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Short Communication

GROWTH RESPONSE OF *Garcinia kola* (HECKEL) PLANT TO NATURAL SHADE IN A RAINFOREST ENVIRONMENT OF NIGERIA

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ABSTRACT

Sustainable production of Garcinia kola can be achieved through the establishment of its plantation with the right silvicultural requirements. The growth response of Garcinia kola (Heckel) plant under a Tectona grandis L. plantation and open field was studied for three years. The experiment was laid out in a Randomized Complete Block Design (RCBD) involving three replicates per treatment. The treatments were shade from Tectona grandis (Teak) and control (open field without shade where fresh clear-felling/harvesting of Tectona grandis (Teak) has just been carried out). Measurement of treatment effects on growth of Garcinia kola commenced six months after planting and was repeated at six-month intervals, while soil temperature was measured at two-week intervals. Significantly ($P \leq 0.05$) higher differences were observed after the first year in height, collar diameter, and crown width on the shaded plant. The soil temperature for the shaded field was significantly ($P \leq 0.05$) lower than the control field. Hence it is recommended that sustainable production of Garcinia kola through plantation establishment should be done under the shade of older trees.

Key words: *Garcinia kola,* plantation, *Tectona grandis*, sustainable production, open field

INTRODUCTION

Garcinia kola (Heckel) is one of the classified endangered forest food trees with the possibility of going into extinction in the nearest future except something is done to conserve and increase its population (Turner *et al.*, 2011). It is a highly valued multi-purpose tree for its fruits, seeds, stems, roots and barks that are used in Western and Central African regions. It is a very useful indigenous fruit that is eaten fresh, served as kola, high in medicinal value and reputed snake repellent (Babatola and Adelaja, 1999; NACGRAB, 2008). Through the collection, processing, and marketing of their products, they provide employment and enhance the rural economy, thus contributing to poverty alleviation (Leakey *et al.*, 2005; Chigbu *et al.*, 2011). Despite its socio-economic importance, the cultivation of the plant is very much limited. As a tropical fruit tree species, it is characterized by slow growth rate which has discouraged farmers from growing it (Oboho and Urughu, 2010).

In Nigeria, *Garcinia kola* is one of the rich plant resources which exist in the wild, home gardens or fallow lands due to rapid deforestation, slow natural regeneration, uncommon seedlings and limited cultivation as a result of the difficulty in its silvicultural requirement. This plant is decreasing because the rate at which the diversity is lost to habitat destruction and over-exploitation far exceeds the rate at which collection and conservation is done, religious and/or socio-cultural beliefs, lack of information on their husbandry as well as reproductive physiology and the long gestation period (Aduse-Poku *et al.*, 2003). If this current practice is allowed to continue, there will be a low probability of obtaining its valued products on a sustainable basis. This, therefore, demands urgent attention. Artificial regeneration and subsequent improvement of this species (domestication) appear to be a very viable option.

There have been studies toward improving the productivity of this forest food tree species in Nigeria. These include comparative evaluation of different organic fertilizers on the soil fertility, leaf mineral composition and growth (Moyin-Jesu and Adeofun, 2008), vegetative propagation (Yakubu *et al.*, 2014a), effects of water soaking and light on the dormancy (Yakubu *et al.*, 2014b) and effects of pre-germination treatments on the germination and early growth (Oboho and Urughu, 2010).

However, there is still scanty information on the crop's silviculture and growth performance in the field. The limitation in its cultivation is traceable to contrasting information on the silvicultural requirements: shade tolerant but grows faster in sun (UNAFAS, 2008) and existence in the understorey of moist semi-deciduous forest with a spreading or fairly narrow crown (Oboho and Ogana, 2011). This information needs to be verified to encourage the plantation establishment of *Garcinia kola*. This study was, therefore, carried out to assess its growth performance under shade of *Tectona grandis* plantation and without shade on the field.

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MATERIALS AND METHODS

Study Area

The experiment was carried out at the Forest Reserve of Rainforest Research Station, Ore in Ondo State, Nigeria (6°44′40.30″-43.04″N; 4°51′37.34″-40.80″E), between May 2016 and May 2018. The soils of the study area are classified as basement complex rocks composed mainly of granite-gneiss, mica-schist, and feldspathic rocks. The soils belong to the Omotosho soil series (Esu *et al.,* 2014).

A land area of 24 × 24 m was marked out in a nine-year-old *Tectona grandis* plantation of 3 m^2 spacing. Similarly, the land area of 24 × 24 m was marked out where fresh clear-felling/harvesting of *Tectona grandis* (Teak) has just been carried out. Pegging of the land area was done within the furrow of the plantation and the clear-felled land at 3 m^2 spacing. Eighty-one (81) relatively similar-sized seedlings (13.0 cm height, 0.46 cm collar diameter, and 14.60 cm crown width) of *Garcinia kola* which were raised a year earlier under a shade in the nursery were selected out of 300 and planted at the points of peg under the *Tectona grandis* (Teak) plantation; the same number was replicated on the open field thus resulting in a total of 162 seedlings.

Experimental Design

The experiment involved two treatments, replicated thrice in a Randomized Complete Block Design (RCBD). The treatments consisted of shade from *Tectona grandis* (Teak) trees and control (open field without shade where clear-felling/harvesting of *Tectona grandis* (Teak) trees have been carried out).

Data Collection

Grid soil sampling method was used to collect representative topsoil (0-15 cm) samples which were air dried, crushed in agate mortar and passed through a 2-mm sieve. Standard methods were used to determine the physical and chemical properties. Initial measurements were taken just at the point of transplanting from the nursery. Measurement of treatment effects on height, collar diameter, and crown width of *Garcinia kola* commenced six months after planting and was repeated at six-month intervals. Soil temperature around the plants was measured using a Gardeners Soil Thermometer (Brannan Thermometers, Cleator Moor, Cumbria, England) at 5 cm depth early in the morning at two-week intervals. Collar diameter was measured using Vernier callipers at stem circumference closest to the soil, height was measured using measuring graduated pole placed beside plant from the ground level to tip of the top leaf and crown width was measured from the tip of the longest branch across to the other using graduated pole. Weeding was done by uprooting with hands and hoe at four-week intervals.

Statistical Analysis

The data obtained in this study were analyzed by "two sample t-test" using *R* statistical software and following the method described by Gosset (1942).

RESULTS

The soil analysis result of the experimental location before the experiment is presented in Table 1. Data obtained showed that the soil belongs to the sandy loam texture class. The soil pH was 6.7 indicating that the soil showed near-neutral pH. It had high levels of residual nutrients with total nitrogen content of 3.2 g kg^{-1}. The available P in the soil was 18.61 mg kg^{-1}, organic carbon was at 33.65 g kg^{-1}, organic matter at 42.66 g kg^{-1} and soil exchangeable acidity 0.15 cmol kg^{-1}. The exchangeable bases in the soil were also determined; Ca (6.21 cmol kg^{-1}), Mg (1.60 cmol kg^{-1}), K (0.90 cmol kg^{-1}) and Na (0.60 cmol kg^{-1}). These values were considered adequate to sustain optimum crop growth on fallowed lands for few years (Kogbe and Adediran, 2003). There, was, therefore sufficient nutrients supply for an efficient plant growth rate.

Data Collected on *Garcinia kola* Morphology during the Experiment

The result of the growth parameters for *Garcinia kola* is presented in Tables 2, 3 and 4. The average height of 44.28 cm was obtained in 2006, while 54.76 cm was obtained in 2017 and 73.61 cm was obtained in 2018 for plants under the open field. The result showed that the average height of 45.41 cm was obtained in 2016, 59.52 cm in 2017, while the

Table 1: Pre-planting soil properties of the site

Soil properties	Value
Particle size distribution (g kg^{-1})	
Sand	740.00
Silt	168.00
Clay	92.00
Textural class	Sandy loam
pH (1:1 H_2O)	6.70
pH (1:2 $CaCl_2$)	5.20
Exchangeable acidity (cmol kg^{-1})	0.15
Organic carbon (g kg^{-1})	33.65
Organic matter (g kg^{-1})	42.66
Total nitrogen (g kg^{-1})	3.20
Available phosphorus (mg kg^{-1})	18.61
Exchangeable bases (cmol kg^{-1})	
Ca^{2+}	6.21
Mg^{2+}	4.65
K^+	0.90
Na^+	0.60
ECEC	6.68

ECEC - effective cation exchange capacity

Table 2: Effect of shade on *Garcinia kola* height

Treatment	Average height (cm)		
	2016	2017	2018
Control (no shade)	44.28^a	54.76^a	73.61^a
Shade	45.41^a	59.52^b	86.56^b
SEM	0.751	1.542	2.545

SEM - standard error of the mean. Means with the same letter in a column are not significantly ($P \leq 0.05$) different.

Table 3: Effect of shade on *Garcinia kola* collar diameter

Treatment	Collar diameter (cm)		
	2016	2017	2018
Control (no shade)	1.09^a	1.16^a	1.72^a
Shade	1.03^a	1.38^b	2.04^b
SEM	0.173	0.331	0.400

SEM - standard error of the mean. Means with the same letter in a column are not significantly ($P \leq 0.05$) different.

Table 4: Effect of shade on *Garcinia kola* crown width

Treatment	Crown width (cm)		
	2016	2017	2018
Control (no shade)	31.34[a]	38.63[a]	48.74[a]
Shade	31.99[a]	42.93[b]	60.93[b]
SEM	0.570	1.466	2.459

SEM - standard error of the mean. Means with the same letter in a column are not significantly ($P \leq 0.05$) different.

average height was 86.56 cm in 2018 for plants under the shade. Statistical analysis showed no significant ($P \leq 0.05$) differences in height, collar diameter, and crown width per plant in the first year of planting for both shade and open field plants. While the plants showed significant ($P \leq 0.05$) differences in height, collar diameter and crown width per plant of *Garcinia kola* in the second and third years consecutively (Tables 2, 3, and 4) for both shade and open field plants.

Data Collected on Soil Temperature around *Garcinia kola*

Data collected on soil temperature around *Garcinia kola* soil are given in Table 5. In the three consecutive years, mean temperature value was 26℃ in 2016, 28℃ in 2017 and 31℃ in 2018, in soil under the open field with no shade while the temperature of soil under the shade of *Tectona grandis* was 25℃ in 2016, 20℃ in 2017 and 18℃ in 2018. However, statistical analysis revealed that there were significant ($P \leq 0.05$) differences in temperature of soil under the different atmospheric conditions.

DISCUSSION

The observable growth with time in *Garcinia kola* seedlings under the two different atmospheric conditions could be attributed to good aeration as well as nutrient availability in the soil supporting the growth of the seedlings. The increase in the growth rate of *Garcinia kola* under shade is an indication that the species will perform best under a low-light environment. A study by Onyekwelu and Akindele (2002) suggests that the effect of light intensity on germination and seedling growth is variable and may be species-dependent. FAO (2005) reported that growth of the plant under shade improved the soil moisture content, increased fertility, protection from sun, wind, rain, and reduced weed infestation. Decomposition organic mulch, by providing organic matter, improves the stability and permeability of the soil (Nwokocha *et al*., 2009; Ezenne *et al*., 2019). This is supported by Sultan (2000) that individuals of many species respond to shading with accelerated stem and leaf elongation, suppressed branching, an increase in specific leaf area (SLA), and a decrease in allocation to root mass. Light is known to affect every aspect of plant growth and development but in the case of *Garcinia kola* in this study, the species needs a dense shade with a little amount of light for its optimum growth in the early stage. This is in agreement with the findings of Bolanle-Ojo *et al.* (2016) that *G. kola* preferred low light intensities for optimum biomass production. Research has shown that if a plant gets limited sunlight, the process of photosynthesis slows down and the plant begins to grow upward and stretch its stems to reach for the sunlight, a process called etiolation which further promotes growth and development of certain tissue and organ types (Sorin *et al.*, 2005; Da Costa *et al.*, 2018; Trinh *et al.*, 2018). However, this result contradicts an earlier postulation by UNAFAS (2008) that *Garcinia kola* grows faster under the open field. The slower growth rate in unshaded *Garcinia kola* either by fallen leaves or vegetation could be attributed to shock from direct sunlight, loss of topsoil, loss of organic matter and nutrients loss through soil erosion.

Table 5: Shade effect on soil temperature around *Garcinia kola*

Treatment	Average soil temperature (℃)		
	2016	2017	2018
Control (no shade)	26[a]	27.53[a]	31[a]
Shade	25[b]	20[b]	18.27[b]
SEM	0.707	1.940	2.523

SEM - standard error of the mean. Means with the same letter in a column are not significantly ($P \leq 0.05$) different.

The effect of shade on soil temperature around the sample units in the experimental sites is reflected in the significant difference in the soil temperature. Soil temperature increase with year is a confirmation of the effect of climate change and increase in global warming with years. Teak as a shade-providing plant was purposively chosen because of its abundant availability and rapid growth rate in the rainforest zone. Though there was shade provision for the plant during the rainy season, Teak is a deciduous tree that sheds its leaves in the dry season serving as mulch thereby regulating the soil temperature. The significantly different temperature in shaded soil compared to the control could be as a result of ameliorated thermal stress and reduced evapotranspiration. A positive effect from tree canopy on the neighbouring plant has been reported by Callaway (2007).

Research has shown that tree canopy serves as shade from direct heat from the sun while the leaf biomass mulches the soil thereby reducing evapotranspiration which in turn positively affects soil temperature (Ji and Unger, 2001; Kar and Kumara, 2007). The result of this study aligns with the report of Kumar *et al.* (2014) on the efficacy of poplar and silver oak tree leaf mulch in reducing high soil temperature extremes. It has been postulated that soil mulching with organic material is one method of soil water protection that also helps to moderate the soil temperature within the root system of crops. (Obalum *et al*., 2011; Edyta, 2015). It is also supported by El-Shaikh and Fouda (2008) who postulated that organic mulches are better than plastic mulching in a hot climate due to their ability for reducing soil temperature. Nwokocha *et al.* (2009) reported that mulching breaks down the kinetic energy of rain drops thereby reducing their impact on the soil, resulting in reduced soil compaction and aggregate disintegration.

CONCLUSION

This study has shown that raising *Garcinia kola* seedlings under shade improves their growth compared to raising them in the open field. Hence, shade has a facilitative effect on the growth and survival of *Garcinia kola.* This implies that the species needs a dense shade with a little amount of light for its optimum growth in the early stage. Lower soil temperature was observed in plants under shade when compared to the plants in the open field hence the amelioration effect of indirect sunlight via reduction in evapotranspiration is confirmed.

RECOMMENDATION

Enabling edaphic and atmospheric conditions for plantation establishment of endangered *Garcinia kola* can be achieved through the provision of shade. It is, therefore, recommended that massive production of *Garcinia kola* seedlings for plantation establishment or beating up could be achieved by raising the seedlings under shade in the early years. This would help solve the problem of its population decline and save the species from going into extinction.

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