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

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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 α<0.05.

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**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 [9]. 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

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**Results:** The C143 performed better than C318 and 150 kg N ha\(^{-1}\) of CPH and PM enhanced the vegetative growth and dry matter of tea better than 300 kg N ha\(^{-1}\) 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 N ha\(^{-1}\) 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 N ha\(^{-1}\) 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 N ha\(^{-1}\) 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.
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].

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 plants were marked out at a spacing of 100x60 cm.

2.4. Soil Sampling and Analysis

The soil samples from 0-30 cm 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 N ha⁻¹ (CPH₁₅₀) (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\(^{\text{th}}\) and 6\(^{\text{th}}\) 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. 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 had 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

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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 watermelon 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). Theideo 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\(_2\)O) 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\(^{3+}\)                     | 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 |
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 cm² 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 cm² 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 C318 under all the fertilizer rates. At Ibadan, interaction of C143 with 150 kg Nha⁻¹ CPH produced the highest leaf area (1693.02, 2116.23, 2922.83 and 6295.15 cm² 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].

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**Table 2. Chemical properties of the organic farm wastes used**

| Properties   | Cocoa pod husk | Poultry manure |
|--------------|----------------|----------------|
| 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           |
Table 3. Effects of cultivars and organic farm wastes (OFW) on number of leaves of tea plants in Ibadan and Owena

| Treatments | Ibadan | Owena |
|------------|--------|-------|
|            | 3MAT   | 6MAT  | 9MAT  | 12MAT  | 3MAT   | 6MAT  | 9MAT  | 12MAT  |
| Cultivars  |        |       |       |        |        |       |       |        |
| C143       | 28.62a | 45.55a| 72.33a| 107.45a| 24.73a | 38.98a| 76.47a| 151.35a|
| C318       | 24.90a | 34.80a| 47.98ab| 54.83b| 19.68b | 27.77b| 45.31b| 59.52b |
| OFW        |        |       |       |        |        |       |       |        |
| CPH150     | 34.19a | 54.75a| 84.25a| 125.38a| 29.00a | 46.19a| 76.06a| 193.38a|
| CPH300     | 23.31a | 34.44bc| 51.25ab| 66.44b| 17.19c | 34.25ab| 65.03a| 91.75bc|
| PM150      | 25.69a | 37.06bc| 71.25a| 91.19ab| 24.44ab| 37.75ab| 73.94a| 121.88b |
| PM300      | 30.12a | 46.00ab| 59.38ab| 69.38b| 22.69abc| 30.25bc| 45.84b| 77.12bc|
| Control    | 20.50a | 28.62b| 34.62b| 53.31b| 17.69bc| 43.59a| 43.06c|        |
| OFW x Cultivars |        |       |       |        |        |       |       |        |
| CPH150 x C143 | 38.88a | 69.88a| 104.25a| 156.75a| 30.88a | 62.50a| 104.69a| 311.00a|
| CPH150 x C318 | 29.50a | 39.63b| 71.75a| 125.25a| 25.75b | 47.88a| 83.25a| 169.50a|
| CPH150 x C318 | 29.50a | 39.63b| 71.75a| 125.25a| 25.75b | 47.88a| 83.25a| 169.50a|
| CPH300 x C143 | 21.00a | 36.13a| 56.88a| 77.13a| 22.13a | 44.00a| 83.25a| 125.00a|
| CPH300 x C318 | 25.63a | 32.75a| 45.63a| 55.75a| 12.25a | 24.50b| 46.81b| 78.50b |
| PM150 x C143 | 30.00a | 47.75a| 100.41a| 147.75a| 27.50a| 36.13a| 82.38a| 169.50a|
| PM150 x C318 | 21.38a | 26.38a| 41.75b| 54.63b| 21.38a | 39.38a| 65.05b| 74.25b |
| PM300 x C143 | 27.88a | 48.63a| 70.25a| 92.00a| 24.50a| 32.25a| 52.38a| 92.00a |
| PM300 x C318 | 32.38a | 42.38| 48.50a| 64.75b| 20.88a| 28.25a| 39.31b| 62.25b |
| Control x C143 | 25.38a | 24.38a| 29.50a| 63.63a| 20.00a| 59.68a| 59.25a|        |
| Control x C318 | 15.63a | 32.88a| 39.75a| 43.00a| 16.75a| 16.88a| 27.50b| 26.88b |
| Mean       | 26.76a | 40.17a| 60.15a| 81.14a| 22.20a| 33.38| 60.89a| 105.44a|
| CV (%)     | 43.93a | 30.71a| 36.22a| 48.28a| 27.71a| 49.37a| 12.29a|        |

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

CPH150 = Cocoa pod husk at 150 kg Nha⁻¹; CPH300 = Cocoa pod husk at 300 kg Nha⁻¹; PM150 = Poultry manure at 150 kg Nha⁻¹; PM300 = 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 |       |       |       |       |       |       |
|------------|--------|-------|-------|-------|-------|-------|-------|
|            | 3MAT   | 6MAT  | 9MAT  | 12MAT | 3MAT  | 6MAT  | 9MAT  | 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|
| 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| 22.12bc|
| PM_{300}   | 5.58a  | 10.75ab| 15.00a| 14.88a| 4.25bc| 7.38b | 15.16ab| 18.88bc|
| Control    | 4.00a  | 7.12c | 9.44a | 10.67a| 2.62c | 3.38c | 7.66c | 8.94c |

OFW x Cultivars

| OFW x Cultivars |       |       |       |       |       |       |       |       |
|----------------|-------|-------|-------|-------|-------|-------|-------|-------|
|                 | 3MAT  | 6MAT  | 9MAT  | 12MAT | 3MAT  | 6MAT  | 9MAT  | 12MAT |
| CPH_{150} x C143| 7.62a | 11.63a| 17.00a| 19.50a| 7.75a | 14.50a| 23.56a| 41.75a|
| C143            | 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|
| C143            | 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|
| C143            | 4.88a | 9.13a | 11.00a| 8.63b | 4.38a | 10.75a| 19.75a| 19.75a|
| PM_{300} x C143 | 5.75a | 10.50a| 12.75a| 17.63a| 4.50a | 6.75a | 13.13a| 15.25a|
| C143            | 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|
| C143            | 3.75a | 8.00a | 12.38a| 8.50a | 3.87a | 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 dry matter. 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 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 |
|------------|--------|-------|
|            | 3MAT   | 6MAT  | 9MAT  | 12MAT | 3MAT | 6MAT | 9MAT | 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 | 2529.78a | 4436.72a |
| 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 | 1253.87a | 1917.56a | 608.50a | 1063.42a | 1842.91bc | 3307.43b |
| PM$_{150}$  | 1042.16a | 1382.62a | 2089.55ab | 2774.56a | 704.01ab | 1963.77a | 3003.14a | 6318.58a |
| PM$_{300}$  | 1058.52a | 1430.77a | 1145.09c | 1419.67a | 2529.78a | 4436.72a | 2382.04b | 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 |
| C143       | 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 | 3153.02a | 575.53a | 1440.51a | 2091.27a | 4257.62a |
| C143       | 1128.85a | 1273.65a | 2242.09a | 413.96a | 961.87b | 1594.04a | 2357.23a | 2409.16b |
| PM$_{150}$  x C143 | 1041.07a | 1526.09a | 2652.49a | 3814.37a | 787.45a | 1184.04a | 3231.48a | 4363.76a |
| C143       | 1043.25a | 1239.16a | 1526.52a | 2895.30a | 971.38a | 1214.87b | 1664.21b | 3021.41b |
| PM$_{300}$  x C143 | 888.48a | 1383.06a | 3598.88a | 867.44a | 1134.44a | 1699.15b | 2461.79a | 3009.80a |
| C143       | 1228.57a | 1409.39a | 907.12a | 1043.71a | 337.86a | 626.72a | 1284.44a | 1484.69a |
| Control x C143 | 456.19a | 776.85a | 631.41a | 1043.71a | 337.86a | 626.72a | 1284.44a | 1484.69a |
| Control x 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
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 chlorophyll. 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 |
|------------|--------|-------|
|            | 3MAT   | 6MAT  | 9MAT | 12MAT | 3MAT | 6MAT | 9MAT | 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<sub>150</sub> | 0.64a  | 0.79a | 0.81a | 1.20a | 0.61a | 0.71a | 0.80a | 1.03a |
| CPH<sub>300</sub> | 0.65a  | 0.71a | 0.73a | 1.16a | 0.52b | 0.62ab | 0.76ab | 0.89ab |
| PM<sub>150</sub> | 0.53a  | 0.63b | 0.73a | 1.16a | 0.57a | 0.61b | 0.73abc | 0.88ab |
| PM<sub>300</sub> | 0.62a  | 0.71a | 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 |

Means followed by same letters are significantly different in same treatments along a column by HSD (P=0.05)

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 |
|------------|--------|-------|
|            |        |       |       |        |       |       |       |       |
|            | 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<sub>150</sub> | 27.10a | 78.04a | 33.90a | 139.04a | 34.31a | 72.07a | 33.11a | 139.49a |
| CPH<sub>300</sub> | 19.02ab | 39.44ab | 17.02ab | 75.48b | 24.84ab | 33.04b | 18.68b | 76.55bc |
| PM<sub>150</sub> | 10.59bc | 16.28b | 9.10a | 35.96b | 27.79a | 45.38ab | 25.88ab | 99.04ab |
| PM<sub>300</sub> | 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 |

Means followed by same letters are significantly different in same treatments along a column by HSD (P=0.05)

* CPH<sub>150</sub> = Cocoa pod husk at 150 kg Nha<sup>-1</sup>; CPH<sub>300</sub> = Cocoa pod husk at 300 kg Nha<sup>-1</sup>; PM<sub>150</sub> = Poultry manure at 150 kg Nha<sup>-1</sup>; PM<sub>300</sub> = Poultry manure at 300 kg Nha<sup>-1</sup>; MAT = Months after transplanting
Table 9. Pearson correlation between the growth parameters of tea plants at 12MAT in Ibadan and Owena

|        | NL  | LA(cm²) | NB  | PH(cm) | SD(cm) |
|--------|-----|---------|-----|--------|--------|
| Ibadan | 1.00| 0.87*** | 0.84*** | 0.73*** | 0.36** |
|        |     | 1.00    | 0.76*** | 0.86*** | 0.37** |
|        |     |         | 1.00  | 0.66*** | 0.32** |
|        |     |         |       | 1.00    | 0.25Ns |
|        |     |         |       |         | 1.00    |
| Owena  | 1.00| 0.78*** | 0.79*** | 0.50*** | 0.66*** |
|        |     | 1.00    | 0.62*** | 0.80*** | 0.69*** |
|        |     |         | 1.00  | 0.41    | 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 N ha⁻¹ of the OFW engendered better performance of tea when compared to other rates. Application of the OFW in excess of 300 kg N ha⁻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 N ha⁻¹.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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