SEED GERMINATION AND SEEDLING VIGOUR ATTRIBUTES OF GMELINA (*Gmelina arborea)* SEEDS AFFECTED BY FRUIT MATURITY LEVELS AND PRE-STORAGE INVIGORATION TREATMENTS UNDER AMBIENT TROPICAL CONDITIONS

Adebisi, M. A and Bello, F. Y

Department of Plant Breeding and Seed Technology, Federal University of Agriculture, Abeokuta, P.M.B 2240, Abeokuta, Ogun State, Nigeria.
E-mail: mayoadebisi@yahoo.co.uk

ABSTRACT
Seed invigoration treatment, fruit maturity and storage period effects on seed germination and seedling vigour attributes of gmelina (*Gmelina arborea* L.) were investigated. The five fruit colour index of maturity (green, yellow, yellow brown, black and brown), five seed invigoration treatments (three organic materials (crude plant powders of scent (*Ocimum.gratissium*) leaves, red chili (*Capsicum frutescens*) fruits and black pepper (*Piper.guineense)* fruits and one inorganic chemical (apron plus-trade name) powder, a synthetic formulation) and control. Seed lots were treated with seed treatments recommended doses, packaged inside polyethylene bags and then stored under natural (ambient) conditions (temp 29^{0}C, Rh. 75 %) for 180 days (6 months). Seed lots at 60 days interval were assessed for seed germination and seedling vigour attributes. Data collected were analysed using ANOVA and treatment means were statistically seperated. Seeds derived from yellow brown and brown fruits were superior in storage for germination, seedling vigour and characteristics. Treatments with powders of scent leaf, red chilli fruits and black pepper fruits resulted in superior seed germination and seedling vigour attributes over control and apron plus treatments, irrespective of fruit maturity colour and storage periods. The superiority gain in germination, seedling vigour, seedling shoot length and number of leaves of seeds from yellow brown and brown fruits across storage was 42, 82, 89 and 82 %, respectively over seeds from black fruits. Seeds of yellow brown and brown fruits dressed with any of the three organic materials at 10 g/100 g seed and stored for 60 to 120 days showed superiority in germinative performance with robust seedling vigour attributes and is thereby advocated. Apron plus proved deleterious as a seed invigoration material. Use of these three organic crude plant materials as a pre-storage treatments in gmelina seeds hold promise and is recommended as a short-term storage strategy.

Keywords: Seed treatment, seed quality, gmelina seed and seed storability

INTRODUCTION
Gmelina arborea is the most important species for timber production and several hectares have been planted in different ecological zones (Moya, 2004). *Gmelina arborea* is a deciduous tree, 12-30 m high and 60-100 cm in diameter which is native to tropical moist forest from India, Burma and Sri Lanka to Southern China, *Gmelina arborea* is widely distributed in Brazil, Gambia, Honduras, Ivory Coast, Malaysia, Malawi, Nigeria, Panama, Philippines and Sierra Leone. However, Gmelina was originally established in Nigeria for supply of pulp wood to the country's pulp and paper mills (Akachukwu (1993). These pulp and paper industries in Nigeria have all closed down and the species is now used as building material. These plantations are now ready sources of raw logs for conversion into saw woods of uniform grades and sizes (Adetogun and Omole, 2007). According to Duke (1983) the wood is one of the best timber of the tropics, useful for particle board, plywood, corestock, pit probs, matches and saw timber for light construction, furniture, general carpentry and packaging.

Longevity of seeds in storage is a good indicator of seed quality and vigour in many crops species (Ellis and Robert, 1980). Seeds are stored for few days, weeks, months or years during which they deteriorate, moving inexorably towards death (Grey *et al.*, 1994). Seed deterioration during storage is a complex physiological and biochemical process leading to loss of viability. Seed storage at ambient condition is a problem particularly due to the high temperature and high humidity in tropical regions. The rate of deterioration of seed depends on storage conditions such as temperature (Walters *et al.*, 2005). Therefore, to maintain seed physiological quality, seed must be stored between harvest period and sowing of the succeeding crop in order to minimize the rate of deterioration. Duffus and Slaughter (1980) also described seed storage as a method after maturation and harvest in which seeds have to be stored until required for use and still be able to germinate to nearly 100% and produce vigorous seedling on the field. Studies have shown that seed quality can be largely influenced by a wide range of environmental factors during seed production, harvesting, processing, storage and treatment such as invigoration priming (Tekrony *et al.,* 1980; Mc Donald, 2002; Adebisi and Ojo, 2001).

Dry seed treatment of freshly harvested seeds with *Capcicum frutescens* powder (red chili pepper fruits), *Ocimum gratissium* powder (scent leaf) and *Piper* guineese powder (black pepper fruits) significantly slowed down seed deterioration over untreated control in crop species (Pal and Basu, 1993; 1994 in wheat; Esuruoso, 2010 in kenaf; Oni, 2012 in sesame and Adebisi, 2013 in okra). Adebisi *et al.* (2003); Adebisi *et al* .(2007) and Adebisi (2013) have reported the effectiveness of apron plus seed treatment chemical on the maintenance of seed germination and seedling vigour in soybean and okra, respectively. From the various studies so far, it is noteworthy that treatment of seeds with organic and inorganic invigoration treatments increase the germinative ability of seeds in storage to greater extent as certain attributes of seed quality are maintained over the period of time.

Different fruit colours in *Gmelina arborea* have been identified and reported by Adebisi *et al.,* (2011). These are yellow, brown, dark brown and green colour. The variation in the fruit colour is an indicator of maturity level of the fruit and they have been reported to influence seed quality of *Gmelina arborea.* A report by Adeb isi *et al.* (2011) on fruit colour and germinative performance of *Gmelina arborea* revealed that of the four fruits colour examined, seeds obtained from yellow brown fruits gave consistent superior germinative performance traits, closely followed by seeds from yellow fruits at each soaking hours and control treatment and seeds of dark brown fruits had a consistent poor germinative performance traits. The inability of *Gmelina arborea* seeds to germinate might be owing to over ripeness or over fermentation of the pulpy part of the fruit which causes the death of the embryo.

Despite the enormous benefits of the tree-plant, unexpected low germination rate had been recorded in *Gmelina arborea* (Adebisi *et al,* 2011). Okoro (1983) and Hartman and Koster (1975) have suggested the possibility of the presence of inhibitory substances in the fleshy pericarp of *Gmelina arborea*. Fruit colour, size, fermentation, depulping and the time of collection were found to affect germination of *Gmelina arborea* seeds (Woessner, 1979, Okoro, 1983, Adebisi *et al*., 2011). Seed quality encompassed all the attributes which contributes to seed performance including genetic purity, physical purity, germination and vigour).

However, improved seed invigoration treatment are known to reduce emergence time, accomplish uniform emergence and give a better crop stand in many horticultural and field crops. These include treatment with dry and wet organic and inorganic materials. Although, seed invigoration treatments have been found effective for better seed germination and seedling establishment in field crops under controlled conditions, however, no comprehensive study and information have yet been recorded and done to evaluate the response to a wide range of seed invigoration treatments to enhance emergence and growth of *Gmelina arborea* seed from different fruits maturity levels. If positive findings are established in this work, it will help to provide a simple, cost effective and affordable management strategy in the maintenance of germplasm of *Gmelina arborea* seeds. This research work investigated the most promising seed invigoration treatments for maintenance of seed germination and seedling vigour attributes of stored *Gmelina arborea* seeds from different fruit maturity levels under ambient tropical conditions.

MATERIALS AND METHODS

Collection of seed materials: Fruits of *Gmelina arborea* were collected from the Forest Reserve. Federal University of Agriculture, Abeokuta, Ogun State, Nigeria, between July and August. 2011.

Seed preparation: Depulping was carried out to remove the seeds from the fruits immediately after collection, after which the fleshy cover was rubbed off using sand and water to remove the pulp from the stones. The stones were then dried under ambient temperature for six weeks to averagely 11.2 % moisture content.

Fruit maturity selection: Based on the physical appearance of the matured fruits of *Gmelina arborea* and using colour as an index of level of maturation and ripeness as reported by Adebisi *et al.* (2011), five categories of fruits (green, yellow, yellow brown, dark-black and brown fruits) of the species were collected from fruiting trees.

Seed invigoration treatment: Five dry seed invigoration treatments consisting of three organic crude plant materials (*Piper guineese* powder (black pepper fruits)**,** *Ocimum gratissium* powder (Scent leaaves), *Capcicum frutescens* powder (red chili pepper friuts) and one inorganic pharmaceutical chemical formulation (Apron plus-$^{\text{trade name}}$) and control (no treatment) were investigated in the study. Organic treatments recommendation used was 10 g/100 g seed and inorganic treatment recommendation was 5 g/100 g seed. These treatments were selected based on previous works which proved their effectiveness in maintaining seed quality during storage in different crop species and also it is economical to and affordable by the poor resource seedling growers.

Experimental design: The experiment was a factorial in a completely randomized design with three replications. There were 300 experimental units which consisted of fruit maturity colours (5), dry invigoration treatments (5) and storage time (4) which was replicated three times.

Seed storage: Each treated seed lot was packaged and stored in polythene bags (11 mm guage) and sealed electrically and then put in storage under natural (ambient) conditions in the laboratory. The seed quality traits were monitored at 60 days interval for a period of 180 days (6 months). The mean temperature and relative humidity of the storage environment was monitored using hygrometer (average temp 29^0 C, relative humidity 75 %).

Seed quality assessment: Seed samples were taken from each treated seed lot and tested for the following seed quality attributes at interval of 0, 60, 120 and 180 days

Seed germination: This was achieved by counting 50 seeds randomly from each replicate in each treatment unit and were sown 5 cm deep in polythene bags (dimension 30 cm x 30 cm each) filled with sterilized soil with 1cm spacing between the seeds. The polythene bags were arranged in a completely randomized design in the screen house and germination count of normal (healthy or strong) seedlings was monitored. Observations on germination were made in the sown seeds every 3 days up till 30 days. The percentage seed germination was determined (ISTA, 1995),

Seedling shoot height: The seedling shoot heights of 20 randomly selected normal seedlings were measured from each treatments unit at 30 days after sowing in each replicate (AOSA, 1983).

Seedling vigour index (SVI): The vigour level of each treated seed lot was calculated according to Kim *et al*., (1994) as percentage normal emergence multiplied by seedling shoot height and divided by 100 (Adebisi, 2004).

Number of leaves per seedling: Total number of leaves on 20 randomly sampled seedlings were recorded and averaged.

Data analysis:

All data collected on the four seed quality attributes were subjected to analysis of variance (ANOVA) according to completely randomized block design. The combined ANOVA was done among fruit maturity colour levels, seed invigoration treatments and storage periods as published by Gomez and Gomez (1984). Means of fruit maturity colour levels, seed invigoration treatments and storage periods were compared using Tukey"s HSD test at 5% probability level using SPSS (statistical package for social science) programme window.

RESULTS AND DISCUSSION

Table 1 shows the summary of ANOVA for effect of seed treatment, storage period and fruit colour level on seed quality attributes of *Gmelina arborea.* From this result, treatment, storage period and fruit colour effects as well as interaction effect of storage time x fruit colour were highly significant ($P = 0.01$) on the four seed quality traits while treatment x fruit colour interaction effect was highly significant ($P \leq 0.01$) on seed germination but had significant ($P \leq 0.01$) effect on seedling vigour index. Also the interaction of treatment x storage period was highly significant ($P \leq 0.01$) on seed germination whereas the three-way interaction effect was highly significant ($P \leq 0.01$) on seed germination only.

Table 1: ANOVA for the effect of seed invigoration treatment, storage period and fruit colour on seed quality attributes of *Gmelina arborea.*

Source of variation	DF	Seed germination%	Seedling shoot height (cm) per seedling	Seedling vigour Index	Number of leaves per seedling
Replicate	2	64.00 ns	12. 56 ns	0.25 ns	17.76 ns
Treatment	4	21479.00 **	13.49 ns	6.49 *	16.73 ns
Storage period	3	93461.11 **	113.19 **	42.89 **	131.14 **
Fruit colour	4	20442.10**	174.64 **	40.63 **	201.58 **
Storage time×fruit colour	12	2478.81**	23.97 **	8.79 **	31.74 **
Treatment× fruit colour	16	1349.08**	9.48 ns	4.26 *	7.53 ns
Treatment×storage period	12	977.22 **	2.06 ns	2.05 ns	2.59 ns
Treatment×storage period×fruit colour	48	856.53**	7.53 ns	2.14 ns	6.64 ns
Error	199	17.52	7.35	2.24	7.34

*Significant at 5 % probability level,**Significant at 1 % probability level, ns not significant.

The differential responses observed in the four seed quality parameters investigated among seed invigoration treatments and storage time examined implies that the quality of seeds from fruits harvested at different levels of maturity was influenced by seed invigoration treatments and storage period. Adebisi *et al.* (2013) and Adebisi *et al*. (2011) reported that seed quality attributes of gmelina seeds were influenced by priming solution or media and fruit maturity level, respectively. This, therefore, suggests that various opportunities are available for the improvement of seed physiological potential of gmelina seeds derived from different fruit maturity colour levels.

In Figure 1, seed germination varied among some fruit colour levels of gmelina. Seeds from yellow brown and brown fruits showed significant highest values of 72 % each whereas seeds from black fruits had lowest value of 42 %. Highest seedling shoot height was recorded in seeds obtained from yellow brown and brown fruits with values of 5.03 and 4.85 cm, respectively but seeds from black fruits had lowest value of 0.89 cm. On seedling vigour index, seeds from yellow brown and brown fruits showed highest values of 3.62 and 3. 49 followed by seeds from yellow fruits while seeds from back fruits gave lowest value of 0.37. Number of leaves per seedling was highest with seeds from yellow brown and brown fruits with values of 5.12 each, followed by seeds from yellow fruits while seeds of black fruits showed lowest value of 0.92. Seeds obtained from yellow brown and brown fruits were 7 % superior in seed germination over green and yellow fruits but the superiority was more pronounced with 42 % over black fruits. For seedling vigour, seedling shoot length and number of leaves, the superiority of seeds from yellow brown and brown fruits was 82, 89 and 82 %, respectively over black fruits.

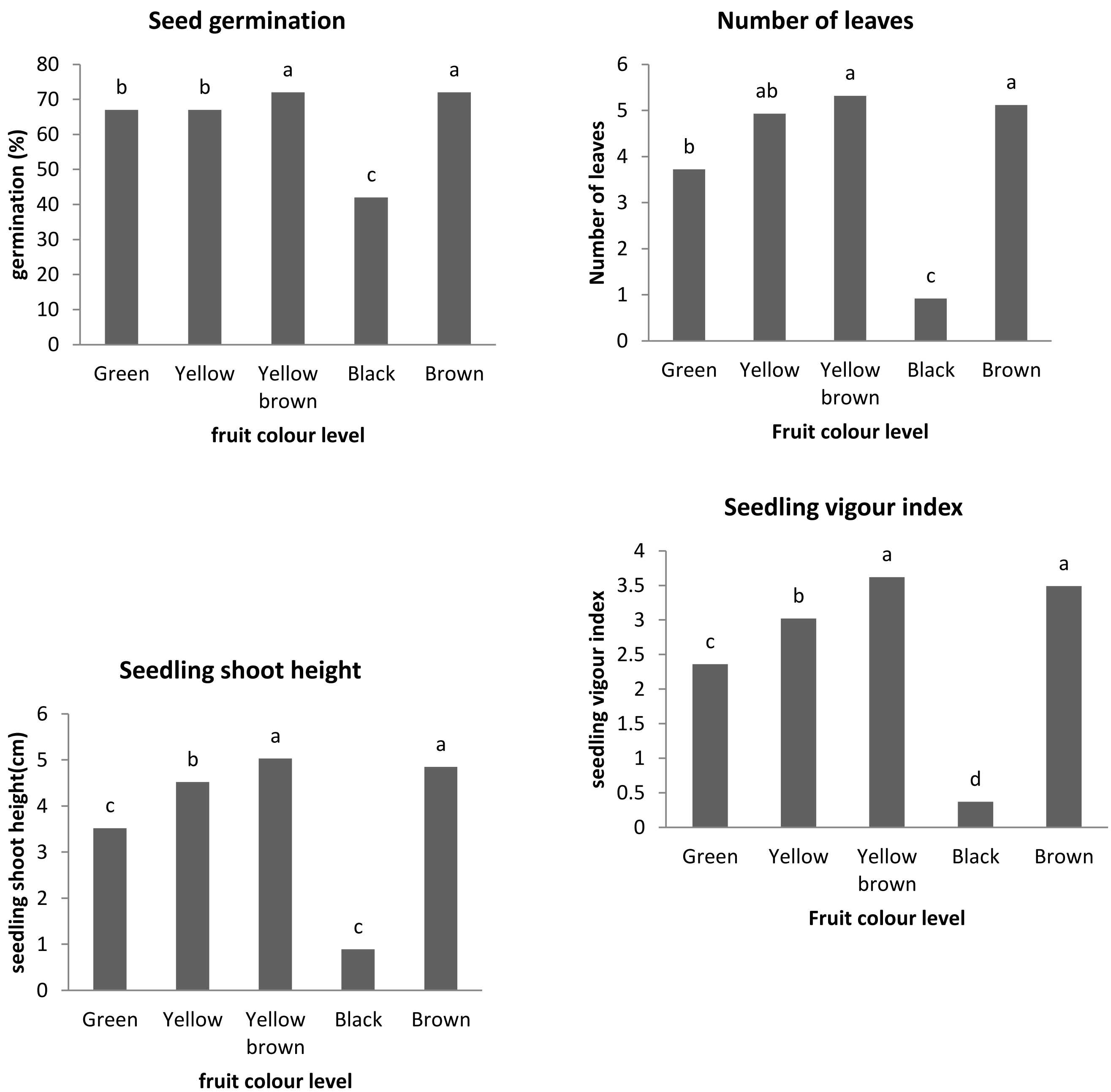

Fig. 1: Influence of fruit colour levels on seed quality of gmelina seed across seed invigoration treatments and storage time. Bars followed with same letters along the same column are not significantly different at 5% probability level.

From the data in Table 2, seeds dressed with powders of red chili fruits and black pepper fruits, followed by scent leaves powder recorded highest seed germination of 69 % above control treatment while apron plus treatment gave the least germination (59 %). Seeds dressed with powders of the three organic crude plant materials showed statistically similar and highest seedling shoot heights of between 4.18 and 4.28 cm above control treatment but apron plus treatment gave lowest value of 3.46 cm. Seed vigour index values of the three organic treated seeds were highest over control and apron plus treatments with values ranging from 2.80 to 2.82 units but apron plus treatment showed lowest value of 2.21 unit. Conversely, values from number of leaves per seedling were statistically similar among the five treatments with values ranging from 3.23 to 4.48. The superiority gain in seed germination in seed dressed with scent leaf, black pepper fruits and red chili fruits was between 7 and 14 % over apron plus and control treated seeds, whereas with seedling vigour index, it was between 12 and 29 % over apron plus and control treatments.

Table 2: Influence of seed invigoration treatments on seed quality attributes of gmelina seeds across fruit colour levels and storage time

Seed invigoration treatment	Seedling emergence	Seedling shoot height	Seedling vigour index	Number of leaves
Scent leaf	67ab	4.18a	2.80a	4.48a
Red chilli fruit	69a	4.28a	2.81a	4.33a
Black pepper	69a	4.10a	2.82a	4.23a
Apron plus	59c	3.76b	2.21b	3.33a
Control	64b	4.29a	2.46c	4.25a

Means followed by the same letters along the same column are not significantly different at 5% probability level.

Data in Figure 2 show that seed germination was highest at 0 day of storage with 76 % and thereafter significantly declined to 70 % at 60 days of storage and further reduced to 61 % after 120 days of storage but at 180 days of storage, seed germination had declined to 44 %. For seedling shoot height, highest values of 5.07and 4.51cm were obtained at 0 and 60 days of storage and thereafter declined to 2.48 cm at the end of storage (180 days). Highest seedling vigour index values of 3.85 was obtained at 0 day of storage and significantly declined to 3.16 at 60 days of storage and further declined to 1.09 at 180 days of storage. Maximum number of leaves was recorded at 0 and 60 days of storage with values of 3.58 and 4.53, respectively and significantly declined to 2.63 at the end of storage 180 days.

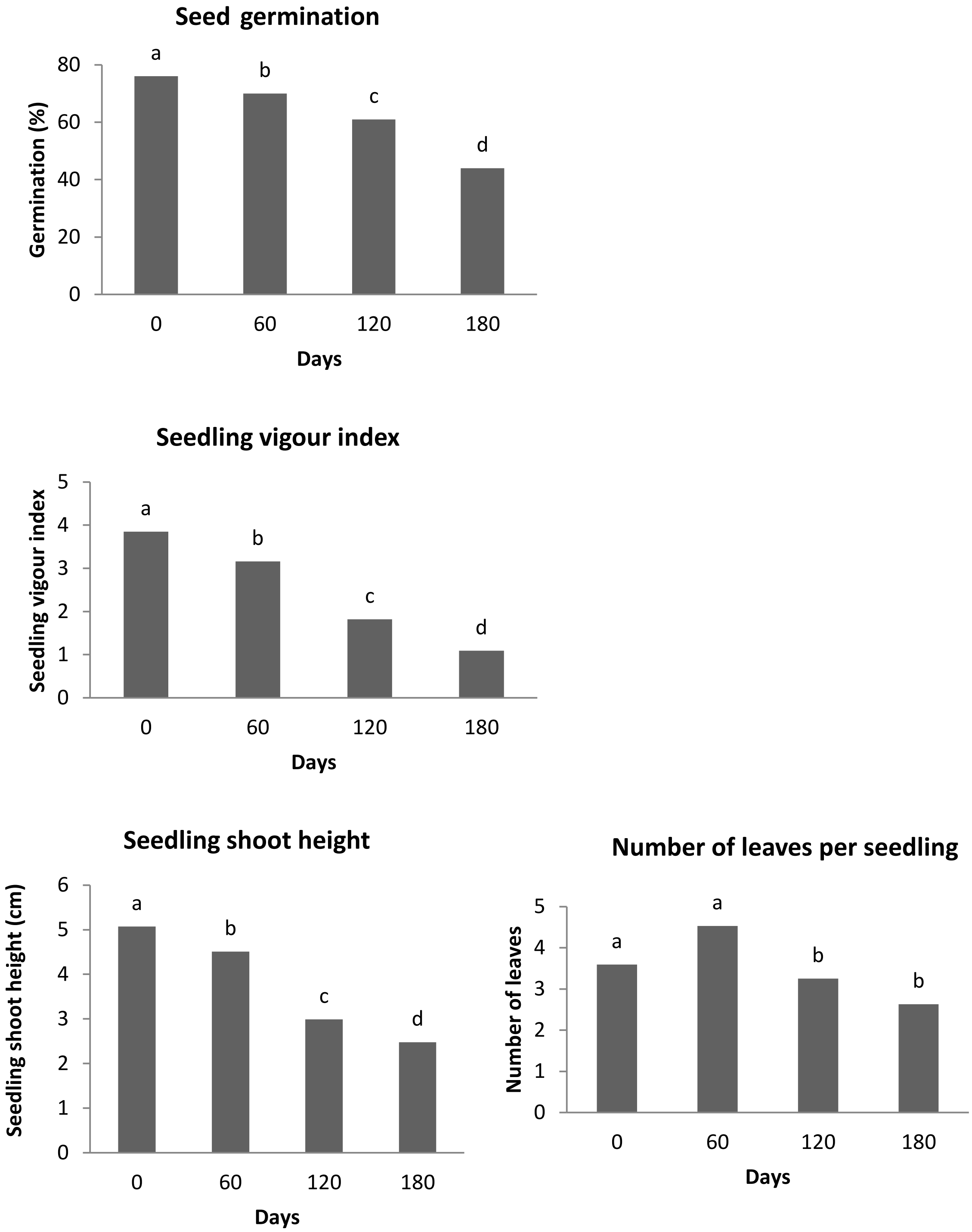

Fig. 2: Changes in seed germination and seedling vigour attributess of gmelina seeds during storage under ambient conditions across seed invigoration treatment and fruit colour levels. Bars with same letters are not significantly different at 5% probability level

In Table 3, at 0 day of storage, seeds from the five fruit colours except seeds of black fruits dressed with any of the five seed invigoration materials had statistically similar and higher germination of 80- 81 %. After 60 days of storage, seeds from green, yellow and brown fruits dressed with scent leaf powder, seeds from yellow and yellow brown dressed with red chilli fruit powder and seeds from yellow brown and brown fruits treated with black pepper as well as control treated seeds showed highest seed germination of between 79-80 % over black fruits (60 %). Furthermore, after 120 days of storage, there was a general reduction in seed germination, irrespective of treatment materials. Seeds obtained from yellow brown and brown fruits dressed with powders of red chili fruits and black pepper recorded statistically highest seed germination of between 74 and 74 % over other treatments including control. Conversely, seeds obtained from any of the fruit colours and dressed with apron plus powder showed statistically lowest seed germination of between 46 and 46 %.

Table 3: Influence of fruit colour level, storage period and seed invigoration treatments on seed germination of gmelina seeds

Fruit colour	Seed treatment(powder)	Storage period (days)			
		0			
Green	Scent leaf	80a	**60**	**120**	**180**
Yellow	Scent leaf	81a	80a	70bc	60b
Yellow brown	Scent leaf	80a	78ab	68c	56c
Black	Scent leaf	61b	75b	71bc	68a
Brown	Scent leaf	80a	43f	40g	37e
Green	Red chilli	80a	80a	73b	69a
Yellow	Red chilli	81a	78ab	70bc	62b
Yellow brown	Red chilli	82a	80a	60d	54c
Black	Red chilli	60b	80a	76a	70a
Brown	Red chilli	80a	60c	52e	40e
Green	Black pepper	80a	76b	74a	68a
Yellow	Black pepper	80a	72b	60d	58a
Yellow brown	Black pepper	80a	74b	67c	60c
Black	Black pepper	62b	80a	74a	68a
Brown	Black pepper	80a	57d	50f	4dd
Green	Apron plus	80a	80a	76a	68a
Yellow	Apron plus	81a	60c	55de	46d
Yellow brown	Apron plus	63b	59d	52e	44de
Black	Apron plus	60b	64c	57d	50c
Brown	Apron plus	81a	51e	46f	35e
Green	Control	80a	68c	60d	53c
Yellow	Control	80a	80a	60d	57c
Yellow brown	Control	80a	78a	52d	50c
Black	Control	60b	80a	65c	56bc
Brown	Control	80a	60d	40g	20f

Means followed by the same letters along the same column are not significantly different at 5% probability level.

At the end of storage (180 days), seeds from yellow brown and brown fruits dressed with crude powders of scent leaves, red chili fruits and black pepper fruits recorded significant highest seed germination of between 68 and 70 % above other treatment combinations including control, closely followed by seeds from yellow fruits while seeds from black fruit showed lowest germination, irrespective of seed treatment materials. Apron plus, an inorganic chemical, had deleterious effect on storability of gmelina seeds. On the contrary, use of apron plus had been found promising in enhancing germination during storage in some crop varieties (Adebisi *et al.*, 2003 in soybean and Adebisi, 2013 in okra).whereas deleterious effect of apron plus (an inorganic chemical) on storage life of sesame seed was documented by Oni (2012). It is, therefore, necessary to pay close attention to seeds from different fruit maturity levels during storage after seed invigoration treatment.

The influence of storage period and seed invigoration treatment on seedling vigour index of gmelina seeds across fruit colour level is shown in Table 4. The data reveal that significant differences occurred among the treatments and storage period for seedling vigour index and declined with advance in storage period. Seed dressed with crude powder of scent leaves showed significant highest seedling vigour index value (3.30), followed by seeds stored for 60 days (2.73) while lowest seedling vigour level (0.77) was recorded at 180 days of storage. With red chilli fruit powder treatment, highest seedling vigour index was obtained at 0 day (2.21) and then declined slightly and non significantly with length of storage up till the end of storage (180 days). Black pepper fruit powder treatment resulted in highest seeding vigour level (2.00-2.31) of gmelina seeds at 0 and 60 days of storage and then declined significantly to less than 1.0 at 120 and 180 days of storage. With apron plus treatment, highest seedling vigour index of 2.47 occurred at 0 day of storage and thereafter declined slightly with increase in storage period. For control treatment, highest seedling vigour of 1.91 to 2.34 was maintained up to 60 days of storage (2.34) and thereafter declined significantly to 1.40 and 1.32 at 120 and 180 days of storage, respectively.

Table 4: Influence of storage period and seed invigoration treatments on seedling vigour index of gmelina seeds across fruit colours

Storage time	Scent leaf powder	Red chilli fruit powder	Black pepper fruit powder	Apron plus powder	Control treatment
0 day	3.30a	2.21a	2.39a	2.47a	1.91a
60days	2.73b	1.04b	2.00a	1.75b	2.34a
120days	1.22c	0.64b	0.93b	1.00b	1.40b
180days	0.77d	0.56b	0.86b	0.84b	1.32b

Means followed by the same letters along the same column are not significantly different at 5% probability level.

From the data in Table 5, significant differences existed for seedling shoot height of gmelina seeds among some fruit colour levels at each storage period. Seed obtained from yellow, yellow brown and brown fruits had highest seedling shoot height at 0 day of storage while seeds from black fruits had the least seedling shoot height (0.57cm).

Table 5: Influence of storage period and fruit colour level on seedling shoot height of gmelina seeds across seed invigoration treatments

Fruit colour	0 day	60 days	120 days	180 days
Green	5.03^{b}	4.50^{b}	2.28^{b}	2.28^{b}
Yellow	6.68^{a}	6.22^{a}	2.57^{b}	2.61^{b}
Yellow brown	6.77^{a}	4.60^{b}	4.35^{a}	4.39^{a}
Black	0.37^{c}	0.57^{c}	2.64^{b}	0.03^{c}
Brown	6.51^{a}	6.67^{a}	3.11^{ab}	3.11^{ab}

Means followed by the same alphabet along the column are not significantly different at 5% probability level.

At 60 days of storage, seeds from brown and yellow fruits had highest seedling shoot heights of 6.67 and 6.22 cm, respectively while seeds from black fruits showed the least seedling shoot height (0.57cm). However, after 120 days of storage, seeds from dark brown fruits gave the highest seedling height (4.35 cm), though were not significantly different from value of 3.11 cm obtained in seeds from brown fruits whereas seeds from other fruits recorded the least seedling shoot height values between 2.28 and 2.64 cm.. Also at the end of storage (180 days), seeds from dark brown had the highest seedling shoot height (4.39 cm) which were not significantly different from value of 3.11cm obtained in seeds from brown fruits while seeds from black fruit showed the least seedling shoot height (0.03 cm).

Data on influence of storage period and fruit clour levels on number of leaves of gmelina seedlings across seed invigoration treatment (Table 6) reveal that significant differences existed for number of leaves of gmelina seedlings among some fruit colours at each storage period. At 0 day of storage, seeds from all the fruit colours except black fruits had similar and higher number of leaves per seedling but seedlings from black fruit had the least number of leaves (0.40). With increase in storage period to 60 days, seeds from yellow and brown fruits were found with highest number of leaves of 6.80 and 6.60, respectively while seeds from black fruits had the least number of leaves (0.53). After 120 days of storage, seeds obtained from yellow brown fruits recorded highest number of leaves (5.13) while seeds from other four fruit colours showed statistically similar and lower number of leaves. Furthermore, at the end of storage (180 days), seeds obtained from yellow brown fruits showed highest number of leaves per seedling (5.13) followed by seeds from green, yellow and brown fruits while seeds from black fruits had the least number of leaves (0.03).

Table 6: Influence of storage period and fruit colour level on number of leaves per seedling of gmelina seeds across seed invigoration treatments

Fruit colour	0 day	60 days	120 days	180 days
Green	6.20a	4.40b	2.13b	2.00c
Yellow	7.47a	6.80a	2.93b	2.53b
Yellow brown	6.67a	4.33b	5.13a	5.13a
Black	0.40b	0.53c	2.73b	0.03d
Brown	7.20b	6.60a	3.33b	3.33b

Means followed by the same alphabet along the column are not significantly different at 5% probability level.

Table 7 shows the influence of seed invigoration treatment and fruit colour level on seedling vigour index of gmelina seeds.

Table 7: Influence of seed invigoration treatment and fruit colour level on seedling vigour index of gmelina seeds across storage periods

Seed Treatment powder	Green	Yellow	Yellow brown	Black	Brown
Scent leaf	2.55a	3.20a	3.70a	0.40a	3.66a
Red chilli fruit	2.55a	3.10a	3.85a	0.47a	3.61a
Piper.fruit	2.36a	3.17a	3.64a	0.49a	3.68a
Apron plus	2.00b	2.65b	3.14c	0.42a	3.00c
Control	2.38a	2.93b	3.31b	0.40a	3.30b

Means followed by the same alphabet along the column are not significantly different at 5% probability level

The data reveal that significant differences occurred among the treatments under each fruit maturity colours. Seeds obtained from green fruits treated with powders of scent leaves, red chili fruit, and black pepper fruits and control treatment had statistically similar seedling vigour level of between 2.38 and 2.55 above apron plus treatment (2.00). Seeds from yellow fruits dressed with three organic crude plant materials (scent leaves, red chili fruit, and black pepper*)* recorded statistically similar and highest seedling vigour of between 3.10 and 3.20 above apron plus and control treatments. Similarly, seeds of yellow brown fruits dressed with three organic crude plant materials showed statistically similar and highest seedling vigour ranging from 3.14 and 3.70 above control and apron plus treatments but control treated seeds recorded significant higher value (3.31) above apron plus treatment (3.04). For seeds from black fruits, all the four treatments as well as control showed statistically similar values, though the values were less than 1.00 unit. Furthermore, seeds obtained from brown fruits dressed with powders of scent leaves, red chili fruit, and black pepper fruits recorded statistically similar and highest seedling vigour of between 3.61 and 3.68 units above apron plus and control treatments but control treatment had higher vigour (3.30) over apron plus treated seeds with value of 3.00.

The performance of seedling vigour after seed treatment during storage showed that seeds dressed with either organic and inorganic materials, in most cases, had robust vigour within (120 days i.e. 4 months of storage. The performance of seedling shoot height among fruit colours in storage indicated that seeds obtained from yellow brown and brown followed by yellow fruits were implicated with superior seedling height at the end of 180 days (6 months) of storage. The result of seedling vigour index of seeds from different fruit colours after seed invigoration dressing during storage showed that seeds of green, yellow, yellow brown and brown fruits dressed with the three organic materials (scent leaves, red chili fruits and black pepper fruits).powders showed superior seedling vigour over apron plus and control. For number of leaves per seedling among the fruit colours during storage, seeds from yellow brown fruits followed by seeds from brown and yellow fruits had highest number of leaves over others at the end of storage (180 days) while seeds from black fruits gave the least.

In this study, there was a gradual decline in the four seed germination and seedling vigour attributes with increase in storage periods, irrespective of pre-storage seed invigoration treatments, and was more pronounced after 180 days (6 months) of storage. Maximum seed germination, seedling vigour and seedling shoot heights and number of leaves were still maintained at between 60 and 120 days of storage. According to Adebisi (2013), the progressive decline could be due to increase in the deteriorative processes which were enhanced by the higher temperature (28^0C) and relative humidity (75 %) of the natural conditions of the storage environment. Higher deterioration of seed quality parameters, irrespective of seed invigoration treatments, has been reported earlier in different crop species (Adebisi and Oyekale, 2005, Ajala and Adebisi, 2005, Adebisi *et al.*, 2008, Oni, 2012 and Adebisi, 2013).

Once seed deterioration has happened, this catabolic process cannot be reversed. It is a sequence of events beginning with a chain of biochemical events, predominantly membrane damage and impairment of biosynthetic reactions and then the resulting losses of various seed performance attribute (Jyoti and Malik, 2013). Viability loss results in irreversible chemical and structural changes to cellular constituents (Walters *et al.*, 2010). Seed deterioration is the alterations occurring with time that increase the seed exposure to external challenges and decrease the ability of the seed to survive. Seed deterioration is a natural process which involves cytological, physiological, biochemical and physical changes in seeds. Seed deterioration is associated with various cellular, metabolic and chemical alterations including lipid peroxidation, membrane disruption, DNA damage, impairment of RNA and protein synthesis and cause several effects on seed (Jyoti and Malik, 2013). These changes reduce seed viability, produce weak seedlings and ultimately cause death of the seeds.

On the mode of action of organic plant materials used as invigoration materials, Basu, (1994); Mandal *et al*. (2000); and Mandal *et al.* (2003) have discussed numerous possibilities. In this study, the organic materials were chosen based on previous reports (Mandal and Basu 1986; Mandal *et al.,* 2003; Adebisi, 2008) on their inherent effectiveness in melting down free radical reactions as antioxidants, antioxidant-synergist and radio protective agents (Slater, 1972, Povard *et al*.,1994). Capsicin derived from *Capsicum frutescens* is a known inhibitor of lipids peroxidation (Mandal *et al.*,2003). Also linalool is the most important constituent of *Ocimum gratissium* and piperaceae, a constituent of *Piper guineense* might act as inhibitors of lipid peroxidation, thereby responsible for maintenance of seed longevity in storage. According to Mandal *et al*.(2002), the role of natural plant preparation in the control deterioration could be due to reduced lipid peroxidation because volatile aldehyde production was lower in seeds treated with such preparation than in the control seed lots.

CONCLUSION

This report confirms the superiority of seeds derived from yellow brown and brown fruits in terms of seed germinability, seedling vigour and seedling characteristics. Seed invigoration treatments with powders of scent leaf (*O.gratissium*), red chilli (*C. frutescens*) fruits and black pepper (*P. guineense)* fruits resulted in superior seed germination and seedling vigour characters over control and apron plus chemical treatments, irrespective of fruit maturity colour levels of gmelina seeds during storage. Apron plus chemical, a synthetic (inorganic material), proved deleterious as a seed invigoration material. The superiority gain in seed germination, seedling vigour, seedling shoot length and number of leaves of seeds from yellow brown and brown fruits across storage was 42, 82, 89 and 82 %, respectively over seeds from black fruits.Storage period of gmelina seeds derived from different fruit maturity levels and dressed with powders of scent leaf, red chilli fruits and black pepper fruits at the rate 10 g/100 g seed should not exceed 60 to 120 days under ambient tropical conditions as maximum seed germination, seedling vigour and seedling shoot heights and number of leaves were still maintained. Use of these three organic crude plant materials as a pre storage seed invigoration treatments in gmelina seeds hold promise and is therefore recommended as a short-term storage strategy. However, the plant materials are readily available, cost effective and environmentally friendly for a poor-resource seedling growers under tropical conditions.

Acknowledgements

The authors sincerely acknowledge the support of the Department of Plant Breeding and Seed Technology and College of Plant Science and Crop Production, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, South-west, Nigeria, in providing the materials for the project. The authors appreciate and thank the management and staff of FUNAAB Forest Reserve for technical assistance and support during the research work..The technical assistance of Miss. Oni, Oluwatosin is highly appreciated and acknowledged.

REFERENCES

Adebisi, M. A. and Ojo, D. K. (2001). Effects of genotype on soybean seed quality development under West Africa Rain fed conditions, *Pertanika J. Trop. Agric. Sci.* 24 (2): 139-145.

Adebisi, M. A. (2004**)**. Variation, stability and correlation studies in seed quality and yield characters of sesame Unpublished Ph.D Thesis. Department of Plant Breeding and Seed Technology, Federal University of Agriculture, Abeokuta, Ogun State. 117pp.

Adebisi, M. A and Oyekale, K. O. **(**2005). Effect of seed treatments and storage containers on the maintenance of viability of okra seed. *ASSET Journal Series A: 5* (1): 81-89.

Adebisi, M. A., Akintobi, D. C and Oyekale, K. O. (2007). Preservation of okro seed vigour by seed treatments and storage containers. *Nigerian Journal of Horticultural Science* 12: 17-24**.**

Adebisi, M. A.. Ola, J. A., Akintobi, D. C. A and Daniel, I. O. (2008). Storage life of sesame (S*esamum indicum* l.) seed under humid tropical conditions. *Seed Science and Technology* 36:379-387.

Adebisi, M. A**.,** Adekunle, M. F and Odebiyi, A. O. (2011). Effect of fruit maturity and pre-sowing water treatment on germinative performance of gmelina (*Gmelina aborea* roxb) seed. *Journal of Tropical Forest Science.* 23 (4): 371-280.

Adebisi, M. A (2012). Efficacy of plant and chemical materials on quality of okra seed stored under natural ageing conditions. *Nigerian Journal of Horticultural Science* 17:157-168.

Adebisi, M. A., Kehinde, T. O., Adekunle, M. F and Adenaike A.C. **(**2013). Seed chemical priming for germination and seedling vigour traits in gmelina (*Gmelina arborea*) seeds from different maturity levels. *Research Journal of Forestry* 7: (1): 26-33.

Adeogun, A. C and Omole, A. O (2007). Treatment of *Gmelina arborea* with CCA using thermal process. *Journal of Tropical Forest Science, 19 (3):186-187.*

Akachukwu, A. E (1993). Wood properties of *Gmelina arborea* Roxb.and their biological control, pp163-168. In Oduwaye, E. (Ed.). *Proceedings of the 23rd Annual Conference of Forestry Association of Nigeria, FAN, Ibadan, Nigeria.*

Basu, R. N (1994). An appraisal of research on wet and dry physiological seed treatment and their applicability with special reference to tropical and sub-tropical countries. *Seed Science and Technology.* 22:107-126.

Copeland, L (1976). Principles of seed science and technology, Burgress Publishing Company Minneapolis Minnesota. 369pp.

Esuruoso, A. O (2010). Effect of storage duration and seed invigouration treatments on quality of kenaf (*Hibiscus cannabinus* l.) seed stored under ambient conditions. Masters of Agric. Dissertation. Department of Plant Breeding and Seed Technolog*y,* Federal University of Agriculture, Abeokuta, Nigeria. 84pp.

Duke, J. A (1983). Handbook of Energy Crops. *Gmelina arborea* Roxbi 4pp

Ellis, R. H and Roberts, E. H (1980): Improved Equation for the prediction of seed longevity. *Annuals of Botany* 45:13-30.

Gomez, K. A and Gomez, A. A (1984). Statistical procedures for agricultural research. 2nd edition. John Wiley and Sons Inc. p109.

Grey, B., Wanus, S. A. E., Bishaw, Z and Van-Castem, A. J. G (1994). Safe seed storage WANPA Seed Network Publication No. 5/4 ICARDA Aleppo, Syria.

Hatman, H. J and Koster, D. E (1975). Plant propagations 3rd edition. Public Prentices Hall.inc. Enlewood Cliffs, M.J. 662pp.

ISTA (1995). International Seed Testing Association. International rules for seed testing. Rule (1995). *Seed Science and Technology* 13:322-326.

Jyoti, J and Malik, C. P (2013). Seed deterioration: A review. *International Journal of Life Sciences. Biotechnology and Pharm. Research* 2 (3): 374-384.

Kim, S. H., Choe, Z. R., Kang, J. H., Copeland, L. O and Elias, S. G (1994). Multiple seed vigour indices to predict field emergence and performance of barley. *Seed Science and Technology* 22:29-38.

Mandal, A. K and Basu, R.N (1986). Vigour and variability of wheat seed treated with bleaching powder. *Seeds and Farms* 12:46-48

Mandal, A. K., De, B. K., Saha, R and Basu, R. N (2000). Seed invigoration treatments for improved storability field emergence and productivity of soybean (*Glycine maximum* L. Merrill). *Seed Science and Technology 28:201-207.*

Mandal, A. K., De, B. K and Basu, R. N (2003). Seed invigoration treatment on different seed sizes of wheat (*Triticum aestivum*) for improved storability and field performance. *Seed Science and Technology*, 31:379-388.

Mcdonald, M. B. (2002). Seed priming; In *seed technology and its biological basis.* 73: 935-938.

Moya, R. (2004). *Gmelina arborea encostaRica*. *Bois et foret des Tropiq ue* 279: 11:47-57.

Okoro, O. O. (1983): Revolutionizing, proceeding of *Gmelina arborea* seed in Nigeria. *Proc. 13th Annual Conf. FAN, Benin* Pp 12-1.

Oni, A. O. (2012). Comparative efficacy of crude plant powders on physiological quality of sesame (*Sesamum indicum* L) seeds stored under ambient conditions. Master Agric. Dissertation. Department of Plant Breeding and Seed Technology. Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.101pp.

Pal, P and Basu, R.N. (1993). Control of seed deterioration by hydration- dehydration treatment *Seed Science and Technology* 8 : 151-160.

Slater, T. P. (1972). Free radical scavengers p.48-64 In: Free radical mechanisms in tissue Injury, pp. *48-64.* Pion Ltd., London.

Walters, C. (1998). Understanding the mechanism and kinetics of seed aging. *Seed Science Research* 8 (2): 223-244.

Walter, C. P., Landre, L., Hill, F., Corbineau, I. and Bailly, C. (2005). Organization of lipid reserves in cotyledons of primed and aged sunflower seeds. *Planta* 222; 397-407.

Walter, C, Ballesteros, D. and Vertucci. V. A. (2010). Structural mechanics of seed deterioration. Standing the test of time. *Plant Science* 179: 565-573.

Tekrony, D. M., Egli D. B, and Philis A. D. (1980). Effect of field weathering on the viability and vigour of soybean seed. *Agronomy Journal* 72: 749-753.

Woessner R. A. (1980). *Gimelina arborea* Roxb. Genetic improvement programmes of Jari, Jari Florestal, Belen, Paval, Brazil In: proceedings of IUFRO symposium and workshop on genetics improvement and productivity of fast growing tree species, SAD, Paulo Brazil. 7pp.