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Growth and seedling establishment of tea (*Camellia sinensis* (L) O. Kuntze) under varying plantain shade in Southwest Nigeria

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Abstract

Tea beverage is reputed worldwide for its numerous medicinal and nutritional benefits. Hot and humid climate is a major abiotic constraint to the cultivation of tea in Southwest Nigeria. Planting tea with shade trees has been used to ameliorate the adverse effects of hot climate on tea. A field experiment was carried out in Cocoa Research Institute of Nigeria stations in Ibadan and Owena, Southwest Nigeria to evaluate the growth and seedling establishment of tea plant under plantain shade. Two tea cultivars (C143 and C318) were planted on the field under three shade regimes (two plantain planting densities [1111 plantain ha^{-1} and 2222 plantain ha^{-1}] and control [zero shade]). The experiment was laid out in randomized complete block design arranged in Split-plots with four replications. Data on Number of Leaves (NL), Number of Branches (NB), Leaf Area (LA), Plant Height (PH), Stem Diameter (SD) and Survival Count (SC) were collected and analysed with ANOVA and descriptive statistics at $\alpha_{0.05}$. The results showed that cultivar 143 was significantly better than cultivar 318 in NL, NB, LA, SD and SC in Ibadan and Owena. In Ibadan, plantain density of 2222 increased NL, NB, PH, SD and LA by 24%, 58%, 69%, 89% and 180%, respectively in comparison with 1111 plantain ha^{-1}, and by 198%, 228%, 320%, 240% and 2364%, respectively compared to zero shade. In Owena, 2222 plantain ha^{-1} increased NL, NB, PH, SD and LA by 17%, 7%, 27%, 8% and 55%, respectively in comparison with 1111 plantain ha^{-1}, and by 94%, 60%, 64%, 18% and 106%, respectively compared to zero shade. Highest tea seedling SC of 79.43% and 78.69% in Ibadan and Owena, respectively was caused by 2222 plantain ha^{-1}. In Ibadan, highest NL (20.06), NB (5.81) and SD (0.53) were recorded in C143 under 1111 plantain ha^{-1}; while in Owena, highest NL (82.81), NB (16.56), SD (0.96) and LA (6295.84) were enhanced in C143 under 2222 plantain ha^{-1}. In conclusion, growing tea cultivar 143 under 1111 plantain/ha and 2222 plantain/ha shade densities enhanced its growth and seedling establishment in Ibadan and Owena.

Keywords: Plantain shade; Plantain density; Tea cultivar; Growth; Seedling establishment

1. Introduction

Tea is the most consumed beverage on earth [1]. It is consumed mainly as black tea (fermented), green tea (non-fermented) or oolong tea (semi-fermented) [2]. Its consumption has a lot of medicinal benefits. Green tea possesses powerful antioxidant which helps to neutralize reactive oxygen species (ROS) [3] and polyphenols [4] which prevents oral diseases, renal failure and cancer [5; 6]. Consumption of tea beverage has been used as treatment for infectious diseases and cold. Since its discovery in China in 2700BC, the cultivation of its plant and drinking of its products have spread to countries like Japan, Russia, India, Sri Lanka, Britain, America and Africa [7]. Today tea plant is cultivated in

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50 countries in all the five continents of the world with major producers being China, India, Kenya, Sri Lanka, Vietnam, Turkey, Indonesia and Iran [8].

The adaptability of tea plant (*Camellia sinensis* [L] O. Kuntze) is a function of its varieties, environmental and edaphic factors. There are two main varieties of tea: *Camellia sinensis var sinensis* and *Camellia sinesis var assamica* [9]. While the former is slow growing and tolerant to cold weather; the latter is fast growing and adaptable to warmer environment. Besides the two varieties above, the following tea varieties have been identified, selected and released to farmers as commercial cultivars on Mambilla highland in Nigeria: 35, 68, 143, 236 and 318 [10; 11]. Cultivars 143 and 318 were outstanding having been adapted to the lowland agro-ecologies of Nigeria [10; 11].

Since its introduction to Nigeria in 1952, tea cultivation has been confined to the highland of Mambilla where its upland varieties are cultivated on commercial scale. Tea is thriving on Mambilla because of its cool climate. However, land for tea cultivation on Mambilla highland is limited by different other agricultural practices and fast expanding urbanization. There is need to expand tea production to other parts of the country, especially the lowland area where the rainfall pattern and the acidic soils are similar to that of the highland. However, among other limiting factors, the hot and humid climate has been a major constraint to the cultivation of tea in Southern Nigeria; hence, the need to provide means of ameliorating the hot weather for enhanced tea cultivation. Shading has been reported to reduce light intensity and its resultant high ambient temperature. The numerous beneficial effects of shading on tea production and products have been documented [12].

Shading exerts positive effects on tea growth and development by reducing photo-inhibition, a common physiological phenomenon in tea when it is grown under full daylight. This explains why tea has been described as a shade loving plant [13]. Moreover, shading has been reported to influence the production of secondary metabolites in tea thereby improving the quality of tea beverage [14; 15] by reducing the flavonoid in tea leaves [16; 17], increasing the theaflavin [18] and the theanine (essential amino acids in tea) contents of tea leaves [19]. Aside from the direct influence of shade on tea plants, the indirect effect of shade in tea production include suppression of weed growth [20], increased soil organic matter [21], reduction of soil erosion [22] and nitrogen fixation especially when it involves planting of leguminous crops [23].

Growing tea and other beverage crops under shade plants is a common agronomic practice in many tea ecologies worldwide. Tea has been intercropped with different shade plants in many of parts of the world to ameliorate the adverse weather conditions. In Nigeria, Iremiren *et al*. [24] reported that plantain enhanced higher survival count of tea cuttings; eucalyptus has been successfully grown with tea on Mambilla Plateau. Pigeon pea (*Cajanus cajan* L.) and *Glyricidia sepium* (Jacq) have been reported to provide shade for growing tea in Sri Lanka and Hawaii [12; 25]. Plantain has been used and recommended as permanent shade for cacao [26]. However, there is dearth of information on the use of plantain as shade plant in field establishment of tea in Nigeria.

Therefore, this trial was conducted to evaluate the effects of different planting densities of plantain on field seedling establishment and vegetative growth of two cultivars of tea plants in Ibadan and Owena, Southwest Nigeria.

2. Material and methods

A field trial was conducted in Cocoa Research Institute of Nigeria (CRIN) stations: Idi-Ayunre, Ibadan (Latitude 07º 10'N; Longitude 03º 52'E [Tropical rain forest belt]) and Owena (Latitude 07º N; Longitude 05º 7'E [Humid rain forest belt]), Southwest Nigeria between 2016 and 2018. The locations experience two main seasons: rainy season and dry season. The rainy season is characterized by heavy rains, humid atmosphere and cloudy sky; while dry season is characterized by little or no rainfall, hot and scorching sun and a very low relative humidity. At Ibadan, 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 [27]. At Owena, relative humidity ranges 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 [28].

The trial was a 2 x 3 factorial which comprised two tea cultivars (143 and 318) and three plantain shade levels: 2,222 plantain stands ha^{-1} (3 x 1.5 m planting distance); 1,111 plantain stands ha^{-1} (3 x 3 m planting distance); zero plantain as control. The experiment was laid out in Randomized Complete Block Design (RCBD) arranged in Split-Plots with four replications (Blocks). Each block contained 2 main plots and 6 sub-plots: tea cultivars as the main plots and plantain densities as subplots; a gap of 2 m was allowed between the blocks and adjacent subplots.

The vegetation on the experimental sites was manually cleared, and plantain suckers were planted 16 months before the transplanting of tea. Tea clonal materials of 143 and 318 cultivars were planted in holes of 20 x 20 x 30 cm dimension at planting distance of 100 x 60 cm. The tea cuttings were transplanted at 8-11 leaf stage in the avenue of the rows of plantain stands. Weeding was done with hoe and cutlass four times per annum. In the dry season water was artificially applied to the base of the tea plants: Each stand of tea received 2 L of water 3 times per week. The watering was done between November 2017 and April 2018 while the dry season lasted.

On monthly basis, starting from 3 MAT (Months after transplanting), data were collected on number of leaves, number of branches, plant height, stem diameter and leaf area. At 9 MAT, data on survival count of established tea plants were collected. All data collected from the experiment were analyzed with descriptive statistics and ANOVA using STAR (Statistical Tools for Agricultural Research) [29] statistical software and the significant means were separated with Fishers Least Significant Difference (P=0.05).

3. Results and discussion

Table 1 shows that cultivars 143 and 318 were significantly (P=0.05) different in their number of leaves at Ibadan and Owena. At Ibadan, cultivar 143 increased in number of leaves from 10.68 at 3 MAT to 16.05 at 12 MAT as against cultivar 318 which increased from 6.32 in number of leaves at 3 MAT to 6.96 at 9 MAT and decreased to 5.92 at 12 MAT. In the same vein. at Owena, number of leaves of C143 increased from 16.50 at 3 MAT to 71.94 at 12 MAT, while that of C318 increased from 9.43 at 3 MAT to 25.99 at 12 MAT. Different plantain densities were significantly (P=0.05) different in enhancing number leaves of tea plants. Plantain densities at 1111 and 2222 per stand caused significantly higher number of leaves in comparison with zero plantain shade especially at 6-12 MAT in Ibadan and Owena. Plantain density at 2222 plantain ha^{-1} increased number of leaves by 24% and 198% compared to 1111 plantain ha^{-1} and zero shade, respectively at Ibadan, and by 17% and 94% at Owena. Tea cultivars were significantly different under all the shade regimes in Ibadan and Owena. However, C143 was superior to C318 in leaf production under the plantain shade and in the zero shade. The highest leaf production was observed in C143 under 2222 plantain stands ha^{-1}.

Branching was significantly (P=0.05) higher in cultivar 143 than in 318 (Table 2). Like in number of leaves, there was significant difference between the plantain densities in enhancing the growth of tea branches, with 2222 plantain ha^{-1} causing the highest number of branches except at 9-12 MAT in Ibadan where 1111 plantain ha^{-1} was superior to 2222 plantain ha^{-1}. Throughout the sampling periods, unshaded tea produced the least number of branches.

Table 3 reveals that tea cultivars were significantly (P=0.05) different in their plant heights. Cultivar 143 plants were taller than cultivar 318 in both locations. The difference was significant only at 6-12 MAT in Owena, but not significant (P>0.05) in Ibadan. Similarly, tea plants grown under plantain shade were taller than those grown in the open (Table 3). At Ibadan, tea plants under 2222 plantain ha^{-1} increased in height by 320% and 69% compared to those grown under 1111 plantain/ha and those grown in the open, respectively; while at Owena, tea plants under 2222 plantain ha^{-1} increased in height by 64% and 27% compared to those grown under 1111 plantain ha^{-1} and those grown in the open, respectively. Tea plants under plantain steadily increased in height from 3 MAT to 12 MAT in both locations; while in Ibadan, tea plants in the open declined in height from 19.07 cm at 3 MAT to 8.07 cm at 12 MAT.

In Table 4, C143 was significantly better than C318 in stem diameter at Ibadan and Owena. Tea under 2222 plantain ha^{-1} were significantly superior to those under zero shade. The same trend was observed in Owena, but the difference was not significant. Similarly, the highest stem diameter was produced in C143 tea under 1111 and 2222 plantain ha^{-1} at Ibadan and Owena, respectively.

The two tea cultivars differ significantly (P=0.05) in their leaf area under the different plantain shade levels (Table 5). The leaf area of C143 (189.56, 165.66 and 216.76 at 3, 6 and 9 MAT, respectively) were significantly higher than those of C318 (145.15, 140.94 and 162.35 at 3, 6 and 9 MAT, respectively). Similarly, at Owena, the leaf area of C143 (349.66, 412.63, 1056.06 and 4650.05 at 3, 6, 9 and 12 MAT, respectively) were significantly higher than those of C318 (205.32, 276.97, 320.24 and 687.79 at 3, 6, 9 and 12 MAT, respectively). In a similar trend, higher leaf expansion was observed in tea plants grown under plantain shade compared to the unshaded ones. Leaf area of shaded tea plants increased steadily throughout the sampling periods at Owena. However, at Ibadan the leaf area declined temporarily at 6 MAT and later continued to increase at 9 MAT. The 2222 plantain ha^{-1} significantly enhanced the leaf area of tea plants better than 1111 plantain and zero plantain especially in Ibadan. However, at Owena, although 2222 plantain ha^{-1} produced the highest leaf area, it was not significantly different from 1111 plantain ha^{-1}.

The superior leaf growth (number of leaves and leaf area), branching, stem diameter and plant height observed in C143 might be a result of its genetic and morphological characteristics as well as its ability to thrive under harsh tropical climate. CRIN [30] had observed C143 to be high yielding, drought tolerant, more adaptable to the lowland and more vigorous in growth than C318. The enhancement of number of leaves, number of branches, stem diameter, plant height and leaf area of tea by shade densities of 2222 and 1111 plantain ha^{-1} could be due to the moderate light quantum incident on the plants occasioned by different levels of plantain canopy. Subdued light intensities produce cooling effect on both the tea plants and the soil in which the plants grow. The subdued light must have precipitated optimal condition for photosynthesis by regulating leaf and canopy temperature [13]. This result corroborates the report of Hajiboland *et al*. [31] that tea growth was enhanced under intermediate light intensities. Besides, the shade imposed on the tea plants and their expanded canopies (as a result of moderate light intensities) had ameliorating effect on the soil in which the plants grew. At lower light intensities, soil water is conserved as a result of reduced evaporation, thus making enough water, an important reagent for photosynthesis more readily available for plant use [32].

Table 1 Effects of cultivars and plantain densities on number of leaves of tea plants on the field at Ibadan and Owena

	Ibadan				**Owena**			
Cultivars	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**
C143	10.68a	9.92a	12.97a	16.05a	16.50a	21.63a	40.52a	71.94a
C318	6.32b	6.35b	6.96b	5.92b	9.43b	13.69b	11.71b	25.99b
Mean	8.50	8.14	9.97	10.98	12.96	17.53	26.12	48.96
Plantain densities (Stands ha^{-1})								
1111	8.36ab	8.23b	11.81a	12.41a	13.75a	19.61a	28.36a	52.86a
2222	9.52a	10.14a	13.91a	15.39a	11.70b	16.77b	31.52a	62.03a
Zero shade	7.62b	6.03c	4.17b	5.16b	13.44a	16.20b	18.87b	32.00b
Mean	8.50	8.14	9.97	10.98	12.96	17.53	26.12	48.86
Plantain densities x Cultivars (Stands ha^{-1})								
1111 C143	12.09a	11.66a	14.89a	20.06a	18.31a	24.44a	41.80a	52.19a
C318	4.63b	4.81b	12.94b	4.75b	9.19a	14.78a	14.93b	11.81b
Mean	8.36	8.24	13.92	12.41	13.75	19.61	28.37	32.00
2222 C143	10.69a	10.28a	16.63a	17.78a	14.15a	19.72a	51.41a	82.81a
C318	8.34b	10.00a	7.00a	13.00a	9.25a	13.81a	11.63b	22.91b
Mean	9.52	10.14	11.82	15.39	11.70	16.77	31.52	52.86
Zero shade C143	9.25a	7.81a	7.41a	10.31a	17.03a	19.94a	28.36a	80.81a
C318	6.00b	4.25a	0.93b	0.00b	9.84a	12.47a	8.58b	43.25b
Mean	7.63	6.03	4.18	5.16	13.44	16.21	18.47	62.03

Means followed by the same letters in a column under a treatment are not significantly different by LSD (P=0.05)

There were significant differences in the effects of different tea cultivars and plantain densities on survival count of tea plants at the two locations (Figures 1 and 2). At Ibadan and Owena, C143 was significantly (P=0.05) superior to C318 in survival count. At Ibadan, the survival of tea under 2222 plantain ha^{-1} was significantly higher than that under 1111 plantain ha^{-1} and zero plantain in the following order: 79.43% > 32.24% > 25.74% for 2222, 1111 and zero plantain ha^{-1} respectively; while at Owena, 2222 plantain ha^{-1} was better than 1111 plantain ha^{-1}, though not significantly, but was significantly better than zero shade. This implies that plantain shade reduced the scorching effect of adverse weather condition resulting from high ambient temperature [33]. This underscores the fact that tea survival was grossly endangered under full light intensity especially during cloudless dry season when light intensity was at its brightest with the accompanying excessive rise in ambient temperature. Cultivar 143 survived better than 318 under 1111, 2222 and zero plantain shade conditions; its survival was significantly (P=0.05) different at Ibadan, especially under 1111 and zero plantain as against the situation at Owena, where the two cultivars were not significantly different under each plantain shade environment. The result of the interaction of cultivars with the different plantain densities shows that under all the plantain densities, C143 was better than C318 in enhancing seedling establishment, with the highest survival counts of 82.81% and 92.71% at Ibadan and Owena, respectively under 2222 plantain density. This was as a result of better ability of C143 to withstand wide range of ambient temperature [34]. Generally, tea plants survived the first dry season and performed better in vegetative growth in Owena than in Ibadan probably because Owena is located in humid forest zone with higher relative humid than Ibadan. The higher relative humidity in Owena could have slowed down the rate of evapotranspiration, thus reducing dehydration and wilting of tea plants as well as enhancing their survival in the hot season.

Table 2 Effects of cultivars and plantain densities on number of branches of tea plants on the field at Ibadan and Owena

	Ibadan				Owena			
Cultivars	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**
C143	2.06a	2.89a	3.09a	4.43a	2.35a	3.34a	8.35a	14.12a
C318	1.55b	0.79b	0.87b	2.52b	1.48b	1.74b	3.94b	6.32b
Mean	1.81	1.84	2.98	3.47	1.92	2.54	6.15	10.22
Plantain densities (Stands ha^{-1})								
1111	2.67a	2.36a	2.05b	3.41b	2.53a	2.73a	7.46a	11.22a
2222	1.66ab	2.47a	3.31a	5.38a	1.61b	2.64a	5.82b	11.98a
Zero shade	1.09b	0.69b	0.58c	1.64c	1.63b	2.25a	5.16b	7.47b
Mean	1.81	1.84	1.98	3.47	1.92	2.54	6.15	10.22
Plantain densities x Cultivars (Stands ha^{-1})								
1111 C143	3.59a	4.22a	3.78a	5.81a	3.25a	3.47a	9.63a	10.19a
C318	1.75a	0.5b	0.31b	1.00b	1.81a	2.00a	5.30b	4.75a
Mean	2.37	2.36	2.05	3.41	2.53	2.74	7.47	7.47
2222 C143	1.41a	3.25a	4.45a	5.44a	1.88a	3.63a	8.77a	16.56a
C318	1.91a	1.69b	2.17b	5.31a	1.34a	1.66a	2.88b	5.88a
Mean	1.66	2.47	3.31	5.38	1.61	2.65	5.83	11.22
Zero shade C143	1.18a	1.19a	1.03a	2.03a	1.94a	2.94a	6.66a	15.63a
C318	1.00a	0.19b	0.13b	0.00a	1.28a	1.56a	3.60b	8.34a
Mean	1.09	0.69	0.58	1.02	1.61	2.25	5.13	11.99

Means followed by the same letters in a column under a treatment are not significantly different by LSD (P=0.05)

Table 3 Effects of cultivars and plantain densities on plant height of tea plants on the field at Ibadan and Owena

	Ibadan				Owena			
Cultivars	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**
C143	18.67a	21.51a	20.22a	22.70a	27.83a	31.96a	52.82a	79.46a
C318	19.47a	18.82a	17.24a	18.67a	24.98a	27.17b	27.68b	51.08b
Mean	19.07	20.16	18.73	20.68	26.40	29.56	40.25	65.27
Plantain densities (Stands ha^{-1})								
1111	18.66a	19.15b	17.11b	20.05b	26.96a	30.84a	41.77ab	64.21b
2222	19.24a	26.60a	27.86a	33.93a	26.30a	30.42a	45.97a	81.73a
Zero shade	19.30	14.74b	11.21	8.07c	25.94a	27.42a	33.02b	49.86b
Mean	19.07	20.16	18.73	20.68	26.40	29.56	40.25	65.27
Plantain densities x Cultivars (Stands ha^{-1})								
1111 C143	21.44a	24.16a	21.03a	21.94a	28.19a	31.86a	52.10a	59.32a
C318	15.89b	14.14b	13.19a	18.17a	25.73a	29.83a	31.43a	40.40a
Mean	18.67	19.15	17.11	20.06	26.96	30.85	41.77	49.86
2222 C143	17.28a	20.83b	23.78a	30.03a	27.26a	36.10a	63.57a	81.78a

C318	21.20a	32.38a	30.94a	37.83a	25.34a	24.74a	28.36a	46.64a
Mean	19.24	26.61	27.36	33.93	26.30	30.42	45.97	64.21
Zero shade C143	17.28a	19.54a	14.84a	16.14a	28.03a	27.91a	42.79a	97.26a
C318	21.33a	9.94b	7.59a	0.00a	23.86a	26.94a	23.25a	66.20a
Mean	19.31	14.74	11.22	8.07	25.95	27.43	33.02	81.73

Means followed by the same letters in a column under a treatment are not significantly different by LSD (P=0.05)

Table 4 Effects of cultivars and plantain densities on stem diameter of tea plants on the field at Ibadan and Owena

	Ibadan				Owena			
Cultivars	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**
C143	0.34a	0.33a	0.30a	0.44a	0.38a	0.44a	0.53a	0.85a
C318	0.31b	0.25b	0.27a	0.19b	0.39a	0.35b	0.36b	0.58b
Mean	0.33	0.29	0.29	0.32	0.38	0.40	0.45	0.72
Plantain densities (Stands ha^{-1})								
1111	0.32a	0.26b	0.20b	0.27b	0.38a	0.45a	0.50a	0.71a
2222	0.34a	0.35a	0.40a	0.51a	0.41a	0.47a	0.61a	0.77a
Zero shade	0.32a	0.24b	0.26b	0.15b	0.35a	0.39a	0.49a	0.65a
Mean	0.33	0.28	0.29	0.30	0.38	0.44	0.53	7.1
Plantain densities x Cultivars (Stands ha^{-1})								
1111 C143	0.37a	0.35a	0.27a	0.54a	0.38a	0.45a	0.50a	0.88a
C318	0.27b	0.18b	0.13b	0.00b	0.38a	0.38a	0.39b	0.55b
Mean	0.32	0.44	0.27	0.27	0.38	0.42	0.45	0.72
2222 C143	0.35a	0.31b	0.37a	0.50a	0.40a	0.47a	0.61a	0.96a
C318	0.33a	0.41a	0.42a	0.52a	0.42a	0.37a	0.38b	0.58b
Mean	0.34	0.36	0.40	0.51	0.41	0.42	0.50	0.77
Zero shade C143	0.32a	0.33a	0.26a	0.27a	0.36a	0.39a	0.49a	0.70a
C318	0.32a	0.16b	0.26a	0.00b	0.36a	0.31a	0.38b	0.60a
Mean	0.32	0.25	0.26	0.14	0.36	0.35	0.44	0.65

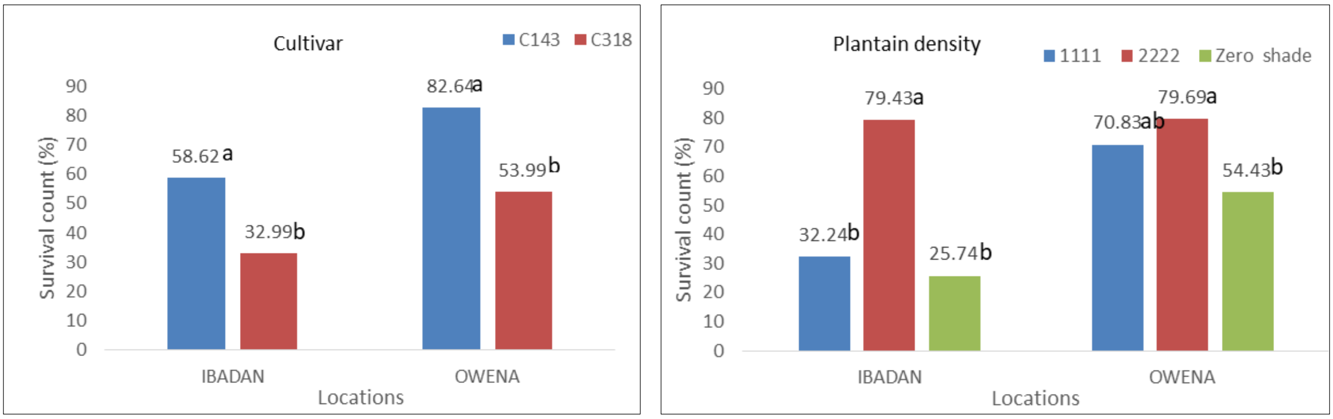
Means followed by the same letters in a column under a treatment are not significantly different by LSD (P=0.05)

Table 5 Effects of cultivars and plantain densities on leaf area of tea plants on the field at Ibadan and Owena

	Ibadan				Owena			
Cultivars	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**
C143	189.56a	165.66a	216.76a	361.32a	349.66a	412.63a	1056.06a	4650.05a
C318	145.15b	140.94b	162.35b	242.73a	205.32b	276.97b	320.24b	687.79b
Mean	167.36	153.30	189.55	302.03	277.49	344.80	688.15	2668.92
Plantain densities (Stands ha^{-1})								
1111	163.10b	159.81b	209.31b	231.58b	279.37a	362.87a	690.78ab	2427.04ab
2222	193.70a	259.47a	333.20a	648.19a	263.83a	371.17a	908.55a	3755.09a

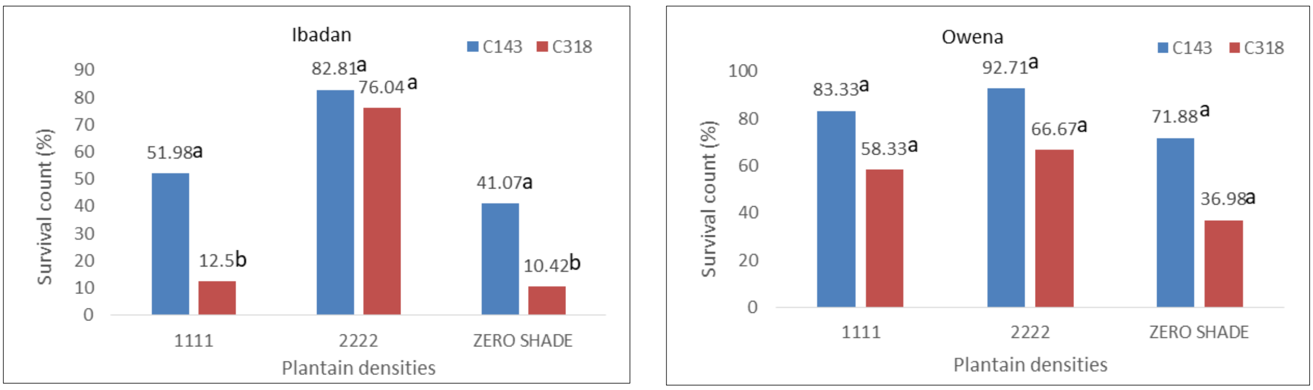
Zero shade	145.27b	40.63c	26.16c	26.31c	283.27a	300.36a	465.12b	1824.63b
Mean	167.36	153.30	189.55	302.03	277.49	344.80	688.15	2668.92
Plantain densities x Cultivars (Stands ha^{-1})								
1111 C143	217.32a	213.81a	328.17a	321.38a	376.58a	369.74a	917.62a	4423.06a
C318	108.89b	105.80b	338.21a	141.78b	182.16a	356.00a	463.94a	431.02b
Mean	163.11	159.81	333.19	231.58	279.37	362.87	690.78	2427.04
2222 C143	173.04a	227.10a	284.72a	709.97a	339.71a	473.10a	1529.33a	6295.84a
C318	214.36a	291.84a	133.89b	586.41a	199.96a	269.24a	287.78b	1214.34b
Mean	193.70	259.47	209.31	648.19	269.84	371.17	908.56	3755.09
Zero C143 shade	178.33a	56.08a	37.37a	52.63a	332.69a	395.06a	721.24a	3231.25a
C318	112.21a	25.19a	14.95a	0.00a	233.86a	205.67a	209.01b	418.10b
Mean	145.27	40.64	26.16	26.32	283.28	300.67	465.13	1824.68

Means followed by the same letters in a column under a treatment are not significantly different by LSD (P=0.05)



Means followed by the same letters in each composite graph are not significantly different by LSD (P=0.05)
C143: cultivar 143; C318: cultivar 318; 1111:1111 plantain stands/ha; 2222: 2222 plantain stands/ha

Figure 1 Main effects of cultivar and plantain density on survival count of tea plants at Ibadan and Owena



Means followed by the same letters in each composite graph are not significantly different by LSD (P=0.05)
C143: cultivar 143; C318: cultivar 318; 1111: 1111 plantain stands/ha; 2222: 2222 plantain stands/ha

Figure 2 Interaction effects of cultivar and plantain density on survival count of tea plants at Ibadan and Owena

4. Conclusion

Growing tea under plantain shade enhanced its growth and seedling establishment at Ibadan and Owena. The growth and seedling establishment of cultivar 143 was better than that of 318 under all the plantain shade regimes, but its optimum was attained under 2222 plantain density ha^{-1}. Tea growth performance was enhanced at Owena than at Ibadan. It is therefore recommended to prospective tea farmers in Southwest Nigeria that C143 should be preferred to C318, and that growing it under 2222 plantain ha^{-1} density would enhance its growth and early field establishment.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest

References

[1] Martins LC. Tea: The Drink that Changed the World. 2007; 8.

[2] Odom D. Cammelia sinensis. The Tea Plant. The Cammellia Journal. June – August 2007; 18.

[3] Mitscher L, Pillai S, Pillai C and Shankel D. Antibiotic resistance preventive properties of green tea. Proceedings of International conference on O-Cha (Tea) Culture and Science, Shizuoka, Japan. October 5-8 2001; 1-4.

[4] Yayabe F. Industrial application of tea extracts. Proceedings of International conference on O-Cha (Tea) Culture and Science, Shizuoka, Japan. October 5-8 2001; 80-83.

[5] Juneja LK. Green tea: A storehouse of exciting nutraceuticals. Proceedings of International conference on O-Cha (Tea) Culture and Science Shizuoka, Japan. October 5-8, 2001; 76-79.

[6] Friedman M, Mackey BE, Kim NJ, Lee IS, Lee KP Lee SU, Kozukue K, Kozukue N. Structure-activity relationship of tea compound against human cancer cells. J. Agric. Food Chem. 2007; 55: 243-253.

[7] Pham T. How tea travels from China to Africa. Ezen Articles. 2012; 1-3.

[8] FAO (Food and Agriculture Organization of the United Nations). FAOSTAT. 2014.

[9] Bonheure D. TEA. The Tropical Agriculturist. (Macmillan Ltd. 1991). 1991; 1-54.

[10] Oloyede AA, Olaniyi OO, Adeosun OA, Muyiwa AA, Akanbi OSO. Variability of selected tea genotypes (Camellia sinensis) to stem cutting propagation in Nigeria. Conference Proceeding: 38th Annual Conference of the Genetics Society of Nigeria. 2014; 546-551.

[11] Oloyede AA, Olaniyi OO, Adeosun SA, Adeigbe OO. Effect of locations, clones on biochemical constituents of tea leaves in Nigeria. Proceeding of the 51st Annual Conference of the Agricultural Society of Nigeria, Abuja. 2017; 227-230.

[12] TRI. Shade in tea. The Tea Research Institute of Sri Lanka Advisory Circular. 2003; Serial No.3/03: 1-8.

[13] Janendra WA, De Costa M, Mohotti AJ, Wijeratne MA. Ecophysiology of Tea. Braz. J. Plant Physiol. 2007; 19(4): 1-3.

[14] Zhang WJ, Liang YR, Zhang FZ, Chen CS, Zhang YG, Chen RB, Wang BQ. Effects on yield and quality of oolong tea by covering with shading net. J. Tea Sci. 2004; 24: 276-282.

[15] Wang KR, Li NN, Su YY, Liang YR. Effect of sunlight shielding on leaf structure and amino acids concentration of light sensitive albino plant. African Journal of Biotechnology. 2013; 12(36): 5535-5539.

[16] Yunsheng Wang, Li Ping Gao, Fao Xia. Influence of shade on flavonoid biosynthesis in tea (Camellia sinensis (L) O. Kuntze). Scientia Horticulturae 141. 2012; 7-16.

[17] Zhang Q, Shi Y, Ma L, Yi X, Ruan J. Metabolomic Analysis Using Ultra-Performance Liquid Chromatography-Quadrupole-Time of Flight Mass Spectrometry (UPLC-Q-TOF MS) Uncovers the Effects of Light Intensity and Temperature under Shading Treatments on the Metabolites in Tea. 2014; PLoS ONE 9(11): e112572.

[18] Owuor PO, Othieno CO, Howard GE, Robinson JM, Cooke RD. Studies on the use of shade in tea plantations in Kenya: Effects on chemical composition and quality of made tea. J. Sci. Food Agriculture. 1988; 46: 63-70.

[19] Ku KM, Choi JN, Kim J, Yoo LG, Lee CH. Metabolomics analysis reveals the compositional differences of shade grown tea (Camellia sinensis L.). J Agric. Food Chem. 2010; 58: 418-426.

[20] Bermudex MM. Erosion hidrica y escorrentia superficial en el sistema de café (Coffea Arabica L.) por (Erythrina poepigiana (Walper) O.F. Cook) en Turrialba, Costa Rica. MSc. Thesis Turrialba/Costa Rica. CATIE-UCR. 1980; 74.

[21] Santana MB, Cabala PX. Reciclagem de nutrients emu ma plantacao de cacao sombreada com Eritrina. In: Proc IX Int coca Res Conf, Togo. 1984; 205-2010.

[22] Wiersium KF. Surface erosion under various tropical agro-forestry systems. In: O'Loughlin CL, Pearce AJ, eds, Symposium on effects of forest land use on erosion and slope stability. 1984; 231-239.

[23] Escalante G, Herrera R, Aranguren J. Fijacion de nitrogeno en arboles de sombre (Erythrina poeppigiana) en cacaotales del Norte de Venezuela. Pesqui Agropecu Bras 19. 1984; 223-230.

[24] Iremiren GO, Ipinmoroti RR, Daniel AM. Effect of shade management on tea cutting survival in two lowland agro-ecological areas in Nigeria. The 4th International Conference on O-CHA (Tea) Culture and Science Abstracts, October 26-28, 2010; 49.

[25] Velenzuella H. Pigeon peas: A multipurpose crop for Hawaii. In: Hana'Ai/The Food Provider. 2011; 1.

[26] Famaye AO, Iremiren GO, Akanbi OSO, Aiyegboyin KO, and Adejobi KB. Effects of Plantain (Musa species) as shade on growth performance of cocoa seedlings in the nursery at Ibadan, Southwest Nigeria. Natural Science. 2014; 6: 447-453.

[27] CRIN (Cocoa Research Institute of Nigeria) Weather reports. 2016.

[28] OSAR (Ondo State Agro-Climatological Report). 2016.

[29] STAR (Statistical Tools for Agricultural Research). 2013.

[30] Annual Report of the Cocoa Research Institute of Nigeria. 1983; 47-56.

[31] Hajiboland R, Bastani S, Rad SB. Effect of light intensity on photosynthesis and antioxidant defence in boron deficient tea plants. Acta Biologica Szegediensis. 2011; 55(2): 265-272.

[32] Mohotti AJ, Lawlor DW. Diurnal variation of Photosynthesis and Photoinhibition in tea: effect of irradiance and nitrogen supply during growth in the field. J. Exp. Bot. 2002; 53: 313-322.

[33] Obatolu CR, Ipinmoroti RR. The comparative study of five clones under plantain shade in Ibadan, South-Western Nigeria. Proc. 18th HORTSON Conference. IAR/ABU, Zaria. 2000; 207-211.

[34] Annual Report of the Cocoa Research Institute of Nigeria. 1985; 55-69.

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