American-Eurasian Journal of Scientific Research 2 (1): 68-74, 2007
ISSN 1818-6785

Studies on the Effect of Storage Period and Nut Size on the Seedling Vigour of Cashew

[1]O.M. Aliyu and [2]G.O. Akintaro

[1]Cocoa Research Institute of Nigeria, P.M.B. 5244, Ibadan, Nigeria
[2]Department of Plant Science, Olabisi Onabanjo University, Ogun State, Nigeria

Abstract: Cashew seedling vigour as influenced by the nut size and period of storage of cashew was investigated, using 4 weeks and 12 months olds of small, medium and large sized nuts categories. This factorial experiment of Randomized Complete Block layout with three replications was carried out in the Nursery unit of the Cocoa Research Institute of Nigeria, Ibadan. Data collected on weight of the nut (g), percentage germination, days to germination, number of leaves, plant height (cm), stem girth (cm), leaf area (cm^2) and shoot and root dry matter contents were statistically analyzed. The results showed that large and current season nuts are superior to old and small nuts both at emergent and seedling growth stage. Current season nut germinated with average of 2 days earlier and three times higher than a-year-old nuts. Seedling vigour characters such as number of leaves, plant height, stem girth and leaf and physiological parameters of shoot and root dry matter contents, consistently ranked highest for the seedlings derived from large nuts than the two other categories of nut sizes through out the period of the study. Similarly, current season nuts produced more vigorous seedlings than the old nuts. Correlation coefficient analysis showed highly significant correlations between nut size, emergent, seedling and physiological characters of cashew. This probably depicts significant relationships between nuts quality and seedling vigour at the early growth and development stage of cashew which is the focus of this study. The implication of the results to practical cashew breeding and production is elucidated.

Key words: Cashew · nut size · storage period · seedling vigour

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is a native to South America with centre of origin in Central Brazil [1]. The crop was introduced into Africa and India by the Portuguese Adventurers in the 16th century [2]. Cashew is an important tropical nut tree crop that is widely cultivated in Asia, Africa and South America. Improvement works in this important crop are limited despite its numerous uses. The kernel which is considered to be of high nutritional value is for direct human consumption [3-7]. The nut shell-liquid called CNSL is an excellent monomer for polymer production [8-10]. The apple is edible, very juicy, sweet and very rich in vitamin C content. Many products have been developed from the apple which include, jam, candy, juice, cashew-type beverages [11]. Trade globalization in the last decade has led to the influx of many affluent farmers into the cashew industry. According to FAO [12] major production is centralized in the third world countries like India, Nigeria, Brazil and Tanzania with current annual raw nut production of 460,000; 186,000; 178,343 and 123,000 metric tonnes, respectively.

High germination and vigorous seedlings are major important factors in the establishment of a good cashew orchard. Therefore, selection for seedling vigour indicators should always be considered in any breeding programme designed to improve a crop species. Many of cashew plantations in the major producing countries of African continent today produce poor yield probably because of low vegetative vigour of the seedlings used in the establishment of such farms [13-16].

Cashew orchards are predominantly established through seed propagation in most producing countries because of low success rate of vegetative propagation techniques where it is available. Seed propagation is considered simple, cheap and safe and the roots tend to go deeper and clamped firmer in the soil than clones derived from vegetative methods [17]. While effort is geared towards development of commercializable

Corresponding Author: Dr. O.M. Aliyu, Cocoa Research Institute of Nigeria, P.M.B. 5244, Ibadan, Nigeria

vegetative method of propagation, adequate attention needs to be paid to the present practice of propagation by seeds among teeming poor resource cashew farmers. This is to minimize the extent of variation in growth, development and yield of the trees from such plantings. Following the increasing awareness of the economic potential of cashew and geometrical increase in both areas of land cultivated and trade in most of the African producing countries in the last decade, it however become highly imperative to quantitatively evaluate some of the current practices recorded among cashew farmers. Because of the poor price often offer for small nuts, farmers are been compelled to sort out these categories of nuts during grading. In the act of unprofessional practice, many road-side agents who deal in raising planting materials are found using these sorted-out nuts in raising seedlings that are giving back to farmers through many Governments agricultural development programmes. Similarly, old nuts of about 12 months from the previous season harvest are often been included in the establishment of new plantations. However, to reassess the suitability or otherwise of the use of old nuts as source of planting materials, it is desirable, therefore, to investigate the extent to which seedlings vigour factors are influenced by the storage period and nut size. It is hope that this study would provide information that would help considerably in our effort to select the right planting materials for cashew seedlings production.

MATERIALS AND METHODS

The study was carried out in the Nursery unit of the Cocoa Research Institute of Nigeria (CRIN), Ibadan, (Lat. 07° 10^{l}N, Long. 03° 52^{l}E) between March and August, 2006. The planting materials used include old and fresh nuts harvested in 2004/2005 and 2005/2005 fruiting season respectively. These two lots comprise of three nut size categories that include small (3.00-5.99 g), medium (6.00-8.99 g) and large (9.00-11.99 g). The nuts were harvested from the same mother tree for the two seasons and stored on-shelf at room temperature for 12 moths and 4 weeks for the old and fresh nuts respectively. The small and medium sized nuts trees were high yielding Indian selections, while the large nut was selected from high yielding tree of Brazilian extraction.

The trial is a factorial experiment of Randomized Complete Block Layout (RCBD), with two factors (age and size of the nuts) and replicated thrice. Each treatment was represented by 5 stands in a replication. The nuts were soaked in water for 24 h and only the sinkers were used for the planting. Watering was carried out in alternate days and the experimental lots were kept weed-free through out the period of the trial. Data were collected on the Weight of the individual Nuts before sowing (NWT), Number of Days to Germination (NDG), percentage germination express in Germination Ratio (GRT), Number of Leaves (NLF), Plant Height (cm) (PHT), Stem Girth (cm) (SGT) and Leaf Area (cm^2) (LAR). Data on the seedling parameters (NLF, PHT, SGT and LAR) were collected at 4, 8, 12 and 16 Weeks after Sowing (WAS) to monitor the growth and development of the cashew seedlings as influenced by the factors (age and size). Dry matter contents for shoot and root were determined at 16WAS. Data generated were statistically analyzed for analysis of variance (ANOVA) and the treatment means were compared using Duncan Multiple Range Test (DMRT). Correlation coefficient analysis was also carried out on the data to see the trend of relationships between the parameters as the plant aged. Costat statistical software packages 1998 version was employed in this analysis.

RESULTS AND DISCUSSION

The results of analysis of variance of the nut and seedling parameters over a period of 4, 8, 12 and 16 Weeks after Sowing (WAS) is presented in Table 1. The nuts selected for this study had wide range of sizes as shown by the significant difference at $p<0.001$ for nut weight. Other 2 nut variables (germination rate and percentage) showed slight significant differences ($p<0.05$) due to nut size. This suggests that there are variations in the rate and percentage germination attributable to nut size. Similarly, number of leaves, plant height and leaf area showed significant differences at $p<0.05$ for nut size. Nut size was not significant for stem girth at this stage (4 WAS) of seedling growth and development. Storage period however showed highly significant difference mostly at $p<0.01$ for both the nut and seedling variables except stem girth. This also suggests that period of nut storage strongly influence rate and percentage germination as well as growth and development of cashew seedlings. The significant interactions recorded among these two factors (nut size and period of storage) is an indication of the critical nature of the factors to germination and seedling development in cashew and possible room for selection of appropriate good planting materials for seedlings production in cashew orcharding. It is important to remark however that the level of significances were stronger on the storage period than nut size suggesting the extent of its influence on germination and growth of cashew seedling.

Table 1: Analysis of variance of nut and seedling characters in cashew

	4 WAS				8 WAS			
Variables	Mean	S F-ratio	T F-ratio	SxT F-ratio	Mean	S F-ratio	T F-ratio	SxT F-ratio
Nut weight (g)	7.00	38.55***	0.75**	6.33***	-	-	-	-
Number of days to germination	18.74	0.53*	22.47**	0.85**	-	-	-	-
Germination ratio	0.66	0.16*	0.98***	0.41***	-	-	-	-
Number of leaves	5.84	3.74*	10.97*	2.59**	8.36	8.60*	4.31*	8.50**
Plant height (cm)	17.45	14.88*	232.13***	53.76*	24.29	32.40*	223.80*	171.00*
Stem girth (cm)	1.44	0.02ns	0.00ns	0.02ns	2.57	0.25*	0.10*	0.27*
Leaf area (cm^2)	48.92	517.55*	1512.13*	559.40*	53.94	373.90*	1112.50*	912.84*

Table 1: Continued

	12 WAS				16 WAS			
Variables	Mean	S F-ratio	T F-ratio	SxT F-ratio	Mean	S F-ratio	T F-ratio	SxT F-ratio
Number of leaves	16.80	87.06***	46.46*	47.35**	18.50	60.17**	40.50*	66.29**
Plant height (cm)	30.81	26.36*	392.65**	37.48**	37.81	4.18**	342.00**	59.68*
Stem girth (cm)	2.40	0.03ns	0.04**	0.08**	2.49	0.01ns	0.03*	0.01*
Leaf area (cm^2)	57.55	268.54**	3266.48**	361.79**	59.20	334.63**	4840.95**	335.55*
Shoot dry matter content (%)	-	-	-	-	33.98	8.91**	6.84**	0.45**
Root dry matter content (%)	-	-	-	-	27.07	5.62**	4.64**	0.32**

*, **, *** and ns = significant differences at p<0.05, 0.01, 0.001 and not significant difference respectively, S = Size of the nuts, T = Time of storage
WAS = Weeks after Sowing

Table 2: Mean separation of the nut and seedling variables in cashew using Duncan Multiple Range Test

	4 WAS							8 WAS			
Size of the nut	Nut weight (g)	Number of days to germination	Germination ratio	Number of leaves	Plant height (cm)	Stem girth (cm)	Leaf area (cm^2)	Number of leaves	Plant height (cm)	Stem girth (cm)	Leaf area (cm^2)
Small	4.78c	19.41a	0.54b	5.03b	15.07b	1.38b	41.82b	6.85b	20.87b	2.40ab	47.33b
Medium	6.47b	19.36a	0.58b	5.92ab	16.89b	1.44ab	45.35b	8.16ab	23.75ab	2.52ab	51.82b
Large	9.77a	17.46b	0.87a	6.60a	20.39a	1.50a	59.60a	10.06a	28.26a	2.80a	62.68a
Time of storage											
4 weeks old	7.20a	17.62b	0.94a	6.63a	21.04a	1.45a	58.08a	9.35a	27.81a	2.79a	61.81a
12 months old	6.80b	19.86a	0.38b	5.07b	13.86b	1.43a	39.75b	7.37b	20.76b	2.35b	46.08b

Table 2: Continued

	12 WAS				16 WAS					
Size of the nut	Number of leaves	Plant height (cm)	Stem girth (cm)	Leaf area (cm^2)	Number of leaves	Plant height (cm)	Stem girth (cm)	Leaf area (cm^2)	Shoot dry matter (%)	Root dry matter (%)
Small	12.88c	27.27b	2.37a	51.40b	16.39b	33.28b	2.45a	54.22b	29.97c	24.73c
Medium	17.02b	30.73ab	2.41a	53.98b	16.97b	37.20ab	2.50a	55.61b	32.70b	26.33b
Large	20.49a	34.44a	2.41a	67.27a	22.14a	42.95a	2.52a	67.79a	39.28a	30.14a
Time of storage										
4 weeks old	18.40a	35.48a	2.52a	66.02a	20.00a	44.84a	2.63a	75.60a	42.02a	32.41a
12 months old	15.19b	26.14b	2.28b	49.08b	17.00b	30.78b	2.34b	42.80b	25.94b	21.73b

NB: The same letters in a column are not significantly different at p<0.05

At 8 WAS, all the four seedling characters evaluated were statistically different at p>0.05 for both nut size and storage period. Although, the trends of significant differences recorded at both 12 and 16 WAS were similar to that of 8 WAS, however, the level of significances increased, depicting that the extent of vigour as manifested by the influence of treatments (size and storage period) on seedling vigour became more evident as plant aged. Plant production of the seedlings measured as percentage dry matter contents for both

Table 3: Correlation coefficients analyses among nut and seedling characters in cashew at different stage of growth

	4 WAS						8 WAS				
Character	NWT	NDG	GRT	NLF	PHT	SGT	LAR	NLF	PHT	SGT	LAR
NWT	1.00										
NDG	0.49*	1.00									
GRT	0.47*	-0.56**	1.00								
NLF	0.59**	-0.58**	0.67**	1.00				1.00			
PHT	0.61**	-0.69**	0.73***	0.76**	1.00			0.87***	1.00		
SGT	0.64**	-0.35ns	0.40ns	0.47*	0.46ns	1.00		0.66**	0.52*	1.00	
LAR	0.50*	-0.69**	0.64**	0.70**	0.88***	0.66**	1.00	0.89***	0.92***	0.56*	1.00

*, **, *** = Significant at p<0.05, 0.01 and 0.001 respectively. ns = not significant

Table 3: Continued

	12 WAS				16 WAS					
Character	NLF	PHT	SGT	LAR	NLF	PHT	SGT	LAR	SDM	RDM
NLF	1.00				1.00					
PHT	0.52*	1.00			0.50*	1.00				
SGT	0.54*	0.50*	1.00		0.47ns	0.47*	1.00			
LAR	0.49*	0.87***	0.52*	1.00	0.48*	0.64**	0.50*	1.00		
SDM	-	-	-	-	0.85**	0.78**	0.54*	0.68**	1.00	
RDM	-	-	-	-	0.66**	0.62**	0.39ns	0.53*	0.63**	1.00

*, **, ***: Significant at p<0.05, 0.01 and 0.001 respectively. ns: not significant, NWT: Nut weight (g), NDG: Number of Days to Germination, GRT: Germination Ratio, NLF: Number of Leaves, PHT: Plant Height (cm), SGT: Stem girth (cm), LAR: Leaf Area (cm^2), SDM: Shoot Dry Matter Content (%), RDM: Root Dry Matter Content (%), WAS: Weeks after Sowing

shoot and root were highly significant for the nut size and storage period too. This is also an indication of significant influence of nut size and the length period of storage on vigour and productivity of the seedlings.

Mean values of the nut and seedlings parameters for the two factors (size and storage period) over the study period were presented in Table 2. The average weight for small nuts was 4.78 g and the large ones 9.77 g, which indicates wide variability in the materials selected for the study. In terms of storage period, current season nuts ranked higher with average of 7.20 over a-year-old nuts. Shrinking of the shell and cotyledon resulting from loss of moisture over the storage period may accounts for this difference. Germination rate (period) ranged from 17.46 to 19.41 days for large and small sized nuts respectively. This however confirms that large nuts have higher germination rate than the smaller ones. Current season nuts germinated with average of 2 days earlier than a-year-old nuts. In terms of viability (percentage germination) of the nuts measured as a germination ratio, large nut were found to be more viable (about 87%) than the other two sizes. This observation has been attributed to the presence of large food reserve and advance embryological development in large nuts. The results also indicated that 94% of the current season nuts were viable against 38% recorded for a-year-old. It is important to mention that this trait (percentage germination) clearly showed that cashew nut loses its viability over a long period of storage. Drastic reduction in germination percentage in old nuts can be attributed to moisture loss and increased temperature during the storage period which may result into the activation of the lipid metabolism within the nuts that eventually result into the death of embryo.

The results further showed clearly that seedling characters such as number of leaves, plant height, stem girth and leaf area consistently ranked highest for the seedlings derived from large nuts than the two other categories of nut sizes across the 16 week study period. Similarly, current season nuts produced more vigorous seedlings than the old nuts. It is important to note that there was general reduction in the stem girth of the seedlings between 8 and 12 WAS. This reduction has been attributed to physiological changes that accompany shrinkage and withering off of cashew cotyledons at early stage of growth and development [18].

Correlation coefficients analyses showing the relationships among the nuts and seedlings variables over the period of study are presented in Table 3. At 4WAS, nut weight showed significant correlation with

all the nut and seedling characters though at $p<0.05$, thus confirming the influence of nut size on the germination and seedling vigour. However, the significant negative correlation between nut weight and germination rate (NDG) showed that large nuts tend to germinate earlier in terms of number of days than small nuts (Table 2). Germination rate (NDG) however showed significant negative correlation with all seedling characters except stem girth. It is thus implies that delay or prolong period of germination could lead to production of weak seedlings with very low vigour. Percentage germination (GRT) significantly correlated with number of leaves, plant height and leaf area; but not significant for stem girth. This probably depicts significant relationships between viability and seedling vigour at the early growth and development stage of cashew, which is the main focus of this study. The implication of this in the practical cashew breeding and production is that nuts to be used as planting materials should be selected from the trees or bulk with higher percentage germination. It may be important to suggest or recommend here that the use of cashew nuts from trees or lots having germination percentage below 60% as planting materials should therefore be discouraged. All the seedling characters showed significant correlations with each other. Similarly, at 8 and 12 WAS all the four seedling characters also showed significant correlations with each other. These strong correlations indicated that the selected seedling characters can be use as selection criteria in screening for vigour in cashew. The level of significances of the correlation r values at 8WAS were stronger/higher mostly at $p<0.01$ than in 12 and 16 WAS. This probably suggests that 8WAS is appropriate time to carry out rouguing among seedlings before transplanting and that period after 12WAS may not be ideal to transplant cashew as the seedling must have established well with enough roots to be called sapling. The reduction in the level of significance is an indication of less interdependency of the seedling characters on each other. The result of analysis at 16WAS also showed highly significant correlation among all the six characters except non significant difference between root dry matter and stem girth. The positive correlation between the morphological characters and physiological parameters (dry matter contents) attests to the selected characters as good indices for evaluating seedling vigour in cashew.

Observation recorded in this study showed that period of storage tends to have significant influence on both the germination (rate and percentage) of the cashew nuts and seedling growth, than the size of the nuts. Small nuts were observed to loose viability faster and more than the large ones. The effects of the nuts size on cashew seedling vigour both at emergent and growth phases showed that nut weight (size) was a significant factor in cashew seedling production. This result however corroborated the previous reports of Ibikunle and Komolafe [19], Faluyi [20] and Adebola *et al*. [21], that large cashew nuts had superior germination than small nuts. Faluyi [20] however opined that initial superior performance of seedlings from large nuts was probably due to the availability of large food reserve in the cotyledons. Cooper [22] observed similar trend in the alfalfa and remarked that a more advanced state of embryology in the large seeds as the main cause of this development. Accumulation of assimilates and the process of physiological maturity are prolonged during the development of large nut than small one [23]. Aliyu and Awopetu [24] also observed that embryo axes from immature large nuts responded faster and produced a more vigorous cashew plantlets *in vitro* than embryo explants from immature small nuts. This observation however lends credence to the assertion by Cooper [22].

Seedling parameters (number of leaves, plant height, stem girth and leaf area) and dry matter contents (shoot and root) showed that seedlings derived from large cashew nuts were superior to those derived from small and medium sized nuts. The outstanding performance of the large nuts should however be linked to the fact that the nuts were selected from high yielding and vigorous Brazilian cashew selections [15]. Where open pollinated nuts from a mix-planting of both large and small nuts trees are planted interwovenly as commonly done by small-holder farmers, nuts obtained from a mother tree that produces small nuts may behave contrary to this observation [28] (pers. comm.). This has been attributed to free flow of genes and genetic impurity resulting from out-breeding among cashew tree populations [15]. Gopikumar *et al*. [25] observed variation in the nuts size and seedlings parameters of nuts collected from a single mother tree. Stem girth was also reported as the least variable attribute. Similarly, Menon *et al*. [26] recorded a superior performance in terms of shoot length, shoot girth, fresh and dry weight of shoots in cashew nuts with high specific gravity compared to nuts with low specific gravity. The authors also remarked that nut specific gravity affected germination and seedling growth significantly.

Average germination of these planting materials at 19.0 days after sowing further corroborated Adebola *et al*. [21] and Aliyu and Hammed [23] that 3rd week is the peak

of germination in cashew. However, significant difference recorded among the three nut sizes in the germination period may be probably attributed to the variation in the in the rate of water imbibitions [27]. Reduction in the weight of the nuts stored for a period of one year was probably due to loss of moisture which is also a critical factor for the survival of embryo. Low moisture content below 4% has been reported to damage seeds due to extreme desiccation. Life of seed largely revolves around its moisture content and the safe moisture content however depends upon storage length and type of seeds. Mwasha *et al*. [27] reported that cashew nuts can only survived desiccation to 6% moisture content and short-term (up to 70 days). Deterioration was detected when nuts were stored at 40°C. The fact that flowering and fruiting in cashew is mostly accompany by dry season with attendant high temperatures that often ranged between 36°C and 46°C in most tropical and cashew producing countries, deterioration of nuts is therefore not implausible during storage. Worse practice among cashew is the storage of the nuts in humid sacks that tends to generate high temperature and moulding of the nuts. Nuts stored for a longer period have the food reserve depleted both in quantity and quality and this has significant effect during germination especially at the lag and cell elongation and mitosis phase where metabolic activity commences. Imbibitions of water in nuts or seeds stored for a longer time is associated with leakage of hydrolytes like sugars, amino acids and this often led to disintegration of cell membranes. The quantity of amino acids and peptides that are translocated to embryo axis become drastically reduced and consequently have effect both in the rate of germination and the survival of emerging plants. *In situ* hydrolysis of lipids inform of triglycerides has been a critical factor for nuts storage and germination especially in an oil seed like cashew with high content of fat.

The results of this study however suggests that cashew nuts of current season harvest of large sized category (10.00-11.99 g) would be most suitable as planting materials to ensure better nut germination (rate and percentage), high seedling vigour and probably good yield (quantity and quality).

ACKNOWLEDGEMENTS

The authors acknowledge the technical support of Mr. Victor Enagu of Department of Plant Breeding for the data collection and the Executive Director of the Cocoa Research Institute for permission to publish this work.

REFERENCES

1. Mitchell, J.D. and S.A. Mori, 1987. The cashew and its relatives (*Anacardium occidentale* L.), Anacardiaceae. Memo NY, Bot. Gardens, 42: 1-76.
2. Johnson, D., 1973. The botany, origin and spread of cashew (*Anacardium occidentale* L.). J. Plant. Crops, 1: 1-7.
3. Howes, F.M., 1953. Nuts: Their production and everyday uses. Society of Education London, Faber Limited.
4. Jain, N.L., D.P. Das and G. Lal, 1954. Utilization of cashew apples. Fruit and Vegetative Preservation Industry, India.
5. Morton, J.F., 1961. The cashew's brighter future. Econ. Bot., 15: 57-78.
6. Babatunde, F. and O. Oyenuga, 1974. Composition and nutritive value of cashew nut to the rat. J. Agric. Food Chem., USA, 4: 678-682.
7. Joseph, K.T., 1975. Cashew nut. A valuable nutritive food product. Ind. Cashew J., India, 10: 5-6.
8. Pillai, C.K.S., V.S. Prasad, J.S. Sudha, S.C. Bera and A.R.R. Menon, 1990. Polymeric resins from renewable resources. J. Applied Sci., 4: 2487-2501.
9. George, J. and C.K.S. Pillai, 1992. Makromol. Chem. Rapid Commun, 13: 255-259.
10. Anthony, R. and C.K.S. Pillai, 1994. In Polymer Science: Recent Advances, I.S. Bhardwaj, Ed. Allied New Delhi, 1: 407-411.
11. Ogutuga, D.B.A. and S.O.A. Williiams, 1977. Development of new product as a method of increasing the consumption of chocolate in Nigeria. Proceeding of 5th International Cocoa Conference, Ibadan, Nigeria, pp: 574-577.
12. FAO, FAOSTAT, 2004. Statistics database. Disponivel em:<htpp://apps.fao.org>
13. Ohler, J.G., 1979. Cashew. Koninklijk instituut voor de Tropen, Teskin, Zutphen Co. Amsterdam, The Netherlands.
14. Topper, C.P., P.D.S. Caligari, M. Camara, S. Diaora, A. Djaha, F. Coulibay, A.K. Asante, A. Boamah, E.A. Ayodele and P.O. Adebola, 2001. West African regional cashew survey covering Guinea, Guinea Bissau, Cote d'Ivore, Ghana and Nigeria. Sustainable Tree Crop Programme (STCP) Report No. BHA-01109. Biohybrids Agrisystem Ltd. P.O. Box: 2411, Earley, Reading RG6 5FY, UK.
15. Aliyu, O.M., 2004. Characterization and compatibility studies in Cashew (*Anacardium occidentale* L). Ph.D Thesis, University of Ilorin, Nigeria, pp: 266.

16. Martin, P.J. and L.J. Kasuga, 1995. Variation in cashew tree yield in South-east Tanzania and the implication for management of cashew smallholding. Trop. Agric. (Trinidad and Tobago), 72: 261-268.
17. Hartman, H. and D. Kester, 2000. Plant Propagation: Principles and practices. Octava Reimpresion, Editorial Continental, Mexico, pp: 760.
18. Hammed, L.A. and O.M. Aliyu, 2002. Effects of time of harvesting and sowing condition on the germination and seedling performance of cashew nut (*Anacardium occidentale* L.). Moor. J. Agric. Res., 3: 175-179.
19. Ibikunle, B.O. and D.A. Komolafe, 1973. Some experiments on the germination of cashew nuts (*Anacardium occidentale* L.). Nig. J. Sci., 7: 19-29.
20. Faluyi, M.A., 1986. Investigations on seedling vigour in cashew (*Anacardium occidentale* L.). Plant Breeding, 97: 237-245.
21. Adebola, P.O., E.B. Esan and A.O. Famaye, 1999. Effect of nut weight on germination and seedling vigour in cashew (*Anarcadium occidentale* L.). Nig. J. Tree Crop Res., 3: 6-11.
22. Cooper, C.S., 1977. Growth of the legume seedlings. Adv. Agron., 29: 119-139.
23. Aliyu, O.M. and L.A. Hammed, 2000. A study of nut and apple development in cashew (*Anacardium occidentale* L.). Nig. J. Tree Crop Res., 4: 1-10.
24. Aliyu, O.M. and J.A. Awopetu, 2005. *In vitro* regeneration of hybrid plantlets of cashew (*Anacardium occidentale* L.) through embryo culture. Afr. J. Biotechnol., 4: 548-553.
25. Gopikumar, M., M. Aravindakshan and M.N. Namboodiri, 1984. Variation in open pollinated seedling progenies in cashew. In: Abstract of Proceeding of the International Cashew Symposium, Cochin, Kerala, India, 12-15 March, 1979.
26. Menon, M.A., P.N. Ravindran and B.P. Nair, 1984. Specific gravity of seeds as a mass selection criterion in cashew. In: Abstract of Proceeding of the International Cashew Symposium, Cochin, Kerala, India, 12-15 March, 1979.
27. Mwasha, A.J., R.H. Ellis and T.D. Hong, 1997. The effect of desiccation on the subsequent survival of seeds of cashew (*Anacardium occidentale* L.). Seed Science and Technology, 25: 115-122.
28. Hammed, L.A., 2006. (pers. comm.). Cashew Agronomist, Cocoa Research Institute of Nigeria, P.M.B. 5244, Ibadan, Nigeria.