

Influence of Nut Size, Hydro Priming Duration and Storage Period on Seedling Emergence and Early Seedling Vigour Characters in Cashew (*Anacardium occidentale* L.)

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ABSTRACT

The influence of seed nut size, storage period and hydro priming duration on seedling emergence and early seedling vigour in Brazilian cashew biotype was investigated. Seed nuts were hand graded into three sizes - large, medium and small - and dried under ambient conditions (29°C, RH70%) for 30 days before storing them under ambient conditions for 210 days. Stored nuts were evaluated at 0, 30, 90, 120, 150 and 210 days under three different pre-sowing hydro priming hours (0, 12 and 24 hrs) for seedling emergence and vigour characters. Data collected were statistically analysed. Significant differences were found to have occurred among storage periods, hydro priming durations and nut sizes for the four seed quality characters examined. In particular, large seed nuts had the highest seedling emergence of 79% above the medium and small nuts with a marginal increase of 5 to 6%, respectively. Meanwhile, small nuts emerged earlier than the other seed nut fractions but large nuts had the longest days to emergence. Seed nuts hydro primed for 24 hrs had the best seedling emergence (79%), reduced days to emergence (15 days) and greater seedling vigour and shoot growth. Highest seedling emergence of 80 to 81% was observed at early storage (30-90 days) and which thereafter declined to 72% at the end

of 210 days, with 10% reduction. Hydro primed small nuts had significant reduction in days to emergence (12-16 days) at each storage time investigated. The beneficial effect of priming was observed in large nuts hydro primed for 24 hrs with the highest storage performance. Thus, in order to obtain good seed nut quality parameters,

ARTICLE INFO

Article history:

Received: 25 November 2014

Accepted: 25 May 2015

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storage period of large nuts can be extended up to 210 days or thereafter, while medium nuts can be stored for 150-210 days but the storage duration of small nuts should not exceed 150 days under ambient conditions. In conclusion, hydro priming of cashew nuts before sowing is a possible way of enhancing seedling emergence and early vigour characters.

Keywords: Germination, seed deterioration, seed enhancement, seed grading, water treatment, seedling growth.

INTRODUCTION

The cashew plant, *Anacardium occidentale*, is a native to Central and South America with its main centre of variation in eastern Brazil. However, cashew is now grown in many parts of the world including Nigeria (Ohler, 1979; FAO, 2001; FAO, 2007). The annual world production of cashew nuts - the main commercial product of the cashew plant – is over 1.2 million tonnes, with India topping the production, followed by Mozambique and Tanzania (FAO, 2004). Nigeria was a foremost producer before it was overtaken by Tanzania, Cote D'Ivoire and Guinea Bissau in 2006 (FAO, 2007). Kogi State, Nigeria, is one of the highest producers of cashew in the category of Kwara, Anambra, Oyo, Imo, Edo and Lagos States, Nigeria. It is grown to a lesser extent in Niger, Ondo, Delta, Ogun and Osun States (Udoh *et al.*, 2005). It is found all the way from the coast to the north but mostly as windbreaks and soil erosion prevention in the northern parts of Nigeria.

Seed nuts are vital to the propagation of the cashew plant (Udoh *et al.*, 2005; FAO, 2007). In Nigeria, these are usually obtained from current season harvests, sun dried and stored under ambient temperature before sowing. The germination of viable seed nuts is a product of many variables, but of significant importance is water imbibition, which depends among other factors on seed size (Turner, 1956; Auckland, 1961; Ibikunle & Komolafe, 1973), the level of water available in the seed as this determines the 'thirst' for water and lastly the permeability of the seed nut coat.

Cashew nuts possess thick seed coat thus requiring considerable time for water imbibition to prompt nut germination. Slow imbibition of dry intact seed nuts is reported to be the main cause of delayed germination in cashew (Subbaiah, 1982), a problem which is greatest in larger seeds (Turner, 1956; Auckland, 1961; Ibikunle & Komolafe, 1973). Previous observations revealed that slow imbibition of dry intact seed is the main cause of delayed germination in cashew (Nmadzhanova *et al.*, 1977; Subbaiah, 1982), with the nut covering structures and epicarp presenting a formidable barrier to embryo growth and germination (Joley, 1960). Similarly, the endocarp nature has been identified to be responsible for reducing the rate of imbibition (Crane & Forde, 1974).

However, early germination can be induced by the following means: cracking the seed nut coat: a delicate operation which must be carried out with care to avoid damage to the embryo; treatment with dilute

sulphuric acid (H₂SO₄); and soaking in water for 24 to 36 hours (Turner, 1956; Auckland, 1961; Ibikunle & Komolafe, 1973). Pre-soaking for 1 or 2 days (Rao *et al.*, 1957a, 1957b; Ibikunle & Komolafe, 1973) or removing the waxy layer of the pericarp by treating with chloroform or acetone (Subbaiah, 1982) have been observed to promote imbibition and reduce the time taken to germinate and increase the proportions of seed nuts germinating. Light (Rocchetti & Panerai, 1968; Rocchetti & Panerai, 1970; Adams, 1975) and gibberellins (Ayfer & Serr, 1961; Shanmugavelu, 1970; Dahab *et al.*, 1975) are also reported to promote germination in cashew seed nuts.

Large seed nuts are more vigorous than small ones and thus, they are more desirable to farmers; however, these are likely to sprout last due to the presence of thicker seed coats (Maggs, 1973; Crane & Forde, 1974; Casini & Conticini, 1979). Cashew orchards are majorly established through nut seeds which are harvested in the dry season of between January and April of every year and thereafter stored for sowing in the rainy season (May – September/October). The length of storage and nut size affect the viability of cashew seeds (Akinyemi *et al.*, 2011; Aliyu & Akintaro, 2007). Similarly, Hammed (2012) reported significant effect of nut sizes of cashew on seedling performance in the nursery. Meanwhile, highly significant correlations between nut sizes, seedling emergence and physiological characters in cashew were reported by Aliyu and Akintaro (2007).

The length of hydro priming affects the emergence and other seedling vigour parameters of cashew (Ibikunle & Komolafe, 1973) and other crop species (Adebisi *et al.*, 2014; Oyedele, 2014 & Ogunbayo, 2014). High emergence and seedling vigour are major factors in the establishment of good and productive cashew orchard. However, information on the combined effects of length of storage, nut size and hydro priming duration for optimum seed emergence and seedling vigour performance under ambient humid tropical conditions is desirable. Hence, the study was initiated to investigate the response of seed emergence and early seedling vigour traits to length of storage, seed nut size and hydro priming duration in Brazilian cashew biotype.

MATERIALS AND METHODS

Collection of Nuts

Seed nuts obtained from the 2010 dry season, with no sign of damage, insect pest attack or disease symptoms, from the cashew plantation (Brazilian type) of Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State (Latitude 7.1°N and longitude 3.2°E) in Nigeria were used in the study. The nuts were collected from five healthy cashew plants with good history of robust fruit production and then air dried for 30 days after collection under ambient laboratory conditions (average temp. 29°C, RH70 %).

Experimental Treatment

The treatments investigated were:

a. Seed nut sizes: Cashew seed nuts were visually graded according to size into large, medium and small. The seed nuts were weighed and classified into categories depending on the size, with nut sizes ranging between 10.0 and 11.9 g/nut for large nuts, while medium nuts ranged between 6.5 and 7.4 g/nut and small nuts between 2.0 and 3.9 g/nut.

b. Storage duration: Five storage times (0, 30, 90, 150, 210 days) were investigated in the study. Pure seed nuts were packed into baskets and then covered with polythene sheet and stored under ambient laboratory conditions for 210 days.

c. Hydro priming hours: Three hydro priming hours were investigated (0, 12 and 24 hrs). Hundred seeds from each nut size were placed in individual net bag and then immersed in water for 0, 12 and 24 hours at each storage duration investigated. All the seeds were then removed from the priming solution and then surface dried lightly for 5 hrs at room temperature (29°C).

Experimental design: The experiment was arranged in a factorial fitted into completely randomised design. There were 3 factors [nut size (3), storage time (5) and hydro priming hours (3)], which gave a total of 45 treatment units which were replicated three times.

Soil Collection and Poly Bags Filling: Top soil (5–9 cm depth) was collected from fallow farm land of the Teaching and Research Farm Unit, FUNAAB, Nigeria.

Soil was freed of extraneous materials: plant roots, weed seeds and pebbles. The soil samples were then filled into polythene bags of 25 x 15 cm to 2.5 cm from the brim to allow for watering and placed inside the screen house at the College of Plant Science and Crop Production, FUNAAB.

Seed nut sowing: A seed nut was sown at 4–5 cm depth with concave end upward into polythene bags and observed daily for seedling emergence parameters.

Seed quality assessment: Data were collected on the following seedling emergence and seedling vigour parameters at each of the storage times and priming hours were investigated.

Seedling emergence: The numbers of emerged seedlings and the percentage of seedling emergence were determined as follows:

$$\frac{\text{Number of emerged seedlings at 30 days}}{\text{Seed sown}} \times 100$$

Days to 50 % seedling emergence: Number of days taken for seeds to emerge up to 50%.

Seedling shoot length: Average lengths of 10 randomly selected seedlings were measured 30 days after emergence in centimetre.

Seedling vigour index: It was calculated using the following formula (Kim *et al.*, 2002; Adebisi, 2004):

$$\frac{\text{Seedling emergence (\%)} \text{ at 30 days} \times \text{seedling shoot length at 30 days}}{100}$$

Data Analysis

Data on seedling emergence involving percentages were transformed using angular transformation ($\arcsin\sqrt{\sin^{-1}}$). Analysis of variance was carried out on the data obtained on the four seed quality parameters examined. Tukey's HSD test at 5% probability level was used to separate significant treatment means. All the analyses were carried out using SPSS version 16 statistical software package.

RESULTS

The mean square values for the characters evaluated in the seed nut sizes of Brazilian cashew biotype after storage and hydro priming treatments are presented in Table 1. From the ANOVA results, the main effects of storage period, hydro priming and nut size were highly significant ($p \leq 0.01$) on seedling emergence, days to 50% seedling emergence, seedling vigour index

and seedling shoot length. All the two-way interaction effects (nut size x hydro priming treatment, nut size x storage, storage x hydro priming treatment) were highly significant ($p \leq 0.01$) on seedling emergence, days to 50% seedling emergence, seedling vigour index and seedling shoot length. The three-way interaction (nut size x storage time x hydro priming treatment) also had significant effect ($p \leq 0.05$) on seedling emergence, days to 50% seedling emergence, seedling vigour index and seedling shoot length.

In Fig.1, the results indicate different responses in seed quality traits among various storage durations investigated. For seedling emergence, the values declined with the increase in storage, durations from 0 day to 210 days. Maximum seedling emergence (81%) was found in the seed nuts stored for 0 day, followed by 80% at 30 days, while the lowest value occurred at the end of storage. In terms of days to 50%

TABLE 1

Summary of analysis of variance showing mean square values for the characters evaluated in nut sizes of Brazilian cashew after storage and water soaking treatment.

Source of Variation	Degree of freedom	Seedling emergence (%)	Days to 50% emergence	Seedling vigour index	Seedling shoot length (cm)
Replicate	2	45.87	1.410	51.257	60.267
Storage Period (S)	4	418.252**	91.220**	56.773**	186.70**
Hydro priming (H)	2	220.089**	106.615**	53.836**	85.031**
Nut size (N)	2	241.422**	155.033**	56.502**	188.034**
S*N	8	115.941**	4.576**	42.979**	145.130**
H*N	8	111.911*	3.445*	35.350*	129.60**
S*H	4	94.385**	1.815**	34.477**	126.77**
S* H*N	8	112.207**	1.181**	42.105**	142.103**
Error	88	13.139	0.330	3.158	6.88

**Significant at 1% probability level

*Significant at 5% probability level

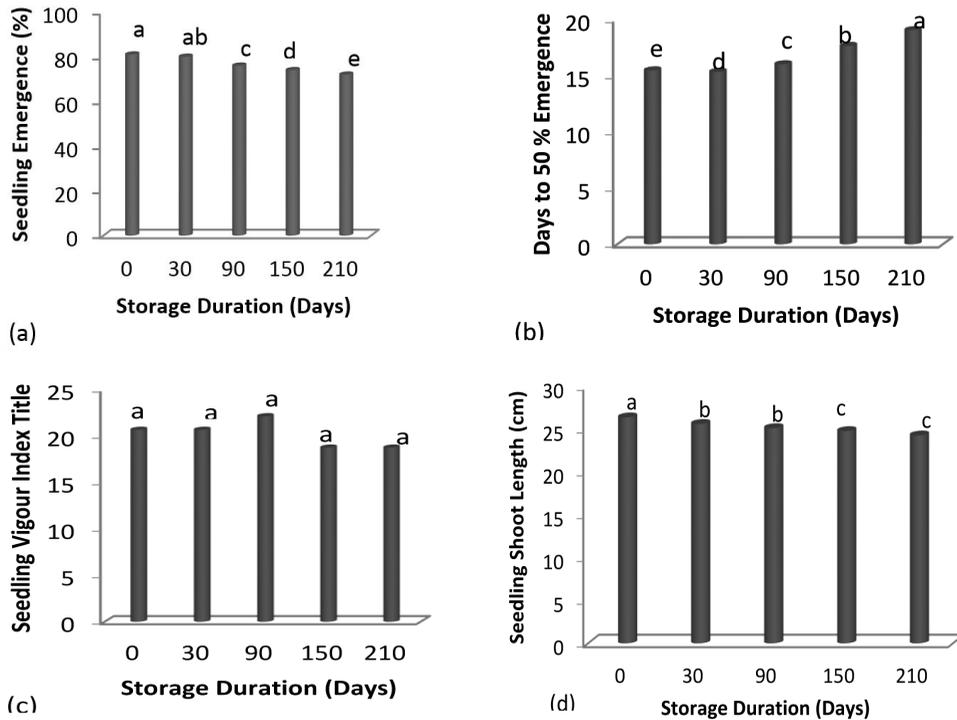


Fig.1 (a-d). Effect of storage period on seedling emergence, days to 50% seedling emergence, seedling vigour and seedling shoot length across hydro priming duration and nut size in Brazilian cashew biotype.

seedling emergence, the values increased with advancement in storage duration, with the highest days to seedling emergence (19 days) obtained at 210 days of storage while the lowest days to emergence occurred at 0 and 30 days of storage. As for seedling vigour index, storage duration did not have any effect on this character at all. Data on seedling growth, as indicated by seedling shoot length, progressively declined with length of storage. The greatest seedling shoot length was obtained at 0 day of storage whereas seedling shoot length values at 30 and 90 days were statistically similar. Thereafter, there was a steady and significant decline up till 210 days.

Data in Fig.2 show that seed nuts hydro primed for 24 hrs had the maximum seedling emergence of 79%, whereas 0 and 12 hrs of hydro priming recorded statistically similar values. Data on days to 50% seedling emergence show that seed nuts hydro primed for 24 hrs recorded the lowest value of 15 days, while longest day to emergence of 18 days was obtained at 0 hr of hydro priming. In terms of seedling vigour index, seed nuts hydro primed for 12 and 24 hrs had higher values of 21.26 and 21.30, respectively, while lower value of 19.69 was recorded at 0 hr of hydro priming. For seedling shoot length, cashew seed nuts soaked for 12 and 24 hrs had significantly

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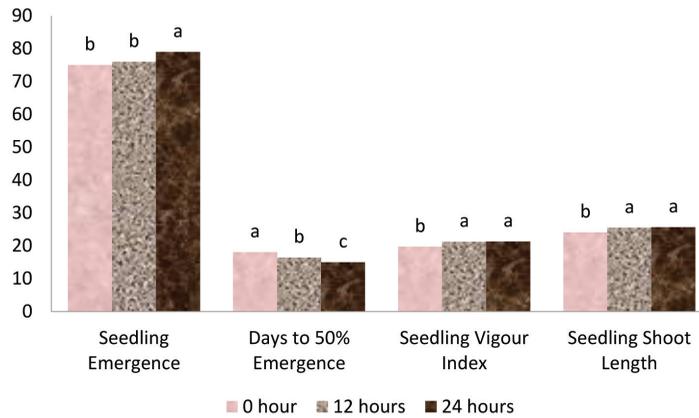


Fig.2 Effects of hydro priming duration on seedling emergence, days to 50% seedling emergence, seedling vigour and seedling shoot length across storage and nut size in Brazilian cashew biotype.

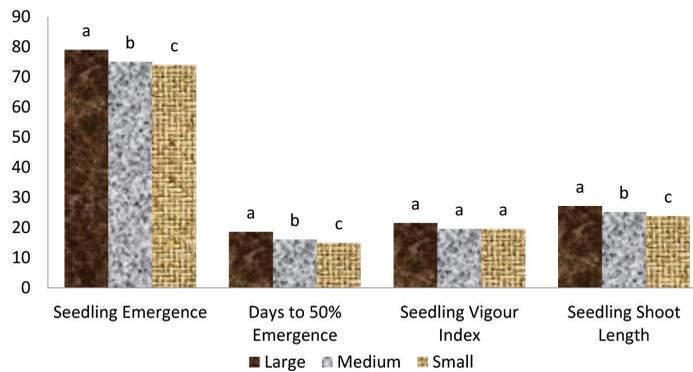


Fig.3 Effects of seed nut sizes on seedling emergence, days to 50% emergence, seedling vigour and seedling shoot length across storage duration and hydro priming hours in Brazilian cashew biotype.

higher seedling shoot length values above unsoaked nuts. Statistically similar values of seedling shoot length were observed after 12 and 24 hrs of priming.

Data represented in Fig.3 show that large seed nuts had the highest emergence of 79%, followed by medium seed nuts, while small seed nuts retained the lowest (74%). For days to 50% seedling emergence trait, small seed nuts had the lowest value of 15 days, followed by medium seed nuts, while longest day (19 days) was obtained for the

large nut size. For seedling vigour index, seed nut sizes did not have any significant effect as the three nut sizes had comparable seedling vigour values. Data on seedling shoot length revealed that large seed nut size of cashew recorded the highest value (27.12 cm), closely followed by medium nut sizes, while the small seed nut sizes had the lowest value of seedling shoot length of 23.84 cm.

Data on the influence of nut size, hydro priming duration and storage periods on seedling emergence are displayed in Table

2. The results indicate different responses in the seed nut emergence among nut sizes after hydro priming duration at each storage time investigated. At 0 day storage time, large seed nuts hydro primed for 24 hrs had the highest emergence of 87%, followed by small nuts while other hydro primed seeds of the three nut sizes had emergence values of between 80 to 81% but un-primed seed had the lowest emergence of less than 80%. At 30 days of storage, large seed nuts hydro primed for 24 hrs retained the highest emergence of 85%, whereas the lowest emergence value of 70% was recorded with small seed nuts at 0 hr of hydro priming. With the increase in storage time to 90 days, large seed nuts that were hydro primed for 24 hrs had the highest emergence of 81%, though not significantly different from the value of 79% obtained for the medium seed nuts that were hydro primed for 24 hrs. At 150 days of storage, large seed nuts still maintained the maximum emergence of 80%, while other treatment combinations had statistically similar emergence except small seed nuts hydro primed for 0 and 12 hrs, which had the lowest values of 60 to 69% emergence. At the end of storage (210 days), large seed nuts hydro primed for 24 hrs recorded the highest seedling emergence (77%), while other treatment combinations had the emergence of between 71 and 74%. However, medium seed nuts hydro primed for 0 hr, as well as small seed nuts hydro primed for 0 and 12 hrs, had the lowest emergence of 65-69%.

A perusal of the data along the row indicates that large seed nuts hydroprimed

for 24 hrs consistently showed the highest emergence values of between 77 and 87% at each storage period. Consistently, un-primed small nuts had the lowest emergence values under each storage period.

Data on the influence of seed nut size, hydro priming duration and storage period on days to 50% seedling emergence in Brazilian cashew biotype are presented in Table 3. The results indicate significant differences in days to 50% seedling emergence in hydro primed cashew nut sizes at each storage period examined. However, the lowest the days to 50% seedling emergence, the better it is for the seed lot. At 0 day of storage, small nut size primed for 24 hrs recorded the lowest days to 50% seedling emergence of 12 days, while medium and small nut sizes hydro primed for 24 and 12 hrs, respectively, had 13 days to seedling emergence. The highest days to 50% seedling emergence of 18 days was recorded for un-primed large seed nut sizes. At 30 days of storage, small nut size hydro primed for 12 and 24 hrs recorded the lowest days to seedling emergence of 13 days whereas large, medium and small seed nuts hydro primed for 24, 12 and 0 hrs, respectively, had 15 days to seedling emergence. However, un-primed large seed nuts recorded the longest days (19 days) to seedling emergence after 30 days of storage. After 90 days of storage, large seed nuts hydro primed for 0 hr had the highest days to seedling emergence of 19 days, followed by the medium nuts hydro primed for 0 hr with 18 days seedling emergence whereas the medium seed nuts hydro primed for 24

TABLE 2

Responses of seed nut emergence (%) to nut size, hydro priming duration and storage period of Brazilian cashew biotype.

Nut size (g)	Hydro priming treatment (hrs)	Storage period (days)				
		0	30	90	150	210
Large	0	81c	77bc	77b	75b	73b
	12	81c	80b	77b	76b	74b
	24	87a	85a	81a	80a	77a
Medium	0	79cd	77bc	77b	77b	69c
	12	80c	79b	76b	75b	71b
	24	81c	80b	79ab	75b	74b
Small	0	77d	75c	73cd	68c	65d
	12	80c	79b	75c	69c	69c
	24	84b	81b	71b	77b	71b

Means followed by the same alphabet along the column are not significantly different from one another according to Tukey's HSD test at 5% probability level.

TABLE 3

Effects of nut size, hydro priming duration and storage period on days to 50% seedling emergence of Brazilian cashew biotype.

Nut size (g)	Hydro priming duration (hrs)	Storage Period (days)				
		0	30	90	150	210
Large	0	18a	19a	19a	24a	30a
	12	16b	17b	17c	20b	21b
	24	14d	15c	16d	18c	21b
Medium	0	16b	17b	18b	18c	19c
	12	14d	15c	16d	17d	19c
	24	13e	14d	14e	16e	18d
Small	0	15c	15c	17c	18c	17e
	12	13e	13e	15d	16e	17e
	24	12f	13e	13f	14f	16f

Means followed by the same alphabet along the column are not significantly different from one another according to Tukey's HSD test at 5% probability level.

hrs had 14 days to emergence and small seed nuts hydro primed for 24 hrs recorded the lowest seedling emergence of 13 days. Data generated at 150 days storage time showed that large nuts hydro primed for 0 hr recorded the longest days to emergence (24 days), followed by large seed nuts hydro primed for 12 hrs with 20 days. However, small seed nuts hydro primed for 24 hrs had the lowest days to emergence (14 days), while medium and small nuts primed for 24 and 12 hrs respectively recorded 16 days

to 50% seedling emergence. At the end of storage (210 days), large seed nuts hydro primed for 0 hr recorded the highest days to seedling emergence (30 days), followed by large seed nuts hydro primed for 12 and 24 hrs with 21 days, while small seed nuts hydro primed for 24 hrs had the lowest days to emergence of 16 days.

Analysis of the data along the row showed that un-primed large nuts had a consistent highest day to emergence at each storage period. Days to emergence progressively increased with the increase in storage time, irrespective of the treatment combination. The highest value of 30 days to emergence was recorded with large nuts stored for 120 days, while the lowest days to emergence (16 days) was observed with small nuts primed for 24 hrs.

Data in Table 4 show the effects of nut size, hydro priming duration and storage period on seedling vigour in Brazilian cashew biotype. The results indicate that at 0 and 30 days of storage, large seed nuts hydro primed for 0, 12 and 24 hrs had statistically similar and greater seedling vigour index of between 21.14 and 23.48 units, whereas other treatment lots had statistically similar and lower seedling vigour. At 90 days of storage, large seed nuts hydro primed for 24 hrs recorded the maximum seedling vigour of 21.97 unit, although were not significantly from other treatment lots except small seed nuts hydro primed for 0, 12 and 24 hrs which had the lowest seedling vigour. A similar trend in seedling vigour was obtained at 150 and 210 days of storage, with large seed nuts hydro primed for 24 hrs

having the highest seedling vigour, which was not significantly different from other treatment lots except for the small seed nuts hydro primed for 0, 12 and 24 hrs with the lowest seedling vigour values.

A cursory analysis of the data along the row indicates that large nuts hydro-primed for 24 hrs gave a consistent highest seedling vigour under each storage period. Seedling vigour values slightly declined with the increase in storage time from 23.84 at 0 day to 19.89 at 210 days of storage. However, seed nuts primed for 0, 12 and 24 hrs generally recorded the lowest seedling vigour values during the storage periods.

Table 5 presents data on the influence of seed nut size, hydro priming duration and storage period on seedling shoot length in Brazilian cashew biotype. The results reveal that at 0 day of storage, large seed nuts hydro primed for 0, 12 and 24 hrs recorded the highest seedling shoot length values of 28.01 to 28.51 cm. The influence of medium seed nuts reveals statistically similar values under the three hydro priming durations while small seed nuts hydro primed for 0 and 12 hrs had the lowest seedling shoot length values. At 30 days of storage, large seed nuts hydro primed for 24 hrs had the maximum seedling vigour of 28.43 cm, followed by large seed nuts hydro primed for 0 and 12 hrs. Similar seedling shoot length values were obtained for the medium seed nuts primed for 0, 12 and 24 hrs, while small seed nuts hydro primed for 0 and 12 hrs had the lowest seedling shoot length values. With the increase in storage days to 90 days, large nuts hydro primed for 0, 12 and 24

TABLE 4
Effects of nut size, hydro priming duration and storage period on seedling vigour of Brazilian cashew biotype.

Nut size (g)	Hydro priming treatment (hrs)	Storage period (days)				
		0	30	90	150	210
Large	0	21.14a	21.12a	20.90ab	19.87ab	18.83ab
	12	23.32a	23.13a	20.70ab	19.47ab	19.10a
	24	23.84a	23.30a	21.97a	20.10a	19.89a
Medium	0	19.95bc	19.73b	19.23ab	18.90ab	18.10ab
	12	20.10b	19.97b	19.03ab	18.33ab	18.32ab
	24	20.87b	20.47b	19.83ab	19.90ab	18.88ab
Small	0	18.00bc	17.53b	17.23b	17.13b	16.01c
	12	18.25bc	18.60b	17.33b	17.10b	16.08c
	24	19.95bc	19.80b	18.60b	17.73b	16.54c

Means followed by the same alphabet along the column are not significantly different from one another according to Tukey's HSD test at 5% probability level.

TABLE 5
Effects of nut size, hydro priming duration and storage period on seedling shoot length (cm) of Brazilian cashew biotype.

Nut size (g)	Hydro priming treatment (hrs)	Storage period (days)				
		0	30	90	150	210
Large	0	28.01a	27.67b	27.03a	26.40b	25.13b
	12	28.21a	27.07b	27.20a	26.93b	25.22b
	24	28.51a	28.43a	27.97a	27.03a	26.23a
Medium	0	25.83b	25.50c	24.90c	24.93d	24.33c
	12	25.87b	25.57c	25.07b	24.94d	24.43c
	24	25.93b	25.60c	25.20ab	25.03c	24.81c
Small	0	23.62d	23.50e	23.33d	23.10e	22.90e
	12	23.81d	23.63e	23.37d	23.23e	22.91e
	24	24.89c	24.37d	23.47d	23.41e	23.10d

Means followed by the same alphabet along the column are not significantly different from one another according to Tukey's HSD test at 5% probability level.

hrs had statistically similar and maximum seedling shoot length, followed by medium nuts hydro primed for 12 and 24 hrs with 25 cm seedling shoot length, while small seed nuts hydro primed for 0, 12 and 24 hrs had the lowest values of approximately 23cm. After 150 days of storage, large seed nuts

hydro primed for 24 hrs showed the highest seedling shoot length value of 27.03 cm. This was closely followed by large seed nuts primed for 0 and 12 hrs whereas small nuts hydro primed for 0, 12 and 24 hrs had the lowest value of 24 cm. At the end of storage (210 days), large seed nuts still maintained

the highest seedling shoot length value of 26.23 cm, closely followed by large seed nuts hydro primed for 0 and 12 hrs with the value of 25 cm, while small seed nuts hydro primed for 0 and 12 hrs showed the lowest seedling shoot length value.

A perusal of data on seedling shoot length along the row reveals that large nuts hydroprimed for 24 hrs had consistent highest values of between 26.23 and 28.51 during the storage periods. Conversely, small nuts primed for 0, 12 and 24 hrs had the lowest values of below 25.00 unit during the storage period evaluated.

DISCUSSION

Many factors can influence the imbibition and germination process, among them integument composition and water availability in the environment, seed physiological condition in storage (Vertucci, 1989; Adebisi *et al.*, 2008; Adebisi, 2012). In this study, significant differences were observed among the storage durations, seed nut sizes and hydro priming durations in respect of seedling emergence, days to 50% seedling emergence, seedling vigour index and seedling shoot length of Brazilian cashew biotype. Seed nut sizes significantly influenced seedling emergence with large nuts having the highest emergence of 79%, which was 5 to 6% higher than the values obtained for medium and small seed nuts. Small nuts were the first to emerge while large nuts were usually the last to emerge. Also, large nuts had the maximum seedling vigour level with greater seedling shoot length. In addition, hydro priming hours

significantly influenced seedling emergence, seedling vigour index, days to 50% seedling emergence and seedling shoot length with hydro priming of 24 hrs having the best performance with reduced days to 50% seedling emergence.

Significant and progressive seed deterioration was noticeable during storage in seedling emergence, irrespective of nut size grading. As the storage time advanced, the seed nuts deteriorated progressively. Meanwhile, higher seedling emergence values of 80-81% were obtained in the early storage time of 30 days, which then declined to 72% at the end of storage (210 days) with 10% reduction in seedling emergence. Days to 50% seedling emergence increased with the increase in storage duration but reduced days to emergence of 15-16 days were observed at 30 to 90 days of storage with greater seedling vigour and seedling shoot length.

The results presented help to understand some earlier observations in the literature. Priming stimulates many of the metabolic processes involved with the early phases of germination (Copeland & McDonald 1995; Dessai *et al.*, 1997). Given that part of germination processes have been initiated, seedlings from primed seeds grow much faster, more vigorously and perform better in adverse conditions (Basker & Halton, 1987; Dessai *et al.*, 1997). According to Simon (1984), water uptake in seeds follows a triphasic pattern with an initial rapid uptake phase known as imbibition (Phase I), followed by lag period (Phase II) and then a second increase in water uptake

associated with seedling growth (Phase III). At each phase, water uptake is controlled by the availability of water to the seed. In seed priming regime, seed water potential is at a level sufficient enough to initiate metabolic events in phase II of germination process but it prevents radical emergence (Simon, 1984).

In this study, the duration of the emergence period decreased, leading to more uniform plant stand (Mikkelsen, 1981; Basker & Halton, 1987). Nulawadi *et al.* (1973) reported that pre-soaking of soybean seeds in water for 24 hrs had significant effects on germination and seedling growth (fresh weight). The increase in germination percentage was from 21.20 to 54.00, while seedling fresh weights were from 1.735 to 3.445g.

The results of the present work corroborated the previous reports of Ibikunle and Komolafe (1973), Faluyi (1986) and Adebola *et al.* (1999) that large cashew nuts had superior germination than small nuts. Medium and small sized nuts also showed high level of emergence but their percentage emergence values were both less than the least emergence (Aliyu & Akintaro, 2007). In this study, small cashew seed nuts had the least days to emergence (earliest emergence), whereas large seed nut had the largest days to emergence (longest emergence). The problem of slow imbibition of dry intact seed is more pronounced in large seed nuts (Casini & Contiani, 1979; Crane & Forde, 1973; Nmadzhanova *et al.*, 1977).

According to Oyewumi (2014), thick shells in large seed nuts pose greater obstacle to water uptake than in medium and small nuts. Moreso, the inability of large seed nuts to readily take up water as a result of thicker seed coats, could have accounted for the observed latest emergence. Pre-soaking cashew nuts for 24 to 48 hrs was reported to promote imbibition and reduce the time for seeds to emerge but increase the proportion of seeds emerging (Turner, 1956; Auckland, 1961; Hartman, 1967; Joley & Opitz, 1971; Ibikunle & Komolafe 1973; Crane & Forde, 1974). The outcome of this study is, therefore, in line with previous findings. Increased storage duration significantly reduces percentage seedling emergence and increases days taken for seeds to emerge.

Large seed nuts hydro primed for 24hrs were found with consistent significant highest seedling emergence of between 87 and 77% at each of the storage period above control and other treatment lots. Small seed lots without hydro priming were generally found with the lowest seedling emergence, which ranged from 65 to 77% at the end of 210 storage days. Higher seedling emergence of between 73 and 77% was found with large seed nuts hydro primed for 0, 12 and 24 hrs, whereas medium seed nuts hydro primed for 0, 12 and 24 hrs retained 69 to 74% emergence. However, small seed nuts that were hydro primed for 0, 12 and 24 hrs had 65-71% seedling emergence at the end of storage period (210 days). In order to obtain good seedling emergence, large seed nuts storage period could be extended

to 210 days, while medium seed nuts can be stored for up to between 150 and 210 days but small nut storage duration should be between 90 and 150 days under ambient humid conditions (28-30°C).

Pre-sowing hydro priming of large seed nuts for 0, 12 and 24 hrs significantly enhanced seedling vigour index up to 18.83 and 23.84 units above other treatment lots at each of the storage times investigated. In addition, small nuts hydro primed for 0, 12 and 24 hrs had significant lowest seedling vigour at the end of storage time of 210 days. In a similar vein, large seed nuts hydro primed for 24 hrs had increase seedling shoot length above other treatment lots at each storage time. Furthermore, large nuts hydro primed for 0 and 12 hrs had comparable values that were higher than the values from the medium and small nuts at these soaking hours. Also, small seed nuts hydro primed between 0 and 12 hrs retained lower seedling shoot length at each storage time investigated.

CONCLUSION

Within the purview of this study, the beneficial effects of hydro priming were found in large seed nuts hydro primed for 24 hrs with the highest storage performance. Therefore, in order to obtain high emergence after storage, cashew nuts should be hydroprimed for 24 hrs prior to sowing. In addition, the seeds should be separated into various sizes, as large seed can be stored for 210 days, while those of medium size only for between 150 and 210 days and small seed nuts for only 150 days.

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