GROWTH AND PHOTOSYNTHETIC PIGMENT CONTENTS OF TEA (*Camellia sinensis* [L.] KUNTZE) AS INFLUENCED BY LIGHT INTENSITY AND ORGANIC AMENDMENTS IN IBADAN AND OWENA

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CERTIFICATION

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DEDICATION

This work is dedicated unto JESUS CHRIST, my EBENEZER

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ABSTRACT

Tea plant is a good source of antioxidants, but its production is largely limited to montane agro-ecology in Nigeria. To meet the increasing demand, there is need to expand its cultivation to the lowland. However, tea production is significantly influenced by Light Intensity (LI) and soil fertility in the lowland. Information on response of tea to Organic Fertilisers (OF) under different LI in the lowland agro-ecology is scanty. Therefore, effects of LI regulation and OF on growth and photosynthetic pigment contents of tea in Ibadan and Owena were investigated.

The response of two tea cultivars, C143 and C318, to eight OF rates [Cocoa Pod Husk (CPH) and Poultry Manure (PM)], each applied at 0-F1, 75-F2, 150-F3 and 300-F4 kg Nha^{-1}; NPK at 150 kg Nha^{-1}-F5 (inorganic check)] was evaluated in pots under four LI which were achieved with sheds of different Palm Frond Layers (PFL): L1=[(4PFL-25% LI ($2.40x10^4$lux)]; L2=[(2PFL-45% LI ($4.57x10^4$lux)]; L3=[(1PFL-65% LI ($6.75x10^4$lux)] and L4=100% LI ($1.04x10^5$lux) (control). The test samples were randomly allotted in completely randomised design in four replicates. Tea performance was further evaluated on the field with best performing treatments from the pot trial: fertiliser rates (F1, F3, F4, F5); LI (L2=45% LI, L3=65% LI, L4=100% LI, using three plantain population/ha (P1-2,222/ha; P2-1,111/ha and P3-0/ha) arranged in a randomised complete block design in four replicates. Data on Number of Leaves (NL), Leaf Area (LA, cm^2), Dry Matter (DM, g), chlorophyll and carotenoids (mg/g) were obtained from pots and field following standard procedures. Seedling Establishment (SE), Leaf nitrogen and magnesium uptake (mg/g) were assessed on the field. Data were analysed with descriptive statistics, ANOVA and correlation at $\alpha_{0.05}$.

Cultivar C143 performed significantly better than C318 in pots with 25.23±9.74NL, 665.93±297.54LA in Ibadan; and 25.38±9.82NL, 898.23±670.34LA in Owena. The L3 was superior to other LI by increasing the DM by 616.5% and 951.1% at Ibadan and Owena, respectively. Application of F4-CPH and F1 enhanced the highest DM-15.97±0.71 and the lowest-8.19±0.71, respectively, at Owena. The C143 supplied with F3-CPH under L2 in Owena had highest DM (30.85±8.66) and lowest (0.80±8.60) in F1 under L4 in Ibadan. Chlorophyll and carotenoids contents ranged from 0.21±0.87 and 0.13±0.25, respectively in C143 treated with F4-PM under L4 to 3.72±0.87 and 1.25±0.25 in C318 treated with F2-CPH and F3-CPH, respectively under L1 in Owena. Higher NL (194.50±56.30) and LA (9615.75±4056.99) were obtained in C143 which received F3-CPH under P1 on the field in Owena. The C318 that received F1 under P3 in Owena had the lowest NL (21.50±56.30), while C143 treated with F4-PM under P3 in Ibadan had the least LA (49.40±2322.08). The P1 increased DM and SE by 117.9% and 92.5%, respectively, at Ibadan, and by 94.5% and 83.3% at Owena compared to P3. Leaf nitrogen positively correlated with magnesium (r=0.96) in Ibadan, and phosphorus with iron (r=0.65) in Owena.

Light intensity at $4.57x10^4$lux achieved with 2,222 plantain/ha enhanced tea growth, seedling establishment, chlorophyll and carotenoids content of C143 tea amended with 150 kg N/ha cocoa pod husk in Ibadan and Owena.

Keywords: Tea cultivars, Light intensity regulation, Cocoa pod husk, Chlorophyll and carotenoids contents

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CHAPTER 1

INTRODUCTION

Tea is the most consumed beverage by the largest number of people in many parts of the world. Tea earned its popularity from its numerous nutritional and health benefits. Regular consumption of tea has been linked with lower susceptibility to diseases like cancer and cardio-vascular diseases (Balentine, 2001). It contains powerful antioxidants which help to neutralize the free radicals that cause damages to body cells, thereby helping to prevent heart diseases and cancer (Mitscher *et al*., 2001). It is anti-inflamatory, antifibriotic and a cardioprotective agent (Aroyeun *et al*., 2013). Tea beverage is made from tea plant (*Camellia sinensis* (L.) O. Kuntze) after infusion of its leaves in hot water.

The tea plant is an evergreen bush beverage tree crop which when cultivated is kept at a low level of 30-60cm to facilitate the plucking of the young shoot (flush) (Famaye *et al*., 2006). It is one of the most important beverage crops in the world (Damayanthi *et al*., 2010). It has strong tap root and thick stem, thick dark green leaves with white or pink flowers (Famaye *et al*., 2006). The importance of tea plant to the economy of some tea producing countries like China, India, Kenya and Tanzania cannot be underestimated. China stood as the world largest producer of tea, producing 1,467,467 metric tonnes in 2010, 1,700,000 metric tonnes in 2013 and 2,620,000 metric tonnes in 2018; while Kenya was Africa largest and the world third largest producer of tea, producing 399,000 metric tonnes in 2010, 369,000 metric tonnes in 2013 and 432,400 metric tonnes in 2018 (FAOSTAT, 2010; FAOSTAT, 2013; Shahbandeh, 2020). Tea production in Nigeria is still marginal, hence the need for its expansion. Moreover, diversification of the economy to agriculture by expanding tea production is very germane to revitalization of the country's economy which has been on the decline especially these days when foreign earning from crude oil export is dwindling.

Production of tea in Nigeria over the decades has been confined to Mambilla Plateau in Taraba State where it is cultivated on commercial scale. However, in recent time, land for tea production in this area has been limited by other agricultural practices

and infrastructural demand. This has necessitated the need to extend tea production to other parts of the country, especially the lowland areas which are yet to be fully explored for teacultivation. Tea thrives well on Mambilla Plateau owing to its cool climate, suitable light intensity and slightly acidic soil (Famaye *et al.*, 2006; Ipinmoroti, 2006). The hot humid climate of the lowland southern Nigeria has been a major constraint to tea production. In order to simulate the Mambilla (highland) environment by manipulating its environment, reduced light intensity was investigated.

Tea plant is a light sensitive plant. Many physiological processes in tea have been reported to be affected by light intensity (Graham, 1998). Various trials around the world have shown the beneficial effect of reduced light intensity for enhanced tea production (Kabir, 2000; Sysoever *et al.*, 2010). Shading has been used severally in many tea ecologies of the world to reduce light intensity for optimum tea production. Potentials of various shrubs and trees used as shade for reducing light intensity for tea and other beverage crops in many parts of the tropics have been documented: In Nigeria, plantain has been successfully grown with cocoa in the South, and eucalyptus with tea on Mambilla Plateau, to reduce light intensity for optimum production (Famaye *et al*., 2014); *Cajanus cajan* and *Glyricidia sepium* have been reported to provide shade for growing coffee and tea in Sri Lanka and Hawaii (T.R.I., 2003;Valenzuella, 2011). However, there is dearth of information on the optimum light intensity that would enhance tea growth and productivity in lowland ecology of Nigeria.

One other factor affecting tea growth and productivity that need to be considered is poor soil fertility. Ogunwale *et al*. (2002) submitted that low fertility was one of the major constraints to crop production in Nigeria and other parts of the tropics. Nigeria has been reported as one of the countries with high declining soil fertility (Agboola and Sobulo, 1981; FAO, 2004; Aghoola and Shittu, 2002). William *et al.* (1991) had also reported that soils of the humid tropics were usually leached to the extent that they contained lower level of plant nutrients than those from drier regions. Besides, the soils of Southwestern Nigeria have been reported to be declining in plant nutrient as a result of constant nutrient mining due continuous cropping (Ande *et al*., 2017). Currently on Mambilla Plateau, soil is becoming depleted due to over-cultivation of the limited land; and this might have accounted for low tea yield. Therefore, application of fertilisers has been found to be inevitable (Ipinmoroti *et al*., 2008).

Application of fertiliser among Nigerian farmers especially tree crop farmers is marginal, probably because of its scarcity, delay in supply, poor transportation network and high cost. This has probably led to increased use of organic fertiliser by tea farmers on Mambilla Plateau (Ipinmoroti *et al*., 2018). It has been reported that only 8.8% of farmers in some parts of Southwest Nigeria apply fertilisers on their farms (Adebiyi *et al*., 2011) due to inaccessibility, high cost and untimely availability (Agbede and Kalu, 1995). Beside poor affordability by resource-poor farmers, continuous and uncontrolled use of inorganic fertilisers have deleterious effect on the soil, the crop and the underground water; hence the need for affordable and environmental friendly alternative means of soil amendment. This has been found in organic fertilisers owing to their immense advantages as they enhance the physical and chemical conditions of the soil and facilitate nutrient uptake by plants. It has been reported that organic manures promote crop growth and increase yield by way of improving soil physical, chemical and biological properties (Wallace, 1994). Organic fertiliser improves the physical properties, fertility status and water holding capacity of the soil (Lal, 1986; Akinbola *et al*., 2004), and releases plant nutrients gradually to meet the need of tea plants (Ipinmoroti, 2013). The potentials of organic manure in enhancing the growth performance and quality of harvest of vegetable and tree crops have been severally reported (Iremiren and Ipinmoroti, 2014; Han *et al.*, 2016).

Togun *et al*. (2004) reported enhanced growth, nutrient uptake and increased yield of tomato in response to plant residue compost. Similarly, Adeosun *et al*. (2013) reported better performance of kola under organic and organo-mineral fertilisers. Moreover, Ipinmoroti and Iremiren (2010) recorded better influence of organic fertiliser on yield and nutrient uptake by young tea cuttings in comparison with NPK fertiliser. However, there is limited information on the use of organic fertilisers on field establishment of tea in lowland ecology of Nigeria.

Possible interaction of light intensity and plant nutrient has been reported. Smith *et al*. (1993) observed an interaction between photoinhibition and N nutrition. They reported that plants that received nitrogen fertiliser rates of 225 kg N ha^{-1} yr^{-1} or less showed photoinhibition at high light intensity. Similarly, Mohotti and Lawlor (2002) have shown that photoinhibition of tea is minimized by abundant nitrogen supply. Besides, Adeosun *et al.* (2019) submitted that efficiency of fertilisers on tea plants was largely dependent on their growing environment.

Therefore, the current study investigated the effect of light intensity and organic amendments on growth and photosynthetic pigments of two tea cultivars in two locations in lowland agro-ecology of Nigeria.

Specific Objectives

1. To determine optimum light intensity and organic fertiliser levels that would enhance vegetative growth of tea plant.
2. To evaluate the effects of varying light intensities and organic fertiliser levels on field establishment, economic yield, nutrient uptake and photosynthetic pigments of tea.
3. To determine optimum plantain shade density that would enhance vegetative growth and field establishment of tea plant.

CHAPTER 2

LITERATURE REVIEW

2.1. History and Origin of Tea

Tea is believed to have originated from Southeastern Asia probably in China (Oi, 2004; Famaye *et al*., 2006). Tea was first discovered in 2737 BC by the Chinese Emperor and inventor, Shen-Nunga who brewed tea for health care as well as a stimulant (Njuguna, 1984). However, tea was not popular in China until 780 AD, and by 1300 AD China began to export tea (Pham, 2007). Today tea plant is cultivated in 50 countries in all the five continents of the world with major producers being China, India, Kenya, Sri Lanka, Vietnam, Turkey, Indonesia and Iran (FAO, 2014). Since its discovery, the cultivation of its plant and drinking of its products have spread to countries like Japan, Russia, India, Sri Lanka, Britain, America and even Africa (Pham, 2012). Commercial plantation started in early part of 19th century in India and in Africa, production started in Kenya, Uganda, Malawi and Tanzania in 20th century.

The British brought tea to Africa after the World War II (Pham, 2007). It entered Africa en route India and was first grown in Kenya from where its cultivation spread to other African countries like Tanzania, Malawi, Zimbabwe, South Africa and Nigeria (Ipinmoroti *et al*., 2018). Tea was introduced into Nigeria agriculture in 1952 with commercial cultivation on Mambilla Plateau along Gembu, Ardo-Gori, Kusuku, Kakara, Maizat-mari and Ngoroje axis (Hainsworth, 1971; Adedeji, 2006). Shaib (1985) reported that a British District Officer introduced tea to Nigeria, when he planted it in his compound in Gembu, Sadauna Local Government Area of the old Gongola State (now Taraba State). In 1972, the Federal Government of Nigeria initiated a tea project on the Mambilla Plateau in partnership with the then Gongola State Government and the new (Northern) Nigeria Development Limited (Awaro, 1985). This company established an all-clonal tea estate

with proven commercial tea varieties at Ardo-Gori for the Nigeria Beverages Production Company (NBPC). Commercial tea production started in Nigeria in 1982 and at the same time, research activities on tea began in Cocoa Research Institute of Nigeria (CRIN). The need to expand tea cultivation to the lowland because of limiting land (Olaniyi *et al*., 2016) on the Plateau led to the establishment of tea adaptability trials at CRIN Headquarters, Ibadan, Iyanomo (Edo State), Akwete (Abia State), Ikorodu (Lagos State) and Ajassor (Cross Rivers State) (Omolaja and Essan, 2005).

2.2. Taxonomy and Varieties of Tea

The tea plant belongs to the genus *Camellia* in the family Theaceae. It was first described as *Thea japonenense* by Kaempfer in 1712 and later as *Thea sinensis* by Carl Linnaeus in 1753 (Bonheure, 1991). In 1818, the genus *Thea* was substituted for *Camellia* (International Association for Plant Taxonomy, 2006). Sealy finally classified tea as *Camellia sinensis* (L.) Kuntze in 1937 (Famaye *et al*., 2006). There are 82 species in the genus *Camellia*. Tea plant is the most important of all the species. The botanical classification of tea is summarized below:

Kingdom…….Plantae
Division……..Tracheophyta
Subdivision…….Spermatophyta
Class……Magnoliospida
Superorder……..Asteranae
Order…….. Ericales
Family…….. ..Theaceae
Genus …….. ..*Camellia*
Species……*Camellia sinensis* (L.) Kuntze

There are two main varieties of tea plant, namely, *Camellia sinensis var. sinensis* (also known as China variety) and *Camellia sinensis var. assamica.* (Assamica variety) (Bonheure, 1991). *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 (Wachira *et al*., 2013). The China varieties are slow growing, but tolerant to cold weather as well as other adverse conditions; while Assamica varieties grow faster and are

adaptable to warmer conditions. Apart from morphological differences, it was also established that catechin and caffeine content of assamica variety were higher than that of sinensis (Akiko *et al.,* 2007a). The China variety is found mainly in China and Japan; while 'Assamica' variety and its hybrids are found in India, Sri Lanka, Indonesia, Africa, South America, Australia, Russia and Middle East (Bonheure, 1991; Jain, 2007).

Besides the aforementioned, there are other varieties in various tea producing regions of the world. In 1982, CRIN acquired 33 clones for commercial production (Oloyede *et al.*, 2014). Among these clones, five high yielding ones (35, 68, 143, 236 and 318) (with an average yield of 2.5 tonnes ha^{-1} yr^{-1}) were identified, selected and released to farmers as commercial cultivars (Oloyede *et al*., 2014; Oloyede *et al*., 2017). Among the five clones, 143 and 318 have been successfully adapted to lowland ecologies of Nigeria. The highly branching C143 has light green, shorter and broader leaves while C318 is less branching, with highly pigmented, dark green, narrower leaves. Cultivar 143 has been adjudged as high yielding, drought tolerant and more adaptable to the lowland (CRIN, 1985; Omolaja and Iremiren, 2012).

2.3. Cultivation of Tea in the Tropics

2.3.1. Climatic and soil requirements

Tea plant thrives best under high and evenly distributed rainfall. Shoot growth of tea is influenced by water deficits in the soil and the aerial environment. Reduction in shoot extension, leaf area and number of lateral branches of tea has been reported to be associated with soil water deficit (Car, 2000). Tea requires an optimum of 3000 mm and at least 1500 mm of water per annum (Bonheure, 1991). A monthly rainfall of 130-150 mm is ideal for tea production. Increased annual rainfall in Bangladesh had been reported to lead to increase in tea leaf production (Ali *et al*., 2014). However, tea plant shows broad adaptability and grows in broad spectrum of climate and soils. It thrives in a hot, moist climate with temperature of 18-30 ^{o}C and on an altitude of 600-2000 m above sea level (Jannedra *et al*., 2007). It dies at temperatures below 5 °C. The rate of shoot initiation in tea increases linearly with rise in temperature from the base temperature to an optimum temperature and thereafter decreases linearly with further increases in temperature up to the maximum (Robbert *et al*., 1997). Although, tea grows in high altitude, but can also be grown at low altitude and at sea level in high latitude regions (Bonheure, 1991).

The tea plant grows badly on too compact and too alkaline soils. Soils for tea production must be good structured, permeable, well drained, with a well-developed humus-bearing layer and with high mineral reserves (Egbe *et al*., 1987). Tea also performs well on acid soil with a pH between 4.5 and 5.5 (Filani and Okelana, 1980; Famaye *et al*., 2006). The soils must be rich in macronutrients like nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) as well as micronutrients such as zinc (Zn), iron (Fe), manganese (Mn), and copper (Cu) (Obatolu, 1984)

2.3.2. Pre-nursery, nursery and field establishment

The standard practice in tea propagation is the use of seed. But rapid loss in viability coupled with great variations found in seedlings has made clonal propagation which ensures large uniform populations better alternative (Hamid *et al*., 2006). Vegetatively propagated tea plants have been reported to reach maturity early and produce high yielding uniform stands (Banerjee, 1993; Opeke, 2005). In pre-nursery, viable seeds are sown in seed boxes and are transplanted into nursery polythene bags (after sprouting), where the plants remain for two years before being transplanted to the field. In vegetative propagation however, nursery is raised using stem cuttings in a shaded nursery beds, often covered with a transparent polythene sheet. When using this technique, it takes about 12 months for cuttings to be ready for transplanting to the field (Opeke, 2005).

In field establishment, the land is cleared, the field is laid out and tea seedlings are transplanted into holes of 20x20x30 cm dimension at a recommended spacing of 100 x 60 cm or 122 x 82 cm (Famaye *et al.*, 2006).

2.3.3. Plucking (Harvesting)

Tea beverage is produced from young actively growing shoots of 2-4 leaves (Botwright, 1997). Plucking is the periodic harvesting of young tea shoots which generally consist of a bud and two or three leaves. Harvesting two leaves and a bud is referred to as fine plucking, while four leaves and a bud is referred to as coarse plucking. The harvested part of the tea plant affects the quality of tea because leaf age is an important factor determining its chemical composition in terms of the polyphenol, especially catechin (Ho *et al*., 2009; Yashin *et al*., 2015). The upper younger shoots have higher levels of catechin (de Costa *et al*., 2007); thus, for high quality tea, 2 or 3 leaves and a bud are harvested because quality declines as more are harvested (Botwright, 1997). Plucking can be done by hand or by machine. Although, harvesting by machine is more efficient, yet harvesting

by hand is more practiced for the production of high quality tea. In Indonesia, mechanical harvesting had been proven to be 573 times more efficient than hand plucking (Dalimoenthe, 2004). Tea plucking is done on Mambilla Plateau during rainy season especially from April to September. However, yield is very high between April and July; afterward, pluckable shoots decline because of formation of leaf bud dormancy. The harvesting is repeated regularly every 10 to 14 days, depending on the growth of the tea bushes (Opeke, 2005).

2.4. The Economic, Cultural and Health Benefits of Tea

Tea is the most consumed beverage on earth (Martins, 2007). It is consumed mainly as black tea (fermented), green tea (non-fermented) or oolong tea (semi-fermented) beverage (Odom, 2007). India, Sri Lanka (South-East Asia), Kenya, Malawi, Tanzania, Uganda, and Mozambique (Eastern and Southern Africa) are the major producers of black tea; while China and Japan produce mainly green tea (FAO, 2015). The chemical and nutritional constituent of tea is to a large extent determined by its processing method. Black tea is rich in theaflavin and thearubugin but contain the lowest level of the antioxidant and catechin. Conversely, green tea leaves contain a large group of compounds including polysaccharides; volatile oils, vitamins, minerals, purines, alkaloids and polyphenols especially catechin and theanine (Hajiboland, 2017). Its consumption has a lot of medicinal benefits. Green tea possesses powerful antioxidant which helps to neutralize reactive oxygen species (ROS) (Mitscher *et al*., 2001), and polyphenols (Yayabe, 2001) which prevents oral diseases, renal failure and cancer (Juneja, 2001). Tea has been used as treatment for infectious diseases and cold. Regular consumption of tea has been linked with lower chances of suffering from diseases like cancer and cardio-vascular diseases (Dufrene and Farnworth, 2001). Recent research has revealed that beverage derived from the tea plant (*Camellia sinensis*) contains powerful antioxidants called flavonoids which help to neutralize the free radicals that cause damage to health cells in the body, helping to prevent heart disease and cancer (Balentine, 2001). It also helps prevent blood clotting, lower cholesterol levels, neutralize enzymes that aid in the growth of tumours and stimulate immune system (Ruxton, 2008). The tea leaf contains a number of chemicals of which 30% is flavonoids (Balentine, 2001); 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 (Feibao, 2010). When drunk without sugar, honey or

milk, tea has no calories and also serves as a crucial component for maintaining the balance of body fluid. Green tea is famous for its calming effect on both body and mind. Other health benefits of tea include antibacterial, antiseptic and detoxifying properties which help reduce digestive complaints and guard against tooth decay (Kavanagh and Renehan, 1997; Hara, 2001). In Asia countries, drinking tea is an ancient tradition accompanied by highly developed tea-based culture which is tied to art and local customs. However, there are possible health risks associated with excessive tea consumption. These include anaemia and aluminum accumulation (du Toit *et al*., 2001; Karak and Bhagat, 2010). High doses of caffeine can also cause negative effects like nervousness, anxiety, restlessness, insomnia and tachycardia (Wang *et al*., 2007)

Tea is grown and produced in more than 40 countries worldwide with 90% coming from Asian countries (Feibao, 2010). Tea production is the economy mainstay of many countries of the world. Its cultivation has contributed to the foreign exchange and rural development of many countries (Hajiboland, 2017). In India, over 2 million workers were employed in various tea farms (Jain, 2007).

2.5. The Importance of Light Intensity in Tea Production

Light intensity is the total amount of light or degree of brightness incident on a surface. Light is an absolute requirement for plant growth. It is the most imperative factor among all the ecological factors (Ghasemzadeh and Ghasemzadeh, 2011). It is a source of energy for plant life (Sysoever *et al.,* 2010). Light influences many physiological processes in tea as in all green plants. For instance, according to Chapman and Carter (1976), the minimum light limit for the process of photosynthesis in most plants is between 100 and 200fc. The growth and development of tea plants have been reported to be influenced in various ways and location by light intensity. Light affects tea growth and production through its use for photosynthesis and through photoperiodic reactions (Kabir, 2000; Sysoever *et al.,* 2010). Rajkumar *et al.* (1999) observed that sub and supra optimal levels of Photosynthetic Active Radiation (PAR) inhibited photosynthesis significantly. Light intensity influences many physiological processes like biosynthesis of phenolics and flavonoids (Graham, 1998) directly or indirectly in tea plants. Photosynthesis, respiration, transpiration, translocation of photoassimilate and development are some of the important physiological processes in *Camellia sinensis* affected by light intensity (Jannedra *et al*., 2007; Too *et al.,* 2015).

Tea has been described as a light sensitive plant. Its production potential is fully expressed under reduced light intensity. Tea being a C3 plant undergoes photoinhibition under excessive light intensity. Photoinhibition is a process whereby photosynthetic rate is reduced or completely hampered under excessive light intensity. Photoinhibition 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), 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). When excessive light intensity is incident on leaf surface, it 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) 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.

Apart from causing poor stomata conductance, extreme sunlight intensity increases soil temperature which leads to excessive water loss and consequent higher Diffusion Pressure Deficit in the plant root. Excessive soil water loss increases solute concentration which makes it difficult for plant root to absorb water since essential plant nutrient must be in relative dilute solution for easy absorption by plant roots (Fatubarin, 2003). Besides, high soil water loss as a result of excessive light intensity can lead to negative turgor pressure of the cell wall, dehydration of plant tissue, rapid ageing of the leaves, early leaf senescence and abscission, wilting and ultimate death of the plant (Mohr and Schopfer, 1995). Apart from its effect on photosynthesis processes, research has shown that light intensity also affects synthesis of photosynthetic pigments especially chlorophyll and carotenoids as well as other biochemical compound in tea and some other plants. Wang *et al.* (2013) submitted that high sunlight resulted in low levels of chlorophyll and carotenoids in albino tea plant. Similarly, Oliveira *et al.* (2014) observed that chlorophyll synthesis was enhanced under low light intensity in cyanobacteria. Too *et al.* (2015) found out that harvesting of tea when light is low enhanced high amount of theanine in tea which have

been shown to reduce high blood pressure, promote relaxation and inhibit caffeine's side effects.

The effect of light intensity on photoinhibition and general tea performance is season-dependent. Karunaratne *et al*. (2003) observed significant photoinhibtion on clear sunny days but not on cloudy days. Therefore, the extent of photoinhibition in a given agroecological region is determined by its proportion of clear sunny days per year. In environments which have only a small proportion of clear, sunny days per year, giving too much shade could cause yield reduction (Jannedra *et al.,* 2007).

2.6. The Significance of Shade in Reducing Light Intensity for Optimum Tea Production

The potentials of reduced light intensity by shading in enhancing growth, yield and quality of harvested products of beverage crops in Nigeria and other parts of the world have been documented. Beer *et al*. (1998) observed that shade trees reduced the stress of coffee (*Coffea spp*. L.) and cacao (*Theobroma cacao* L.) by ameliorating adverse climatic conditions and nutritional imbalances. The entire photosynthetic apparatus of tea is adapted to function with maximum capacity under shade (Jannedra *et al*., 2007). Shading has the following general merits in tea production: suppression of weed growth (Bermudez, 1980); removal of excess soil water by transpiration of a heavy shade tree cover (Martinez and Enriquez, 1981); reduction of damage caused by hail and heavy rain (Beer, 1987); reduction of wind velocity in the crop strata (Lait *et al*.,1981); provision of soil mulch (Wiersum, 1984); increased soil organic matter (Santana and Cabala, 1985); reduction of erosion (Wiersum, 1984) and nitrogen fixation especially when it involves planting of leguminous crops (Escalante, 1984). Inclusion of shade trees in tea ecosystem is a common practice in India (Ghosh *et al*., 2008). In Kenya, removal of shade from tea garden led to a loss in quality (Owuor *et al.*, 1988).

Tea is a shade loving plant. Shading has significant effect on photosynthetic capacity of tea plant. Shade reduced photo inhibition by increasing stomatal conductance and thereby channelling a greater proportion of excited energy towards carboxylation especially when sunlight is excessive (Jannedra *et al.*, 2007). Mohotti *et al*. (2000) and Mohotti and Lawlor (2002) have shown that seedlings of tea were consistently taller under shade as compared to un-shaded ones. Shade also reduces transpiration rate primarily by reducing the irradiance incident on the tea canopy and by reducing canopy temperature.

Tea grown under the shade of *Gravillea robusta* A. Cunn. ex R. Br. had substantially lower transpiration rates than unshaded tea (Anadacoomaraswarmy *et al*., 2000). The use of shade in tea production has been shown to produce black tea with higher theaflavin and reduced thearubigin concentration with a better flavour index and tester's evaluation than did tea grown without shade (Owuor, 1988; Kanda, 2010). Theaflavins are brick-red pigments of black tea which are known to have beneficial effect against some diseases (Tanak *et al.,* 2001). In Japan, it was observed that shading helped tea plants increase in a special aroma, flavour and caffeine content, which cannot be found in tea leaves grown in full light (Akiko and Tetsuji, 2010; Maho, 2010). Although there is dearth of information on the use of shade plants to grow tea, especially in lowland ecology of Nigeria, few empirical observations have been documented on the effects of shade on tea performance. Iremiren *et al*. (2010) reported that extra shade from erected palm fronds and plantain resulted in higher survival count of tea cuttings. However, level of shade that would reduce light intensity for optimum growth and productivity of tea plant is location specific. For instance, in environments which have only a small proportion of clear, sunny days per year, giving too much shade could cause yield reductions due to a reduced radiation by the canopy (Jannedra *et al*., 2007). Beside, Eiji *et al.* (2010) observed that 85% shade made the colour of tea plants dark green, 98% shading made it lighter green while 100% shading etiolated it to white. Gamage *et al.* (2007) also reported that the optimum shading level for tea growing at lower altitudes up to 600 m above sea level in the humid zone of Sri Lanka was between 30% and 40%.

2.7. The Use of Shade Plants in Nigeria and other Tea Producing Regions of the World

The growing of tree crops like cocoa, kola, coffee and tea under various shade plants is a common practice in Nigeria and many parts of the world. The benefits of growing tree crops under shade plants have been documented. Plantain at 1600 plants ha^{-1} (2.5m planting distance) and 1040 plants ha^{-1} (3.1m planting distance) has been used and recommended as permanent shade for cocoa seedlings (Famaye *et al.*, 2014). Vegetative growth and nutrient uptake of *Coffea canephora* L. was enhanced when grown under oil palm (Famaye *et al*., 2017; Famaye *et al*., 2018). Various plants have been used as shade plants for reducing light intensity for tea production in many tea growing regions of the world. Inclusion of shade trees in tea ecosystem is a common practice in India (Ghosh *et*

al., 2008). In Kenya, removal of shade from tea garden led to a loss in quality (Owuor, 1988). In Nigeria tea has been grown successfully under plantain (Obatolu and Ipinmoroti, 2000). However, there is dearth of information on the optimum plantain density that could enhance optimum performance of tea in Nigeria. That is the essence of the current study. Apart from supplying shade for optimum growth of tea, inclusion of plantain in tea ecosystem can afford the farmers addition source of income and also maximize the land use. Besides, since tea is a slow growing plant which cannot guaranty commercial scale harvest until 3 years of field establishment, farmers can sustain on plantain harvest before tea reaches maturity with tea/plantain intercrop. In spite of their numerous advantages to the growth and yield of tea and other tree crops, shade and shade plants have some disadvantages especially when they are not well managed. Natural fall of shade trees can damage the under storey crop (Barua and Sarma, 1983); heavy uncontrolled shading can increase fungal attack and insect pest attack (Smith, 1981), labour cost (Enriquez, 1986) and competition for nutrients by shade plants (Beer, 1987).

2.8. Nutrient Deficiency and Soil Amendment in Tea Production

The importance of fertiliser amendment in tea production cannot be overemphasized. This is due to the fact that tropical soils are generally deficient in soil nutrients. It has been documented that most soils in many tea producing areas of the world are deficient in essential plant nutrients which has resulted in low tea production. The main reasons for low tea production in Yunnan, China, are poor soil fertility and unbalanced fertilisation (Fan *et al*., 2005). Besides, soils under tea cultivation and adaptation trials locations in Nigeria are poor in fertility when compared to soils of other tea producing nations of the world (Hainsworth, 1971; Obatolu, 1984). On Mambilla Plateau, Nigeria, macro-nutrients such as N, P, K, Ca and Mg and micro-nutrients such as Zn, Mn, Fe, and Cu low levels have been implicated (Ogunmoyela and Obatolu, 1984) in poor tea seedling establishment, poor yield, depressed growth of the apical meristem with leaves appearing dark green, thick, leathery, misshapen and crinkled (Ipinmoroti, 2006). The poor fertility status of Mambilla soil has led to as much as 80% reduction in economic yield of tea (Ipinmoroti *et al*., 2002). Tea requires substantial amount of nutrients for optimum production. Ruan (2007) had postulated that limited supply of plant nutrients was the major factor restricting tea productivity and synthesis and accumulation of its quality components. Among all plant nutrients, nitrogen is the most critical for tea production.

Adeosun (2005) opined that nitrogen was the most limiting of all plant nutrients in the soil due to its high mobility in the soil. Akiko *et al.* (2007b) and Ananthacumaraswarmy *et al*. (2007) observed that nitrogen was a key factor for tea growth; it is required for good yield and quality improvement as it increases the content of amino acids in tea leaves, and that production of tea biomass occurred with increasing nitrogen rate (Kumar *et al.,* 2008; Itani *et al.,* 2013). Consequently, tea exerts much demand on soil nitrogen. There have been systematic research efforts by the Cocoa Research Institute of Nigeria (CRIN) in establishing fertiliser rates for consistent tea optimal. For a harvest of 1500 kg made tea, a total of 68.2 kg Nha^{-1}, 18.0 kg Kha^{-1}, and 7.2 kg Pha^{-1} are being extracted from the soil (Ogunmoyela and Obatolu, 1984). The result of fertiliser trials conducted in CRIN have shown that 150 kg Nha^{-1} was the optimum for the growth and leaf production of tea, and that NPK ratio of 5:1:1 applied at 150 kg Nha^{-1}, 30 kg Pha^{-1} and 30 kg Kha^{-1} was most effective for the optimum growth as well as optimum leaf production of tea (Obatolu, 1985 and 1987).

2.9. Organic and Organo-Mineral Fertiliser Trials in Nigeria and other Tea Producing Areas of the World

The vital roles of nitrogenous fertilisers in plant growth and yield must have led to its accelerated and indiscriminate use among farmers in Japan. Over dependence on the use of nitrogenous fertilisers (Saba and Matsunaga, 2010) and other inorganic fertilisers have numerous demerits. Anan (2001) reported that increased use of nitrogenous fertilisers in Japan had led to pollution of ground water and acidification of the soil. In Nigeria however, the use of the inorganic fertilisers by Nigerian farmers is marginal as it has been reported that the use of fertiliser was low with 6 kg in nutrients applied per hectare of farmland annually between 2005 and 2009 (Takeshima *et al.*, 2012). Most Nigeria tea farmers do not apply inorganic fertilisers owing to their high, unpredictable and uncontrolled price, poor fund and untimely availability of the fertiliser and high cost of transportation of these fertilisers from urban areas to the farming villages (Fagbenro and Agboola, 1983; Egbe *et al*., 1987). Another probable cause of farmers' apathy against the use of fertilisers on their farms is the poor subsidy (Olaniyan, 2000) by the government. When subsidy exists, the subsidized fertilisers are distributed through complex channels which lead to late delivery and adulteration of the fertilisers (Banful *et al*., 2010; Takeshima *et al.,* 2012). Apart from their high cost of purchase, uncontrolled application

of chemical fertilisers is potentially harmful to the soil, the wildlife and underground water (Katsuyuki, 2007; Famaye *et al.,* 2016). These demerits of the use of nitrogenous and other inorganic fertilisers have necessitated the need for low cost and environmental friendly alternative source of soil amendments which could be found in organic fertilisers. This is the current situation on Mambilla Plateau as the afore-mentioned constraints to the availability and application of inorganic fertilisers have necessitated the shift by tea farmers on Mambilla Plateau to the use of organic fertilisers. It has been established that 79.1% of fertilisers used by Mambilla tea farmers are organic based (Ipinmoroti *et al.,* 2018). The shift from the use of inorganic to the organic has been reported to have many advantages. Organic tea production which involves the use of organic fertilisers as against mineral fertilisers has been linked with improved tea quality and maintenance of health benefits of the made tea (Hajiboland, 2017).

The results of the use of organic and organo-mineral fertiliser in the production of vegetable and beverage crops in Nigeria have been documented (Togun and Akanbi, 2002; Togun *et al.,* 2003; Akanni *et al*., 2005; Akanni and Ojeniyi, 2007). It had been reported that cocoa pod husk ash (an organic-based fertiliser) enhanced the vegetative growth of cocoa (Adejobi *et al.,* 2013; Akanbi *et al*., 2014) and cashew seedlings (Adejobi *et al*., 2011). Similarly, Adeosun *et al*. (2013) had reported better performance of kola seedlings under organic and organo-mineral fertiliser. Also, Obatolu (1995) had earlier reported the use of cocoa pod husk as fertiliser for coffee and maize production. Works on the Mambilla Plateau and some lowland areas at Ibadan, Ikom, Mayo-selbe and Owena where tea has been grown and adapted showed the effectiveness and efficacy of organic materials like cattle dung, maize Stover and *Pennisetum purpureum* as good nutrient supplying sources for coffee (Obatolu, 1991). Adeoye *et al*. (2007) and Ipinmoroti and Iremiren (2010) had reported that cocoa pod husk, cow dung, poultry manure, siam weed and tea fluff used as manure and in combination with inorganic fertiliser as organo-minerals resulted to significantly ($P<0.05$) higher tea seedling growth and dry matter yield than NPK. In Japan, the yield of green tea grown under organic fertilisers was as good as those grown under inorganic fertiliser (Nobuyuki *et al*., 2010). In Beijing, China, combination of nitrogen fertilisation and litter incorporation was reported to enhance dry matter production of tea plants (Ruan *et al*., 2004). Apart from enhancing the growth performance of crops, compost manure had been reported to bind up, degrade, transform and reduce the concentration of heavy metals in the soil (Adejumo, 2010). Besides, organic fertilisers have

been shown to increase the abundance of theaflavin and thearubigin content in tea leaf (Miyuki *et al.*, 2007). However, organic fertiliser has its own demerits. The bulkiness of organic manure which makes its transportation very difficult coupled with its offensive odour form part of its drawbacks.

CHAPTER 3

MATERIALS AND METHODS

3.1. Description of experimental sites: This study was carried out in Cocoa Research Institute of Nigeria (CRIN) Headquarters, Idi-Ayunre, Ibadan, Oyo State and CRIN substation, Owena, Ondo State (Figure. 3.1). Ibadan is located on Latitude 07º 10'N and Longitude 03º 52'E on 122m elevation above sea level in the tropical rain forest zone of Nigeria. There are two distinct seasons: rainy and dry seasons. The rainy season which is characterized by humid atmosphere and cloudy sky runs from April to October with short dry spell in August. Ibadan has bimodal rainfall distribution pattern with peak in June and September. The annual rainfall is 1100-1150 mm. The average maximum and minimum temperature are 27.0 ºC and 19.8 ºC, respectively. Relative humidity varies from 89% during rainy season to 57% during dry season. The dry season is characterized by little or no rainfall, hot and scotching sun. It runs from early November to late March. Part of the dry season is characterized by cold and dry harmattan wind (CRIN Weather Reports, 2016).

Owena is located in Idanre LGA of Ondo State on Latitude 07º N and longitude 05º 7'E in the humid tropical rain forest zone of Nigeria and is characterized by two seasons, the rainy and dry seasons. The rainy season is characterized by heavy rainfall, humid atmosphere and cloudy sky. It runs from late March to late November. The annual rainfall is 1340-1804 mm. The dry season which is characterized by scanty rainfall, dry atmosphere and intense sun heat, runs from late November to early March. Relative humidity varies from 89% during raining season to 76% during dry season. The average maximum and minimum temperature are 29.9 ºC and 20.7 ºC, respectively (OSAR, 2016).

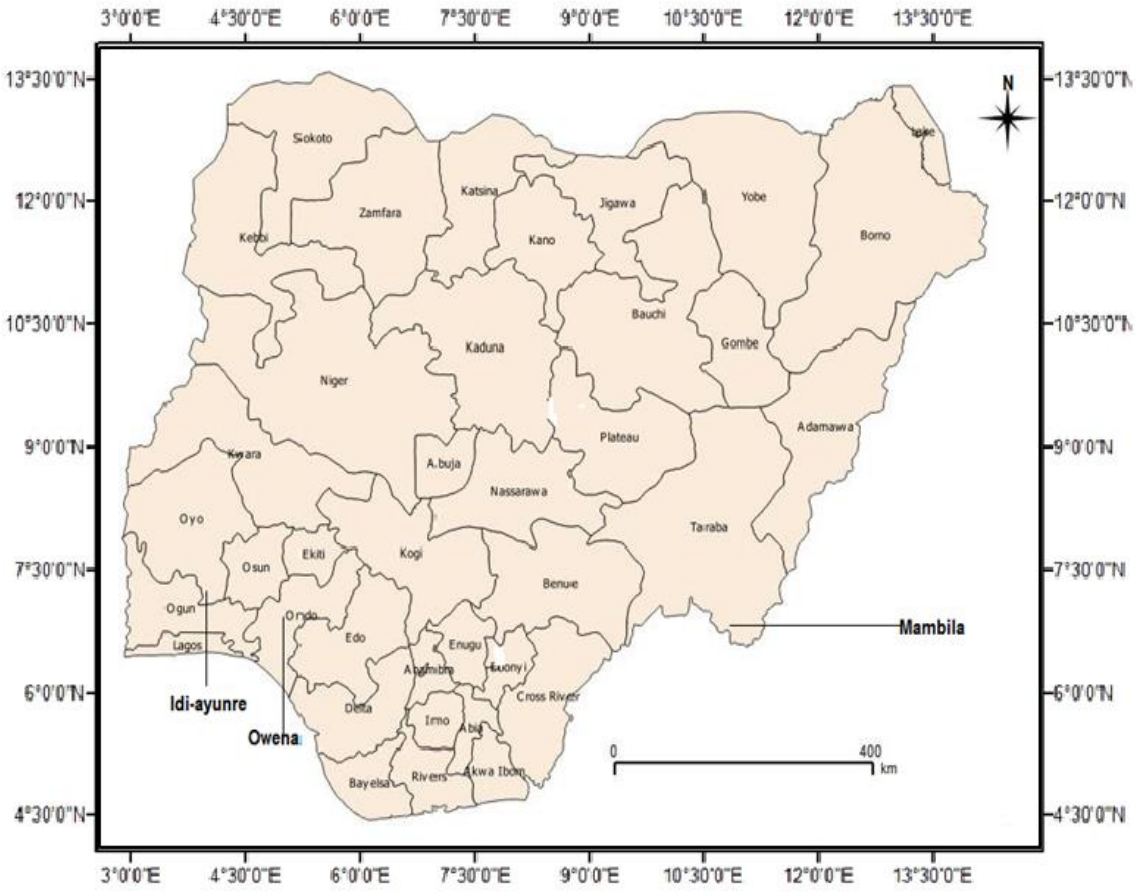


Figure 3.1: The map of Nigeria showing Mambilla Plateau and the two locations of the experiments [Ibadan (Idi – ayunre) and Owena]

3.2. Experiment 1: Effects of light intensity and organic fertilisers on growth, dry matter accumulation and photosynthetic pigments of potted tea plants at Ibadan and Owena, Nigeria

This experiment was conducted between November 2014 and March 2017 and it was aimed at evaluating the effects of varying degrees of light intensity as well as different levels of organic fertilisers on growth, dry matter accumulation, leaf chlorophyll and carotenoids composition of two tea cultivars grown in plastic pots.

3.2.1. Sources of organic fertilisers

Two types of organic farm waste were used in the current study: Poultry Manure (PM) and Cocoa Pod Husk (CPH). Poultry manure was collected from deep litter house of Poultry Section of Ajanla farms Nigeria Limited located along Ibadan-Ijebu-Ode road, Ibadan and was cured four weeks before application to the transplanted tea plants. Fresh cocoa pod husks were collected from the Fermentary Unit of CRIN, Ibadan. The cocoa pod husks were sun-dried for two weeks, and milled into powder with milling machine. The organic materials were assayed in the laboratory for their nutrient elements contents following standard procedures

3.2.2. Sources and preparation of mineral fertiliser

Urea (46% N), Single Super Phosphate (SSP) (18% P_2O_5) and Muriate of Potash (MoP) (60% K_2O) were obtained as sources of nitrogen (N), phosphorus (P) and potassium (K), respectively and formulated into NPK 5:1:1. Urea and SSP were obtained from CRIN, Ibadan, while MoP was obtained from International Institute of Tropical Agriculture (IITA), Ibadan.

3.2.3. Pre-cropping soil sampling and analysis

The top soil used for the pot experiments was collected from the sites of the experiment in Ibadan and Owena. The soil was randomly collected between 0-30 cm profile. Five composite soil samples were collected, thoroughly mixed, dried and sieved with a 2 mm mesh screen and was assayed in the Soil Laboratory of Olufunke Laboratory Services, Alaka Road, Elebu, Ibadan, for physical and chemical properties. Soil pH (1:1 soil/water) was determined with pH meter, while organic matter was determined by Wet Oxidation method (Walkey and Black, 1934). Soil available P was extracted by the Bray

PI and measured by the Murphy blue colouration and determined on a Spectronic 20 at 882µm (Murphy and Riley, 1962). Soil K, Ca and Mg were extracted with IMNH4 OAC. Phosphorus, magnessium and total nitrogen were determined with flame photometer, atomic absorption spectrophotometer and Microkjedahl methods, respectively (AOAC, 1990)

3.2.4. Sources of planting materials

Healthy tea cuttings of 143 and 318 cultivars were raised in CRIN Substation Kusuku, Mambilla Plateau, Taraba State Nigeria. The cuttings were raised in polythene bags of 25x10 cm size for 12 months before being transported to Ibadan and Owena. The cuttings were raised using two layers of soil, the top soil, and sub soil. The top soil was pu**t** into the polythene pots first to a height of 2/3 of the polythene pot. The remaining 1/3 space of the polythene pots was filled with sub soil. The stem cuttings, 3-4 cm long, comprising a leaf and a bud were obtained from a mature tea bush, placed in buckets of water and transported to the already prepared platform. The cuttings were planted into the soil-filled polythene pots (1 kg soil). The cuttings were adequately watered and the platform was covered with transparent polythene sheet (150-400 µm thickness). The sheet was held above the cuttings by some flexible sticks which were curved parallel to each other and which ends were buried to avoid evaporation and to maintain high humidity (Famaye *et al*., 2006). The high humidity was necessary for early sprouting of the cuttings.

3.2.5 Experimental design and layout

Experiment 1 was a 2x4x8 factorial which comprised two tea cultivars (C143 and C318), four levels of light intensities [25% ($2.40x10^4$lux), 45% ($4.57x10^4$lux), 65% ($6.75x10^4$lux) and 100% ($1.04x10^5$lux)] and eight fertiliser treatments [three levels of Poultry Manure (PM): 75 kg Nha^{-1} (PM_{75}) (5.43 g pot^{-1}), 150 kg Nha^{-1} (PM_{150}) (10.87 g pot^{-1}) and 300 kg Nha^{-1} (PM_{300}) (21.75g pot^{-1}); three levels of Cocoa Pod Husk (CPH): 75 kg Nha^{-1} (CPH_{75}) (13.39 g pot^{-1}), 150 kg Nha^{-1} (CPH_{150}) (26.79 g pot^{-1}) and 300 kg Nha^{-1} (CPH_{300}) (53.57 g pot^{-1}); one level of NPK 5:1:1[(150 kg Nha^{-1}) (1.94 g pot^{-1}) (as inorganic check) (Obatolu, 1987); zero (0 $kgha^{-1}$) fertiliser as control]. These resulted in 64 treatment combinations arranged in factorial experiment and laid out in Completely Randomised Design (CRD) with four replications (Figure 3.2).

$L_2V_1F_0$	$L_2V_1F_7$	$L_2V_2F_7$	$L_2V_1F_0$	$L_3V_2F_3$	$L_3V_2F_4$	$L_3V_2F_2$	$L_3V_1F_2$	$L_1V_2F_2$	$L_1V_1F_4$	$L_1V_2F_1$	$L_1V_1F_7$	$L_4V_1F_0$	$L_4V_1F_6$	$L_4V_1F_2$	$L_4V_1F_3$
$L_2V_2F_1$	$L_2V_1F_3$	$L_2V_1F_5$	$L_2V_1F_0$	$L_3V_1F_2$	$L_3V_1F_6$	$L_3V_2F_7$	$L_3V_2F_5$	$L_1V_1F_3$	$L_1V_1F_0$	$L_1V_1F_3$	$L_1V_2F_5$	$L_4V_2F_7$	$L_4V_1F_1$	$L_4V_1F_7$	$L_4V_1F_5$
$L_2V_1F_1$	$L_2V_2F_0$	$L_2V_1F_3$	$L_2V_2F_7$	$L_3V_1F_7$	$L_3V_2F_1$	$L_3V_1F_5$	$L_3V_1F_5$	$L_1V_1F_1$	$L_1V_2F_0$	$L_1V_2F_6$	$L_1V_1F_6$	$L_4V_1F_0$	$L_4V_2F_2$	$L_4V_2F_6$	$L_4V_1F_2$
$L_2V_1F_0$	$L_2V_1F_6$	$L_2V_2F_6$	$L_2V_1F_7$	$L_3V_2F_2$	$L_3V_2F_0$	$L_3V_1F_1$	$L_3V_2F_0$	$L_1V_1F_6$	$L_1V_1F_1$	$L_1V_1F_4$	$L_1V_1F_1$	$L_4V_2F_5$	$L_4V_1F_3$	$L_4V_1F_1$	$L_4V_1F_4$
$L_2V_1F_1$	$L_2V_1F_5$	$L_2V_2F_4$	$L_2V_2F_6$	$L_3V_1F_0$	$L_3V_1F_4$	$L_3V_2F_3$	$L_3V_2F_4$	$L_1V_2F_1$	$L_1V_2F_2$	$L_1V_1F_0$	$L_1V_2F_5$	$L_4V_1F_6$	$L_4V_2F_0$	$L_4V_2F_5$	$L_4V_2F_7$
$L_2V_1F_6$	$L_2V_1F_2$	$L_2V_2F_2$	$L_2V_2F_7$	$L_3V_1F_3$	$L_3V_1F_4$	$L_3V_1F_7$	$L_3V_2F_3$	$L_1V_2F_1$	$L_1V_2F_3$	$L_1V_2F_3$	$L_1V_2F_1$	$L_4V_1F_3$	$L_4V_1F_1$	$L_4V_1F_5$	$L_4V_2F_1$
$L_2V_2F_1$	$L_2V_2F_0$	$L_2V_2F_2$	$L_2V_2F_3$	$L_3V_2F_1$	$L_3V_1F_0$	$L_3V_1F_2$	$L_3V_1F_3$	$L_1V_1F_1$	$L_1V_2F_0$	$L_1V_1F_0$	$L_1V_1F_3$	$L_4V_1F_7$	$L_4V_2F_3$	$L_4V_2F_6$	$L_4V_1F_4$
$L_2V_2F_3$	$L_2V_2F_6$	$L_2V_1F_3$	$L_2V_2F_1$	$L_3V_2F_6$	$L_3V_2F_4$	$L_3V_1F_4$	$L_3V_2F_7$	$L_1V_2F_7$	$L_1V_1F_7$	$L_1V_1F_2$	$L_1V_2F_5$	$L_4V_1F_4$	$L_4V_2F_3$	$L_4V_1F_0$	$L_4V_1F_6$
$L_2V_2F_3$	$L_2V_1F_2$	$L_2V_2F_4$	$L_2V_1F_5$	$L_3V_1F_0$	$L_3V_2F_5$	$L_3V_1F_5$	$L_3V_1F_2$	$L_1V_1F_5$	$L_1V_2F_6$	$L_1V_1F_7$	$L_1V_1F_5$	$L_4V_1F_7$	$L_4V_1F_5$	$L_4V_2F_0$	$L_4V_1F_5$
$L_2V_1F_2$	$L_2V_2F_1$	$L_2V_1F_6$	$L_2V_2F_5$	$L_3V_2F_4$	$L_3V_2F_3$	$L_3V_1F_1$	$L_3V_1F_6$	$L_1V_1F_2$	$L_1V_2F_0$	$L_1V_1F_6$	$L_1V_2F_0$	$L_4V_1F_2$	$L_4V_2F_2$	$L_4V_2F_5$	$L_4V_2F_4$
$L_2V_2F_6$	$L_2V_2F_0$	$L_2V_1F_4$	$L_2V_2F_5$	$L_3V_2F_1$	$L_3V_2F_5$	$L_3V_2F_0$	$L_3V_1F_5$	$L_1V_2F_6$	$L_1V_1F_7$	$L_1V_1F_3$	$L_1V_1F_2$	$L_4V_2F_4$	$L_4V_2F_6$	$L_4V_2F_0$	$L_4V_2F_4$
$L_2V_1F_3$	$L_2V_1F_1$	$L_2V_1F_7$	$L_2V_2F_4$	$L_3V_1F_1$	$L_3V_1F_1$	$L_3V_2F_2$	$L_3V_2F_1$	$L_1V_2F_4$	$L_1V_2F_7$	$L_1V_2F_4$	$L_1V_2F_7$	$L_4V_2F_1$	$L_4V_1F_1$	$L_4V_1F_4$	$L_4V_2F_2$
$L_2V_1F_4$	$L_2V_2F_5$	$L_2V_2F_2$	$L_2V_2F_0$	$L_3V_1F_3$	$L_3V_1F_7$	$L_3V_2F_2$	$L_3V_2F_7$	$L_1V_2F_6$	$L_1V_2F_3$	$L_1V_2F_3$	$L_1V_1F_5$	$L_4V_1F_2$	$L_4V_1F_6$	$L_4V_2F_7$	$L_4V_2F_2$
$L_2V_1F_1$	$L_2V_2F_7$	$L_2V_1F_2$	$L_2V_2F_4$	$L_3V_1F_4$	$L_3V_1F_6$	$L_3V_2F_6$	$L_3V_2F_0$	$L_1V_1F_5$	$L_1V_1F_4$	$L_1V_2F_4$	$L_1V_2F_4$	$L_4V_1F_3$	$L_4V_2F_3$	$L_4V_1F_7$	$L_4V_2F_1$
$L_2V_2F_2$	$L_2V_1F_4$	$L_2V_1F_5$	$L_2V_1F_7$	$L_3V_1F_0$	$L_3V_2F_7$	$L_3V_2F_5$	$L_3V_1F_7$	$L_1V_2F_7$	$L_1V_1F_0$	$L_1V_2F_2$	$L_1V_2F_2$	$L_4V_2F_1$	$L_4V_2F_3$	$L_4V_2F_4$	$L_4V_2F_6$
$L_2V_2F_3$	$L_2V_1F_6$	$L_2V_1F_4$	$L_2V_2F_5$	$L_3V_2F_6$	$L_3V_1F_3$	$L_3V_1F_6$	$L_3V_2F_6$	$L_1V_1F_6$	$L_1V_1F_4$	$L_1V_1F_2$	$L_1V_2F_5$	$L_4V_2F_5$	$L_4V_2F_7$	$L_4V_2F_0$	$L_4V_1F_0$

Figure 3.2: Experiment 1 lay-out

L_1:25% light intensity; L_2: 45% light intensity; L_3: 65% Light intensity; L_4: 100% Light intensity; V_1: Cultivar 143;V_2: Cultivar 318; F_1: 75 kg Nha^{-1} poultry manure; F_2: 150 kg Nha^{-1} poultry manure; F_3: 300 kg Nha^{-1} poultry manure; F_4: 75 kg Nha^{-1} cocoa pod husk; F_5: 150 kg Nha^{-1} cocoa pod husk; F_6: 300 kg Nha^{-1} cocoa pod husk; F7: 150 kg Nha^{-1} NPK 5:1:1; F_0: Control (No fertiliser

3.2.6. Construction of sheds

Three sheds of 10x2x2 m dimension were constructed with bamboo poles and oil palm fronds covering the top and the sides (Plates 3.1 and 3.2). Three sheds were constructed each representing different light intensities. Bamboo poles were cut to a length of 2.6 m. Each shed was made of two rows of 6 bamboo poles each. The rows and the poles along each row were 2 m apart, to give the shed a rectangular shape. The poles were erected in 50 cm deep holes and a loop was made at the top of the poles into which narrower bamboo stems were inserted horizontally to join the erected poles together at the top. Bamboo stems were placed at the top of the shed along its length mid-way between the two sides of the shed to hold the palm fronds at the top. The density of oil palm fronds used for each shed was varied according to the different levels of light intensity. The palm fronds covering the sides were held in place by a pair of slit bamboo stem tied to the poles with polythene thread horizontally along the length of the shed wall.

3.2.7. Determination of the different levels of light intensity

Four different light intensities were determined. These were 25%, 45%, 65% and 100%. Light intensities of 25% ($2.40x10^4$lux), 45% ($4.57x10^4$lux), 65% ($6.75x10^4$lux) and 100% ($1.04x10^5$lux) were determined by varying the density of oil palm fronds at the sides and top of the three sheds; the open space with no shed cover represented 100% light intensity. For 25, 45 and 65% light intensities, 4, 2 and 1 oil palm frond layers, respectively were used. To determine the varying light intensities, Lux Meter, model LX1010BS was used to measure light intensities three times per day (8.00 am, 12 noon and 4.00 pm) for seven days. The Lux Meter was used by holding the sensor face-up inside each shed and recording the corresponding light intensity values on its screen. The light intensity value for each shed was calculated by finding the means of the seven days readings. The percentage light intensity was determined by comparing the light intensity value inside the shed with the light intensity value in the open space using the equation below:

$$\%Light\ Intensity = \frac{Light\ Intensity\ inside\ the\ shed}{Light\ intensity\ in\ the\ open} \times 100$$

Plate 3.1: A cross-section of Experiment 1 site at Ibadan

Plate 3.2: A cross-section of Experiment 1 site at Owena

3.2.8. Pot filling

Top soil was collected from the forest land of CRIN stations in Ibadan and Owena. The soil was allowed to dry and was sieved with 2 mm soil sieve. Two-hundred and fifty-six (256) 5-litre plastic pots were filled with 5 kg of the sieved soil. The plastic pots were perforated at the base to allow drainage of excess water from the soil.

3.2.9. Transplanting of tea cuttings and application of fertilisers

Tea stem cuttings of cultivars 143 (C143) and 318 (C318) which were raised for 12 months on Mambilla Plateau, were transplanted into the soil-filled pots. The cuttings were transplanted at 6-8 leaves stage. The soil was watered to field capacity. The transplanted tea cuttings were later set in the already constructed light sheds according to the lay-out (Figure 3.1). Sixteen rows of 4 potted tea plants were set inside the sheds. There was a space of 50 cm between the rows and 30 cm within the rows. Four weeks after transplanting, fertiliser treatments were applied to the established tea plants according to the layout (Figure 3.1). No fertiliser was applied to the control plants. The soil was watered to field capacity.

3.2.10. Routine cultural practices

The following cultural practices were carried out in the course of the experiment:

Shed maintenance: The sheds were maintained by regular replacement of fallen or damaged bamboo poles.

Weeding: Weed control was done manually without the use of herbicide. The exterior of the sheds was weeded with cutlass, the interior, with hoe, and the weeds in the pots by pulling with hands. Fire traces of 2 m wide were made round the experimental sites during the dry season to prevent fire hazard in the plots.

Irrigation: To prevent the tea plants from drying up during the dry season the plots were watered manually between January and April 2015. Each plant received 1 L of water twice per week.

Pest control: Grasshopper (*Zonocerus variegatus* L.) infestation was observed at 8 MAT in Ibadan and Owena sites. The infestation was controlled by spraying Lamda-cyalothrin 2.5 EC at 24 mL in 20 L of water (Manufacturer's recommended dosage) at 2 weeks interval. The spraying was done with the use of Knap-sac sprayer.

3.2.11. Data collection

At two Months After Transplanting (MAT), the following morphological parameters were taken on each plant per treatment on monthly basis: Number of leaves, leaf area, number of branches, plant height, stem diameter and number of dropped leaves (number of leaf abscission scars). Number of leaves, number of branches and number of dropped leaves were determined by visual count; plant height (cm) and stem diameter (cm) by meter rule and veneer calipers, respectively. Plant height (cm) was measured from the soil surface to the terminal bud of the plants. Stem diameter (cm) was measured at the 4 cm height of the stem.

Leaf area (cm^2) was determined by measuring the length and width of the 5^{th} and 6^{th} leaves from the apex of each plant. The area of the leaves (Length x Width) was multiplied by Leaf Area Correction Factor, 0.61 which gave the actual leaf area of each leaf. The leaf area of each leaf was multiplied by the number of leaves per plant to give the leaf area per plant. Leaf area correction factor was determined according the method of Famaye (2000). To determine the correction factor, one hundred fresh tea leaves were plucked randomly from the tea population. Their length and width were taken with meter rule. Each leaf was traced on graph sheets and the number of 1cm squares within the traces was counted as the actual area of the leaves. The sum of the graph area was divided by the sum of the product of L x W of the leaves as follows:

$$Leaf\ Area\ Correction\ Factor = \frac{Graph\ area\ of\ 100\ fresh\ leaves}{Actual\ length\ x\ width\ of\ 100\ leaves}$$

$$= \frac{3472.96}{5703.53}$$

$$= 0.61$$

At 8 months after transplanting (8 MAT), dry matter accumulation was determined. All the plants were uprooted by pouring the soil out and separating the plants from the soil. Plant roots were washed in clean water to remove soil particles. The plants were partitioned into root, stem and leaf. The fresh weight of the root, stem and leaf were taken with KERRO Electronic Compact Scale (Model BL5002). The plants were enveloped and dried to constant weight with an Electric oven at 70 ^oC for 48 hours in the Plant Physiology Lab of the Department of Crop Protection and Environmental Biology. The dry weight of the plant samples was taken with the same weighing balance.

3.2.12. Residual effects of organic fertilisers on growth and dry matter yield of tea plants in the pot experiment at Ibadan and Owena

The tea plants in the plastic pots were uprooted at 8 MAT. The soil in the plastic pots was poured out and the pots were refilled with the same soil. One stand of pre-germinated tea cuttings (143 and 318 cultivars) was planted into each of the plastic pots. The tea plants were well watered. At 1, 2, 3, 4, 5 and 6 MAT, the following morphological data were collected on the tea plants as described in 3.2.10: Number of leaves, leaf area, number of branches, plant height, stem diameter and number of dropped leaves (number of leaf abscission scars). At 6 MAT, the plants were uprooted and partitioned into leaf, stem and root. The fresh and dry weights of the plant samples were determined as described in 3.2.10.

3.2.13. Chlorophyll and carotenoids determination in tea leaves in the pot experiment

At 6 MAT, fresh leaves were randomly plucked from the tea plants in each treatment and replication. The leaves were assayed for chlorophyll and carotenoids content at the Plant Physiology Laboratory of the Department of Crop Protection and Environmental Biology, University of Ibadan. Tea leaf sample (1g) was weighed into 15 mL centrifuge tubes. The centrifuge tube was filled with 90% ethanol. The content of the centrifuge tube was heated in water bath at 78.4 ^{o}C for 3 hours in order to extract the chlorophyll and carotenoids pigments in the leaf. After 3 hours, pigments were completely extracted as the ethanol turned completely green and the leaves turned grey. The chlorophyll solution was allowed to cool and the remains of the leaf were separated from the solution. The solution was then read on Spectrophotometer, SPECTRUM LAB 752s: Carotenoids at 440 nm wavelength; Chlorophyll a and b at 665 nm and 649 nm wavelengths, respectively. The total chlorophyll and carotenoids in mg/g leaf fresh weight were determined using the Wintermans and Mots (1965) equations below:

Chlorophyll (a+b) = (6.10 x A_{665} + 20.04 x A_{649}) x 15/1000/FW (mg/g fw)

Where 6.10, 20.04 = Constants; A_{665} = Absorbance coefficient 665 nm for chlorophyll a; A_{649} = Absorbance coefficient 665 nm for chlorophyll b; 15/1000 = Volume of supernatant; FW = Fresh weight of the leaf

Carotenoids = 4.69 x A_{440} – 1.96 x A_{665} – 4.74 x A_{649} x 10 x 15/1000/ FW (mg/g fw)

Where 4.49, 1.96, 4.74 = constants; A_{649}= Absorbance coefficient 440 nm for carotenoids; 10 = dilution factor; 15/1000 = Volume of supernatant; FW/fw = Fresh weight of the leaf

3.2.14. Data analysis

The analysis of variance (ANOVA) of all data collected from the experiment was done using STAR (Statistical Tools for Agricultural Research) (2013) software package and the significant means were separated with Tukey's Honest Significant Difference (HSD) Test (P=0.05).

3.3. Experiment 2: Effects of light intensity and organic fertilisers on growth, field establishment, dry matter yield, economic yield, nutrient uptake and photosynthetic pigments of tea at Ibadan and Owena, Nigeria

This experiment was carried out between 2015 and 2017 and was aimed at evaluating the effects of varying degrees of light intensity, different rates of organic fertilisers on field establishment, growth, dry matter accumulation, leaf yield and leaf chlorophyll and carotenoids composition of two tea cultivars at Ibadan and Owena, Nigeria.

3.3.1. Acquisition of experimental materials

Tea clonal materials of 143 and 318 cultivars were raised in CRIN Substation Kusuku, Mambilla Plateau, Taraba State for 16 months and were transported to the experimental sites. The process of raising the tea cuttings was as described in Experiment 1 above.

3.3.2. Land preparation of experimental sites

The land was cleared of all vegetations manually with cutlass. After land clearing, the plot lay-out was done with the use of ranging pole, measuring tape, wooden pegs and measuring line. The plot was laid out into four blocks, each comprising 2 main plots, 6 sub-plots and 36 sub-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 area of the experimental site was 1044 m^2. Soil auger was used to collect composite soil samples which were collected at five locations on the experimental plots at 0-30 cm depth for pre-cropping soil analysis. The soil samples were thoroughly mixed, dried and sieved with a 2 mm mesh sieve and analyzed for physical and chemical properties according to the method described in Experiment 1.

3.3.3. Experimental design and layout

It was a 2x3x6 factorial arrangement which consisted of two tea cultivars (C143 and C318); 3 levels of light intensities [45% ($4.57x10^4$lux), 65% ($6.75x10^4$lux) and 100% ($1.04x10^5$lux)], and six fertiliser treatments: two levels of Poultry Manure (PM): 150 kg Nha^{-1} (PM_{150}) and 300 kg Nha^{-1} (PM_{300}); two levels of Cocoa Pod Husk (CPH): 150 kg Nha^{-1} (CPH_{150}) and 300 kg Nha^{-1} (CPH_{300}) and one level of NPK 5:1:1; (150 kg Nha^{-1}) (NPK_{150}) [as inorganic check (Obatolu,1987)]; and zero fertiliser served as control. These resulted in 36 treatment combinations laid out in Randomised Complete Block Design (RCBD) arranged in Split-Split Plots with four replications (blocks). Cultivars, light intensities and fertiliser rates served as main plots, sub-plots and sub-sub-plots, respectively (Figure 3.3).

3.3.4. Construction of sheds

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. The shed construction was as described in Experiment 1 except that the pairs of slit bamboo stem were tied to the poles with copper wire (for longer stability) horizontally along the length of the shed wall at the middle of its height. The 65 and 45% light intensities were achieved with 2 and 1 palm fronds layers, respectively. The 100% light intensity had no shed cover (Plates 3.3 and 3.4).

3.3.5. Sources and preparation of fertiliser materials

The poultry manure and cocoa pod husk were sourced and prepared as described in Experiment 1. Samples of the poultry manure and cocoa pod husk were assayed for their nutrient content. Urea (46%N) used as nitrogen source of the NPK fertiliser was procured from open market. Single Super Phosphate (SSP) (18% P_2O_5) was sourced from the Oyo State Agricultural Development Programme (OYSADEP) office, Moor Plantation, Ibadan; and Muriate of Potash (MoP) (60% K_2O) was obtained from International Institute of Tropical Agriculture (IITA), Moniya Ibadan. The 150 kg Nha^{-1} rate of NPK 5:1:1 fertiliser used in this experiment was formulated as follows: 19.58 g of urea, 22.73 g of SSP and 3.6

BLOCK I	BLOCK II	BLOCK III	BLOCK IV
V1L2F5	V1L1F4	V2L2F0	V2L1F3
V1 L2F0	V1 L1F2	V2 L2F2	V2 L1F2
V1 L2F3	V1 L1F0	V2 L2F1	V2 L1F5
V1 L2F1	V1 L1F1	V2 L2F3	V2 L1F1
V1 L2F4	V1 L1F3	V2 L2F5	V2 L1F0
V1 L2F2	V1 L1F5	V2 L2F4	V2 L1F4
V1L1F4	V1L3F2	V2L1F5	V2L2F5
V1 L1F0	V1 L3F3	V2 L1F4	V2 L2F2
V1 L1F2	V1 L3F5	V2 L1F3	V2 L2F1
V1 L1F5	V1 L3F0	V2 L1F0	V2 L2F3
V1 L1F1	V1 L3F1	V2 L1F2	V2 L2F0
V1 L1F3	V1 L3F4	V2 L1F1	V2 L2F4
V1L3F3	V1L2F0	V2L3F0	V2L3F0
V1 L3F5	V1 L2F4	V2 L3F5	V2 L3F1
V1 L3F2	V1 L2F5	V2 L3F4	V2 L3F4
V1 L3F4	V1 L2F1	V2 L3F2	V2 L3F3
V1 L3F0	V1 L2F3	V2 L3F3	V2 L3F5
V1 L3F1	V1 L2F2	V2 L3F1	V2 L3F2
V2L1F5	V2L3F0	V1L2F2	V1L3F0
V2 L1F1	V2 L3F5	V1 L2F1	V1 L3F3
V2 L1F4	V2 L3F2	V1 L2F4	V1 L3F1
V2 L1F3	V2 L3F4	V1 L2F3	V1 L3F5
V2 L1F0	V2 L3F3	V1 L2F0	V1 L3F4
V2 L1F2	V2 L3F1	V1 L2F5	V1 L3F2
V2L3F1	V2L1F1	V1L1F0	V1L2F2
V2 L3F5	V2 L1F0	V1 L1F5	V1 L2F5
V2 L3F3	V2 L1F4	V1 L1F1	V1 L2F4
V2 L3F2	V2 L1F5	V1 L1F2	V1 L2F1
V2 L3F4	V2 L1F3	V1 L1F3	V1 L2F3
V2 L3F0	V2 L1F2	V1 L1F4	V1 L2F0
V2L2F4	V2L2F3	V1L3F5	V1L1F3
V2 L2F0	V2 L2F2	V1 L3F0	V1 L1F5
V2 L2F2	V2 L2F5	V1 L3F3	V1 L1F1
V2 L2F1	V2 L2F4	V1 L3F2	V1 L1F0
V2 L2F5	V2 L2F0	V1 L3F1	V1 L1F4
V2 L2F3	V2 L2F1	V1 L3F4	V1 L1F2

Figure 3.3: Experiment 2 lay out

V_1: Cultivar 143; V_2: Cultivar 318; L_1:45% light intensity; L_2: 65% light intensity; L_3: 100% Light intensity; F_1: 150 kg Nha^{-1} poultry manure; F_2: 300 kg Nha^{-1} poultry manure; F_3: 150 kg Nha^{-1} cocoa pod husk; F4: 300 kg Nha^{-1} cocoa pod husk; F5: 150 kg Nha^{-1} NPK 5:1:1; F_0: Control (No fertiliser)

Plate 3.3: A cross-section of Experiment 2 site at Ibadan

Plate 3.4: A cross-section of Experiment 2 site at Owena

g of MoP were mixed (45.91 g stand^{-1}) and applied to supply to the soil 150 kg Nha^{-1}, 30 kg Pha^{-1} and 30 kg Kha^{-1}.

3.3.6. Planting and allotment of treatments

Planting holes (20 cm long, 20 cm wide and 25 cm deep) were dug. The tea plants were planted in the dug holes at a spacing of 100x60 cm. In each sub-subplot, a row of four stands of tea plants was planted. For the plants inside the sheds, a space of 1 m was allowed between the shed wall and the tea plants. There were six sub-sub plots in each sub plot, each receiving one fertiliser treatment. At 2 months after transplanting (2 MAT), fertiliser treatments were applied to the established tea plants. Based on the %N of the organic manure, 0.5 kg and 1.0 kg of poultry manure (PM) were applied per stand to supply 150 kg Nha^{-1} (PM_{150}) and 300 kg Nha^{-1} (PM_{300}), respectively; while 0.6 kg and 1.2 kg of milled cocoa pod husk (CPH) were applied per stand to supply 150 kg Nha^{-1} (CPH_{150}) and 300 kg Nha^{-1} (CPH_{300}), respectively. For NPK 5:1:1 application (NPK_{150}), 45.91 g was applied per stand to supply to the soil 150 kg Nha^{-1}, 30 kg Pha^{-1} and 30 kg Kha^{-1}. The fertilisers were applied in ring form at 20 cm radius from the base of the plants. No fertiliser was applied to the control plants.

3.3.7. Routine cultural practices

The following cultural practices were carried out in the course of the experiment:

Shed maintenance: The sheds were maintained by replacing old palm fronds every two months and by regular replacement of fallen or damaged bamboo poles.

Weeding: Weed control was done manually without the use of herbicide. The sub-plots were hoed once in two months. The gap between the sub-plots and the blocks were slashed with cutlass once in three months. Fire traces of 3 m wide were made round the experimental sites during the dry season to prevent fire hazard in the plots.

Irrigation: To prevent the tea plants from drying up during the dry season, the plots were watered manually between November 2016 and April 2017 (i.e. 4 – 8 MAT). Each plant received 2 L of water twice per week.

Pest control: Grasshopper (*Zonocerus variegatus* L.) infestation was observed at 3 MAT and 9 MAT in Ibadan and Owena sites. The infestation was controlled by spraying Lamda-cyalothrin 2.5 EC at 24 mL in 20 L of water (Manufacturer's recommended dosage) at 2 weeks interval. The spraying was done manually with the use of Knap-sac sprayer.

3.3.8. Data collection

At 3 MAT, two tea plants per treatment per replicate were randomly tagged for the following data collection. Morphological parameters: number of leaves, number of branches, leaf area, number of dropped leaves (number of leaf abscission scars), plant height and stem diameter. The measurement of the morphological parameters was done on monthly basis as described in Experiment 1. At 9 MAT, two plants were pruned per treatment per replicate with secateurs at 30 cm height from the ground. The pruning yield was collected; the fresh weight was measured and the plant samples were shade-dried for 5 weeks to constant weight. The fresh and dry weights of each sample were measured with KERRO Electronic Compact Scale model BL5002. From 12 to 15 MAT newly flushed tea leaves were harvested from the pruned tea stands. The harvesting was done manually by plucking 2-3 leaves and a bud from the main stem, the branches and the twigs (Botwright, 1997). The plucking was done at 2 weeks interval within the harvesting period (Opeke, 2005). Harvested tea leaves were measured for fresh weight; they were shade-dried for two weeks. Their fresh and dry weights were measured with the KERRO Electronic Compact Scale.

At 11 MAT, survival counts were carried out on the tea plants to determine the level of survival of the tea plants after the first dry season of transplanting. At 15 MAT plant samples which were 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 leaves. 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 (Ipinmoroti, 2006). Both the fresh and dry weights were measured with the KERRO Electronic Compact Scale used previously. The dried leaf samples were assayed for determination of plant nutrient content in the Laboratory of the Department of Agronomy, University of Ibadan following standard

procedures. Nutrients uptake in the leaf samples were determined using the Ombo (1974) equation:

Nutrient uptake = % Nutrient content x Sample dry weight

3.3.9. Chlorophyll and carotenoids determination in tea leaves on the field

At 8 and 14 MAT, fresh leaves were randomly plucked from the tea plants in each treatment and replication. The leaves were assayed for chlorophyll and carotenoids composition at the Soil and Plant Nutrition Laboratory, Cocoa Research Institute of Nigeria, Ibadan as described in Experiment 1.

3.3.10. Data analysis

Data were analysed with Analysis of Variance (ANOVA) using STAR (Statistical Tools for Agricultural Research) (2013) software package and the significant means were separated with Tukey's Honest Significant Difference (HSD) Test (P=0.05).

3.4. Experiment 3: Effects of different densities of plantain shade and organic fertilisers on growth and field establishment of tea plants in Ibadan and Owena, Nigeria

This experiment was carried out between 2016 and 2018 and was aimed at determining the optimum plantain shade density that would enhance the growth and field seedling establishment of tea plants in Ibadan and Owena.

3.4.1. Land preparation of experimental sites

The land was cleared of all vegetations manually with cutlass. The plot lay-out was done with the use of ranging pole, measuring tape, wooden pegs and measuring line. The plot was laid out into four blocks, each comprising 2 main plots, 6 sub-plots and 24 sub-sub plots. Soil auger was used to collect composite soil samples at five locations on the experimental plots at 0-30 cm depth for pre-cropping soil analysis. The procedures for sample preparation and laboratory assay of the soil samples were as described in Experiments 1 and 2 above.

3.4.2. Acquisition and preparation of experimental materials

Plantain suckers were obtained from CRIN Headquarters, Ibadan and CRIN substation, Owena. Tea cuttings of 143 and 318 cultivars were raised in the nursery for twelve months between 2016 and 2017 at CRIN Substation Kusuku, Mambilla Plateau, Taraba State and were transported to the experimental sites in Ibadan and Owena.

3.4.3. Experimental design and layout

This is a 2x3x4 factorial experiment. It consisted of two tea cultivars (C143 and C318); three plantain populations: 1,111 stands ha^{-1} ($2.27x10^4$lux) (3x3 m planting distance), 2,222 stands ha^{-1} ($1.61x10^4$lux) (3x1.5 m planting distance) and zero shade as control ($3.65x10^4$lux); four levels of fertiliser comprising three fertiliser materials (Poultry Manure (PM), Cocoa Pod Husk (CPH) and NPK (5:1:1)) each at one level of 150 kg Nha^{-1}; and zero (0 kg ha^{-1}) fertiliser as control. The experiment was laid out in Randomised Complete Block Design (RCBD) arranged in Split-Split Plots with four replications (Blocks). Each block contained 2 main plots, 6 sub-plots and 24 sub-subplots: tea cultivars as the main plots; plantain densities as subplots and fertiliser types as sub-subplots. Each main plot contained 3 subplots; and each sub-plot containd 4 sub-subplots (Figure 3.4).

The size of each subplot was 18 m^2 (6 m long; 3 m wide) with a gap of 2 m between the subplots. The whole experiment was 504 m^2. The subplots of 2222 plantain ha^{-1} density was made of 2 rows of 5 plantain stands, 3 m between rows and 1.5 m within rows; while the subplot of 1111 plantain ha^{-1} density was made of 2 rows of 3 plantain stands spaced 3 m apart (3 m between rows and within rows). Tea cuttings were transplanted in the avenue of the 2 rows of the plantain. A gap of 2 m was allowed between the four blocks and between the subplots within each block. Four tea plant stands were planted in each sub-sub plot.

3.4.4. Establishment of plantain shade

After land preparation, the land was marked out into four blocks and plantain suckers were planted 16 months before planting out of the tea cuttings. The plantain was planted at 2 planting densities: 2222 plantain ha^{-1} at planting distance of 3x1.5 m and 1111 plantain ha^{-1} at planting distance of 3x3 m. The plantain suckers were planted in holes of 30x30x40 m dimension. By 16 months after the planting, the plantain had closed canopy

BLOCK I	BLOCK II	BLOCK III	BLOCK IV
V1P1F3	V2P0F2	V1P1F0	V2P0F2
V1P1F0	V2P0F3	V1P1F1	V2P0F0
V1P1F2	V2P0F0	V1P1F3	V2P0F3
V1P1F1	V2P0F1	V1P1F2	V2P0F1
V1P2F1	V2P1F3	V1P0F2	V2P1F3
V1P2F0	V2P1F2	V1P0F0	V2P1F0
V1P2F2	V2P1F0	V1P0F3	V2P1F2
V1P2F3	V2P1F1	V1P0F1	V2P1F1
V1P0F3	V2P2F2	V1P2F3	V2P2F0
V1P0F1	V2P2F3	V1P2F0	V2P2F3
V1P0F0	V2P2F1	V1P2F2	V2P2F2
V1P0F2	V2P2F0	V1P2F1	V2P2F1
V2P2F2	V1P0F0	V2P0F0	V1P2F2
V2P2F3	V1P0F2	V2P0F2	V1P2F3
V2P2F1	V1P0F1	V2P0F1	V1P2F1
V2P2F0	V1P0F3	V2P0F3	V1P2F0
V2P1F0	V1P1F2	V2P1F3	V1P0F0
V2P1F1	V1P1F1	V2P1F1	V1P0F1
V2P1F3	V1P1F0	V2P1F0	V1P0F2
V2P1F2	V1P1F3	V2P1F2	V1P0F3
V2P0F3	V1P2F0	V2P2F3	V1P1F1
V2P0F2	V1P2F3	V2P2F1	V1P1F3
V2P0F0	V1P2F1	V2P2F2	V1P1F0
V2P0F1	V1P2F2	V2P2F0	V1P1F2

Figure 3.4: Experiment 3 lay out

V1: Cultivar 143; V2: Cultivar 318; P1: 1111 plantain ha^{-1}; P2: 2222 plantain ha^{-1}; P0: No shade; F1: Poultry manure (150 kg Nha^{-1}); F2: Cocoa pod husk (150 kg Nha^{-1}); F3: 150 kg Nha^{-1} NPK 5:1:1; F0: 0 $kgha^{-1}$(Control)

(Plates 3.5 and 3.6). In maintaining the plantain, weeding was done by slashing with cutlass 5 times within the first 16 months of plantain establishment.

3.4.5. Planting and allotment of treatments

At 16 months of plantain establishment, tea cuttings were transplanted under the plantain. Stands for tea were marked out with measuring tapes, measuring lines and wooden pegs. Holes of 20x20x25 cm were dug. Tea cuttings were planted at 8-11 leaf stage. The polythene bags containing the tea cuttings were slit with cutlass and they were planted in the dug holes with the ball of soil. The planting was done at a spacing of 100x60 cm. At 1 MAT, fertiliser treatments were applied to the newly transplanted tea plants. The fertilisers were spread in ring form round the tea stands at a radius of 20 cm from the base of the tea stands.

3.4.6. Routine cultural practices

Weeding was done with hoe and cutlass at 2 MAT and at every 3 months subsequently. The subplots were weeded with hoe while the gap between the subplots and the blocks were slashed with cutlass. In the dry season, water was applied to the base of the tea plants: 2 L of water was applied per tea stand 3 times per week.

3.4.7. Data collection

On monthly basis, starting from 3 MAT, two tea plants per treatment per replication were randomly tagged for the following data collections. Morphological parameters: number of leaves, leaf area, number of leaf fall (abscission scars) and number of branches. The morphological parameter measurement was done as described in Experiment 1. At each sampling period, the light intensities under the plantain were measured with Lux Meter to monitor variation in light intensities as influenced by the leafiness of the plantain plants. At 9 MAT, survival counts were carried out on the tea plants to determine the level of survival of the tea plants after the first dry season of transplanting.

Plate 3.5: A cross-section of Experiment 3 site 14 months after plantain establishment at Ibadan

Plate 3.6: A cross-section of Experiment 3 site 14 months after plantain establishment at Owena

3.4.8. Data analysis

All data collected from the experiment were analysed with Analysis of Variance (ANOVA) using STAR (Statistical Tools for Agricultural Research) (2013) software package and the significant means were separated with Tukey's Honest Significant Difference (HSD) Test (P=0.05).

CHAPTER 4

RESULTS

4.1. Ibadan and Owena experimental sites

There were variations in the climatic factors of Ibadan and Owena. For instance, amount of rainfall in Owena was higher than of Ibadan in greater part of the year especially, January-February, and June-November (Figure. 4.1). Similarly, Figure 4.2 shows higher ambient temperature in Owena for most months of the year. However, relative humidity of Ibadan was slightly higher than that of Owena (Figure 4.3).

4.2. Pre-cropping physical and chemical properties of the soils

The physical and chemical properties of the soils used for the pot experiments are shown in Table 4.1. Ibadan experimental location soil contained 100.00, 845.00 and 55.00 g kg^{-1} sand, silt and clay, respectively; whereas in Owena the sand, silt and clay content were 98.00, 880.00 and 22.00 g kg^{-1} soil; thus classifying both soils as Sand-loam. The pH of the soils were 6.7 and 6.3 in Ibadan and Owena, respectively. The soil in Owena had higher values of 0.13 cmol kg^{-1}, 0.10 cmol kg^{-1}, 1.64 and 1.20 cmol $kg^{-1}$for Al^{+}, H^{+}, CEC and ECEC me/100 g, respectively as against 0.11 cmol kg^{-1}, 0.08 cmol kg^{-1}, 1.29 and 0.92 cmol kg^{-1}in Ibadan for the same properties, respectively.

Similarly, Owena soil (Table 4.1) contained higher values of 0.54 $cmolkg^{-1}$, 0.31 $cmolkg^{-1}$ and 0.25 $cmolkg^{-1}$ for K, Ca and Mg contents, respectively as against 0.45, 0.22 and 0.18 $cmolkg^{-1}$, respectively in the soil at Ibadan. Conversely, Ibadan location soil contained higher 36.00% OM compared to 24.51% in Owena. The Total N of Ibadan location soil (21.20 g kg^{-1}) was higher than that of Owena (11.60 g kg^{-1}); whereas Available P in Owena (35.74 mg kg^{-1}) was higher than that of Ibadan location soil (31.75 mg kg^{-1}). Owena soil was higher in micro-nutrients as it contained 45 $cmolkg^{-1}$ Na and 0.14 $cmolkg^{-1}$ Mn as against 0.37 $cmolkg^{-1}$ Na and 0.12 $cmolkg^{-1}$ Mn in Ibadan location soil.

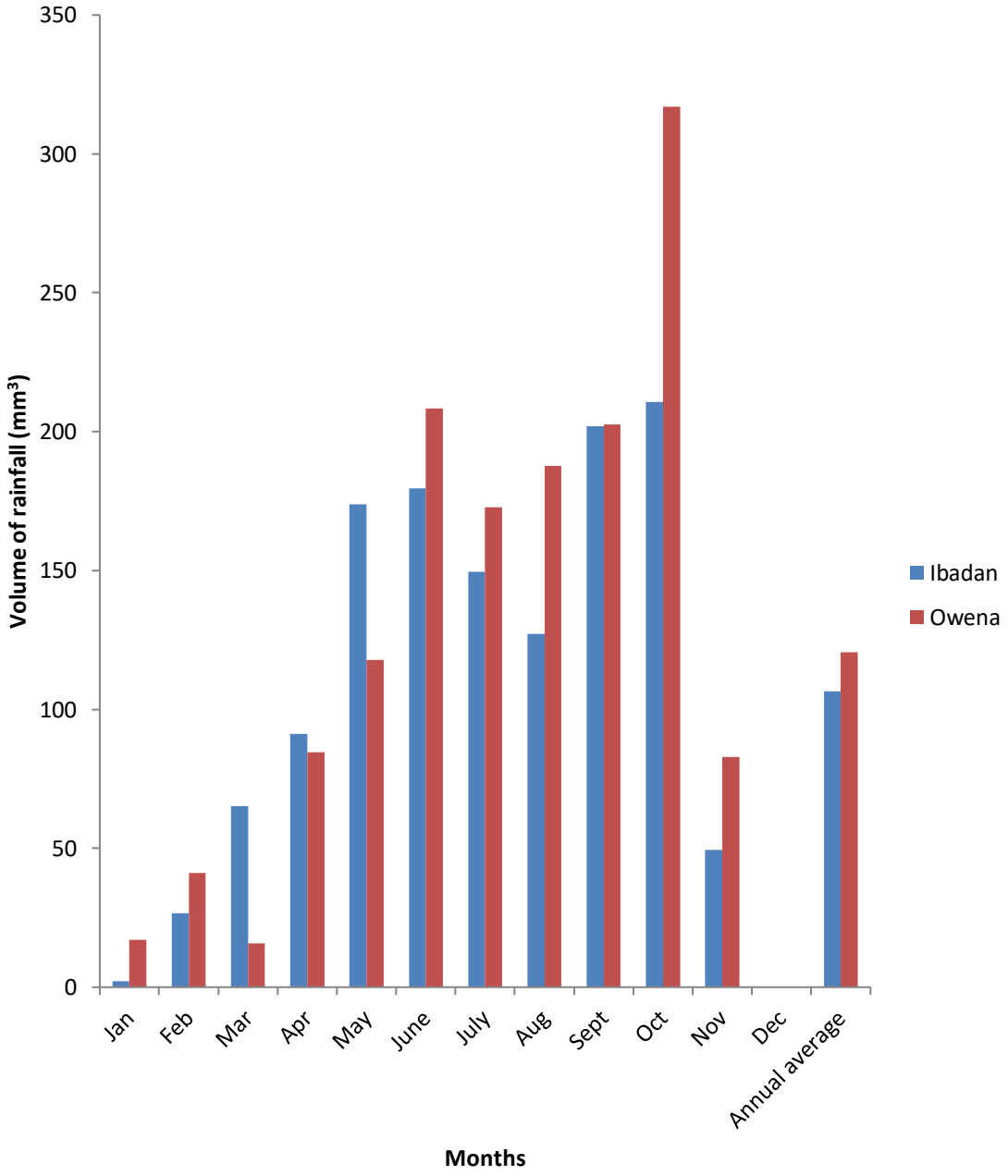
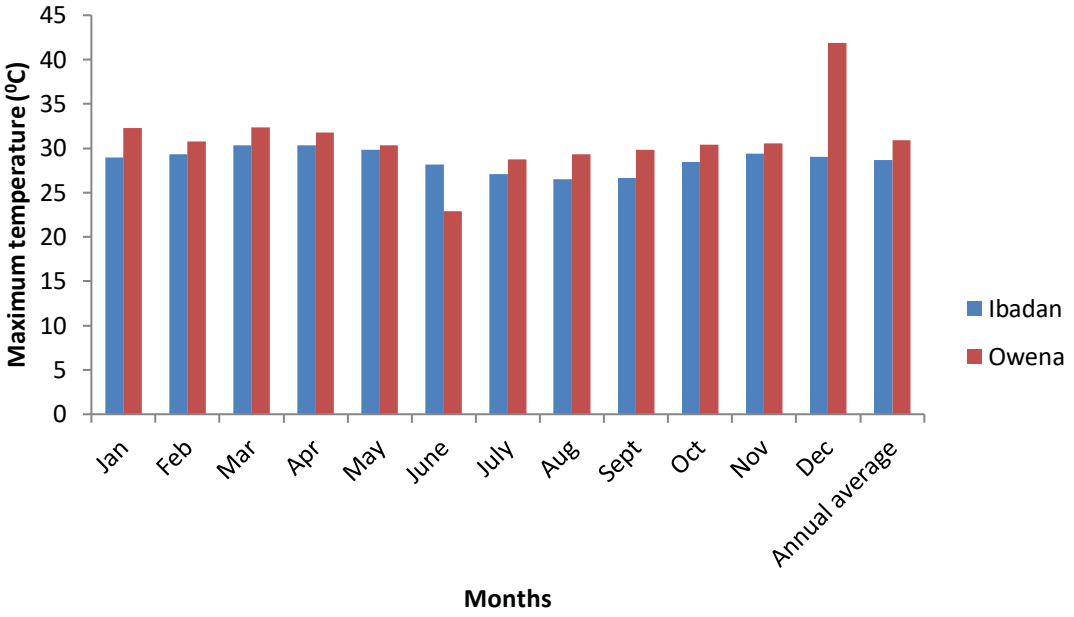


Figure 4.1: Average monthly rainfall of 2010-2016 at Ibadan and Owena
Source: CRIN Weather Reports, 2010-2016; Ondo State Agro-Climatological Reports, 2010-2016



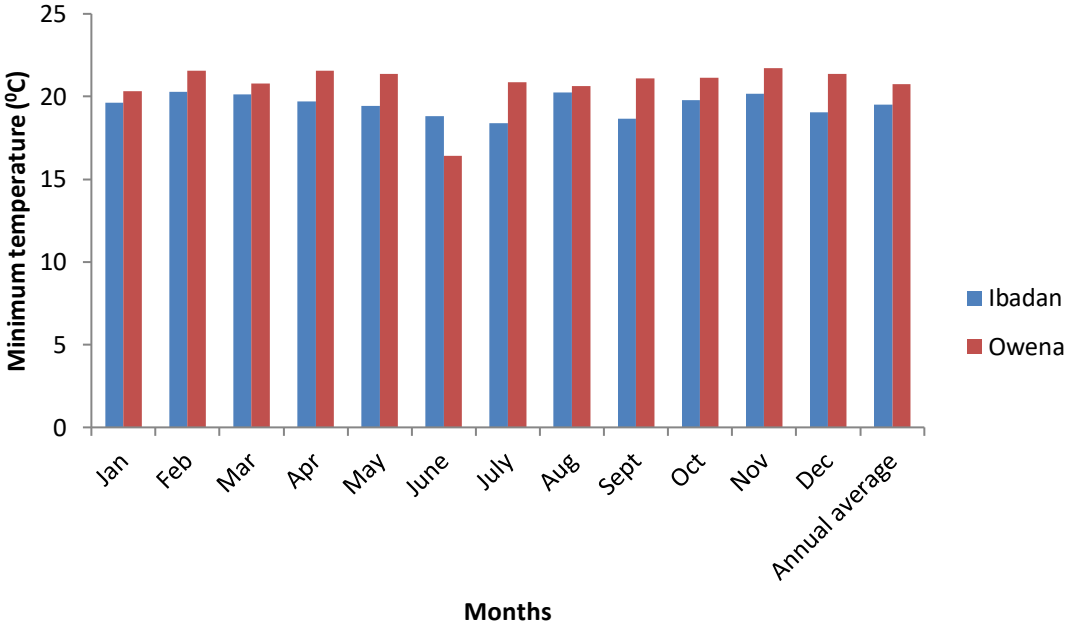


Figure 4.2: Average monthly minimum and maximum temperature of 2010-2016 at Ibadan and Owena

Source: CRIN Weather Reports, 2010-2016; Ondo State Agro-Climatological Reports, 2010-2016

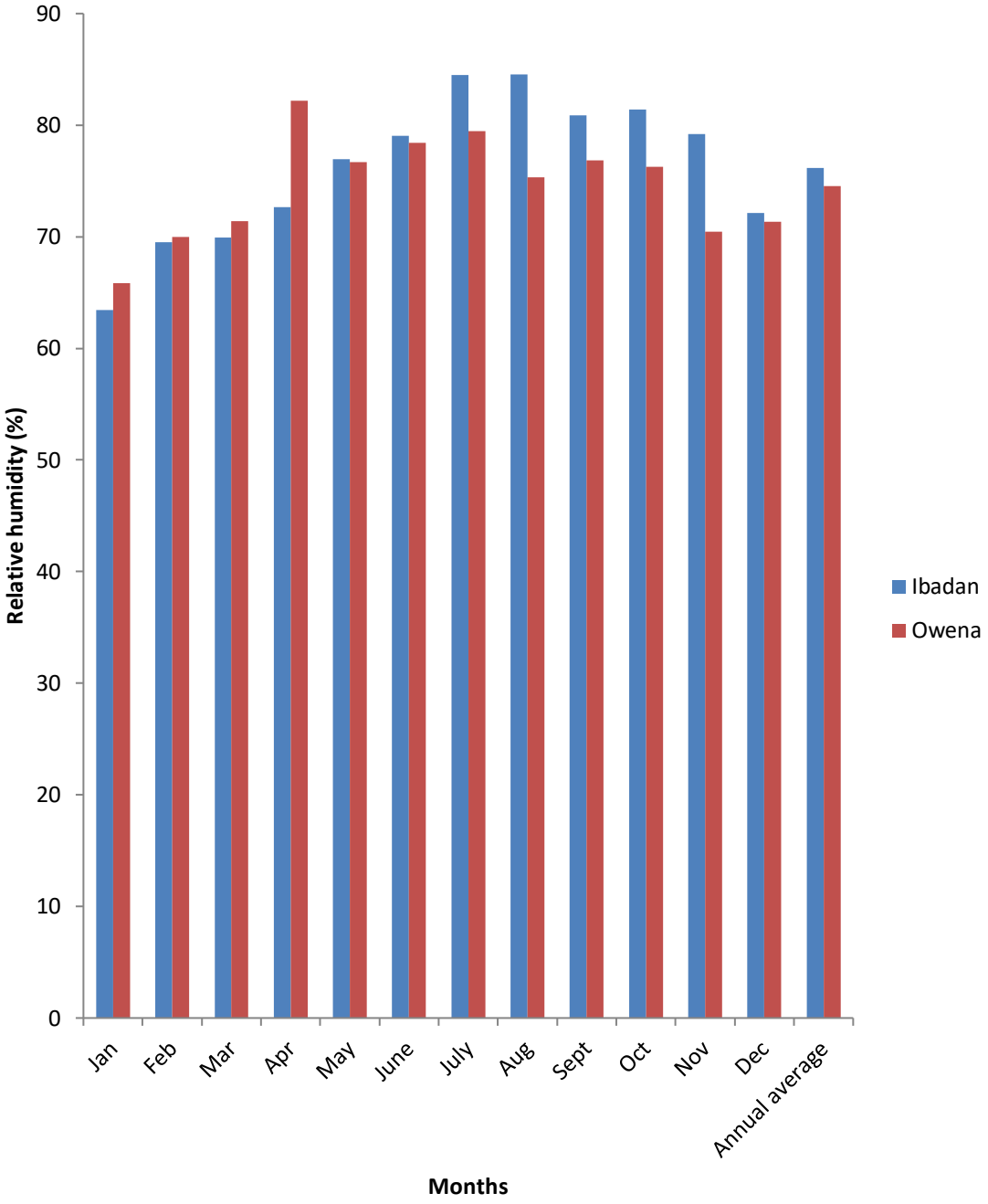


Figure 4.3: Average monthly relative humidity of 2010-2016 at Ibadan and Owena
Source: CRIN Weather Reports, 2010-2016; Ondo State Agro-Climatological Reports, 2010-2016

Table 4.1: Pre-cropping particle size and chemical properties of soils used in the pot experiment in 2014

Soil properties	Ibadan	Owena
pH	6.7	6.3
Exchangeable cations (cmol kg^{-1})		
Na^{+}	0.37	0.45
K^{+}	0.45	0.54
Ca^{+}	0.22	0.31
Mg^{2+}	0.18	0.25
%OM	36.00	24.51
Total N (g kg^{-1})	21.20	11.60
Available P ($mgkg^{-1}$)	31.75	35.74
Exchangeable micronutrients (cmol kg^{-1} soil)		
Mn^{2+}	0.12	0.14
Al^{+}	0.11	0.13
H^{+}	0.08	0.10
CEC	1.29	1.64
ECEC ($cmolkg^{-1}$)	0.92	1.20
%Base Saturation	94.19	94.18
Particle size analyses (g kg^{-1})		
Sand	100.00	98.60
Silt	845.00	880.00
Clay	55.00	21.40
Textural class	Sand-loam	Sand-loam

Table 4.2 shows the pre-cropping physical and chemical properties of the soils used for the field trials. The soil pH values of 7.4 and 6.2 at Ibadan and Owena, are indications of a slightly alkaline and slightly acidic conditions, respectively. The N, P, K and Mn values of 23.10 $mgkg^{-1}$ 14.90 $mgkg^{-1}$, 0.32 $cmolkg^{-1}$ and 0.11 $cmolkg^{-1}$, respectively of Ibadan are higher than those of Owena (15.60 gkg^{-1} N, 10.40 $mgkg^{-1}$ P, 0.29 $mgkg^{-1}$K and 0.11 $cmolkg^{-1}$ Mn). However, Owena soil contained higher values of 0.33 $cmolkg^{-1}$, 0.17 $cmolkg^{-1}$, 0.13 $cmolkg^{-1}$, 1.01 and 0.68 for Na, Ca, Mg, CEC and ECEC $cmolkg^{-1}$, respectively as against Ibadan values of 0.30 $cmolkg^{-1}$, 0.15 $cmolkg^{-1}$, 0.10 $cmolkg^{-1}$, 0.90 and 0.61 $cmolkg^{-1}$for the same properties, respectively. The sand, silt and clay of 140.00, 800.00 and 60.00 gkg^{-1}, respectively of Ibadan location soil and 120.00, 822.00 and 58.00 g kg^{-1} of Owena classify both soils as sand-loam.

4.3. Nutrient contents of the fertiliser materials

Table 4.3 shows the nutrient contents of the fertiliser materials used in the pot experiments. Poultry manure (PM) was higher in nutrients than Cocoa pod husk (CPH). PM contained 3.45, 0.02, 0.01, 0.05 and 0.01% N, P, K, Ca and Mg, respectively; whereas, CPH contained 1.4, 0.01, 0.01, 0.02 and 0.003% of same nutrients, respectively. The micro-nutrients in PM were 5021.13 $mgkg^{-1}$ Fe, 643.0 $mgkg^{-1}$ Mn, 475.20 $mgkg^{-1}$ Zn and 75.85 $mgkg^{-1}$ Cu; while 54.22, 27.18, 24.82 and 31.81 $mgkg^{-1}$ of the same nutrients were contained in CPH. The % OM and C:N in PM were, 66.76 and 12.5 as against 33.77 and 7.5 in CPH, respectively. The inorganic fertilisers used (Urea, SSP and MoP) contained 46, 7.92 and 49.8 % N, P and K respectively. The pH of poultry manure and cocoa pod husk were 6.4 and 6.6, respectively.

The nutrient content, physical and chemical properties of the fertiliser materials used in the field experiments are shown in Table 4.4. Poultry manure was superior to cocoa pod husk in all the chemical properties, except in C:N and Fe content values of 10.44 and 169.57 $mgkg^{-1}$, respectively which were higher than 9.56 and 128.60 $mgkg^{-1}$ in poultry manure. The major plant nutrient values of 1.96, 0.99, 1.37, 2.86 and 0.26% of N, P, K, Ca and Mg, respectively for poultry manure were higher than those of cocoa pod husk (1.40, 0.41, 0.73, 0.24 and 0.25% for the same plant nutrients, respectively).

Table 4.2: Pre-cropping particle size and chemical properties of soils used in field experiments in 2014

Soil properties	Ibadan	Owena
pH (H_2O) 1:1	7.4	6.2
Exchangeable cations ($cmolkg^{-1}soil$)		
Na^+	0.30	0.33
K^+	0.32	0.29
Ca^{2+}	0.15	0.17
Mg^{2+}	0.10	0.13
OM (%)	48.59	29.14
Total N (gkg^{-1})	23.10	15.60
Average P ($mgkg^{-1}$)	14.90	10.40
Exchangeable micronutrients ($cmolkg^{-1}soil$)		
Mn^{2+}	0.11	0.11
Al^+	0.12	0.11
H^+	0.04	0.10
CEC	0.90	1.01
ECEC me/100g	0.61	0.68
%base saturation	95.69	90.14
Particle size analyses (gkg^{-1})		
Sand	140.00	120.00
Silt	800.00	822.00
Clay	60.00	58.00
Textural class	Sand-loam	Sand-loam

Table 4.3: Chemical properties of fertiliser materials used in the pot experiment

Properties	CPH	PM	UREA	SSP	MoP
%K	0.01	0.01	-	-	49.8
%Ca	0.02	0.05	-	-	-
%Mg	0.003	0.01	-	-	-
%OM	33.77	66.76	-	-	-
%N	1.40	3.45	46	-	-
%Phosphorus	0.01	0.02	-	7.92	
Mn ($mgkg^{-1}$)	27.18	643.00	-	-	-
pH	6.4	6.6	-	-	-
C:N	7.5	12.5	-	-	-
Iron ($mgkg^{-1}$)	54.22	5021.13	-	-	-
Zinc($mgkg^{-1}$)	24.82	475.20	-	-	-
Copper($mgkg^{-1}$)	31.81	75.85	-	-	-

CPH: Cocoa pod husk; PM: Poultry manure; SSP: Single Super Phosphate; MoP: Muriate of Potash

Table 4.4: Chemical properties of fertiliser materials used in the field experiments

Properties	CPH	PM	UREA	SSP	MoP
%K	0.73	1.37	-	-	49.8
Ca (%)	0.24	2.86	-	-	-
Mg (%)	0.25	0.26	-	-	-
%OM	41.15	68.34	-	-	-
%N	1.40	1.96	46	-	-
%Phosphorus	0.41	0.99	-	7.92	
Mn ($mgkg^{-1}$)	32.30	33.15	-	-	-
pH	7.2	8.3	-	-	-
C:N	10.44	9.56	-	-	-
Iron ($mgkg^{-1}$)	169.57	128.60	-	-	-
Zinc($mgkg^{-1}$)	15.20	15.70	-	-	-
Copper($mgkg^{-1}$)	4.30	6.10	-	-	-

CPH: Cocoa Pod Husk; PM: Poultry Manure; SSP: Single Super Phosphate; MoP: Muriate of Potash

Similarly, poultry manure was richer in micro nutrients (33.15 $mgkg^{-1}$, 15.70 $mgkg^{-1}$ and 6.10 $mgkg^{-1}$ for Mn, Zn and Cu respectively in PM as against 32.30 $mgkg^{-1}$, 15.20 $mgkg^{-1}$ and 4.30 $mgkg^{-1}$ for the same nutrients in CPH). The %OM and pH of cocoa pod husk were 41.15 and 7.2, respectively, while those of poultry manure were 68.34 and 8.3 for %OM and pH, respectively (Table 4.4).

4.4. Experiment 1: Effects of light intensity and organic fertilisers on growth, dry matter accumulation and photosynthetic pigments of tea in the pot experiment at Ibadan and Owena, Nigeria

4.4.1. The effects of cultivar, light intensity and organic fertiliser on vegetative growth of tea plants in the pot experiment at Ibadan and Owena

Cultivars 143 and 318 differed significantly (P=0.05) in their vegetative growth response to light intensity and applied fertilisers in both locations (Table 4.5 and Figures 4.4). At Ibadan (Table 4.5), C143 performed better than C318 significantly (P=0.05) in number of leaves and number of branches. Although, the leaf area of C143 was higher than that of C318, the difference was not significant (P>0.05). In Owena, C143 produced significantly (P=0.05) higher number of leaves and leaf area, but C318 had higher number of branches. The C143 and C318 increased in plant height and stem diameter from 4 to 8 MAT except at Owena where plant height declined at 8 MAT (Figure 4.4). At Ibadan, although C318 enhanced higher plant height, the difference was significant only at 8 MAT. At Ibadan and Owena, C318 had higher stem diameter than C143.

Reduced light intensity enhanced vegetative growth of potted tea plants compared to full light intensity across the two locations (Table 4.5). At Ibadan, number of leaves and number of branches (29.19 and 5.30, respectively) enhanced by 65% light were significantly (P=0.05) higher than those produced by 100% light but were not significantly (P>0.05) higher than those produced by 45 and 25% lights. Similarly, 65% light produced the highest leaf area of 891.77 cm^2 and it was similar to 45% light (818.42 cm^2) but significantly different from those of 25 and 100% light (678.27 cm^2 and 15.19 cm^2, respectively).

Table 4.5: Main effects of cultivars, light intensities and fertilisers on number of leaves, number of branches and leaf area of tea plants at 8 MAT in the pot experiment at Ibadan and Owena in 2015

Treatments	Ibadan			Owena		
Cultivars	**NL**	**NB**	**LA (cm^2)**	**NL**	**NB**	**LA (cm^2)**
C143	25.23a	5.02a	665.93a	25.38a	0.66b	898.23a
C318	19.99b	4.38b	602.09a	20.74b	1.70a	669.28b
Mean	22.57	4.70	634.01	23.06	1.03	783.76
Light Intensities (%)						
25	27.11a	4.62ab	678.27b	28.95b	4.17b	894.44b
45	27.80a	4.97a	818.42ab	29.25ab	4.12b	1006.06b
65	29.19a	5.30a	891.77a	32.64a	5.24a	1226.51a
100	6.36b	3.92b	15.19c	1.41c	0.04c	8.01c
Mean	22.62	4.70	600.91	23.06	0.51	783.76
Fertilisers(kg Nha^{-1})						
CPH_{75}	20.69c	4.50bc	480.05b	23.09a	1.23c	510.55ab
CPH_{150}	21.16c	4.09bc	510.04ab	22.72b	2.00bc	525.54ab
CPH_{300}	29.00a	6.34a	699.80a	26.19a	2.00bc	598.44a
NPK_{150}	21.84bc	4.62bc	470.40b	23.00a	1.48bc	589.43a
PM_{75}	25.19b	4.31bc	619.78ab	23.09a	3.37a	503.10ab
PM_{150}	22.12bc	4.88ab	506.14ab	22.38b	1.41bc	587.21a
PM_{300}	23.28bc	5.53ab	482.19bc	26.78a	3.52a	607.04a
Ctrl	17.61c	3.34c	338.33c	17.25c	2.60ab	208.62b
Mean	22.61	4.70	513.34	23.06	2.01	783.76

Means followed by the same letters in a column under each treatment are not significantly different by HSD (P=0.05) CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry manure; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control; NL = Number of leaves; NB = Number of branches; LA = Leaf area; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

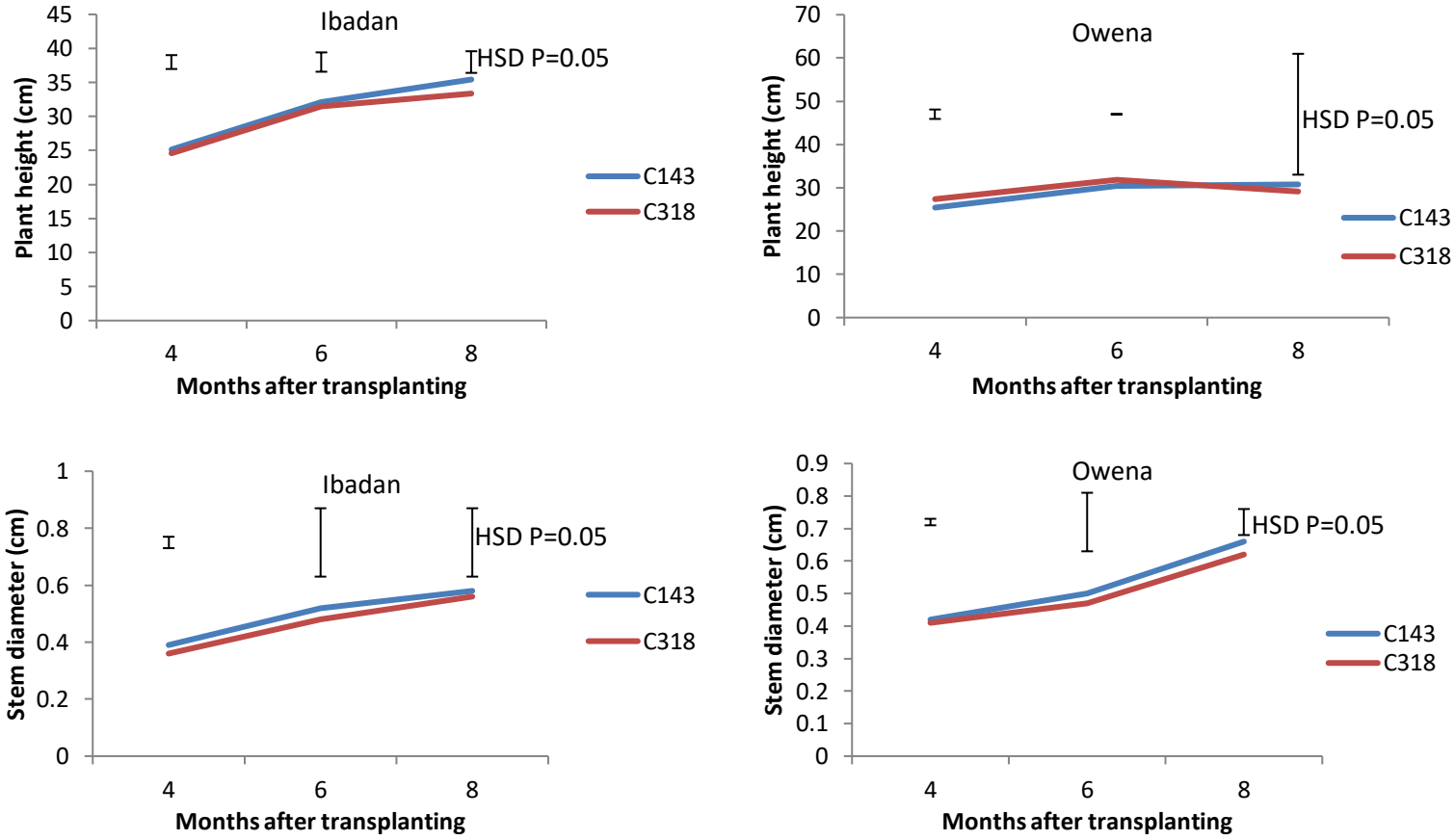


Figure 4.4: Main effects of cultivars on plant height and stem diameter of tea plants in the pot experiment at Ibadan and Owena in 2015

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

Similar trend was observed in Owena as tea plants grown under 65% light had the highest number of leaves, number of branches and leaf area; however, the values of these growth parameters for 25 and 45% lights were not significantly ($P>0.05$) different. The height and stem diameter of the tea plants increased from 4 MAT to 8 MAT at different proportion as influenced by the different light intensities at both locations (Figure 4.5). At both locations, the heights of tea plants under 45 and 65% light were significantly ($P=0.05$) higher than those of tea plants under 25 and 100% light but were not significantly different from each other. Similarly, 65% light enhanced the highest stem diameter at 4-8 MAT at Owena, and Ibadan, at 4-6 MAT; but 45% light produced the highest stem diameter at 8 MAT but was not significantly different from 65% light. For all parameters under observation across Ibadan and owena, 100% light significantly reduced the growth and development of tea plants. Plate 4.1 shows how 100% light caused stunted growth, lower height and diminished number and size of leaves of the tea plants at Owena.

The organic and inorganic fertilisers enhanced the growth of the tea plants significantly ($P=0.05$) (Table 4.5). At Ibadan, milled cocoa pod husk applied at 300 kg Nha^{-1} (CPH_{300}) enhanced the highest number of leaves, number of branches and leaf area of the tea plants while the control produced the least vegetative growth. CPH_{300} increased the number of leaves, number of branches and leaf area by 65, 90 and 107% respectively compared to control. However, at Owena, PM_{300} engendered the highest number of leaves, number branches and leaf area; while the control produced the least number of leaves and leaf area, CPH_{75} produced the least number of branches. The PM_{300} increased the number of leaves, number of branches and leaf area by 55, 35 and 191% respectively compared to control.

Figure 4.6 shows that there were significant ($P=0.05$) differences in the effect of the fertiliser types and rates on plant height and stem diameter of the tea plants. At Ibadan, the different fertilisers increased the plant height and stem diameter from 4 to 8 MAT. Tea plants that received NPK_{150} were taller than those that received other rates of fertilisers especially at 4 and 6 MAT, although the difference was significant ($P=0.05$) only when compared with CPH_{150} and control; while tea plants that received CPH_{300} were the tallest at 8 MAT although the difference was significant ($P=0.05$) only when compared with control.

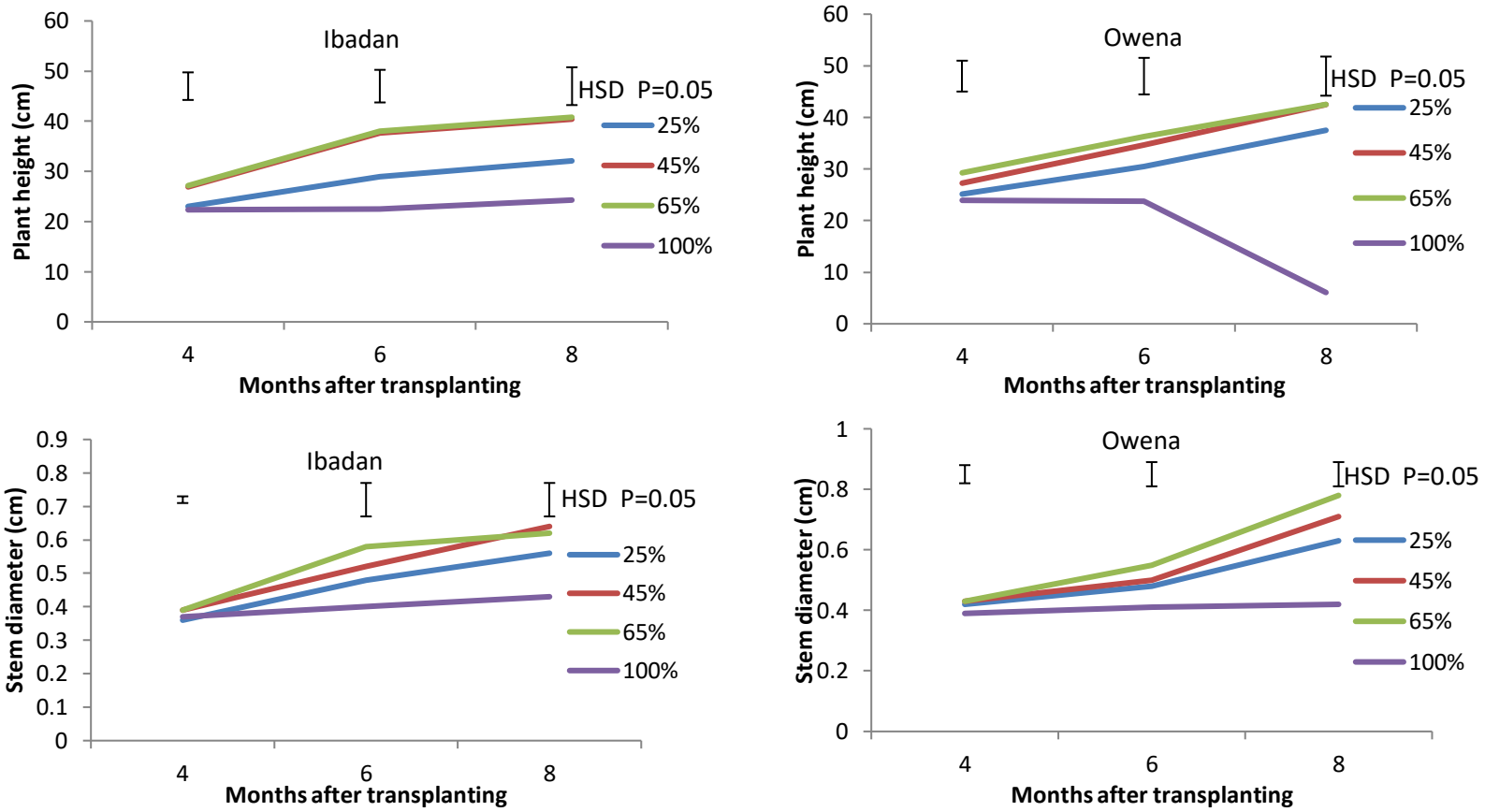


Figure 4.5: Main effects of light intensities on plant height and stem diameter of tea plants in the pot experiment at Ibadan and Owena in 2015

25% = 25% light intensity; 45% = 45% light intensity; 65% = 65% light intensity; 100% = 100% light intensity; MAT = Months after transplanting

25% Light

45% Light

65% Light

100% Light

Plate 4.1: The vegetative growth of tea plants in the pot experiment as affected by different light intensities at 8 MAT at Owena in 2015

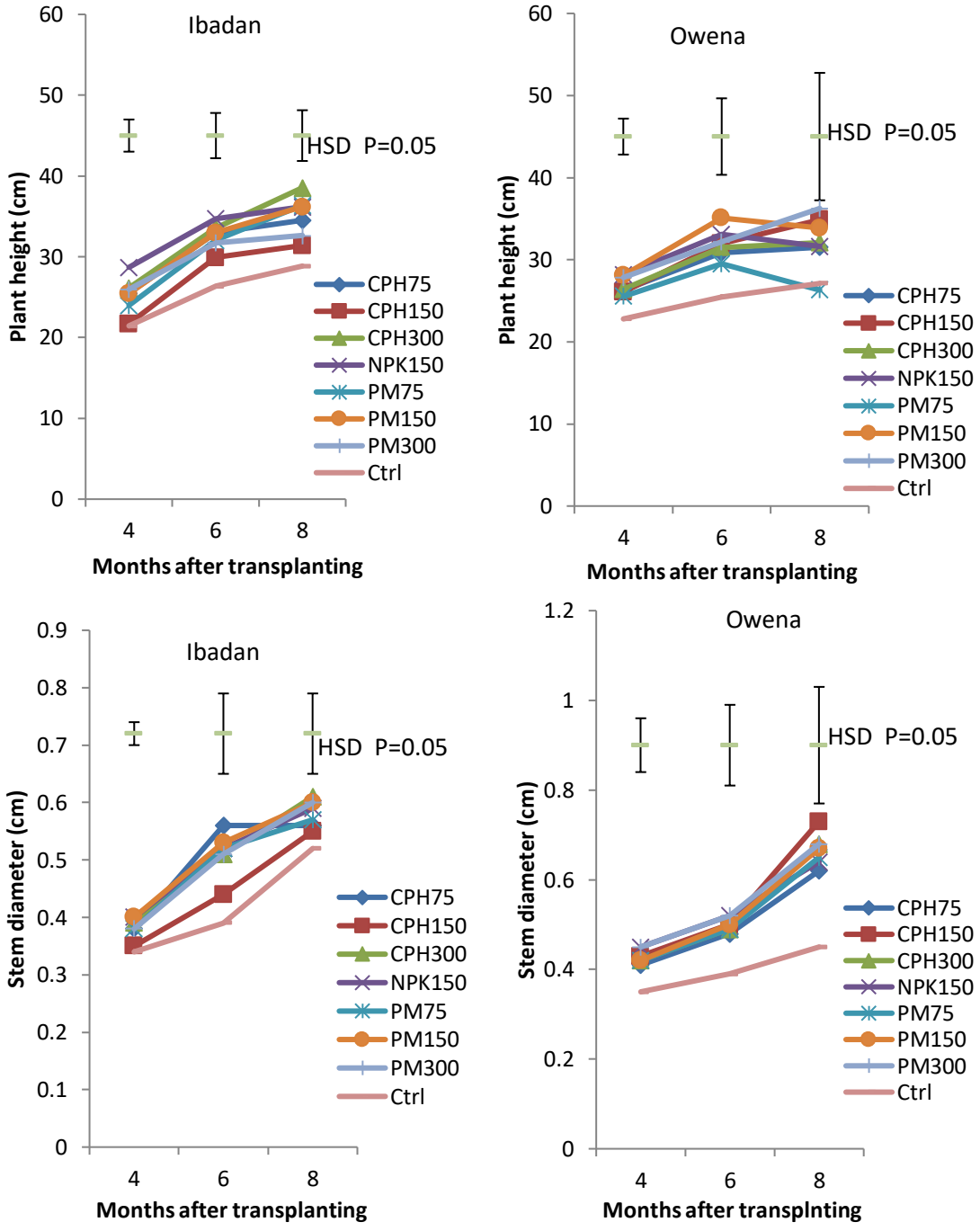


Figure 4.6: Main effects of fertilisers on plant height and stem diameter of tea plants in the pot experiment at Ibadan and Owena in 2015

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry manure; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control; MAT = Months after transplanting

In Owena, the tea plant that received PM_{150} grew taller than those that received other fertiliser rates especially at 4 and 6 MAT, while the tea plants that received PM_{300} were taller at 8 MAT. The effect of PM_{150} on plant height was not significantly ($P>0.05$) different from the effect of other fertiliser rates but significantly ($P=0.05$) different from the effect of control especially at 6 MAT. Different rates of the fertilisers enhanced stem diameter of the tea plants at Ibadan as PM_{150} produced the highest stem diameter at 4 and 8 MAT. At Owena, PM_{300} engendered the highest stem diameter at 4 and 6 MAT while CPH_{150} enhanced the highest stem diameter at 8 MAT, but the differences were not significant except when compared with control.

Table 4.6 and Figure 4.7 show that tea cultivars were different in vegetative growth under the varying light intensities. At Ibadan, C143 had higher number of leaves, number of branches and leaf area compared with C318 under all the light intensities, the difference in leaf area being significant under 45% light (Table 4.6). Similarly, C143 grew taller and had significantly ($P=0.05$) thicker stem than C318 under 100% light (Figure 4.7). In a similar trend at Owena (Table 4.6), all the light intensities enhanced the number of leaves of C143 better than C318 although not significantly. The leaf area of C143 was higher significantly ($P=0.05$) than that of C318 under 45 and 65% lights. However, the number of branches of C318 under 25 and 100% and its plant height under 100% light were significantly higher than those of C143; while neither the cultivars was significantly superior in stem diameter under all the light intensities (Table 4.6 and Figure 4.7).

Table 4.7 shows that there were significant differences in the interaction effects of the fertilisers with light intensities on number of leaves, number of branches, and leaf area of the tea plants at Ibadan. There was better performance of these vegetative parts in C143 plants that received PM_{300}, CPH_{300}, and NPK_{150} under 25, 45 and 65% lights respectively; while in C318 plants, CPH_{300}, NPK_{150} and PM_{75} enhanced better vegetative growth under 25, 45 and 65% lights, respectively. Similarly, CPH_{300} engendered the highest vegetative growth of C143 and C318 under 100% light intensity.

Generally, all tea plants under 100% light intensity performed poorly despite the fertiliser treatments. The number of leaves and number of branches produced by PM_{75} and PM_{300} in C143 plants were significantly ($P=0.05$) higher than those produced by the control under 25% light; while CPH_{300} enhanced significantly ($P=0.05$) higher leaf area value than CPH_{75}, CPH_{150}, PM_{150}, PM_{300}, NPK_{150} and control in C143 plants under the same light

Table 4.6: Effect of interaction of cultivars and light intensities on number of leaves, number of branches and leaf area of tea plants at 8 MAT in the pot experiment at Ibadan and Owena in 2015

Treatments Light intensities (%) x Cultivars		Number of leaves	Number of branches	Leaf area (cm^2)
		Ibadan		
25	C143	29.19a	4.72a	729.91a
	C318	25.03a	4.53a	753.80a
Mean		27.11	4.63	781.55
45	C143	31.41a	5.38a	898.67a
	C318	24.19a	4.56a	738.18b
Mean		27.80	4.97	818.43
65	C143	32.88a	5.56a	948.02a
	C318	25.50a	5.03a	847.82a
Mean		29.19	5.30	897.92
100	C143	7.47a	4.44a	87.14a
	C318	5.25a	3.41a	68.57a
Mean		6.39	3.93	77.86
		Owena		
25	C143	31.28a	3.93b	609.67a
	C318	26.63a	4.40a	560.01a
Mean		28.96	4.17	584.84
45	C143	33.50a	4.56a	749.41a
	C318	25.00a	3.98b	504/38b
Mean		29.25	4.27	749.41
65	C143	36.19a	6.13a	815.85a
	C318	29.09a	4.61b	693.75b
Mean		32.64	5.37	754.80
100	C143	0.56a	0.01b	151.29a
	C318	2.25a	0.20a	117.57a
Mean		1.41	0.11	137.43

Means followed by the same letters along a column under each light intensity and location are not significantly different by HSD (P=0.05)

C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months After Transplanting

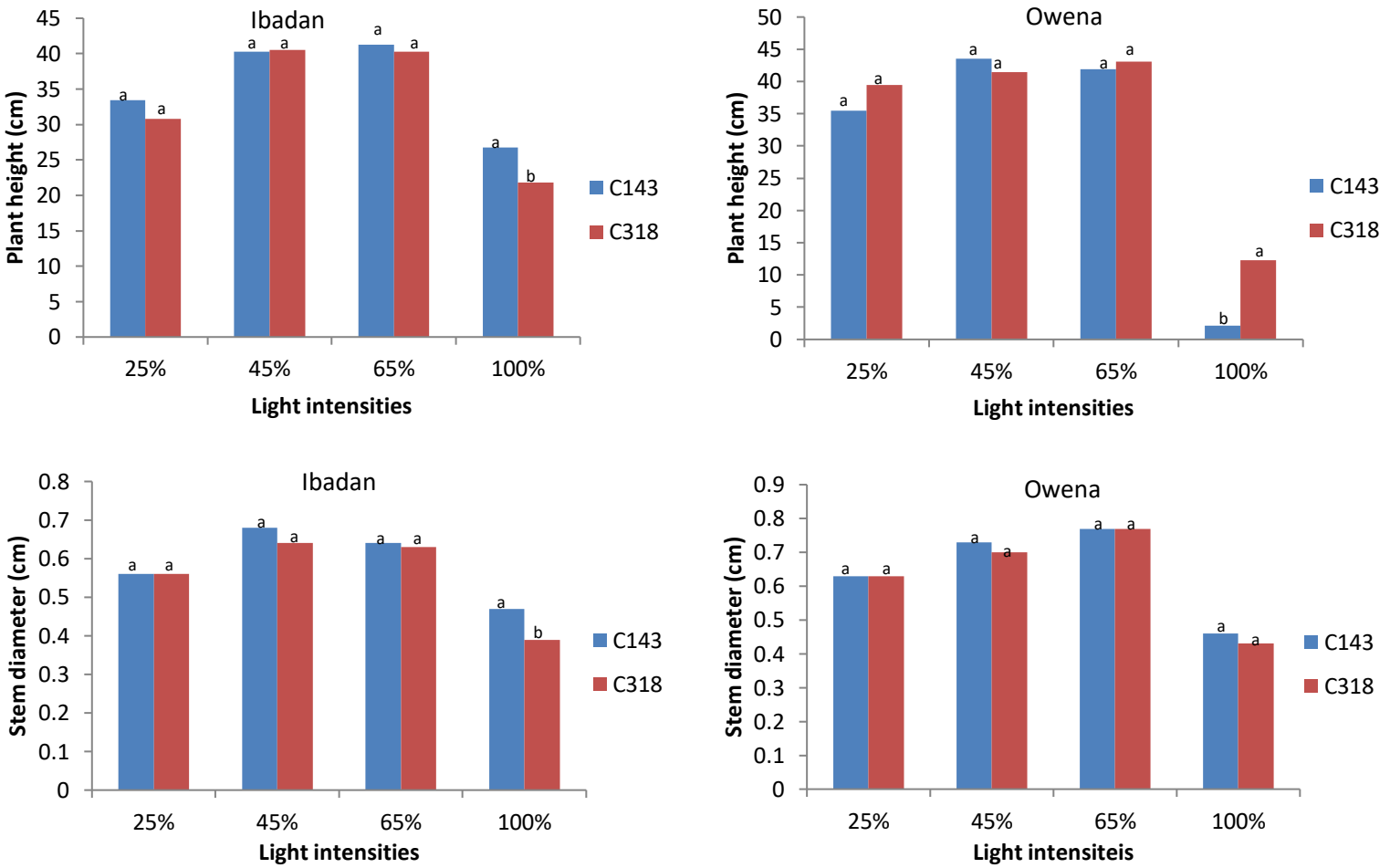


Figure 4.7: Effect of interaction of cultivars and light intensities on plant height and stem diameter of tea plants at 8 MAT in the pot experiment at Ibadan and Owena in 2015

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

Table 4.7: Effect of interaction of light intensities and fertilisers on number of leaves, number of branches and leaf area of two cultivars of tea plants at 8 MAT in the pot experiment at Ibadan in 2015

Treatments		C143			C318		
Light Intensities (%) x fertiliser (kg Nha^{-1})		NL	NB	LA (cm^2)	NL	NB	LA (cm^2)
25	CPH_{75}	17.08ab	3.04ab	363.71c	17.54ab	2.88ab	360.83c
	CPH_{150}	18.21ab	4.00ab	414.00bc	15.63b	2.25b	264.77cd
	CPH_{300}	23.50ab	4.92a	703.76a	32.00a	5.25a	867.09a
	NPK_{150}	23.29ab	3.25ab	508.93b	17.29b	2.79ab	422.25c
	PM_{75}	30.83a	4.79a	689.55a	12.33b	2.46b	249.79cd
	PM_{150}	19.25ab	3.58ab	373.77c	24.75ab	4.08ab	644.61b
	PM_{300}	25.67ab	5.58a	487.65bc	24.21ab	3.50ab	797.27a
	Ctrl	15.13b	2.00b	233.75d	10.82b	2.25b	151.46d
Mean		21.62	3.895	471.89	19.3175	3.1825	469.76
45	CPH_{75}	22.25b	2.92ab	618.84c	18.38c	2.58a	474.42bc
	CPH_{150}	21.33bc	3.54ab	637.34bc	19.17bc	2.13a	409.34bcd
	CPH_{300}	30.38a	5.21a	799.94a	16.50cd	3.29a	372.07c
	NPK_{150}	18.67c	2.63b	423.13de	23.96a	4.46a	697.64a
	PM_{75}	22.96b	3.38ab	534.84cd	22.75ab	3.63a	678.68a
	PM_{150}	22.25bc	3.71ab	613.00c	14.71d	3.54a	430.24bc
	PM_{300}	28.42a	4.46ab	747.00ab	18.38c	3.58a	518.56b
	Ctrl	19.13bc	3.50ab	323.40e	15.17d	2.46a	290.55d
Mean		23.17	3.67	587.19	18.63	3.21	483.94
65	CPH_{75}	24.88b	4.29ab	574.30cd	20.42ab	3.67a	619.44a
	CPH_{150}	23.46a	3.54b	620.20bc	21.42ab	3.54a	551.68abc
	CPH_{300}	28.17a	4.25ab	697.74a	17.79bc	3.38a	465.57bcd
	NPK_{150}	31.63a	6.33a	776.67a	21.04ab	4.13a	578.52ab
	PM_{75}	24.50b	3.63b	738.70ab	24.33a	3.92a	602.66a
	PM_{150}	21.17b	3.58b	451.77de	16.63c	2.83a	430.54cd
	PM_{300}	27.50b	4.50ab	602.89c	19.25bc	4.42a	441.65cd
	Ctrl	19.50c	3.71b	345.67e	17.46bc	3.00a	376.46d
Mean		25.10	4.23	601.00	19.79	3.61	508.32
100	CPH_{75}	7.88b	4.08a	100.44a	6.54a	3.71a	139.40ab
	CPH_{150}	8.67b	3.88a	151.36a	3.17b	1.50a	31.80b
	CPH_{300}	16.79a	4.46a	198.39a	9.03a	3.54a	152.19a
	NPK_{150}	5.75b	4.63a	109.57a	4.06b	1.75a	48.37ab
	PM_{75}	4.75b	2.79a	34.26b	5.38a	2.21a	70.01ab
	PM_{150}	7.54b	2.83a	141.55a	5.79a	3.33a	115.49ab
	PM_{300}	5.79b	4.29a	72.31b	4.13b	2.94a	52.21ab
	Ctrl	4.83b	2.38a	37.76b	4.17b	1.92a	29.60b
Mean		7.75	3.67	105.71	5.28	2.6	79.89

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

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry manure; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control; NL = Number of leaves; NB = Number of branches LA = Leaf area; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

intensity. However, CPH_{300} had an overriding effect over other fertiliser types and rates in C318 plants as it enhanced the highest number of leaves (32.00), number of branches (5.25) and leaf area (867.09 cm^2) under 25% light in C318 plants; while the lowest values of these growth parameters were observed under control. Similarly, number of leaves, number of branches and leaf area of C143 and C318 plants that received CPH_{300} and NPK_{150}, respectively were enhanced under 45% light intensity. In C143, there were significant differences between the number of leaves and leaf area produced by CPH_{300} and other fertiliser treatments except PM_{300} under 45% light. However, the higher number of branches enhanced by CPH_{300} was only significantly (P=0.05) different from that of NPK_{150}. In a similar trend, for C318 plants, NPK_{150} in interaction with 45% light produced the highest number of leaves, number of branches and leaf area, but the values of number of leaves and leaf area were significantly (P=0.05) higher than those produced by the interaction of 45% light with the control and other fertiliser treatments especially CPH_{75}, CPH_{150}, CPH_{300}, PM_{150} and PM_{300}. However, there was no significant difference between the number of branches produced by the interaction of 45% light with all the fertiliser treatments.

Following a trend similar to that under 45% light, NPK_{150} caused a significantly higher number of leaves (31.63), number of branches (6.33) and leaf area (776.66 cm^2) in C143 plants under 65% light intensity; although, these values were only significantly (P=0.05) different from those enhanced by CPH_{75}, PM_{75}, PM_{150}, PM_{300} and control (number of leaves), CPH_{150}, PM_{75}, PM_{150} and control (number of branches); and CPH_{75}, CPH_{150}, PM_{150}, PM_{300} and control (leaf area). However, unlike in C143, where NPK_{150} had overriding influence on the vegetative growth, PM_{75}, PM_{300} and CPH_{75} enhanced higher number of leaves, number of branches and leaf area, respectively in C318.

Influence of fertiliser treatments on plant height and stem diameter of tea plants was affected by the different light intensities at Ibadan as CPH_{300}+65% light and NPK_{150}+45% light produced the highest plant height and stem diameter, respectively (Figure 4.8). While CPH_{300}, PM_{75} and PM_{150} enhanced higher plant height under 25% light; and NPK_{150} engendered higher plant height under 45% light, it was CPH_{300} that caused higher plant height under 65 and 100% light intensities. The plant heights of tea that received CPH_{300}, PM_{75} and PM_{150} were significantly higher than those that received other fertiliser treatments and control but were not significantly different from each other under 25% light. The plant heights of tea plants fertilised by NPK_{150} and PM_{75} under 45%

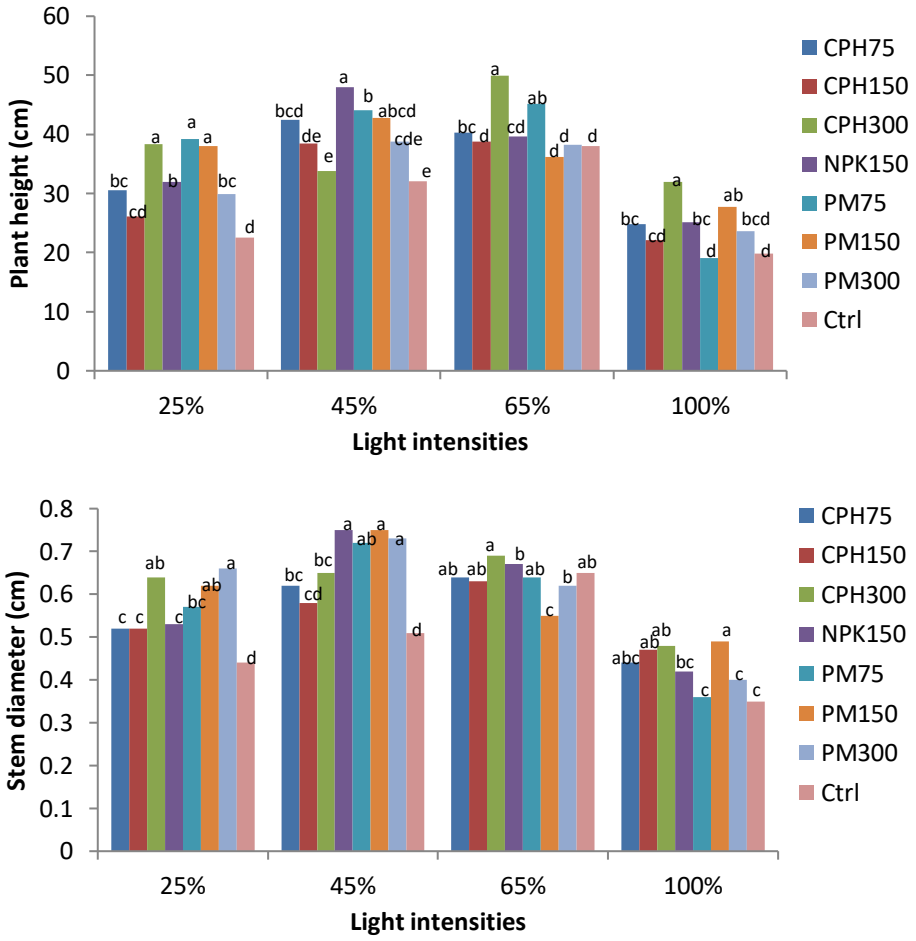


Figure 4.8: Effect of interaction of light intensities and fertilisers on plant height and stem diameter of tea plants at 8 MAT in the pot experiment at Ibadan in 2015

Means followed by the same letters in each composite bar in each graph are not significantly different by HSD (P=0.05)
CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry manure; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control. MAT = Months after transplanting

light, CPH_{300} and PM_{75} under 65% light, as well as CPH_{300} and PM_{150} under 100% light were significantly different from other fertiliser + light treatment interactions but were not significantly ($P>0.05$) different from each other. However, stem diameter enhanced by PM_{300}, PM_{150}, CPH_{300} and PM_{150} were the highest under 25, 45, 65, and 100% light intensities, respectively. The plant height and stem diameter enhanced by all the fertiliser treatments under 100% light were generally lower than those under 25, 45 and 65% light intensities.

In a similar trend, vegetative growth of tea plants responded to different interactions of fertilisers with light intensities at Owena (Table 4.8). Generally, in C143, the highest number of leaves was enhanced by CPH_{300}+25% light, followed by CPH_{300}+65% light and PM_{300}+65% light; the highest number of branches was produced by CPH_{300}+65% light, followed by PM_{150}+65% light and PM_{300}+65% light; while the highest leaf area was caused by CPH_{150}+45% light followed by CPH_{75}+65% light and CPH_{300}+65% light. Similarly, in C318, the highest number of leaves was enhanced by PM_{300}+25% light, followed by PM_{150}+65% light and CPH_{150}+65% light; the highest number of branches was produced by PM_{150}+65% light, followed by PM_{300}+25% light and NPK_{150}+45% light, while the highest leaf area was caused by PM_{300}+25% light, followed by PM_{150}+65% light and NPK_{150}+25% light.

In C143, under 25% light, the values of number of leaves, number of branches and leaf area: 36.08, 5.50 and 835.92 cm^2, respectively enhanced by CPH_{300} were significantly ($P=0.05$) higher than those produced by other fertiliser treatments and control except CPH_{150} (number of branches) and PM_{75} (number of branches and leaf area) (Table 4.8). In C318, under the same light intensity, it was PM_{300} that enhanced significantly ($P=0.05$) higher number of leaves, number of branches and leaf area. However, the number of branches enhanced by the fertiliser treatments were not significantly different from each other; likewise, there was no significant difference between the leaf area produced by PM_{300} and NPK_{150} (934.29 cm^2 and 822.08 cm^2) under the same light intensity. Similar trend was observed under 45% light as CPH_{150} enhanced the highest number of leaves, number of branches and leaf area C143, but the difference was not significant between CPH_{150} and CPH_{300} in number of leaves and number of branches, CPH_{150}, CPH_{300} and PM_{75} in number of branches.

Table 4.8: Effect of interaction of light intensities and fertilisers on number of leaves, number of branches and leaf area of two cultivars of tea plants at 8 MAT in the pot experiment at Owena in 2015

Treatments		C143			C318		
Light Intensities (%) x fertiliser (kg Nha^{-1})		NL	NB	LA (cm^2)	NL	NB	LA (cm^2)
25	CPH_{75}	22.95bc	3.50c	636.92cd	15.71c	4.00a	356.58d
	CPH_{150}	23.29bc	4.75ab	662.30bc	16.46c	3.50a	351.94d
	CPH_{300}	36.08a	5.50a	835.92a	17.25c	4.25a	475.62c
	NPK_{150}	25.88b	4.75ab	693.07bc	23.79b	4.00a	822.08ab
	PM_{75}	26.00b	4.75ab	707.00ab	18.83bc	4.00a	463.11c
	PM_{150}	18.25d	3.25c	517.03d	21.17b	5.25a	720.89b
	PM_{300}	22.21c	4.50b	566.87c	30.50a	5.50a	934.29a
	Ctrl	14.21e	1.75d	258.24e	17.29c	4.00a	355.56d
Mean		19.04	3.70	525.24	19.04	3.70	525.24
45	CPH_{75}	26.67c	2.75d	642.58c	19.83ab	4.75a	396.43bc
	CPH_{150}	31.75a	6.75a	1258.44a	18.42b	4.00a	503.28ab
	CPH_{300}	30.08ab	6.00a	817.79b	19.00ab	4.00a	572.64a
	NPK_{150}	23.13d	4.25b	700.30bc	21.88a	5.50a	617.57a
	PM_{75}	26.92bc	6.00a	790.69b	17.29b	3.25a	542.06a
	PM_{150}	21.75e	3.75bc	696.23bc	18.21b	4.00a	545.89a
	PM_{300}	26.04cd	3.25cd	754.38bc	17.83b	3.25a	536.26a
	Ctrl	15.54f	3.25cd	334.88d	13.46c	3.00a	320.88c
Mean		25.24	4.50	749.41	18.24	3.97	504.38
65	CPH_{75}	30.50bc	5.25c	1079.36a	21.21acd	3.50b	656.04cd
	CPH_{150}	18.25e	4.50c	592.24c	24.58ab	5.00ab	722.44bc
	CPH_{300}	34.25a	8.50a	1051.11a	23.54bc	5.25ab	737.32bc
	NPK_{150}	23.33d	5.25c	873.61b	19.71d	3.50b	699.11bc
	PM_{75}	27.75c	6.75b	620.63c	19.42d	4.75ab	554.81de
	PM_{150}	31.79ab	7.50b	1038.23ab	27.42a	7.25a	908.97a
	PM_{300}	32.38ab	7.50b	998.05ab	23.54bc	5.00ab	794.43ab
	Ctrl	13.71f	3.75c	273.61d	19.50d	3.25b	476.87e
Mean		26.50	6.13	815.86	22.37	4.69	693.75
100	CPH_{75}	12.42a	0.00b	211.92a	4.83d	0.00e	104.60ab
	CPH_{150}	5.17b	0.00b	66.11b	4.79d	1.00cd	47.55b
	CPH_{300}	9.33a	0.00b	179.72ab	5.50cd	0.50d	117.38ab
	NPK_{150}	6.96b	0.00b	122.00ab	8.63abc	0.00e	187.69a
	PM_{75}	9.21a	0.50b	201.23a	10.38a	3.00b	145.25ab
	PM_{150}	10.29a	0.00b	166.52ab	6.92bc	0.00e	103.91ab
	PM_{300}	10.00a	0.00b	153.79ab	8.33abc	5.50a	118.23ab
	Ctrl	9.13b	1.50a	108.99ab	9.13ab	3.00b	115.97ab
Mean		9.06	0.25	151.29	7.31	1.63	117.57

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

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry manure; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control; NL = Number of leaves; NB = Number of branches; LA = Leaf area; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting;

However, in C318 plants under the same light intensity, NPK_{150} enhanced the highest number of leaves, number of branches and leaf area but the number of branches were not significantly different under all the fertilisers, there was no significant difference in number of leaves produced by NPK_{150}, CPH_{75} and CPH_{300} (21.88, 19.83 and 19.00, respectively); while there was significant (P=0.05) difference between the leaf area caused by NPK_{150}, CPH_{75} and control (617.57 cm^2, 396.43 cm^2 and 320.88 cm^2, respectively). The CPH_{300} enhanced the highest number of leaves and number of branches as CPH_{75} caused the highest leaf area under 65% light. In C143, the number of branches value of 8.50 caused by CPH_{300} was significantly (P=0.05) higher than those caused by other fertilisers and control. There was no significant difference between the number of leaves enhanced by CPH_{300}, PM_{150} and PM_{300} (34.25, 31.79 and 32.38), and their leaf area (1051.11 cm^2, 1038.23 cm^2 and 998.05 cm^2) under same light intensity. However, in C318 the number of leaves enhanced by PM_{150} (27.42) was significantly higher than those enhanced by CPH_{300}, $PM_{300,}$ NPK_{150}, PM_{75} and control (23.54, 23.54, 19.71, 19.42 and 19.50, respectively). The number of branches enhanced by PM_{150} (7.25) was significantly different from those enhanced by CPH_{75}, NPK_{150} and control (3.50, 3.50 and 3.25); while there was significant (P=0.05) difference in the leaf area of PM_{150} (908.97 cm^2) and those of control and other fertiliser treatments except PM_{300} (794.43 cm^2) under same light intensity (65%).

Generally, at Owena, all the fertiliser treatments under 100% light intensity performed very poorly in enhancing number of leaves, branches and leaf area of tea compared to 25, 45 and 65% light intensities. However, in C143, while the control and PM_{75} produced significantly higher number of branches than the zero values caused by other fertiliser treatments; CPH_{75}, CPH_{300}, PM_{75}, PM_{150} and PM_{300} produced significantly higher number of leaves (12.42, 9.33, 9.21, 10.29 and 10.00, respectively) compared to CPH_{150}, NPK_{150}, and control (5.17, 6.96 and 9.13, respectively); and CPH_{75} enhanced highest leaf area (211.92 cm^2) which were significantly different only from CPH_{150} (66.11 cm^2) but not different from other fertilisers and control. For C318 plants, PM_{75}, PM_{300} and NPK_{150} engendered the highest number of leaves, number of branches and leaf area, respectively. Unlike in 25, 45 and 65% light intensities, the control enhanced better vegetative growth than some of the fertiliser treatments under 100% light intensity. For instance, control performed better than CPH_{150} and NPK_{150} (number of leaves of C143 plants), all the fertilisers (number of branches of C143 plants), CPH_{150} (leaf area of C143

plants), all the fertiliser treatments except PM_{75} (Number of leaves of C318 plants), all the fertilisers except PM_{75} and PM_{300} (Number of branches of C318 plants), CPH_{75}, CPH_{150} and PM_{150} (leaf area of C318 plants).

Figure 4.9 shows that there were significant (P=0.05) differences in the influence of interaction of fertilisers with the different light intensities on plant height and stem diameter at Owena. The highest plant height and stem diameter were obtained by the interaction of CPH_{150} with 45% light (plant height) and 65% light (stem diameter). Tea plants that received PM_{300} grew significantly (P=0.05) taller than the unfertilised ones under 25% light; whereas, it was the tea plants that received CPH_{150} and CPH_{300} under 45% light, and PM_{150} under 65% light that grew significantly (P=0.05) taller than the control. The unfertilised tea plants grew taller than all the fertilised ones under 100% light. For stem diameter, the control significantly enhanced lower stem diameter compared to NPK_{150} and PM_{300} under 25% light; CPH_{150} and CPH_{300} under 45% light and all the fertilisers except CPH_{75} under 65% light. However, under 100% light, none of the fertilisers enhanced the stem diameter significantly better than the control.

In Figure 4.10, tea cultivars responded differently to fertilisation in plant height and stem diameter. At Ibadan, C143 that received CPH_{300} grew significantly (P=0.05) taller than those that received other fertiliser rates and control; while C318 that received NPK_{150}, CPH_{300}, PM_{75} and PM_{150} also grew taller than those that received other fertiliser rates and control. Similarly, CPH_{300}, NPK_{150} and PM_{300} in C143 and PM_{150} in C318 enhanced significantly higher values of stem diameter. At Owena, the cultivars did not differ in response to the various fertiliser rates, although C143 and C318 that received CPH_{150} and PM_{300}, respectively were the tallest. Conversely, the stem diameter of C143 and C318 that were fertilised was significantly higher than the unfertilised ones.

4.4.2. Effects of cultivar, light intensity and fertiliser on dry matter accumulation of of tea plants in the pot experiment at 8 MAT at Ibadan and Owena.

Table 4.9 shows that the different cultivars, light intensities and fertilisers significantly affected the dry matter accumulation in tea plants at Ibadan and Owena. Dry matter of tea plants was produced more at Owena than at Ibadan. The C143 enhanced more root and total dry matter in Ibadan and Owena than C318 in both locations. Tea plants that grew under 100% light had significantly (P=0.05) lower root, stem and leaf dry matter than the reduced light (25-65% light) at Ibadan and Owena. Higher values of root, stem, leaf

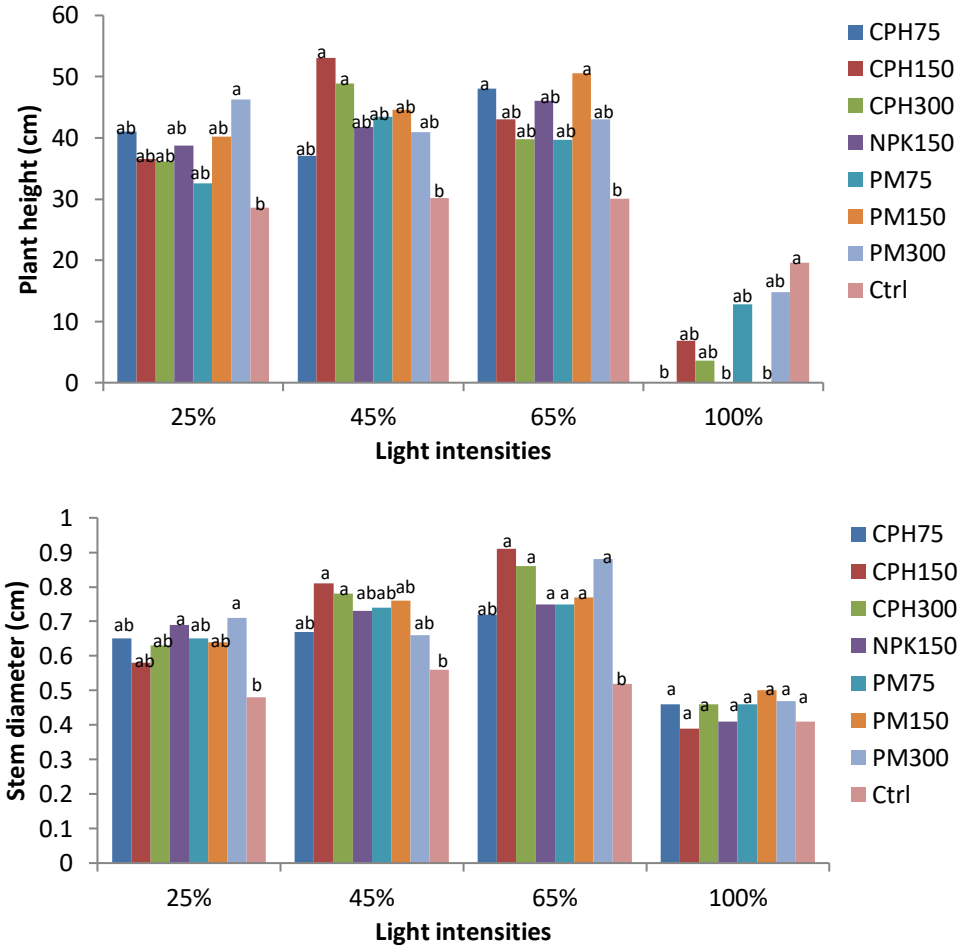


Figure 4.9: Effect of interaction of light intensities and fertilisers on plant height and stem diameter of tea plants at 8 MAT in the pot experiment at Owena in 2015

Means followed by the same letters in each composite bar of each graph are not significantly different by HSD (P=0.05) CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control. MAT = Months after transplanting

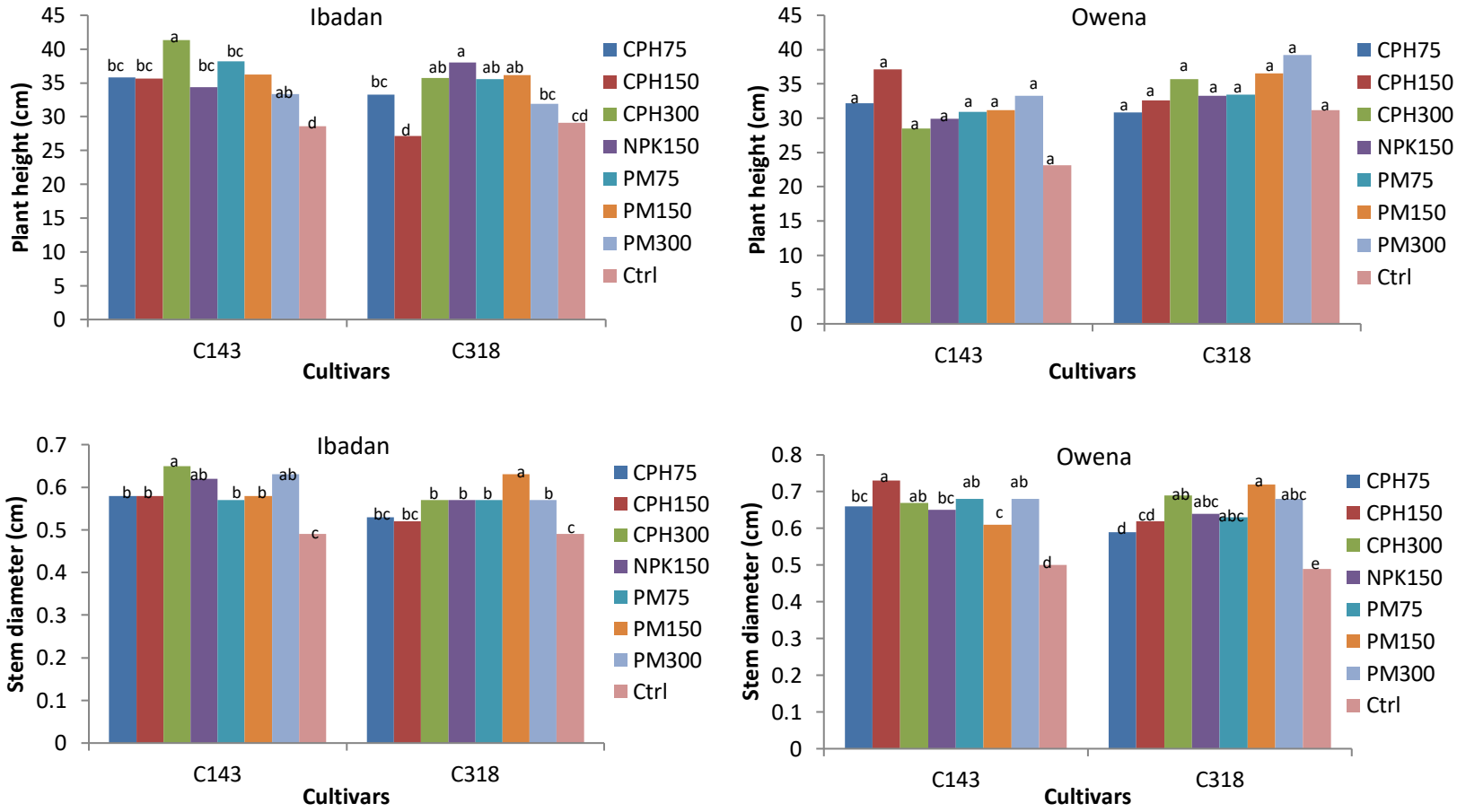


Figure 4.10: Effect of interaction of cultivars and fertilisers on plant height and stem diameter of tea plants at 8 MAT in the pot experiment at Ibadan and Owena in 2015

Means followed by the same letters in each composite bar of each graph are not significantly different by HSD (P=0.05)

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control. MAT = Months after transplanting

Table 4.9: Main effects of cultivars, light intensities and fertilisers on dry matter accumulation (g plant^{-1}) of tea plants at 8 MAT in the pot experiment at Ibadan and Owena in 2015

Treatments	Ibadan				Owena			
Cultivars	**Root**	**Stem**	**Leaf**	**Total dry matter**	**Root**	**Stem**	**Leaf**	**Total dry matter**
C143	4.04a	3.77a	4.23a	12.05a	5.35a	4.09a	4.60a	14.03a
C318	3.07b	3.71a	4.29a	11.07a	3.65b	4.32a	4.74a	12.71a
Mean	3.56	3.74	4.26	11.56	4.50	4.20	4.67	13.37
Light Intensities (%)								
25	3.70c	3.96b	4.77b	12.53b	4.98b	4.64b	5.61b	15.23b
45	5.30a	5.15a	5.56a	16.01a	5.38b	5.61a	5.86b	16.84b
65	4.54b	4.98a	6.10a	15.62a	6.68a	6.00a	6.88a	19.55a
100	0.68d	0.87c	0.62c	2.18c	0.95c	0.56c	0.34c	1.86c
Mean	3.56	3.74	4.26	11.56	4.50	4.20	4.67	13.37
Fertilisers (kg N ha^{-1})								
CPH_{75}	2.73bc	3.19ab	3.49b	9.42b	3.85a	3.63ab	4.47ab	11.95ab
CPH_{150}	3.47abc	3.42ab	4.19ab	11.07ab	4.41a	5.09a	4.97a	14.47ab
CPH_{300}	5.03a	4.96a	5.64a	15.63a	5.52a	4.75a	5.71a	15.97a
NPK_{150}	3.94ab	3.62ab	3.97ab	11.53ab	5.52a	4.61a	4.90ab	15.03a
PM_{75}	3.42abc	3.88ab	4.00ab	11.30ab	3.72a	3.76ab	3.97ab	11.45ab
PM_{150}	3.76abc	3.94ab	4.44ab	12.13ab	4.88a	4.50ab	4.92ab	14.30ab
PM_{300}	3.97ab	4.09ab	4.99ab	13.04ab	4.76a	4.95a	5.89a	15.61a
Control	2.13c	2.84b	3.37b	8.34b	3.30a	2.34b	2.56b	8.19b
Mean	3.56	3.74	4.26	11.56	4.50a	4.20	4.67	13.37

Means followed by the same letters in a column under each treatment are not significantly different by HSD (P=0.05)
CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry manure; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

and total dry matter of 5.30, 5.15, 5.56 and 16.01 g plant^{-1}, respectively was enhanced by 45% light at Ibadan; while at Owena, it was 65% light that enhanced higher root, stem, leaf and total dry matter of 6.68, 6.00, 6.88 and 19.55 g plant^{-1}, respectively. The total dry matter of tea under 45 and 65% lights (16.01 and 15.62 g plant^{-1} respectively) were significantly (P=0.05) higher than the total dry matter under 25% light (12.53 g plant^{-1}) and 100% light (2.18 g plant^{-1}) at Ibadan. At Owena, 65% light was significantly superior to 25, 45 and 100% lights in total dry matter accumulation.

The fertilisers differ in their effect on dry matter accumulation of the tea plants in both locations, but they caused accumulated dry matter more in Owena than in Ibadan. In Ibadan, CPH_{300} was superior to other fertilisers and the control in enhancing root, stem, leaf and total dry matter and was significantly (P=0.05) better than CPH_{75} and the control in total dry matter. However, at Owena, none of the fertilisers had an overriding influence on dry matter accumulation in the root, but CPH_{150}, CPH_{300} and NPK_{150} significantly enhanced higher stem dry matter; CPH_{150}, CPH_{300} and PM_{300} caused higher leaf dry matter; and CPH_{300}, NPK_{150} and PM_{300} produced higher total dry matter compared to control.

Table 4.10 shows how the two cultivars, C143 and C318 performed in dry matter accumulation under the different light intensities. Generally, C143 was significantly superior to C318 in total dry matter accumulation under all the light intensities in both locations except under 100% light.

Tables 4.11 reveals that interaction of fertilisers with the different light intensities had significant effect on dry matter accumulation of tea plants at Ibadan. The highest total dry matter was enhanced by CPH_{300}+45% light and NPK_{150}+25% light in C143 and C318, respectively. The C143 and C318 plants that received CPH_{300} under 25 and 65% lights enhanced significantly (P=0.05) higher dry matter in root, stem and leaf in comparison with other fertilisers and the control. The CPH_{300} under 25% light, was significantly (P=0.05) better in total dry matter than other fertilisers and the control except PM_{75} in C143 and PM_{300} in C318. The CPH_{300} was also superior in total dry matter to other fertilisers under 65% light except CPH_{150}, NPK_{150} and PM_{300} (in C143 plants); while it was significantly better than PM_{300} in C318. Similarly, under 45% light, CPH_{300} in C143 was significantly (P=0.05) outstanding in total dry matter accumulation over other fertilisers (CPH_{75}, NPK_{150} and PM_{75}) and control; while NPK_{150} was significantly (P=0.05) superior to others in C318 except PM_{75}, PM_{150} and PM_{300}. Contrary to the trend under reduced light intensities, 100% light intensity diminished the effect of all the fertilisers on dry matter

Table 4.10: Effect of interaction of cultivars and light intensities on dry matter accumulation (g plant^{-1}) of tea plants at 8 MAT in the pot experiment at Ibadan and Owena in 2015

Treatments Light intensities (%) x	Cultivars	Root	Stem	Leaf	Total dry mattter
			Ibadan		
25	C143	4.34a	4.08a	4.91a	13.36a
	C318	3.06b	3.88a	4.62a	11.49b
Mean		3.7	3.98	4.77	12.43
45	C143	6.16a	5.29a	5.71a	17.17a
	C318	4.44b	4.66b	5.41a	14.85b
Mean		5.3	4.98	5.56	16.01
65	C143	4.98a	5.00a	5.86b	15.79a
	C318	4.09b	5.02a	6.33a	15.45a
Mean		4.54	5.01	6.10	15.62
100	C143	0.69a	0.12b	0.44a	1.87a
	C318	0.68a	0.33a	0.81a	2.49a
Mean		0.69	0.23	0.63	2.18
			Owena		
25	C143	5.44a	4.21b	5.26b	14.94a
	C318	4.32b	5.30a	6.25a	15.52a
Mean		4.88	4.76	5.76	15.23
45	C143	6.28a	5.95a	5.78a	18.86a
	C318	3.93b	5.13a	5.37a	14.83b
Mean		5.11	5.54	5.58	16.85
65	C143	7.98a	6.23a	6.69a	21.32a
	C318	4.60b	5.62a	6.60a	17.79b
Mean		6.29	5.93	6.65	19.56
100	C143	0.77a	0.15a	0.11b	1.02a
	C318	1.14a	1.00a	0.57a	2.69a
Mean		0.96	0.58	0.34	1.86

Means followed by the same letters along a column under each light intensity and location are not significantly different by HSD (P= 0.05).

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

Table 4.11: Effect of interaction of light intensities and fertilisers on dry matter accumulation (g plant^{-1}) of two cultivars of tea plants at 8 MAT in the pot experiment at Ibadan in 2015

Light Intensities (%)	x fertilisers (kg Nha^{-1})	C143				C318			
		Root	Stem	Leaf	Total	Root	Stem	Leaf	Total
25	CPH_{75}	2.63cd	2.53c	3.41c	8.57bc	2.14b	2.53cd	3.33c	8.01cd
	CPH_{150}	3.94bcd	3.51c	3.90bc	11.34bc	1.48b	2.00d	2.91c	6.38d
	CPH_{300}	6.89a	6.62ab	8.22a	21.72a	5.70a	7.09ab	8.34a	21.13a
	NPK_{150}	4.37bc	3.49c	3.47c	11.33bc	2.40b	3.47cd	4.70c	10.56cd
	PM_{75}	5.71ab	7.28a	8.04a	21.03a	1.49b	1.94d	2.42c	5.85d
	PM_{150}	5.20ab	4.22bc	3.80bc	13.22b	4.75a	4.57bc	4.80bc	14.12bc
	PM_{300}	4.11bcd	3.27c	6.53ab	13.91b	4.84a	7.15a	7.71ab	19.70ab
	Ctrl	1.90d	2.02c	1.88c	5.80c	1.72b	1.66d	2.79c	6.16d
Mean		4.34	4.12	4.91	13.37	3.07	3.80	4.63	11.49
45	CPH_{75}	5.96bc	4.66b	4.84b	15.46bcd	3.58b	4.60abc	4.74ab	12.92bc
	CPH_{150}	6.43bc	5.83ab	7.11ab	19.37ab	3.68b	3.69bc	4.75ab	12.12bc
	CPH_{300}	7.95ab	7.87a	8.42a	24.24a	4.80b	2.89c	2.87b	10.56c
	NPK_{150}	6.46bc	4.27b	4.33b	15.06bcd	8.02a	7.14a	6.65a	21.80a
	PM_{75}	4.53cd	3.61b	4.75b	12.89cd	4.36b	6.08ab	6.61a	17.04ab
	PM_{150}	6.15bc	5.63ab	6.38ab	18.16abc	4.43b	5.72ab	6.53a	16.68abc
	PM_{300}	8.84a	6.08ab	5.53ab	20.45ab	3.67b	6.18ab	6.61a	16.46abc
	Ctrl	2.98d	4.38b	4.32b	11.68d	2.98b	3.77bc	4.51ab	11.25bc
Mean		6.16	4.29	5.71	17.16	4.44	5.01	5.41	14.85
65	CPH_{75}	2.74c	4.56ab	5.11ab	12.41c	3.20b	4.50a	5.60ab	13.30ab
	CPH_{150}	6.08ab	5.32ab	6.91ab	18.31abc	4.34ab	5.09a	6.41ab	15.83ab
	CPH_{300}	7.17a	6.50a	7.37a	21.06a	6.12a	5.90a	6.74ab	18.76a
	NPK_{150}	5.35ab	4.93ab	5.95ab	16.23abc	4.13ab	4.80a	6.21ab	15.14ab
	PM_{75}	4.55bc	4.91ab	4.06b	13.52bc	4.73ab	5.09a	4.79b	14.61ab
	PM_{150}	4.18bc	3.77b	5.20ab	13.15bc	4.10ab	5.50a	8.03a	17.62ab
	PM_{300}	6.91a	4.94ab	7.13a	18.97ab	2.62b	4.20a	5.46ab	12.28b
	Ctrl	2.87c	4.59ab	5.20ab	12.66c	3.48b	5.18a	7.44ab	16.09ab
Mean		4.98	4.94	5.87	15.79	4.09	5.03	6.34	15.45
100	CPH_{75}	0.97a	1.07a	0.47a	2.51a	0.66a	1.12a	0.40a	2.17a
	CPH_{150}	1.24a	1.40a	1.01a	3.65a	0.58a	0.51a	0.50a	1.59a
	CPH_{300}	0.84a	1.13a	1.05a	3.01a	0.77a	1.66a	2.15a	4.57a
	NPK_{150}	0.00a	0.00a	0.00a	0.00a	0.76a	0.89a	0.49a	2.14a
	PM_{75}	0.75a	0.57a	0.10a	1.42a	1.24a	1.59a	1.20a	4.03a
	PM_{150}	0.52a	0.57a	0.16a	1.25a	0.72a	1.52a	0.64a	2.87a
	PM_{300}	0.35a	0.36a	0.17a	0.88a	0.42a	0.51a	0.78a	1.70a
	Ctrl	0.86a	0.84a	0.55a	2.25a	0.27a	0.27a	0.30a	0.84a
Mean		0.69	0.74	0.44	1.87	0.68	1.01	0.81	2.49

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

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry manure; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

accumulation compared to the control, and none of the fertilisers had consistent superiority in root, stem, leaf and total dry matter accumulation. However, while CPH_{150} engendered higher total dry matter in C143 plants; CPH_{300} was better than other fertilisers in C318 plants.

Table 4.12 shows the effect of the interaction of the different light intensities and fertilisers on the dry matter accumulation in tea plants at Owena. Generally, the interaction of the fertilisers with 45 and 65% light intensities enhanced higher dry matter accumulation in C143 plants, while it was their interaction with 25% light level that enhanced higher dry matter in C318 plants. Also, NPK_{150}+65% light, CPH_{150}+45% light and PM_{300}+65% light enhanced the highest root, stem and leaf dry matter, respectively in C143 plants; while the interaction of PM_{300} with 25% light caused the highest root, stem and leaf dry matter accumulation in C318 plants. For C143 plants under 25% light, dry matter accumulation was significantly (P=0.05) higher under NPK_{150} (root and total dry matter), CPH_{150} (stem), and CPH_{300} (leaf) than control; whereas, in C318 plants, PM_{300} had an overriding influence over other fertilisers and the control in dry matter accumulation under the same light intensity. Similarly, under 45% light, CPH_{150} produced significantly higher root, stem and leaf in C143; and in C318 plants, higher total dry matter (Table 4.12). However, under 65% light, NPK_{150} and PM_{300} engendered the highest total dry matter in C143 and C318, respectively. The deleterious effect of 100% light intensity is apparent as almost all the tea plants had been scorched and had died before the dry matter of the tea plants were assayed. It is also obvious that the unfertilised tea produced some dry matter accumulation as they survived the dry season.

4.4.3. Effects of cultivar, light intensity and fertiliser on leaf abscission in potted tea plants at Ibadan and Owena

Table 4.13 reveals that C143 enhanced significantly higher leaf fall than C318 at Ibadan and Owena and that 100% light engendered significantly higher leaf fall than all the reduced light intensities at Ibadan and Owena; although, the highest leaf abscission occurred in Owena under 100% light. Similarly, the fertilisers also differed in their effect on the leaf abscission at Ibadan and Owena, where CPH_{300} caused the highest leaf fall. At Owena, fertilisers produced no significant effect on rate of leaf abscission in tea. However, in Ibadan, tea fertilised with CPH_{300} significantly (P=0.05) enhanced the highest leaf fall different from the leaf fall in thosed fertilised with PM_{150} and control.

Table 4.12: Effect of interaction of light intensities and fertilisers on dry matter accumulation (g plant^{-1}) of two cultivars of tea plants at 8 MAT in the pot experiment at Owena in 2015

Light intensities (%)	x fertilisers (kg Nha^{-1})	C143				C318			
		Root	Stem	Leaf	Total	Root	Stem	Leaf	Total
25	CPH_{75}	5.01bc	5.06a	5.51ab	16.40ab	3.32bc	3.60cd	4.05c	10.97cd
	CPH_{150}	6.24ab	5.21a	5.93ab	17.38ab	4.00bc	5.34bc	6.40bc	15.74bc
	CPH_{300}	7.38ab	4.99a	6.92a	19.29ab	4.74bc	5.59b	7.48b	17.81b
	NPK_{150}	8.75a	4.71a	5.67ab	19.43a	4.84b	6.29b	6.21bc	17.33b
	PM_{75}	6.44ab	4.20ab	5.06abc	15.05ab	2.77bc	3.33d	4.60c	10.69d
	PM_{150}	6.44ab	2.87bc	3.67bc	14.55b	5.45ab	6.21b	5.92bc	17.58bc
	PM_{300}	2.89cd	4.92a	6.85a	14.63ab	8.23a	8.98a	10.67a	26.79a
	Ctrl	2.00c	1.71c	2.48c	2.80c	2.00c	3.06d	4.65c	7.29d
Mean		5.64	4.21	5.26	14.94	4.42	5.3	6.25	15.53
45	CPH_{75}	6.34ab	5.29bc	4.67cd	17.19c	4.32a	4.00cd	5.42a	14.74a
	CPH_{150}	8.36a	13.14a	8.98a	30.85a	4.47a	6.84a	6.13a	18.04a
	CPH_{300}	7.50a	6.91b	7.66ab	22.06b	3.99ab	5.99ab	5.47a	15.45a
	NPK_{150}	7.49a	4.13cd	4.38cd	16.00c	5.76a	5.94ab	6.30a	17.98a
	PM_{75}	6.79ab	5.12bc	5.68bcd	17.60bc	3.72ab	5.20abc	4.97a	13.88a
	PM_{150}	6.09ab	5.43bc	6.46abc	18.92bc	3.88ab	4.61bc	5.90a	14.51a
	PM_{300}	7.28a	5.29bc	4.97bcd	18.22bc	4.40a	5.91ab	5.21a	17.66a
	Ctrl	1.41b	3.08d	3.44d	10.04d	1.41b	2.62d	3.55a	6.38b
Mean		6.41	6.05	5.78	18.86	4.00	5.14	5.37	14.83
65	CPH_{75}	7.27bc	5.10cd	5.83bc	20.59cd	4.52ab	6.04ab	5.15c	15.70bc
	CPH_{150}	6.65cd	4.59de	5.67bc	16.91de	5.57ab	5.65ab	5.61bc	16.83ab
	CPH_{300}	9.99ab	6.71bc	8.67a	25.37bc	6.60a	4.44b	8.35ab	20.93a
	NPK_{150}	11.72a	8.35ab	7.93ab	30.90a	5.62ab	5.87ab	6.50abc	18.60ab
	PM_{75}	5.25cd	4.90de	4.78c	14.92e	2.83b	5.02b	5.75bc	13.60c
	PM_{150}	11.29a	9.18a	6.90abc	27.66ab	5.64ab	7.03a	7.55abc	21.16a
	PM_{300}	9.92ab	7.21b	9.56a	26.15ab	5.45ab	6.01ab	8.67a	21.42a
	Ctrl	4.18ab	3.11e	4.23c	8.04_{f}	4.18ab	4.94b	5.22c	14.09bc
Mean		8.28	6.14	6.70	21.32	5.05	5.63	6.60	17.79
100	CPH_{75}	0.00b	0.00b	0.00a	0.00b	0.00b	0.00c	0.00a	0.00b
	CPH_{150}	0.00b	0.00b	0.00a	0.00b	0.00b	0.00c	0.00a	0.00b
	CPH_{300}	0.00b	0.00b	0.00a	0.00b	3.95a	1.79b	0.95a	6.90a
	NPK_{150}	0.00b	0.00b	0.00a	0.00b	0.00b	0.00c	0.00a	0.00b
	PM_{75}	0.00b	0.00b	0.00a	0.00b	1.99ab	2.93ab	0.96a	5.88a
	PM_{150}	0.00b	0.00b	0.00a	0.00b	0.00b	0.00c	0.00a	0.00b
	PM_{300}	0.00b	0.00b	0.00a	0.00b	0.00b	0/00c	0.00a	0.00b
	Ctrl	6.16a	1.62a	0.91a	8.14a	3.11a	3.32a	2.67a	8.77a
Mean		0.77	0.20	0.11	1.02	1.13	1.01	0.57	2.69

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

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

Table 4.13: Effect of cultivars, light intensities and fertilisers on rate of leaf abscission in tea plants at 8 MAT in the pot experiment at Ibadan and Owena in 2015

Treatments		Ibadan	Owena
Cultivars			
C143		10.55a	10.70a
C318		7.60b	7.75b
Mean		9.07	9.23
Light Intensities (%)			
25		8.16b	7.28b
45		7.66b	5.33c
65		8.26b	5.50c
100		12.20a	18.80a
Mean		9.07	9.23
Fertilisers (kg Nha^{-1})			
CPH_{75}		8.87ab	9.66a
CPH_{150}		8.87ab	8.50a
CPH_{300}		10.77a	11.25a
NPK_{150}		9.86ab	9.41a
PM_{75}		9.13ab	8.94a
PM_{150}		7.85b	7.69a
PM_{300}		9.07ab	8.66a
Control		8.16b	9.73a
Mean		9.07	9.23
Light Intensities (%) x Cultivars			
25	C143	9.00a	7.72a
	C318	7.33b	6.84a
Mean		8.17	7.28
45	C143	8.49a	5.88a
	C318	6.84b	4.78a
Mean		7.67	5.33
65	C143	9.27a	6.09a
	C318	7.26b	4.91a
Mean		8.27	5.50
100	C143	15.44a	23.13a
	C318	8.97b	14.47b
Mean		12.21	18.80

Means followed by the same letters along a column in each treatment are not significantly different by HSD (P=0.05)
CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

The two tea cultivars responded differently under each light intensity in causing leaf abscission, especially at Ibadan (Table 4.13). Leaf abscission in C143 was significantly higher than in C318 under each light intensity at Ibadan; while the interaction of C143 with 100% light produced the highest leaf abscission. However, at Owena, although C143 plants produced higher leaf fall under each light intensity, it did not differ significantly from C318 plants except under 100% light.

4.4.4. Residual effects of fertilisers on some growth parameters of tea plants in the pot experiment at Ibadan and Owena

Table 4.14 shows the residual effect of fertilisers on number of leaves, number of branches and leaf area of the tea plants at Ibadan and Owena. In Ibadan, PM_{300} had overriding influence on the vegetative growth of the tea plants as it enhanced significantly (P=0.05) higher number of leaves, number of branches and leaf area compared to CPH_{75}, CPH_{300}, PM_{75}, PM_{150} and control; while at Owena, CPH_{150} produced higher number of leaves, leaf area, while CPH_{300} enhanced higher number of branches compared to other fertiliser rates. In Ibadan, PM_{300} increased number of leaves, number of branches and leaf area by 42%, 49% and 63%, respectively; while CPH_{150} increased number of leaves and leaf area by 65% and 110%, respectively compared to control in Owena.

The heights and stem diameter of tea plants responded to the residual fertilisers in the soil (Figure 4.11). Tea plants increased in height under all the fertilisers from 2 MAT to 4 MAT and thereafter decreased at Ibadan. At Owena, the height of tea plants that received PM_{300} increased steadily from 2 to 6 MAT; while those that received other fertiliser rates decreased in height from 4-6 MAT. At Ibadan, tea plants that received PM_{300} were significantly (P=0.05) taller than control at 2 and 6 MAT, and were taller than those that received other fertilisers and control at 4 MAT at Ibadan and Owena. In a similar trend, residual PM_{300} enhanced significantly higher stem diameter above other fertilisers and the control at Ibadan and Owena; while the residual CPH_{300} had a similar overriding effect at Owena. However, at Ibadan, the residual PM_{75}, PM_{300} and NPK_{150} led to a decline in the stem diameter from 2 MAT through to 6 MAT; while tea plants under residual CPH_{75}, CPH_{150} CPH_{300} and control increased in stem diameter from 2-4 MAT and thereafter declined. Similarly, stem diameter at Owena increased from 2-4 MAT and afterwards decreased. Comparing tea performance in the main experiment with the residual experiment, there was an increase in the effect of residual fertilisers on tea

Table 4.14: Residual effects of fertilisers on number of leaves, number of branches and leaf area of tea plants at 6 MAT in the pot experiment at Ibadan and Owena in 2016

Treatments Fertilisers (kg Nha^{-1})	←Ibadan→			←Owena→		
	Number of Leaves	Number of Branches	Leaf Area (cm^2)	Number of Leaves	Number of Branches	Leaf Area (cm^2)
CPH_{75}	32.41bc	7.05ab	1084.79c	25.38abc	4.26c	839.74abc
CPH_{150}	38.01a	6.12c	1298.76b	30.75a	6.96a	1077.43a
CPH_{300}	32.56bc	6.25bc	1192.10b	29.84ab	7.48a	977.25ab
NPK_{150}	38.06a	6.17c	1141.15b	26.97ab	6.12ab	847.91ab
PM_{75}	34.24b	5.79cd	1122.67c	23.00bc	5.11bc	727.95bc
PM_{150}	34.83b	5.94cd	1228.15b	29.91ab	7.30a	995.25ab
PM_{300}	40.71a	7.68a	1495.11a	29.16ab	6.98a	969.94ab
Control	28.73c	5.15d	917.40c	18.59c	4.23c	513.83c
Mean	34.94	6.27	1185.02	26.70	6.01	868.66

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

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control. MAT = Months after transplanting

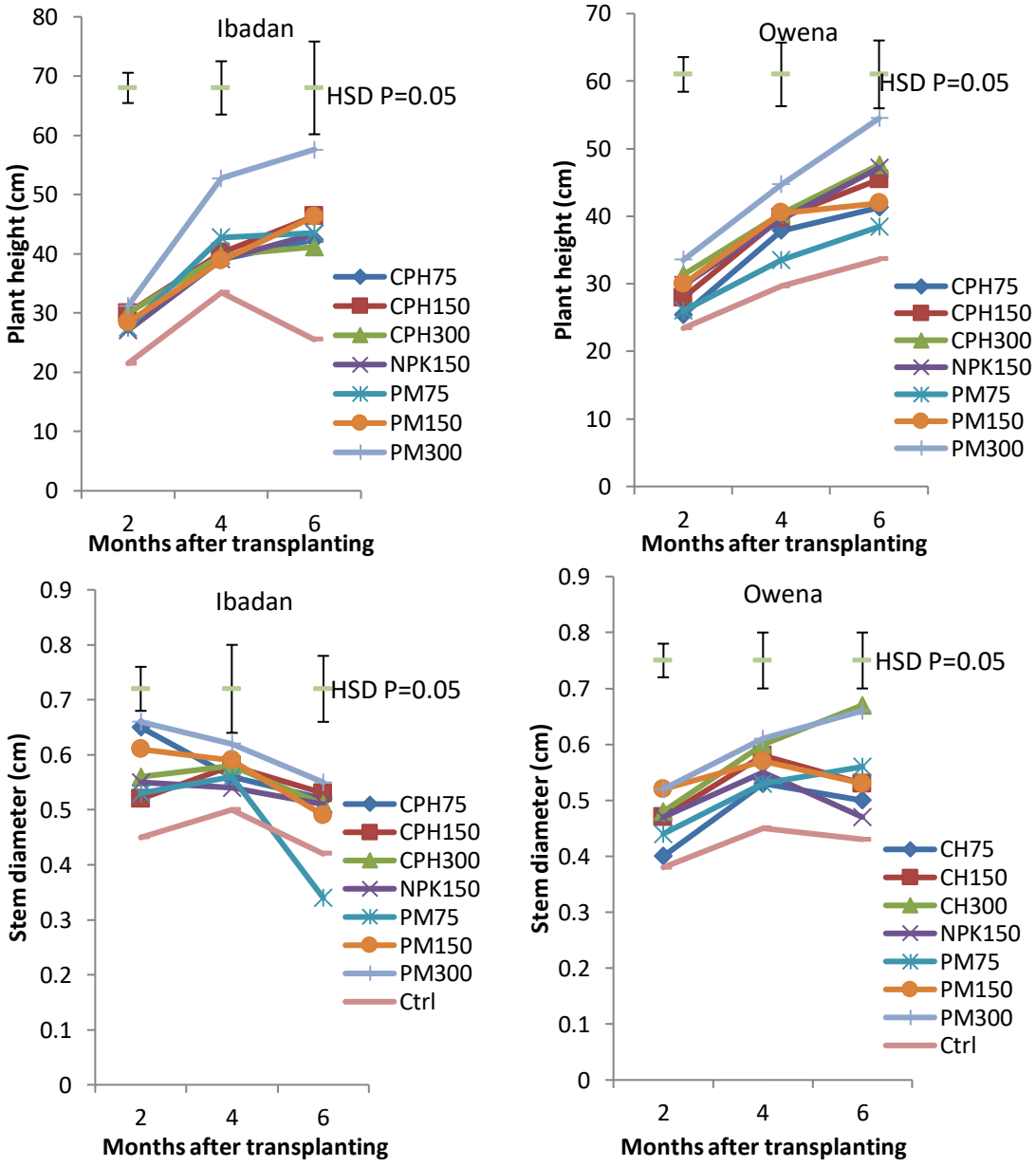


Figure 4.11 Residual effects of fertilisers on plant height and stem diameter of tea plants at 6 MAT in the pot experiment at Ibadan and Owena in 2016

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry manure; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control. MAT = Months after transplanting

vegetative growth. For number of leaves, number of branches and leaf area, there was 55, 33 and 13% increase, respectively at Ibadan; while it was 16, 200 and 11% increase at Owena. Generally, tea vegetative growth under residual fertilisers performed better at Ibadan than at Owena.

Differences in light intensities affected the efficiency of residual fertilisers in enhancing tea vegetative growth at both locations (Tables 4.15 and 4.16; Figures 4.12 and 4.13). Tea fertilised with PM_{300} under 25% light and 65% light had the tallest height at Ibadan (Figure 4.12) and Owena (Figure 4.13), respectively, which were significantly higher than the heights of tea with other fertilisers under the same light intensities. However, on stem diameter, CPH_{150} interaction with 65% light and CPH_{300} interaction with 25% light enhanced the highest values at Ibadan and Owena, respectively.

At Ibadan (Table 4.15), the interaction of CPH_{150} with 65% light in C143 led to the highest number of leaves and leaf area as PM_{150} and PM_{300} under 45% light enhanced the highest number of branches; while interaction of CPH_{300} with 65% light in C318 caused the highest number of leaves, number of branches and leaf area values. Under 25% light, leaf area of C143 plants that received PM_{300} were significantly higher than those that received other fertiliser rates. Under 45% light, C143 plants that received PM_{300} were significantly (P=0.05) better than those that received CPH_{300} in number of leaves, CPH_{150} and CPH_{300} in number of branches, and CPH_{75}, CPH_{150}, CPH_{300}, $PM_{75,}$ NPK_{150} and control in leaf area. Under the same light intensity, C318 plants that received CPH_{150} and CPH_{300} were superior to those that received other residual fertiliser rates in leaf area, but none of the residual fertilisers was significantly superior in enhancing number of leaves and branches of C318 plants under 45% light. The effectiveness of the fertilisers in enhancing growth parameters of tea plants under 100% light increased in the residual experiment compared to the main experiment. For number of leaves, number of branches and leaf area, there were 249, 70 and 419% increase, respectively in C143 plants under the residual experiment compared to the main experiment; while it was 129, 53 and 129% increase, respectively in C318 plants under the residual experiment compared to the main experiment.

The trend was rather different at Owena (Table 4.16). In C143 plants, the highest number of leaves was produced by residual CPH_{300} under 45 and 65% lights, the highest number of branches by residual CPH_{300} under 65% light and the highest leaf area by CPH_{300} under 45% light.

Table 4.15: Residual effects of fertilisers on number of leaves, number of branches and leaf area of two cultivars of tea plants under different light intensities at 6 MAT in the pot experiment at Ibadan in 2016

Treatments		←C143→			←C318→		
Light intensities (%) x	fertilisers (kg Nha^{-1})	NL	NB	LA (cm^2)	NL	NB	LA (cm^2)
25	CPH_{75}	35.00a	9.50a	1339.44c	38.25a	6.00a	1811.37a
	CPH_{150}	35.75a	4.25a	1228.45d	37.50a	6.50a	1410.72b
	CPH_{300}	31.00a	5.50a	1276.81c	32.00a	5.00a	1488.39b
	NPK_{150}	36.00a	6.00a	1182.64d	27.00a	4.33a	882.48c
	PM_{75}	46.33a	6.00a	1759.23b	40.25a	7.50a	1597.01a
	PM_{150}	41.00a	5.25a	1619.01bc	31.67a	4.33a	1317.66b
	PM_{300}	50.25a	9.00a	2148.12a	41.50a	6.00a	1713.73a
	Ctrl	39.33a	6.33a	1264.15c	38.00a	5.00a	1376.89b
Mean		39.33	6.48	1477.23	35.77	5.58	1449.78
45	CPH_{75}	48.33ab	8.25ab	1514.51b	39.00a	8.33a	1340.89bc
	CPH_{150}	40.00ab	3.00b	1177.64c	34.67a	7.33a	1891.82a
	CPH_{300}	3.00b	3.25b	859.93c	42.75a	7.75a	1952.08a
	NPK_{150}	43.75ab	7.50ab	1561.13b	29.00a	5.00a	1111.87c
	PM_{75}	39.33ab	6.67ab	1402.69b	30.50a	4.50a	1101.41c
	PM_{150}	55.08ab	10.00a	2087.73a	30.00a	5.00a	1114.25c
	PM_{300}	60.75a	10.00a	2061.02a	35.67a	7.67a	1465.91b
	Ctrl	37.75ab	7.00ab	1263.64b	30.50a	3.75a	1171.04c
Mean		44.75	6.96	1263.64	34.01	6.17	1393.66
65	CPH_{75}	37.00b	7.25a	1114.41bc	40.00ab	6.33a	1327.85bc
	CPH_{150}	71.00a	7.67a	2169.92a	36.67ab	9.50a	1520.93b
	CPH_{300}	40.75b	8.00a	1246.23bc	49.00a	10.00a	2148.98a
	NPK_{150}	49.00ab	6.75a	1521.68abc	41.00ab	5.50a	1406.63b
	PM_{75}	55.25ab	6.67a	1563.49abc	34.00ab	7.00a	1185.29c
	PM_{150}	67.00a	9.67a	1986.58ab	32.67ab	6.00a	1352.10bc
	PM_{300}	56.00ab	9.00a	1708.11abc	28.50ab	8.00a	1446.35bc
	Ctrl	33.00b	6.25a	1019.16c	21.00b	4.50a	751.22d
Mean		51.13	7.66	1541.20	35.36	7.10	1392.42
100	CPH_{75}	16.00cd	8.00ab	126.88d	5.67b	2.75bc	102.99b
	CPH_{150}	44.00ab	9.25ab	884.78b	4.50b	1.50bc	105.84b
	CPH_{300}	24.00cd	3.50bc	429.80c	8.00b	7.00ab	134.61b
	NPK_{150}	38.25abc	5.25abc	736.46b	40.50a	9.00a	726.33a
	PM_{75}	7.00d	1.50c	199.12cd	21.25ab	6.50abc	173.18b
	PM_{150}	16.00cd	4.67bc	265.22cd	5.25b	2.63bc	82.64b
	PM_{300}	49.00a	11.25a	1322.75a	3.50b	0.50c	94.89b
	Ctrl	22.25bcd	6.38abc	428.01c	8.00b	2.00bc	45.08b
Mean		27.06	6.23	549.13	12.08	3.99	183.20

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

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; NL = Number of leaves; NB = Number of branches; LA = Leaf area; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

Table 4.16: Residual effects of fertilisers on number of leaves, number of branches and leaf area of two cultivars of tea plants under different light intensities at 6 MAT in the pot experiment at Owena in 2016

Treatments		←C143→			←C318→		
Light intensities (%) x	Fertilisers (kg Nha^{-1})	NL	NB	LA (cm^2)	NL	NB	LA (cm^2)
25	CPH_{75}	33.25a	4.25bc	1187.43b	26.50a	5.17b	1132.56d
	CPH_{150}	34.00a	8.50a	1046.67b	36.00a	9.00a	1971.13a
	CPH_{300}	31.25a	7.25ab	1156.12b	32.00a	5.50b	1410.11c
	NPK_{150}	30.50a	6.25abc	1054.66b	25.50a	6.50ab	1075.56d
	PM_{75}	20.50a	4.50bc	734.52c	28.50a	7.33ab	1339.60c
	PM_{150}	31.25a	6.33abc	1100.37a	37.75a	7.25ab	1687.24b
	PM_{300}	33.50a	6.00abc	1124.33b	25.00a	4.83b	985.50d
	Ctrl	24.00a	4.00c	824.19c	22.15ab	5.00b	710.15e
Mean		29.78	5.89	1028.54	29.18	6.32	1288.98
45	CPH_{75}	31.25ab	6.75ab	1035.59ab	21.00a	3.00d	664.33e
	CPH_{150}	26.75ab	5.25bc	929.70b	27.50a	4.83cd	972.71c
	CPH_{300}	40.00a	6.00abc	1300.71a	28.25a	14.33a	1009.89b
	NPK_{150}	27.00ab	5.00bc	897.86bc	32.00a	7.00bc	860.44cd
	PM_{75}	17.00b	3.00c	567.32d	22.00a	5.00cd	794.22de
	PM_{150}	27.00ab	8.50a	853.61c	30.75a	8.67b	1138.79ab
	PM_{300}	39.75a	8.00ab	1236.50a	24.75a	7.00bc	1256.11a
	Ctrl	19.00b	3.33c	399.10e	23.25a	7.00bc	664.91e
Mean		28.47	5.73	902.55	26.19	7.10	920.18
65	CPH_{75}	25.75c	4.50cd	956.64ab	29.00bc	6.50c	954.65de
	CPH_{150}	31.25b	7.25bc	853.41bc	31.00b	7.00bc	1214.39b
	CPH_{300}	40.00a	11.00a	1115.57a	25.00c	6.33c	820.20e
	NPK_{150}	17.00d	3.00d	551.94d	30.50b	11.17a	1169.82bc
	PM_{75}	18.25d	4.50cd	519.89d	25.25bc	4.50cd	836.32e
	PM_{150}	33.50b	8.67ab	828.36bc	31.00b	9.67ab	1018.58cd
	PM_{300}	26.75c	5.75bcd	769.23c	37.25a	11.50a	1418.20a
	Ctrl	18.75d	4.75cd	424.27d	14.75d	2.50d	519.55f
Mean		26.41	6.18	752.41	29.97	7.40	993.96
100	CPH_{75}	22.00b	3.00bc	513.05bc	14.25c	2.00e	273.70cd
	CPH_{150}	22.00c	5.25ab	522.05bc	37.50a	7.00ab	1109.38a
	CPH_{300}	25.50b	5.25ab	649.87b	16.75c	4.25cde	355.49bc
	NPK_{150}	27.75b	6.75a	747.47a	25.50b	7.50a	425.55b
	PM_{75}	32.50a	5.33ab	670.16ab	20.00c	5.00abcd	361.55bc
	PM_{150}	28.00b	6.25ab	485.26c	20.00c	4.50bcde	549.84b
	PM_{300}	28.25ab	8.50a	716.57a	18.00c	6.30abc	253.03d
	Ctrl	14.50c	1.50c	335.66d	12.25d	3.25de	232.76d
Mean		25.06	5.76	580.01	20.53	4.97	445.16

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

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; NL = Number of leaves; NB = Number of branches; LA = Leaf area; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

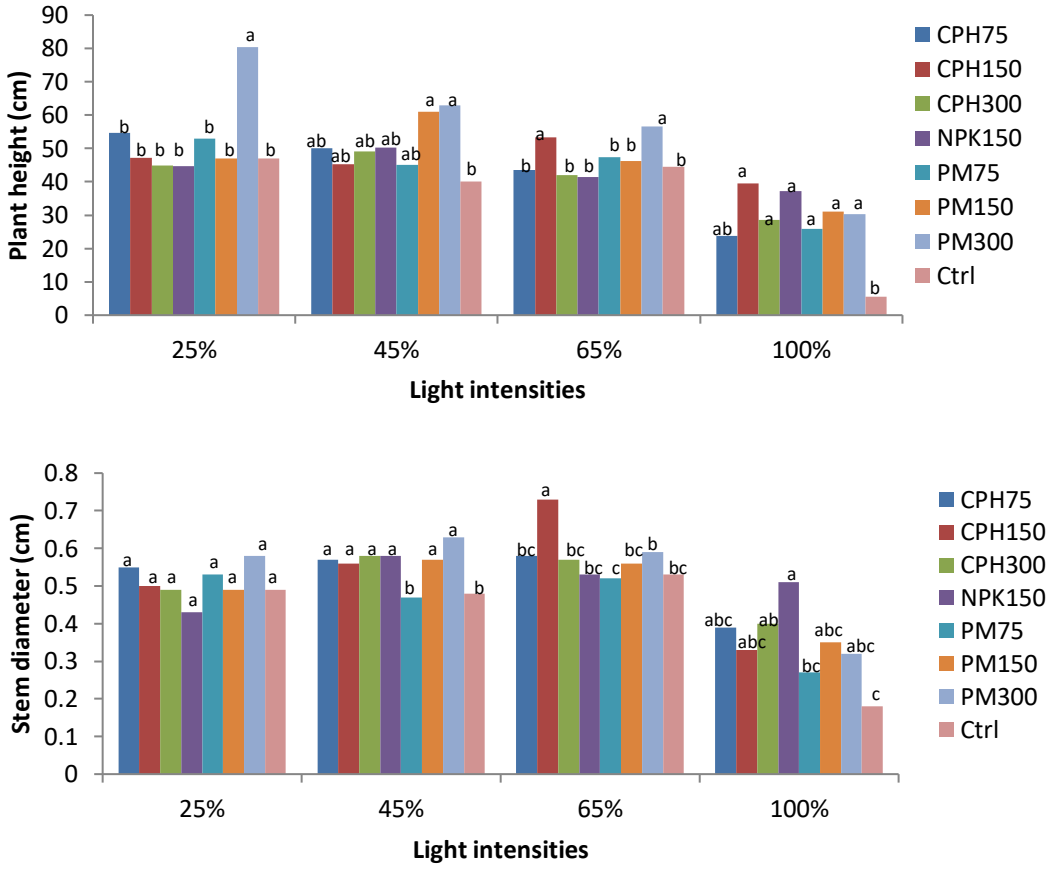


Figure 4.12: Residual effects of fertilisers on plant height and stem diameter of tea plants under different light intensities at 6 MAT in the pot experiment at Ibadan in 2016

Means followed by the same letters in each composite bar in each graph are not significantly different by HSD (P=0.05)

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry manure; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control. MAT = Months after transplanting

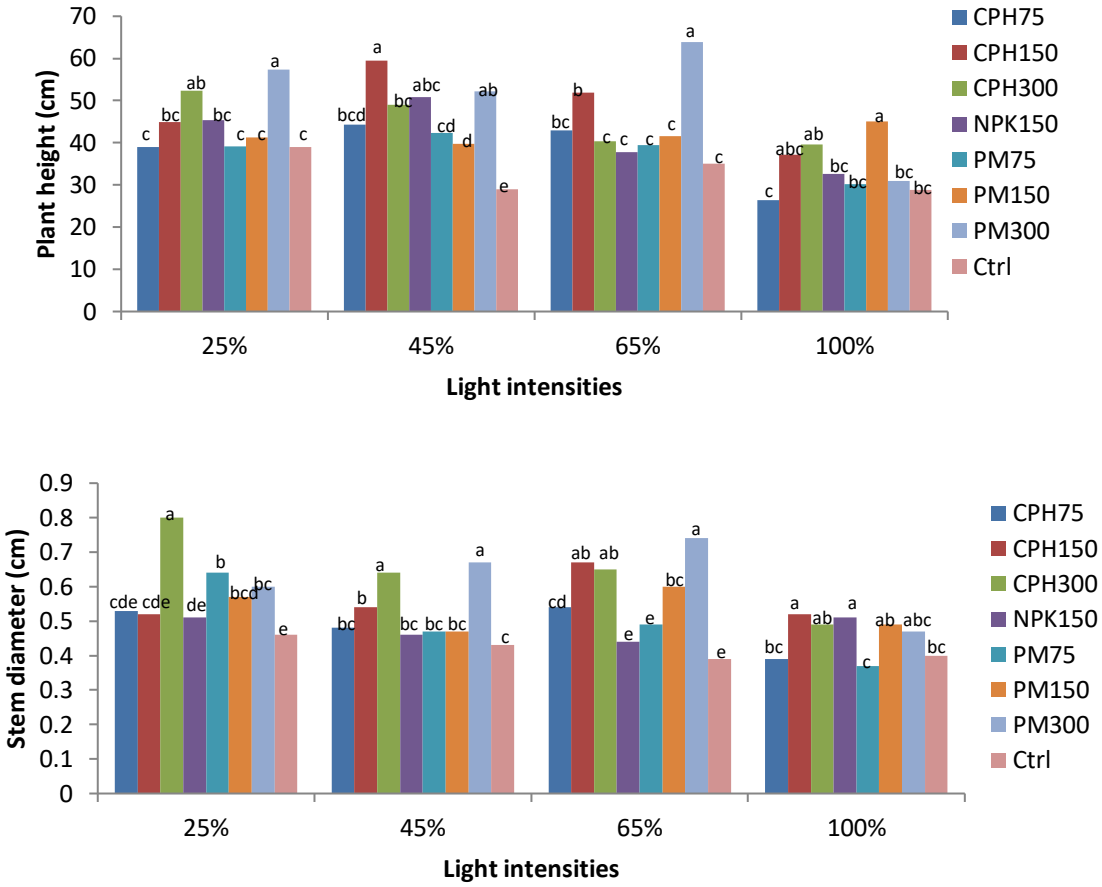


Figure 4.13: Residual effects of fertilisers on plant height and stem diameter of tea plants under different light intensities at 6 MAT in the pot experiment at Owena in 2016

Means followed by the same letters in each composite bar in each graph are not significantly different by HSD (P=0.05)

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry manure; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control. MAT = Months after transplanting

On the other way round, in C318, the highest number of leaves and leaf area were produced by PM_{150} and CPH_{150}, respectively under 25% light; and highest number of branches by CPH_{300} under 45% light. Under 25% light, leaf area of C318 plants that received CPH_{150} was significantly higher (P=0.05) than leaf area of other fertilised C318 and control; while under 45% light, CPH_{300} in C143 plants and PM_{300} in C318 plants enhanced significantly (P=0.05) higher leaf area than other fertilisers except CPH_{75} and PM_{300} in C143 plants, and PM_{150} in C318 plants. However, under 65% light, CPH_{300} and PM_{300} in C143 and C318 plants, respectively significantly (P=0.05) produced higher number of leaves, number of branches and leaf area than other fertilisers and control. According to the trend at Ibadan, effectiveness of the fertilisers in enhancing growth parameters of tea plants under 100% light increased in the residual experiment compared to the main experiment. For number of leaves, number of branches and leaf area, there were 177, 2204 and 283% increase, respectively in C143 plants under the residual experiment compared to the main experiment; while it was 181, 205 and 279% increase respectively in C318 plants under the residual experiment compared to the main experiment. However, residual NPK_{150} and CPH_{150} in C143 and C318 plants, respectively significantly enhanced higher leaf area than other fertilisers under 100% light, except PM_{75} and PM_{300} in C143.

Figure 4.14 shows the effect of interaction of residual fertilisers with the two tea cultivars (C143 and C318) on their plant height and stem diameter. At Ibadan, fertilised C318 plants were significantly (P=0.05) taller than control, while C143 plants that received PM_{150} and PM_{300} were taller than those that received other fertiliser rates. Similarly, C143 plants fertilised with CPH_{150}, NPK_{150}, PM_{150} and PM_{300} as well as the C318 plants that received CPH_{75} were superior in stem diameter. However, at Owena, while fertilised C143 plants were not significantly taller than control; C318 plants that received NPK_{150} and PM_{300} were significantly (P=0.05) taller than those that received other fertilisers and control. In stem diameter, both C143 and 318 plants that received CPH_{300} and PM_{300} were superior to those that received other fertiliser rates.

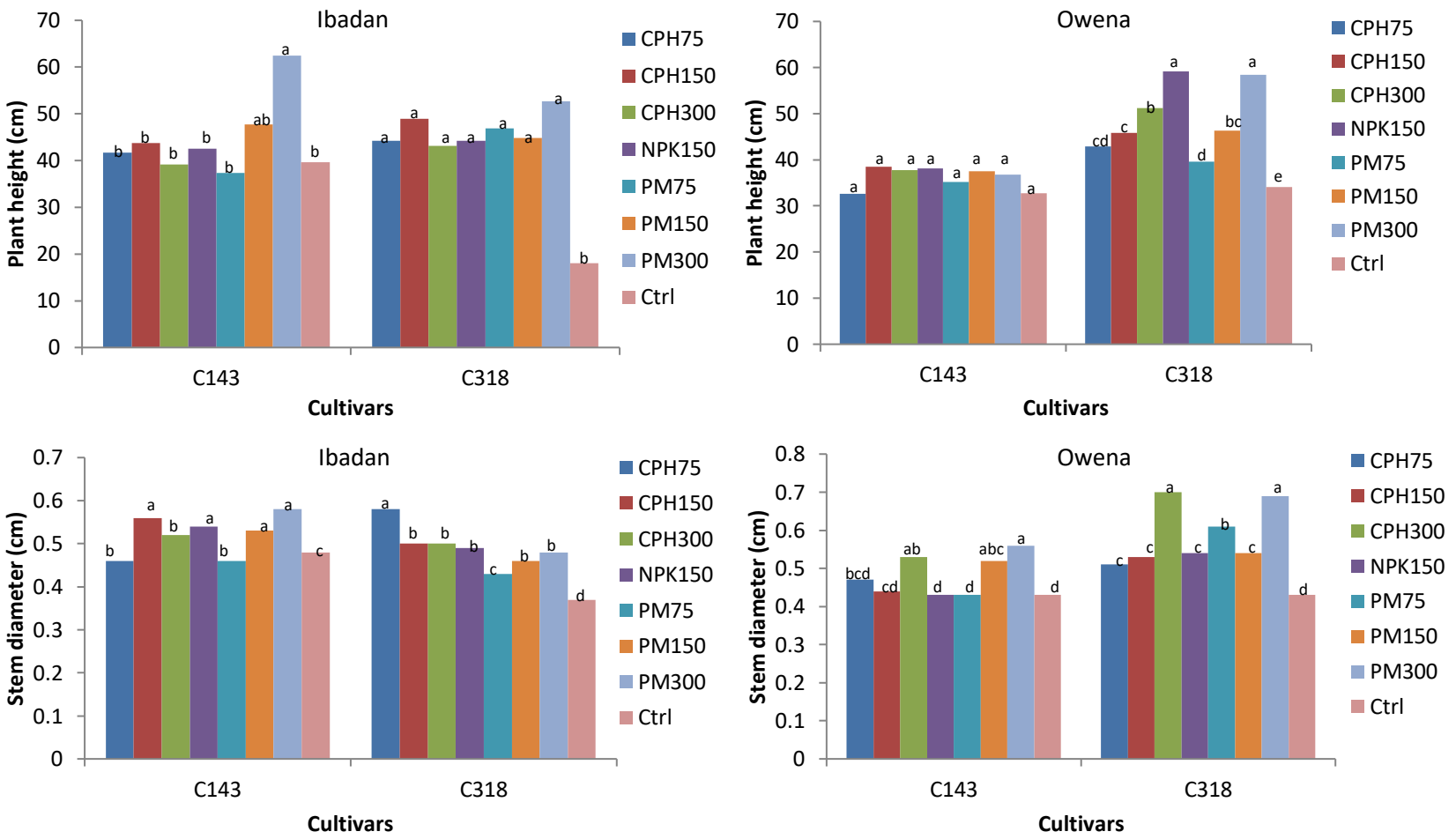


Figure 4.14: Residual effects of fertilisers on plant height and stem diameter of two cultivars of tea plants at 6 MAT in the pot experiment at Ibadan and Owena in 2016.

Means followed by the same letters in each composite bar of each graph are not significantly different by HSD (P=0.05)

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control. MAT = Months after transplanting

4.4.5. Residual effects of fertilisers on dry matter accumulation of tea plants in the pot experiment at 6 MAT at Ibadan and Owena

Table 4.17 shows that the residual fertilisers produced significant effect on dry matter accumulation of tea plants at Ibadan and Owena. At Ibadan, all the fertilisers except PM_{75} (root), NPK_{150} (stem), CPH_{75} and PM_{75} (leaf) were significantly (P=0.05) better than control in dry matter accumulation in root, stem and leaf. However, at Owena, CPH_{300} was superior to other fertilisers and control as it produced more root, stem, and leaf dry matter and was significantly different from PM_{75} (root, stem and leaf), CPH_{75}, CPH_{150} (stem) and control (root, stem and leaf).

The interaction of the residual fertilisers with the various light intensities in enhancing root, stem and leaf dry weights of the two tea cultivars at Ibadan and Owena is shown in Tables 4.18 and 4.19. The highest total dry matter was produced under 45% light by PM_{150} and CPH_{300} in C143 and C318 plants, respectively at Ibadan; while at Owena, PM_{300} under 100% light in C143 plants and CPH_{300} under 25% light in C318 plants enhanced the highest total dry matter. At Ibadan (Tables 4.18), PM_{300} was superior to other fertilisers and control in root, stem and leaf dry matter accumulation in C143 under 25% light but was not significantly (P>0.05) different from CPH_{150} and PM_{150} in root dry matter; while PM_{300} was better than other fertiliser rates in C318. Under 45% light, the residual effect of CPH_{150}, CPH_{300}, PM_{150} and PM_{300} in C143 plant, CPH_{300} and PM_{300} in C318 plants in enhancing total dry matter was significantly (P=0.05) higher than that of other fertilisers and control. Residual effect of the fertilisers in dry matter production was generally lower under 100% light intensity than in 25, 45 and 65% light. However, CPH_{300} and CPH_{75} in C143 and C318 plants, respectively were better under 100% light in dry matter production; although, CPH_{300} was not significantly (P>0.05) different from NPK_{150}, and CPH_{75} was significantly (P=0.05) different only from CPH_{300} and the control.

In a similar trend at Owena (Table 4.19), CPH_{75}, CPH_{300} and PM_{150} caused significantly (P=0.05) higher total dry matter accumulation in C143 plants, under 25% light; while CPH_{300} was significantly superior to other fertilisers and control in C318 plants under the same light intensity. In C143 plants, all the fertilisers had significant (P=0.05) overriding effect over the control, especially in total dry matter under 45% light but were not significantly different from each other. In C318, CPH_{300} was significantly (P=0.05)

Table 4.17: Residual effects of fertilisers on dry matter accumulation (g plant^{-1}) of tea plants at 6 MAT in the pot experiment at Ibadan and Owena in 2016

Treatments Fertilisers (kg Nha^{-1})	Ibadan				Owena			
	Root	Stem	Leaf	Total dry matter	Root	Stem	Leaf	Total dry matter
CPH_{75}	4.97a	4.91ab	5.40ab	15.28b	4.33abc	3.50cd	4.67ab	12.50c
CPH_{150}	5.90a	5.90ab	5.91a	17.71ab	4.75ab	4.15bc	4.93ab	13.83bc
CPH_{300}	5.38a	5.25ab	6.83a	17.46ab	5.62a	5.76a	6.18a	17.55a
NPK_{150}	5.88a	4.43bc	6.04a	16.35ab	4.95ab	4.75abc	5.05ab	14.76abc
PM_{75}	4.71ab	4.93ab	5.43ab	15.07b	3.98bc	3.78bcd	4.11b	11.88c
PM_{150}	6.04a	5.53ab	5.89a	17.46ab	5.53a	4.85ab	5.95a	16.57ab
PM_{300}	6.24a	6.58a	7.83a	20.65a	4.43a	4.83abc	5.72a	15.98ab
Control	2.91b	2.77c	3.44b	9.12c	3.30c	2.50d	2.58c	8.37d
Mean	5.25	5.04	5.85	16.14	4.73	4.26	4.90	13.93

Means followed by the same letters in a column are not significantly different by HSD (P = 0.05).
CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control. MAT = Months after transplanting

Table 4.18: Residual effects of fertilisers on dry matter accumulation (g plant^{-1}) of two cultivars of tea plants under different light intensities at 6 MAT in the pot experiment at Ibadan in 2016

Treatments Light intensities (%) x	Fertilisers (kg Nha^{-1})	C143				C318			
		Root	Stem	Leaf	Total dry matter	Root	Stem	Leaf	Total dry matter
25	CPH_{75}	4.64cd	6.56bc	6.08b	17.27bc	5.32a	4.50b	8.96ab	18.78ab
	CPH_{150}	5.86ab	7.03b	7.05b	19.94b	3.14bc	3.56c	6.71abc	13.40ab
	CPH_{300}	5.24bc	2.82d	5.07b	13.12bc	2.12c	3.53c	7.74ab	13.38ab
	NPK_{150}	4.97bc	3.77cd	6.08b	14.82bc	4.97a	2.94c	4.38c	12.29b
	PM_{75}	3.79d	4.37bcd	4.68b	12.83c	4.05b	5.56a	7.51ab	17.12ab
	PM_{150}	6.00ab	4.05bcd	6.07b	16.12bc	3.59b	4.89ab	6.25ab	14.73ab
	PM_{300}	6.63a	10.45a	10.65a	27.73a	4.92a	5.68a	9.14a	19.73a
	Ctrl	3.90d	3.60cd	4.83b	12.33c	2.44c	4.30b	5.93bc	12.66b
Mean		5.13	5.33	6.31	16.77	3.82	4.37	7.08	15.26
45	CPH_{75}	7.41ab	4.39cd	5.43bc	17.23de	5.16b	5.11c	5.79bc	16.05bc
	CPH_{150}	7.71ab	5.91bcd	7.96abc	21.57abcd	5.19b	4.85c	7.02bc	17.05bc
	CPH_{300}	8.91ab	7.28bc	8.14ab	24.33abc	6.69a	8.26ab	13.56a	28.51a
	NPK_{150}	7.42ab	5.86bcd	7.51abc	20.79bcde	7.42a	5.77bc	7.51b	20.70b
	PM_{75}	8.18ab	4.24cd	5.59bc	18.01cde	3.23c	4.21c	6.23bc	13.67bc
	PM_{150}	8.02ab	10.45a	9.87a	28.33a	5.22b	6.15bc	8.74b	20.10b
	PM_{300}	10.56a	7.74ab	7.02abc	25.31ab	6.20b	9.69a	12.06a	27.95a
	Ctrl	5.61b	3.58d	4.92c	14.11e	2.90c	3.98c	4.36c	11.23c
Mean		7.98	6.18	7.06	21.21	5.25	6.00	8.16	19.41
65	CPH_{75}	5.79cd	4.45c	5.57ab	15.81c	3.28d	4.62cd	7.14bc	15.03cd
	CPH_{150}	11.87a	7.79a	8.23a	27.89a	6.57a	10.23a	9.28ab	26.08a
	CPH_{300}	7.94bc	4.71c	5.67ab	18.31bc	4.30c	5.51cd	10.07ab	19.88abc
	NPK_{150}	5.53cd	4.80c	5.86ab	16.19bc	5.53ab	4.31cd	9.24ab	19.07abc
	PM_{75}	5.76cd	4.58c	6.43a	16.76bc	5.46b	8.70ab	10.73a	24.89ab
	PM_{150}	7.25bc	4.78c	6.90a	18.92_{bc}	5.62ab	6.99bc	8.14ab	20.75bc
	PM_{300}	9.63ab	6.06b	7.19a	22.88ab	2.62d	6.44bc	9.29ab	18.75bc
	Ctrl	2.91d	1.98d	2.76b	7.65d	2.20e	3.25d	4.72c	10.17d
Mean		7.09	4.89	6.08	18.05	4.45	6.26	8.58	19.33
100	CPH_{75}	3.50bc	4.14bc	1.83b	9.47c	4.67ab	5.52a	2.44a	12.63a
	CPH_{150}	3.94bc	4.66b	0.81bc	9.41c	2.90d	3.22b	0.24bc	6.36abc
	CPH_{300}	6.88ab	7.58a	4.06a	18.52a	0.98e	2.33c	0.36bc	3.67bc
	NPK_{150}	5.62abc	6.87a	5.42a	17.91a	5.62a	1.11de	2.31a	9.03ab
	PM_{75}	3.84bc	2.92d	1.86b	8.62c	3.38cd	4.87a	0.43bc	8.68ab
	PM_{150}	8.12a	3.53cd	1.07bc	12.72b	4.49b	3.44b	0.09bc	8.02abc
	PM_{300}	5.37abc	3.78bcd	4.15a	13.30b	4.03bc	2.84bc	3.11a	9.98ab
	Ctrl	2.83c	0.00d	0.00c	3.82d	0.50e	0.50e	0.00c	1.00c
Mean		5.01	4.19	2.40	11.72	3.32	2.98	1.12	7.425

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

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

Table 4.19: Residual effects of fertilisers on dry matter accumulation (g plant^{-1}) of two cultivars of tea plants under different light intensities at 6 MAT in the pot experiment at Owena in 2016

Treatments Light intensities (%)	x Fertilisers (kg Nha^{-1})	C143 Root	C143 Stem	C143 Leaf	C143 Total dry matter	C318 Root	C318 Stem	C318 Leaf	C318 Total dry matter
25	CPH_{75}	6.52a	3.61ab	5.72a	15.89a	3.82bc	4.06bc	5.75bc	13.63bc
	CPH_{150}	5.91ab	3.66ab	3.93b	13.50b	5.20abc	6.59b	7.84ab	19.63b
	CPH_{300}	6.28ab	4.18a	5.55a	16.01a	7.66a	9.74a	9.71a	27.10a
	NPK_{150}	3.57b	3.51b	4.28b	11.35c	6.16abc	5.24bc	5.81bc	17.21bc
	PM_{75}	3.48b	2.83c	3.80b	10.10c	6.47ab	4.65bc	5.34bc	16.45bc
	PM_{150}	6.23ab	4.06ab	5.80a	16.10a	4.18bc	5.72bc	7.72ab	17.61bc
	PM_{300}	4.20ab	3.86ab	5.32a	13.37b	4.02bc	5.74bc	6.49bc	16.25bc
	Ctrl	4.10ab	3.59a	3.81b	11.49c	3.38c	3.58c	3.94c	10.90c
Mean		4.04	3.66	4.78	13.48	5.11	5.67	6.58	17.35
45	CPH_{75}	6.23c	3.99abc	5.03b	15.25a	3.66de	4.04c	5.52bc	13.22bc
	CPH_{150}	7.13b	3.52bc	3.70cd	14.34a	3.73cde	4.09c	4.68bc	12.49bc
	CPH_{300}	5.72cd	4.47abc	5.38ab	15.49a	5.57a	8.84a	9.01a	23.41a
	NPK_{150}	5.27d	6.59a	5.38ab	17.23a	4.34bc	3.44d	4.48bc	12.25bc
	PM_{75}	3.24e	5.66ab	3.34d	12.23ab	3.63e	4.50c	5.51bc	13.63bc
	PM_{150}	5.19d	4.73abc	6.07a	15.99a	5.15a	5.23b	6.56ab	16.95ab
	PM_{300}	7.94a	3.83abc	4.30bc	16.07a	5.09a	5.47b	6.47ab	17.03ab
	Ctrl	2.44f	2.51c	1.80e	6.76b	3.92bcde	2.59e	3.34c	9.84c
Mean		4.40	4.41	4.38	14.17	4.39	4.78	5.70	14.85
65	CPH_{75}	5.77bc	3.35ab	4.87abc	13.99ab	4.63b	4.14bc	5.06e	13.32bc
	CPH_{150}	5.34c	4.29a	4.50abc	14.13ab	4.21b	4.28bc	5.68de	14.17bc
	CPH_{300}	6.18ab	4.47a	4.52abc	15.17ab	5.04b	5.83ab	6.20cd	17.07b
	NPK_{150}	4.08d	4.58a	6.45a	15.11ab	5.38ab	4.43bc	5.14e	14.94bc
	PM_{75}	4.24d	2.48ab	2.95bc	9.67b	3.48b	4.30bc	6.74c	14.53bc
	PM_{150}	6.51a	5.16a	4.93abc	16.60a	5.10ab	5.98ab	7.51b	18.58ab
	PM_{300}	5.54bc	3.86ab	5.69ab	15.09ab	7.98a	8.47a	8.85a	25.29a
	Ctrl	5.32c	1.34b	2.40c	9.05b	3.97b	2.96c	3.25f	10.18c
Mean		4.37	3.69	4.54	13.60	4.97	5.05	6.05	16.01
100	CPH_{75}	2.44bc	2.57c	4.50c	9.50bc	1.54d	2.23de	0.93c	4.70e
	CPH_{150}	1.34c	1.21d	1.37e	3.92c	5.12a	5.60ab	7.77a	18.48a
	CPH_{300}	4.44ab	4.46ab	5.62ab	14.52ab	4.05b	4.09bc	3.49bc	11.62bcd
	NPK_{150}	6.85a	4.92a	4.57c	16.33a	4.00b	5.30a	4.34b	13.64abc
	PM_{75}	4.92ab	4.18b	3.40d	12.50ab	2.41c	1.68e	1.84bc	5.93de
	PM_{150}	6.21a	4.41ab	4.91bc	15.52ab	5.68_a	3.51c	4.12b	15.26ab
	PM_{300}	6.95a	4.63ab	6.27a	17.84a	1.72cd	2.81d	2.41bc	6.94cde
	Ctrl	1.44c	1.46d	0.40f	3.29c	1.81cd	1.97e	1.74bc	5.46de
Mean		4.32	3.48	3.88	11.68	3.29	3.40	3.33	10.25

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

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

superior to other fertilisers and control in dry matter accumulation in root, stem and leaf except PM_{150} and PM_{300} (root and leaf). In C143 plants under 65% light, while PM_{150} enhanced significantly higher total dry matter than PM_{75} and the control, PM_{300} was superior to other fertilisers and control in C318 plants. Similarly, under 100% light, PM_{300} and CPH_{150} in C143 and C318 plants, respectively had an overriding residual effect on dry matter partitioning to the root, stem and leaf of the tea plants. There was a general increase in the efficiency of the fertilisers in dry matter accumulation under 100% light in the residual experiment in comparison with the main experiment. There was increase of 1045 and 281% total dry matter in C143 and C318, respectively.

4.4.6. Effect of cultivar, light intensity and fertiliser on chlorophyll and carotenoids composition of tea plants in the pot experiment at 6 MAT at Ibadan and Owena.

It is apparent in Table 4.20 that the main effects of cultivar, light intensity and fertiliser was significant in chlorophyll and carotenoids synthesis in potted tea plants at the two locations; although Ibadan was superior in chlorophyll, Owena was better in carotenoids production. Cultivar 318 enhanced significantly (P=0.05) more chlorophyll synthesis at Ibadan and Owena; while it was superior to C143 in carotenoids only at Owena. The effect of light intensities on chlorophyll and carotenoids accumulation in tea was in the order of 25% > 45% > 65% > 100% lights. The 25% light was significantly (P=0.05) superior to other light intensities in chlorophyll and carotenoids synthesis at both locations. Similarly, NPK_{150} had an overriding effect on chlorophyll and carotenoids especially at Owena. At Ibadan, the values of chlorophyll and carotenoids enhanced by PM_{75} and NPK_{150} respectively were significantly higher (P=0.05) than those of other fertilisers. At Owena however, although NPK_{150} enhanced more chlorophyll and carotenoids production, its effect was not significantly different from other fertilisers in chlorophyll but was different from CPH_{75} and PM_{300} in carotenoids.

Table 4.21 reveals that the cultivars differ in their influence on chlorophyll and carotenoids synthesis under all the light intensities. At Ibadan the highest chlorophyll and carotenoids was obtained with the interactions of C143 with 25% light and that of C318 with 45% light respectively; while the least occurred with the interaction of C318 with 100% light. At Ibadan, while cultivars 143 and 318 were not significantly different under 25 and 100% lights; C318 was significantly superior to C143 in chlorophyll and cartenoids accumulation under 45 and 65% lights. Similar trend was observed in Owena,

Table 4.20: Main effects of cultivars, light intensities and fertilisers on chlorophyll and carotenoids (mg/g fresh weight) in the leaves of tea plants at 6 MAT in the pot experiment at Ibadan and Owena in 2016.

Treatments	Ibadan		Owena	
Cultivars	**Total Chlorophyll**	**Carotenoids**	**Total Chlorophyll**	**Carotenoids**
C143	2.00b	0.45a	1.81b	0.51b
C318	2.13a	0.44a	2.19a	0.54a
Mean	2.06	0.44	2.00	0.53
Light intensities (%)				
25	3.14a	0.57a	2.89a	0.79a
45	2.01b	0.48b	2.21b	0.61b
65	1.90b	0.46b	1.71c	0.40c
100	1.20c	0.33c	1.17d	0.30d
Mean	2.06	0.44	2.00	0.53
Fertilisers (kg Nha^{-1})				
CPH_{75}	2.10ab	0.43b	1.96a	0.43bc
CPH_{150}	1.87c	0.44b	2.01a	0.60a
CPH_{300}	2.09ab	0.46b	1.92a	0.49abc
NPK_{150}	2.20a	0.54a	2.27a	0.63a
PM_{75}	2.27a	0.43b	2.07a	0.55ab
PM_{150}	1.84c	0.40b	1.93a	0.55ab
PM_{300}	1.99bc	0.43b	1.86a	0.41c
Control	2.15ab	0.44b	1.96a	0.52abc
Mean	2.06	0.44	2.00	0.53

Means followed by the same letters in a column under each treatment are not significantly different by HSD (P=0.05). CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

Table 4.21: Effect of interaction of cultivars and light intensities on chlorophyll and carotenoids (mg/g fresh weight) in the leaves of tea plants at 6 MAT in the pot experiment at Ibadan and Owena in 2016

Treatments Light intensities x Cultivars (%)		Total chlorophyll (mg/g fw)	Carotenoids (mg/g fw)
		Ibadan	
25	C143	3.15a	0.57a
	C318	3.14a	0.56a
Mean		3.15	0.57
45	C143	1.87b	0.46b
	C318	2.15a	0.6a
Mean		2.01	0.53
65	C143	1.70b	0.43b
	C318	2.11a	0.48a
Mean		1.91	0.46
100	C143	1.29a	0.36a
	C318	1.11a	0.30b
Mean		1.20	0.33
		Owena	
25	C143	2.41a	0.74a
	C318	2.97a	0.83a
Mean		2.69	0.79
45	C143	2.01b	0.60a
	C318	2.41a	0.62a
Mean		2.21	0.61
65	C143	1.35b	0.39a
	C318	2.08a	0.41a
Mean		1.72	0.4
100	C143	1.05a	0.29a
	C318	1.29a	0.31a
Mean		1.17	0.3

Means followed by the same letters along a column under each light intensity and location are not significantly different by HSD (P=0.05).
C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

although neither of the cultivars was significantly better in carotenoids composition under each light intensity.

Table 4.22 shows how the results of interaction of light intensity and fertiliser influenced chlorophyll and carotenoids synthesis in the two tea cultivars in Ibadan and Owena. Generally, organic fertilisers enhanced higher chlorophyll and carotenoids accumulation than NPK and control especially under 25 and 45% lights. However, at Ibadan, the highest chlorophyll was produced by C143 plants fertilised with PM_{300} under 25% light, and the highest carotenoids by the same cultivar fertilised with CPH_{75} under 25% light; whereas at Owena, cultivar C318 fertilised with CPH_{75} and CPH_{150} under 25% light enhanced the highest chlorophyll and carotenoids, respectively.

At Ibadan, under 25% light, the chlorophyll value-3.64 enhanced by PM_{300} in C143 was significantly (P=0.05) higher than 2.73 and 2.57 enhanced by CPH_{150} and PM_{150}, respectively; while 0.71 carotenoids enhanced by CPH_{75} was significantly (P=0.05) higher than carotenoids values enhanced by other fertiliser rates [CPH_{300} (0.51), NPK_{150} (0.54), PM_{75} (0.54), PM_{150} (0.55) and control (0.56)] except CPH_{150} and PM_{300} (0.62 and 0.61). In C318 under 25% light, the chlorophyll produced by CPH_{150} was significantly (P=0.05) lower than the chlorophyll produced by all other fertiliser rates; while PM_{300} caused higher carotenoids in C318 than other fertiliser rates. Although, none of the fertilisers was significantly (P>0.05) better in enhancing chlorophyll in C143 plants under 45% light, PM_{75} was significantly better than PM_{150} in enhancing their carotenoids contents.

Similarly, C318 plants fertilised with PM_{75} was significantly (P=0.05) superior to the ones fertilised with CPH_{300} in chlorophyll content under 45% light; while those fertilised with NPK_{150} were significantly better than all others in carotenoids except the ones that received PM_{300} and control. In 65% light, as CPH_{300} and NPK_{150} enhanced higher chlorophyll in C143 plants and carotenoids in C318 plants, respectively; the fertiliser rates under 65% light were not significantly different in enhancing chlorophyll and carotenoids in C318 and C143 plants, respectively. Under 100% light, C143 plants that received PM_{75} were most outstanding and significantly superior to the ones that were fertilised with NPK_{150} in total chlorophyll, CPH_{300}, PM_{150} and control in carotenoids; while C318 plants that received NPK_{150} produced significantly higher chlorophyll and carotenoids, followed closely by those that received CPH_{150} (chlorophyll and carotenoids) and PM_{75} (carotenoids).

Table 4.22: Effect of interaction of light intensities and fertilisers on chlorophyll and carotenoids (mg/g fresh weight) in the leaves of tea plants at 6 MAT in pot experiment at Ibadan and Owena in 2016

Treatments Light intensities (%)	x Fertilisers (kg Nha^{-1})	Ibadan				Owena			
		C143		C318		C143		C318	
		Total chloro-phyll	Carot-enoids	Total chloro-phyll	Carot-enoids	Total chloro-phyll	Carot-enoids	Total chloro-phyll	Carot-enoids
25	CPH_{75}	3.37ab	0.71a	3.25a	0.55ab	2.28cd	0.16d	3.72a	0.54d
	CPH_{150}	2.73bc	0.62ab	2.11b	0.38c	3.70a	0.98a	2.31b	1.25a
	CPH_{300}	3.35ab	0.51b	5.15a	0.50bc	3.07ab	0.72bc	2.51b	0.67cd
	NPK_{150}	3.35ab	0.54b	3.20a	0.68a	2.08d	0.71c	3.48a	1.00b
	PM_{75}	3.17abc	0.54b	3.21a	0.63ab	2.72bcd	0.96ab	3.59a	0.91bc
	PM_{150}	2.57c	0.55b	3.36a	0.51bc	3.02abc	0.79abc	3.06ab	0.73cd
	PM_{300}	3.64a	0.61ab	3.52a	0.69a	2.75bcd	0.72bc	2.44b	0.88bc
	Ctrl	3.00abc	0.56b	3.32a	0.58ab	2.90bc	0.82abc	2.67b	0.76bcd
Mean		3.15	0.58	3.39	0.57	2.82	0.73	2.47	0.84
45	CPH_{75}	1.75ab	0.42ab	2.08abc	0.46c	1.94ab	0.61a	2.53abc	0.66ab
	CPH_{150}	1.62b	0.43ab	2.38abc	0.48bc	1.58b	0.49a	1.94bc	0.50b
	CPH_{300}	2.13ab	0.43ab	1.67c	0.56bc	1.84ab	0.61a	1.80c	0.47b
	NPK_{150}	1.52b	0.48ab	2.42ab	0.72a	1.91ab	0.71a	3.14a	0.79a
	PM_{75}	2.21ab	0.54a	2.70a	0.24d	2.50a	0.71a	2.60ab	0.67ab
	PM_{150}	1.62b	0.35b	2.20abc	0.47bc	2.10ab	0.62a	2.52abc	0.63ab
	PM_{300}	1.66b	0.45ab	1.76bc	0.60ab	1.85ab	0.54a	2.50abc	0.46b
	Ctrl	2.46a	0.53a	1.98abc	0.48bc	2.41a	0.54a	2.30bc	0.65ab
Mean		1.87	0.45	2.15	0.50	2.02	0.60	2.42	0.60
65	CPH_{75}	1.78abc	0.43ab	2.03a	0.44b	1.37b	0.12c	1.80bc	0.57ab
	CPH_{150}	1.28bc	0.35b	1.96a	0.56c	1.47ab	0.39b	2.54ab	0.68a
	CPH_{300}	2.26a	0.36b	1.99a	0.57ab	1.28b	0.42b	1.93bc	0.27c
	NPK_{150}	1.85ab	0.46ab	2.49a	0.69a	2.18a	0.70a	1.58c	0.25c
	PM_{75}	1.89ab	0.40ab	2.11a	0.36d	1.46ab	0.45ab	1.56c	0.40bc
	PM_{150}	1.11c	0.50ab	2.24a	0.46b	1.03b	0.35bc	1.34c	0.39bc
	PM_{300}	1.57abc	0.42ab	2.04a	0.30d	1.22b	0.47ab	3.02a	0.17c
	Ctrl	1.91ab	0.54a	2.01a	0.39d	0.80b	0.24bc	2.89a	0.70a
Mean		1.71	0.43	2.11	0.47	1.35	0.41	2.08	0.43
100	CPH_{75}	1.49ab	0.37ab	1.04bc	0.30bc	0.83bc	0.20bc	1.23bcd	0.51a
	CPH_{150}	1.41ab	0.37ab	1.46ab	0.38b	0.95abc	0.26abc	1.61abc	0.34ab
	CPH_{300}	1.07ab	0.31b	1.15abc	0.36b	1.16ab	0.50a	1.79ab	0.27b
	NPK_{150}	0.91b	0.36ab	1.84a	0.51a	1.65a	0.38abc	2.14a	0.37ab
	PM_{75}	1.67a	0.44a	1.25abc	0.38b	1.45ab	0.42ab	0.70d	0.24b
	PM_{150}	1.03ab	0.31b	0.64c	0.23cd	1.33ab	0.32abc	1.10bcd	0.36ab
	PM_{300}	1.19ab	0.46a	0.59c	0.15d	0.21c	0.13c	0.88cd	0.29ab
	Ctrl	1.58ab	0.32b	0.93bc	0.27bc	0.81bc	0.18bc	0.87cd	0.26b
Mean		1.29	0.37	1.11	0.32	1.05	0.30	1.29	0.33

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

CPH_{75} = 75 kg Nha^{-1} Cocoa Pod Husk; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150}= 150 kg Nha^{-1} NPK 5:1:1; PM_{75} = 75 kg Nha^{-1} Poultry Manure; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

In a similar trend at Owena, C143 plants that received CPH_{150} accumulated significantly (P=0.05) more chlorophyll and carotenoids than those that received other fertiliser rates especially, CPH_{75}, NPK_{150} and PM_{300} (in chlorophyll and carotenoids), PM_{75} and control (in chlorophyll only) as well as CPH_{300} (in carotenoids only) under 25% light. However, in C318 plants, CPH_{75}, PM_{75} and NPK_{150} under 25% light produced significantly more chlorophyll than other fertiliser rates; while CPH_{150} was most outstanding and significantly better in enhancing carotenoids content than all other fertilisers and control. Under 45% light, none of the fertilisers was significantly (P>0.05) outstanding in chlorophyll and carotenoids except that PM_{75} and NPK_{150} in C143 and C318 plants, respectively enhanced the highest chlorophyll and carotenoids under the light intensity. Similar trend was observed under 100% light, as fertilised plants were better than control in both cultivars. However, under 65% light, NPK_{150} was better than other fertilisers and control in chlorophyll and carotenoids accumulation in C143 plants; PM_{300} and CPH_{150} were outstanding in chlorophyll and carotenoids accumulation, respectively in C318 plants.

4.5. Experiment 2: Effects of light intensity and organic fertilisers on growth, seedling establishment, leaf harvest, nutrient uptake and photosynthetic pigments of tea plants on the field at Ibadan and Owena, Nigeria

4.5.1. Effects of cultivar, light intensity and fertiliser on vegetative growth of tea plants on the field at Ibadan and Owena.

Different cultivars, light intensities and fertilisers significantly (P=0.05) enhanced number of leaves (Table 4.23), number of branches (Table 4.24) and leaf area (Table 4.25) of tea plants on the field. Number of leaves, number of branches and leaf area increased from 32.31, 5.66 and 1055.50 cm^2 at 3 MAT, respectively to 88.94, 18.73 and 2194.56 cm^2 in C143 plants, and from 28.85, 5.42 and 1086.00 to 49.47, 12.93 and 1276.59 in C318 plants at Ibadan. Similar trend was observed at Owena. The C143 plants were superior to C318 plants in number of leaves and leaf area throughout the sampling periods, but they were significantly (P=0.05) different at 6-12 MAT in both locations; while number of branches were significantly higher in C143 plants than in C318 plants from 9-12 MAT. Reduced light intensities enhanced vegetative growth of tea (Plate 4.2).

Table 4.23: Main effects of cultivars, light intensities and fertilisers on number of leaves of tea plants on the field at Ibadan and Owena in 2017

Treatments	Ibadan				Owena			
Cultivars	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**
C143	32.31a	43.85a	68.33a	88.94a	25.65a	40.49a	77.70a	103.43a
C318	28.85a	33.37b	41.64b	49.47b	21.19b	29.24b	40.53b	42.59b
Mean	30.58	38.61	54.98	69.20	23.92	34.86	59.11	73.01
Light intensities (%)								
45	29.07b	41.05a	64.00a	84.07a	22.39a	34.61b	61.60a	87.74a
65	26.81b	34.05a	61.40a	66.50ab	26.50a	42.96a	72.09a	77.49a
100	35.86a	40.73a	39.55a	57.03b	22.39a	27.01c	43.65b	53.80b
Mean	30.58	38.61	54.98	69.20	23.92	34.86	59.11	73.01
Fertilisers (kg Nha^{-1})								
CPH_{150}	28.00b	42.83ab	65.19ab	79.60ab	23.15ab	39.79a	60.59bc	104.79a
CPH_{300}	26.06b	38.88c	56.27b	71.46ab	22.00b	37.56a	58.29b	77.10b
NPK_{150}	43.58a	47.75a	70.17a	97.75a	31.33a	42.48a	72.17a	106.02a
PM_{150}	30.33b	35.79c	55.90b	64.65ab	25.06ab	35.48a	67.25ab	78.48b
PM_{300}	31.44b	36.42c	44.67b	48.92b	23.04ab	33.46ab	51.31cd	68.65b
Control	24.08b	29.99d	37.71c	52.83b	18.96b	20.40b	45.05d	47.21c
Mean	30.58	38.61	54.98	69.20	23.92	34.86	59.11	73.01

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

CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

Table 4.24: Main effects of cultivars, light intensities and fertilisers on number of branches of tea plants on the field at Ibadan and Owena in 2017

Treatments	Ibadan				Owena			
Cultivars	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**
C143	5.66a	9.83a	14.90a	18.73a	5.90a	8.85a	15.80a	20.25a
C318	5.42a	9.80a	11.14b	12.93b	4.81b	7.71a	9.87b	16.53b
Mean	5.54	9.81	13.02	15.83	5.35	8.28	12.83	18.39
Light intensities (%)								
45	5.62a	10.02a	14.00a	15.86a	4.65a	7.90b	13.56a	20.02a
65	5.02a	8.16b	14.08a	16.40a	5.81a	9.42a	15.69a	20.72a
100	5.97a	11.26a	10.97a	15.20a	5.60a	7.52b	9.26b	14.44b
Mean	5.54	9.81	13.02	15.83	5.35	8.28	12.83	18.39
Fertilisers (kg Nha^{-1})								
CPH_{150}	5.40b	10.48ab	14.17ab	16.17bc	5.67ab	10.04a	14.35a	20.60b
CPH_{300}	5.06b	9.78ab	14.46a	16.55b	4.49b	8.19a	11.57ab	18.69bc
NPK_{150}	7.77a	10.92a	15.92a	22.61a	7.40a	9.94a	16.06a	26.07a
PM_{150}	5.62b	10.54ab	11.98b	14.17b	5.44ab	8.88a	12.82ab	16.96c
PM_{300}	5.31b	9.73ab	12.35b	12.52c	5.10b	8.25a	14.43a	16.48c
Control	4.06b	7.42b	9.23c	12.93c	3.73b	4.38b	7.76b	11.56d
Mean	5.54	9.81	13.02	15.83	5.35	8.28	12.83	18.39

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

CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

Table 4.25: Main effects of cultivars, light intensities and fertilisers on leaf area (cm^2) of tea plants on the field at Ibadan and Owena in 2017

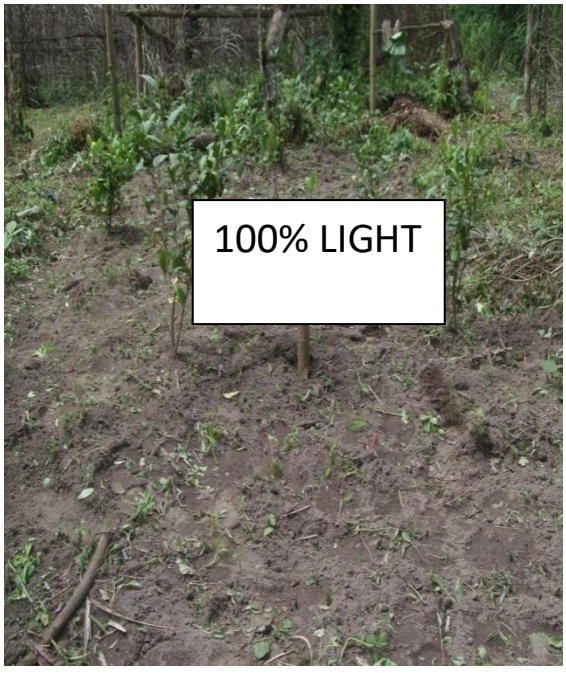
Treatments	Ibadan				Owena			
Cultivars	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**
C143	1055.50a	1234.05a	1296.17a	2194.56a	724.24a	1311.76a	1890.19a	3631.62a
C318	1086.00a	958.48b	817.55b	1276.59b	687.48a	989.84b	1211.84b	1617.07b
Mean	1070.75	1096.27	1056.86	1735.57	705.86	1150.80	1551.02	2624.35
Light intensities (%)								
45	1207.87a	1387.51a	1595.12a	2885.75a	684.67ab	1257.08a	2155.61a	3627.47a
65	1017.55a	1087.14b	1200.58b	1660.59b	860.58a	1484.91a	1877.44a	2879.53a
100	986.82a	814.16c	374.88c	660.38c	572.33b	710.41b	620.00b	1366.04b
Mean	1075.75	1096.27	1056.86	1735.57	705.86	1150.80	1551.02	2624.35
Fertilisers (kg Nha^{-1})								
CPH_{150}	1088.64b	1286.06a	1435.26a	2448.60a	657.82ab	1363.69ab	1860.69a	3452.68a
CPH_{300}	964.64bc	1159.86a	991.94b	1796.48b	633.73ab	1128.29c	1519.52b	2326.19b
NPK_{150}	1672.71a	1443.76a	1606.23a	2503.70a	982.03a	1457.42a	1796.95a	3914.08a
PM_{150}	1046.60b	1102.28ab	1138.24b	1566.62b	798.01ab	1079.10c	1677.80ab	2308.79bc
PM_{300}	1008.81bc	989.85ab	727.76c	1385.38b	760.37ab	1254.51bc	1584.94ab	2067.57b
Control	643.10c	595.79b	441.74d	712.67c	493.21b	621.76d	866.20c	1676.77c
Mean	1075.75	1097.27	1056.86	1735.57	705.86	1150.80	1551.02	2624.35

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

CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry manure; PM_{300} = 300 kg Nha^{-1} Poultry manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

45% Light

65% Light



100% Light

Plate 4.2: Tea plants under 45%, 65% and 100% light intensities at 13 MAT in Owena

Tea plants performed better in number of leaves and number of branches under 100% light than they did under 45 and 65% lights between 3 and 6 MAT in Ibadan and Owena. However, 45 and 65% lights enhanced these growth parameters better than 100% light at 9-12 MAT. Conversely, 45 and 65% lights enhanced leaf area better than 100% light throughout the sampling periods. In both locations, 45% light was better than 65% light in enhancing number of leaves and leaf area at 9-12 MAT, while the latter was superior to the former in branches production. Tea plants fertilised with 150 kg Nha^{-1} generally had higher number of leaves, number of branches and leaf area throughout the sampling periods than those that received 300 kg Nha^{-1} and control. The NPK_{150} and CPH_{300} were not significantly ($P>0.05$) dfferent, but they enhanced the highest number of leaves and leaf area from 6-12 MAT in Ibadan and Owena. The highest number of branches was enhanced by NPK_{150} and CPH_{300} as well as NPK_{150} and CPH_{150} in Owena from 9-12 MAT. The control precipitated the least values of these growth parameters. Generally, more leaves, branches and leaf area were produced in tea plants at Owena than at Ibadan.

Figures 4.15, 4.16 and 4.17 show how cultivars, light intensities and fertilisers influenced the plant height and stem diameter of tea plants. The C143 plants significantly ($P=0.05$) enhanced higher plant height and stem diameter than C318 plants at Ibadan and Owena especially at 12 months after transplanting; although C143 was not significantly different from C318 in plant height at Ibadan (Figure 4.15). However, tea plants at Owena grew taller than those at Ibadan, especially at 12 MAT.

Tea plants under 45 and 65% lights grew taller than those under 100% light (Plate 4.3). Besides, Figure 4.16 reveals that tea plants under 45% light grew taller and had more stem diameter than those under 65 and 100% lights especially at 12 MAT. The 45 and 65% lights were not significantly ($P>0.05$) different in enhancing tea plant height in both locations; but tea plants under 45% light were significantly ($P=0.05$) taller than those under 100% light at 9 MAT in Ibadan and at 12 MAT in Owena.

In stem diameter at Ibadan, while both 45 and 65% lights were significantly better than 100% light at 9 MAT, 45% light was significantly better than both 65 and 100% lights at 12 MAT. But at Owena, 45 and 65% lights were better than 100% light in enhancing stem diameter. The 100% light enhanced the least plant height and stem diameter especially from 6 MAT-12 MAT at both locations.

Figure 4.17 shows that highest tea plant height was caused by NPK_{150} and CPH_{150} at 3 MAT, CPH_{300} and NPK_{150} at 6 MAT, CPH_{300} and CPH_{150} at 9-12 MAT at Ibadan, and

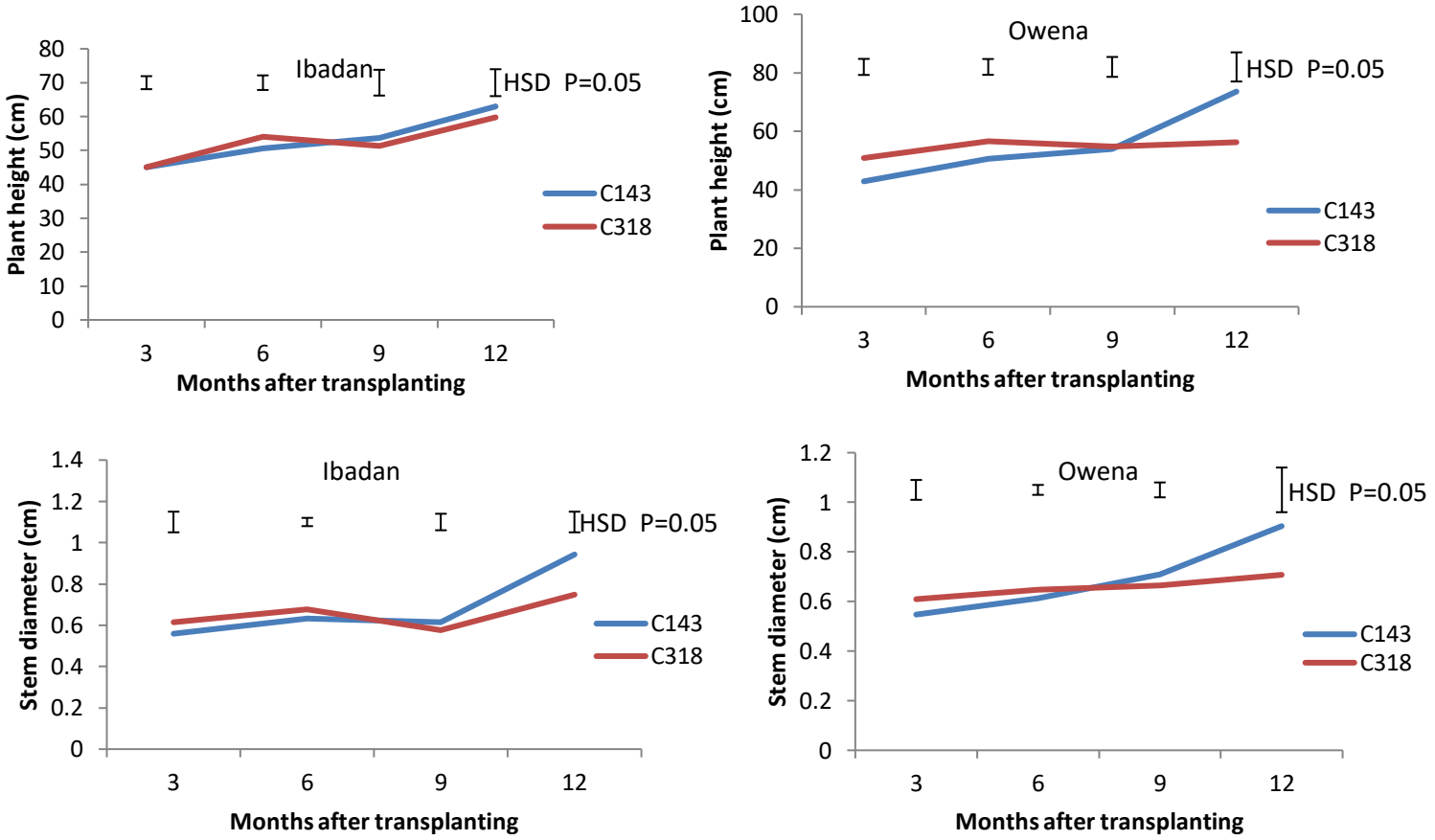


Figure 4.15: Main effects of cultivars on plant height and stem diameter of tea plants on the field at Ibadan and Owena in 2017

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

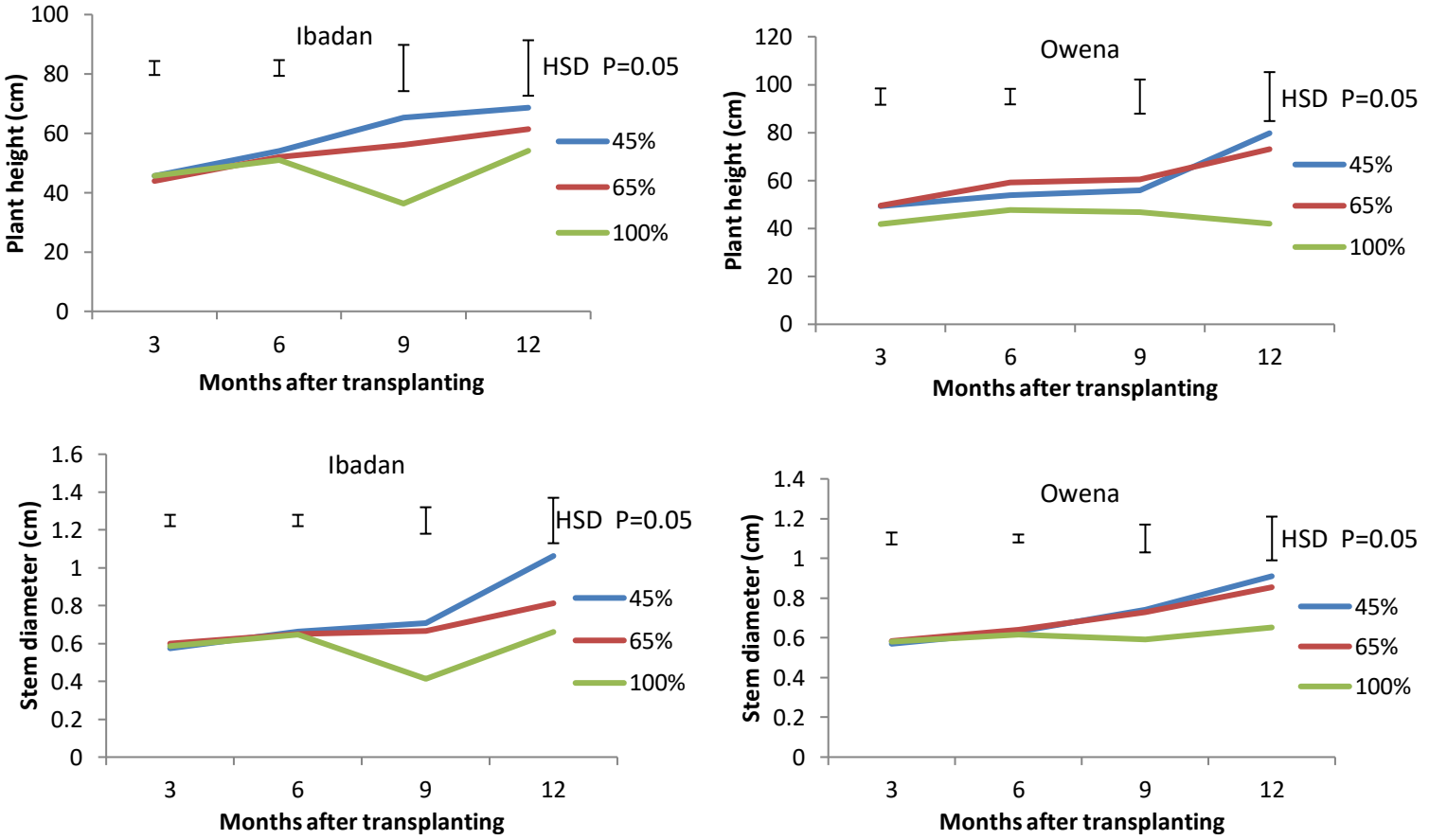


Figure 4.16: Main effects of light intensities on plant height and stem diameter of tea plants on the field at Ibadan and Owena in 2017

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

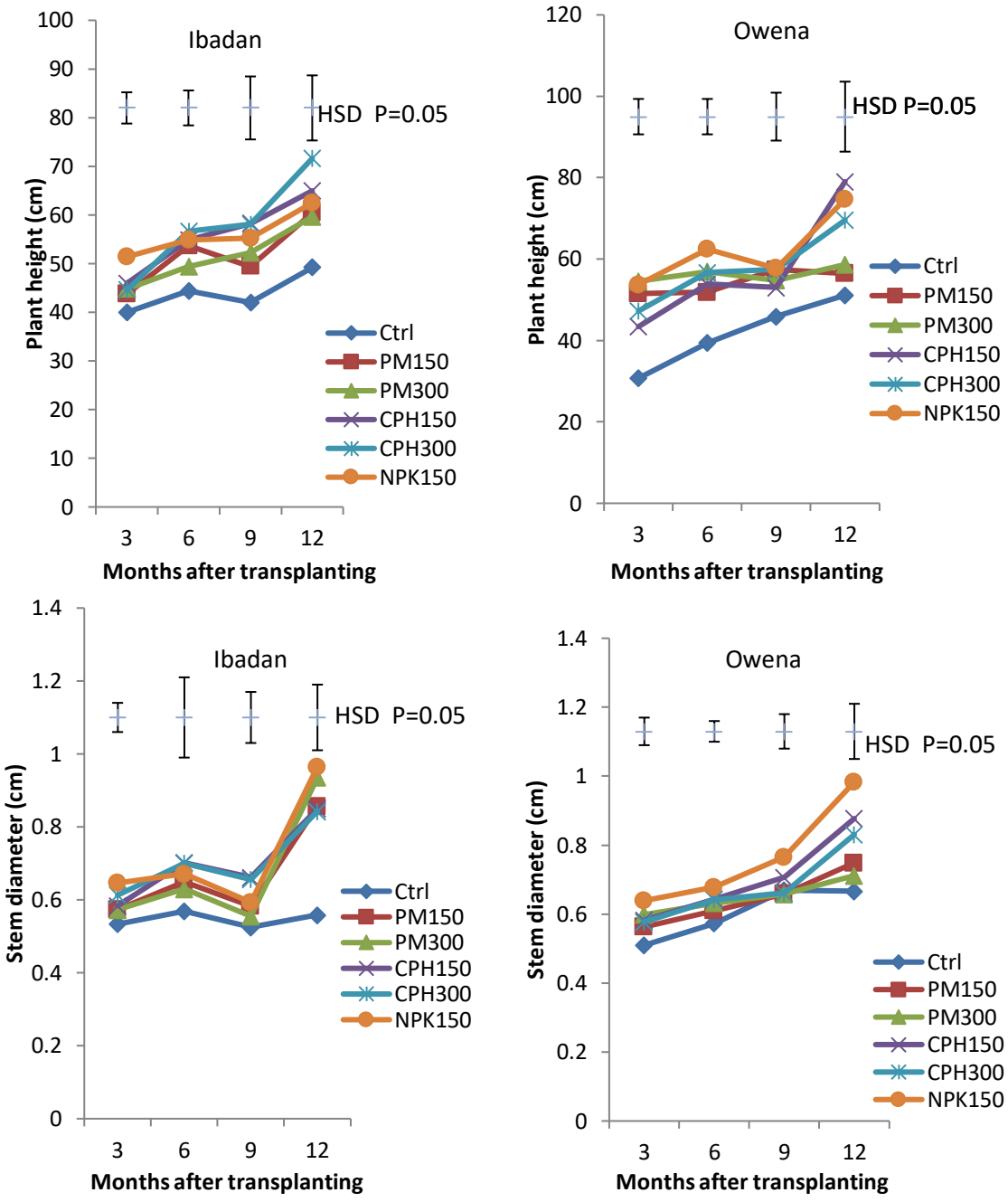


Figure 4.17: Main effects of fertilisers on plant height and stem diameter of tea plants on the field at Ibadan and Owena in 2017

PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control. MAT = Months after transplanting

45% Light **65% Light** **100% Light**

Plate 4.3: The relative heights of tea plants at 16 MAT under the varying light intensities at Ibadan

by PM_{300} and NPK_{150} at 3-6 MAT, CPH_{300}, NPK_{150} and PM_{150} at 9 MAT, CPH_{150} and NPK_{150} at 12 MAT in Owena. In enhancing plant height of tea at 12 MAT, CPH_{300} was significantly (P=0.05) better than control at Ibadan; while CPH_{150} was significantly better than PM_{150} and control at Owena. Higher stem diameter was maintained at Owena by NPK_{150} and PM_{300} compared to other fertiliser rates at 3 MAT, NPK_{150} and CPH_{150} at 6-12 MAT; and at Ibadan, higher stem diameter was enhanced by NPK_{150} and CPH_{300} compared to other fertiliser rates at 3 MAT, CPH_{150} and CPH_{300} at 6-9 MAT, NPK_{150} and PM_{300} at 12 MAT. All the fertilisers were significantly better than control at Ibadan; while NPK_{150} and CPH_{150} were significantly better than other fertilisers and control in enhancing stem diameter at 12 MAT in Owena.

Table 4.26 **s**hows the growth performance of tea as influenced by interaction of the two tea cultivars with the various light intensities. The C143 plants maintained superiority over C318 plants under all the light intensities in all the sampling periods from 3 – 12 MAT. The number of leaves of C143 under 45 - 100% lights was significantly (P=0.05) higher than that of C318, especially at 3, 9 and 12 MAT at Ibadan, and at 3 – 12 MAT at Owena. In number of branches, although C143 was superior to C318 under all the light intensities, its superiority was not significant (P>0.05) except under 45 and 100% lights at 3 MAT and 6 MAT, respectively at Ibadan; while at Owena, its number of branches was significantly (P=0.05) higher than that of C318 under 45 – 100% lights at 9 MAT and under 45% light at 12 MAT. Similarly, at 12 MAT, the interaction of cultivar 143 with 45, 65 and 100% lights increased the leaf area by 100.86, 34.56 and 80.35%, respectively compared to cultivar 318 at Ibadan; and by 121.70, 123.27 and 135.42% respectively at Owena. Still on leaf area, C143 was significantly (P=0.05) better than C318 under 45 and 65% lights at 6 MAT, and under 45% light at 12 MAT; while at Owena, it was significantly better than C318 under 45 and 65% lights at 9 MAT, and under 45, 65 and 100% lights at 12 MAT.

Figure 4.18 shows how cultivars 143 and 318 responded to the different light intensities in their plant height and stem diameter. At Ibadan, C143 tea plants were taller than C318 under all the light intensities except 100%; while the stem diameter of C318 under all the light intensities was significantly (P=0.05) higher than that of C143. However, at Owena, all the light intensities enhanced higher plant height and stem diameter of C143 and the difference was significant (P=0.05) in stem diameter under 65% light.

Table 4.26: Effect of interaction of cultivars and light intensities on number of leaves, number of branches and leaf area of tea plants on the field at Ibadan and Owena in 2017

Treatments		Ibadan				Owena			
Light intensities x (%)	Cultivars	3 MAT	6 MAT	9 MAT	12 MAT	3 MAT	6MAT	9 MAT	12 MAT
					Number of leaves				
45	C143	31.98a	79.79a	48.02a	115.33a	25.27a	79.88a	79.88a	123.25a
	C318	26.17b	48.21a	34.08b	52.81b	19.50b	43.32b	43.32b	52.23b
Mean		29.08	64.00	41.05	84.07	22.39	61.60	61.60	87.74
65	C143	28.88a	73.00a	40.50a	82.67a	29.27a	96.38a	93.78a	106.19a
	C318	24.79b	49.79a	27.61b	50.33b	23.73b	47.81b	47.03b	48.79b
Mean		26.84	61.40	34.06	66.50	26.50	72.10	70.41	77.49
100	C143	36.13a	52.19a	43.04a	68.81a	25.42a	56.84a	55.68a	80.85a
	C318	35.60b	26.92a	38.41a	45.25b	20.35b	30.45b	27.05b	26.75b
Mean		35.87	39.56	40.73	57.03	22.89	43.65	41.37	53.80
					Number of branches				
45	C143	6.38a	14.85a	10.10a	18.81a	5.29a	8.40a	15.60a	23.40a
	C318	4.48b	13.15a	9.93a	12.92a	4.00a	7.40a	11.51b	16.64b
Mean		5.43	14.00	10.02	15.87	4.65	7.90	13.56	20.02
65	C143	5.10a	15.40a	8.17a	19.04a	6.44a	10.33a	19.51a	21.75a
	C318	4.94a	12.77a	8.15a	13.76a	5.75a	8.50a	11.86b	19.69a
Mean		5.02	14.09	8.16	16.40	6.10	9.42	15.69	20.72
100	C143	5.50a	14.44a	11.21a	18.33a	6.53a	7.81a	12.27a	15.61a
	C318	6.44a	7.50b	11.31a	12.10a	4.58a	7.23a	6.24b	13.27a
Mean		5.97	10.97	11.26	15.22	5.56	7.52	9.26	14.44
					Leaf area (cm^2)				
45	C143	1250.53a	1924.73a	1574.93a	3853.20a	728.81a	751.25a	2544.62a	4999.74a
	C318	1165.22a	1265.52b	1200.08a	1918.29b	618.10a	618.10a	1766.59b	2255.19b
Mean		1207.88	1595.13	1387.51	2885.75	673.46	684.68	2155.61	3627.47
65	C143	978.36a	1507.70a	1244.44a	1899.18a	886.25a	886.25a	2301.77a	3977.58a
	C318	1056.75a	893.47b	929.83a	1422.01a	812.43a	834.90a	1453.11b	1781.48b
Mean		1017.56	1200.59	1087.14	1660.60	849.34	860.58	1877.44	2879.53
100	C143	937.61a	456.10a	882.79a	831.30a	535.22a	535.22a	824.19a	1917.55a
	C318	1036.03a	293.63a	745.53a	489.47a	609.44a	609.44a	415.81a	814.54b
Mean		986.82	779.58	814.16	660.39	572.33	572.33	620.00	1366.05

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

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

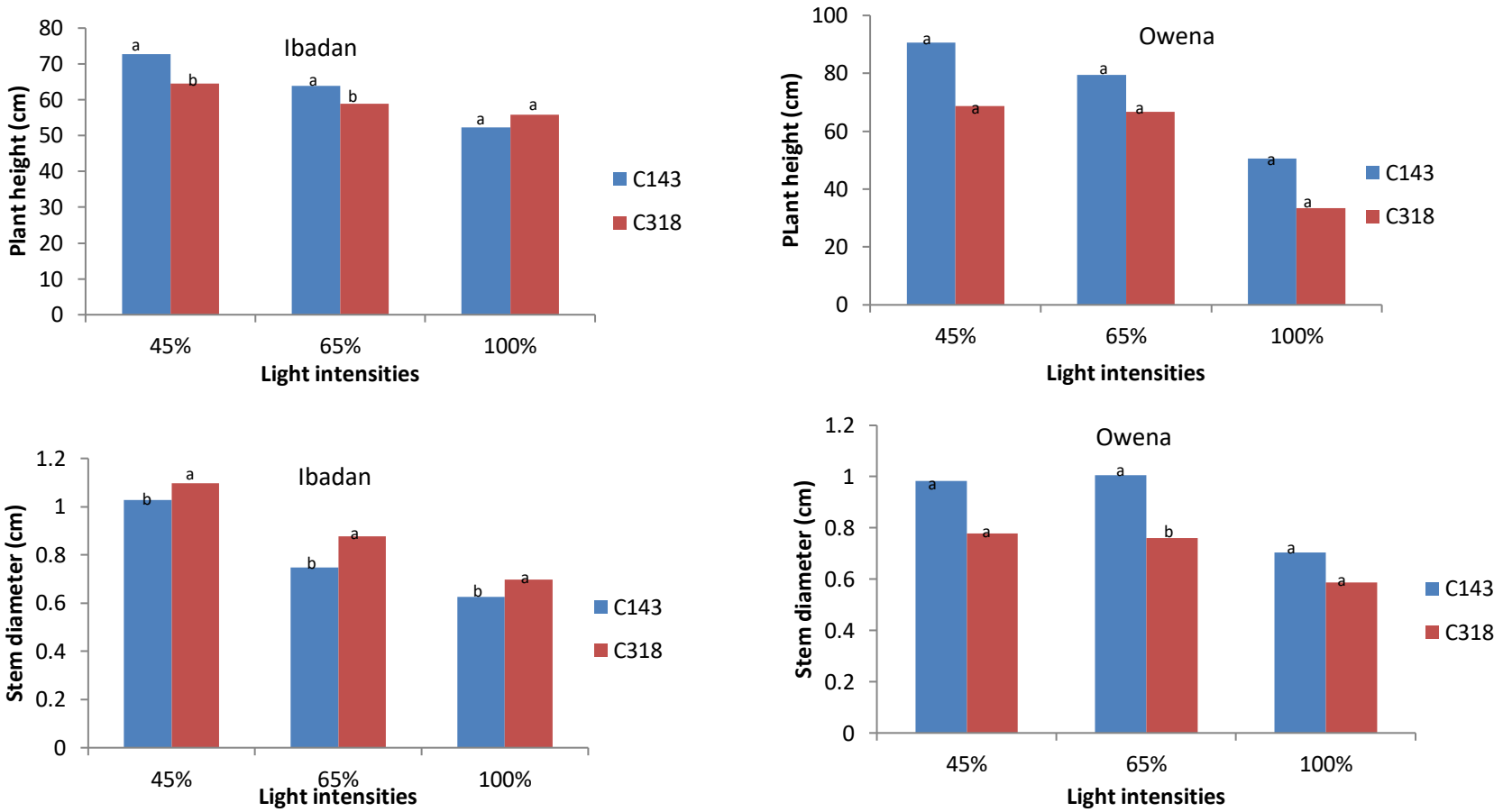


Figure 4.18: Effect of interaction of cultivars and light intensities on plant height and stem diameter of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

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

The result of the interaction of light intensities and fertilisers on number of leaves, number of branches and leaf area is shown in Tables 4.27, 4.28 and 4.29, repsectively. It was found out that at 12 months after transplanting (MAT) to the field, the interaction of C143 with CPH_{150} and 45% light produced the highest number of leaves and leaf area across the two locations (Tables 4.27 and 4.29); while the highest number branches was enhanced by NPK_{150} in C143 plants under 65% light in Ibadan, and by CPH_{150} in C143 under 45% light in Owena (Table 4.28). Owena was superior to Ibadan in enhancing these growth parameters as the highest mean number of leaves, number of branches and leaf area of 123.25, 23.40 and 4999.74 cm^2, respectively in Owena were greater than mean number of leaves, number of branches and leaf area of 115.34, 19.04 and 3853.70 cm^2, respectively in Ibadan.

Table 4.27 reveals that at 12 MAT in Ibadan, CPH_{150} produced significantly (P=0.05) higher number of leaves compared to CPH_{300}, PM_{300} and control under 45% light in C143, and all other fertiliser rates under 100% light. Similarly, at this period, in C318 plants, CPH_{150} was significantly superior to other fertiliser rates under 45 and 100% lights except CPH_{300} under 100% light. However, under 65% light, number of leaves of C143 plants fertilised with NPK_{150} and CPH_{300} was higher than those that received other fertiliser rates; while CPH_{150} and CPH_{300} were better than other fertilisers and control in C318 under the same light intensity. Similar trend was observed in Owena as CPH_{150} and NPK_{150} under 45 and 65% lights, respectively were superior to other fertilisers and control in C143 (3, 9 and 12 MAT) and in C318 (3 and 12 MAT) plants. However, under 100% light, NPK_{150} applied to C143 and control in C318 plants were significantly better than other fertiliser rates in enhancing number of leaves at 12 MAT.

Table 4.28 shows the result of the interaction of light intensities and fertilisers on number of branches. The highest number of branches at Ibadan was obtained in C143 plants and was enhanced among all the organic fertiliser rates by PM_{300} under 45% light (3 MAT), CPH_{150} under 100% light (6 MAT), CPH_{300} under 100% light (9 MAT), and PM_{150} under 45% light (12 MAT). Similarly, in Owena, the highest number of branches was obtained in C143 plants and was enhanced among all the organic fertiliser rates by CPH_{300} under 65% light (3 MAT), CPH_{150} under 45% light (6, 9 and 12 MAT). At Ibadan, 12 MAT, C143 plants fertilised with NPK_{150} and PM_{150} under 45% light, NPK_{150} and CPH_{300} under 65 and 100% lights, had higher number of branches compared with the same plants fertilised with other fertilisers and control under the same light intensities; while

Table 4.27: Effect of interaction of light intensities and fertilisers on number of leaves of two cultivars of tea plants on the field at Ibadan and Owena in 2017

Treatments		C143				C318			
Light intensities x Fertilisers (%)	(kg Nha^{-1})	3 MAT	6 MAT	9 MAT	12 MAT	3 MAT	6 MAT	9 MAT	12 MAT
					Ibadan				
45	CPH_{150}	38.88b	69.88a	104.25a	156.75a	29.50ab	39.63a	64.25a	94.00a
	CPH_{300}	21.00d	36.13bc	56.88d	77.13bc	25.63b	32.75a	45.63b	55.75b
	NPK_{150}	48.75a	60.38ab	117.13a	154.75a	32.50a	30.50a	49.38a	42.75b
	PM_{150}	30.00cd	47.75abc	100.75b	147.75a	21.38b	26.38a	41.75b	34.63b
	PM_{300}	27.88c	49.63ab	70.25c	92.00b	32.38a	42.38a	48.50b	46.75b
	Ctrl	25.38cd	24.38c	29.50e	63.63c	15.63c	32.88a	39.75b	43.00b
Mean		30.58	38.61	54.82	115.34	30.58	38.61	48.21	52.81
65	CPH_{150}	20.13c	23.75b	52.40c	44.63c	21.75b	28.13a	58.00a	61.63a
	CPH_{300}	28.25b	47.50ab	70.75b	97.63b	22.75b	28.53a	51.13a	58.88a
	NPK_{150}	45.88a	65.13a	111.13a	147.25a	23.13b	22.63a	44.63a	47.38a
	PM_{150}	30.63b	44.00ab	103.63a	76.50b	32.00a	31.88a	47.00a	49.75a
	PM_{300}	29.00b	33.50b	48.25c	53.50c	24.13b	25.50a	46.50a	44.50a
	Ctrl	19.13c	29.13b	46.13c	76.50b	25.00b	29.00a	51.50a	39.88a
Mean		30.58	38.61	54.82	82.67	30.58	38.61	49.79	50.34
100	CPH_{150}	23.75d	55.88ab	67.13b	94.00a	34.00b	39.75a	39.38a	54.25a
	CPH_{300}	35.25b	53.13abc	79.13a	55.75b	23.50c	35.25a	34.13a	53.75a
	NPK_{150}	62.63a	59.13a	80.00a	42.75b	48.63a	48.75a	18.75b	61.00a
	PM_{150}	30.88c	31.00bc	20.63d	34.63b	37.13b	33.75a	21.63b	23.25b
	PM_{300}	37.00b	30.88bc	32.25c	46.75b	38.25b	36.63a	22.25b	41.75b
	Ctrl	27.25cd	28.25c	34.00cd	43.00b	32.13b	36.33a	25.38a	37.50b
Mean		30.58	38.61	54.82	52.81	30.58	38.61	26.92	45.25
					Owena				
45	CPH_{150}	30.88a	62.50ab	104.69a	194.50a	27.13a	29.88ab	47.44b	75.75a
	CPH_{300}	22.13cd	44.00bc	83.25b	88.88c	12.25c	24.50ab	46.81b	48.25bc
	NPK_{150}	28.00ab	65.13a	96.88a	188.75a	18.63b	16.50b	33.33bc	44.50bc
	PM_{150}	27.50ab	36.13cd	82.38b	116.50b	21.38b	39.38a	65.50a	64.50ab
	PM_{300}	24.50bc	32.25cd	52.38c	62.50d	20.88bc	28.25ab	39.31bc	47.25bc
	Ctrl	18.63d	20.00d	59.69c	88.38c	16.75bc	16.88b	27.50c	33.13c
Mean		25.27	43.34	79.89	123.25	19.50	25.90	43.32	52.23
65	CPH_{150}	21.25cd	60.88a	91.63c	76.25c	18.75c	34.50ab	44.75bc	51.00a
	CPH_{300}	34.25b	56.38a	89.00c	123.63b	23.50b	44.00a	42.94bc	35.00b
	NPK_{150}	54.75a	71.25a	132.13a	179.25a	34.00a	42.50a	65.94a	73.25a
	PM_{150}	24.75c	26.25b	118.06ab	96.88c	24.38b	44.25a	44.25bc	44.75b
	PM_{300}	22.88c	53.75a	99.88bc	75.25c	24.25bc	37.75ab	52.25ab	38.50b
	Ctrl	17.75d	22.50b	47.56d	85.88c	17.50c	21.50b	36.75c	50.25b
Mean		29.27	48.50	96.38	106.19	23.73	37.42	47.81	48.79
100	CPH_{150}	24.88b	29.88b	50.50b	93.25b	16.00bc	21.13a	24.56a	21.50bc
	CPH_{300}	21.75bc	31.25b	51.81b	62.25c	18.13bc	25.25a	35.94a	29.00b
	NPK_{150}	32.75a	35.00ab	79.81a	125.38a	19.88b	24.50a	24.94a	25.00b
	PM_{150}	25.38b	39.88a	55.75b	56.25c	27.00a	27.00a	37.56a	0.00c
	PM_{300}	19.50c	21.00c	40.25c	73.88bc	26.25a	27.75a	23.81a	24.50b
	Ctrl	28.25ab	20.75c	62.94b	74.13bc	14.88c	20.75a	35.88a	60.50a
Mean		25.42	29.63	56.84	80.86	20.36	24.40	30.45	26.75

Means followed by the same letters along a column under each light intensity are not significantly different by HSD (P=0.05)
CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kgN ha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318.
MAT = Months after transplanting

Table 4.28: Effect of interaction of light intensities and fertilisers on number of branches of two cultivars of tea plants on the field at Ibadan and Owena in 2017

Treatments		C143				C318			
Light Intensities (%) x	Fertilisers (kg Nha^{-1})	3 MAT	6 MAT	9 MAT	12 MAT	3 MAT	6 MAT	9 MAT	12 MAT
					Ibadan				
45	CPH_{150}	5.25c	11.63a	17.00b	19.50ab	6.25a	12.75a	14.63b	20.67a
	CPH_{300}	5.25c	7.75c	12.00c	13.13b	4.25bc	10.83b	11.63a	14.63ab
	NPK_{150}	10.00a	12.00a	22.38a	25.25a	5.13b	7.88c	12.00bc	13.00ab
	PM_{150}	5.38c	12.50a	16.23b	24.50a	4.88b	9.13c	11.00b	8.63b
	PM_{300}	7.63b	10.50b	12.75c	17.63ab	5.00b	11.00b	11.25a	12.13ab
	Ctrl	4.25d	6.25c	6.50d	12.83b	3.75c	8.00c	12.38b	8.50b
Mean		6.29	10.11	14.48	18.81	4.88	9.93	12.15	12.93
65	CPH_{150}	3.50d	6.00c	13.00c	12.50b	5.00a	6.63c	9.88c	13.13a
	CPH_{300}	4.75c	9.63b	18.25ab	19.50b	5.13a	7.63c	17.38a	15.50a
	NPK_{150}	7.63a	11.50a	21.00a	36.50a	4.63a	6.38c	12.13bc	15.67a
	PM_{150}	5.63b	9.13b	15.63bc	17.17b	5.00a	11.88a	14.13b	12.63a
	PM_{300}	5.13b	6.38c	14.00c	12.33b	5.25a	10.00b	11.13c	13.38a
	Ctrl	4.00c	6.38c	10.50d	16.25b	4.63a	6.38c	12.00bc	12.25a
Mean		5.11	8.17	15.40	19.04	4.94	8.18	12.78	13.76
100	CPH_{150}	3.25d	13.50b	17.38b	19.00b	6.75b	12.38a	13.13a	12.25a
	CPH_{300}	5.25c	12.75b	19.75a	23.88ab	5.75c	10.13b	7.75b	12.67a
	NPK_{150}	10.13a	16.13a	23.00a	29.25a	9.13a	11.63a	5.00b	16.00a
	PM_{150}	6.13b	8.88c	6.38d	15.13bc	6.75b	11.75a	6.25b	7.00a
	PM_{300}	5.50c	8.50c	12.50c	8.00c	5.25c	12.00a	6.50b	11.67a
	Ctrl	2.75d	7.50c	7.63d	14.75bc	5.00c	10.00_b	6.38b	13.00a
Mean		5.50	11.21	14.44	18.34	6.44	11.32	7.50	12.09
					Owena				
45	CPH_{150}	7.75a	14.50a	23.56a	41.75a	5.88a	8.50b	12.19ab	20.00ab
	CPH_{300}	6.25b	8.75bc	11.88c	18.88d	2.50c	8.25b	12.00ab	13.50c
	NPK_{150}	6.88a	9.63b	21.81a	29.50b	3.38b	5.00c	8.50b	16.75bc
	PM_{150}	5.00c	7.88cd	15.75b	24.50c	4.38b	10.75a	11.38ab	19.75ab
	PM_{300}	4.50c	6.75d	13.13bc	15.25d	4.00b	8.00b	17.19a	22.50a
	Ctrl	1.38d	2.88e	7.50d	10.50e	3.88b	3.88c	7.81b	7.38d
Mean		5.29	8.40	15.61	23.40	4.00	7.40	11.51	16.65
65	CPH_{150}	5.38c	13.25b	19.94b	14.75d	4.00c	8.00b	11.63b	25.00b
	CPH_{300}	10.25b	8.13d	20.00b	23.88b	6.25b	8.50b	11.13b	24.50b
	NPK_{150}	12.25a	16.25a	28.50a	37.25a	9.75a	13.50a	18.13a	33.50a
	PM_{150}	4.88c	9.13d	18.00b	24.50b	7.00b	8.25b	11.25b	9.00d
	PM_{300}	4.38c	10.63c	23.50ab	19.75c	5.00c	8.50b	13.94b	17.50c
	Ctrl	1.50d	4.63e	7.13c	10.38e	2.50d	4.25c	5.13c	8.63d
Mean		6.44	10.34	19.51	21.75	5.75	8.50	11.87	19.69
100	CPH_{150}	5.50c	7.88bc	13.31b	13.88b	5.50a	8.13a	5.50b	8.25c
	CPH_{300}	8.38a	7.13cd	6.94c	13.56b	4.88a	8.38a	7.50a	17.81b
	NPK_{150}	7.38a	8.88ab	16.69a	27.25a	4.75ab	6.38bc	2.75b	12.17c
	PM_{150}	7.38a	9.50a	10.94b	14.25b	4.00a	7.75ab	9.63a	9.75c
	PM_{300}	7.00b	8.38abc	11.38b	15.00b	5.75a	7.25ab	7.44a	8.88c
	Ctrl	3.63d	5.13d	14.38a	9.75c	2.63c	5.50c	4.63b	22.75a
Mean		5.52	7.82	12.27	15.62	4.59	7.23	6.24	13.27

Means followed by the same letters along a column under each light intensity are not significantly different by HSD (P=0.05)
CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kgN ha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318.
MAT = Months after transplanting

Table 4.29: Effect of interaction of light intensities and fertilisers on leaf area (cm^2) of two cultivars of tea plants on the field at Ibadan and Owena in 2017

Treatments		C143				C318			
Light intensities x Fertilisers (%)	(kg Nha^{-1})	3 MAT	6 MAT	9 MAT	12 MAT	3 MAT	6 MAT	9 MAT	12 MAT
					Ibadan				
45	CPH_{150}	1693.02b	2116.23a	2922.83a	6295.15a	1403.75b	1439.27a	2185.34a	6295.15a
	CPH_{300}	1199.84c	1313.46b	1423.47b	3153.02b	1128.85c	1273.65a	1217.19bc	3153.02ab
	NPK_{150}	2224.60a	2264.81a	2535.30a	5214.07a	1721.70a	1148.48a	1323.75bc	5214.07b
	PM_{150}	1041.07cd	1526.09b	2652.49a	3817.37b	1043.25c	1239.16a	1526.62b	1734.74b
	PM_{300}	888.48d	1452.14b	1383.06b	3598.88b	1228.57bc	1409.39a	907.12c	1699.13b
	Ctrl	456.19e	776.85c	631.41c	1043.71c	465.18d	690.55b	433.07d	1016.40c
Mean		1250.53	1574.93	1924.76	3853.70	1165.22	1200.08	1265.52	3185.42
65	CPH_{150}	703.02c	805.64cd	1579.08b	977.02b	919.49b	1249.31a	783.59bc	2269.00a
	CPH_{300}	1177.90b	1552.42b	1533.02b	2423.38b	855.86b	932.67ab	712.04bc	1260.54b
	NPK_{150}	1813.62a	2073.35a	3421.52a	4777.89a	1389.02a	1010.36ab	1408.46a	1397.69ab
	PM_{150}	892.72b	1380.95c	1293.46b	1647.46b	1291.90a	1026.98a	972.65b	1381.09ab
	PM_{300}	751.00c	1009.79c	667.95c	1091.65b	994.70b	830.35b	1005.67b	1485.64a
	Ctrl	531.91c	644.52d	551.16c	477.69b	889.54b	529.32c	478.42c	738.10b
Mean		978.36	1244.45	1507.70	1899.18	1156.75	929.83	893.47	1422.01
100	CPH_{150}	801.84b	1211.38a	634.25a	1378.96a	1010.73b	894.55a	506.46a	876.03a
	CPH_{300}	815.74b	1162.30a	571.21a	1268.95a	609.65c	724.66ab	494.93a	430.90a
	NPK_{150}	1608.51a	1275.01a	785.91a	1123.24a	1278.82a	890.56a	162.43a	587.39a
	PM_{150}	808.18b	732.60b	157.34b	593.50a	1202.48a	707.90ab	226.90a	228.56a
	PM_{300}	853.59b	532.28bc	194.79b	49.40b	1336.52a	705.18ab	207.97a	387.57a
	Ctrl	737.81b	383.18c	393.07a	573.73a	777.99b	550.35b	163.35a	426.39a
Mean		937.61	882.79	456.10	831.30	1036.03	745.53	293.67	489.47
					Owena				
45	CPH_{150}	850.99a	2712.67a	4342.08a	9615.75a	971.38a	1214.87ab	1664.22b	3021.41a
	CPH_{300}	575.53b	1440.51c	2091.77cd	4257.62c	413.96c	961.87b	1594.04b	2357.23ab
	NPK_{150}	953.60a	2098.52b	2618.84bc	7814.82b	666.11b	570.92c	1375.15b	1620.96bc
	PM_{150}	787.45a	1184.04cd	3231.48b	4363.76c	620.58b	1276.62a	2761.86a	3009.80a
	PM_{300}	867.42a	1134.44d	1699.15cd	2461.79d	667.96b	1297.98a	2475.46a	2356.53ab
	Ctrl	472.49b	626.72e	1284.44d	1484.69e	368.63c	565.77c	728.85c	1165.24c
Mean		751.25	1532.82	2544.63	4999.74	618.10	981.34	1766.60	2255.20
65	CPH_{150}	546.20d	1749.47b	2456.79abc	2429.07e	587.10b	1265.55bc	1445.09b	2143.23a
	CPH_{300}	1107.81b	1642.99b	2357.46bc	3397.68cd	704.82b	1408.81b	1632.96b	1488.27a
	NPK_{150}	1924.83a	2500.65a	3465.99a	7694.06a	940.49a	1844.97a	2123.64a	2341.49a
	PM_{150}	543.92d	872.71c	1643.02cd	3348.39c	1062.05a	1490.56b	1362.43b	1810.01a
	PM_{300}	757.44c	2492.52a	2837.91ab	4163.22b	1133.76a	1139.14c	1374.91b	1269.81a
	Ctrl	437.30d	685.23c	1049.43d	2833.04de	581.20b	726.28d	779.65c	1636.05a
Mean		886.25	1657.26	2301.77	3977.58	834.90	1312.55	1453.11	1781.48
100	CPH_{150}	552.93a	760.63a	733.18a	2466.12a	438.31b	478.95a	522.78a	1040.50a
	CPH_{300}	370.86b	722.54a	1019.55a	1720.19b	629.41a	593.01a	421.32a	736.12b
	NPK_{150}	728.94a	845.27a	1012.95a	3318.39a	678.19a	884.23a	185.11a	694.74b
	PM_{150}	577.30a	972.59a	709.70a	1320.77b	656.80a	678.13a	358.36a	0.00b
	PM_{300}	424.09b	634.66a	667.00a	1494.83b	711.54a	828.31a	455.20a	659.2b
	Ctrl	557.22a	535.47a	802.77a	1185.00b	542.40a	591.08a	552.08a	1756.61a
Mean		535.22	745.19	824.19	1917.55	609.44	675.62	415.81	814.54

Means followed by the same letters along a column under each light intensity are not significantly different by HSD (P=0.05)
CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318.
MAT = Months after transplanting

C318 plants that received CPH_{150} and CPH_{300} under 45% light, CPH_{300} and NPK_{150} under 65 and 100% lights had higher number of branches, compared with the same plants fertilised with other fertiliser sand control. However, at Owena, 12 MAT, CPH_{150} under 45% light, NPK_{150} and PM_{150} under 65% light, NPK_{150} and PM_{300} under 100% light were significantly (P=0.05) superior to other fertiliser rates in the same light intensities, in enhancing number of branches in C143; whereas in C318, PM_{300} under 45% light, NPK_{150} and CPH_{150} under 65% light, and CPH_{300} under 100% light were better than other fertiliser rates in causing enhanced number of branches.

On leaf area, Table 4.29 reveals that CPH_{150} and NPK_{150} had overriding influence under 45 and 65% light intensities in the two locations. As NPK_{150} under 65% light consistently and significantly (P=0.05) enhanced C143 leaf area (1813.62, 2073.35, 3421.52 and 4777.89 cm^2 at 3, 6, 9 and 12 months after transplanting, respectively at Ibadan and 1924.83, 2500.65, 3465.99 and 7694.06 cm^2 at 3, 6, 9 and 12 MAT at Owena), CPH_{150} was superior to other fertilisers and the control under 45% light especially at 9-12 MAT in both locations. Although the effectiveness of the fertilisers in enhancing the leaf area significantly declined under 100% light, CPH_{150} still performed better than other fertilisers except in C318 at Owena where the control enhanced leaf area better than the fertilisers under 100% light at 12 MAT.

The effect of interaction of fertilisers and light intensities on plant height and stem diameter of tea are shown in Figure 4.19 which reveals that tea plants that received CPH_{150} under 45% light and CPH_{300} under 65% light at Ibadan and Owena grew taller than those that received other fertilisers and control under the same light condition. Tea plants under 100% light intensities were generally shorter than those under 45 and 65% lights in spite of the applied fertilisers. At Ibadan, while PM_{300} enhanced the highest stem diameter which was significantly (P=0.05) different from NPK_{150} and the control under 45% light, NPK_{150} was superior to other fertilisers under 65 and 100% lights. However, at Owena, CPH_{150} and NPK_{150} under 45% light, and NPK_{150} under 65% light engendered significantly (P=0.05) higher stem diameter than other fertilisers and control, while the unfertilised tea plants grew thicker in stem than the fertilised ones under 100% light.

In Figure 4.20, tea cultivars differed in their interactions with the fertilisers in enhancing their height and stem diameter. In Ibadan, while CPH_{300} enhanced the highest height of C143 and C318 plants, all the fertilisers produced significantly (P=0.05) higher

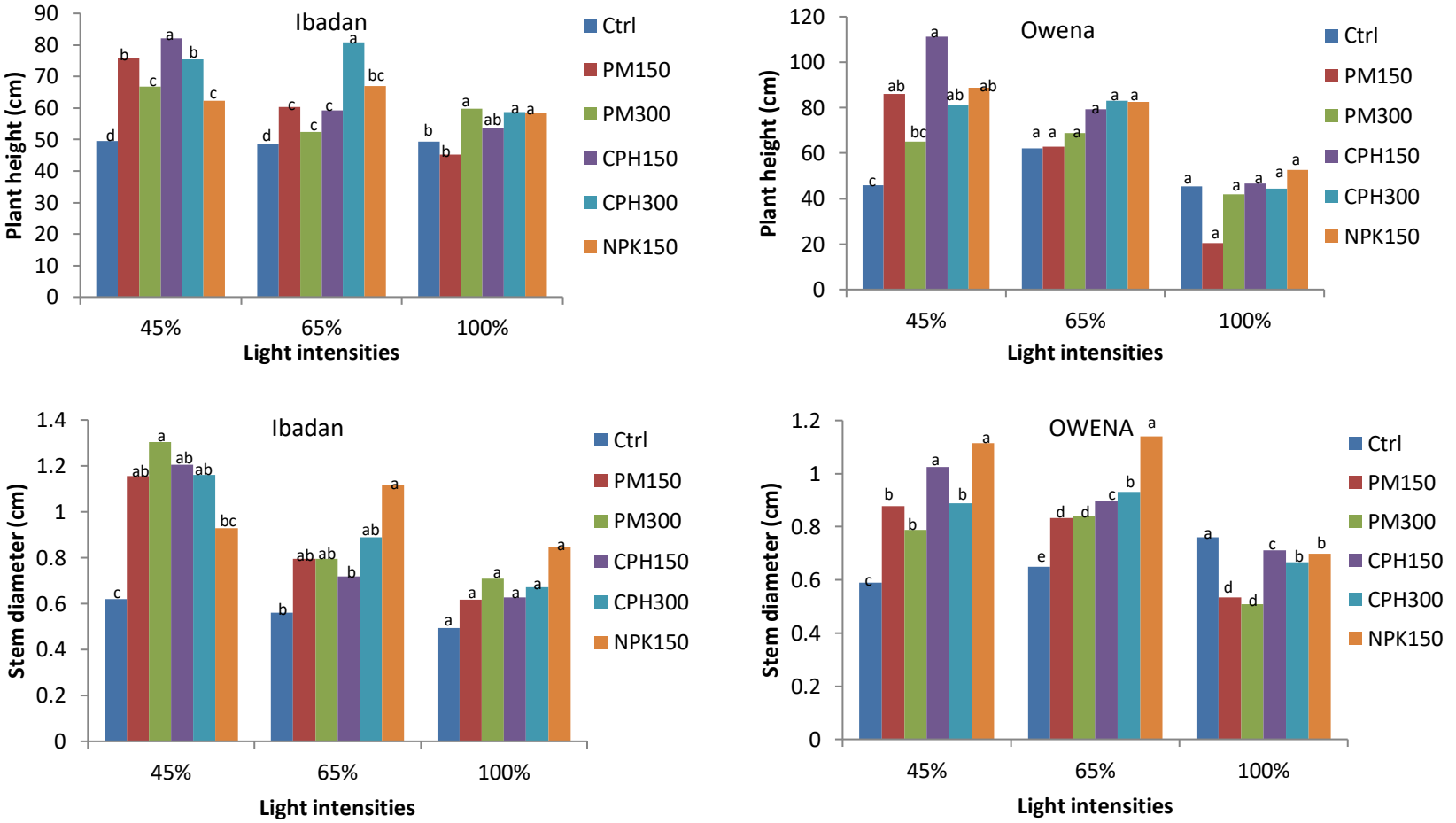


Figure 4.19: Effect of interaction of light intensities and fertilisers on plant height and stem diameter of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05)

PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control. MAT = Months after transplanting

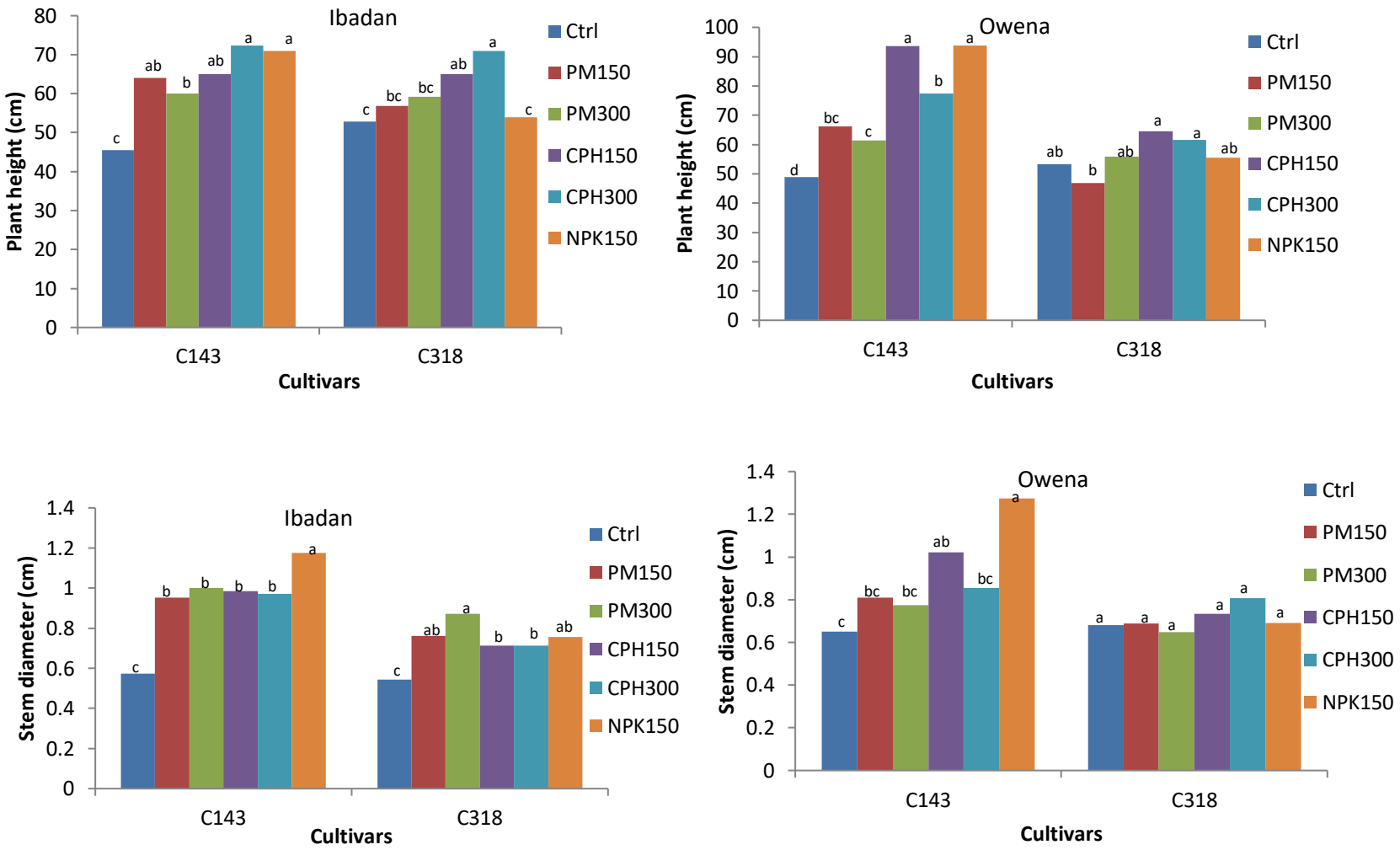


Figure 4.20: Effect of interaction of cultivars and fertilisers on plant height and stem diameter of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05)

PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Contro; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

plant height of C143 plants relative to control, CPH_{150} and CPH_{300} significantly enhanced the height of C318 plants relative to NPK_{150} and control. However, in stem diameter, the interaction of C143 with NPK_{150} enhanced significantly (P=0.05) higher stem diameter relative to other fertiliser rates; and the interaction of C318 with PM_{300} enhanced significantly higher stem diameter relative to CPH_{150}, CPH_{300} and control. At Owena, the fertilisers were more effective in C143 than in C318 plants in enhancing their plant height. However, NPK_{150} and CPH_{150}, which were not significantly (P>0.05) different, were significantly (P=0.05) superior to other fertiliser rates in enhancing plant height of C143; as CPH_{150} and CPH_{300} were better than other fertilisers and control in C318 plants height. Similarly, NPK_{150} and CPH_{150} were significantly more effective than control in enhancing the stem diameter of C143. Although, the fertilisers were not significantly different from one another and from control in C318 stem diameter, CPH_{300} and CPH_{150} were slightly better than other fertiliser rates.

4.5.2. Effects of cultivar, light intensity and fertiliser on leaf abscission in tea plants on the field at Ibadan and Owena.

The effect of different cultivars, light intensities and fertilisers on rate of leaf abscission is shown in Figures 4.21, 4.22 and 4.23. The C318 plants shed more leaves than C143 plants between 3 and 9 MAT, and by 12 MAT, C143 plants had shed more leaves than C318 plants at Ibadan and Owena (Figure 4.21). At Ibadan and Owena, the light intensities were not significantly (P>0.05) different on leaf abscission at 3 MAT. However, as the plants grew further, 100% light was significantly (P=0.05) superior to 45 and 65% lights in causing leaf drop in the tea plants from 6 MAT till 12 MAT (Figure 4.22). The 45% light was least in enhancing leaf abscission in the two locations at 3-12 MAT and it was significantly (P=0.05) lower than 65% light at 12 MAT in Owena.

At Ibadan, the fertiliser rates were not significantly (P>0.05) different in enhancing leaf abscission at 3-6 MAT (Figure. 4.23). However, all the fertilisers were significantly (P=0.05) higher than control at 9-12 MAT. As from 6-12 MAT, tea plants that received NPK_{150} shed more leaves than those that received organic fertilisers and control. The unfertilised tea plants shed the least leaves. The trend was different at Owena as tea plants that received PM_{300} and NPK_{150} shed more leaves than other fertilised plants and the control, and those that received CPH_{150}; PM_{150} and control shed the least leaves at 12 MAT.

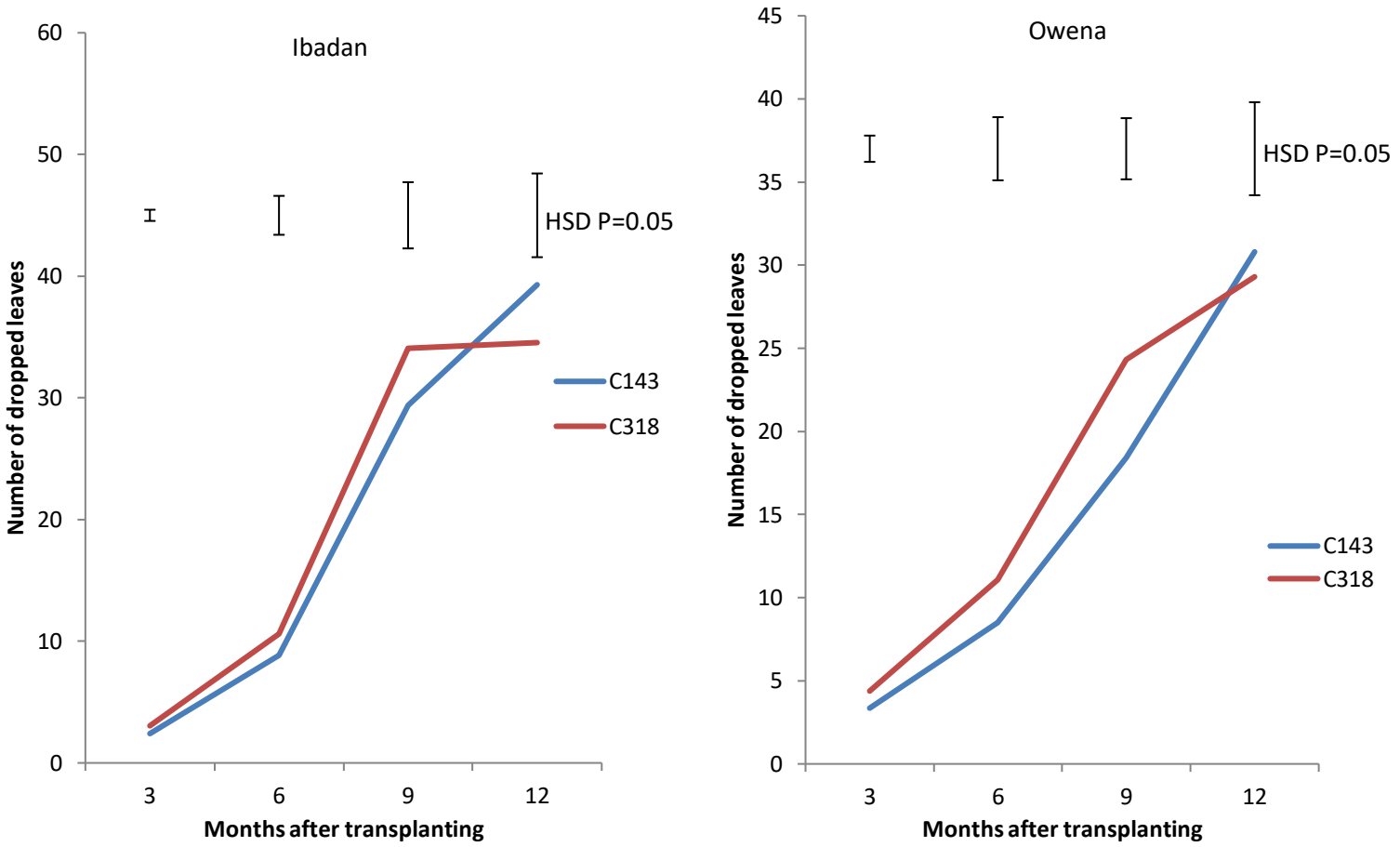


Figure 4.21: Main effects of cultivars on rate of leaf abscission in tea plants on the field at Ibadan and Owena in 2017

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

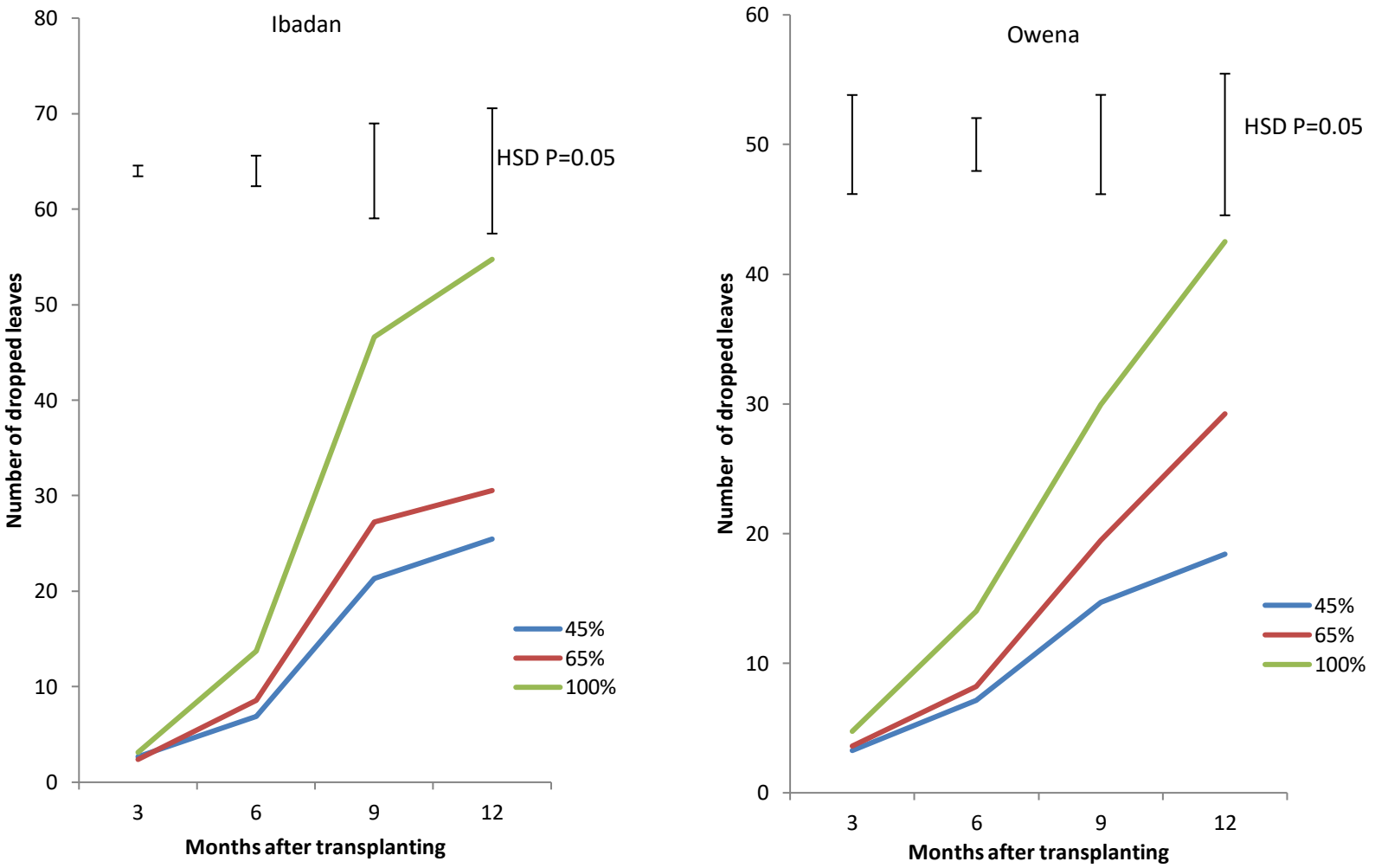


Figure 4.22: Main effects of light intensities on rate of leaf abscission in tea plants on the field at Ibadan and Owena in 2017

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

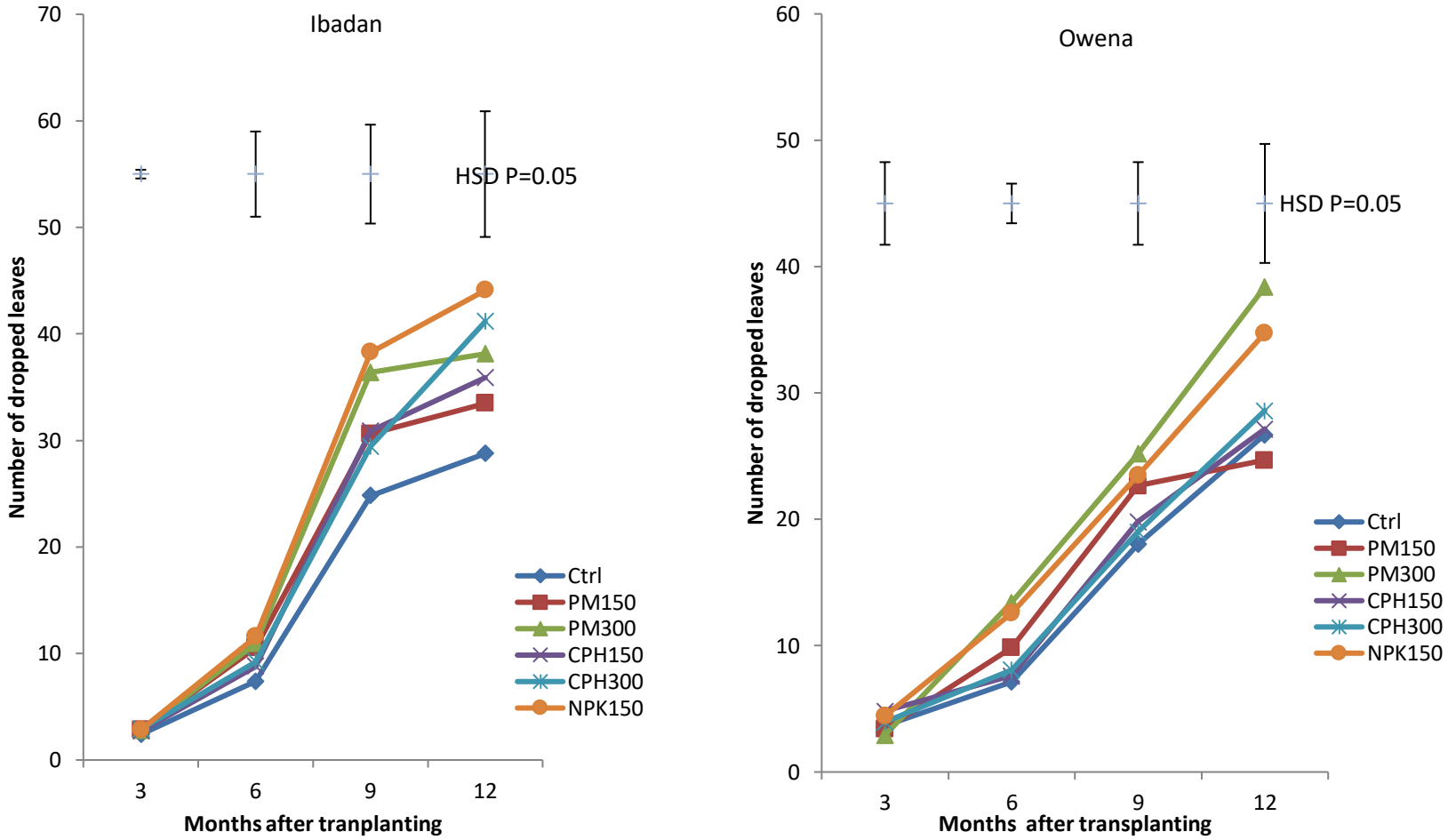


Figure 4.23: Main effects of fertilisers on rate of leaf abscission in tea plants on the field at Ibadan and Owena in 2017

PM_{150}=150 kg Nha^{-1} Poultry Manure; PM_{300}=300 kg Nha^{-1} Poultry Manure; CPH_{150}=150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300}=300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} =150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control

Figures 4.24, 4.25 and 4.26 show the effect of interaction of cultivars, light intensities and fertilisers on rate of leaf abscission in tea plants at 14 MAT. The C143 shed more leaves than C318 plants under all the light intensities at Ibadan and under 100% light at Owena (Figure 4.24).

The different fertilisers differ under the varying light intensities in causing leaf abscission (Figure 4.25). At Ibadan, all tea plants that received PM_{150}, PM_{300}, CPH_{150} and NPK_{150} under 45% light shed more leaves than those that received CPH_{300} and control; while under 65% light, PM_{150} and NPK_{150} enhanced more leaf drop than other fertilisers and the control. However, under 100% light where leaf abscission was at the peak, CPH_{300} enhanced significantly (P=0.05) higher leaf abscission than PM_{150} and the control. A different trend was observed at Owena: while none of the fertilisers under 45% light was significantly superior, CPH_{150} enhanced the highest leaf drop. However, NPK_{150} and PM_{300} under 65 and 100% lights caused the highest leaf drop and were significantly different from CPH_{150}, PM_{150}, control (under 65% light), PM_{150}, CPH_{150} and CPH_{300} (under 100% light).

The rate of leaf abscission was also affected by the interaction of the fertilisers with the cultivars (Figure 4.26). The highest leaf abscission was obtained in C143 tea plants that received NPK_{150} in Ibadan. At Ibadan, while NPK_{150} was significantly (P=0.05) superior to other fertiliser rates in C143 plants, PM_{300} enhanced more leaf drop in C318. Similarly, in Owena, C143 plants fertilised with NPK_{150} and PM_{300} shed significantly higher number of leaves than those that received other fertiliser rates; while PM_{300} was significantly more outstanding than other fertilisers and control in causing leaf abscission in C318 plants.

4.5.3. Effects of cultivar, light intensity and fertiliser on dry matter accumulation of tea plants at 14 MAT on the field at Ibadan and Owena.

Table 4.30 reveals that the different cultivars, light intensities and fertilisers significantly influenced dry matter accumulation in tea plants at Ibadan and Owena. Cultivar 143 significantly (P=0.05) produced higher root (12.83 g), stem (28.61 g) and leaf (14.94 g) dry weight than cultivar 318 that produced 9.06 g root, 16.55 g stem and

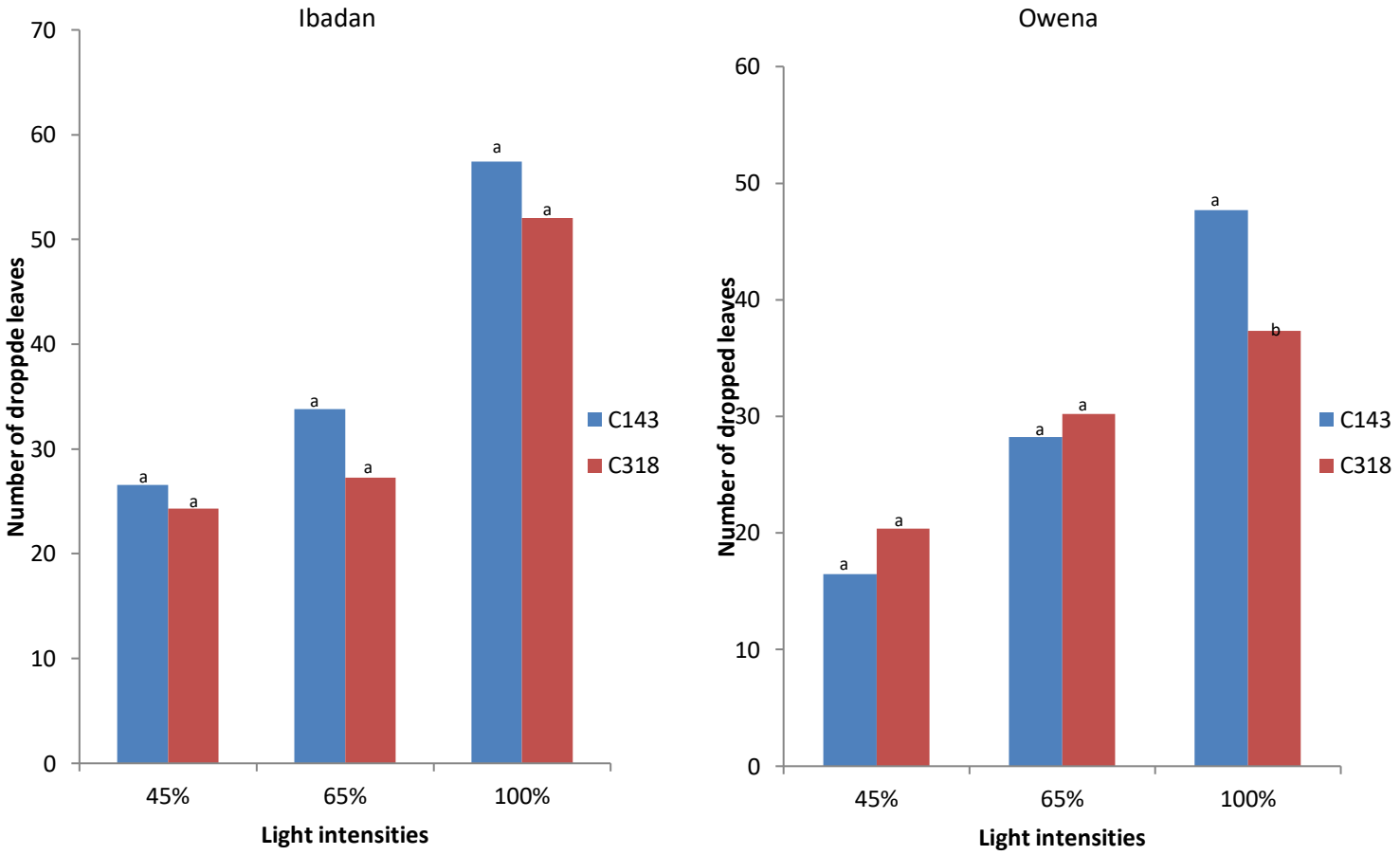


Figure 4.24: Effect of interaction of cultivars and light intensities on rate of leaf abscission in tea plants at 14 MAT on the field at Ibadan and Owena in 2017

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

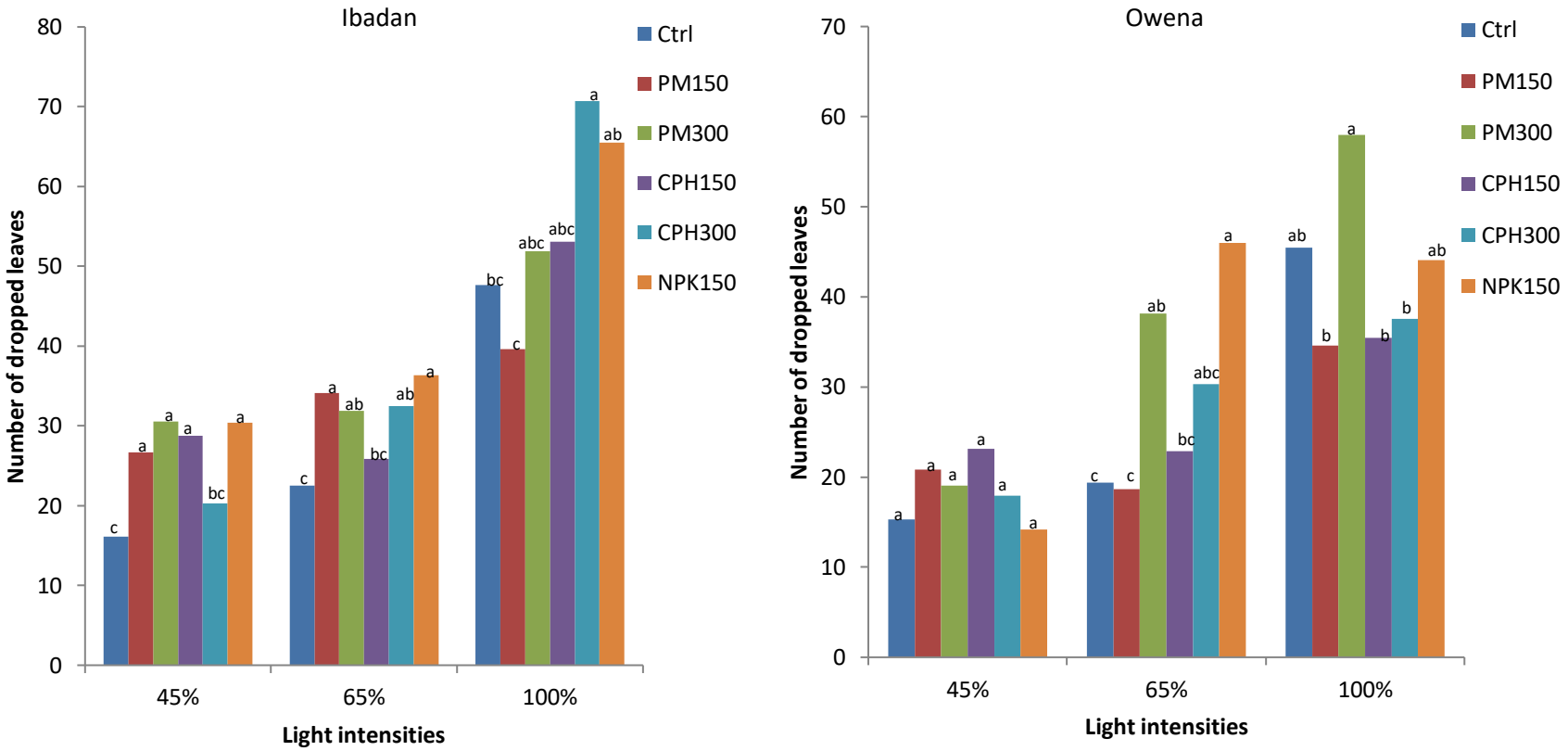


Figure 4.25: Effect of interaction of light intensities and fertilisers on rate of leaf abscission in tea plants 14 MAT on the field at Ibadan and Owena in 2017

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05)

PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control. MAT = Months after transplanting

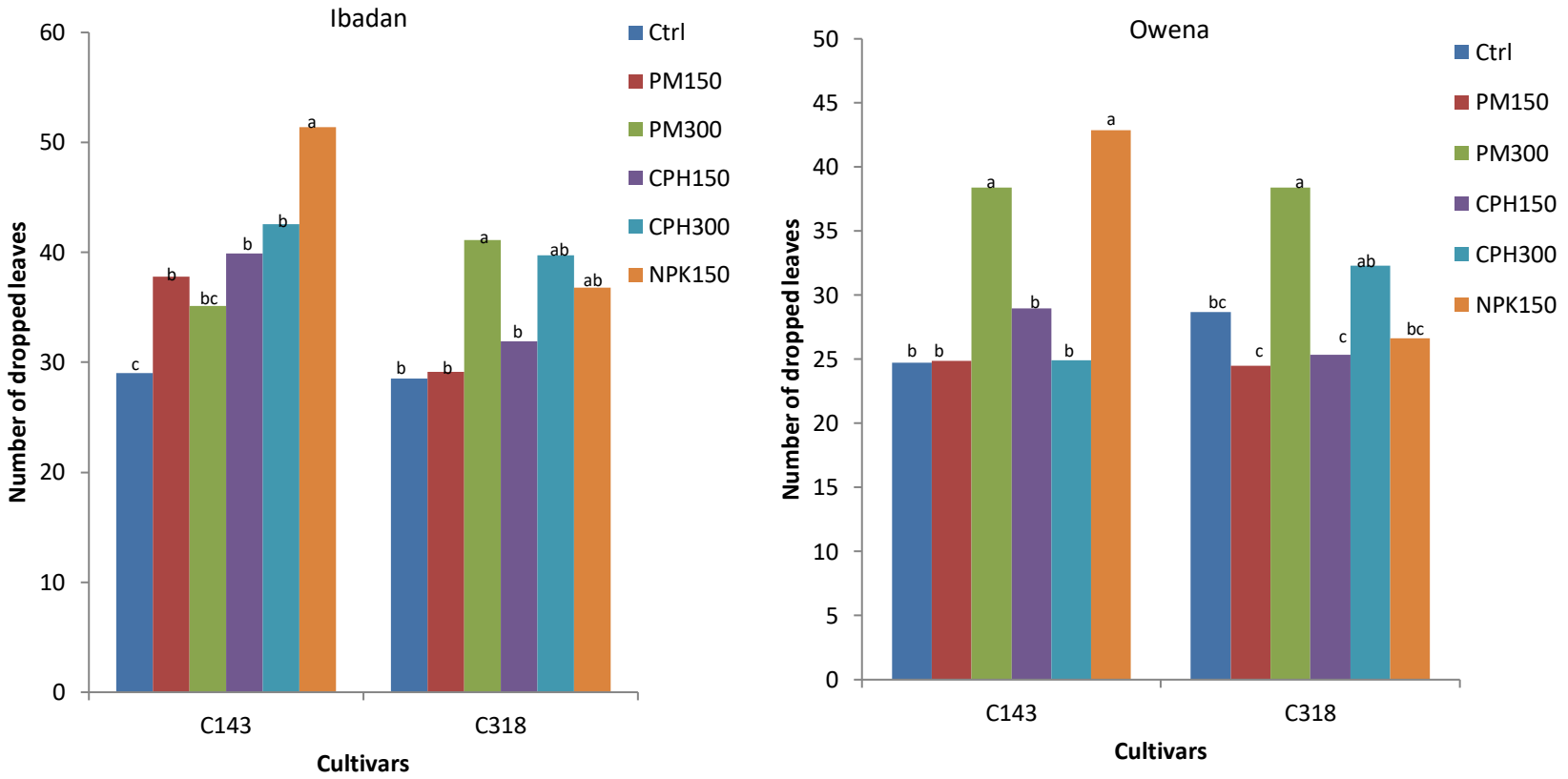


Figure 4.26: Effect of interaction of cultivars and fertilisers on rate of leaf abscission in tea plants 14 MAT on the field at Ibadan and Owena in 2017

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05)

PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

Table 4.30: Main effects of cultivars, light intensities and fertilisers on dry matter accumulation (g plant^{-1}) of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

Treatments	Ibadan				Owena			
Cultivars	**Root**	**Stem**	**Leaf**	**Total**	**Root**	**Stem**	**Leaf**	**Total**
C143	12.83a	28.61a	14.94a	56.38a	25.47a	43.40a	22.13a	90.99a
C318	9.06b	16.55b	9.72b	36.05b	10.62b	19.19b	10.12b	39.93b
Mean	10.94	22.58	12.33	46.22	18.05	31.30	16.12	65.46
Light intensities (%)								
45	15.15a	33.74a	16.91a	65.80a	23.23a	42.28a	21.36a	86.86a
65	9.00b	20.24b	12.32ab	42.65b	18.44a	30.65b	15.79b	64.87b
100	8.68b	13.76b	7.75b	30.20b	12.47b	20.96b	11.22b	44.65b
Mean	10.94	22.58	12.33	46.22	18.05	31.30	16.12	65.46
Fertilisers (kg Nha^{-1})								
CPH_{150}	14.38a	34.94a	16.41a	65.74a	23.64a	44.24a	20.37ab	88.25a
CPH_{300}	13.98ab	26.60b	14.45ab	55.03a	19.31ab	30.29ab	15.24c	64.84b
NPK_{150}	11.73b	30.93ab	17.96a	60.62a	12.81a	44.96a	22.75a	93.52a
PM_{150}	9.00c	14.95c	7.60bc	31.55b	16.84b	30.54ab	17.36bc	64.73b
PM_{300}	9.05c	17.63c	10.79b	37.47b	12.27bc	19.25b	11.05d	43.07b
Control	7.50c	10.44c	6.75c	26.88b	9.90c	18.50b	9.96d	38.36c
Mean	10.94	22.58	12.33	46.22	18.05	31.30	16.12	65.46

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

CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318.
MAT = Months after transplanting

9.72 g leaf dry matter at Ibadan. Similarly, at Owena, C143 produced 25.47 g root, 43.40 g stem, and 22.13 g leaf dry matter which were significantly higher than 10.62 g root, 19.19 g stem, and 10.12 g leaf dry matter of C318 plants.

In the same vein, 45% light was superior to 65 and 100% lights significantly (P=0.05) in enhancing root, stem, and leaf dry matter of tea plants at Ibadan and Owena. The total dry matter produced were in the following order: 65.80 g > 42.65 g > 30.20 g under 45, 65 and 100% lights, respectively at Ibadan; and 86.86 g > 64.87 g > 44.65 g under 45, 65 and 100% lights, respectively at Owena. The 45% light increased total dry matter of tea by 35.2 and 54.1% compared with 65 and 100% lights, respectively in Ibadan and by 25.3 and 48.6% in Owena.

Organic fertilisers enhanced the biomass (Plate 4.4) and dry mater accumulation (Table 4.30) in tea plants in Ibadan and Owena. The unfertilised tea biomass looked much stunted vegetatively when compared with the fertilised ones (Plate 4.4). Tea plants that received CPH_{150} accumulated more root, stem, and leaf dry matter compared to those that received other organic fertilisers and unfertilised ones at Ibadan and Owena. The CPH_{150} increased total dry mater by 16.3, 52.0, 43.0 and 59.1% in comparison with CPH_{300}, PM_{150}, PM_{300} and control, respectively at Ibadan, and by 26.5, 26.7, 51.2 and 56.5% at Owena. However, CPH_{150}, CPH_{300} and NPK_{150} were significantly better than other fertiliser rates in enhancing total dry matter at Ibadan; while CPH_{150} and NPK_{150} were significantly superior to other fertilisers and control in Owena. Generally, more dry matter accumulation was observed at Owena than at Ibadan.

Light intensity influenced dry matter accumulation in the root, stem and leaves of the two tea cultivars differently (Table 4.31). In enhancing root, stem and leaf dry matter accumulation, C143 was superior to C318 under all the light intensities at both locations except under 100% light at Ibadan, and the difference was significant under 45% light at Ibadan, and under 45, 65 and 100% lights at Owena. The total dry matter of C143 plants under 45 and 65 lights increased by 123.3 and 42.4%, respectively in comparison with C318 at Ibadan, and by 144.3, 101.5 and 140.4% under 45, 65 and 100% lights, respectively at Owena.

Control

PM (150 kg Nha^{-1})

PM (300 kg Nha^{-1})

CPH (150 kg Nha^{-1})

CPH (300 kg Nha^{-1})

NPK 5:1:1 (150 kg Nha^{-1})

PM: Poultry Manure; CPH: Cocoa Pod Husk

Plate 4.4: Tea biomass under the different fertilisers at 14 MAT in Ibadan in 2017

Table 4.31: Effect of interaction of cultivars and light intensities on dry matter accumulation (g plant^{-1}) of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

Treatments Light intensities (%) x Cultivars		Root	Stem	Leaf	Total
			Ibadan		
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
			Owena		
45	C143	33.48a	59.60a	30.12a	123.20a
	C318	12.98b	24.94b	12.60b	50.43b
Mean		23.23	42.27	21.36	86.82
65	C143	25.09a	41.34a	20.28a	86.72a
	C318	11.78b	19.96b	11.29b	43.03b
Mean		18.44	30.65	15.79	64.88
100	C143	17.83a	29.26a	15.98a	63.06a
	C318	7.11b	12.67b	6.46b	26.23b
Mean		12.47	20.97	11.22	44.65

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

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

Tables 4.32 and 4.33 show that interaction of fertilisers with light intensities exerted significant effect on dry matter accumulation in both locations. The C143 plants that received CPH_{150} under 45% light produced the highest root, stem, and leaf dry matter at Ibadan (Table 4.32). The dry matter accumulation produced by fertiliser+light intensity interactions at Owena was higher than that produced at Ibadan. At Ibadan, CPH_{150} interaction with 45% light, NPK_{150} with 65% light, NPK_{150} and CPH_{300} with 100% light were significantly (P=0.05) better than other interactions of fertiliser with respective light intensities in causing enhanced total dry matter in C143 tea plants. Also, CPH_{150}, CPH_{300} and NPK_{150} interactions with 45, 65 and 100% lights, respectively were significantly superior to other interactions of fertiliser with respective light intensities in precipitating enhanced total dry matter in C318 plants.

A similar trend was observed at Owena (Table 4.33) as the highest root dry matter was enhanced by NPK_{150} under 45% light, highest stem and leaf dry matter by CPH_{150} under 45% light. The C143 plants that received CPH_{150}, NPK_{150} and CPH_{300} under 45, 65 and 100% lights, respectively were significantly (P=0.05) better than other fertilisers and control in causing enhanced total dry matter accumulation under respective light intensities. However, C318 plants fertilised with PM_{150} under 45 and 65% lights, and CPH_{150} under 100% light were superior to others under respective light intensities in total dry matter. Generally, the applied fertilisers produced less dry matter under 100% light than they did under 45 and 65% lights.

4.5.4. Effects of cultivar, light intensity and fertiliser on survival count, pruning yield and leaf harvest of tea plants on the field at Ibadan and Owena

Table 4.34 shows that cultivars, light intensities and fertilisers significantly (P=0.05) influenced the seedling establishment (Survival), pruning yield and leaf harvest of tea plants at Ibadan and Owena. Cultivar C143 was significantly (P=0.05) superior to C318 especially at Owena with its survival values of 76.4 and 83.0% at Ibadan and Owena, respectively, as against 72.3 and 64.9% of C318. Similarly, while 45% light was significantly superior to 65 and 100% lights at Ibadan; both 45 and 65% lights were significantly better than 100% light at Owena. There was no significant difference among the fertiliser rates on their effect on survival count. However, the highest seedling survival was achieved in tea fertilised with CPH_{300}.

Table 4.32: Effect of interaction of light intensities and fertilisers on dry matter accumulation (g plant^{-1}) of two cultivars of tea plants at 14 MAT on the field at Ibadan in 2017

Treatments		C143				C318			
Light intensities (%)	x Fertilisers (kg Nha^{-1})	Root	Stem	Leaf	Total	Root	Stem	Leaf	Total
45	CPH_{150}	38.51a	125.94a	49.23a	213.67a	15.63a	30.15a	18.58a	64.41a
	CPH_{300}	23.13b	60.73b	27.34abc	111.37b	14.74a	18.15ab	6.71b	39.59b
	NPK_{150}	15.00c	35.84bc	20.06bcd	70.90bc	7.68b	15.01b	10.64b	33.33b
	PM_{150}	12.16c	15.67c	7.18cd	35.00c	9.02b	16.88b	11.03b	36.92b
	PM_{300}	23.19b	45.69bc	29.65ab	98.53b	9.39b	16.89b	8.10b	34.38b
	Ctrl	4.05d	8.23c	4.35d	16.64c	9.05b	15.76b	10.07b	34.88b
Mean		19.34	48.68	22.97	91.02	10.92	18.81	10.86	40.59
65	CPH_{150}	8.18c	13.72b	5.81c	27.71b	8.54b	19.17ab	12.69b	40.41a
	CPH_{300}	12.46b	19.14b	15.32b	46.92b	12.35a	26.33a	19.58a	58.27a
	NPK_{150}	17.10a	78.70a	45.34a	141.13a	4.06c	4.99b	3.63d	12.67c
	PM_{150}	9.75b	19.93b	6.95c	36.63b	8.05b	14.32ab	8.08bcd	30.45bc
	PM_{300}	5.46c	10.75b	8.27c	24.48b	7.46bc	17.61ab	9.61bc	34.68b
	Ctrl	8.05c	9.94b	5.77c	23.75b	6.49bc	8.28b	6.83cd	34.68b
Mean		10.17	25.36	14.58	50.10	7.83	15.12	10.07	35.19
100	CPH_{150}	7.53b	6.58b	2.79c	16.89c	7.86b	14.13b	9.39a	31.37b
	CPH_{300}	13.52a	15.88ab	10.05b	39.44ab	7.54b	19.41ab	7.69a	34.63a
	NPK_{150}	14.49a	22.11a	16.96a	53.56a	12.06a	28.93a	11.16a	52.15a
	PM_{150}	6.33b	8.94b	5.42b	20.68bc	8.72a	13.94b	6.97a	29.62b
	PM_{300}	3.17c	5.42b	1.93c	10.52c	5.62b	9.41b	7.20a	22.22b
	Ctrl	8.63b	11.87ab	6.52b	27.00bc	8.76a	8.59b	6.98a	24.33b
Mean		8.95	11.80	7.28	28.02	8.43	15.74	8.23	32.39

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

CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

Table 4.33: Effect of interaction of light intensities and fertilisers on dry matter accumulation (g plant^{-1}) of two cultivars of tea plants at 14 MAT on the field at Owena in 2017

Treatments		C143				C318			
Light intensities (%) x Fertilisers (kg Nha^{-1})		Root	Stem	Leaf	Total	Root	Stem	Leaf	Total
45	CPH_{150}	53.16a	112.86a	50.58a	216.59a	15.46ab	31.28a	15.65ab	62.39ab
	CPH_{300}	30.36bc	41.63bc	27.14d	99.12bc	19.32a	24.46a	10.21c	53.99abc
	NPK_{150}	53.82a	91.85a	41.98b	187.65a	6.53b	24.38a	11.15bc	42.05bc
	PM_{150}	37.47ab	60.74b	32.63c	130.84b	18.10a	30.01a	19.13a	67.24a
	PM_{300}	14.24cd	26.12c	16.74e	57.10cd	11.01b	19.21a	11.03b	41.25bc
	Ctrl	11.87d	24.43c	11.63e	47.92d	7.45b	20.36a	8.42c	36.23c
Mean		33.49	59.61	30.12	123.20	12.98	24.95	12.60	50.53
65	CPH_{150}	26.16b	49.78b	20.29b	96.22b	13.92a	23.02a	10.34b	47.27a
	CPH_{300}	23.13bc	43.82b	19.77b	86.72b	13.00a	21.05a	8.31b	42.36a
	NPK_{150}	51.10a	76.35a	38.88a	166.33a	13.19a	17.14a	12.24ab	42.56a
	PM_{150}	19.28c	31.16c	16.42b	66.87b	10.22a	21.92a	15.98a	48.11a
	PM_{300}	18.48cd	19.20d	10.32c	47.99b	11.64a	20.48a	10.57b	42.68a
	Ctrl	12.42d	27.75cd	16.02b	56.19b	8.73a	16.15a	10.33b	35.20a
Mean		25.10	41.34	20.28	86.72	11.78	19.96	11.30	43.03
100	CPH_{150}	25.59a	33.98bc	14.59bc	74.15ab	7.55a	14.53a	10.79a	32.86a
	CPH_{300}	22.02a	39.29b	21.56a	82.86a	8.03a	11.50a	4.48b	24.00a
	NPK_{150}	22.78a	43.44a	25.11a	91.32a	7.46a	16.61a	7.14ab	31.20a
	PM_{150}	11.96b	27.50cd	14.85b	54.31bc	4.01a	11.90a	5.13b	21.04a
	PM_{300}	11.69b	18.53de	11.33b	41.56c	9.58a	11.99a	6.31ab	27.88a
	Ctrl	12.92b	12.82e	8.45c	34.19c	6.02a	9.49a	4.92b	20.43a
Mean		17.83	29.26	15.98	63.07	7.11	12.67	6.46	26.24

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

CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting

Table 4.34: Main effects of cultivars, light intensities and fertilisers on survival count, pruning yield and leaf harvest of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

Treatments	Ibadan			Owena		
Cultivars	**SV (%)**	**PY (g plant^{-1})**	**LH (g plant^{-1})**	**SV (%)**	**PY (g plant^{-1})**	**LH (g plant^{-1})**
C143	76.39a	34.63a	16.07a	82.99a	25.60a	16.61a
C318	72.34a	25.41b	16.86a	64.93b	19.94b	12.12b
Mean	74.37	30.02	16.46	73.96	22.77	14.36
Light intensities (%						
45	92.54a	47.77a	22.04a	83.33a	22.76b	14.41a
65	77.26b	18.70b	14.32b	82.81a	33.62a	15.62a
100	53.30c	23.59b	13.01b	55.73b	11.93c	13.05a
Mean	74.36	30.02	16.46	73.96	22.77	14.36
Fertilisers (kg Nha^{-1})						
CPH_{150}	74.65a	31.60ab	18.22abc	68.06a	27.13a	20.47a
CPH_{300}	82.64a	23.53ab	18.82ab	83.33a	23.69a	17.46ab
NPK_{150}	80.90a	42.05a	21.40a	67.71a	22.22a	14.87bc
PM_{150}	67.71a	40.15a	20.36a	73.96a	25.76a	11.98cd
PM_{300}	59.72a	26.79ab	9.20c	65.97a	30.15a	11.74cd
Ctrl	80.56a	16.01b	10.78bc	84.72a	7.67b	9.66d
Mean	74.36	30.02	16.46	73.96	22.77	14.37

Means followed by the same letters along a column in each treatment are not significantly different by HSD (P=0.05)
PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318. MAT = Months after transplanting; SC = Survival count; PY = Pruning yield; LH = Leaf harvest

Pruning yield of C143 was significantly more than that of C318 as it increased pruning yield by 26.6 and 22.1% at Ibadan and Owena, respectively. The C143 and C318 produced 34.63g and 25.41g pruned shoot, respectively at Ibadan; and 25.60g and 19.94g pruned shoot at Owena. The 45 and 65% lights enhanced significantly higher pruning yield at Ibadan and Owena, respectively. At Ibadan, the pruning yield produced by 45, 65 and 100% lights were in the order of 47.77g > 18.70g < 23.59g, respectively and 45% light was significantly better than 65 and 100% lights; while at Owena, 45, 65 and 100% lights were significantly different in the order of 22.76g < 33.62g > 11.93g, respectively. The fertilisers were not significantly different from each order; but at Ibadan, PM_{150} and NPK_{150} were significantly superior to control, while all the fertilisers were significantly better than control at Owena in enhancing pruning yield.

In leaf harvest, C143 and C318 were not significantly (P>0.05) different at Ibadan; but at Owena, C143 was significantly (P=0.05) better. At Ibadan, the quantity of harvested tea leaves caused by 45% light was significantly more than the one caused by 65 and 100% lights; while none of the light intensities was significantly superior at Owena. The fertilisers were significantly different in leaf harvest production. At Ibadan, $NPK_{150,}$ PM_{150} and CPH_{300} produced the highest leaf harvest and were significantly different in effect from PM_{300} and control. Similarly, at Owena, CPH_{150} and CPH_{300} produced the highest leaf harvest, and were significantly superior to PM_{150}, PM_{300} and control.

The light intensities affected the seedling survival of the two tea cultivars differently (Table 4.35). At Ibadan, while the C318 survival count of 93.06 and 80.55% under 45 and 65% lights, respectively were not significantly (P>0.05) different from C143 survival count of 92.01 and 73.96% under the same light intensities respectively; C143 survived significantly (P=0.05) better than C318 at 100% light. However, at Owena, C143 survived better than C318 under all the light intensities: 90.63% C143 > 76.04% C318 under 45% light; 90.63% C143 > 75.00% C318 under 65% light and 67.71% C143 > 43.75% C318 under 100% light. The pruning yield of C143 was significantly (P=0.05) more than that of C318 under 45 and 65% lights at Ibadan and under 45% light at Owena. The highest pruning yield of 57.65 g/plant at Ibadan and 34.19 g/plant at Owena was obtained in C143 under 45 and 65% lights, respectively; while the least pruning yield of 9.74 g/plant at

Table 4.35: Effect of interaction of cultivars and light intensities on survival count, pruning yield and leaf harvest of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

Treatments Light intensities (%) x Cultivars		Survival Count (%)	Pruning Yield (g plant^{-1})	Leaf Harvest (g plant^{-1})
		Ibadan		
45	C143	92.01a	57.65a	23.26a
	C318	93.06a	37.89b	20.83a
Mean		92.54	47.77	22.05
65	C143	73.96a	27.64a	11.63b
	C318	80.55a	9.74b	17.02a
Mean		77.26	18.69	14.33
100	C143	63.19a	18.58a	13.31a
	C318	43.40b	28.59a	12.72a
Mean		53.30	23.59	13.02
		Owena		
45	C143	90.63a	29.61a	17.91a
	C318	76.04a	15.90b	10.92b
Mean		83.34	22.76	14.42
65	C143	90.63a	34.19a	17.14a
	C318	75.00a	33.05a	14.11a
Mean		82.82	33.62	15.63
100	C143	67.71a	12.99a	14.77a
	C318	43.75a	10.87a	11.33a
Mean		55.73	11.93	13.05

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

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

Ibadan and 10.87 g/plant at owena was obtained in C318 under 65 and 100% lights respectively.

There were more harvested leaves from C143 plants under 45% light than from other cultivar+light intensity interactions at Ibadan and Owena (Table 4.35). While C318 was significantly better than C143 under 65% light, C143 was superior to C318 under 45 and 100% lights at Ibadan, and under all the light intensities at Owena. Generally, the highest leaf harvest of 23.26 g/plant and 17.91 g/plant at Ibadan and Owena, respectively was obtained from C143 under 45% light; while the least leaf harvest of 11.63 g/plant at Ibadan was obtained under 65% light, and the least leaf harvest of 11.33 g/plant at Owena was obtained under 100% light intensity.

The interaction of the fertilisers with the light intensities did not enhance significant difference on seedling survival count of the tea plants at Owena (Table 4.36) although, survival of the fertilised tea plants under 45 and 65% lights were generally higher than those under 100% light, and the highest survival count (100%) was obtained in C143 fertilised with NPK_{150} and CPH_{300} under 45 and 65% lights, respectively, unfertilised C143 plants and C318 fertilised with CPH_{300}; while the least (37.50%) was found in C318 fertilised with NPK_{150}, PM_{150} and PM_{300} under 100% light. However, at Ibadan (Table 4.37), C143 fertilised with CPH_{300}, NPK_{150}, PM_{150} under 45% light, unfertilised C143 under 100% light, C318 fertilised with CPH_{300} and NPK_{150} under 45% light and unfertilised C318 under 65% light had the highest survival count (100%); while the least survival count (25.00%) was obtained in C143 fertilised with PM_{150} under 100% light. Besides, $CPH_{150,}$ CPH_{300}, NPK_{150} and PM_{150} were significantly better than PM_{300} and control under 45% light in the survival of C143 plants; while CPH_{300} and NPK_{150} were significantly better than PM_{150} under the same light condition in the survival of C318 plants. Similarly, under 65% light, $CPH_{150,}$ CPH_{300} and NPK_{150} were better than PM_{150}, PM_{300} and control in the survival of C143 plants; while the unfertilised C318 plants under 65% light had 100% survival as against the fertilised ones. The survival of C143 and C318 plants under 100% light were generally the least except the unfertilised C143 plants which still survived one hundred percent under the harsh light intensity.

The interaction of the fertilisers and the different light intensities enhanced significant difference on pruning yield and leaf harvest of tea plants in the two locations.

Table 4.36: Effect of interaction of light intensities and fertilisers on survival count, pruning yield and leaf harvest of two cultivars of tea plants at 14 MAT on the field at Owena in 2017

Treatments		C143			C318		
Light intensities x (%)	Fertilisers (kg Nha^{-1})	SV* (%)	PY (g $plant^{-1}$)	LH (g $plant^{-1}$)	SV* (%)	PY (g $plant^{-1}$)	LH (g $plant^{-1}$)
45	CPH_{150}	81.25	17.17c	21.70b	77.08	17.17a	15.10a
	CPH_{300}	91.67	22.61bc	34.96a	100.00	23.53a	10.56bc
	NPK_{150}	100.00	70.79a	19.96b	41.67	8.58b	9.07bc
	PM_{150}	91.67	25.73b	12.65c	72.92	17.10a	12.82ab
	PM_{300}	79.17	28.06b	8.70d	72.92	17.50a	10.55bc
	Ctrl	100.00	13.35c	9.52d	91.67	11.52b	7.41c
Mean		90.63	29.62	17.92	76.04	15.99	10.92
65	CPH_{150}	93.75	57.52a	15.07c	41.66	37.34b	22.28a
	CPH_{300}	100.00	33.50b	7.91d	83.33	37.28b	20.88a
	NPK_{150}	77.09	9.14c	20.21b	70.83	21.34c	15.41b
	PM_{150}	93.75	38.84b	11.91c	91.67	52.22a	10.35c
	PM_{300}	87.50	60.08a	33.43a	70.83	38.99b	8.11c
	Ctrl	91.67	6.09c	14.33c	91.67	11.14d	7.63c
Mean		90.63	34.20	17.14	75.00	33.05	14.11
100	CPH_{150}	60.42	23.36a	32.63a	54.17	10.24b	16.05a
	CPH_{300}	75.00	12.57b	14.98b	50.00	12.64b	15.49a
	NPK_{150}	79.17	10.58b	11.75bc	37.50	12.92ab	12.81a
	PM_{150}	56.25	13.39b	16.25b	37.50	7.31bc	7.93b
	PM_{300}	47.92	16.25ab	2.30d	37.50	20.05a	7.36b
	Ctrl	87.50	1.81c	10.72c	45.83	2.10c	8.37b
Mean		67.71	12.99	14.77	43.75	10.88	11.34

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

CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318; SC = Survival count; PY = Pruning yield; LH = Leaf harvest; MAT = Months after transplanting

*The means along this column under each light intensity are not significantly different.

Table 4.37: Effect of interaction of light intensities and fertilisers on survival count, pruning yield and leaf harvest of two cultivars of tea plants at 14 MAT on the field at Ibadan in 2017

Treatments		C143			C318		
Light intensities (%) x	Fertilisers (kg Nha^{-1})	SV (%)	PY (g $plant^{-1}$)	LH (g $plant^{-1}$)	SV (%)	PY (g $plant^{-1}$)	LH (g $plant^{-1}$)
45	CPH_{150}	91.67a	54.11c	44.79a	91.67ab	39.43b	13.11bc
	CPH_{300}	100.00a	17.93d	30.28a	100.00a	21.21cd	27.12ab
	NPK_{150}	100.00a	105.08a	11.46b	100.00a	25.79c	24.14b
	PM_{150}	100.00a	80.68b	30.08a	83.34b	80.53a	41.27a
	PM_{300}	77.09b	77.05b	8.50b	91.67ab	17.07d	6.63c
	Ctrl	83.34b	11.06e	14.43b	91.67ab	43.36b	12.75bc
Mean		92.02	57.65	23.26	93.06	37.90	20.84
65	CPH_{150}	79.17a	8.34e	15.38b	70.83c	10.50bc	10.22b
	CPH_{300}	87.50a	14.71d	11.46b	75.00bc	7.31bc	18.37ab
	NPK_{150}	77.09a	71.84a	32.52a	85.42b	6.50bc	21.89a
	PM_{150}	75.00b	34.24b	5.47c	81.25bc	11.11b	18.93ab
	PM_{300}	52.08c	14.54d	1.39c	70.83c	17.71a	18.47ab
	Ctrl	72.92b	22.23c	3.55c	100.00a	5.37c	14.26b
Mean		73.96	27.65	11.63	80.56	9.75	17.02
100	CPH_{150}	62.50c	35.48a	9.18ab	52.08a	41.73b	16.63ab
	CPH_{300}	79.17b	14.97c	10.86ab	54.17a	65.03a	14.82ab
	NPK_{150}	79.17b	27.64b	22.36a	43.75ab	15.46d	16.05ab
	PM_{150}	25.00d	8.10d	6.76b	41.67ab	26.26c	19.65a
	PM_{300}	33.33d	20.05c	15.20ab	33.33b	14.33d	5.00ab
	Ctrl	100.00a	5.28d	15.53ab	33.42b	8.76e	4.15b
Mean		63.20	18.59	13.32	43.07	28.60	12.72

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

CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318.

SC = Survival count; PY = Pruning yield; LH = Leaf harvest; MAT = Months after transplanting

In Ibadan (Table 4.37), C143 plants that received NPK_{150}+45% light and CPH_{150}+45% light produced the highest pruning yield (105.08) and leaf harvest (44.79), respectively; while C143 plants under control+100% light had the least pruning yield, and C143 plants under PM_{300}+65% light produced the least leaf harvest. The NPK_{150} and PM_{150} under 45 and 65% lights were superior significantly (P=0.05) to other fertilisers under respective light intensities in enhancing pruned shoot of C143 plants; PM_{150} under 45% light and PM_{300} under 65% light were superior significantly (P=0.05) to other fertilisers and control under respective light intensities in enhancing C318 pruned shoot; while CPH_{150} and CPH_{300} in C143 and C318 plants, respectively under 100% light, were significantly (P=0.05) better than other fertilisers and control in enhancing their pruned shoot. The C143 plants fertilised with CPH_{150}, CPH_{300} and PM_{150} under 45% light and NPK_{150} under 65% light were significantly better than the ones that received other fertiliser rates under respective light intensities in enhancing leaf harvest; while PM_{150} and NPK_{150} under 45 and 65% lights, respectively were superior to other fertiliser rates in enhancing leaf harvest in C318 plants. Although, leaf harvest under 100% light was generally low, there was more leaf harvest from C143 and C318 plants that received NPK_{150} and PM_{150}, respectively compared to those that received other fertiliser rates.

However, at Owena (Table 4.36), C143 plants fertilised with NPK_{150} under 45% light and CPH_{300} under 45% light produced the highest pruning yield and leaf harvest, respectively; while unfertilised C143 and C143 fertilised with PM_{300} under 100% light produced the least pruning yield and leaf harvest, respectively. The C143 plants that received NPK_{150} under 45% light, CPH_{150} and PM_{300} under 65 and 100% lights were significantly (P=0.05) higher in pruning yield than those that received other fertilisers and control under respective light intensities. While C318 that received organic CPH_{150}, CPH_{300}, PM_{150} and PM_{300} under 45% light, were significantly superior to those that received inorganic NPK_{150} and the unfertilised ones in pruning yield; C318 plants fertilised with PM_{150} under 65% light and PM_{300} under 100% light, produced more pruned shoots than C318 that received other fertilisers and control under respective light conditions. Similarly, as C143 fertilised with CPH_{300}, PM_{300} and CPH_{150} under 45, 65 and 100% lights, respectively produced significantly more leaf yield (harvest) than those that received other fertilisers and control under respective light intensities, C318 plants that received CPH_{150} was superior to the ones that received other fertilisers and control under 45, 65 and 100% lights in leaf harvest.

4.5.5. Effects of cultivar, light intensity and fertiliser on nutrient uptake of tea plants at 14 MAT on the field at Ibadan and Owena

The main effect of cultivars, light intensities and fertilisers on the uptake of nitrogen, phosphorus, potassium, calcium, magnesium and iron is shown in Table 4.38. The different cultivars, C143 and C318 were significantly different (P=0.05) in the uptake of these nutrient elements in tea plants in Ibadan and Owena. There was more uptake of N, P, K, Ca, Mg and Fe at Owena than at Ibadan. In both locations, C143 was superior to C318 in the absorption of all the plant nutrients. At Ibadan, the N, P, K, Ca, Mg and Fe uptake (95.85, 1.04, 8.36, 23.76, 8.66 and 1.60 mg/g, respectively) in C143 was significantly (P=0.05) higher than that of C318 (55.66, 0.48, 4.10, 11.62, 4.31 and 0.81 mg/g respectively). Similarly, at Owena, the N, P, K, Ca, Mg and Fe uptake (135.49, 1.93, 9.57, 41.80, 11.16 and 3.22 mg/g, respectively) in C143 was significantly (P=0.05) higher than that of C318 (60.69, 0.78, 4.42, 14.15, 4.80 and 1.66 mg/g respectively).

In both locations, 45 and 65% lights were better than 100% light in enhancing nutrient uptake. The highest N, P, K, Ca, Mg and Fe were caused by 45% light while the least were found in tea plants under 100% light. The P and K uptake at Ibadan as well as P and Fe uptake at Owena enhanced by 45% light was significantly higher (P=0.05) than that of 65 and 100% lights. The 45 and 65% lights were not significantly (P>0.05) different in enhancing N, Ca, Mg and Fe at Ibadan, and N, K, Ca and Mg at Owena; but both were significantly (P=0.05) better than 100% light in the uptake of these nutrients.

The 150 kg Nha^{-1} rate of organic and NPK fertilisers, especially CPH_{150}, NPK_{150} and $PM_{150,}$ were superior to other rates in the uptake of nutrients in tea plants. While NPK_{150} and CPH_{150} were superior to other fertiliser rates in enhancing the uptake of N, P, K, Ca and Fe in Ibadan, N, K, Mg and Fe in Owena; NPK_{150} and PM_{150} were better than other fertiliser rates in Owena. The NPK_{150} and CPH_{150} were significantly higher than control in enhancing the uptake of all the plant nutrients at Ibadan and Owena.

Table 4.38: Main effects of cultivars, light intensities and fertilisers on nutrient uptake (mg/g) in the leaves of tea plant at 14 MAT on the field at Ibadan and Owena in 2017

Treatments	N	P	K	Ca	Mg	Fe
			Ibadan			
Cultivars						
C143	95.85a	1.04a	8.36a	23.76a	8.66a	1.60a
C318	55.66b	0.48b	4.10b	11.62b	4.31b	0.81b
Mean	75.76	0.76	6.23	17.69	6.49	1.21
Light intensities (%)						
45	108.73a	1.14a	9.82a	24.46a	9.26a	1.77a
65	75.01ab	0.64b	5.72b	18.75ab	6.57ab	1.21ab
100	43.53b	0.50b	3.15b	9.87b	3.63b	0.64b
Mean	75.76	0.76	6.23	17.69	6.49	1.21
Fertilisers (kg Nha^{-1})						
CPH_{150}	99.35a	0.75b	8.87a	22.17b	7.89b	1.71ab
CPH_{300}	97.92ab	0.75b	7.24a	20.54b	6.90b	1.20ab
NPK_{150}	121.20ab	1.65a	8.99a	33.76a	12.43a	2.23a
PM_{150}	42.62c	0.48b	3.54b	8.63bc	3.74bc	0.680b
PM_{300}	73.88b	0.74b	7.12a	15.52b	6.49b	1.12ab
Control	19.57c	0.19c	1.60c	5.53c	1.48c	0.29b
Mean	75.76	0.76	6.23	17.69	6.49	1.21
			Owena			
Cultivars						
C143	135.49a	1.93a	9.57a	41.80a	11.16a	3.22a
C318	60.69b	0.78b	4.42b	14.15b	4.80b	1.66b
Mean	98.09	1.35	7.00	27.98	7.98	2.44
Light intensities (%)						
45	130.90a	1.91a	9.23a	38.70a	10.00a	3.50a
65	96.46ab	1.37b	7.19ab	27.50ab	8.53a	2.28b
100	66.91b	0.77c	4.57b	17.73b	5.41b	1.53b
Mean			7.00	27.98	7.98	2.44
Fertilisers (kg Nha^{-1})						
CPH_{150}	129.93ab	1.54a	9.77a	30.99abc	9.73b	3.62a
CPH_{300}	84.53abc	0.90c	6.99ab	17.77bc	7.18cd	1.69ab
NPK_{150}	147.55a	1.67a	10.02a	49.71a	13.76a	3.43a
PM_{150}	111.83abc	1.58a	8.03a	37.18ab	8.57bc	3.11a
PM_{300}	73,09bc	1.13bc	5.20ab	17.54bc	6.13d	1.99ab
Control	41.62c	1.28ab	1.96b	14.67c	2.53e	0.77b
Mean	98.09	1.35	7.00	27.98	7.98	2.44

Means followed by the same letters along a column in each treatment are not significantly different by HSD (P=0.05)
CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; MAT = Months after transplanting

The two cultivars differed in their nutrient uptake based on the light intensities under which they were grown (Table 4.39). The interaction of C143 with 45% light was superior in the uptake of all the nutrients at both locations. The interaction of C143 with 45% light enhanced the highest uptake of N, P, K, Ca, Mg and Fe in both locations. The C143 had an overriding effect over C318 under 45 and 65% lights. It performed significantly (P=0.05) better than C318 under 45% in the uptake of the nutrients in both locations. The C143 plants increased N, P, K, Ca, Mg and Fe uptake by 162.2, 256.0, 199.9, 227.6, 174.9 and 202.3%, respectively in comparison with C318 plants under 45% light; while under 65% light, C143 plants increased N, P, K, Ca, Mg and Fe by 64.5, 136.8, 76.3, 97.9, 101.4 and 158.1% respectively in comparison with C318 plants at Ibadan. Under 100% light, C318 was better than C143, but not significantly (P>0.05) in the uptake of all the plant nutrients.

In a similar trend at Owena, C143 was significantly (P=0.05) better than C318 under 45, 65 and 100% lights in the uptake of all the plant nutrients except N and Fe under 65% light, and P under 100% light where the difference was not significant. The C143 plants increased in N, P, K, Ca, Mg and Fe by 160.0, 174.5, 161.3, 213.7, 142.6, and 103.9%, respectively in comparison with C318 plants under 45% light; while under 65% light, C143 plants increased N, P, K, Ca, Mg and Fe by 56.9, 112.5, 63.2, 129.2, 85.8 and 26.9%, respectively in comparison with C318 plants.

The interactions of fertilisers and light intensities produced significant effect on the nutrient uptake in tea at Ibadan and Owena (Tables 4.40 and 4.41). Fertilised tea under 45, 65 and 100% light intensities had better nutrient uptake than the unfertilised ones. Nutrient uptake was generally low under interaction of 100% light with all the fertilisers in both locations. At Ibadan (Table 4.40), CPH_{150}+45% light and NPK_{150}+65% light had overriding effects in the nutrient uptake. The interaction of CPH_{150} with 45% light enhanced significantly higher uptake of N (302.34 mg/g), K (29.57 mg/g), Ca (74.72 mg/g), Mg (25.42 mg/g) and Fe (6.03 mg/g) in C143 plants and N (111.88 mg/g), P (0.66 mg/g), K (9.33 mg/g), Ca (15.04 mg/g), Mg (7.05 mg/g) and Fe (1.76 mg/g) in C318 plants. Similarly, while the interaction of NPK_{150} produced significantly higher N, P, K, Ca, Mg and Fe uptake under 65% light in C143 plants; CPH_{300} caused significantly higher uptake of N and Mg, CPH_{150} the higher uptake of P, K and Ca, in C318 plants under the same

Table 4.39: Effect of interaction of cultivars and light intensities on nutrient uptake (mg/g) in the leaves of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

Treatments		Ibadan					
		N	P	K	Ca	Mg	Fe
Light intensities x Cultivars (%)							
45	C143	157.9a	1.78a	14.72a	37.48a	13.58a	2.66a
	C318	60.23b	0.50b	4.92b	11.44b	4.94b	0.88b
Mean		109.07	1.14	9.82	24.46	9.26	1.77
65	C143	93.30a	0.90a	7.30a	24.91a	8.78a	1.60a
	C318	56.72a	0.38a	4.14a	12.59a	4.36b	0.62a
Mean		75.01	0.64	5.72	18.75	6.57	1.11
100	C143	37.06a	0.45a	3.07a	8.89a	3.63a	0.53a
	C318	50.01a	0.56a	3.23a	10.85a	3.63a	0.75a
Mean		43.54	0.51	3.15	9.87	3.63	0.64
				Owena			
45	C143	189.06a	2.80a	13.35a	58.64a	14.17a	4.69a
	C318	72.73b	1.02b	5.11b	18.75b	5.84b	2.30b
Mean		230.90	1.91	9.23	38.70	11.01	3.50
65	C143	117.75a	1.87a	8.91a	38.30a	11.09a	2.55a
	C318	75.06a	0.88b	5.46b	16.71b	5.97b	2.01a
Mean		96.41	1.38	6.44	27.51	8.53	2.28
100	C143	99.55a	1.11a	6.44a	28.47a	8.22a	2.41a
	C318	34.28b	0.43a	2.71b	6.99b	2.60b	0.66b
Mean		66.92	0.77	4.58	17.73	5.41	1.54

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

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

Table 4.40: Effect of interaction of light intensities and fertilisers on nutrient uptake (mg/g) in the leaves of two cultivars of tea plants at 14 MAT on the field at Ibadan in 2017

Treatments		C143						C318					
Light intensities (%) x	**Fertilisers (kg Nha^{-1})**	**N**	**P**	**K**	**Ca**	**Mg**	**Fe**	**N**	**P**	**K**	**Ca**	**Mg**	**Fe**
45	CPH_{150}	302.34a	2.43b	29.57a	74.72a	25.42a	6.03a	111.88a	0.66ab	9.33a	15.04a	7.05a	1.76a
	CPH_{300}	216.91b	1.59c	17.02b	66.31a	16.08b	2.82bc	49.01b	0.28b	3.85b	6.01a	3.41a	0.45a
	NPK_{150}	155.60c	4.11a	11.13c	20.56c	13.27b	3.15b	74.35ab	0.53ab	5.03b	13.43a	6.49a	0.75a
	PM_{150}	46.12d	0.41d	3.96d	11.35cd	4.24c	0.57bc	66.19b	0.41ab	5.02b	10.94a	4.70a	1.02a
	PM_{300}	209.55b	1.86c	25.90a	48.32b	21.58a	2.98bc	50.60b	0.85a	4.11b	10.15a	4.71a	0.93a
	Ctrl	12.62d	0.30d	0.75d	3.63d	0.91c	0.41c	9.46c	0.25ab	2.21b	13.08a	3.27a	0.37a
Mean		157.19	1.78	14.72	37.48	13.58	2.66	60.25	0.50	4.93	11.44	4.94	0.88
65	CPH_{150}	42.59c	0.18c	3.02c	4.51b	2.21bc	0.60b	69.10b	0.69a	6.62a	26.51a	7.24a	0.99a
	CPH_{300}	84.35b	0.81b	7.53b	10.32b	5.53b	1.16b	131.47a	0.58ab	6.22a	15.63ab	8.49a	1.20a
	NPK_{150}	306.60a	3.24a	23.99a	114.36a	38.08a	6.13a	17.48c	0.14bc	2.06a	5.17bbc	1.84b	0.27a
	PM_{150}	49.76bc	0.40b	3.81bc	7.58b	3,16bc	0.64b	35.51bc	0.32ab	3.48ab	10.26bc	3.97b	0.85a
	PM_{300}	52.08bc	0.62b	4.11bc	8.02b	3.31bc	0.94b	67.89b	0.51ab	4.56ab	14.98b	3.85b	1.35a
	Ctrl	24.45c	0.16c	1.33c	4.68b	0.39c	0.15b	18.89c	0.02c	1.88b	2.98c	0.78b	0.25a
Mean		93.31	0.90	7.30	24.91	9.90	1.60	56.72	0.38	4.14	12.59	4.36	0.81
100	CPH_{150}	12.47c	0.11b	1.12c	0.87c	1.46b	0.23a	57.73a	0.45ab	3.54a	11.40ab	3.95a	0.64a
	CPH_{300}	56.30b	0.57b	5.11ab	13.08b	5.00b	0.55a	49.50a	0.66ab	3.73a	11.91ab	2.94a	1.03a
	NPK_{150}	100.74a	1.29a	7.90a	29.30a	9.83a	1.41a	72.43a	0.60ab	3.91a	19.76a	5.07a	1.69a
	PM_{150}	23.38bc	0.38b	2.04bc	4.97bc	2.94b	0.58a	34.78a	0.95a	2.97a	6.70b	3.41a	0.44a
	PM_{300}	12.97c	0.12b	0.81c	2.36bc	1.09b	0.12a	50.09a	0.47ab	3.28a	9.30ab	4.39a	0.43a
	Ctrl	16.49bc	0.20b	1.53c	2.79bc	1.51b	0.32a	35.53a	0.22b	1.93a	6.02b	2.01a	0.25a
Mean		37.06	0.45	3.09	8.90	3.64	0.54a	50.01	0.56	3.23	10.85	3.63	0.75

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

CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318; MAT = Months after transplanting

Table 4.41: Effect of interaction of light intensities and fertilisers on nutrient uptake (mg/g) in the leaves of two cultivars of tea plants at 14 MAT on the field at Owena in 2017

Treatments		C143						C318					
Light intensities (%) x Fertilisers (kg Nha^{-1})		N	P	K	Ca	Mg	Fe	N	P	K	Ca	Mg	Fe
45	CPH_{150}	328.43a	3.81a	22.93a	88.65a	21.38a	11.40a	96.88a	1.59a	8.54a	24.12ab	9.58a	2.78a
	CPH_{300}	163.42c	2.06c	14.83b	44.17b	13.24b	2.02c	70.06a	0.60bc	4.70bc	11.69c	3.74c	1.66a
	NPK_{150}	246.89b	2.36c	17.32b	82.40a	24.19a	2.92c	68.85ab	0.89b	3.98bc	25.53ab	7.08ab	2.68a
	PM_{150}	214.26b	3.00bc	14.63b	82.58a	14.57b	6.66b	95.03a	1.89a	6.05ab	30.98a	7.28ab	3.09a
	PM_{300}	118.81d	2.29c	7.44c	34.64b	9.00c	3.44c	72.95a	0.84bc	5.12bc	15.74bc	5.86b	2.73a
	Ctrl	62.59e	3.29b	2.97d	19.44b	2.65d	1.73c	32.61b	0.30c	2.30c	4.47c	1.48c	0.89a
Mean		189.07	2.80	13.35	58.65	14.17	4.70	72.73	1.02	5.12	18.76	5.84	2.31
65	CPH_{150}	12.88b	1.69b	10.56b	31.72b	10.32b	1.60b	61.50bc	0.68bc	5.32b	12.78b	5.46bc	2.05b
	CPH_{300}	60.63c	0.93c	4.87cd	17.02b	12.00b	1.54b	52.92bc	0.42c	4.26b	9.15b	3.79c	1.02bc
	NPK_{150}	275.00a	3.12a	20.15a	102.72a	24.79a	9.23a	87.72b	1.13ab	6.01b	18.68b	8.53ab	1.65bc
	PM_{150}	105.77b	1.34bc	8.44bc	33.44b	8.92bc	1.99b	137.80a	1.62a	11.12a	30.66a	10.39a	4.03a
	PM_{300}	72.75b	1.09c	6.07cd	15.51b	6.70cd	0.69b	81.99c	0.85b	5.43b	13.11b	4.36c	2.38b
	Ctrl	68.10c	3.05a	3.42d	29.39b	3.85d	0.25b	28.47	0.57c	0.60b	15.89b	3.30c	0.95c
Mean		99.19	1.87	8.92	38.30	11.10	2.55	75.07	0.88	5.46	16.71	5.97	2.01
100	CPH_{150}	107.97bc	1.00b	6.91b	21.92b	7.78b	2.80a	59.91a	0.50a	4.37a	6.75a	3.87a	1.12a
	CPH_{300}	130.85ab	1.11b	11.13a	22.16b	8.70b	3.39a	29.31a	0.30a	2.18ab	2.44a	1.62a	0.54a
	NPK_{150}	181.08a	1.88a	8.49b	58.72a	15.46a	3.37a	25.75a	0.64a	4.20a	10.20a	2.49a	0.77a
	PM_{150}	86.53cd	1.20b	5.77c	39,82ab	7.73b	2.30a	31.58a	0.42a	2.18ab	5.64a	2.52a	0.59a
	PM_{300}	55.28de	1.15b	4.89c	16.28b	6.93b	2.10a	36.77a	0.58a	2.28ab	2.44a	3.91a	0.64a
	Ctrl	35.60e	0.34c	1.48d	11.92b	2.75c	0.50a	22.34a	0.15b	1.03b	6.95a	1.18a	0.29a
Mean		99.55	1.11	6.45	26.20	8.23	2.41	34.28	0.43	2.71	5.74	2.60	0.66

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

CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; Ctrl = Control; C143 = Cultivar 143; C318 = Cultivar 318; MAT = Months after transplanting

light. None of the fertilisers was better significantly in enhancing Fe uptake in C318 plants under all the light intensities.

At Owena (Table 4.41), PM_{150} and NPK_{150} interactions with all the light intensities were outstanding in precipitating nutrient uptake of tea plants. The highest uptake of N, P, K, and Fe was obtained in C143 under CPH_{150}+45% light, as the highest Ca and Mg was enhanced by NPK_{150}+65%. In C143 plants under 45% light, CPH_{150} was significantly (P=0.05) better than other fertilisers and control in enhancing the uptake of N, P, K, Ca, Mg and Fe; while in C318 plants, CPH_{150} was superior to other fertilisers and control in N, K and Mg uptake, and PM_{150} was better than other fertilisers and control in P, Ca and Fe uptake. However, under 65% light, NPK_{150} and PM_{150} were outstanding in uptake of plant nutrients. The NPK_{150} and PM_{150} in C143 and C318 plants, respectively were significantly better than other fertilisers and control in uptake of N, P, K, Ca, Mg and Fe under 65% light. Although uptake of plant nutrients was generally low under 100% light, NPK_{150} and CPH_{300} were outstanding in N, Mg and Fe of C143 plants, NPK_{150} and PM_{150} in P and Ca, and CPH_{300} in K. The CPH_{150} was better than other fertiliser rates in the uptake of all the plant nutrients in C318 plants except P and Ca where NPK_{150} and CPH_{150} were superior.

4.5.6. Effects of cultivar, light intensity and fertiliser on chlorophyll and carotenoids composition of tea plants on the field at Ibadan and Owena.

The diminished light intensities (45 and 65% lights) enhanced chlorophyll accumulation in tea plants; and this was apparent in the pigmentation of the plants (Plate 4.5) where tea under 45% light appeared greenish and those under full light (100% light) appeared yellowish. Moreover, cultivars C143 and C318 differed in their chlorophyll and carotenoids contents at Ibadan and Owena (Figure 4.27). The C318 plants were consistently superior to C143 plants in chlorophyll and carotenoids contents through out the sampling periods both at Ibadan and Owena, and were significantly different in Ibadan at 8 MAT (chlorophyll) and 14 MAT (carotenoids) and in Owena at 8 MAT (chlorophyll and carotenoids). There was a decline in chlorophyll content in both cultivars at Ibadan between 8 and 14 MAT. At Owena, C143 plants increased, as C318 plants decreased in chlorophyll accumulation at 14 MAT, but both were not significantly different.

45% LIGHT INTENSITY

100% LIGHT INTENSITY

Plate 4.5: Pigmentation of tea plants under 45 and 100% light intensities at 7 MAT in Ibadan in 2017

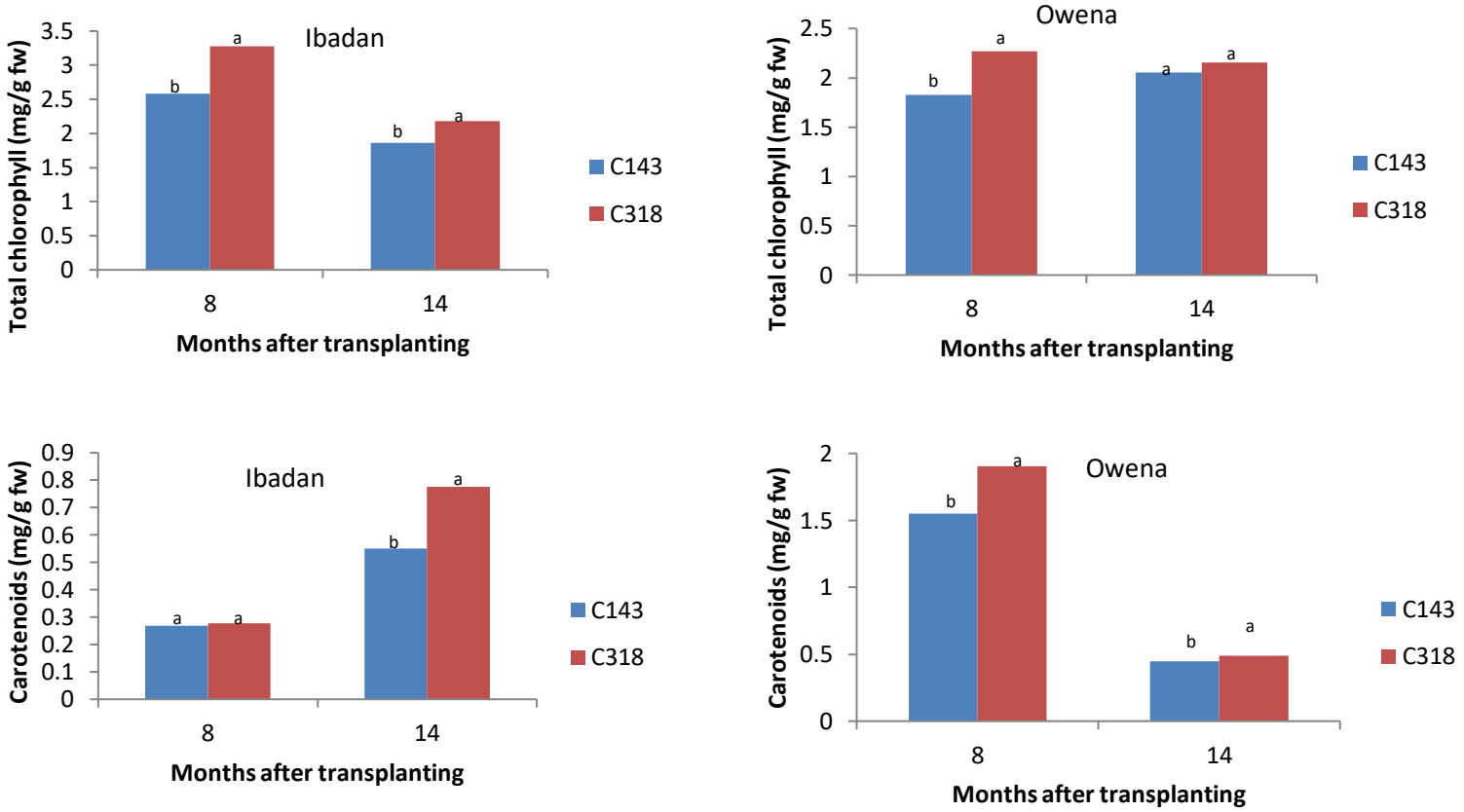


Figure 4.27: Main effects of cultivars on chlorophyll and carotenoids composition of tea plants on the field at Ibadan and Owena in 2017

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 MAT).

At Ibadan, while there was a rise in carotenoids of both C143 and C318 plants between 8 and 14 MAT, they constantly declined at the same periods at Owena. However, at 14 MAT in Ibadan and 8 MAT in Owena, C318 was significantly (P=0.05) richer in carotenoids.

The different light intensities differ in their influence on chlorophyll and carotenoids composition of tea plants (Figure 4.28). While 45% light increased chlorophyll content, 100% light significantly diminished it at 8-14 MAT in Ibadan and Owena. The 45% light was superior to 65 and 100% lights in enhancing chlorophyll in tea. However, it was significantly superior to 65 and 100% lights at 8 and 14 MAT at Ibadan; whereas at Owena, both 45 and 65% lights were not significantly different but were both significantly better than 100% light in enhancing tea chlorophyll. At Ibadan, while 100% light enhanced the highest carotenoids at 8 MAT, it caused the least at 14 MAT; and as tea plants under 45% light accumulated significantly more carotenoids at 14 MAT in Ibadan, 65% light enhanced higher carotenoids content at 8 and 14 MAT in Owena.

In Figure 4.29, the different fertiliser rates differed in their effect at enhancing chlorophyll and carotenoids contents in tea plants. At Ibadan, $NPK_{150,}$ PM_{150} and PM_{300} were superior to other fertilisers and control in chlorophyll enhancement. At Owena, CPH_{150} was superior to all the fertiliser rates at 8 MAT. While all the fertilisers were better than control, NPK_{150}, PM_{150}, CPH_{150} and CPH_{300} were outstanding in causing chlorophyll accumulation in tea at 14 MAT. A similar trend occurred in carotenoids accumulation. At Ibadan, while the unfertilised plants were the highest at 8 MAT and lowest six months after (14 MAT); NPK_{150}, CPH_{300} and PM_{300} increased their superiority from being the least (8 MAT) to being the highest (14 MAT) in enhancing carotenoids content in tea. However, at Owena, PM_{300} and CPH_{150} (which were not significantly (P>0.05) different) were the highest in precipitating carotenoids accumulation and were significantly (P=0.05) higher than NPK_{150} and control at 8 MAT. Although, all the fertilisers were equal in enhancing carotenoids accumulation in tea plants at 14 MAT, they were better than control. Generally, carotenoids increased from 8-14 MAT in tea plants at Ibadan, but declined at Owena; and while there was more chlorophyll accumulation in tea at Ibadan than at Owena, Owena enhanced higher carotenoids production than Ibadan did.

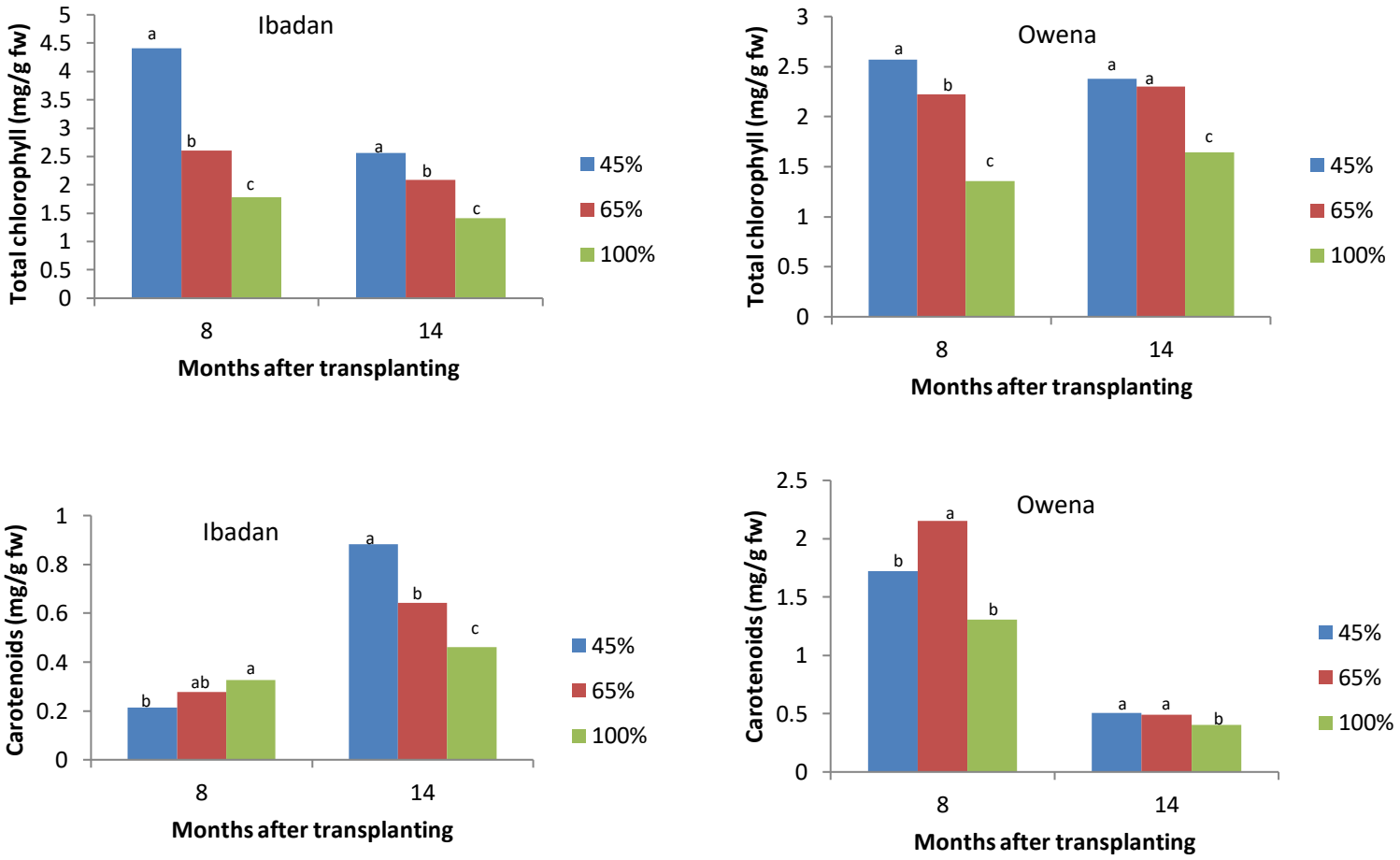


Figure 4.28: Main effects of light intensities on chlorophyll and carotenoids composition of tea plants on the field at Ibadan and Owena in 2017

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05)
45% = 45% light intensity; 65% = 65% light intensity; 100% = 100% light intensity; MAT = Months after transplanting

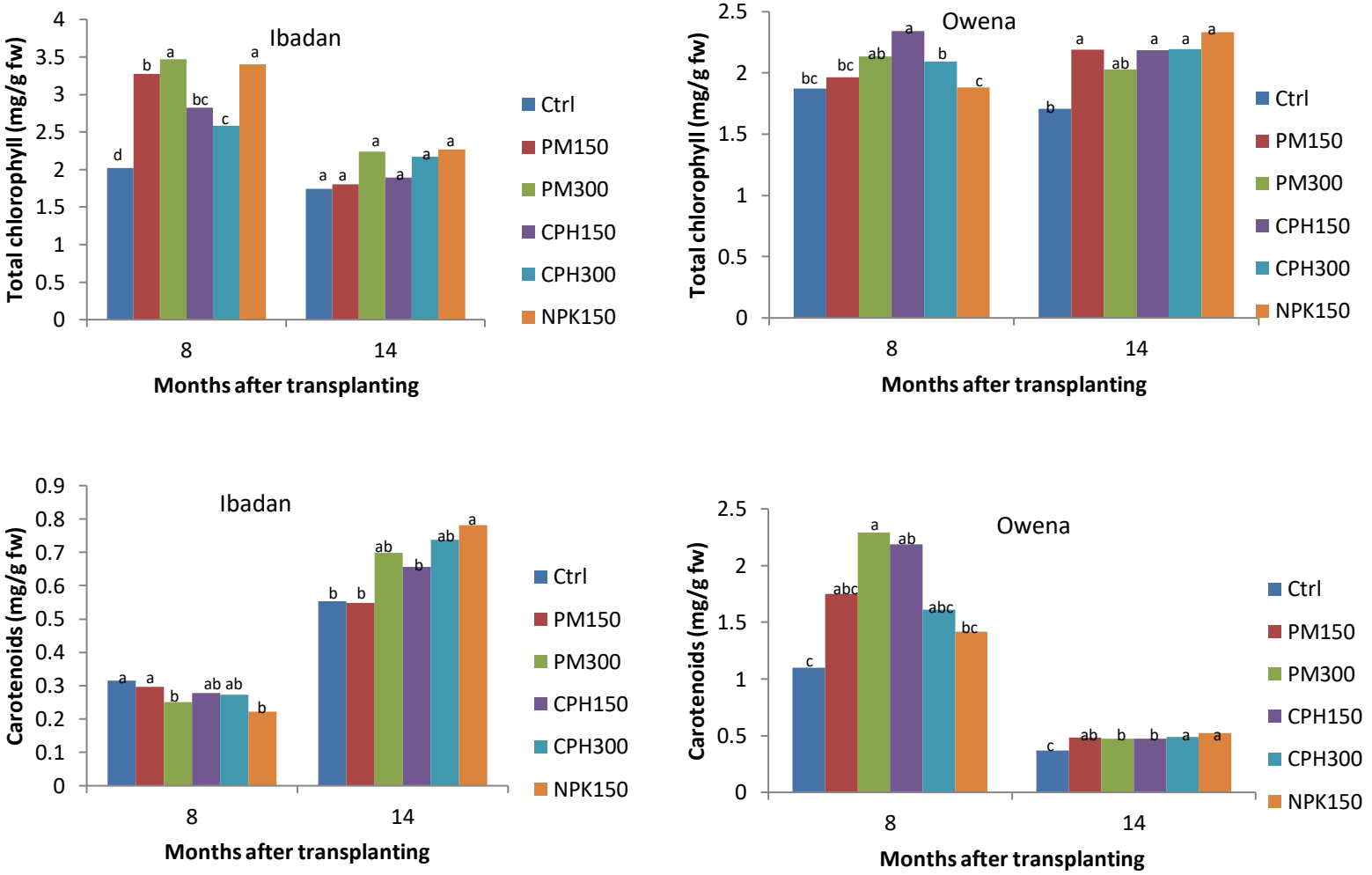


Figure 4.29: Main effects of fertilisers on chlorophyll and carotenoids composition of tea plants on the field at Ibadan and Owena in 2017

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05)

PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control. MAT = Months after transplanting

Cultivars, light intensities and fertilisers differed in their interaction effect on chlorophyll and carotenoids contents of tea. Cultivar C318 maintained its superiority over C143 under the light intensities in enhancing chlorophyll and carotenoids content of tea at Ibadan (Figure 4.30) and Owena (Figure 4.31). Its superiority was significant (P=0.05) in Ibadan at 14 MAT under 45% light (chlorophyll and carotenoids), and in Owena, at 8 MAT under 65% light (chlorophyll and carotenoids) and at 14 MAT under 100% light (carotenoids). However, C143 was slightly and insignificantly better than C318 in chlorophyll under 65% light (14 MAT) at Ibadan, in chlorophyll under 65% light (14 MAT) and in carotenoids under 100% light (8 MAT) at Owena.

The fertilisers were different in their influence on chlorophyll and carotenoids production based on the different light intensities (Figures 4.32 and 4.33). At Ibadan (Figure 4.32), 8 MAT, the highest chlorophyll was enhanced by PM_{150} under 45% light and by CPH_{300} under the same light at 14 MAT. At 8 MAT, the highest carotenoids were caused by PM_{150} under 100% light and CPH_{300} under 45% light at 14 MAT. At 8 MAT, interaction of PM_{150} and PM_{300} with 45% light, PM_{300} and NPK_{150} with 65% light, at 14 MAT, CPH_{300} and PM_{300} with 45% light, NPK_{150} and PM_{300} with 65% light were better than other fertiliser-light interactions under respective sampling periods in enhancing chlorophyll content of the tea. However, fertilisers were not significantly (P>0.05) different from each other and the control under 100% light. A similar trend was observed in carotenoids production at 8 MAT; but at 14 MAT, CPH_{300}, NPK_{150} and PM_{300} under 45, 65, and 100% lights, respectively were significantly (P=0.05) superior to other fertilisers and the control under respective light intensities.

At Owena (Figure. 4.33), at 8 MAT, the highest chlorophyll was enhanced by CPH_{150} under 45% light and the highest carotenoids by PM_{300} under 65% light; while at 14 MAT, the highest chlorophyll and carotenoids was caused by PM_{300} under 45% light. At 8 MAT, PM_{300}, CPH_{150} and CPH_{300} were more effective significantly (P=0.05) under 45% light in causing chlorophyll synthesis; PM_{150} and CPH_{150} under 65 and 100% lights, respectively engendered higher chlorophyll; while PM_{150} under 65% light and CPH_{150} under 100% light were superior significantly compared to other fertiliser rates under respective light intensities. Similarly, at 14 MAT, PM_{300} and CPH_{300} under 45% light, NPK_{150} and PM_{150} under 65% light, as well as PM_{150}, CPH_{150} and NPK_{150} under 100% light enhanced more chlorophyll production in tea than other fertiliser+light treatment combinations.

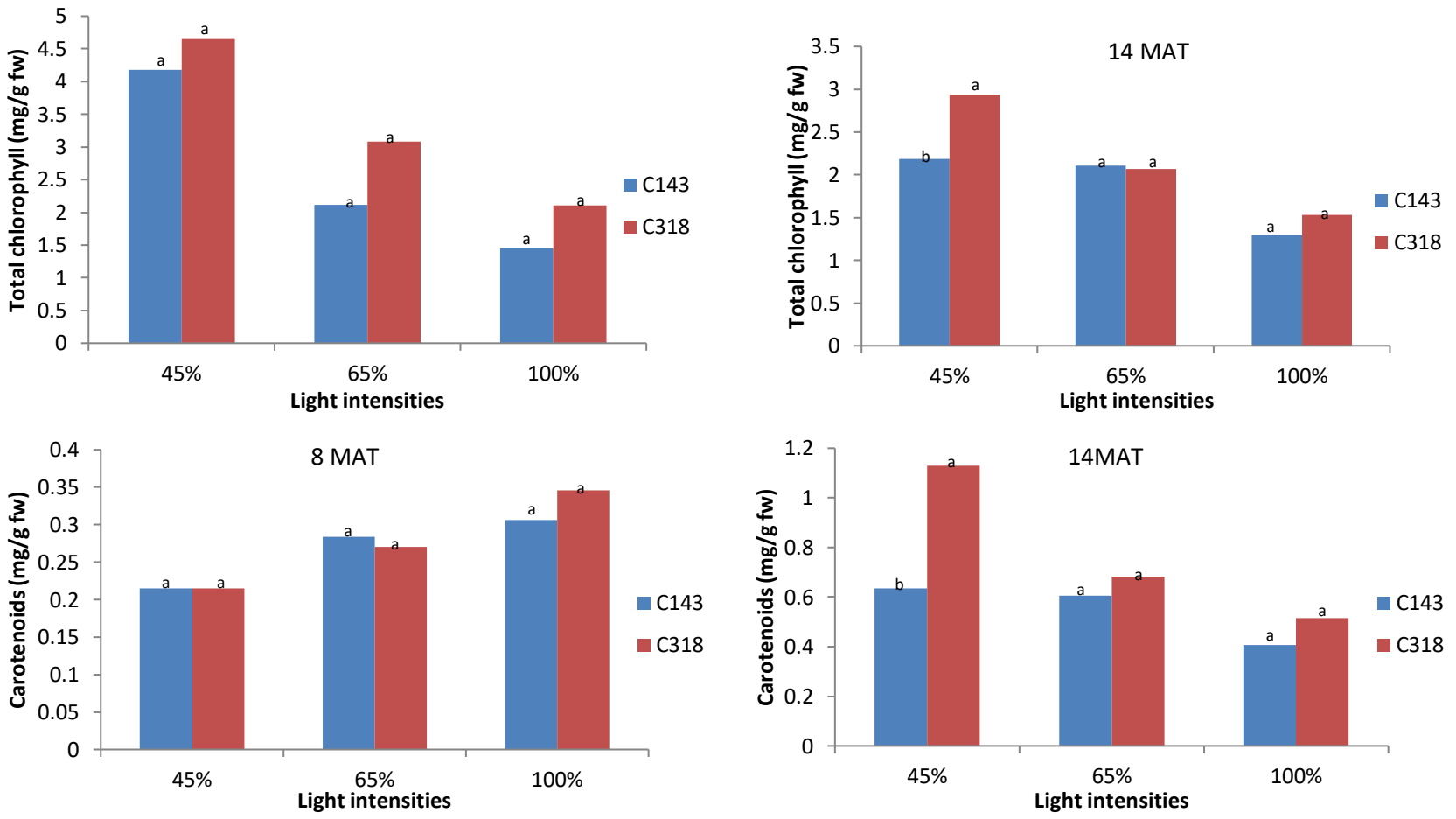


Figure 4.30: Effect of interaction of cultivars and light intensities on chlorophyll and carotenoids composition of tea plants on the field at Ibadan in 2017

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

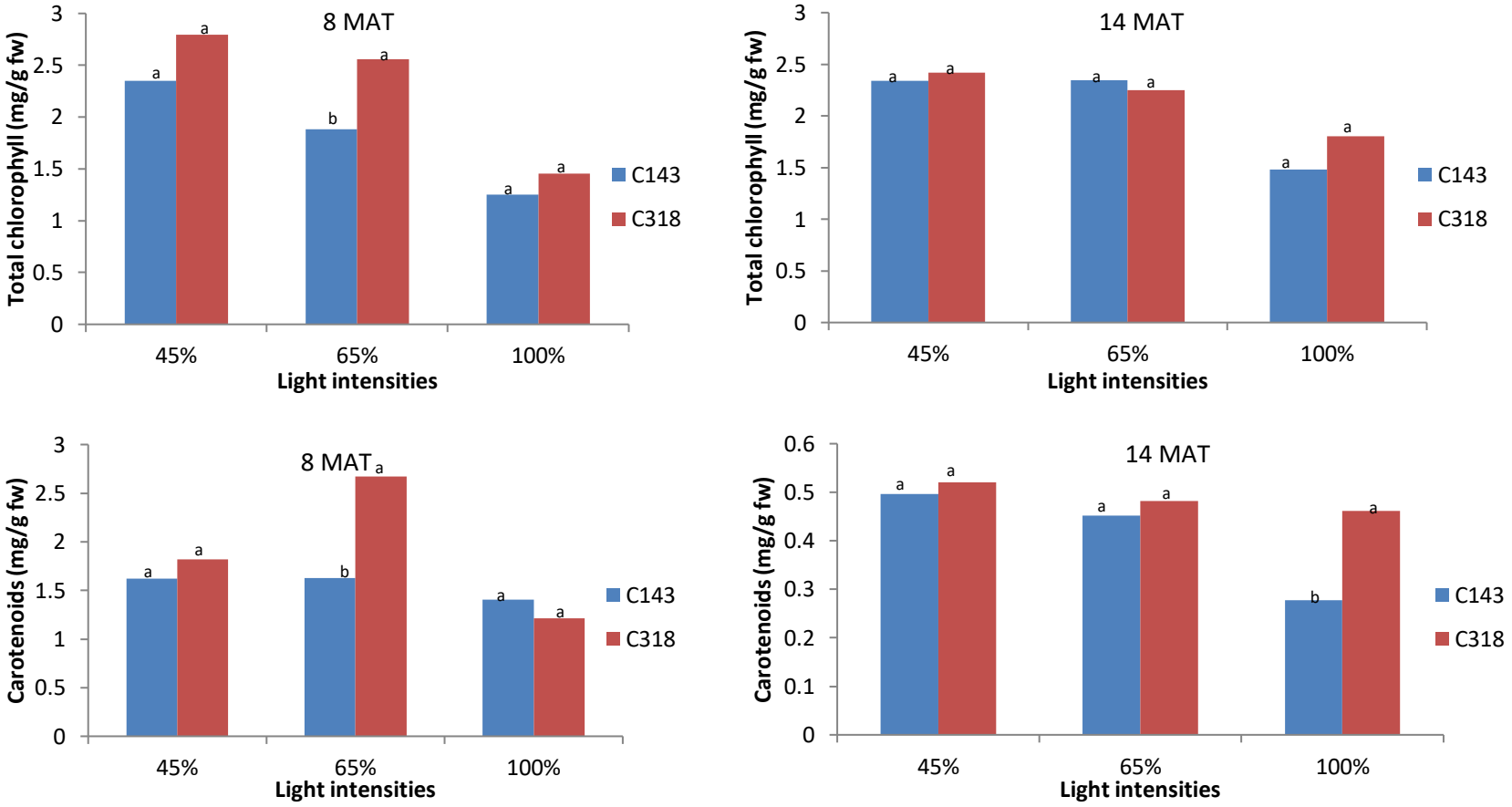


Figure 4.31: Effect of interaction of cultivars and light intensities on chlorophyll and carotenoids composition of tea plants on the field at Owena in 2017

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

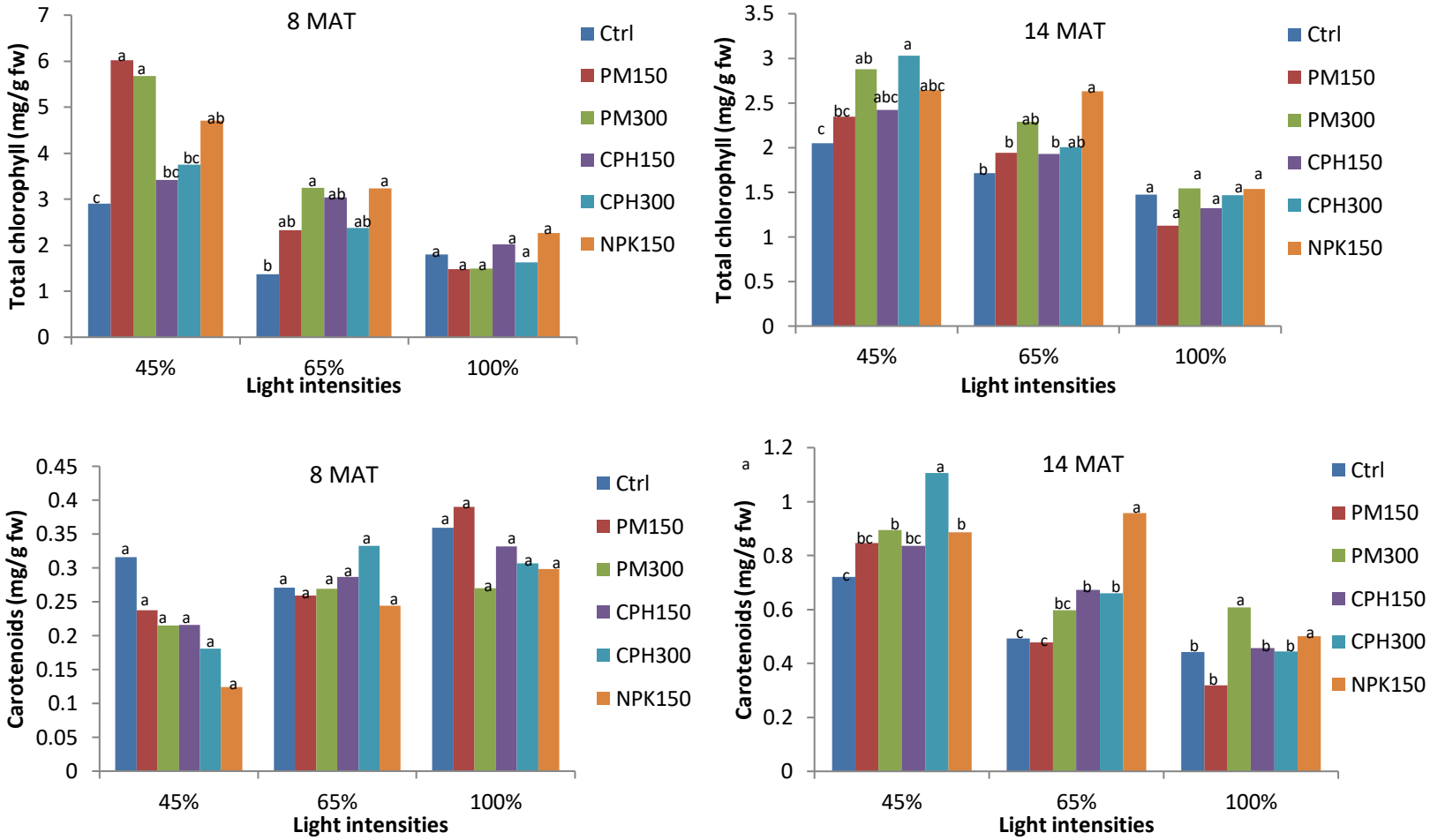


Figure 4.32: Effect of interaction of light intensities and fertilisers on chlorophyll and carotenoids composition of tea plants on the field at Ibadan in 2017

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05)

PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control. MAT = Months after transplanting

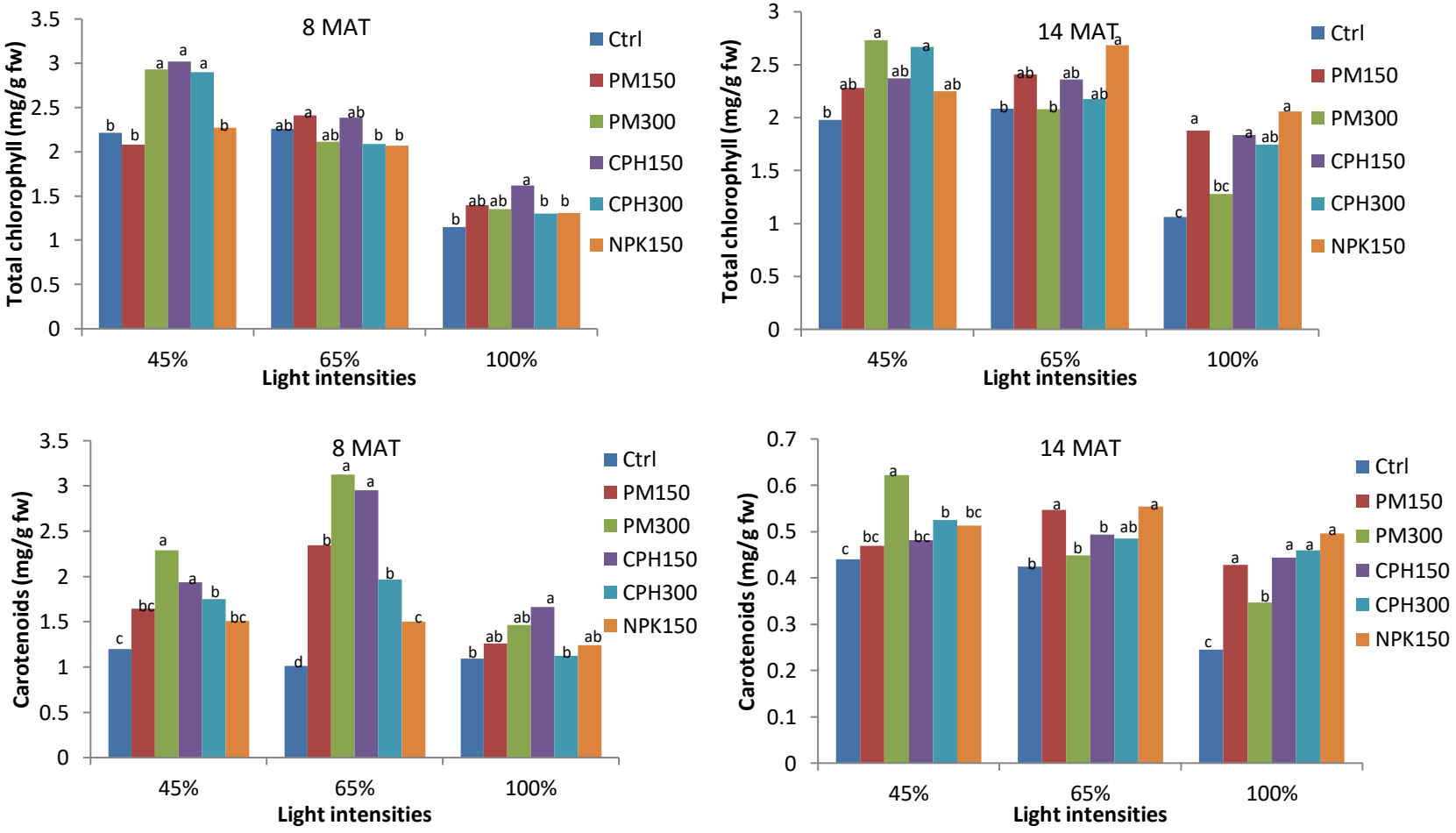


Figure 4.33: Effect of interaction of light intensities and fertilisers on chlorophyll and carotenoids composition of tea plants on the field at Owena in 2017

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05)

PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control. MAT = Months after transplanting

In a similar trend, PM_{300} under 45% light, PM_{300} and CPH_{150} under 65 and 100% lights, respectively were outstanding in enhancing carotenoids synthesis in tea at 8 MAT; while at 14 MAT, PM_{300} under 45% light, PM_{150} and NPK_{150} under 65% light, as well as NPK_{150}, CPH_{300}, CPH_{150} and PM_{150} under 100% light were significantly (P=0.05) superior to other fertilisers and control under their respective light intensities.

Figures 4.34 and 4.35 show the effect of interaction of the fertilisers with the cultivars on chlorophyll and carotenoids synthesis in tea. At Ibadan (Figure 4.34), C143 that received PM_{150}, and C318 that received PM_{300} and NPK_{150} produced significantly (P=0.05) more chlorophyll at 8 MAT. Although, there was no significant (P>0.05) difference in the effect of interaction of cultivars and fertilisers in chlorophyll synthesis in tea at 14 MAT; yet, C143 and C318 plants that received PM_{300}, CPH_{300} and NPK_{150} were better in chlorophyll production than those that received other fertilisers and control. The same trend was observed in carotenoids production especially, at 14 MAT. However, at Owena (Figure 4.35), C318 plants that received CPH_{150} at 8 MAT, C143 that received NPK_{150} and PM_{150} as well as C318 that received CPH_{300} at 14 MAT were superior to others in chlorophyll synthesis. Similarly, C318 plants that received PM_{300} at 8 MAT, and C143 and C318 plants that received PM_{150} and NPK_{150}, respectively at 14 MAT enhanced significant (P=0.05) more carotenoids synthesis than other treatment combinations. There was no significant difference in the effect of the fertilisers on rates of chlorophyll and carotenoids composition in C143 at 8 MAT.

4.5.7 Correlation analysis among the nutrient elements in the leaf biomass of tea plants at 14 MAT on the field at Ibadan and Owena

Table 4.42 reveals that there were significant correlations between the uptake of the nutrient elements in the leaf biomass of tea plants at Ibadan and Owena. The uptake of N increased the uptake of P, K, Ca, Mg and Fe and vice versa; while uptake of P had weak influence on the uptake of other nutrients. The N uptake was positively and strongly correlated with the uptake of P, K, Ca, Mg and Fe in both locations. At Ibadan, the strongest correlations were obtained between N and K as well as N and Mg (0.96***); while the weakest correlations were observed between P and Ca (0.73***). Similarly, at Owena, there was strong, positive and highly significant (P<0.01) correlations between all the nutrient elements in the leaf biomass of tea plants. However, strongest relationship existed

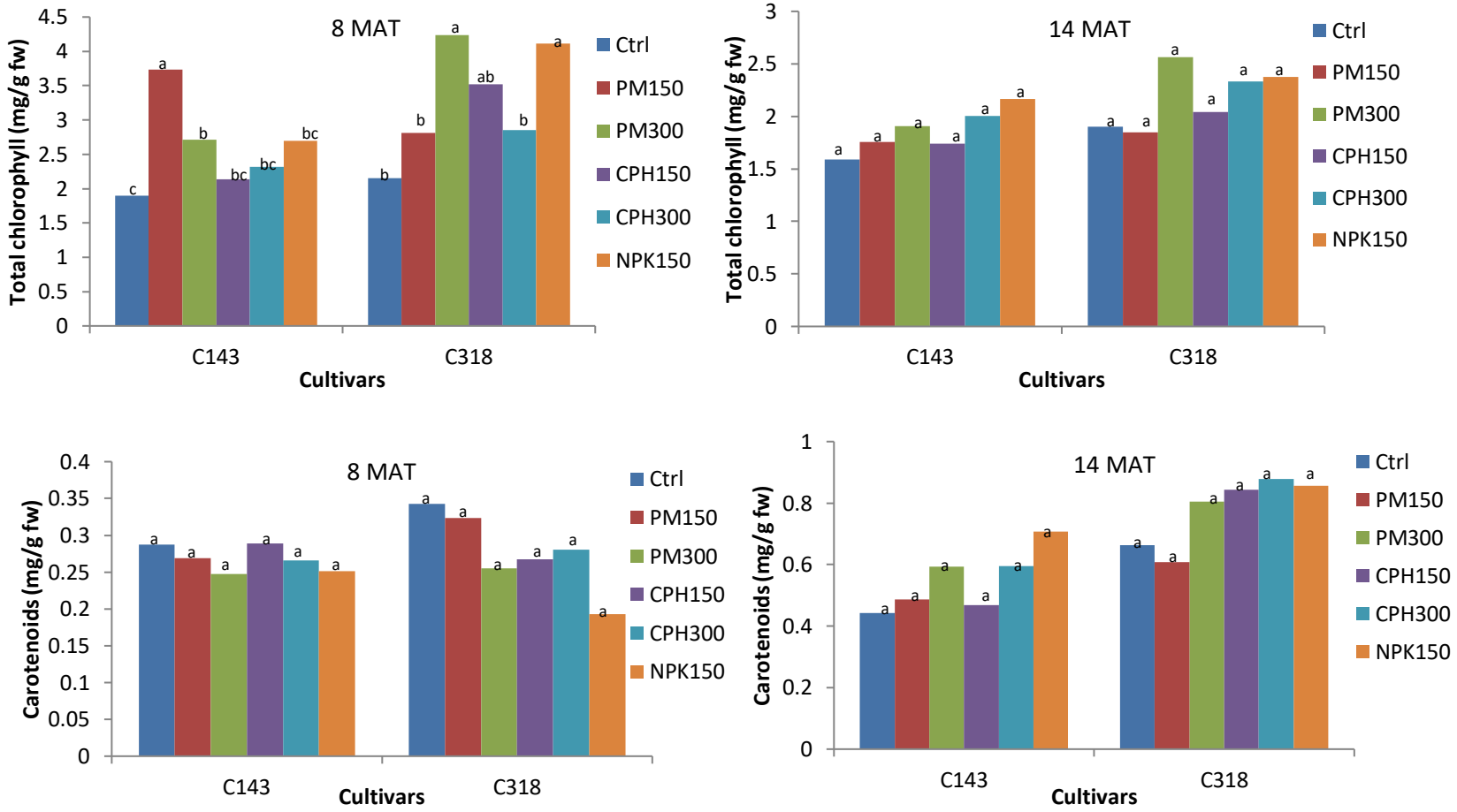


Figure 4.34: Effect of interaction of cultivars and fertilisers on chlorophyll and carotenoids composition of tea plants on the field at Ibadan in 2017

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05)

PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control. MAT = Months after transplanting

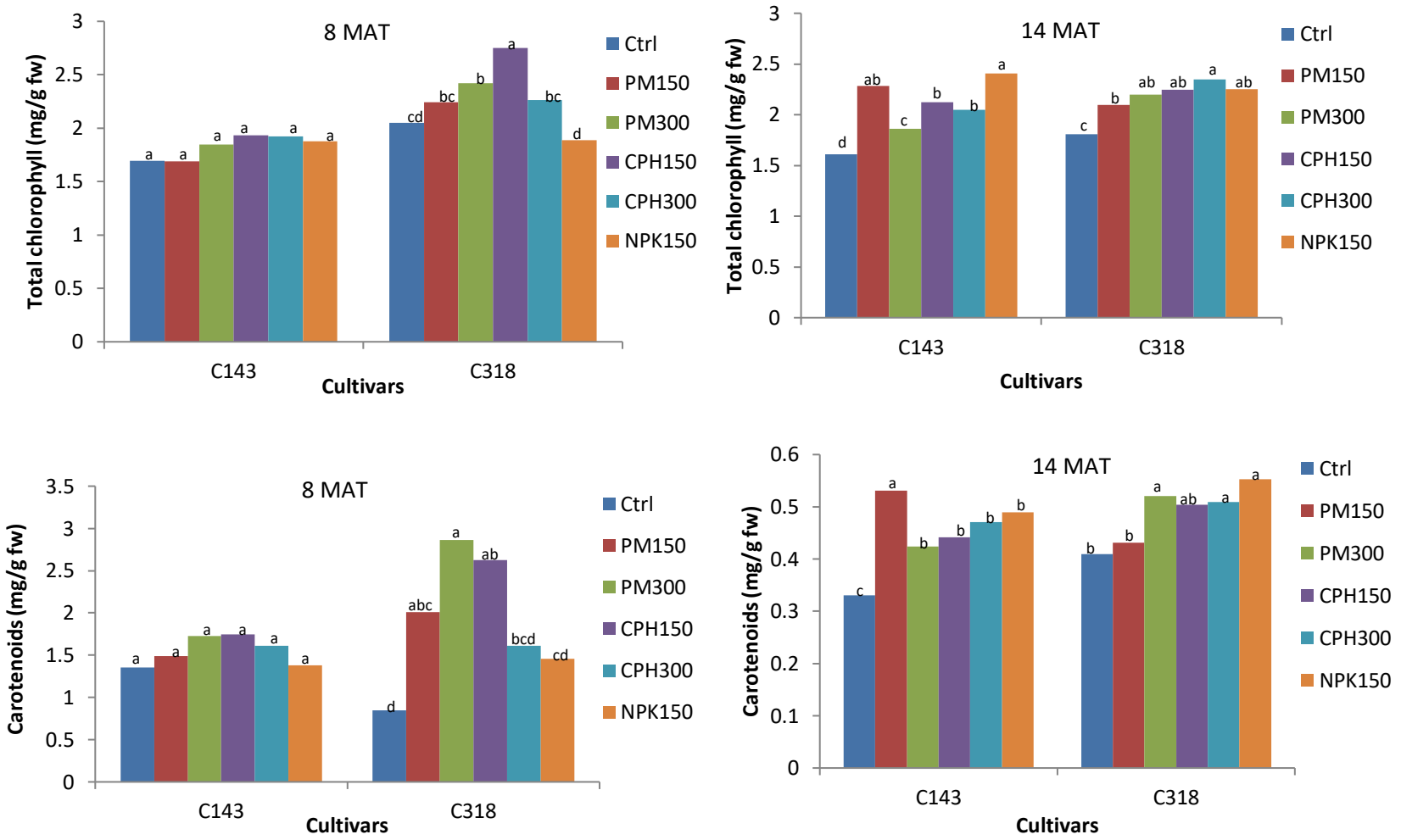


Figure 4.35: Effect of interaction of cultivars and fertilisers on chlorophyll and carotenoids composition of tea plants on the field at Owena in 2017

Means followed by the same letters in each composite bars in each graph are not significantly different by HSD (P=0.05)

PM_{150} = 150 kg Nha^{-1} Poultry Manure; PM_{300} = 300 kg Nha^{-1} Poultry Manure; CPH_{150} = 150 kg Nha^{-1} Cocoa Pod Husk; CPH_{300} = 300 kg Nha^{-1} Cocoa Pod Husk; NPK_{150} = 150 kg Nha^{-1} NPK 5:1:1; Ctrl = Control. MAT = Months after transplanting

Table 4.42: Pearson correlation among the nutrient elements in the leaf biomass of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

		N (mg/kg)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)
Ibadan	**N (mg/kg)**	1.00***					
	P (mg/kg)	0.83***	1.00				
	K (mg/kg)	0.96***	0.78***	1.00			
	Ca (mg/kg)	0.93***	0.73***	0.90***	1.00		
	Mg (mg/kg)	0.96***	0.82***	0.95***	0.95***	1.00	
	Fe (mg/kg)	0.95***	0.84***	0.93***	0.93***	0.94***	1.00
Owena	**N (mg/kg)**	1.00					
	P (mg/kg)	0.73***	1.00				
	K (mg/kg)	0.92***	0.70***	1.00			
	Ca (mg/kg)	0.93***	0.74***	0.81***	1.00		
	Mg (mg/kg)	0.91***	0.66***	0.93***	0.87***	1.00	
	Fe (mg/kg)	0.89***	0.65***	0.78***	0.85***	0.76***	1.00

***=Correlation was significant at P<0.01

MAT = Months after transplanting

between N and Ca as well as K and Mg (0.93***), while the least was observed between P and Fe (0.65***).

4.5.8. Correlation analysis among the growth parameters of tea plants at 14 MAT on the field at Ibadan and Owena

The vegetative growth parameters (number of leaves, number of branches, leaf area, plant height and stem diameter) positively correlated both in Ibadan and Owena (Table 4.43). At Ibadan, number of leaves positively correlated with other growth parameters (number of branches, leaf area, plant height and stem diameter). The strongest relationship existed between number of leaves and leaf area (0.83***) followed by plant height and leaf area (0.80***), and number of leaf and number of branches (0.79***). Although, stem diameter positively correlated with number of leaves, leaf area, number of branches and plant height, the correlation coefficients were weak as they ranged between 0.33*** and 0.51***. The least correlation coefficient existed between stem diameter and number of branches. At Owena, there were stronger correlations between the growth parameters when compared to Ibadan location. However, the strongest correlation existed between number of leaves and leaf area (0.84***), followed by leaf area and plant height (0.77***), and leaf area and stem diameter (0.73***); while the weakest correlation at $P<0.01$ was between number of branches and plant height (0.56***).

4.5.9. Correlation analysis among the nutrient elements in the leaf biomass, leaf chlorophyll and carotenoids of tea plants on the field at Ibadan and Owena

Table 4.44 reveals positive correlation among nutrient uptake in tea leaves and their chlorophyll and carotenoids composition at Ibadan and Owena. In both locations, there was no significant ($P>0.05$) correlation among leaf carotenoids and N, P, K, Ca, Mg and Fe except in Owena where K significantly ($P<0.05$) correlated with carotenoids, although the correlation coefficient (0.17**) was low. Conversely, the uptake of all the plant nutrients positively correlated with leaf chlorophyll, except in Ibadan, where the correlation between P and cholorophyll was not significant ($P>0.05$). At Ibadan, the correlations among N, K, Ca, Mg and Fe and chlorophyll were weak (between 0.20** and 0.21**). However, at Owena there were stronger correlations between nutrient uptake in tea leaves and leaf chlorophyll compared to Ibadan, with highly significant ($P<0.01$) and

Table 4.43: Pearson correlation among the growth parameters of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

		NL	LA(cm^2)	NB	PH(cm)	SD(cm)
Ibadan	**NL**	1.00				
	LA(cm^2)	0.83***	1.00			
	NB	0.79***	0.60***	1.00		
	PH(cm)	0.69***	0.80***	0.49***	1.00	
	SD(cm)	0.42***	0.51***	0.33***	0.39***	1.00
Owena	**NL**	1.00				
	LA(cm^2)	0.84***	1.00			
	NB	0.68***	0.60***	1.00		
	PH(cm)	0.72***	0.77***	0.56***	1.00	
	SD(cm)	0.67***	0.73***	0.63***	0.71***	1.00

NL = Number of leaves; LA = Leaf area; NB = Number of branches; PH = Plant height; SD = Stem diameter

***= Correlation was significant at P<0.01

MAT = Months after transplanting

Table 4.44: Pearson correlation among the nutrient elements in the nutrient uptake and photosynthetic pigments of tea plants at 14 MAT on the field at Ibadan and Owena in 2017

		Chlorophyll (mg/g)	Carotenoids (mg/g)	N (mg/kg)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)
Ibadan	**Chlorophyll (mg/g)**	1.00	0.60***	0.21**	0.13ns	0.20**	0.21**	0.21**	0.21**
	Carotenoids (mg/g)		1.00	0.11ns	0.08ns	0.12ns	0.13ns	0.16ns	0.09ns
Owena	**Chlorophyll (mg/g)**	1.00	0.34***	0.24***	0.20**	0.27***	0.27***	0.24***	0.24***
	Carotenoids (mg/g)		1.00	0.15ns	0.09ns	0.17**	0.16ns	0.16ns	0.14ns

*** = Correlation was significant at P<0.01

** = Correlation was significant at P<0.05

Ns = Correlation was not significant at P≤0.05

MAT = Months after transplanting

stronger correlation coefficients among chlorophyll and N, K, Ca, Mg and Fe compared to P. Moreover, chlorophyll and carotenoids positively correlated at Ibadan and Owena, and the correlations were highly significant (P<0.01). However, the correlation coefficient of chlorophyll and carotenoids was higher in Ibadan (0.60***) than in Owena (0.34***).

4.6. Experiment 3: Effects of different densities of plantain shade and organic fertilisers on growth and field establishment of tea plants at Ibadan and Owena, Nigeria

4.6.1. Varying light intensities under different plantain densities at Ibadan and Owena

The different plantain population densities were significantly (P=0.05) different in reducing light intensity at different periods of the experiment (Table 4.45). At Ibadan, light intensity varied between 53.37 and 72.51% under 1111 plantain ha^{-1}, while it varied between 31.90 and 55.84% under 2,222 plantain ha^{-1}. However, at Owena, light intensity varied between 54.39 and 74.07% under 1111 plantain ha^{-1}, while it varied between 29.56 and 55.14% under 2222 plantain ha^{-1}. Hence, average light intensity received by the tea plants under 1111 plantain ha^{-1} and 2222 plantain ha^{-1} at Ibadan was 62.23 and 44.18%, respectively; while at Owena, it was 64.71 and 46.79% for 1111 plantain ha^{-1} and 2222 plantain ha^{-1}, respectively.

Light intensity increased under each plantain density from October 2017 till March 2018, and decreased afterwards till June 2018. Light intensity under 2222 plantain ha^{-1} was significantly (P=0.05) lower than that of 1111 plantain ha^{-1}at the four sampling periods in both locations. At Ibadan, 1111 plantain ha^{-1} and 2222 plantain ha^{-1} reduced light intensity to 53.37 and 31.90%, 69.00 and 51.42%, 72.51 and 55.84%, 53.98 and 37.56% in October, December, March and June, respectively. Similarly, at Owena, 1111 plantain ha^{-1} and 2222 plantain ha^{-1} reduced light intensity to 54.39 and 29.56%, 68.68 and 53.63%, 74.07 and 55.14%, 61.71 and 48.82% in October, December, March and June, respectively.

Table 4.45: Variation in light intensities under different plantain densities on the field at Ibadan and Owena in 2017-2018

Plantain densities (Stands ha^{-1})	Light intensities (%)				
			Ibadan		
	October (2017)	**December (2017)**	**March (2018)**	**June (2018)**	**Average**
1111	53.37a	69.00a	72.51a	53.98a	62.23a
2222	31.90b	51.42b	55.84b	37.56b	44.18b
Mean	42.64	60.21	64.18	45.77	53.21
			Owena		
1111	54.39a	68.68a	74.07a	61.71a	64.71a
2222	29.56b	53.63b	55.14b	48.82b	46.79b
Mean	41.98	61.16	64.61	55.27	55.75

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

4.6.2. Effects of cultivar, plantain density and fertiliser on vegetative development of tea plants on the field at Ibadan and Owena

Table 4.46 describes main influence of the cultivars, plantain densities and fertiliser types on number of leaves, number of branches and leaf area of the tea plants at Ibadan and Owena. The C143 plants performed significantly (P=0.05) better than C318 plants in leaf production, branches initiation and leaf expansion all through the sampling periods. At Ibadan, 9 MAT, C143 increased in number of leaves, number of branches and leaf area by 86.4, 255.2 and 33.5%, respectively, relative to C318; and by 246.0, 111.9 and 229.8% at Owena.

At Ibadan, 2222 plantain $ha^{-1}$was superior to 1111 plantain ha^{-1} and zero plantain ha^{-1} shade in enhancing all the growth parameters, while both 2222 and 1111 plantain ha^{-1} were significantly (P=0.05) better than zero plantain shade in enhancing number of leaves, number of branches and leaf area, especially at 6-9 MAT. At 9 MAT, 2222 plantain ha^{-1} increased number of leaves, number of branches and leaf area by 17.8, 61.5 and 59.2%, respectively, compared to 1111 plantain ha^{-1}, and by 233.6, 470.7 and 1,173.7% compared to zero plantain ha^{-1}. A similar trend was observed in Owena. However, at 9 MAT, 2222 plantain ha^{-1} increased number of leaves and leaf area by 11.1 and 31.2%, respectively, compared to 1111 plantain ha^{-1} and by 67.0 and 95.3% compared to zero plantain ha^{-1}; while 1111 plantain ha^{-1} increased number of branches by 28.2 and 44.6% compared to 2222 and zero plantain, respectively.

For number of leaves and leaf area, none of the fertiliser types was superior to others at both locations, especially at 6-9 MAT, but they were significantly (P=0.05) better than control. However, for number of branches, a different observation was made at 9 MAT as NPK and CPH were superior to PM and control at Ibadan; while PM and NPK were better than CPH and control at Owena. Generally, Owena enhanced higher number of leaves, number of branches and leaf area than Ibadan. The mean number of leaves at Ibadan varied from 8.50 → 8.14 → 9.97 at 3, 6 and 9 MAT, respectively and from 12.96 → 17.53 → 26.12 at Owena.

Table 4.46: Main effects of cultivars, plantain densities and fertilisers on number of leaves, number of branches and leaf area of tea plants on the field at Ibadan and Owena in 2018

Treatments	Ibadan			Owena		
	3 MAT	6 MAT	9 MAT	3MAT	6 MAT	9 MAT
Cultivars			**Number of leaves**			
C143	10.68a	9.92a	12.97a	16.50a	21.36a	40.52a
C318	6.32b	6.35b	6.96b	9.43b	13.69b	11.71b
Mean	8.50	8.14	9.97	12.96	17.53	26.12
Plantain densities (Stands ha^{-1})						
1111	8.36ab	8.23b	11.81a	13.75a	19.61a	28.36a
2222	9.52a	10.14a	13.91a	11.70b	16.77b	31.52a
Zero plantain	7.62b	6.03c	4.17b	13.44a	16.20b	18.87b
Mean	8.50	8.14	9.97	12.96	17.53	26.12
Fertilisers (150 kg Nha^{-1})						
CPH	8.79a	10.06a	10.38a	13.08a	20.08a	26.55a
PM	9.23a	8.38a	11.12a	15.60a	22.60a	33.27a
NPK	11.21a	10.33a	12.11a	15.98a	17.79a	34.40a
Control	4.77b	3.77b	6.25b	7.19	9.62b	10.24b
Mean	8.50	8.14	9.97	12.96	17.53	26.12
Cultivars			**Number of branches**			
C143	2.06a	2.89a	3.09a	2.35a	3.34a	8.35a
C318	1.55b	0.79b	0.87b	1.48b	1.74b	3.94b
Mean	1.81	1.84	2.98	1.92	2.54	6.15
Plantain densities (Stands ha^{-1})						
1111	2.67a	2.36a	2.05b	2.53a	2.73a	7.46a
2222	1.66ab	2.47a	3.31a	1.61b	2.64a	5.82b
Zero plantain	1.09b	0.69b	0.58c	1.63b	2.25a	5.16b
Mean	1.81	1.84	1.98	1.92	2.54	6.15
Fertilisers (150 kg Nha^{-1})						
CPH	3.12a	2.19a	2.30ab	1.52b	2.65a	6.24a
PM	2.31ab	1.42b	1.06c	2.40a	3.79a	8.32a
NPK	1.29bc	2.21a	2.59a	2.81a	2.69a	6.93a
Control	0.50c	1.54b	1.96b	0.94b	1.04b	3.09b
Mean	1.81	1.84	1.98	1.92	2.54	6.15
Cultivars			**Leaf area (cm^2)**			
C143	189.56a	165.66a	216.76a	349.66a	412.63a	1056.06a
C318	145.15b	140.94b	162.35b	205.32b	276.97b	320.24b
Mean	167.36	153.30	189.55	277.49	344.80	688.15
Plantain densities (Stands ha^{-1})						
1111	163.10b	159.81b	209.31b	279.37a	362.87a	690.78ab
2222	193.70a	259.47a	333.20a	263.83a	371.17a	908.55a
Zero plantain	145.27b	40.63c	26.16c	283.27a	300.36a	465.12b
Mean	167.36	153.30	189.55	277.49	344.80	688.15
Fertilisers (150 kg Nha^{-1})						
CPH	168.51b	168.12a	218.86a	281.96a	389.85a	665.52a
PM	205.51a	174.78a	212.89a	316.39a	429.28a	795.50a
NPK	165.21b	223.24a	243.11a	396.78a	401.86a	1027.57a
Control	130.19c	47.07b	83.55b	114.84b	158.21b	264.01b
Mean	167.36	153.30	189.55	277.49	344.80	688.15

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

C143 = Cultivar 143; C318 = Cultivar 318; CPH = Cocoa pod husk; PM = Poultry manure; MAT = Months after transplanting

Table 4.47 shows how the two tea cultivars under the different densities of plantain shade were significantly different from each other in causing vegetative development in tea. The C143 tea generally performed better than C318 in leaf, branches and leaf area development under all the plantain shade densities at Ibadan and Owena. For instance, at Owena, under 2222 plantain ha^{-1} density, number of leaves, number of branches and leaf area of 51.41, 8.77 and 1529.33 cm^2, respectively produced by C143 tea was significantly (P=0.05) higher than that of C318: 11.63, 2.88 and 287.78 cm^2, respectively. Under zero plantain shade, C143 plants were better than C318 plants in number of leaves, number of branches and leaf area in both locations, but they were not significantly different in number of branches and leaf area in Ibadan.

Table 4.48 shows effect of interaction of the different plantain densities and fertilisers at 150 kg Nha^{-1} on vegetative development of two tea cultivars at Ibadan and Owena. The highest vegetative development was obtained at Owena among the C143 plants where 2222 plantain ha^{-1} + PM engendered the highest number of leaves (83.00), number of branches (15.00) and leaf area (2211.00). At Ibadan, higher number of leaves, number of branches and leaf area were obtained in C143 plants fertilised with NPK and PM under 1111 plantain ha^{-1} and in those fertilised with CPH and NPK under 2222 plantain ha^{-1}. The C318 plants fertilised with CPH and PM under 1111 plantain ha^{-1}, NPK and PM under 2222 plantain ha^{-1} produced more leaves and leaf area, while CPH under 1111 plantain ha^{-1} as well as NPK and CPH under 2222 plantain ha^{-1} enhanced higher branches of the cultivar. Although, all the fertilisers performed poorly in both cultivars under zero plantain, CPH caused higher leaf, branches and leaf area production than other fertilisers and control.

Similarly, at Owena, NPK and PM under 1111 plantain ha^{-1} and 2222 plantain ha^{-1}, respectively enhanced significantly more leaves, branches and leaf area of C143 plants; while in C318, PM under 1111 plantain ha^{-1} and CPH under 2222 plantain ha^{-1} caused significantly (P=0.05) more leaves and branches, but CPH under 1111 plantain ha^{-1} and NPK under 2222 plantain ha^{-1} caused higher leaf area. The NPK under zero plantain produced more leaves and wider leaf area of the two tea cultivars, while CPH enhanced more branches of the tea.

Table 4.47: Effect of interaction of cultivars and plantain densities on number of leaves, number of branches and leaf area of tea plants at 9 MAT on the field at Ibadan and Owena in 2018

Treatments		Ibadan		
Plantain densities x Cultivars (Stands ha^{-1})		**Number of leaves**	**Number of branches**	**Leaf area**
1111	C143	14.89a	3.78a	328.17a
	C318	12.94b	0.31b	338.21a
Mean		13.92	2.05	333.19
2222	C143	16.63a	4.45a	284.72a
	C318	7.00a	2.17b	133.89b
Mean		11.82	3.31	209.31
Zero plantain	C143	7.41a	1.03a	37.37a
	C318	0.94b	0.13a	14.95a
Mean		4.18	0.58	26.16
			Owena	
1111	C143	41.80a	9.63a	917.62a
	C318	14.93b	5.30b	463.94a
Mean		28.37	7.47	690.78
2222	C143	51.41a	8.77a	529.33a
	C318	11.63b	2.88b	287.78b
Mean		31.52	5.83	908.56
Zero plantain	C143	28.36a	6.66a	721.24a
	C318	8.58b	3.6b	209.01b
Mean		18.47	5.13	465.13

Means followed by the same letters along a column under each plantain density and location are not significantly different by HSD (P= 0.05).
C143 = Cultivar 143; C318 = Cultivar 318; MAT = Months after transplanting

Table 4.48: Effect of interaction of plantain densities and fertilisers on number of leaves, number of branches and leaf area of two cultivars of tea plants at 9 MAT on the field at Ibadan and Owena in 2018

Treatments		Ibadan					
		C143			C318		
Plantain densities x Fertilisers (Stands ha^{-1})	(150 kg Nha^{-1})	Number of Leaves	Number of branches	Leaf area (cm^2)	Number of Leaves	Number of branches	Leaf area (cm^2)
1111	CPH	9.87b	4.00b	203.14a	13.00a	1.25a	335.57a
	PM	23.75a	6.13a	343.93a	13.75a	0.00a	200.00b
	NPK	28.88a	3.63b	591.83a	0.00b	0.00a	0.00c
	Control	4.00c	1.38c	9.62b	1.25b	0.00a	14.33c
Mean		16.63	3.79	379.63	7.00	0.31	133.89
2222	CPH	15.38ab	5.38a	339.09b	11.50a	2.44a	304.35ab
	PM	14.00b	4.31ab	323.03b	11.75a	2.38a	390.19a
	NPK	18.56a	5.25a	384.83a	15.25a	2.50a	452.03a
	Control	11.63b	2.88b	265.81c	13.25a	1.38a	206.26b
Mean		14.89	4.46	328.19	12.94	2.18	338.21
Zero plantain	CPH	11.50a	2.25a	100.48a	1.00a	0.25a	30.56a
	PM	3.50b	1.00ab	19.00a	0.00a	0.00a	0.00a
	NPK	10.00a	0.38b	30.00a	0.00a	0.00a	0.00a
	Control	4.63b	0.50b	10.21b	2.75a	0.25a	29.25a
Mean		7.41	1.03	49.83	0.94	0.13	14.95
				Owena			
1111	CPH	27.06c	7.38c	596.67b	20.25a	4.75b	765.22a
	PM	49.63b	14.38a	690.55b	24.19a	7.44a	693.42ab
	NPK	66.63a	11.00b	2021.32a	4.60b	6.69ab	233.47bc
	Control	23.88c	5.75d	361.97b	10.69ab	2.31c	163.65c
Mean		41.80	9.63	917.63	14.93	5.30	463.94
2222	CPH	46.25b	6.38c	1259.97b	14.56a	5.13a	300.15a
	PM	83.00a	15.00a	2211.00a	10.88a	1.63b	247.23a
	NPK	61.38b	10.44b	1954.85a	14.19a	2.75b	452.76a
	Control	15.00c	3.25c	692.48c	6.88a	2.00b	150.99a
Mean		51.41	8.77	1529.58	11.63	2.88	287.78
Zero plantain	CPH	38.00ab	9.44a	808.32a	13.19ab	4.38a	262.83a
	PM	28.94b	7.38a	816.82a	3.00b	4.13a	115.00a
	NPK	44.63a	7.31a	1223.91a	15.00a	3.38a	279.10a
	Control	1.88c	2.50b	35.90b	3.13b	2.75a	179.10a
Mean		28.36	6.66	721.24	8.58	3.66	209.01

Means followed by the same letters in a column under each plantain density and location are not significantly different by HSD (P=0.05).

CPH = Cocoa pod husk; PM = Poultry manure; MAT = Months after transplanting

4.6.3. Effects of cultivar, plantain density and fertiliser on survival count (%) of tea plants at 9 MAT on the field at Ibadan and Owena

There were significant differences in the effects of the different cultivars, plantain densities and fertiliser types on survival count of tea plants after the first dry season of planting at the two locations (Tables 4.49 and 4.50). At Ibadan and Owena, C143 was significantly (P=0.05) superior to C318 (Table 4.49). 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 in Owena, 1111 and 2222 plantain ha^{-1} were not significantly (P>0.05) different, but 1111 plantain ha^{-1} was significantly better than zero plantain in enhancing tea seedling survival. At Owena, CPH enhanced the survival of tea significantly (P=0.05) more than PM and the control, while none of the fertilisers was superior at Ibadan. Generally, more tea plants survived the first dry season at Owena (Mean seedling survival = 68.32%) than at Ibadan (Mean seedling survival = 45.80%).

In Table 4.50, C143 plants survived better than C318 under 1111, 2222 and zero plantain shade conditions; its survival was significantly 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.

There were significant differences in the effects of the interaction of plantain densities (shade) with the fertiliser types on survival of tea after the first dry season of planting (Table 4.51). At Ibadan, while PM and NPK were better than CPH and the control in the survival of C143 under 1111 plantain ha^{-1} shade; it was only the C318 plants that were grown with CPH that survived the first dry season under the same plantain density. The interaction of the fertilisers with 2222 plantain ha^{-1} in C143 plants enhanced the highest plant survival as C143 that received CPH and zero fertiliser under 2222 plantain ha^{-1} shade had survival count of 93.75 and 100.00%, respectively, the values being significantly (P=0.05) higher than those of PM and NPK. However, while the unfertilised C318 under 2222 plantain ha^{-1} had 100% survival, the value was not significantly different from those of the fertilised ones with lower survival count. More of fertilised C143 plants survived under zero plantain than C318 as it was only the C318 that received CPH that survived the first dry season.

Table 4.49: Main effects of cultivars, plantain densities and fertilisers on survival count (%) of tea plants at 9 MAT on the field at Ibadan and Owena in 2018

Treatments		
Cultivars	**Ibadan**	**Owena**
C143	58.62a	82.64a
C318	32.99b	53.99b
Mean	45.80	68.32
Plantain densities (Stands ha^{-1})		
1111	32.24b	70.83ab
2222	79.43a	79.69a
zero plantain	25.74b	54.43b
Mean	45.80	68.32
Fertilisers (150 kg Nha^{-1})		
CPH	51.32a	79.17a
PM	38.89a	58.68c
NPK	44.79a	70.14ab
Control	48.21a	65.28bc
Mean	45.80	68.32

Means followed by the same letters along a column in each treatment are not significantly different by HSD (P=0.05). C143 = Cultivar 143; C318 = Cultivar 318; CPH = Cocoa pod husk; PM = Poultry manure; MAT = Months after transplanting

Table 4.50: Effect of interaction of cultivars and plantain densities on survival count (%) of tea plants at 9 MAT on the field at Ibadan and Owena in 2018

Treatments Plantain densities (Stands ha^{-1})	x Cultivars	Ibadan	Owena
1111	C143	51.98a	83.33a
	C318	12.50b	58.33a
Mean		32.74	70.83
2222	C143	82.81a	92.71a
	C318	76.04a	66.67a
Mean		79.43	79.69
Zero plantain	C143	41.07a	71.88a
	C318	10.42b	36.98a
Mean		25.75	54.43

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

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

Table 4.51: Effect of interaction of plantain densities and fertilisers on survival count (%) of tea plants at 9 MAT at Ibadan and Owena in 2018

Treatments		Ibadan	
Plantain densities x (Stands ha^{-1})	Fertilisers (150 kg Nha^{-1})	C143	C318
1111	CPH	35.00b	50.00a
	PM	66.67a	0.00b
	NPK	56.25a	0.00b
	Control	50.00ab	0.00b
Mean		51.98	12.50
2222	CPH	93.75a	62.50a
	PM	66.67b	66.67a
	NPK	70.84b	75.00a
	Control	100.00a	100.00a
Mean		82.82	76.04
Zero plantain	CPH	50.00ab	16.67a
	PM	33.33ab	0.00b
	NPK	66.67a	0.00b
	Control	14.29b	25.00a
Mean		41.07	10.42
		Owena	
1111	CPH	100.00a	58.34a
	PM	50.00b	50.00b
	NPK	100.00a	50.00b
	Control	83.34a	75.00a
Mean		83.34	58.34
2222	CPH	100.00a	100.00a
	PM	100.00a	58.34b
	NPK	87.50a	58.34b
	Control	83.34a	50.00b
Mean		92.71	66.67
Zero plantain	CPH	75.00b	41.67b
	PM	81.25a	12.50c
	NPK	93.75a	31.25b
	Control	37.50c	62.50a
Mean		71.88	36.98

Means followed by the same letters along a column under each plantain density are not significantly different by HSD (P=0.05).

C143 = Cultivar 143; C318 = Cultivar 318; CPH = Cocoa pod husk; PM = Poultry manure; MAT = Months after transplanting

At Owena however, while C143 fertilised with CPH and NPK experienced higher survival rate under 1111, the unfertilised C318 and C318 fertilised with CPH survived better than those that received other fertilisers under the same plantain shade density. The C143 that received CPH and PM and C318 plants that received CPH under 2222 plantain ha^{-1} survived significantly better than others. Conversely, C143 that received NPK and PM under zero plantain shade survived better than the unfertilised ones and those that received CPH; while the unfertilised C318 survived better significantly (P=0.05) than the fertilised ones.

CHAPTER 5
DISCUSSION

Light intensity and soil fertility constitute the abiotic factors affecting tea growth and productivity globally. The outcome of this research revealed that field establishment and growth of tea, its yield potentials and accumulation of its photosynthetic pigments were enhanced under reduced light intensities and organically amended soils. It also revealed that reduced light intensities and applied organic materials for soil amendment were fundamental to tea production in Ibadan and Owena, SouthWest Nigeria.

The pH of Ibadan and Owena experimental location soils were slightly acidic and were considered suitable for tea production (Egbe *et al.*, 1989). However, in the field trials, the slightly alkaline and acidic soils of Ibadan and Owena indicate that tea was likely to perform better at Owena than at Ibadan. The soils of the two locations in both pot and field experiments were sand-loam; hence they could enhance better drainage and prevent water logging which is detrimental to tea growth since tea thrives well on well drained soils (Famaye *et al.*, 2006). However, the soils might not retain water for optimum tea growth during dry season if irrigation was not applied. Both soils in the pot and field trials were high in available P content but low in K, Ca, and Mg. This is an index of low fertility status of the soils. The N content of the pot experiments soil (2.12% and 1.16 % for Ibadan and Owena soils, respectively) and that of the field trials (2.31% and 1.56%) was above the critical soil value of 3.4 g/kg (0.34%) for soils under tea production in Kenya (Othieno, 1980).

Generally, Owena soil was superior to Ibadan soil in some important soil properties like Mg, Ca, CEC and ECEC. Considering these properties with its lower pH, under higher annual rainfall, it could be suggested that Owena could enhance better tea performance than Ibadan. This is because these properties could enhance better release of essential plant nutrients for plant growth. However, the higher ambient temperature in Owena probably might make shading more desirable for tea production. The general low nutrient status of the soils in both pot and field trials corroborates the submission of

FAO (2001) and Agboola and Shittu (2002). This further suggestes the need for fertiliser application in order to enhance optimum tea growth.

Poultry manure (PM) was higher in all the macro and micro nutrients than cocoa pod husk (CPH). This is consistent with the findings of Ipinmoroti (2006). The lower %N value of cocoa pod husk indicates that it would be applied in higher quantity to supply the same nitrogen value with that of poultry manure. This implies that higher applied quantity of cocoa pod husk that supplied equivalent amount of nitrogen in poultry manure could compensate for its low nitrogen content in the soil. The higher Ca and Mg contents in PM in the pot experiment could be due to possible addition of bone meal in poultry feed. The lower nutrient content of cocoa pod husk was an indication that most cocoa farmers do not apply fertilisers on their farms (Adebiyi *et al*., 2011), hence the lower nutrient content of cocoa pod husk.

The growth performance of tea at Owena was better than that of Ibadan both in the nursery and in the field trials. The difference in the weather and soil conditions of the two locations could be attributed for this, especially as Owena receives more rainfall annually than Ibadan. This could have led to higher tea survival in the location. In addition, the lower soil pH (6.2) of Owena must have favoured tea growth better than Ibadan.

The C143 and C318 tea plants differed in their growth both in field and nursery trials with the former being superior to the latter. This better growth performance of C143 plants also translated to better dry matter accumulation, shoot pruning and leaf yield as well as nutrient uptake. The C318 was only superior to C143 in the uptake of Ca at Ibadan and Fe at Owena. This might be due to difference in their genetic constitutions. The C143 had been reported to be more vigorous in growth than C318 (CRIN, 1983). The higher leaf abscission observed in C143 might probably be its drought tolerance and adaptability mechanisms since the higher leaf abscission also resulted in higher field establishment as observed in its higher survival count values. However, the greener pigmentation of C318 is an indication of more chlorophyll and carotenoids accumulation in it than in C143.

Reduced light intensity under palm frond sheds enhanced vegetative growth of tea plants compared to full light intensity across the two locations. Tea plants grown under subdued light at 45% ($4.57x10^4$lux) and 65% ($6.75x10^4$lux) light intensities had more leaf area and better plant height compared to plants grown in the open [100% light ($1.04x10^5$lux)]. This is in consonance with the report by Sadgheti *et al.* (2018) who reported an increased leaf size of Sage (*Salvia officinalis* L.) under 50% light intensity.

Besides, Famaye (2002) reported that 50% light reduction enhanced seedling growth of coffee.

Many factors could be responsible for this. First, it could be due to the moderate light quantum incident on the plants occasioned by different levels of both natural (Plantain shade) and artificial (palm fronds) shade imposed on the plants. Subdued light intensities have beneficial effect on both the plant and the soil in which the plant grows. The subdued light must have precipitated optimal condition for photosynthesis by regulating leaf and canopy temperature (Jannedra *et al*., 2007). The unhindered photosynthesis led to expanded leaf area which enhanced the growth of other plant parts. Hajiboland *et al*. (2011) and Wijeratne *et al*. (2008) had reported enhanced growth of tea under intermediate light intensities. Odeleye *et al*. (2001) 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. Secondly, the shade imposed on the tea plants and their expanded canopies (as a result of moderate light intensities) must have 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 available for plant use (Mohotti and Lawlor, 2002).

Very bright and scotching sun light significantly reduced tea growth in the nursery and field trials. At the two locations, C143 and C318 plants that grew under 100% light intensity produced the least vegetative growth. However, the better growth performance of C143 in comparison with C318 under this light intensity corroborated CRIN (1983) that the former cultvar was more drought tolerant than the later. The critical period of vegetative growth and leaf abscission in tea under 100% light intensity was at March and April. These are the peak of dry season in South-West Nigeria, when ambient temperature was at its highest. At this period, all the growth indices were at their lowest level and the increase in leaf abscission at its highest. It could be as a result of excessive rise in leaf temperature and evapo-transpiration which makes soil water less available for plant growth and build up of vapour pressure gradient between the leaf and the surrounding air (Hopkin, 1995). 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: a fact which corroborates the findings of Smith *et al* (1993) and Sivapalan (1993). The lowest light intensity, 25% ($2.40x10^4$lux) that produced lower vegetative growth especially in Ibadan, could be due to higher critical light intensity

level. This implies that medium shade favours leaf photosynthesis compared to no shade and high shade (Wijeratne *et al.,* 2008).

At Owena, the effect of 100% light intensity was more pronounced on the nursery trial as most of the tea plants under this light intensity shed all their leaves by 5 months after transplanting. This was probably as a result of higher maximum (29.9 ℃) ambient temperature of Owena compared to Ibadan temperature (27.0 ℃). The probable cause of this was the full light intensity which might have brought about lower water potential gradient between the soil and the plant root, leading to excessive water shortage in the plant i.e. higher Diffusion Pressure Deficit (DPD) or negative water potential as a result of higher turgor pressure and lower osmotic pressure culminating in cell wall plasmolysis, leaf wilting and eventual death of the plant. This finding was similar to that of Jannedra *et al*. (2007) that subdued light intensity precipitated by shading reduces ambient and soil temperature.

Plantain shade at 2222 plantain stands per ha reduced the light intensity better than 1111 plantain ha^{-1} owing to better canopy cover as a result of higher density of plantain stands. Besides, the ability of plantain shade to reduce light intensity for optimum tea growth was significantly reduced in the month of March. The reason that could be advanced for this is that it was the peak of the dry season. The hot weather of that period must have resulted in closing of the plantain canopy especially in the day time and subsequent reduction in their canopy spread which open more space for light penetration. The slightly lower light intensity enhanced by plantain shade at Ibadan is an indication of the obvious plantain better vegetative growth.

Organic fertilisers enhanced tea growth and development in the nursery and field trials. Tea performed better under cocoa pod husk and poultry manure than under NPK fertiliser. This result corroborates the work of Ogunlade *et al.* (2017) and Adejobi *et al*. (2015) as they postulated that application of cocoa husk enhanced vegetative growth of cocoa seedlings and cocoa chupons. In the nursery trials, cocoa pod husk at Ibadan and poultry manure at Owena at 300 kg Nha^{-1} enhanced the growth parameters (number of tea leaves, number of branches, leaf area, plant height and stem diameter) better than the control. This underscores the importance of organic manuring to the crop. In similar studies on other crops, organic fertilisers were found to promote the growth and yield of crops like Amaranthus (Akanbi and Togun, 2002), tomato (Togun *et al.*, 2004), kola (Adeosun *et al*., 2013) and okra (Dada and Adejumo, 2015).

However, the 300 kg Nha^{-1} cocoa pod husk that caused the highest vegetative growth in the main pot experiment enhanced a lower vegetative growth in the residual pot experiment, and vice versa for 300 kg Nha^{-1} poultry manure. This might be because the fertiliser that engendered higher growth in the main pot experiment must have released most of its nutrients, leaving lower amount of nutrients for subsequent cropping. The difference in the rate of nutrient release by the organic fertilisers between the two locations might probably be because of the differences in the physical and chemical properties of the soils of the two locations. In first field trial, tea plants growth was enhanced by 150 kg Nha^{-1} as against 300 kg Nha^{-1} in the pot experiment. However, 150 kg Nha^{-1} NPK application caused significantly more leaves and branches, and higher leaf area, plant height and stem diameter. This might probably be because of early nutrient release by NPK fertiliser. This corroborated the work of Obatolu (1984), Ipinmoroti (2006) and Ipinmoroti (2013). The NPK_{150} was closely followed by CPH_{150} in enhancing tea plants growth and development as the vegetative growth under NPK_{150} was not significantly higher than that under CPH_{150}. In the second field trial, none of the fertilisers was significantly superior in enhancing vegetative growth of tea; but they all performed significantly better than the control. This indicates that organic fertilisers could compete favourably with the popular NPK fertilisers in causing better vegetative growth of tea and in nutrient release to the soil for plant use in addition to their other benefits to the soil (Adeosun *et al*., 2019).

Tea growth responded favourably to all fertiliser rates under reduced light intensities compared to full day light. In first field trial, organic fertilisers also enhanced vegetative growth of tea under reduced light intensities better than NPK fertiliser and the control. The CPH_{150} under 45% light advanced higher tea growth parameters at both locations. This could probably be due to the fact that soil nutrients in these fertilisers were readily made available due to optimum condition of the soil occasioned by moderate light intensities incident on the soil. Moreover, reduced transpiration and optimum leaf temperature engendered by moderate light intensities could have enhanced optimum photo-assimilate accumulation which could have engendered the growth.

The efficiency of the fertilisers was greatly undermined under 100% light intensity. This was because of the unfavourable environmental condition of the growth medium. The high soil temperature occasioned by full light intensity which might have engendered excessive evaporation must have hindered the mineralization of the fertilisers and the

subsequent absorption of these minerals by plant root. Besides, dehydration (especially during dry season) which can reduce the assimilation of the absorbed nutrients and availability of H_2O; the closure of the leaf stomata which limit CO_2 absorption must have lowered the photosynthetic capacity of the tea plants. This result corroborated the earlier postulation of Smith *et al*. (1993). This is evident in the general poor growth observed on tea plants grown under full light intensity, though they were fertilised.

Similarly, in the second field experiment, the fertilised tea plants grew vegetatively more than the unfertilised ones under the different plantain densities. The growth was more pronounced at Ibadan in cultivar 143 (C143) plants that received NPK fertiliser under 1111 plantain ha^{-1}, cultivar 318 (C318) plants that received NPK under 2222 plantain ha^{-1}; and at Owena the growth was more pronounced in C143 plants that received poultry manure under 2222 plantain ha^{-1} and in C318 that received poultry manure under 1111 plantain ha^{-1}. This implies that the well developed plantain canopy that reduced the light intensity incident on the tea enhanced more effectiveness of the fertilisers. Generally, C143 plants under moderate light intensities and under the two plantain densities performed better than C318 plants. However, the interaction of C143 with 65% light in the pot experiment, 45% light in the first field experiment, and 2222 plantain ha^{-1} density in the second field experiment promoted vegetative growth of tea. This corroborates CRIN (Cocoa Research Institute of Nigeria) Annual Report (1983). Tea plants grown in full light intensity (100%) shed more leaves significantly than those grown under reduced light intensities. However, there was more leaf abscission at Ibadan than at Owena, with C143 having the highest dropped leaves across the two locations. This might probably be as a result of the fact that evapotranspiration is always high under full light intensity; and that the mechanism of drought tolerance in C143 could probably be leaf shedding. Interaction of 300 kg Nha^{-1} cocoa pod husk with 45% light intensity engendered the least leaf fall. This could be as a result of the optimum environmental condition for nutrient absorption by the plants and translocation by the vascular system. Tea plants under full light undergo photo-inhibition as a result of their C3 pathway, a condition that usually precipitates stomata closure at high light intensity. This is consistent with the submissions that photo-inhibition reduces the photosynthetic potential of tea plants (Smith *et al*., 1993; Mohotti and Lawlor, 2002; Wijeratne *et al*., 2008).

Generally, there was increase in tea vegetative growth in the residual pot experiment compared to the main pot experiment. Besides, the fertilisers enhanced tea

growth under 100% light better in the residual experiment than in the main experiment. This might be as a result of seasonal variation in the period of establishment of the experiments. The main experiment was established in the dry season, while the residual experiment commenced at the peak of raining season. In the residual experiment, the regular rainfall must have led to vigorous early growth of the tea, and this might have conferred on them ability to tolerate the dry season they passed through later better than they did in the main experiment.

The dry matter accumulation was significantly affected by the different cultivars, light intensities and fertilisers. Moderate light intensities of 45 and 65% enhanced significant higher dry weight of root, stem and leaf compared to lower and higher light intensity (25 and 100%). The dry matter accumulation in pot and field trials was higher at Owena than at Ibadan owing to the difference in their weather and edaphic factors. In the pot experiment, the superiority of C143 to C318 in vegetative growth did not translate to dry matter accumulation significantly except where the root dry weight of C143 was better than that of C318 in the two locations. The stronger root of C143 must have enhanced its ability to penetrate deeper into the soil for water absorption especially during dry season when soil water is at its lowest level. This might further explain why C143 was able to perform better than C318 under 100% light. However, in the field trial with freer and ample medium of growth and longer period of field observation, the higher dry matter accumulation in C143 might be the consequence of its enhanced vegetative growth.

Similarly, the reduced light intensity of 65% in the pot experiment, and 45% in the field trial were consistently outstanding, in enhancing dry matter of tea at Ibadan and Owena. This was a consequence of enhanced photosynthetic capacity of tea as 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 the plant parts (Wijeratne *et al.*, 2008). As expected, dry matter accumulation was lowest under 100% light in both pot and field trials. However, in the field trial, the reduction in dry matter accumulation was not as low as in the pots. This might probably be because the sampling period in the field trial coincided with the peak of raining season with overcast atmosphere which made 100% light less injurious to tea growth. In spite of this, tea plants under 100% light could not overtake those under 45% light in growth and dry matter accumulation because of the significant decline in vegetative growth the tea plants suffered under it during the dry season.

Both organic and inorganic fertilisers applied in these trials enhanced dry matter accumulation in tea. This underscores the efficiency of the plant nutrients in the fertilisers especially nitrogen in enhancing growth and dry matter yield of crops when applied at optimum rate (Fatubarin, 2003; Adeosun, 2005). However, organic fertilisers were as equally effective as NPK fertiliser in enhancing dry matter accumulation in the tea especially in the field trial. Even where NPK_{150} seemed to be better in enhancing dry matter accumulation, it was not significantly different as it was closely followed by cocoa pod husk at the same nitrogen rate. This might be as result of the slow release of nutrients by the organic fertilisers; the other plant nutrients especially calcium contained in them must have enhanced more absorption of nitrogen by the plants roots (Ipinmoroti, 2013). Milled cocoa pod husk at 300 kg Nha^{-1} (CPH_{300}) increased dry matter accumulation of tea at the two locations in the main pot experiment, while in the residual pot trial, poultry manure at 300 kg Nha^{-1} (PM_{300}) and cocoa pod husk at 300 kg Nha^{-1} increased dry matter at Ibadan and Owena, respectively. The varying light intensities affected the efficiency of the residual effect of the fertilisers in the residual pot experiment. As it was the case in the main experiment, 45% and 65% light intensities enhanced the efficiency of fertilisers on dry matter partitioning in the residual experiment. Cocoa pod husk and poultry manure at 150-300 kg Nha^{-1} in interaction with 45% light significantly enhanced dry matter accumulation.

In the first field trial, cocoa pod husk confirmed its superiority over poultry manure by enhancing root, stem and leaf dry weight of tea in comparison with NPK at both locations. Generally, tea plants that were fertilised with 150 kg Nha^{-1} accumulated more dry matter than those that were fertilised with 300 kg Nha^{-1} and the control. This corroborates the results of Obatolu (1984) as he affirmed that optimum growth and productivity of tea were achieved under fertilisers containing N, P and K at 150 kg, 30 kg and 30 kg Nha^{-1}, respectively (NPK 5:1:1). Although, in the main pot experiment, under 25% light there was no significant difference among the root dry weight of fertilised tea plants and the control at Ibadan, those fertilised with poultry manure especially 150 and 300 kg Nha^{-1} accumulated more dry matter in the root than others. The increase in growth observed in the residual experiment also resulted in higher dry matter values compared to the main pot experiment as there was an increase of 40 and 4% of total dry matter at Ibadan and Owena respectively in the residual experiment. Similarly, fertilisers under 100% light resulted in more dry matter accumulation in residual experiment than in the

main experiment. The seasonal variation in the periods of establishment of the two experiments as earlier mentioned could be responsible for this.

Tea seedling establishment on the field was affected by different cultivars, light intensities and fertilisers in the two field trials. The weather and soil variations between Ibadan and Owena could be responsible for a slightly higher field seedling establishment at Ibadan in the first field trials but much lower seedling establishment observed in the second field trial. The C143 tea maintained its superiority over C318 in field establishment both at Ibadan and Owena in the two field trials. This is consistent with the result of adaptability trial involving the two cultivars carried out at Cocoa Research Institute of Nigeria, Ibadan where C143 was found to have better field establishment than C318 (CRIN, 1985). This might be because of the drought tolerance ability of C143. The C143 possessed stronger root for deeper soil penetration and better water absorption during dry season. It has smaller leaf size and undergoes higher rate of leaf abscission which reduce transpiration and excessive water loss via leaf surface especially in dry season. This is in tandem with the submissions of Andrian *et al.* (2008) that closure of the stomata, wilting or rolling of leaves which result in reduction of water loss from plant increase their ability to survive drought condition.

There was significant difference among the light intensities in enhancing field seedling establishment of tea. The 45 and 65% lights increased the survival rate of tea by 74 and 45%, respectively at Ibadan, and at Owena, by 50 and 49%, respectively in comparison with 100% light. Similarly, in the second field trial, plantain at 2222 and 1111 plants ha^{-1} increased tea survival by 183 and 25%, respectively at Ibadan, and by 46 and 13%, respectively at Owena, in comparison with 100% light (zero plantain density). This implies that plantain shade reduced the scorching effect of adverse weather condition resulting from high ambient temperature (Obatolu and Ipinmoroti, 2000). The higher survival of tea plants under 100% light at Owena compared to Ibadan might be as a result of the weather and soil variations between the two locations. Tea survival was grossly endangered under full light intensity especially during cloudless dry season when ambient light intensity is at its brightest with the accompanying excessive rise in ambient temperature. The result of the interaction of cultivars with the varying light intensities shows that under all the light intensities, C143 was better than C318 in enhancing seedling field establishment. This was as a result of better ability to withstand wide range of ambient temperature.

Although, the fertilisers at their different rates are not significantly different in field seedling establishment of tea plants, but their interactions with different light intensities brought about significant difference especially at Ibadan. In the first field trial, the efficiency of CPH_{150}, CPH_{300}, NPK_{150} and PM_{150} enhancing significant C143 tea survival increased under 45% light intensity; while the interaction of CPH_{300} and NPK_{150} with 45% brought about significant higher survival of C318 plants. In the same vein, significant higher survival count was achieved under 2222 plantain ha^{-1} in C143 fertilised with cocoa pod husk. Similarly, at Owena, cocoa pod husk maintained its superiority over other fertilisers in causing better survival count of the tea plants under 1111 and 2222 plantain ha^{-1}. The high organic matter content of the organic fertilisers could be responsible for their higher effectiveness under the reduced and full light intensities in field seedling establishment. The high organic matter content also might have caused improved soil physical characteristics, thus ameliorating negative effects of adverse weather factors on the soil, and by extension, on the plants. The higher field seedling establishment enhanced by the control under 100% light intensity could be as a result of the lower soil nutrient solution of the unfertilised soil compared to the fertilised one especially as there was high soil water loss where there was no shade cover during dry season. The extremely low soil water makes essential plant nutrient unavailable for plant use because essential plant nutrients must be in relative dilute solution for ease of absorption by plant roots. As a matter of fact, high concentration of nutrient solution often leads to the death of plants growing in them (Fatubarin, 2003).

The C143 was better than C318 in pruning yield because of higher number of leaves in the former. The higher number of leaves enhanced by 45 and 65% lights in tea plants also translated to their higher pruning yield in the field experiment (Experiment 2). This is in consonance with the findings of Famaye (2002) that fruit yield of coffee was the highest under 50% shade regime.

Similarly, 150 kg $Nha^{-1}$of NPK, poultry manure (PM) and cocoa pod husk (CPH) enhanced the pruning yield at Ibadan and Owena. This corroborates the findings of Ipinmoroti and Iremiren (2010) who observed an enhanced growth and pruning yield of tea cuttings under organic fertilisers. Moreover, the interaction of organic fertilisers with reduced light intensities engendered higher pruning yield of tea. None of the fertilisers under the light intensities had overriding effect on the pruning yield of tea. However, while NPK and poultry manure were more effective under 45% and 65% lights, cocoa

pod husk performed better under 100% light. This shows that cocoa pod husk improved the pruning yield better than others even at the brightest light intensity. The organic matter component of cocoa pod husk must have given it this advantage especially above NPK. As it was the case in growth parameters, C143 was superior in pruning yield of tea. The better vegetative growth observed in C143 must have translated to the higher pruning yield.

The different tea cultivars, light intensities and fertilisers enhanced leaf yield in the first field trial. Although there was an insignificant increase in leaf yield of C318 above C143 at Ibadan, the latter generated more leaf yield than the former at Owena. Diminished light intensities maintained their overriding effect over the full light. The leaf yield under 45 and 65% lights increased by 69 and 10% compared to 100% light. At Owena, diminished light also enhanced higher leaf yield compared to the 100% light. This underscores the fact that reduced light intensities are indispensible for optimum shoot regeneration after pruning. This is consistent with the postulation of Panda (2011) that yield of plucked shoots of tea plants was maximum under moderate light intensity. In similar research findings on coffee, reduced light intensity was found to enhance berry yield of coffee (Famaye *et al*., 2000; Famaye *et al*., 2017).

Application of organic fertilisers especially cocoa pod husk and poultry manure at 150 kg Nha^{-1} increased leaf yield of tea at Ibadan and Owena compared to the control. NPK and Poultry manure at 150 kg Nha^{-1} enhanced higher leaf yield at Ibadan, while CPH at 150 kg Nha^{-1} exerted better influence at Owena. In a similar trend, organic fertilisers had been found out to enhance berry yield of coffee (Famaye *et al*., 2016), cob yield of maize (Akanbi, 2002; Adeniyan and Ojeniyi, 2003), nitrogen and carbohydrate content of cowpea (Amujoyegbe and Alofe, 2003), fruit yield of tomato (Togun and Akanbi, 2002), fruit yield of okra (Akanbi *et al*., 2005), grain yield of rice (Odigbo and Okeleye, 2006) and cormel yield of cocoyam (Osundare, 2004). Generally, leaf yield of tea at Ibadan was slightly higher than that of Owena. This is an indication that tea shoot regenerated faster after initial pruning since pruning was routinely done before the commencement of leaf harvest.

It is noteworthy that the highest C143 leaf yield (44.79 g $plant^{-1}$) was obtained at Ibadan under 45% light with cocoa pod husk at 150 kg N ha^{-1} and that of C318 (41.27 g $plant^{-1}$) was caused by poultry manure at the same fertiliser rate, light intensity and location. The reason that could be attributed to this was that lower ambient temperature

that resulted from reduced light intensities must have led to enhanced mineralization of the fertilisers, absorption of the nutrient by plant root, assimilation of the nutrient, photosynthesis and translocation of the photoassimilate to various parts of the plant. Moreover, the light intensities also affected the productivity of the two tea cultivars. However, C143 productivity was higher than that of C318 under all the light intensities, yet the best of its performance was obtained under 45% light.

The different cultivars of tea, light intensities and fertilisers affected accumulation of chlorophyll and carotenoids in the tea in both pot and field trials. In the pot experiment however, C318 was superior to C143 in chlorophyll and carotenoids accumulation. This is evident in the greener pigmentation observed in C318 tea. The 25, 45 and 65% lights increased chlorophyll of tea by 166, 68 and 58%, respectively in comparison with 100% light, while they increased carotenoids content by 73, 45 and 39% respectively. Similarly, at Owena, 25, 45 and 65% lights increased chlorophyll of tea by 147, 89 and 46% respectively compared to 100% light, while they increased carotenoids content by 163 103 and 33% respectively. This implies that the lower the light intensity, the higher the chlorophyll and carotenoids synthesis in tea plants. This is consistent with the findings of Wang *et al.* (2013) who submitted that high light sunlight resulted in low levels of chlorophyll and carotenoids in albino tea plant. Similarly, Zhang *et al*. (2014) and Oliveira *et al.* (2014) observed that chlorophyll synthesis was enhanced under low light intensity in field grown tea. The NPK_{150} that engendered the highest values of chlorophyll and carotenoids at Owena is an index of early nitrogen release by NPK. Nitrogen is a major nutrient requirement for chlorophyll synthesis in green plants and was the nutrient in the highest proportion in NPK_{150}.

Moreover, accumulation of chlorophyll and carotenoids in the two tea cultivars vary according to the different light intensities. Moderate light intensity brought about more chlorophyll and carotenoids synthesis and accumulation in C318 than in C143; while extreme light intensities of 25 and 100% reduced chlorophyll and carotenoids accumulation in C318 compared with C143. This implies that extreme light intensities have more adverse effect on C318 than on C143 in chlorophyll and carotenoids synthesis. The hardiness (ability to tolerate harsh weather) of C143 plants could be responsible for this attribute.

The interaction of the fertilisers with 25% light was outstanding. Although, sole effect of organic fertilisers was not prominent in chlorophyll and carotenoids content of

the tea, but when in interaction with 25% light they had overriding influence above NPK. The PM_{300} enhanced total chlorophyll of C143 and carotenoids of C318 plants at Ibadan. Similarly, CPH_{150} under 25% light enhanced carotenoids and total chlorophyll of C143 plants at Ibadan and Owena, as CPH_{150} produced the highest chlorophyll in C318 plants at Ibadan and C143 plants at Owena, carotenoids of C143 and C318 plants at Owena. This is an indication that low light intensity enhanced better absorption and assimilation of N which is an important constituent of chlorophyll and carotenoids and was largely present in the organic fertilisers. The chlorophyll and carotenoids content of tea was generally low under 100% light; it was even worse with fertiliser application. The closure of stomata and consequent poor absorption of plant nutrients from the soil at extreme light intensities could be responsible for this. Moreover, the weather variation between Ibadan and Owena was responsible for higher chlorophyll and carotenoids in tea at Ibadan than at Owena.

As it was in the pot experiment, C318 was superior to C143 in chlorophyll and carotenoids composition of tea in the field experiment. While there was more chlorophyll accumulation at Ibadan; tea plants accumulated carotenoids more at Owena than in Ibadan, possibly as result of the weather variation between the two locations. However, while at Ibadan chlorophyll of C143 and C318 declined from 8 MAT (peak of dry season) to 14 MAT (peak of raining season); at Owena, both C143 and C318 maintained high chlorophyll between 8 MAT and 14 MAT with C318 and C143 declining and increasing, respectively. However, in carotenoids accumulation, while C143 and C318 increased in carotenoids from 8 MAT to 14 MAT in Ibadan, they decreased in the same period at Owena. Moreover, C318 maintained significant higher chlorophyll and carotenoids content than C143 at the two sampling periods at Ibadan and Owena.

The alternate pattern of chlorophyll and carotenoids accumulation trend between 8 and 14 MAT at Ibadan shows that the bright cloudless weather at the peak of dry season (8 MAT) favoured chlorophyll synthesis; while the overcast atmosphere at the peak of raining season enhanced carotenoids synthesis. At Ibadan, the 45% light maintained high chlorophyll and carotenoids in tea. However, while 45% light increased chlorophyll synthesis at 8 MAT and carotenoids at the same period, chlorophyll and carotenoids accumulation was more stable under 65% and 100% lights. The sharp decline and rise of chlorophyll and carotenoids, respectively between 8 MAT and 14 MAT implies that 45% light was more effective at enhancing higher chlorophyll synthesis under bright cloudless atmosphere of the dry season than in cloudy atmosphere of the raining season and vice

versa for carotenoids. The situation was quite different at Owena as 65 and 100% lights increased chlorophyll of tea, while carotenoids declined between 8 and 14 MAT under all the light intensities with 65% light sustaining higher carotenoids all through the sampling period. The implication of this is that the cloudy weather at 14 MAT reduced the effectiveness of 45% light but increased that of 65% and 100% lights at enhancing chlorophyll content of tea. Conversely, the higher carotenoids production at 8 MAT and a sharp decline at 14 MAT imply that the cloudy weather at 14 MAT (peak of raining season) drastically undermined the effectiveness of the light intensity in enhancing carotenoids synthesis in tea.

The CPH_{150} competed favourably with NPK_{150} in chlorophyll and carotenoids accumulation in tea leaf. The unfertilised tea produced the least chlorophyll and carotenoids at Ibadan and Owena. This implies that the nitrogen content of the unfertilised soil was lower than that of the fertilised one. The additional N and other plant nutrients in the fertilised soil led to more N uptake and subsequent increase in chlorophyll and carotenoids synthesis where N and Mg play very active role.

The C318 maintained its superiority over C143 in chlorophyll and carotenoids accumulation under all the light intensities; implying that C318 is genetically superior to C143 in chlorophyll and carotenoids accumulation, the variation in light intensity notwithstanding. The interaction of organic fertilisers with light intensity in chlorophyll and cartenoids was more pronounced at 8 MAT. At Ibadan the highest chlorophyll was produced by PM_{150} and PM_{300} under 45% light; whereas the highest carotenoids were achieved by PM_{150} under 100% light at 8 MAT, and CPH_{300} under 45% light at 14 MAT. This implies that 45% light enhanced the efficiency of the organic fertilisers in chlorophyll accumulation in tea at 8-14 MAT, and carotenoids at 14 MAT at Ibadan. However, in carotenoids at 8 MAT, 100% light enhanced the efficiency of organic fertiliser. The efficiency of the fertilisers at enhancing chlorophyll accumulation under 100% light was generally low. The poor nutrient absorption coupled with closure of the stomata which resulted in low photosynthesis rate and assimilation of plant nutrients could be responsible for this. In the same vein at Owena, organic fertilisers enhanced better chlorophyll and carotenoids accumulation in tea leaf under reduced light intensities at 8 MAT when sunlight and ambient temperature were very high. However, at 14 MAT when the atmosphere was cloudy, NPK_{150} efficiency at increasing chlorophyll and carotenoids accumulation was enhanced. This indicates that effect of reduced light on

efficiency of fertilisers in chlorophyll and carotenoids accumulation in tea was more pronounced in the dry season (8 MAT) than in the raining season (14 MAT) and that reducing light intensity at the peak of rainy season is not desirable for chlorophyll and carotenoids synthesis in tea. In both locations, the efficiency of the fertilisers was generally enhanced more in C318 than in C143 especially at 8 MAT. This attribute of C318 could be its physiological characteristic.

Nutrient uptake in tea was more at Owena than at Ibadan. At Ibadan, nutrient uptake was significantly higher under reduced light than under full light intensity. The highest N, P, K, Ca, Mg and Fe uptake was enhanced by 45% light. This might be because reduced light precipitated conducive edaphic environment for easy absorption of this nutrient. This corroborates the work of Ogawa *et al.* (2010) who submitted that reduced light intensity enhanced the accumulation of amino acids in tea leaves. Nutrient uptake was the lowest under 100% light. The increased soil water loss and volatilization of some highly mobile nutrients especially N could have reduced availability of such nutrients in the soil. Excessive evaporation could make some of the nutrients less available for absorption by plant root because excessive loss of soil water increases the concentration of soil nutrient solution, thus making it difficult for root absorption (Fatubarin, 2003). At Ibadan the fertilisers were better than control in the uptake of N, P, K, Ca, Mg and Fe. However, at Owena N, P, K, Ca, Mg and Fe uptake was enhanced by NPK_{150}, CPH_{150} and PM_{150}. This elucidates the fact that organic fertilisers were equally effective in enhancing nutrient uptake in tea plants as the inorganic check (NPK 5:1:1). This corroborates earlier reports that organic manure enhanced the uptake of N, P, and K in kola seedlings (Adeosun *et al.*, 2013) and uptake of N, P, K, Ca and Mg in cocoa seedlings (Adejobi *et al.*, 2015).

The efficiency of the fertilisers in precipitating nutrient uptake in tea was affected by the varying light intensities. The 45 and 65% lights enhanced effectiveness of the fertilisers in nutrient uptake while 100% light reduced their effectiveness. This underscores the significance of 45 and 65% lights in nutrient uptake. The buffering effect of the reduced light intensity on the high soil and plant temperature must have facilitated better mineralization of the organic fertilisers and the subsequent uptake of the mineralized nutrients by plant roots. Apart from their effect on the fertilisers, light intensities also influenced the effectiveness of each cultivar in nutrient uptake. The highest N, P, K, Ca, Mg and Fe uptake was obtained in C143 under 45% light in Ibadan

and Owena. This result underscores the superiority of interaction of C143 with 45% light. It is an indication that at 45% light, the full potentials of C143 were expressed.

The tea plant nutrients, N, P, K, Ca, Mg and Fe positively correlated in their uptake in the tea leaves. The strongest positive correlation of N with other nutrients might be an indication of its high mobility in the soil and in the plant. Phosphorus (P) is an highly immobile nutrient, a characteristic which might probably be responsible for its weak correlation with other plant nutrients.

The number of leaves and leaf area were outstanding in their positive correlation with other vegetative parts. This implies that they have higher influence on other vegetative parts. This might be the result of their photosynthetic capacity. The leaf is the most important photosynthetic site of the plant, and its surface area has positive correlation with photosynthetic rate which in turn determines the plant growth rate. This corroborates the report of Oloyede *et al.* (2014) who submitted that number of leaves and leaf area of rooted cuttings of various tea clones were positively correlated with other morphological parts of the plants. The positive correlation of number of leaves with leaf area and other vegetative growth indicators implies that the higher the number of leaves, the higher the leaf area and number of branches, and vice versa. Besides, plant height correlating positively with leaf area is an indication that the taller the plant height, the higher the leaf area. This means that leaves on taller plants tend to receive more light energy, thus making them develop their leaf area as they are more exposed to light

Leaf chlorophyll positively correlated with all the nutrient elements in tea leaves. Higher N, P, K, Ca, Mg and Fe in tea leaves also increased the leaf chlorophyll. The strongest correlation between N and leaf chlorophyll explains essential role of nitrogen in chlorophyll synthesis. Besides, Mg which exhibited one of the strongest correlations with leaf chlorophyll indicates its essential role in chlorophyll synthesis as an elemental constituent of chlorophyll compound (Fatubarin, 2003). Carotenoids accumulation in tea leaves increases or decreases with a rise or decline in chlorophyll accumulation. The fact that chlorophyll and carotenoids are both photosynthetic pigments in the grana of leaf chloroplasts explains the strong and highly significant positive correlation between them.

CHAPTER 6

SUMMARY AND CONCLUSIONS

The potentials of reduced light intensities and applied organic materials in factorial combinations in enhancing the field seedling establishment, growth, leaf yield as well as photosynthetic pigments of two tea cultivars in two lowland ecological locations of Nigeria were investigated. Tea cultivars, C143 and C318, were grown in one pot experiment and two field trials in Ibadan and Owena. In the pot experiment and in the first field trial, growth, field seedling establishment, and photosynthetic pigments of tea were assessed under 25% ($2.40x10^4$lux), 45% ($4.57x10^4$lux), 65% ($6.75x10^4$lux) and 100% ($1.04x10^5$lux) light intensities in factorial combination with 0, 75, 150 and 300 kg Nha^{-1} of cocoa pod husk and poultry manure as well as 150 kg Nha^{-1} NPK 5:1:1. Different layers of palm fronds were used to achieve the different light intensities, while milled cocoa pod husk and cured poultry manure were sources of organic materials. In the second field experiment, the field establishment and growth of the two tea cultivars were assessed further under plantain population of 2222 plantain/ha ($1.61x10^4$lux), 1,111 plantain/ha ($2.27x10^4$lux) and zero shade cover ($3.65x10^4$lux) in factorial combination with 150 kg Nha^{-1} rate of cocoa pod husk, poultry manure and NPK 5:1:1. From the results of both nursery and field trials, the following findings and conclusions were made:

1. The plantain shade established at 2,222 stands/ha 14 months before tea establishment reduced light intensity to as low as 44%.
2. The highest growth, yield and seedling establishment was obtained in cultivar 143 under 45% light intensity and 2,222 plantain ha^{-1}.
3. Cultivar 143 thrived better than cultivar 318 in the dry season under 100% light intensity ($1.04x10^5$ lux).
4. Cultivar 143 performed better than cultivar 318 in growth, seedling establishment and dry matter accumulation under all the light intensities, while C318 was

superior to C143 in chlorophyll and carotenoids contents.

5. Reduced light intensity of 45% enhanced vegetative growth, dry matter accumulation, leaf yield and chlorophyll and carotenoids contents in tea.
6. The cocoa pod husk and poultry manure at 300 kg Nha^{-1} under 45 and 65% light intensities enhanced the growth and dry matter of tea in pots.
7. The cocoa pod husk at 150 kg Nha^{-1} under 45 and 65% light intensities enhanced the growth, dry matter and leaf yield of tea in the field.
8. The residual effect of the organic materials increased the vegetative growth of tea plants.
9. Leaf abscission was higher in cultivar 143 than in cultivar 318.
10. Reduced light intensities of 45 and 65% reduced leaf abscission in tea plants.
11. All the fertiliser materials at 150 kg Nha^{-1} applied sole and in combination with 45 and 65% light intensities enhanced the pruning yield of tea.
12. The highest leaf yield of tea was obtained under 45% light intensity
13. The extreme light intensity of 100% reduced chlorophyll and carotenoids composition of tea. The applied organic materials and NPK fertiliser enhanced the chlorophyll content of tea leaf.
14. The uptake of N, P, K, Ca, Mg and Fe was highest under 45% light intensity. The 45 and 65% light intensities increased the effectiveness of the fertilisers in precipitating nutrient uptake in tea. Cultivar 143 was better than C318 in nutrient uptake when grown under 45% light intensity.
15. There were positive correlations among the leaf biomass nutrients, the growth of vegetative parts, and the photosynthetic pigments of tea.
16. The extreme light intensity at 100% undermined the growth of tea. It reduced seedling establishment, chlorophyll and carotenoids composition of tea, and effectiveness of fertiliser in enhancing general tea performance.

CONTRIBUTIONS TO KNOWLEDGE

At the end of both pot and field trials, the following contributions to knowledge were made:

1. Tea was successfully grown in Ibadan and Owena under light intensity of 45%; but it performed and survived better in Owena than in Ibadan
2. The organic materials at 150 and 300 kg Nha^{-1} competed favourably with the inorganic fertiliser in enhancing vegetative growth, leaf yield, dry matter accumulation, nutrient uptake, as well as chlorophyll and carotenoids contents of tea.
3. Palm fronds at 1, 2 and 4 layers reduced the light intensities to 65% ($6.75x10^4$ lux), 45% ($4.57x10^4$ lux) and 25% ($2.4x10^4$ lux) respectively. The plantain shade established at 2,222 stands/ha 14 months before tea establishment reduced light intensity to 44%. Light intensity of 45% enhanced vegetative growth, dry matter accumulation, leaf yield and chlorophyll and carotenoids contents in tea.
4. The highest growth, yield and seedling establishment was obtained in cultivar 143 under 45% light intensity and 2,222 plantain ha^{-1}.
5. Cultivar 143 survived the dry season better than cultivar 318 under 100% light intensity ($1.04x10^5$ lux). It also performed better than cultivar 318 in growth, seedling establishment and dry matter accumulation; while C318 was superior to C143 in chlorophyll and carotenoids contents.
6. The effectiveness of the fertilisers was affected by light intensity as cocoa pod husk and poultry manure at 300 and 150 kg Nha^{-1} in pots and on the field, respectively under 45% and 65% light intensities enhanced the growth, dry matter, nutrient uptake and leaf yield of tea.
7. The critical period for shade provision for tea cultivation at Ibadan and Owena was dry season and early rainy season.

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APPENDICES

APPENDIX I

Fertiliser Calculations

Organic Fertiliser for Field Experiments

Poultry manure

Nitrogen (N) = 1.96%

100 kg poultry manure contains 1.96 kg N

At 150 kg Nha^{-1} rate:

$\frac{100}{1.96} \times 150 = 7653.06$ kg poultry manure ha^{-1}

Plant population $ha^{-1} = 16666.67$

Poultry manure per stand: $\frac{7653.06}{16666.67} = 0.46$ kg/stand

At 300 kg N ha^{-1} rate: 0.46 kg x 2 = 0.92 kg poultry manure per stand

Milled Cocoa pod husk

Nitrogen (N) = 1.51%

100 kg cocoa pod husk contains 1.51 kg N

At 150 kg Nha^{-1} rate: $\frac{100}{1.51} \times 150 = 9933.77$ kg cocoa pod husk ha^{-1}

Plant population $ha^{-1} = 16666.67$

Milled Cocoa pod husk per stand:

$\frac{9933.77}{16666.67} = 0.6$ kg/stand

At 300 kg Nha^{-1} rate: 0.6 kg x 2 = 1.20 kg cocoa husk per stand

Organic Fertiliser for Pot Experiments

Milled Cocoa pod husk

Nitrogen (N) = 1.4%

100 kg cocoa pod husk contains 1.4 kg N

At 75 kg Nha^{-1} rate:

1ha→2000000 kg soil

2000000 kg →75 kg N

5 kg soil→ $\frac{75}{2000000}$ x 5 = 0.0001875 kg N

1.4%N→100 kg cocoa pod husk

75 kg N→$\frac{100}{1.4}$ x 75 = 5357.14 kg cocoa pod husk ha^{-1}

For 5 kg soil:

$\frac{5357.14}{2000000}$ x 5 = 0.01339 kg (13.39 g) cocoa pod husk per 5 kg soil

At 150 kg Nha^{-1}

13.39 x 2 = 26.78 g cocoa pod husk per 5 kg soil

At 300 kg Nha^{-1}:

13.39 x 4 = 53.56 g cocoa pod husk per 5 kg soil

Poultry manure

Nitrogen = 3.45%

100 kg poultry manure contains 3.45 kg N

At 75 kg Nha^{-1} rate:

1ha→2000000 kg soil

2000000 kg →75 kg N

5 kg soil→ $\frac{75}{2000000}$ x 5 = 0.0001875 kg N

3.45% N→100 kg poultry manure

75 kg N→$\frac{100}{3.45}$ x 75 = 2173.91 kg poultry manure ha^{-1}

For 5 kg soil:

$\frac{2173.91}{2000000}$ x 5 = 0.005435 kg (5.44g) poultry manure per 5 kg soil

At 150 kg N ha^{-1}

5.44 x 2 = 10.89 g poultry manure per 5 kg soil

At 300 kg Nha^{-1}:

5.44 x 4 = 21.74 g poultry manure per 5 kg soil

NPK Fertiliser Calculation for Pot Experiment

Nitrogen (N) (150 kg Nha^{-1})

Source: Urea (46%)

1ha = 2000000 kg soil

2000000 $kgha^{-1}$ → 150 kg N

1 kg→ $\frac{150}{2000000} = 7.5 \times 10^{-5}$

For 5 kg soil

N = 7.5 x 10^{-5} x 5 = 0.000375 kg

46 kg N → 100 kg urea

1 kg = 100/46

0.000375 kg → $\frac{100}{46}$ x 0.000375 = 0.00082 kg urea (0.82 g urea) per pot (5 kg soil)

Phosphorus (P) (30 kgP ha^{-1})

Source: Single Superphosphate (SSP) (18% P_2O_5)

1ha = 2000000 kg soil

2000000 kg ha^{-1} → 150 kg N

1 kg→ $\frac{30}{2000000} = 1.5 \times 10^{-5}$

For 5 kg soil

1.5 x 10^{-5} x 5 = 7.5 x 10^{-2}

SSP contains 18% P_2O_5

18% P_2O_5 x 0.44 = 7.92 kg P

7.92 kg P = 100 kg SSP

1 kg→$\frac{100}{7.92}$ x 7.5 x 10^{-2} (for 5 kg soil)

= 0.00095 kg (0.95 g) SSP per pot

Potassium (K) (30 kg Kha^{-1})

Source: Muriate of Potash (KCl) (60% K_2O)

1ha = 2000000 kg soil

2000000 kg ha^{-1} → 150 kg N

5 kg→ $\frac{30}{2000000}$ = 1.5 x 10^{-5}

For 5 kg soil

1.5 x 10^{-5} x 5 = 7.5 x 10^{-2}

KCl contains 60% K_2O

60% K_2O x 0.83 = 49.8%K

49.8%K → 100 kg KCl

5 kg → $\frac{100}{49.8}$ x 7.5 x 10^{-2}

= 0.2 g KCl (MoP) per pot

NPK Fertiliser Calculation for Field Experiment

Nitrogen (N) (150 kg Nha^{-1})

Source: Urea (46%N)

1ha →10000 m^2

1 Plot → 57.6 m^2

10000 m^2 → 150 kg N

1 m^2 → $\frac{150}{10000}$ kg N

57.6 m^2 →$\frac{150}{10000}$ x 57.6 = 0.864 kg N

Urea → 46%N

46 kg N → 100 kg

1 kg N→$\frac{100}{46}$

0.864 kg N = $\frac{100}{46}$ x 0.864

= 1.878 kg urea per 57.6 m^2

1 Plot → 96 Plants

1.878 kg urea →96 plants

1 plant→$\frac{1.88}{96}$= 0.01958 kg per stand

= 19.58 g urea per stand (Plant)

Phosphorus (30 kg P)

Source: Single Superphosphate (SSP) (18% P_2O_5)

30 kg Pha^{-1} SSP →18%P_2O_5

1ha →10000 m^2

1 Plot → 57.6 m^2

10000 m^2 → 30 kg Pha^{-1}

1 m^2 = $\frac{30}{10000}$ kg P

57.6 m^2 → $\frac{30}{10000}$ x 57.6 = 0.1728 kg P

Conversion of 18% P_2O_5 to %P

18% x 0.44 = 7.92%P

7.92 kg P → 100 kg SSP

1 kg P → $\frac{100}{7.92}$ SSP

0.1728 kg P → $\frac{100}{7.92}$ x 0.1728 = 2.19 kg SSP per 57.6 m^2

1 Plot → 96 Plants

SSP per stand → $\frac{2.19}{96}$ = 0.0228 kg (22.81 g) SSP per stand

Potassium (MoP) (K)

Source: Muriate of Potash (KCl) (60% K_2O)

30 kg K_2O → 100 kg KCl

1ha →10000 m^2

1 Plot → 57.6 m^2

MoP (KCl) → 30 kg Kha^{-1}

10000 m^2→ 30 kg K

1 m^2 → $\frac{30}{10000}$ kg K

57.6 m^2 → $\frac{30}{10000}$ x 57.6 = 0.1728 kg K

Conversion of %K_2O to %K

60% K_2O x 0.83 = 49.8 kg

1 kg → $\frac{100}{49.80}$ KCl

0.1728 kg K → $\frac{100}{49.80}$ x 0.1728 = 0.34699 KCl (MoP) per 57.6 m^2

1 Plot → 96 Plants

MoP per stand → $\frac{0.34699}{96}$ = 0.00361 kg (3.61 g)

APPENDIX II

Summary of ANOVA of the effects of cultivars, light intensities and fertilisers on some vegetative parts of plants tea in the main and residual pot experiments

Source of variation	Df	Ibadan			Df	Owena		
		Means square				Means square		
		Number of leaves	Number of branches	Leaf area		Number of leaves	Number of branches	Leaf area
Main experiment								
Light intensity	3	3527.9173**	6.6305**	2997080.5460**	3	3480.9287**	26.4130**	4678752.8290**
Cultivar	1	854.2833**	32.3951**	194497.4721ns	1	1057.6046**	22.6616**	811843.8940**
Fertiliser	7	196.3916**	9.4913**	257035.1882**	7	190.9501**	5.3716**	368247.8788**
Light intensity x Cultivar	3	36.2140ns	1.0130ns	38135.7106**	3	78.6787ns	4.7458**	148334.2646**
Light intensity x Fertiliser	21	46.7626**	2.3661**	68372.3595**	21	65.1974**	3.5461**	113198.9602**
Cultivar x Fertiliser	7	16.2639ns	1.5773ns	29214.1385ns	7	132.8420**	3.7618**	132989.5489**
Light intensity x Cultivar x fertiliser	21	78.2032**	2.4823**	74366.8138**	21	52.9633**	2.6039**	72407.4911**
Error	192	44.5378	1.4174	43095.9877	192	42.0970	1.4730	65061.3605
Total	255							
Residual experiment								
Light intensity	3	7052.9841**	58.3354**	19079500.9472**	3	503.8789**	26.8753**	4779079.3094**
Cultivar	1	8140.8890**	80.2816**	1648855.0260**	1	136.5977**	66.8175**	482359.7667**
Fertiliser	7	473.6176**	19.2530**	907343.5188**	7	566.0709**	105.0690**	1045175.5997**
Light intensity x Cultivar	3	502.2523**	9.2460**	339828.8432**	3	106.6289**	12.5419**	514123.0566**
Light intensity x Fertiliser	21	406.1141**	10.5206**	392150.2702**	21	92.9801**	23.6902**	150732.9340**
Cultivar x Fertiliser	7	736.0146**	42.0147**	967069.5359**	7	175.5798**	17.4632**	359699.2861**
Light intensity x Cultivar x fertiliser	21	298.2146**	21.8406**	351830.7963**	21	121.5634**	30.3056**	156641.6871**
Error	192	121.1829	8.0215	178134.8860	192	74.9518	2.4642	107301.9651
Total	255							

****** = significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX III

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on plant height and stem diameter at different stages of development of tea plants in the main pot experiment

Source of variation		Ibadan			Owena	
4MAT	**Df**	**Plant height**	**Stem diameter**	**Df**	**Plant height**	**Stem diameter**
Light intensity	3	410.0426**	0.0152**	3	353.9455**	0.0189**
Cultivar	1	19.1899ns	0.0597**	1	246.8630**	0.0098**
Fertiliser	7	185.9046**	0.0156**	7	100.4198**	0.0304**
Light intensity x Cultivar	3	63.7396**	0.0133**	3	232.5928**	0.0183**
Light intensity x Fertiliser	21	68.0803**	0.0059**	21	100.4948**	0.0095**
Cultivar x Fertiliser	7	39.5708ns	0.0139**	7	53.9690**	0.0084**
Light intensity x Cultivar x fertiliser	21	83.4560**	0.0062**	21	106.1043**	0.0038ns
Error	192	56.2058	0.0056	192	63.6943	0.0051
6 MAT						
Light intensity	3	3563.3699**	0.3757**	3	2058.8712**	0.2160**
Cultivar	1	24.9001ns	0.0943**	1	174.1319**	0.0328**
Fertiliser	7	218.3988**	0.1183**	7	251.0221**	0.0489**
Light intensity x Cultivar	3	172.1658**	0.0425**	3	215.6292**	0.0093**
Light intensity x Fertiliser	21	158.4614**	0.0226**	21	165.0176**	0.0217**
Cultivar x Fertiliser	7	86.6208**	0.0182**	7	227.7808**	0.0212**
Light intensity x Cultivar x fertiliser	21	137.8638**	0.0238**	21	160.3679**	0.0146**
Error	192	68.2040	0.0218	192	83.9950	0.0093
8MAT						
Light intensity	3	3943.1547**	0.6581**	3	19984.8794**	1.8381**
Cultivar	1	272.3738**	0.0199**	1	895.2089ns	0.0399**
Fertiliser	7	332.3103**	0.0826**	7	242.7518**	0.1135**
Light intensity x Cultivar	3	82.2101**	0.0214**	3	479.1983**	0.0033ns
Light intensity x Fertiliser	21	151.2812**	0.0296**	21	386.5167**	0.0406**
Cultivar x Fertiliser	7	110.8460**	0.0152**	7	155.3002**	0.0315**
Light intensity x Cultivar x fertiliser	21	159.9273**	0.0231**	21	234.3676**	0.0250**
Error	192	100.8916	0.0186	192	92.9797	0.0144

MAT = Months after transplanting

**** =** significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX IV

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on plant height and stem diameter at different stages of development of tea plants in the residual pot experiment

Source of variation		Ibadan			Owena	
2MAT	**Df**	**Plant height**	**Stem diameter**	**Df**	**Plant height**	**Stem diameter**
Light intensity	3	236.1855**	4.7954**	3	80.2866**	0.6310**
Cultivar	1	645.5728**	0.3691ns	1	5409.6025**	6.7405**
Fertiliser	7	281.8014**	15.5212**	7	360.3181**	8.1465**
Light intensity x Cultivar	3	49.1035**	4.6224**	3	439.1759**	5.5917**
Light intensity x Fertiliser	21	293.5677**	7.8082**	21	213.7682**	2.0737**
Cultivar x Fertiliser	7	185.6863**	4.0888**	7	209.9311**	3.7558**
Light intensity x Cultivar x fertiliser	21	284.3184**	7.2669**	21	118.7263**	1.7270**
Error	192	56.8944	1.9919	192		0.7838
4 MAT						
Light intensity	3	242.4712**	2.2786**	3	947.2399**	9.8734**
Cultivar	1	217.5870**	0.0280ns	1	6271.1514**	29.3754**
Fertiliser	7	973.5921**	4.1886**	7	761.2786**	9.8515**
Light intensity x Cultivar	3	211.9577**	1.6227**	3	327.9048**	4.3818**
Light intensity x Fertiliser	21	226.6340**	6.1676**	21	251.1311**	3.6920**
Cultivar x Fertiliser	7	98.0963**	4.5888**	7	390.6004**	2.4515**
Light intensity x Cultivar x fertiliser	21	293.0040**	3.9493**	21	147.2426**	2.5424**
Error	192	58.4038	0.9328	252	60.9493	0.6937
6MAT						
Light intensity	3	12888.1426**	117.5013**	3	4459.7600**	19.3581**
Cultivar	1	322.9302**	84.4118**	1	14345.8593**	112.7596**
Fertiliser	7	1980.0927**	25.3547**	7	2407.0562**	52.3019**
Light intensity x Cultivar	3	785.3887**	2.0478**	3	1852.6169**	14.1687**
Light intensity x Fertiliser	21	489.6168**	4.9817**	21	552.1143**	9.1590**
Cultivar x Fertilizer	7	370.1433**	4.1874**	7	532.7472**	4.1078**
Light intensity x Cultivar x fertiliser	21	431.2129**	6.3355**	21	123.73.03**	4.1121**
Error	192	122.3948	0.6114	780	33.6051	0.3114

MAT = Months after transplanting

**** =** significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX V

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on dry matter accumulation of tea plants in the main pot experiment

Source of variation	Df	Root	Stem	Leaf	Total
				Ibadan	
Light intensity	3	261.9431**	251.6795**	396.0930**	2667.6013**
Cultivar	1	61.1035**	0.2438ns	0.2607ns	60.8400ns
Fertiliser	7	24.0655**	13.1842**	18.3740**	157.0500**
Light intensity x Cultivar	3	8.4473**	1.2972**	2.7153**	29.5391**
Light intensity x fertiliser	21	6.2845**	5.1114**	8.2795**	44.7389**
Cultivar x fertilizer	7	4.7800**	5.7986**	6.8475**	38.8993**
Light intensity x Cultivar x fertiliser	21	4.9489**	7.2876**	7.2707**	49.6767**
Error	192	1.1379	1.3800	1.8962	8.0413
Total	255				
				Owena	
Light intensity	3	391.3801**	1017.1155**	524.6105**	3975.6853**
Cultivar	1	184.6541**	1.1141ns	3.5156ns	112.1613ns
Fertiliser	7	21.7743**	17.1122**	22.7613**	224.4036**
Light intensity x Cultivar	3	43.3743**	24.2777**	6.0909**	132.2745**
Light intensity x fertiliser	21	20.2421**	24.1045**	11.4318**	138.3001**
Cultivar x fertilizer	7	4.1431**	6.9014**	3.1654**	36.6874**
Light intensity x Cultivar x fertiliser	21	10.9236**	9.5152**	3.2664**	47.3188**
Error	192	1.6965	0.7204	1.6804	5.0081
Total	255				

****** = significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX VI

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on dry matter accumulation of tea plants in the residual pot experiment

Source of variation	Df	Root	Stem	Leaf	Total
				Ibadan	
Light intensity	3	83.1921**	71.9679**	483.9943**	1427.2129**
Cultivar	1	280.0184**	4.9618**	38.2465**	163.2485**
Fertiliser	7	37.8739**	40.9968**	50.7195**	354.3146**
Light intensity x Cultivar	3	7.8509**	22.8353**	38.9607**	81.8305**
Light intensity x fertilizer	21	8.4403**	16.5602**	14.1965**	88.5799**
Cultivar x fertilizer	7	14.5301**	9.3434**	7.2184**	35.1299**
Light intensity x Cultivar x fertiliser	21	5.6096**	9.3985**	7.2280**	40.0187**
Error	192	2.7895	2.0525	2.0840	10.5444
Total	255				
				Owena	
Light intensity	3	25.41.98**	20.5004**	52.4509**	259.0879**
Cultivar	1	22.3670**	52.9802**	66.6570**	125.6081**
Fertiliser	7	21.6692**	32.36.18**	43.3864**	284.0599**
Light intensity x Cultivar	3	4.5401**	14.2626**	18.0917**	83.9662**
Light intensity x fertilizer	21	6.7773**	3.6922**	3.5094**	26.4334**
Cultivar x fertilizer	7	4.3652**	9.0445**	11.4332**	44.1297**
Light intensity x Cultivar x fertiliser	21	9.4897**	6.3707**	8.0704**	54.3378**
Error	192	1.8224	1.7067	1.9636	9.6126
Total	255				

**** =** significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX VII

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on chlorophyll and carotenoids composition of plants tea in the pot experiment

Source of variation	Df	Ibadan		Owena	
Main experiment		**Chlorophyll**	**Carotenoid**	**Chlorophyll**	**Carotenoid**
Light intensity	3	41.2249**	1.6155**	34.4855**	7.2659**
Cultivar	1	0.9665**	0.0032ns	9.3445**	0.1968**
Fertiliser	7	0.7402**	0.1255**	0.5091ns	0.3777**
Light intensity x Cultivar	3	1.1312**	0.1101**	1.0277**	0.0410ns
Light intensity x fertilizer	21	0.4560**	0.0699**	0.8398**	0.3018**
Cultivar x fertilizer	7	0.7205**	0.1445**	0.5930**	0.3559**
Light intensity x Cultivar x fertiliser	21	0.3642**	0.0721**	1.2958**	0.1625**
Error	192	0.1139	0.0085	0.1207	0.0298**
Total	255				

**** =** significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX VIII

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on rate of leaf abscission in tea plants in the main pot experiment

Source of variation	Df	Ibadan	Owena
Light intensity	3	283.2123**	2655.1510**
Cultivar	1	557.1665**	558.1406**
Fertiliser	7	27.1551**	35.9263ns
Light intensity x Cultivar	3	88.7523**	231.5677**
Light intensity x fertiliser	21	14.4146.**	22.6629**
Cultivar x fertiliser	7	7.0311**	13.6228**
Light intensity x Cultivar x fertiliser	21	14.8384**	21.2760**
Error	192	6.8976	14.5990
Total	255		

**** =** significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX IX

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on vegetative parts of tea plants in the field experiment (Experiment 2) at Ibadan

Source of variation	Df	Number of leaves	Number of branches	Leaf area	Plant height	Stem diameter
3MAT						
Rep	3	762.9769**	20.1962**	1009002.9489**	146.3618**	0.0325**
Cultivar	1	430.5625ns	2.1267ns	33484.7301ns	0.0400ns	0.1145**
Error (a)	3	80.8449	6.6962	110180.5182	289.4403	0.0136
Light intensity	2	1065.4115ns	11.0538ns	688245.2423	45.6031	0.0070ns
Cultivar x Light intensity	2	87.0677**	17.8767**	121921.9703ns	65.7729ns	0.0006ns
Error (b)	12	204.8067**	4.8958	260248.5191	203.4142	0.0252
Fertiliser	5	1147.9375**	35.8434**	2693949.6199**	330.9377**	0.0365**
Cultivar x fertilizer	5	3108750**	12.7184**	512563.8068**	111.7798**	0.0266**
Light intensity x fertiliser	10	180.6240**	6.9684**	389315.5430**	164.3228**	0.0302**
Cultivar x Light intensity x fertiliser	10	119.5302**	1.6372ns	59980.4450ns	59.9569ns	0.0114ns
Error (c)	90	123.3581	3.9140	214386.3473	115.6250	0.0167
6 MAT						
Rep	3	500.9770**	1.3813ns	1305698.9033**	51.2396ns	0.0065ns
Cultivar	1	3959.2410**	0.0336ns	2733833.5206**	407.3669**	0.0743**
Error (a)	3	198.6285	13.6216	1140781.9950	192.0660	0.0263
Light intensity	2	748.6862ns	117.1513**	3947707.0054**	115.8266**	0.0040ns
Cultivar x Light intensity	2	311.8105ns	0.2347ns	183061.9716ns	208.1672**	0.0094ns
Error (b)	12	988.6236**	36.4198	1542413.2065	337.4181	0.0294
Fertiliser	5	904.5909**	38.1269**	2028728.0704**	505.0007**	0.0622**
Cultivar x fertilizer	5	746.3218**	36.4094**	590033.6231**	104.7161**	0.0149**
Light intensity x fertiliser	10	436.0857**	17.4017**	211389.1389ns	187.5207ns	0.0282**
Cultivar x Light intensity x fertiliser	10	286.6065**	11.5392**	230476.2998**	55.7585	0.0170**
Error (c)	90	147.7437	8.0629	216683.7923	136.332	0.0159
9 MAT						
Rep	3	1268.0210ns	43.9512**	338479.8953**	247.8476ns	0.0179**
Cultivar	1	25032.6165ns	474.5304**	82466799.6894**	182.0476ns	0.0568**
Error (a)	3	2416.3855	31.6787	247734.5323	655.2116	0.0172
Light intensity	2	8509.8572**	142.8054ns	18611364.8313**	10498.4772**	1.2224**
Cultivar x Light intensity	2	271.9545ns	103.4552**	905885.3591**	131.1455ns	0.0026ns
Error (b)	12	2309.2190**	81.8154	618291.6058	638.9212	0.0475
Fertiliser	5	3471.8191**	137.1742**	4824012.0022**	917.6123**	0.0708**
Cultivar x fertilizer	5	3280.1634**	139.9982**	1143472.1108**	149.2969ns	0.0183ns
Light intensity x fertiliser	10	1385.0783**	53.6879**	1672486.0998**	522.7662**	0.0364**
Cultivar x Light intensity x fertiliser	10	837.2356**	26.0975**	349967.5070**	182.2445ns	0.0305**
Error (c)	90	697.6884	34.6476	278685.4960**	321.0083	0.0358
12MAT						
Rep	3	5440.5671ns	24.6172**	14383712.9421**	1311.4179**	0.0713**
Cultivar	1	56090.0278**	1211.3300**	30335906.7384**	371.7827ns	1.3631**
Error (a)	3	9172.8750	20.3890	19239189.8739	1687.1136	0.0007
Light intensity	2	9037.7309**	16.8734ns	59629152.0747**	2531.4326**	1.9663**
Cultivar x Light intensity	2	5011.9288**	2.7736ns	9362420.5332**	439.1496**	1.2953**
Error (b)	12	7578.5127**	95.2900	12379207.4776**	1721.7962	0.0044
Fertiliser	5	7816.6611**	329.8626**	11038350.7794**	1303.7720**	0.5210**
Cultivar x fertilizer	5	5979.4986**	194.5511**	4062407.8085**	404.8653**	0.1133**
Light intensity x fertiliser	10	2576.8642**	75.5547**	3160723.2036**	557.5932**	0.1796**
Cultivar x Light intensity x fertiliser	10	1331.3622**	55.4524**	2545380.0885**	502.3140**	0.2703**
Error (c)	90	1079.5697	22.3435	1525315.7063	310.3192	0.0046

MAT = Months after transplanting

**** =** significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX X

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on vegetative parts of tea plants in the field experiment (Experiment 2) at Owena

Source of variation	Df	Number of leaves	Number of branches	Leaf area	Plant height	Stem diameter
3MAT						
Rep	3	406.1227**	4.6528**	512105.3085**	270.8737**	0.1246**
Cultivar	1	1072.5625**	46.6944**	48638.6267ns	2289.2238**	0.1389**
Error (a)	3	95.2986**	1.1806**	261324.4554**	212.6959	0.0264
Light intensity	2	241.9601ns	48.3819ns	1013180.1075**	923.0292**	0.0026ns
Cultivar x Light intensity	2	1.5677ns	4.8611**	130913.1403ns	137.3667**	0.0270**
Error (b)	12	145.4398**	4.8437**	241789.6294**	176.3233	0.0134
Fertiliser	5	412.5028**	103.0236**	633482.4086**	1922.4570**	0.0434**
Cultivar x fertilizer	5	178.8333**	20.6403**	289844.7563**	379.4301**	0.0098ns
Light intensity x fertiliser	10	270.2601**	29.0507**	291786.8257**	538.6616**	0.0182**
Cultivar x Light intensity x fertiliser	10	61.5885ns	8.3382**	211466.6121**	305.1949**	0.0067ns
Error (c)	90	83.0037	5.8375	153358.1164	146.1960	0.0155
6 MAT						
Rep	3	75.2407**	31.6277**	394150.2021**	54.9486ns	0.0705**
Cultivar	1	4556.2500**	832.5629	3730772.7296**	1323.1406**	0.0416ns
Error (a)	3	116.1944**	16.3141**	96063.9851**	183.8019	0.0266
Light intensity	2	3054.2205**	190.7973**	7604839.6925**	1597.7863**	0.0072ns
Cultivar x Light intensity	2	447.3802**	11.9666**	701369.7903**	125.6913ns	0.0069**
Error (b)	12	180.8721**	18.3090**	344994.4054**	206.5287	0.0104
Fertiliser	5	1445.9361**	49.0036**	2091018.3174**	1455.7327**	0.0299**
Cultivar x fertilizer	5	956.6583**	81.4848**	800154.5752**	504.1825**	0.0163**
Light intensity x fertiliser	10	346.3038**	68.0791**	795870.8023**	498.4280**	0.0174**
Cultivar x Light intensity x fertiliser	10	283.7385**	17.5806ns	687380.3482**	194.0457**	0.0091**
Error (c)	90	99.3734	26.8508	216364.0982	148.9625	0.0106
9 MAT						
Rep	3	2935.4855**	46.2153**	1805829.0355**	1042.3693**	0.2163**
Cultivar	1	37998.0298**	1263.2101**	11288228.0417**	0.1863ns	0.0765ns
Error (a)	3	852.8487**	15.1036**	504867.6660**	162.8267	0.0705
Light intensity	2	5945.0540**	515.3607**	21603431.7397**	7534.5230**	0.3338**
Cultivar x Light intensity	2	270.3011ns	37.9562**	810233.8318**	71.5036ns	0.0081ns
Error (b)	12	1029.2624**	24.5062**	1066363.6753**	343.7944	0.0577
Fertiliser	5	2093.0380**	204.4979**	1687734.4087**	356.8089**	0.0441**
Cultivar x fertilizer	5	1428.2839**	95.8247**	582166.8188**	495.9978**	0.0391**
Light intensity x fertiliser	10	1024.7100**	79.0680**	1489943.0798**	759.3456**	0.0287**
Cultivar x Light intensity x fertilizer	10	199.8231**	39.53.01**	167884.5612ns	273.4803**	0.0160ns
Error (c)	90	559.1394	16.1462	423500.6130	261.9323	0.0266
12MAT						
Rep	3	5690.1591**	88.2556**	4410192.4267**	470.5487**	0.0838**
Cultivar	1	133255.4184**	498.1452**	146102906.5055**	10784.8225**	1.2882**
Error (a)	3	2895.3212**	117.9932**	597648.0796**	29.2671	0.0296
Light intensity	2	14543.3125**	568.2463**	63712556.4862**	19505.9901**	0.8805**
Cultivar x Light intensity	2	965.2986ns	82.8786**	8380573.2538**	248.1133ns	0.0514**
Error (b)	12	2876.5093**	77.7792**	3736436.1011**	932.7089	0.0474
Fertiliser	5	8858.8531**	558.1568**	17980363.6028**	2962.9760**	0.3298**
Cultivar x fertilizer	5	5723.5142**	163.1461**	14259808.1135**	1431.3303**	0.2894**
Light intensity x fertiliser	10	3406.8063**	281.3092**	8723491.5577**	1372.4945**	0.1139**
Cultivar x Light intensity x fertiliser	10	1565.6757**	176.2862**	5505595.7187**	653.4258**	0.0693**
Error (c)	90	1178.2654	48.4606	1304663.2094	343.2869	0.0450

MAT = Months after transplanting;**** =** significant at 95% level of significance (P=0.05); ns = not significant

APPENDIX XI

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on rate of leaf abscission in tea plants in the field experiment (Experiment 2)

Source of variation	Df	Ibadan	Owena
3MAT			
Rep	3	11.1440**	8.7894**
Cultivar	1	14.8097ns	38.0278**
Error (a)	3	4.2366	0.5046
Light intensity	2	6.6794ns	28.7622ns
Cultivar x Light intensity	2	2.7578**	1.1059ns
Error (b)	12	3.9551	6.2512
Fertiliser	5	0.7014ns	11.6778ns
Cultivar x fertilizer	5	2.8619**	4.4903**
Light intensity x fertiliser	10	2.2316	7.6017**
Cultivar x Light intensity x fertiliser	10	1.6950	5.4122**
Error (c)	90	1.4319	4.9595
6 MAT			
Rep	3	28.6908**	33.4745**
Cultivar	1	113.7956ns	242.8403**
Error (a)	3	21.8045	42.9560
Light intensity	2	610.5643**	653.2153**
Cultivar x Light intensity	2	49.5677**	7.1319ns
Error (b)	12	24.5755	29.5625
Fertiliser	5	58.0116ns	170.6444**
Cultivar x fertilizer	5	12.4508**	3.7944ns
Light intensity x fertiliser	10	20.0208**	51.4486**
Cultivar x Light intensity x fertiliser	10	13.4990**	20.0111**
Error (c)	90	10.1137	13.4440
9 MAT			
Rep	3	43.6944ns	24.6927ns
Cultivar	1	784.7468ns	1263.2101**
Error (a)	3	204.8483	93.5122
Light intensity	2	8407.2726**	2911.3294**
Cultivar x Light intensity	2	124.1868ns	80.5734**
Error (b)	12	298.4048	75.7222
Fertiliser	5	574.5349**	191.0417**
Cultivar x fertilizer	5	196.6060**	122.3361**
Light intensity x fertiliser	10	128.6272**	106.1102**
Cultivar x Light intensity x fertiliser	10	120.3199**	51.5603ns
Error (c)	90	103.6277	73.9872
12MAT			
Rep	3	192.1437ns	29.5625ns
Cultivar	1	813.8658**	81.0000**
Error (a)	3	370.1745	65.6574
Light intensity	2	11754.1044**	6996.3038**
Cultivar x Light intensity	2	59.4446ns	723.0052**
Error (b)	12	475.5548	70.1499
Fertiliser	5	720.7564**	682.5153**
Cultivar x fertilizer	5	310.8878**	400.2917**
Light intensity x fertiliser	10	419.5196**	502.6101**
Cultivar x Light intensity x fertiliser	10	267.7482**	229.8906**
Error (c)	90	184.8835	110.9782

MAT = Months after transplanting

**** =** significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX XII

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on dry matter accumulation of tea plants on the field (Experiment 2)

Source of variation	Df	Root	Stem	Leaf	Total
			Ibadan		
Rep	3	2.1155ns	1363.3050**	163.9962ns	1867.9165ns
Cultivar	1	510.9484**	5238.7438**	981.0990**	14870.7863**
Error (a)	3	33.3251**	1296.3738**	251.9820**	2882.2005**
Light intensity	2	637.5667**	4987.8652**	1006.7310**	15667.9546**
Cultivar x Light intensity	2	206.6359**	3459.5671**	517.1138**	9274.5558**
Error (b)	12	102.8238**	821.4753**	111.8065**	2097.3373**
Fertiliser	5	196.2626**	2250.5412**	521.9139**	6394.1405**
Cultivar x fertilizer	5	75.2111**	1071.4178**	364.2637**	3653.4001**
Light intensity x fertilizer	10	171.8701**	1857.5303**	348.6046**	5405.7539**
Cultivar x Light intensity x fertiliser	10	91.2315**	1863.3247**	393.9682**	4992.8880**
Error (c)	90	49.7150	380.3187	115.9882	770.3198
Total	143				
			Owena		
Rep	3	97.0197**	398.0760**	77.1389**	1394.7342**
Cultivar	1	7934.3556**	21100.2255**	5192.6436**	93877.3854**
Error (a)	3	67.0283	88.4313	39.9890	430.0238
Light intensity	2	1396.1247**	5466.5853**	1236.9005**	21397.7415**
Cultivar x Light intensity	2	308.6074**	1050.6439**	273.9263**	4345.2356**
Error (b)	12	184.4558	1227.7164	285.0354	4129.5867
Fertiliser	5	905.7931**	3190.0973**	614.2994**	12205.8470**
Cultivar x fertilizer	5	767.5496**	2190.8002**	422.1503**	8832.8669**
Light intensity x fertilizer	10	211.8520**	613.7565**	147.8947**	2321.3791**
Cultivar x Light intensity x fertiliser	10	138.6173**	512.6296**	98.2664**	1770.1876**
Error (c)	90	70.9938	187.6481	60.7102	600.9021
Total	143				

****** = significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX XIII

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on survival count, pruning yield and leaf harvest of tea plants in the field experiment (Experiment 2)

Source of variation	Df	Ibadan			Owena		
		Survival count	Pruning yield	Leaf harvest	Survival count	Pruning yield	Leaf harvest
Rep	3	831.0975**	15.2515**	663.9914**	2469.7590**	132.5075**	168.0423**
Cultivar	1	590.8140ns	3056.6155**	22.5546ns	11736.6528**	1152.9986**	725.4493**
Error (a)	3	229.4324	1.2152	18.5956	688.0072	32.5049	42.2655
Light intensity	2	1960.1178**	11634.0525**	1142.9845**	11966.1510**	5644.9376**	79.4950
Cultivar x Light intensity	2	480.8233**	3336.6667**	200.5078**	316.8455ns	587.3954**	56.9685**
Error (b)	12	406.0919	6.0658	29.7195	948.6063	69.9683	86.4770
Fertiliser	5	18775.9830ns	2393.8862**	639.8911**	1638.8792**	1496.6840**	392.5663**
Cultivar x fertilizer	5	2322.4599**	3526.8781**	312.9251**	517.3861ns	328.4822**	7.7500ns
Light intensity x fertilizer	10	494.4634**	2063.4087**	364.5809**	410.6122ns	966.2309**	158.9627**
Cultivar x Light intensity x fertiliser	10	919.1490**	1139.9035**	319.4603**	875.8594**	704.6874**	326.7962**
Error (c)	90	501.0714	6.6908	52.7465	660.6376	56.6262	31.3648
Total	143						

****** = significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX XIV

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on nutrient uptake in tea plants in the field experiment (Experiment 2)

Source of variation	Df	N	P	K	Ca	Mg	Fe
				Ibadan			
Rep	3	18041.24**	2.77**	262.31**	905.58**	258.72**	3.42**
Cultivar	1	58139.66**	11.57**	655.15**	5303.12**	683.43**	22.07**
Error (a)	3	14636.60	1.08	121.91	730.82	138.89	2.67
Light intensity	2	51020.71**	5.43**	544.37**	2594.74**	380.87**	15.30**
Cultivar x Light intensity	2	36333.87**	5.89**	308.49**	2351.47**	223.92**	11.89**
Error (b)	12	6234.23	1.37	55.68	302.81	55.21	1.16
Fertiliser	5	35380.85**	5.74**	215.95**	2501.70**	336.50**	11.61**
Cultivar x fertilizer	5	15164.34**	5.44**	113.86**	1667.08**	226.39**	6.38**
Light intensity x fertilizer	10	13417.15**	1.02**	142.36**	1521.40**	148.11**	5.39**
Cultivar x Light intensity x fertiliser	10	17033.01**	0.89ns	140.71**	2476.65**	219.14**	6.06**
						53.20**	
Error (c)	90	5796.21	0.90	55.14	364.5		1.61
Total	143						
				Owena			
Rep	3	7630.84**	5.38**	235.35**	34.32**	131.60**	0.20ns
Cultivar	1	201432.66**	47.84**	953.47**	27526.68**	1456.57**	87.67**
Error (a)	3	1924.12	1.81	18.50	84.82	10.71	1.37
Light intensity	2	49220.00**	15.57**	261.76**	5284.45**	264.31**	47.26**
Cultivar x Light intensity	2	17043.27**	3.83**	86.27**	1348.24**	35.86ns	10.61**
Error (b)	12	12840.65	2.01	60.93	967.07	65.12	8.16
Fertiliser	5	36701.89**	2.11**	223.07**	4588.89**	338.45**	30.70**
Cultivar x fertilizer	5	21033.51**	1.57**	79.32**	2353.87**	160.55**	13.19**
Light intensity x fertilizer	10	7404.69**	1.69**	45.95**	808.18**	39.67**	16.71**
Cultivar x Light intensity x fertiliser	10	4604.82**	0.94ns	34.75**	517.17**	11.32ns	17.84**
Error (c)	90	3046.80	0.98	19.12	214.33	22.04	2.37
Total	143						

****** = significant at 95% level of significance (P=0.05); ns = not significant

APPENDIX XV

Summary of ANOVA on the effects of cultivars, light intensities and fertilisers on chlorophyll and carotenoids composition of tea plants in the field experiment (Experiment 2)

Source of variation	Df	Ibadan		Owena	
8MAT		Chlorophyll	Carotenoid	Chlorophyll	Carotenoid
Rep	3	0.2357**	0.0177**	0.6433**	3.3002**
Cultivar	1	17.5100**	0.0027ns	6.9991**	4.4249**
Error (a)	3	0.0723	0.0020	0.4131**	3.3841**
Light intensity	2	87.0682**	0.1490**	18.7815**	8.5513**
Cultivar x Light intensity	2	0.7370ns	0.0092ns	0.6635**	4.8035**
Error (b)	12	1.3874	0.0379	0.1635**	1.3900**
Fertiliser	5	7.6188**	0.0258**	0.7698**	4.9682**
Cultivar x fertilizer	5	5.4242**	0.0116ns	0.4477**	2.2430**
Light intensity x fertilizer	10	5.0881**	0.0145**	0.5202**	0.9771**
Cultivar x Light intensity x fertiliser	10	5.7063**	0.0391**	0.6353**	1.8990**
Error (c)	90	0.7366	0.0235	0.1857	0.5281
Total	143				
14MAT					
Rep	3	0.3277**	0.2432**	0.1559**	0.0050**
Cultivar	1	3.5992**	1.8468**	0.3751ns	0.0573ns
Error (a)	3	0.1795	0.0660	0.1302**	0.0066**
Light intensity	2	15.9860**	2.1261**	7.8470**	0.1534**
Cultivar x Light intensity	2	1.9365**	0.6464**	0.5172ns	0.0571**
Error (b)	12	0.3293	0.0563	0.0711**	0.0341**
Fertiliser	5	1.2925ns	0.2225**	1.1299**	0.0629**
Cultivar x fertilizer	5	0.2176ns	0.0511ns	0.3061**	0.0300**
Light intensity x fertilizer	10	0.4055**	0.1091**	0.5626**	0.0291**
Cultivar x Light intensity x fertiliser	10	0.3593**	0.1491**	0.3366**	0.0370**
Error (c)	90	0.1053	0.1247	0.0944	0.0329**
Total	143				

MAT = Months after transplanting

**** =** significant at 95% level of significance (P=0.05); ns = not significant

APPENDIX XVI

Summary of ANOVA on the effects of cultivars, plantain densities and fertilisers on vegetative parts of tea plants in the field experiment (Experiment 3) at Ibadan and owena

		Ibadan			Owena		
Source of variation	**Df**	**Number of Leaves**	**Number of branches**	**Leaf area**	**Number of leaves**	**Number of branches**	**Leaf area**
3 MAT							
Rep	3	10.4653**	2.0074**	12974.6706**	2.8637ns	1.3958**	11840.0754ns
Cultivar	1	455.0104**	6.2017**	47333.5103**	1200.6276**	18.3750**	499998.0904**
Error (a)	3	9.8229	0.8886	14013.9159	16.0582	1.5625	31573.5847
Plantain	2	29.0703**	20.5428**	19197.4577**	38.9089**	9.0651**	1529.7658ns
Cultivar x Plantain	2	59.8464**	11.6282**	47678.0920**	35.6745**	1.9297**	18404.0561**
Error (b)	12	4.6076	1.4245	2387.5647	42.9479	1.5807	17506.5160
Fertiliser	3	174.8681**	31.7663**	22738.4472**	395.5512**	17.1806**	337757.3537**
Cultivar x fertilizer	3	45.1563**	0.4753**	42090.7307**	186.3151**	3.6944**	285760.0160**
Plantain x fertilizer	6	27.7092**	32.0991ns	32354.7480**	53.0304**	1.9436**	54683.6347**
Cultivar x Plantain x fertiliser	6	95.5547**	9.3039**	42280.9411**	76.6432**	3.7804**	101578.8960**
Error (c)	54	3.5165	1.3027	3109.2500	12.6027	1.1696	17249.9724
6MAT							
Rep	3	76.9549**	1.0512**	5097.8538**	41.1484**	1.7569**	37661.1719**
Cultivar	1	304.5937**	105.2109**	14665.1400**	1414.5026**	61.7604**	441714.3868**
Error (a)	3	61.8715	0.5095	7859.1941	26.0443	0.3924	18894.3131
Plantain	2	135.3307**	31.8932**	384131.8583**	106.6979**	2.1120ns	47945.4328ns
Cultivar x Plantain	2	86.1328**	16.4766**	599919.8625**	28.3854**	0.8151ns	89612.2105**
Error (b)	12	11.8325	1.1293	5460.4485	48.4062	1.7726	35763.4966
Fertiliser	3	221.2118**	4.1970**	134849.2453**	758.5929**	30.7569**	377921.4974**
Cultivar x fertilizer	3	301.0174**	2.7943**	91565.0242**	389.5720**	12.5590**	215466.3566**
Plantain x fertilizer	6	108.0113**	2.1189**	27510.1408**	109.3611**	1.8168**	70695.7560**
Cultivar x Plantain x fertiliser	6	43.9939**	3.3411**	45105.0501**	105.0486**	14.3325**	63195.1283**
Error (c)	54	19.9080	1.6450	4981.5093	37.0205	2.5584	31509.3927
9 MAT							
Rep	3	62.9520**	3.4462**	37784.8110**	359.3615**	13.9236**	1072211.5581**
Cultivar	1	868.5059**	118.1484**	71049.1221**	19920.0983**	465.9609**	12994308.9466**
Error (a)	3	81.6534	1.8377	57906.2572	48.6304	2.9332	548200.8182
Plantain	2	841.0983**	59.9245**	763524.7296**	1482.9977**	45.0358**	1573227.2661**
Cultivar x Plantain	2	118.9473**	13.1563**	57885.1190**	822.6496**	16.7480**	1541396.9233**
Error (b)	12	80.8066	2.7930	24440.8914	43.3773	15.3451	202842.0233
Fertiliser	3	159.4850**	10.5816**	123995.0568**	2976.7023**	117.3924**	2457051.7619**
Cultivar x fertilizer	3	191.2559**	4.2960**	47087.9605**	2013.4042**	46.6276**	1704282.7764**
Plantain x fertilizer	6	147.7441**	2.7092**	42416.8838**	395.5746**	13.8136**	147310.8042**
Cultivar x Plantain x fertiliser	6	123.5723**	2.9444**	81750.7932**	526.2363**	19.5449**	565229.7921**
Error (c)	54	44.0530	1.0852	14637.3458	117.4141	2.5812	139065.7907

MAT = Months after transplanting; **** =** significant at 95% level of significance (P=0.05); ns = not significant

APPENDIX XVII

Summary of ANOVA on the effects of cultivars, plantain densities and fertilisers on survival count of tea plants in the field experiment (Experiment 3)

Source of variation	Df	Ibadan	Owena
Rep	3	193.9227ns	112.6046ns
Cultivar	1	15771.4211**	19694.0104**
Error (a)	3	524.4488	1320.0752
Plantain	2	27471.7051**	5257.1534**
Cultivar x Plantain	2	2290.9461**	236.5747ns
Error (b)	12	562.1279	325.7652
Fertiliser	3	680.4795ns	1784.9981**
Cultivar x fertiliser	3	987.9810**	1916.0706**
Plantain x fertiliser	6	1047.4065**	941.6132**
Cultivar x Plantain x fertiliser	6	2150.1259**	1804.8617**
Error (c)	54	634.7353	895.1507
Total	95		

**** =** significant at 95% level of significance (P=0.05)

ns = not significant

APPENDIX XVIII

Summary of ANOVA on variation in light intensities under different plantain densities on the field at Ibadan and Owena

Source of variation	Df	Ibadan				
		October	**December**	**March**	**June**	**Average**
Rep	3	34.1208**	17.8292**	3160.49**	11.9076ns	2.8261ns
Plantain	1	921.8672**	618.4645**	555.9445**	538.5762**	650.5225**
Error	3	36.2741	10.5497	4.1752	41.7720**	5.7533
Total	7					
				Owena		
Rep	3	167.6268**	72.6526**	18.5691**	57.3581**	18.8060**
Plantain	1	1232.8095**	452.8545**	716.3113**	332.3042**	500.3866**
Error	3	11.8749	35.5460	22.7667	18.9777	18.4304
Total	7					

**** =** significant at 95% level of significance (P=0.05)

ns = not significant