Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 178 (2023) 56862 - 56867

ISSN: 2229-712X

Response of Cashew Seedlings (*Anacardium occidentale* L.) to Shade Regimes, Soil Moisture and Light Intensity

Nduka Beatrice Abanum and Aremu-Dele Olufemi

Agronomy and Soil Division, Cocoa Research Institute of Nigeria, P.M.B. 5244, Ibadan, Oyo State, Nigeria.

ARTICLE INFO

Article history:

Received: 11 March 2023;

Received in revised form:

25 April 2023;

Accepted: 30 April 2023;

Keywords

Cashew,
Seedlings,
Shade Regimes,
Soil,
Light.

ABSTRACT

To provide cashew seedlings with the optimum growing conditions possible during the early phases of establishment, it is crucial to reduce stress. The purpose of this study was to analyze the physiological response of cashew to soil moisture and light conservation under various shading regimes. The seedlings were raised in a 2.8 litter plastic container filled with topsoil under partial shade, semi-partial shade and unshaded (control) conditions at the Cocoa Research Institute of Nigeria, (CRIN) Ibadan. The experiment was laid out in a Complete Randomized Design with 4 replications per treatment. The shade effects were studied for 7 months and data on morphological parameters such as plant height, stem girth, numbers of leaves were collected. Light and moisture meter were used to read the amount of sunlight penetration and soil moisture. Data collected were subjected to analysis of variance and treatment means. From the result, plant height growth was highest in the control (full sun) at 50.52cm as the control also had the thickest stem girth and highest number of leaves. Shade imposes a limitation on growth and development of cashew seedlings but varies with shading levels. It should be noted that the results observed in this study are specific to the environmental conditions of the study site.

Introduction

Nigeria is one of the major contributors to the world's global cashew production like India, Brazil, Vietnam, Tanzania, Mozambique, Indonesia, Sri Lanka, and Australia (Oluyole et al., 2017). The cashew tree from which the economic nut and apple is produced is often propagated by seed (Yeboah *et al*., 2020) and usually nurtured in the nursery for about two to three months before transplanting (Hammed et al., 2012). Most cashews seedlings produced in the nurseries are done in a relatively controlled environment in favour to the young plant (Jain, 2021). However, these nursery structures vary. In humid locations, nursery structures may be needed only to provide shade or to keep pests out, whereas under arid conditions, nursery enclosures are needed to maintain a higher humidity for the germinating seed, rooting cuttings, and successful grafting. Shade is important in the initial establishment; as it affects plant growth and development (Santelices et al., 2015 and Kelly et al., 2015). Murray (1975) has summarized most of the factors associated with shading effects, as reduction in diurnal variations in soil and air temperatures, reduction in wind movement and improved mineral recycling. Similarly, Beer et al., (1998) in their work concludes that shading management reduces air temperature fluctuation, wind, humidity, soil moisture and maintains soil fertility. On the other hand, Tree crops like cocoa seedlings growing under shade has been observed to be more vigorous and produces more biomass than the unshaded seedlings (Mensah et al., 2022). Agele et al., (2017) also observed that oil palm seedling raised under shade had enhanced morphological traits than seedlings raised in the open.

One of the factors that affects soil moisture content is availability of a cover or shade crop (Gwak and Kim, 2017). Soil moisture according to Seneviratne et al., (2010), is the amount of water that is retained on unsaturated zone on soil. Its plays a crucial component in the food cycle because apart from it's been a key part in the food chain, it also flourishes the plants with water needed for growth. Light being another important determining factor for growth affects plants in many ways. According to Poorer et al., (2019) report plants respond differently to light intensity, while Chaar et al., (1997) stated that environmental factors such as light intensity changes cause changes to the final quality of seedlings. Seedling producers can regulate the seedlings growth, development, and plant vegetative quality by changing and optimizing the light intensity according to Lavender, (1984). This agrees with Whitelam and Halliday, (2007) who reported that light is one of the important factors that affects young seedlings growth character while Tang et al., (2015) reports on young tree seedling survival. However, it is not known if light shading adversely affects the growth of young seedlings of the shade-intolerant, species like that of *Anacardium occidentale* L., Moreso scientific information on this aspect will not only bridge the knowledge gap but also aptly supplement the high yielding varieties, thereby boosting the cashew plant productivity. Thus, in the initial stages of establishment it is essential to minimize stress for plants with the best growing conditions possible. The present study was designed with the objective of evaluating the physiological response of cash

Tele: +2348029592716
E-mail address: beatricenduka@yahoo.com

to soil moisture and light conservation under different shading conditions.

Materials and Method

Cashew (*Anacardium occidentale* L.), seedlings were raised on a 2.8 litter plastic container under different shade conditions at the experimental station of Cocoa Research Institute of Nigeria (CRIN) Headquarters situated in the rain forest zone of Nigeria (latitude7^{o} 25'N, 3^{o} 25'E., altitude 122m above sea level). The rainfall is between 1250-1500mm per annum and average temperature of 30^{o}C. The Rapitest equipment was used to measure soil moisture and light intensity. The Rapitest equipment was imposed into the soil at 5cm to 40cm deep, while the monthly minimum air temperatures and minimum relative humidity used was from the metrological station in CRIN Ibadan.

Shading Material

Shade net was used for the partial and semi partial shade treatments, while the natural sunlight penetration in the nursery house was designated as the un-shaded treatment-full sun (control). Shade treatments were imposed two days before sowing of the cashew nuts.

Plant Material

Cashew nuts were sown with forest topsoil at temperatures between approximately 24°C and 31°C in a partial, semi partial and control (full sun).

Experimental design

The experiment was laid out in a Complete Randomized Design (CRD) with four replications per treatments. The shade effects were studied for seven months and arranged in the following manner; four fork stands of 1.5m high were erected above treatment and then shading material was spread over fork stick in such a way that it was hanging on all sides, but not touching the ground to ensure ventilation on the semi partial, while the partial was stretched all over to the ground and a control put directly without shading material (full sun). Sixteen pots were arranged per treatment in a 4 x 4 combination.

Data collection

Morphological parameters such as plant height stem girth and leave count was recorded, while the light and moisture meter were used to read both the amount of sunlight penetration and moisture of the soil. Metrological report used were from a nearby metrological station CRIN Ibadan to know the environmental conditions.

Data analysis

Data collected were subjected to analysis of variance (ANOVA) using SAS statistical package at 5% probability level.

Results

Effect of shading on cashew seedling growth

Graphical representations of plant height, stem girth, number of leaves and leaf area are shown in Fig 1- 4 showing the trend of cashew seedling adaptations to different shading regime. Seedling survival was 100% in all shade treatments, but growth performance was affected in some treatments.

Plant height growth was highest in the control (full sun) at 50.52cm indicating that treatment differences in height growth were as a result of differences of environmental behaviour within the experimental periods, however the months of November, December and January was significantly enhance although similar in growth pattern was shown in fig 1 while in the semi partial shade plant height increased significantly early from October till January unlike the control (full sun) that was only significant in the month of October. Stem girth on the other hand, under the partial and semi-partial shade, increased significantly in the months of October – December following a similar pattern to that of leaf number. In fig 2, Stem girth on the other hand, under the partial and semi-partial shade, increased significantly in the months of October – December following a similar pattern to that of leaf number. In fig 3, leaf number was significantly affected in the partial shade only in the months of September, October, and November, with the semi partial shade and the control showing no significant improvement in the number of leaves in the cashew seedlings. The level of moisture in the soil was more under partial shade treatments in the month of September, although not significant.

Table 1 shows the soil nutrient table levels which was okay for cashew production while table 2 shows the atmospheric condition in the location. Plants under the semi partial shade treatment, good percentage (0.27%-5.85%) moisture content was observed to have an increased from September to February throughout the experiment (Table 3). Generally, soil water content remained at a higher level under shaded plant than in full sun. The light treatments influenced plants under the control treatments and was significant in the month of December and January as shown in (Table 4). Lower but similar rates were also observed in seedlings in the partial treatments, with a decrease in decreasing irradiance, providing unhealthy condition for growth. 24 weeks after treatment was imposed, root length was longest in the semi partial shade treatment 52.08cm although not significantly different from the partial and control treatments (Table 5), however the root weight was different with the full sun treatment (control) (84.00g) when compared to other treatments. In all treatments, the seedlings grew exponentially and differences among treatments increased in absolute terms with time.

Plant level adaptation to shade

Cashew seedlings in this experiment was significantly affected by semi partial shading regime and were found to produce significantly taller plants when compared to full sun (control) treatments, this is evident in the study of Thangam and Thamburaj (2008) who stated that plants grown under shade exhibited better growth in terms of plant height as compared to those in open field in tomatoes. This is contrary to the number of leave; the results showed that the direct effect of the solar radiation increased the number of leave in the no shaded treatments. It should be noted here that the no shade treatment grown in full sun (control) produces smaller average leaf area significantly. The variation of temperature and relative humidity for the period used are presented in table 2, and the difference between shade and (full sun) control decreased with increase in level of shade. These changes in climate can influence the physiological process of the plant.

Discussion

The right amount of light is critical for healthy development of seedlings, however too much light may lead to sun scorching and drying out of the tender tissue in a plant. According to Mohotti et al., (2020), an environment which have only small proportion of clear, sunny days per year, giving too much shade could cause yield reduction due to a reduced radiation by the canopy. Yang, et al., (2019) observed adaptations under shaded conditions with an increased in leaf area and improved light capture, and lower respiration rates. Franck and Vaast, (2009) also examined how coffee adapts to different shade levels by taking spot measurements of the plant, a negative relationship was observed between the average leaf to light exposure leaf and quantum use efficiency

and a positive one between average leaf light exposure and maximum photosynthesis rates. In this experiment, cashew seedlings preferentially invested in stem elongation in the month of February to the detriment of the other parts of the plant, this is in line with Isaac et al., (2007) observation on a gradient effect due to shade with cocoa growing closer to shade trees, where shade was highest its was significantly larger than those grown further away. The treatment (full sun) was reduced to less than half of the control value (semi partial), stem girth, leaf area and the number of leaves were not affected. Matos et al., (2009) study of coffee leaf physiological response to light found that shading caused a significant increase in leaf area, like those observed to this study, as well as concurrent increases in leaf mass per area in comparison to coffee grown in full sun. In this study, cashew seedlings survived in artificial shade, but growth was severely altered by the low irradiance treatments. The shade-induced reduction in height growth was mainly a result of a reduction in inter node number, because the number of leaves was almost constant in all shade treatments. Growth of stem girth and leaf area was also reduced in the low irradiance treatments, an effect observed in other species (Regnier and Harrison 1993). While Baltzer and Thomas, (2007) identified the whole plant light compensation point (WPLCP) as a simple measure of shade tolerance below their light compensation points are predicted to be incapable of long-term survival.

Conclusion

Shade imposes a limitation on growth and development of cashew seedlings but varies with shading levels. However, cashew farmer's preference sowing in the nursery than sowing directly is important if they are aware of the ecological impart. It should be noted that the results observed in this study are specific to the environmental conditions of the study site and the full sun was good but partial. Although in Ibadan (rain forest zone) rainfall and average light levels at this site are not consistent like those from the savannas' belt of Nigeria, the soil found in this region is characteristic of that found in the majority of cashew growing regions.

Fig 1: Plant Height (cm)

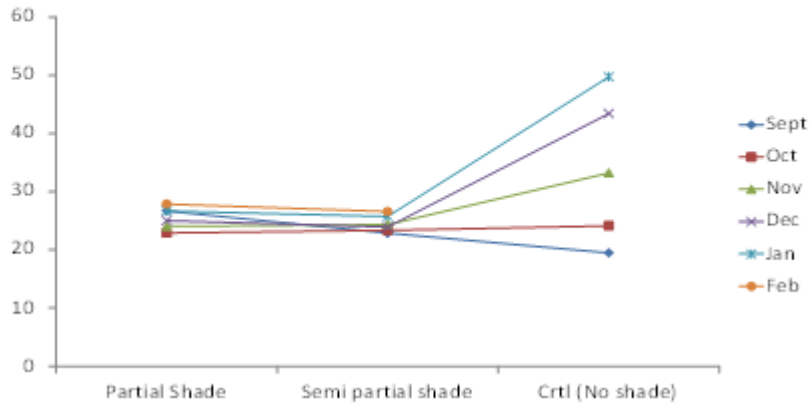

Fig 1. Treatment-Plant height from Sept. 2021 to Feb. 2022.

Fig 2: Stem girth(cm)

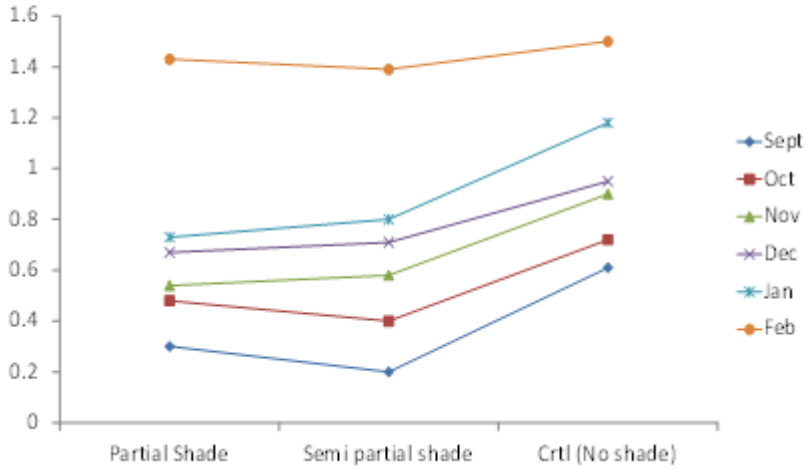

Fig 2. Treatment - Stem girth from Sept. 2021 to Feb. 2022.

Fig 3 : Number of leaf

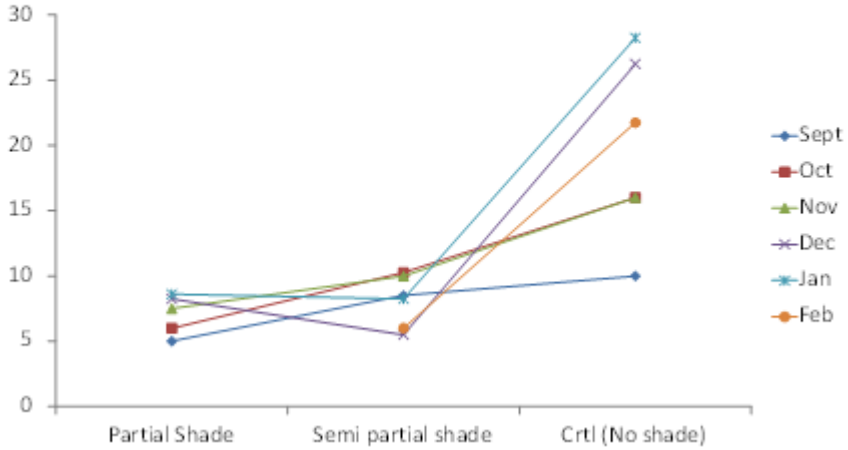

Fig 3. Treatment- number of leaves from Sept. 2021 to Feb. 2022

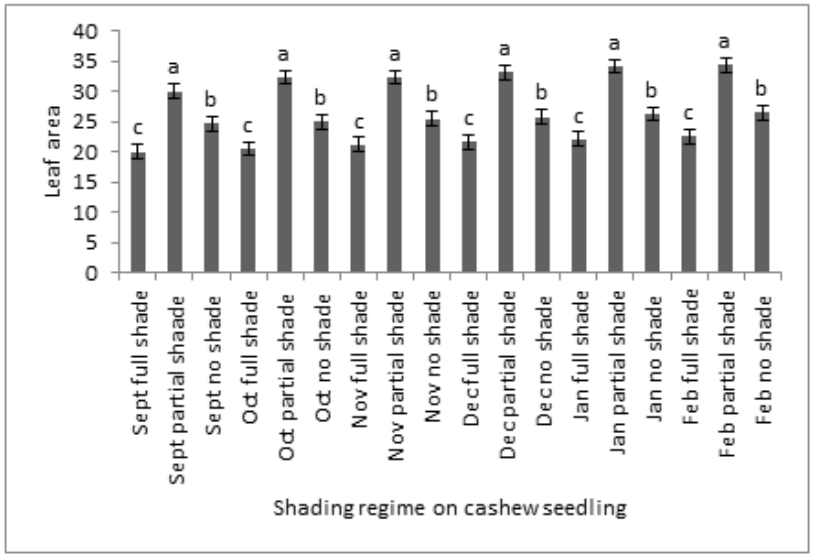

Fig 4. Effect of shading regime on leaf area of cashew seedlings from Sept. 2021 to Feb. 2022.

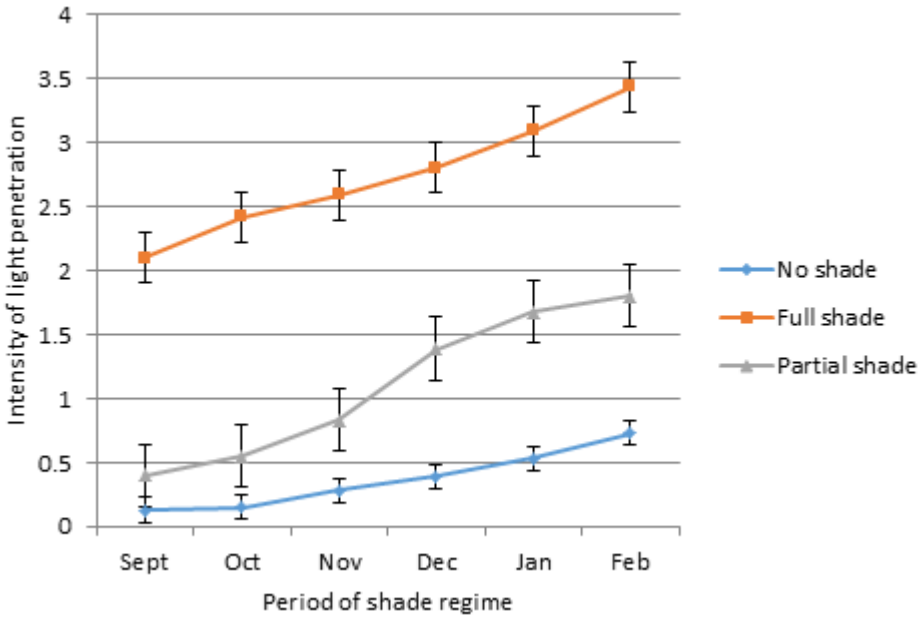

Fig 5. Intensity of light penetration as against periods of shade regime from Sept. 2021 to Feb. 2022

Table 1. Physical and Chemical characteristics of the soil used before planting of cashew seedlings.

Parameters	Value
Soil PH (H2O) 1:1	5.3
Organic matter	5.22%
Organic carbon	3.03 g kg-1
Total Nitrogen	0.26g/100g
Available phosphorus	14.03mg kg-1

Table 2. Mean rainfall (mm), temperature (ºc) and relative humidity (%) during the experimental period (2021-2022)

Months/year	Temperature (°C)		Rainfall (mm)	Relative humidity (%)		Sunshine (hrs)
	Min	Max		a.m	p.m	
2021						
July	19.7	25.6	146.8	88	80	2.2
August	19.8	25.1	37.9	89	88	1.2
September	19.4	25.2	198.9	87	78	2
October	19.5	27.2	142.3	85	75	4.1
November	20.8	28.2	52.4	83	66	5
December	20.7	27.4	Nill	76	51	3.8
2022						
January	18.2	27.7	Nill	76	50	4.1
February	17.5	29.5	49.3	75	50	3.5

Table 3. Soil moisture % under different shade regimes

Treatments	P1	P2	P3	P4	P5	P6
Partial	0.18B	0.38B	1.04B	1.75B	2.73B	5.35A
Semi-partial	0.27D	1.29D	2.69C	3.88B	5.03A	5.85A
Control (full sunlight)	0.16E	0.64DE	1.91DC	2.76BC	3.38AB	4.70A

Key: P: Periods of months (p1-Sept, p2-Oct, p3 Nov, p4- Dec, p5-Jan and p6-Feb) Means with the same letter are not significantly different.

Table 4. Light intensity under different shade regimes

Treatments	P1	P2	P3	P4	P5	P6
Partial shade	0.15D	0.22CD	0.18D	0.72A	0.37BC	0.43B
Semi-partial	0.40B	0.90B	1.80A	1.87A	0.53B	1.41A
Control (full sunlight)	2.90C	3.47C	4.10C	5.73BC	8.68A	7.70AB

Key: P: Periods of months (p1-Sept, p2-Oct, p3 Nov, p4-Dec, p5-Jan and p6-Feb) Means with the same letter are not significantly different.

Table 5. Effect of shade after 24 weeks after planting

Treatments	Root length(cm)	Root weight(g)	Light	Moisture
Partial shade	30.93A	8.00B	10.375B±0.0478714	5.000.B±0.5787918
Semi-partial	52.08A	32.00B	1.813B±0.0314516	6.775A±0.5105144
Control (Full sunlight)	30.93A	84.00A	18.725A±0.0853913	4.100A±0.4490731

References

Agele, S. O., Aiyelari, P., and Friday, C. (2017). Effects of shading, irrigation and mycorrhizal inoculation on growth and development of oil palm Elaeis guineensis Jacq. (Magnoliophyta: Arecaceae) seedlings in the nursery. *Brazilian Journal of Biological Sciences*, *4*(7), 113-126.

Baltzer, J. L., and Thomas, S. C. (2007). Determinants of whole-plant light requirements in Bornean rain forest tree saplings. *Journal of Ecology*, *95*(6), 1208-1221.

Chaar, H., Colin, F., and Leborgne, G., (1997). Artificial defoliation, decapitation of the terminal bud, and removal of the apical tip of the shoot in sessile oak seedlings and consequences on subsequent growth. Can.J.Res., 27: 1614-1621.

Franck, N., and Vaast, P. (2009). Limitation of coffee leaf photosynthesis by stomatal conductance and light availability under different shade levels. *Trees*, *23*(4), 761-769.

Gwak, Y., and Kim, S. (2017). Factors affecting soil moisture spatial variability for a humid forest hillslope. *Hydrological Processes*, *31*(2), 431-445.

Hammed L., Olaniyan A. and Lucas E. (2012). Field Establishment of Cashew (Anacardium occidentale L.) Transplants as Affected by Nursery Periods. J. Agric. Sci. Tech. 2(11B): 1158 1164.

Isaac, M. E., Erickson, B. H., Quashie-Sam, S. J.,and Timmer, V. R. (2007). Transfer of knowledge on agroforestry management practices: the structure of farmer advice networks.*Ecology and society*, *12*(2).

Jain, S. K. (2021). Assessment of microenvironment under hardening shed on mango and cashew grafts. The Pharma Innovation Journal 2021; 10(4): 475-479.

Kelly, J. W. G., Landhäusser, S. M., and Chow, P. S. (2015). The impact of light quality and quantity on root-to-shoot ratio and root carbon reserves in aspen seedling stock. *New Forests*, *46*(4), 527-545.

Lavender, D. P. (1984). Plant physiology and nursery environment: interactions affecting seedling growth. In *Forestry nursery manual: production of bareroot seedlings* (pp. 133-141). Springer, Dordrecht.

Matos, F. S., Wolfgramm, R.,Gonçalves, F. V., Cavatte, P. C., Ventrella, M. C., and DaMatta, F. M. (2009).Phenotypic plasticity in response to light in the coffee tree. *Environmental and Experimental Botany*, *67*(2), 421-427.

Mensah, E. O., Asare, R., Vaast, P., Amoatey, C. A., Markussen, B., Owusu, K., and Ræbild, A. (2022). Limited

effects of shade on physiological performances of cocoa (Theobroma cacao L.) under elevated
temperature. *Environmental and Experimental Botany*, *201*, 104983.
Mohotti, A. J., Pushpakumara, G.,and Singh, V. P. (2020). Shade in tea plantations: a new dimension with an agroforestry approach for a climate-smart agricultural landscape system. In *Agricultural Research for Sustainable Food Systems in Sri Lanka* (pp. 67-87). Springer, Singapore.
Oluyole, K. A., Agbeniyi, S. O.,and Ayegbonyin, K. O. (2017). Competitiveness of cashew production in
Nigeria. *International Journal of research in Agriculture and Forestry*, *4*(8), 1-7.
Poorter, H., Niinemets, Ü., Ntagkas, N., Siebenkäs, A.,
Mäenpää, M., Matsubara, S., and Pons, T. (2019). A meta-analysis of plant responses to light intensity for 70 traits ranging from molecules to whole plant performance. *New Phytologist*, *223*(3), 1073-1105.
Regnier, E. E., and Harrison,S. K. (1993).Compensatory responses of common cocklebur (Xanthium strumarium) and velvetleaf (Abutilon theophrasti) to partial shading. *Weed Science*, *41*(4), 541-547.
Santelices, R., Espinoza, S., and Cabrera, A. M. (2015). Effects of shading and slow-release fertilizer on early growth of Nothofagus leonii seedlings from its northernmost distribution in Central Chile. *Bosque*, *36*(2), 179-189.
Seneviratne, S. I., Corti, T., Davin, E. L. et al., (2010). "Investigating soil moisture–climate interactions in a changing climate: A review." Earth-Science Reviews, 99: 125–161.
Tang, H., Hu, Y. Y., Yu, W. W., Song, L. L.,and Wu, J. S. (2015). Growth, photosynthetic and physiological responses of Torreya grandis seedlings to varied light.
environments. *Trees*, *29*(4), 1011-1022.
Thangam, M., and Thamburaj, S. (2008). Comparative performance of tomato varieties and hybrids under shade and open conditions. *Indian Journal of Horticulture*, *65*(4), 429-433.
Whitelam, G. and K. Halliday. (2007). Light and plant development. Blackwell Publishing, Oxford, UK.
Yang, M., Liu, M., Lu, J., and Yang, H. (2019) Effects of shading on the growth and leaf photosynthetic characteristics of three forages in an apple orchard on the Loess Plateau of eastern Gansu, China. *PeerJ*, *7*, e7594.
Yeboah J., Dadzie A.M., Segbefia M.A.D., Lowor S.T., Agene V.N., Osei-Akoto S., Owuse-Ansha F., Banful B.K.B. and Atuah L. (2020). Vegetative Propagation of Cashew (Anacardium occidentale L.) by Softwood Grafting in Ghana. Journal of Agricultural Science. 2020; 12(8).