0.72a	8.88a
	C318	0.50a	0.57a	0.66a	0.90b	0.62a	0.67a	0.74a	8.67a
PM_{300} x	C143	0.64a	0.67a	0.65a	1.54a	0.62a	0.61a	0.71a	8.08a
	C318	0.50a	0.74a	0.73a	1.07b	0.65a	0.60a	0.66a	7.66a
Control x	C143	0.40a	0.50a	0.64a	0.60a	0.43a	0.47a	0.63a	5.95a
	C318	0.55a	0.52a	0.59a	0.64a	0.47a	0.57a	0.66a	5.82a
Mean		0.58	0.67	0.72	1.09	0.56	0.61	0.72	8.33
CV (%)		25.88	20.66	23.56	7.94	20.62	14.06	13.39	19.12

Means followed by same letters are significantly different in same treatments along a column by HSD (P=.05)
CPH_{150} = Cocoa pod husk at 150 kg Nha^{-1}; CPH_{300} = Cocoa pod husk at 300 kg Nha^{-1} PM_{150} = Poultry manure at 150 kg Nha^{-1}; PM_{300} = Poultry manure at 300 kg Nha^{-1} MAT= Months after transplanting

Table 8. Effects of cultivars and organic farm wastes (OFW) on dry matter accumulation (g/plant) of tea plants in Ibadan and Owena 15 MAT

Treatments		Ibadan				Owena			
Cultivars		**RDW**	**SDW**	**LDW**	**TDM**	**RDW**	**SDW**	**LDW**	**TDM**
C143		21.24a	51.25a	23.55a	95.04a	29.42a	53.15a	27.74a	110.31a
C318		11.58a	19.56b	10.90a	42.04b	14.27b	25.06b	12.89b	52.22b
OFW									
CPH_{150}		27.10a	78.04a	33.90a	139.04a	34.31a	72.07a	33.11a	139.49a
CPH_{300}		19.02ab	39.44ab	17.02ab	75.48b	24.84ab	33.04b	18.68b	76.55bc
PM_{150}		10.59bc	16.28b	9.10b	35.96b	27.79a	45.38ab	25.88ab	99.04ab
PM_{300}		16.29abc	31.29b	18.88ab	66.45b	12.62bc	22.66b	13.88bc	49.17bc
Control		6.55c	12.00b	7.21b	25.76b	9.66c	22.39b	10.02c	42.08c
OFW x Cultivars									
CPH_{150} x	C143	38.51a	125.94a	49.23a	213.67a	53.24a	112.86a	50.58a	216.59a
	C318	15.68a	30.15b	18.58b	64.41b	15.46b	31.28b	15.65b	62.39b
CPH_{300} x	C143	23.30a	60.73a	27.34a	111.37a	30.36a	41.63a	27.14a	99.12a
	C318	14.74a	18.15a	6.71b	39.59a	19.32a	24.46a	10.21a	53.99a
PM_{150} x	C143	12.16a	15.67a	7.18a	35.00a	37.47a	60.74a	32.63a	130.84a
	C318	9.02a	16.88a	11.03a	36.92a	18.10b	30.01a	19.13a	67.24b
PM_{300} x	C143	23.19a	45.69a	29.65a	98.53a	14.24a	26.12a	16.74a	57.10a
	C318	9.39a	16.89a	8.10b	34.38a	11.01a	19.21a	11.03a	41.25a
Control x	C143	4.05a	8.23a	4.35a	16.64a	11.87a	24.43a	11.63a	47.92a
	C318	9.05a	15.76a	10.07a	34.88a	7.45a	20.35a	8.42a	36.23a
Mean		21.84	39.11	20.31	81.27	21.84	39.11	20.31	81.27
CV (%)		75.38	92.06	98.78	63.22	38.83	42.74	50.07	40.19

Means followed by same letters are significantly different in same treatments along a column by HSD (P=.05)
CPH_{150} = Cocoa pod husk at 150 kg Nha^{-1}; CPH_{300} = Cocoa pod husk at 300 kg Nha^{-1}; PM_{150} = Poultry manure at 150 kg Nha^{-1}; PM_{300} = Poultry manure at 300 kg Nha^{-1}; RDW = Root dry weight; SDW = Stem dry weight; LDW = Leaf dry weight; TDM = Total dry matter

Table 9. Pearson correlation between the growth parameters of tea plants at 12MAT in Ibadan and Owena

		NL	LA(cm^2)	NB	PH(cm)	SD(cm)
Ibadan	NL	1.00				
	LA(cm^2)	0.87***	1.00			
	NB	0.84***	0.76***	1.00		
	PH(cm)	0.73***	0.86***	0.66***	1.00	
	SD(cm)	0.36**	0.37**	0.32**	0.25Ns	1.00
Owena	NL	1.00				
	LA(cm^2)	0.78***	1.00			
	NB	0.79***	0.62***	1.00		
	PH(cm)	0.50***	0.61***	0.41	1.00	
	SD(cm)	0.66***	0.80***	0.69***	0.57***	1.00

NL = Number of leaves; LA = Leaf area; NB = Number of branches; PH = Plant height; SD = Stem diameter
**** = Correlation was significant at P<.01; ** = Correlation was significant at P<.05; Ns = Not significant at P>.05*

4. CONCLUSION

Organic farm wastes (OFW) when applied as organic fertilizer to tea enhanced its growth and dry matter accumulation. The 150 kg Nha^{-1} of the OFW engendered better performance of tea when compared to other rates. Application of the OFW in excess of 300 kg Nha^{-1} did not increase tea growth and hence may lead to wastage and nutrient toxicity. Besides, fertilizer effectiveness in growth enhancement was dependent on the tea cultivar planted as the response of cultivar 143 to the application of fertilizer was better than that of cultivar 318. It follows that growing C143 tea plants is recommended to prospective tea farmers in Ibadan and Owena, Southwest Nigeria, and that it can be successfully established on the field under applied milled cocoa pod husk at 150 kg Nha^{-1}.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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