World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

Growth performance of tea (*Camellia sinensis* [L.] Kuntze) as influenced by light intensities on the field in Ibadan, Southwest Nigeria

Seun Adewale Adeosun *

Agronomy and Soils Division, Cocoa Research Institute of Nigeria, P.M.B 5244, Ibadan, Nigeria.

World Journal of Advanced Research and Reviews, 2023, 20(03), 764–773

Publication history: Received on 23 October 2023; revised on 07 December 2023; accepted on 10 December 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.20.3.2234

Abstract

Tea is one of the most important beverage crops consumed for its antioxidant properties in many parts of the world. Growing tea in Southwest Nigeria is constrained by the warm climate occasioned by high light intensity of the area. Regulation of Light intensity (LI) is necessary for possible cultivation of tea in this area. Information on response of tea to LI in Southwest Nigeria is scanty. Therefore, field experiment was carried out in Cocoa Research Institute of Nigeria Ibadan to assess the growth of two tea cultivars, 143 and 318 under three light intensities: 100% ($1.04x10^5$lux), 65% ($6.75x10^4$lux) and 45% ($4.57x10^4$lux) achieved by using sheds of 0, 1 and 2 palm fronds layers, respectively. 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), Plant height (PH, cm), Stem diameter (SD, cm), Leaf area (LA, cm^2) and Dry matter (DM, g) accumulation were obtained following standard procedures, and were analyzed with descriptive statistics and ANOVA at $\alpha_{0.05}$. Cultivar 143 performed significantly better than 318 with 88.94NL, 18.73NB, 62.99PH, 0.94SD, 2194LA and 56.38DM under 45% light intensity. The highest NL (84.07), NB (15.86), PH (68.63), SD (1.06) and LA (2885.75) was produced under 45% light, while the least was produced under 100% LI. Total DM ranged from 30.20 g/plant under 100% LI to 65.80 g/plant under 45% LI. In conclusion, optimal vegetative growth and dry matter accumulation of tea cultivar 143 was achieved under 45% LI using sheds of 2 layers of palm fronds.

Keywords: Tea cultivars; Light intensity; Vegetative growth; Dry matter accumulation

1. Introduction

Tea plant is an evergreen bush beverage tree crop in the family Theaceae which when cultivated is kept at a low level of 30-60cm to facilitate the plucking of the young shoot (flush). It is one of the most important beverage crops in the world [1]. Based on processing methods it is classified as black tea (fermented), green tea (non-fermented) or oolong tea (semi-fermented) beverage [2]. Consumption of its beverage affords many health benefits owing to its anti-oxidant property. Regular consumption of tea has been linked with lower chances of suffering from diseases like cancer and cardio-vascular diseases [3]. Besides, it also helps to prevent blood clotting, lower cholesterol levels, neutralize enzymes that aid in the growth of tumours, lower chances of suffering from cancer and cardio-vascular diseases and stimulate immune system [3, 4]. Tea leaf contains a number of chemicals of which 30% is flavonoids [5]; 20-30% is tannic acid known for its anti-inflammatory and germicidal properties, alkaloid (5% caffeine), a stimulant for the nerve centre and the process of metabolism [6]. These numerous health benefits have led to its fast and wide spread to all the continents of the world. However, supra bright and warm weather of the dry season with accompanying high light intensity in Southern Nigeria has constituted major constraint to tea cultivation in the area.

Light is an absolute requirement for plant growth. It is the most imperative factor among all the ecological factors [7]. Growth and development of tea plants have been reported to be influenced in various ways and locations by light

* Corresponding author: Adeosun, Seun Adewale; Email:seunfunmi1999@gmail.com

intensity. Light affects tea growth and production through its role in photosynthesis and through photoperiodic reactions [8, 9]. Adeosun *et al.* (2023) [10] found out that sub and supra Photosynthetic active radiation undermined the photosynthetic capacity of potted tea plants as it reduced their chlorophyll and carotenoids contents. Besides, Wang *et al.* (2013) [11] submitted that high sunlight resulted in low levels of chlorophyll and carotenoids in albino tea plant.

Tea has been described as a light sensitive plant [12]. Its production potential is fully expressed under reduced light intensity. Tea being a C3 plant undergoes photo-inhibition under excessive light intensity. Photo-inhibition is a process whereby photosynthetic rate is reduced or completely hampered under excessive light intensity. It is initiated by excessive irradiation which causes stomata closure. Light intensity exerts direct and indirect effect on guard cells that control the opening and closing of stomata. According to Jannedra *et al.* (2007) [13], stomata conductance is affected by light intensity as its opening is sensitive to several stimuli from external environment like light intensity, water availability, leaf temperature and Vapour Pressure Deficit (VPD). Excessive light intensity increases leaf temperature and transpiration rate. When transpiration rate exceeds water absorption in the plant, it precipitates low leaf water potential, making the guard cells to lose turgor and collapse. The collapse of the guard cells implies stomata closure which leads to poor stomata conductance and consequent blocking of CO_2 diffusion into the leaf. Jannedra *et al.* (2007) [13] had earlier posited that there was positive relationship between photosynthesis and stomata conductance because at higher stomata conductance there is higher CO_2 flux for photosynthesis and vice versa.

Tea cultivars vary in their response to light intensity owing to their genetic constitution differential. While some tea cultivars tolerate high light intensity, the growth of some is significantly retarded under same light intensity. It has been reported by Wachira *et al.* (2013) [14] that *Camellia sinensis* var. sinensis with smaller relatively erect dark green leaves which originated from China is hardier than *Camellia sinensis* var. assamica with more horizontally held, glossy surface, light green leaves, which originated from Assam in India. Also, 143 and 318 tea cultivars normally cultivated on Mambilla highland in Nigeria differ in their response to reduced light intensity [12]. However, there is dearth of information on the optimum light intensity that could enhance establishment and growth of tea on the field in Nigeria. Therefore, this field trial was carried out to assess the influence of different levels of light intensity on establishment and growth of two cultivars of tea on the field in Ibadan, Southwest Nigeria.

2. Materials and methods

2.1. Description of experimental sites

Ibadan, the site of the experiment, is located in Southwest Nigeria, on latitude 07^{o} 10'N and longitude 03^{o} 52'E on 122 m elevation above sea level. It experiences a rainy season which is characterized by humid atmosphere and cloudy sky from April to October with short dry spell in August, and a dry season which is characterized by little or no rainfall and runs from November to March. The annual rainfall ranges from 1100 to 1150 mm, average temperature from 19.8 °C to 27.0 °C and relative humidity from 57% to 89% [15].

2.2. Acquisition of experimental materials

Tea clonal materials of 143 and 318 cultivars were obtained from CRIN Substation Kusuku, Mambilla Plateau, Taraba State.

2.3. Experimental design and layout

This field experiment was a factorial of 2 factors: 2 cultivars (143 and 318) and 3 levels of light intensity (45% = $4.57x10^4$lux ; 65% = $6.75x10^4$lux and 100% = $1.04x10^5$lux). These resulted in 6 treatment combinations laid out in randomized complete block design (RCBD) arranged in Split plots with four replications (blocks). Cultivars and light intensities served as main and sub-plots, respectively. The varying light intensities were achieved through the construction of sheds of varied palm fronds layers

2.4. Land preparation of experimental sites

The land was cleared of all vegetation manually. The plot was laid out into four blocks (replicates) by using ranging pole, measuring tape, wooden pegs and measuring line. Each block comprised 2 main plots and 6 sub-plots. Each subplot was 8 m long and 3 m wide. A gap of 2 m was allowed between the blocks and between the subplots in each block. The total land area of the experimental site was 1044 m^2.

2.5. Construction of sheds and transplanting of tea clones

The experimental site was laid out into four blocks (replicates). Each block consisted of six subplots. Each block of the experiment contained four sheds. Each shed was 8 m long, 3 m wide and 2 m high. The sheds were erected with bamboo poles and palm fronds covering the top and sides of the sheds. Light intensities of 45 and 65% were predetermined by varying the layers of oil palm fronds at the sides and top of the sheds. The open space with no shed cover represented 100% light intensity; while 45 and 65% light intensities were achieved with 2 and 1 oil palm frond layers, respectively [12]. Transplanting of tea clones that have been raised for 16 months were transplanted into already dug holes of 20 x 20 x 25 dimension. The transplanting was done at a planting distance of 100 cm x 60 cm. In each sub-plot, six rows of four stands of tea plants were planted. For the plants inside the sheds, a space of 1 m was allowed between the shed wall and the tea plants.

2.6. Data collection and analysis

At 3 MAT (months after transplanting), a sample of twelve tea plants per treatment per replicate was randomly tagged for morphological parameters: number of leaves, number of branches, leaf area, plant height and stem diameter. The measurement of the morphological parameters was done on monthly basis. At 15 MAT plant samples used for morphological data collection were uprooted. A circumference of 15-20 cm radius from the base of the plant was dug to a depth of 50 cm round the plant to expose the roots and each of the plant was carefully uprooted. The uprooted plants were partitioned into root, stem and leaf. The roots were washed in clean water to remove soil particles. The fresh weight of the plant parts was measured. The plant parts were packaged in paper envelopes, oven dried at 70 ^{o}C for 48 hours to constant weights and their dry weight was measured [16]. Both the fresh and dry weights were measured with the KERRO Electronic Compact Scale. All the data collected were analysed with Analysis of Variance (ANOVA) using STAR (Statistical Tools for Agricultural Research) (2013) [17] software and the significant means were separated with Tukey's Honest Significant Difference (HSD) Test (P=0.05).

3. Results

Cultivar 143 and 318 were significantly (P=0.05) different in number of leaves (Table 1). Number of leaves increased from 3 MAT through 12 MAT. Number of leaves of C143 was significantly higher than that of C318 especially between 6 and 12 MAT. Number of leaves of C143 increased from 43.88 at 6 MAT to 88.94 at 12 MT as against 318 that increased in number of leaves from 33.37 to 49.47 at the same time interval. Light intensities were significant (P=0.05) in enhancing leaf growth of tea (Table 1). At 3 MAT, tea plants under 100% light were significantly superior in flushing compared to those under reduced light intensities of 45 and 65%. However, as the growth of tea progressed with time, 45 and 65% light intensities superseded 100% in enhancing leaf growth especially from 6 MAT, and by 12 MAT, tea under 45% light had produced significantly more leaves of 84.07 compared to 100% light intensities which caused 57.03 leaves. The effect of interaction of light intensities with cultivars on leaf production of tea was significant (P=0.05). Cultivar 143 was superior to cultivar 318 under 45, 65 and 100% light intensities especially at 3 MAT and 12 MAT.

Table 1 Effects of cultivars and light intensities on number of leaves of tea plants on the field at Ibadan

Treatments	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**
Cultivars				
C143	32.31a	43.85a	68.33a	88.94a
C318	28.85a	33.37b	41.64b	49.47b
Mean	30.58	38.61	54.98	69.20
Light intensities (%)				
45	29.07b	41.05a	64.00a	84.07a
65	26.81b	34.05a	61.40a	66.50ab
100	35.86a	40.73a	39.55a	57.03b
Mean	30.58	38.61	54.98	69.20

Light intensities (%) x Cultivars					
45	C143	31.98a	79.79a	48.02a	115.33a
	C318	26.17b	48.21a	34.08b	52.81b
Mean		29.08	64.00	41.05	84.07
65	C143	28.88a	73.00a	40.50a	82.67a
	C318	24.79b	49.79a	27.61b	50.33b
Mean		26.84	61.40	34.06	66.50
100	C143	36.13a	52.19a	43.04a	68.81a
	C318	35.60b	26.92a	38.41a	45.25b
Mean		35.87	39.56	40.73	57.03

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

Stem branching in tea was significantly influenced by the different cultivars (Table 2). Cultivar 143 was significantly (P=0.05) higher in number of branches than 318, but its superiority was significant only at 9 – 12 MAT. Light intensities were not significantly different in enhancing the number of branches of tea except at 6 MAT when 45 and 100% lights produced significantly higher branches compared to 65% light intensities. However, C143 performed better than 318 under all the light intensities, especially at 12 MAT, although the difference was not significant (P>0.05).

Table 2 Effects of cultivars and light intensities on number of branches of tea plants on the field at Ibadan

Treatments		**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**
Cultivars					
C143		5.66a	9.83a	14.90a	18.73a
C318		5.42a	9.80a	11.14b	12.93b
Mean		5.54	9.81	13.02	15.83
Light intensities (%)					
45		5.62a	10.02a	14.00a	15.86a
65		5.02a	8.16b	14.08a	16.40a
100		5.97a	11.26a	10.97a	15.20a
Mean		5.54	9.81	13.02	15.83
Light intensities (%) x Cultivars					
45	C143	6.38a	14.85a	10.10a	18.81a
	C318	4.48b	13.15a	9.93a	12.92a
Mean		5.43	14.00	10.02	15.87
65	C143	5.10a	15.40a	8.17a	19.04a
	C318	4.94a	12.77a	8.15a	13.76a
Mean		5.02	14.09	8.16	16.40
100	C143	5.50a	14.44a	11.21a	18.33a
	C318	6.44a	7.50b	11.31a	12.10a
Mean		5.97	10.97	11.26	15.22

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

Figures 1, 2 and 3 show the response of tea height and stem diameter to the different cultivars and light intensities. The height of C143 consistently increased throughout the sampling periods, while that of C318 increased from 3 to 6 MAT and from 9 to 12 MAT, but declined between 6 and 9 MAT (Figure 1). The height of C318 was taller than that of C143 between 3 and 6 MAT and the difference was significant at 6 MAT. But as from 6 MAT through to 12 MAT, C143 tea grew taller than C318 tea, although the difference was not significant. In the same vein, cultivar 318 had thicker stem than cultivar 143 between 3 and 6 MAT and the difference was significant only at 6 MAT. However, C143 was better in stem diameter than C318 from 9 – 12 MAT, and the difference was significant at 12 MAT. Similarly, in figure 2, light intensities were not significantly different in enhancing tea plant height, especially at 3 – 6 MAT. However, at 9 MAT, tea plants under 45 and 65% lights were significantly taller than those under 100% light as 45% light enhanced the tallest height at 9 and 12 MAT, while the 100% light caused the least plant height. Similarly, tea plants under the different light intensities were not significantly different in stem diameter at 3 – 6 MAT. However, at 9 MAT, tea under 45 and 65% lights were better in stem diameter than those under 100% light, while those under 45% light had thicker stem than those under 65 and 100% lights. On interaction, figure 3 reveals that C143 grew taller than C318 under 45 and 65% lights but had lower height under 100% light especially at 12 MAT. On stem diameter, however, C318 was significantly thicker in stem diameter than C143 under all the light intensities (Figure 3).

Table 3 shows that C143 was significantly (P=0.05) superior to 318 in leaf area throughout the sampling periods. Light intensities were significantly different in their effects on the leaf area of tea plants (Table 3). Leaf area of tea under 45% light was significantly higher than that of 65 and 100% lights. The leaf areas under 45, 65 and 100% lights were in the following order: 2885.75 > 1660.59 > 660.38, respectively. Cultivar 143 was consistently better than 318 under the three light intensities throughout the sampling periods except at 3 MAT when 318 had higher leaf area under 65 and 100% lights. However, by 12 MAT, 143 had produced wider leaves under all the light intensities.

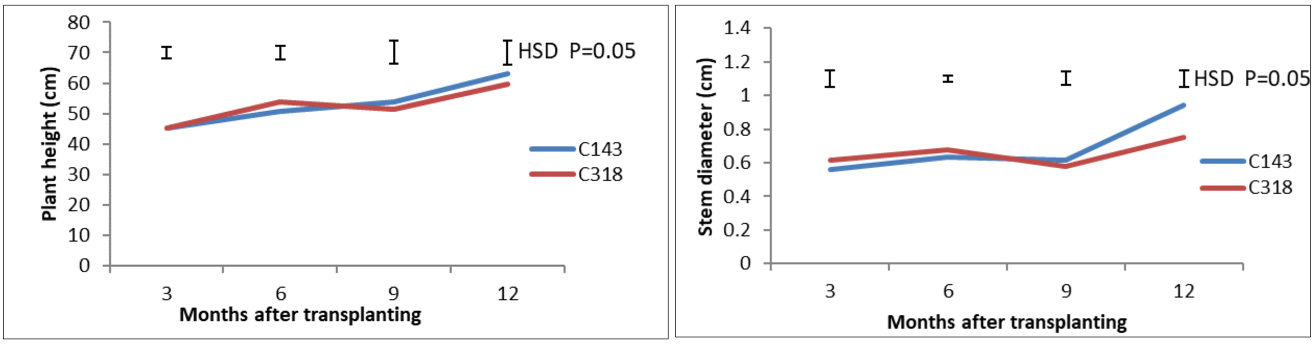

Figure 1 Main effects of cultivars on plant height and stem diameter of tea plants on the field at Ibadan

C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

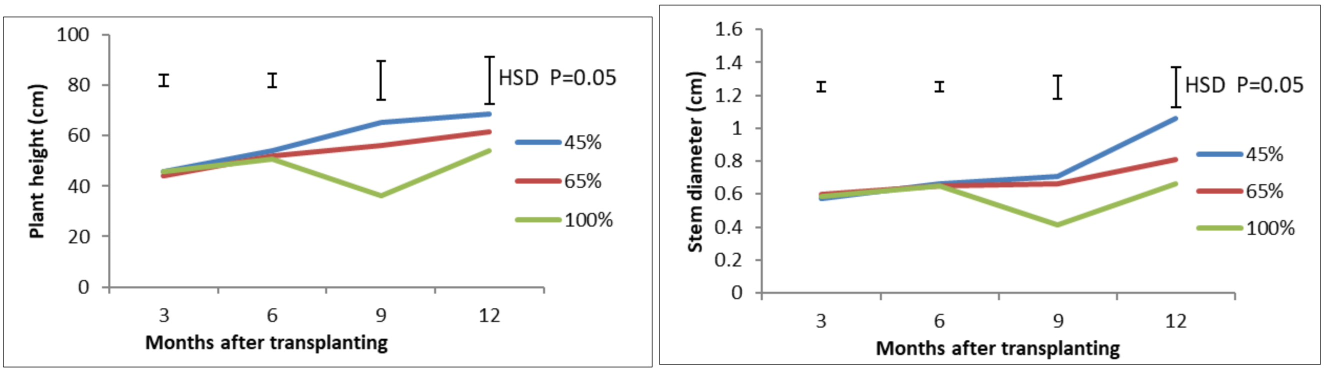

Figure 2 Main effects of light intensities on plant height and stem diameter of tea plants on the field at Ibadan

45% = 45% light intensity; 65% = 65% light intensity; 100% = 100% light intensity. MAT = Months after transplanting

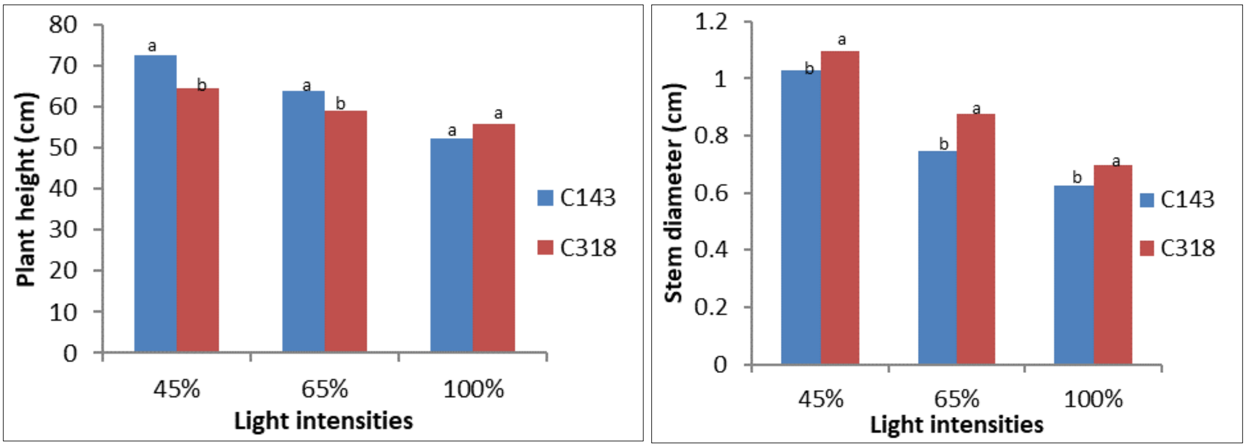

Figure 3 Effect of interaction of cultivars and light intensities on plant height and stem diameter of tea plants at 12 MAT on the field at Ibadan

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05); C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

Table 3 Effects of cultivars and light intensities on leaf area (cm^2) of tea plants on the field at Ibadan

Treatments	3 MAT	6 MAT	9 MAT	12 MAT
Cultivars				
C143	1055.50a	1234.05a	1296.17a	2194.56a
C318	1086.00a	958.48b	817.55b	1276.59b
Mean	1070.75	1096.27	1056.86	1735.57
Light intensities (%)				
45	1207.87a	1387.51a	1595.12a	2885.75a
65	1017.55a	1087.14b	1200.58b	1660.59b
100	986.82a	814.16c	374.88c	660.38c
Mean	1075.75	1096.27	1056.86	1735.57
Light intensities (%) x Cultivars				
45 C143	1250.53a	1924.73a	1574.93a	3853.20a
C318	1165.22a	1265.52b	1200.08a	1918.29b
Mean	1207.88	1595.13	1387.51	2885.75
65 C143	978.36a	1507.70a	1244.44a	1899.18a
C318	1056.75a	893.47b	929.83a	1422.01a
Mean	1017.56	1200.59	1087.14	1660.60
100 C143	937.61a	456.10a	882.79a	831.30a
C318	1036.03a	293.63a	745.53a	489.47a
Mean	986.82	779.58	814.16	660.39

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

Table 4 reveals that dry matter yield of tea was influenced by the different tea cultivars and varied light intensities. The root, stem and leaf dry weights of C143 (12.83, 28.61 and 14.94, respectively) were significantly higher than those of C318 (9.06, 16.55 and 9.72, respectively). Moderate light intensities of 45 and 65% enhanced significant higher dry weight of root, stem and leaf compared to higher light intensity (100%). Moreover, light intensity of 45% was significantly (P=0.05) superior to 65 and 100% lights in enhancing dry matter yield of tea. The highest total dry matter of tea plants (65.80) was produced under 45% light and was significantly higher than the dry matter of tea under 65% light (42.65) and 100% light which produced the least dry matter (30.20). The different cultivars responded differently under the various light intensities. The C143 was superior to C318 significantly (P=0.05) under 45% light; while the later was superior to the former under 100% light, although, the difference was not significant (P>0.05). The dry matter accumulation was lowest under 100% light.

Table 4 Effects of cultivars and light intensities on dry matter accumulation (g plant^{-1}) of tea plants at 15 MAT on the field at Ibadan

Treatments		Root	Stem	Leaf	Total
Cultivars					
C143		12.83a	28.61a	14.94a	56.38a
C318		9.06b	16.55b	9.72b	36.05b
Mean		10.94	22.58	12.33	46.22
Light intensities (%)					
45		15.15a	33.74a	16.91a	65.80a
65		9.00b	20.24b	12.32ab	42.65b
100		8.68b	13.76b	7.75b	30.20b
Mean		10.94	22.58	12.33	46.22
Light intensities (%) x Cultivars					
45	C143	19.37a	48.68a	22.97a	91.02a
	C318	10.93b	18.81b	10.85b	40.58b
Mean		15.15	33.75	16.91	65.8
65	C143	10.17a	25.36a	14.57a	50.10a
	C318	7.83a	15.12a	10.07a	35.19a
Mean		9.00	20.24	12.32	42.65
100	C143	8.95a	11.80a	7.27a	28.01a
	C318	8.42a	15.73a	8.23a	32.39a
Mean		8.69	13.77	7.75	30.20

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

4. Discussion

The better growth performance of Cultivar 143 under all the light intensities underscores its ability to thrive under the harsh weather condition of the lowland [18, 19, 20]. Although 318 has more chlorophyll than 143 [10] under reduced light intensities, its inability to tolerate high light intensity might impede chlorophyll synthesis which is an important reagent for photosynthesis.

Reduced light intensities of 45 and 65% under palm frond sheds enhanced vegetative growth of tea plants compared to full light intensity. Many factors could be responsible for this. First, it could be due to the moderate light quantum incident on the plants occasioned by reduced light intensities. The subdued light must have precipitated optimal condition for photosynthesis by regulating leaf and canopy temperature [13]. The unhindered photosynthesis led to expanded leaf area which enhanced the growth of other plant parts. This is in consonance with the report by Sadgheti *et al.* (2018) [21] who reported an increased leaf size of Sage (*Salvia officinalis* L.) under 50% light intensity and Famaye (2002) [22] who submitted that 50% light reduction enhanced seedling growth of coffee. Wijeratne *et al.* (2008) [23] and Hajiboland *et al*. (2011) [24] had reported enhanced growth of tea under intermediate light intensities. Odeleye *et* *al.* (2001) [25] also had similarly observed that soya beans plants that were grown under subdued light had more leaf area and grew taller as compared to plants grown in full day light. Besides, the shade imposed on the tea plants and their expanded canopies (as a result of moderate light intensities) must have had cooling 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 essential reagent of photosynthesis available for plant use [26].

Bright and scotching sun light significantly reduced tea growth. The critical period of vegetative growth in tea under 100% light intensity was at 9 – 10 MAT (March). This is the peak of the dry season in Southwest Nigeria, when ambient temperature was at its highest and all the growth indices were at their lowest level as result of excessive rise in leaf temperature and evapo-transpiration which makes soil water less available for plant growth and causes build-up of vapour pressure gradient between the leaf and the surrounding air [27]. The negative water potential in the leaf leads to flaccidity and closure of the guard cells and resultant inhibition of diffusion of CO_2 into the leaf, thus limiting the photosynthetic capacity of the leaf [28, 29].

The temporary better growth performance of C318 plants at 3 MAT is an indication that this period fell within the rainy season when the atmosphere was humid and cloudy with low light intensities. At this time, reducing the light intensities was more beneficial to C318 than C143. However, as tea growth progressed into cloudless dry season with very bright light intensities, C143 performed better than C318 under all the light intensities including 100% light, indicating that 143 possesses the potential to tolerate light stress more than 318 [30, 19, 20].

The better dry matter produced by cultivar 143 shows that the more high yielding C143 [31] accumulated more photo-assimilate than C318 did. The reduced light intensity of 45% in the field trial was outstanding in enhancing the dry matter of tea. This might be the consequence of enhanced photosynthetic capacity of tea, since the growing environment of the tea was conducive for stomata conductance, CO_2 absorption by the leaf, water absorption by the root as well as translocation of photo-assimilate to all plant parts [24].

5. Conclusion

Growing tea cultivars 143 and 318 under light intensities of 45, 65 and 100% produced outstanding results. It could be inferred from the results that C143 was superior to 318 in all growth indices and dry matter yield. Both cultivars performed well under cool rainy season with naturally reduced light intensities as a result of the cloudy sky. However, as the dry season set in with its attendant bright light intensity, C318 declined in growth, while C143 performed better than C318 in growth and dry matter accumulation. Besides, 45% light was outstanding in enhancing the growth parameters of tea especially during critical dry season. The extreme light intensity at 100% undermined the growth of tea and reduced its seedling establishment. The critical period for provision of shade for growing of tea at Ibadan was the dry season and early rainy season. It then follows that 45% light created by sheds of 2 layers of palm fronds is crucial to the sustenance of tea growth especially during dry season. It could then be recommended that prospective tea farmers can grow C143 tea cultivar under sheds of 2 layers of palm fronds with 45% light intensity.

Compliance with ethical standards

Acknowledgments

The author recognizes the contribution of the Management of Cocoa Research Institute of Nigeria Ibadan, Nigeria, in providing the land and conducive environment for the conduct of this research.

Disclosure of conflict of interest

There is no conflict of interest.

References

[1] Damayanthi, M.M.N., Mohotto, A.J. and Nissanka, S.P. Comparison of tolerant ability of mature field grown tea (*Camellia sinensis* L.) cultivars to a drought stress in Passara area. *Tropical Agricultural Research 2010; Vol. 22 (1): 66-75.*

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

[3] Dufresne, C.J., Farnworth, E.R.A. Review of latest research findings on health promotion properties of tea. *J. Nutr. Biochem, 2001; 12:404-421*.

[4] Ruxton, C.H.S. The impact of caffeine in mood, cognitive function, performance and hydration: a review of benefits and risks. *Nutrition Bulletin, 2008; Vol. 33, Issue 1 Pp 15-25*.

[5] Balentine, D.A. The role of tea flavonoids in cardiovascular health. *Proceedings of International conference on O-Cha (Tea) Culture and Science, Shizuoka, Japan. October 5-8 2001. Pp. 84-89*.

[6] Feibao, D. China the home of tea In: China Virtual Tour, 2010; P1.

[7] Ghasemzadeh, A. and Ghasemzadeh, N. Effect of shading on synthesis and accumulation of polyphenolic compounds in ginger (Zingiber officinale Roscoe) varieties. *J. Med. Plant Re, 2011; 5:2435-2442*.

[8] Kabir, S.E. A study on ecophysiology of tea (*Camellia sinensis*) with special reference to the influence of climatic factors on physiology of a few selected tea clones of Darjeeling. *International journal of tea Science, 2001; Vol. 1 No. 4. Pp. 1-9.*

[9] Sysoeva, M.I., Marcovskaya, E.F. and Shibaeva, T.G. Plant under continuous light. *Plant Stress, 2010; 4:5-17.*

[10] Adeosun, S.A., Togun, A.O. and Adejumo, S.A. Growth, chlorophyll and carotenoids contents of tea (*Camellia sinensis* (L) O. Kuntze) under varied light intensity in Southwest Nigeria. *Elixir Environment and Forestry, 2023; 178 (2023) 56908 - 56915*

[11] Wang, K.R., Li, N.N., Su, Y.Y. and Liang, Y.R. Effect of sunlight shielding on leaf structure and amino acids concentration of light sensitive albino plant. *African Journal of Biotechnology, 2013; Vol. 12(36). Pp.5535-5539*.

[12] Adeosun, S.A., Togun, A.O., Adejumo, S.A. and Famaye, A.O. The effect of cocoa pod husk as organic fertilizer on the growth of tea (*Camellia sinensis* (L) O. Kuntze) under varying light intensities in Ibadan – South West Nigeria. *Journal of Global Biosciences, 2019; Vol. 8 No.2 Pp5916-5989*

[13] Janendra, W.A., De Costa M., Mohotti, A.J., Wijeratne, M.A. Ecophysiology of Tea. Braz. J. *Plant Physiol, 2007; Vol. 19 no.4 pp.1-3*.

[14] Wachira, F.N., Kamunya, S.M., Karori, S. and Muok, C.R. The tea plants: Botanical Aspects. December 2013. Researchgate.net/publication/281925711_The_Tea_Plants_Botanical_Aspects.

[15] Cocoa Research Institute of Nigeria Weather reports, 2016. (Unpublished)

[16] Ipinmoroti, R.R. Assessment of growth and productivity of tea (*Camellia sinensis*) seedlings as influenced by organomineral and NPK fertilizers in Ibadan and kusuku, Nigeria. Ph.D Thesis, University of Ibadan, 2006; Pp15-18.

[17] Statistical Tools for Agricultural Research, 2013.

[18] Annual report of the Cocoa Research Institute of Nigeria, 1983; Pp 47-56.

[19] Adeosun, S A., Famaye, A.O., Adejobi, K.B., Ugioro, O. and Adeleke, S.A. The growth and field establishment of tea (*Camellia sinensis* (L) O. Kuntze) as influenced by its intercrop with plantain in Ibadan, Nigeria. *Proceedings of 39th Annual Conference of Horticultural Society of Nigeria. Cocoa Research Institute of Nigeria Ibadan, 2021; Pp 920-924.*

[20] Adeosun, S.A., Togun, A.O., Adejobi, K.B. and Ayegboyin, K.O. Growth and seedling establishment of tea (*Camellia sinensis* (L.) O. Kuntze) under varying plantain shade in South West of Nigeria. *World journal of Advanced Research and Review, 2022, 13(01) 638-646*.

[21] Sadgheti, R., Nemetolla, E., Ali N., Mostafa Y. and Mohamad M.M. Effect of light intensity on leaf morphology, photosynthetic capacity and chlorophyll content in Sage (Salvia officinalis L.). *Korean Journal of Agricultural Science and Technology Vol. 36 No. 1 2018. 246-257*.

[22] Famaye, A.O. Effect of shade regimes on growth of coffee species in Nigeria. *Moor Journal of Agricultural Research, 2002; Vol. 3 No.2 2002 184-194*.

[23] Wijeratne, T.L., Mohottti, A.J. and Nissanka, S.P. Impact of long term shade on physiological, anatomical and biochemical changes in Tea (*Camellia sinensis* (L) O. Kuntze). *Tropical Agricultural Research, 2008; Vol. 20: 376-387*.

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

[25] Odeleye, F.O., Togun, A.O. and Tayo, T.O. The effect of light intensity on the growth, development and yield of soyabean in southwest Nigeria. *African Crop Science Journal, 2001; Vol. 9, No. 3, pp557-590*.

[26] Mohotti, A.J. and Lawlor, D.W. 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*.

[27] Hopkin, W. G. The Physiology of Plant under Stress. In: Introduction to Plant Physiology, 1995; Pp434-438.

[28] Smith, B.G., Stephens, W.P., Burgess, J. and Carr, M.K.V. Effect of light, temperature, irrigation and fertilizer on photosynthetic rate in tea (*Camellia sinensis*). *Exp. Agric., 1993; 29:291-306*.

[29] Sivapalan, K. Shade and green manure trees in tea – holistic appraisal. *Sri Lanka Journal of Tea Science, 1993; 62: 41-46*.

[30] Annual report of the Cocoa Research Institute of Nigeria, 1985; Pp 55-69.

[31] Omolaja, S.S. and Iremiren, G.O. Tea Improvement in Nigeria. *Advance topics in sciences and technology in China, 2012; Pp.323-342*.

Author's short biography

Dr. Seun Adewale Adeosun was born on 27 August 1969 in Iwo, Osun State, Nigeria. He obtained B.Agric (Crop Production and Crop Protection) from Federal University of Agriculture Abeokuta, Abeokuta, Nigeria in 1998; MSc. (Environmental Biology) and PhD. (Crop Physiology) from University of Ibadan, Ibadan, Nigeria in 2006 and 2021, respectively. He began his research career in Cocoa Research Institute of Nigeria, Ibadan in 2010 as a Research Officer 1. He is presently a Chief Research Officer with over 40 research publications on Cocoa, Cashew, Coffee, Kola and Tea in both local and international journals as well as Conference proceedings