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EFFECT OF PRETREATMENTS ON SEED VIABILITY (TZ) DURING FRUIT DEVELOPMENT OF *Irvingia gabonensis* VARIETIES

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ABSTRACT

Studies to identify the stage at which developing fruits of *Irvingia gabonensis* (Var. *excelsa and Var. gabonensis*) picked from standing trees and / or forest floors attain maximum viability and germinability were conducted in two harvest seasons in 2000 and 2001. Some pretreatment methods were used as a means of stimulating expression of maximum germinability as source of seeds for seedling production. The moisture contents of whole seeds decreased steadily and significantly (P= 0.05) throughout the developmental stages of both varieties and in both harvests. Seeds harvested from standing trees and forest floors, pretreated by steeping in water for 24 hours at 26°C and sown in sawdust and petri dishes on moist filter paper gave 80% germination in variety *gabonensis* 20 weeks after fruiting, WAF. Germination potentials of seeds in both harvests were enhanced significantly (P 0.05) with seeds pretreated by steeping in water for 24 hours at 26°C and sown in sawdust and petri dishes on moist filter paper by as much as 60% and 80% for var. *excelsa* and var. *gabonensis* respectively in the developmental stages 14 – 20 weeks after fruiting (WAF) with significant (P = 0.05) decrease in germination time to 21 and 15 days respectively. There was also significant (P = 0.05) relationship between viability and germination in both harvests and in the two varieties throughout the developmental stages. Potassium Nitrate (KNO_3) significantly (P = 0.05) enhanced germination potentials of the seeds over the control when soaked in 1.5g/l concentration in both varieties and in the two harvests (18 – 20 WAF) by 80%. Mannitol significantly (P = 0.05) reduced germination potential (40%) of the seeds with increased germination time in both harvests and in the two varieties throughout the developmental stages. There was a high significant (P = 0.05) increase in germination potential (60%) of seeds treated with Polyethylene glycol (PEG) when soaked in concentration of 10g/l for 48 and 72 hours in both varieties and in the two harvests (18 – 20 WAF). The study shows that the fruits of *Irvingia gabonensis* assume ripening characteristics (yellowing) and that the viable seeds can be obtained from standing trees and / or picked from forest floors from the twelveth to twentieth week after fruiting.

KEY WORDS: Viability – germinability – *Irvingia gabonensis* – WAF: Week after fruiting – moisture content

INTRODUCTION

Irvingia gabonensis (bush mango) is one of the most economically viable forest tree species in the Rainforest zone of West Africa. It is a source of food, income, an essential raw materials for the pharmaceutical industries and above all, a potential foreign exchange earner (Okafor, 1989; Okafor et al. 1994; Omokaro et al. 1999 and Omoluabi, 1994). In recognition of its importance, the Federal Government of Nigeria, through her Agency, Directorate for Food, Road and Rural Infrastructure has shown great interest in the development of *Irvingia gabonensis* plantation (Oni, 1984; Adeyoju and Enabor, 1985). Efforts so far made have met with little success because the only successful propagation method (budding) presently used in seedling production is not adequate for rapid multiplication of seedlings. Besides *Irvingia gabonensis* seeds exhibit poor germination potential with less than 50% germination capacity when freshly collected (Nya et al. 2000).

In the local communities of Cross River State (Nigeria) where *Irvingia gabonensis* trees are found growing in the wild, fruits from standing trees and forest floor can be harvested if permitted by the community (Nya, 1997). In order to help establish this viable tree species as a plantation crop, this study was therefore undertaken to investigate the stage of development when mature fruits on standing trees or falling fruits from forest floors attain maximum germinability and also to determine pretreatment methods that may stimulate expression of maximum germinability.

MATERIALS AND METHODS

Seed Collection and Treatment

Five hundred fruits of each variety of *Irvingia gabonensis* (var. *excelsa* and var. *gabonensis*) were harvested between December, 2000 and June, 2001 from standing trees of age range between 20 and 30 years or forest floor at Abredang Abeyong rainforest zone located South West of Ugep, in Cross River State of Nigeria (latitude 05° 44' 14"N, longitude 08° 02' 25"E). The harvesting was started ten weeks from commencement of fruiting and continued at forth-nightly intervals until the 20th week. At each harvest, 50 freshly plucked or picked fruits of each variety (standing tree and forest floor respectively) of approximately the same size, were immediately depulped to extract the seeds.

Seeds extracted from both harvests were used for moisture content (MC) determination. Viability tests using tetrazolium and germination studies were carried out.

Determination of Moisture Content

Moisture Content (MC) of whole seeds was determined on five randomly picked seeds from both harvests after oven drying at 80°C to constant weight. Moisture content was calculated on a fresh weight basis according to ISTA (1985 a and b) as follows:

RMC (Relative Moisture Content) =

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$$\frac{\text{Fresh weight of seed - Dry weight of seed}}{\text{Fresh weight of seed}} \times \frac{100}{1}$$

Triphenyl Tetrazolium Chloride (TZ) Test for Viability

Ten seeds of each variety from both harvests were imbibed in distilled water for 12 hours followed by dissection of the embryos into equal halves. Half of the dissected embryos were then placed in petri dishes containing 0.5% solution of TZ. The petri dishes were then wrapped in aluminium foil and incubated for four hours after which the embryos were then washed and observed for red colouration. The coloured embryos were counted as viable. Percentage viability from five replicates were recorded (Demir and Ellis, 1992).

Seed Pretreatments and Germination Tests

Five seeds from each seed lots of the two harvests from freshly depulped fruits of each variety (standing tree and forest floor) were surface – sterilized with 0.1% mercuric chloride and then washed several times in sterile distilled water. The seeds were either sown in Petri dishes on Whatman's Filter Paper (No. 1) or in polyethylene bags filled with moist sawdust. Similarly, batches of five seeds were pretreated by steeping in water for 24 hours at room temperature before sowing as above.

Sixty seeds from both harvests of the two varieties were pretreated with different concentrations of KNO_3 (1.5g/l and 3.0g/l). Five seeds from each concentration were removed, after 24, 48 and 72 hours, washed with distilled water and immediately sown in moist sawdust. Another batch of seeds were also soaked in manitol with the same concentrations and sown as above.

Sixty seeds of both harvests were also pretreated by soaking in two concentrations of Polyethylene glycol (PEG) 5g/l and 10g/l for 24, 48 and 72 hours. The seeds were removed after these periods, washed and sown in moist sawdust. The Petri dishes and polyethylene bags were arranged in a randomized complete block design with five replications on the laboratory bench and in the botanical garden respectively of the University of Calabar

Germination counts were made daily and recorded. The emergence of plumule and radicle protrusion (2mm) were used as indicators of germination in sawdust and Petri dishes respectively.

All data were subjected to an analysis of variance and the Standard Error (S.E) of means were compared. Linear correlation and regression analysis was carried out in order to ascertain the level of relationship between viability and germinability during development.

RESULTS

Results showed that any single parent tree of *Irvingia gabonensis* bears fruits of varying physiological maturity and / or viability in a fruiting season. All seeds of both varieties (var. *gabonensis* and var. *excelsa*) harvested from standing trees and forest floor in the first ten weeks are physiologically immature and not viable (Tables 1 and 2).

The moisture contents of whole seeds were high in the immature seeds and this decreased significantly ($P < 0.05$) during development (Tables 1 and 2). Results showed that unimbibed seeds sown in sawdust, moist filter paper in petri dishes recorded 40% germination 20 weeks after fruiting in both varieties at both harvests (Tables 1 and 2).

Pretreating whole seeds harvested from standing trees and forest floor by steeping in water for 24 hours at 26°C recorded 80% germination in both varieties 20 weeks after fruiting.

Germination potentials of seeds in both harvests were enhanced significantly ($P < 0.05$) by treatment as much as 80% and 60% in varieties *gabonensis* and *excelsa* respectively in the developmental stages (16 – 20 weeks after fruiting).

Pretreatment of seeds from both harvests by steeping in water for 24 hours at 26°C resulted in a significant ($P < 0.05$) decrease in germination time to 15 and 21 days in varieties *gabonensis* and *excelsa* respectively (Tables 1 and 2).

Results also showed that there was a positive correlation and significant ($P < 0.05$) relationship between viability and germinability in both harvests throughout the developmental stages in the two varieties of *Irvingia* (Tables 1 and 2).

TABLE 1: Effect of pretreatment on germination of fruits of *Irvingia gabonensis* plucked from standing trees (Mean ± S.E)

				Unimbibed seeds sown in sawdust		Unimbibed seeds sown in moist filter paper (26°C)		Imbibed seeds (24 hours) sown in sawdust		Imbibed seeds (24 hours) sown in moist filter paper (26°C)	
Variety	Harvest Time (Week)	MC (%)	Viability TZ (%)	Germ %	Germ Time (days)	Germ %	Germ Time (days)	Germ %	Germ Time (days)	Germ %	Germ Time (days)
Var. gabonensis	10	50.6 ± 2.0	0 ± 0.0	0 ± 0.0	60*	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0
	12	49.2 ± 2.9	40 ± 1.2	00 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0
	14	48.5 ± 3.0	60 ± 2.2	00 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	20 ± 2.6	22 ± 1.3	20 ± 1.2	23 ± 1.3
	16	44.8 ± 2.8	80 ± 0.2	20 ± 2.1	25 ± 1.2	40 ± 1.8	26 ± 0.9	60 ± 3.0	18 ± 1.0	60 ± 1.0	18 ± 1.0
	18	36.6 ± 2.4	100 ± 3.2	40 ± 3.1	20 ± 1.3	40 ± 4.0	24 ± 0.0	60 ± 1.7	18 ± 1.7	80 ± 4.0	18 ± 1.0
	20	30.4 ± 2.6	100 ± 3.1	60 ± 4.0	20 ± 1.0	40 ± 3.7	24 ± 0.7	80 ± 3.0	17 ± 0.0	80 ± 2.0	15 ± 0.0
Var. excelsa	10	45.1 ± 2.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0
	12	44.9 ± 1.2	40 ± 1.2	0 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 0.0	0 ± 0.0
	14	43.8 ± 2.6	80 ± 2.3	0 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	40 ± 2.0	30 ± 1.5	20 ± 0.7	33 ± 2.0
	16	41.7 ± 1.2	80 ± 3.1	20 ± 3.0	30 ± 2.0	40 ± 1.2	28 ± 1.7	60 ± 3.1	26 ± 1.4	40 ± 1.2	31 ± 0.0
	18	34.1 ± 1.6	80 ± 3.3	20 ± 1.6	26 ± 1.3	40 ± 1.0	28 ± 1.2	60 ± 1.1	25 ± 1.3	60 ± 2.0	29 ± 1.3
	20	29.6 ± 2.0	80 ± 2.5	40 ± 2.3	24 ± 1.2	40 ± 1.2	25 ± 1.3	60 ± 2.0	60 ± 2.0	60 ± 2.0	24 ± 0.3

Key: 60* = There was no germination 60 days after sowing; MC = Moisture Content; Germ. % = Germination Percentage; Germ. Time = Germination Time

Regression relationship: Viability on maximum germination, with steeping.
$y = 139.8 - 2.55x$ with $r = 0.71$ ($P < 0.05$)

Table 2: Effect of pretreatment on germination of fruits of *Irvingia gabonensis* plucked from forest floor (Mean ± S.E)

				Unimbibed seeds sown in sawdust		Unimbibed seeds sown in moist filter paper (26°C)		Imbibed seeds (24 hours) sown in sawdust		Imbibed seeds (24 hours) sown in moist filter paper (26°C)	
Variety	Harvest Time (Week)	MC (%)	Viability TZ (%)	Germ %	Germ Time (days)	Germ %	Germ Time (days)	Germ %	Germ Time (days)	Germ %	Germ Time (days)
Var. gabonensis	10	52.4 ± 1.1	40 ± 2.1	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	00 ± 0.0	0 ± 0.0	0 ± 0.0
	12	48.4 ± 2.0	60 ± 0.0	0 ± 0.0	00 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	00 ± 0.0	0 ± 0.0	0 ± 0.0
	14	44.3 ± 2.2	80 ± 0.2	0 ± 0.0	00 ± 0.0	0 ± 0.0	0 ± 0.0	20 ± 0.0	17 ± 0.2	40 ± 2.1	21 ± 1.6
	16	36.6 ± 1.2	80 ± 2.3	20 ± 1.0	23 ± 1.2	40 ± 1.0	34 ± 1.0	60 ± 2.1	18 ± 0.2	60 ± 2.1	19 ± 0.8
	18	31.3 ± 2.0	100 ± 3.4	40 ± 2.0	20 ± 0.6	40 ± 3.1	26 ± 3.1	80 ± 3.1	15 ± 0.1	60 ± 2.1	18 ± 0.5
	20	29.2 ± 2.0	100 ± 4.1	40 ± 3.6	16 ± 0.4	40 ± 3.1	26 ± 3.1	80 ± 3.0	15 ± 0.1	80 ± 3.2	18 ± 0.6
Var. excelsa	10	46.8 ± 1.4	40 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0
	12	44.1 ± 2.1	60 ± 2.1	0 ± 0.0	0 ± 0.0	0 ± 0.6	0 ± 0.0	20 ± 0.6	37 ± 0.8	20 ± 0.5	36 ± 1.0
	14	40.6 ± 1.4	80 ± 3.3	0 ± 0.0	0 ± 0.0	0 ± 0.7	0 ± 0.0	40 ± 0.7	31 ± 0.6	40 ± 0.1	35 ± 1.0
	16	35.7 ± 1.6	80 ± 3.6	0 ± 0.0	0 ± 0.0	0 ± 0.6	0 ± 0.0	40 ± 0.8	29 ± 0.9	40 ± 0.6	34 ± 1.2
	18	30.6 ± 1.6	100 ± 2.5	20 ± 1.0	29 ± 1.4	40 ± 0.9	27 ± 1.0	40 ± 0.7	27 ± 0.8	60 ± 1.3	30 ± 0.9
	20	28.1 ± 1.6	100 ± 3.1	40 ± 1.0	27 ± 1.0	40 ± 1.0	24 ± 1.1	60 ± 1.3	26 ± 0.7	60 ± 2.1	26 ± 0.5

Key: 60* = There was no germination 60 days after sowing; MC = Moisture Content; Germ. % = Germination Percentage; Germ. Time = Germination Time

Regression relationship: Viability on maximum germination, with steeping.
$y = 36.76 - 0.78x$ with $r = 0.77$ ($P < 0.05$)

Pretreatment with KNO_3 resulted in 80% germination in both varieties from seeds harvested from standing trees and forest floors between 18 and 20 WAF (Tables 3 and 4). Results also showed that the longer the soaking period, the higher the germination percentage with significantly ($P < 0.05$) reduced germination time (Tables 3 and 4). The concentration (3.0g/l) of KNO_3 solution used also affected the germinability. Hence, seeds soaked in 1.5g/l significantly ($P < 0.05$) enhanced germination potentials in both varieties and in the two harvests (Tables 3 and 4).

Mannitol treatment resulted in lower percentage germination (40%) in both varieties and harvests throughout the developmental stages (Tables 5 and 6). However, prolonged soaking of seeds in mannitol significantly ($P < 0.05$) reduced germination potentials of the seeds of *Irvingia gabonensis* with increased germination time. Seeds soaked in 3.0g/l for 72 hours failed to germinate 60 days after sowing (DAS) (Tables 5 and 6).

Generally, there was an increased in germinability (60%) of seeds soaked in polyethylene glycol (PEG) as compared to those in mannitol in both varieties and harvests between 18th and 20th WAF (Tables 7 and 8). Seeds soaked in concentration of 10.0g/l recorded 60% germination in both varieties and harvests between the 16 and 20 WAF (Tables 7 and 8). PEG treatment also significantly ($P < 0.05$) reduced germination time of both varieties in both harvests (Tables 7 and 8).

DISCUSSION

The study has shown that *Irvingia gabonensis* trees produce both physiologically immature and mature fruits with varying degrees of viability which increases with age throughout the developmental stages. This finding shows that the fruits that are harvested during the first 10 weeks of fruiting are immature, not viable and lack capacity to germinate because they contain seeds that are still undergoing stages of embryo development. The fruits which assume ripening characteristics (yellowing) and are palatable shortly after harvest on standing trees and from the forest floor may be gotten from the 14th to 20th week after fruiting.

The low germination capacity recorded in *Irvingia gabonensis* could be due to the recalcitrant nature of the seeds which, unlike orthodox seeds, do not confirm with the rule of increasing longevity with fall in temperature and moisture content (Roberts, 1973; Bishnoi, 1974; Ellis et al. 1989; Ellis et al. 1990a and Omokaro et al. 1999). Such seeds are produced by large – seeded plant species. Also, most tropical fruit crops like cocoa, mango, citrus have been identified to produce recalcitrant seeds (Chin, 1980; Aiyelaagbe, 1994 and Awodoyan and Ogbonnaya, 1994). Nya et al. (2000) also reported that *Irvingia gabonensis* seeds exhibit poor germination potential with less than 50% germination capacity. Oni (1984) working on some tropical forest trees reported similar germinability (40%). This work has shown that fruits of *Irvingia* harvested from standing trees and forest floor 16th to 20th week after fruiting respectively and contain seeds that have attained a measure of physiological maturity and germination capacity of 20% which can be enhanced to 80% following pretreatments. However, seeds harvested 18th to 20th week after fruiting contain mature seeds capable of 80% germinability which was confirmed by TZ staining. This finding shows that viable seeds can be obtained from standing trees of *Irvingia gabonensis* and picked from forest floor for seedlings production.

The increase in germination capacity (80%) of seeds soaked in 1.5g/l of KNO_3 for 48 and 72 hours could be due to increase in embryo length as Asiegbu and Onugua (1994) had noted that 1 – 3g/l KNO_3 increased the embryo length of Nsukka yellow pepper. The depression in germination of seeds with 3.0g/l of KNO_3 was probably due to toxicity of the salt solution to the seeds, as Asiegu and Onugua, (1994) also noted that 5g/l KNO_3 was toxic to African spinach.

PEG significantly ($P < 0.05$) increased percentage germination of *Irvingia* seeds in both harvests. Increase in germination (60%) with seeds soaked for 72 hours could be due to increase in embryo length. Similar result was obtained by Black, (1972) who reported that PEG increased the embryo

Table 3: Effect of potassium nitrate (KNO_3) on percentage germination of fruits of *Irvingia* varieties *plucked* from standing trees (Mean ± S.E)

	Var. *gabonensis*												Var. *excelsa*											
	Concentration (g/l)												Concentration (g/l)											
	1.5						3.0						1.5						3.0					
Harvest Period (WK)	Hours of Soaking												Hours of Soaking											
	24		48		72		24		48		72		24		48		72		24		48		72	
	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT
10	0 ± 0.0	0	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-
12	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	20 ± 0.0	28 ± 1.1	20 ± 1.1	24 ± 0.0	0 ± 0.0	27 ± 1.2	0 ± 0.0	-	20 ± 0.6	20 ± 0.0	20 ± 1.3	22 ± 0.7
14	20 ± 2.0	36 ± 3.0	40 ± 2.1	21 ± 3.2	40 ± 2.0	25 ± 1.0	20 ± 0.0	25 ± 1.6	20 ± 1.1	[illegible] ± 0.5	20 ± 1.3	34 ± 3.0	20 ± 0.6	27 ± 1.3	40 ± 2.6	25 ± 1.1	40 ± 2.6	36 ± 1.3	20 ± 1.3	30 ± 1.9	20 ± 0.6	27 ± 2.1	20 ± 1.4	26 ± 2.3
16	20 ± 1.6	30 ± 1.1	40 ± 2.3	23 ± 2.1	60 ± 3.0	19 ± 2.3	20 ± 1.1	31 ± 0.6	20 ± 0.0	[illegible] ± 1.3	20 ± 1.6	30 ± 2.0	40 ± 3.0	26 ± 1.3	40 ± 2.1	17 ± 1.7	60 ± 3.1	29 ± 2.1	20 ± 0.0	26 ± 1.1	20 ± 0.0	31 ± 1.3	40 ± 2.1	20 ± 0.0
18	20 ± 1.0	29 ± 3.6	40 ± 2.1	21 ± 3.1	60 ± 2.9	18 ± 2.6	20 ± 1.3	20 ± 0.0	20 ± 0.0	[illegible] ± 3.0	40 ± 2.9	20 ± 2.1	60 ± 3.3	17 ± 1.0	80 ± 2.6	18 ± 1.1	80 ± 2.1	15 ± 0.7	40 ± 1.3	22 ± 1.3	40 ± 2.1	26 ± 1.1	60 ± 1.9	24 ± 0.0
20	40 ± 2.3	20 ± 2.1	60 ± 3.0	18 ± 0.0	80 ± 2.0	16 ± 2.4	20 ± 0.0	20 ± 0.0	40 ± 2.1	[illegible] ± 2.9	40 ± 0.0	19 ± 1.1	80 ± 2.6	16 ± 0.3	80 ± 0.6	15 ± 0.0	80 ± 3.6	16 ± 1.1	40 ± 1.3	20 ± 0.0	60 ± 1.7	19 ± 2.0	60 ± 1.4	18 ± 1.1

= There was no germination 60 days after sowing

Key: G% = Germination Percentage; GT = Germination Time ([illegible]ys)

Table 4: Effect of potassium nitrate (KNO_3) on percentage germination of fruits of *Irvingia* varieties *plucked* from forest floor (Mean ± S.E)

	Var. *gabonensis*												Var. *excelsa*											
	Concentration (g/l)												Concentration (g/l)											
	1.5						3.0						1.5						3.0					
Harvest Period (WK)	Hours of Soaking												Hours of Soaking											
	24		48		72		24		48		72		24		48		72		24		48		72	
	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT
10	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-
12	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	20 ± 0.0	30 ± 3.1	40 ± 1.0	20 ± 2.0	20 ± 0.0	31 ± 3.1	20 ± 0.0	33 ± 3.0	20 ± 1.4	34 ± 3.6	20 ± 0.6	37 ± 5.1
14	20 ± 2.0	40 ± 3.1	20 ± 0.0	33 ± 2.0	20 ± 1.9	29 ± 2.7	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	40 ± 2.0	21 ± 1.1	40 ± 2.1	30 ± 3.1	40 ± 1.1	23 ± 2.1	20 ± 0.0	30 ± 0.7	40 ± 2.1	27 ± 0.6	20 ± 0.0	39 ± 1.1
16	20 ± 2.1	30 ± 1.1	40 ± 0.6	29 ± 2.6	40 ± 1.1	21 ± 2.1	20 ± 1.1	29 ± 0.0	20 ± 0.0	30 ± 2.7	20 ± 1.1	25 ± 1.6	60 ± 2.1	20 ± 2.1	60 ± 1.6	19 ± 1.7	60 ± 2.6	18 ± 2.6	20 ± 0.6	26 ± 0.6	40 ± 2.3	23 ± 1.7	40 ± 0.0	27 ± 0.0
18	60 ± 1.7	19 ± 0.0	80 ± 3.3	15 ± 0.0	80 ± 2.7	16 ± 0.0	40 ± 0.0	25 ± 0.0	40 ± 1.1	21 ± 2.6	40 ± 0.0	20 ± 3.1	60 ± 2.0	18 ± 0.0	80 ± 2.5	16 ± 0.0	80 ± 3.0	15 ± 0.1	20 ± 0.0	28 ± 2.4	40 ± 1.1	19 ± 0.0	40 ± 1.0	18 ± 0.0
20	60 ± 2.1	20 ± 0.9	80 ± 0.6	15 ± 0.0	80 ± 2.3	15 ± 0.0	40 ± 0.6	24 ± 0.0	40 ± 0.0	23 ± 2.1	40 ± 0.0	24 ± 2.6	60 ± 1.3	17 ± 0.0	80 ± 2.9	15 ± 0.7	80 ± 0.0	15 ± 0.1	40 ± 0.1	21 ± 2.6	40 ± 0.0	23 ± 1.7	40 ± 0.6	25 ± 2.6

- = There was no germination 60 days after sowing

Key: G% = Germination Percentage; GT = Germination Time (days)

Table 5: Effect of D - manitol on percentage germination of fruits of *Irvingia* varieties *plucked* from standing trees (Mean ± S.E)

	Var. gabonensis												*Var. excelsa*											
	Concentration (g/l)												Concentration (g/l)											
	1.5						3.0						1.5						3.0					
Harvest	Hours of Soaking												Hours of Soaking											
Period	24		48		72		24		48		72		24		48		72		24		48		72	
(WK)	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT
10	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-
12	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-
14	20 ± 0.6	31 ± 1.6	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	20 ± 0.0	26 ± 0.0	20 ± 0.0	24 ± 0.0	20 ± 0.7	31 ± 1.6	20 ± 2.1	38 ± 0.0	20 ± 1.6	26 ± 1.2	20 ± 0.6	31 ± 3.6
16	20 ± 1.2	24 ± 1.7	20 ± 0.0	29 ± 1.2	20 ± 0.0	20 ± 1.1	0 ± 0.0	-	0 ± 0.0	-	20 ± 1.1	36 ± 1.7	20 ± 0.0	31 ± 2.3	40 ± 1.1	24 ± 1.6	20 ± 0.1	26 ± 0.0	40 ± 2.0	20 ± 0.0	40 ± 2.1	30 ± 2.1	20 ± 2.3	26 ± 1.1
18	40 ± 1.8	27 ± 3.1	20 ± 0.0	27 ± 3.1	40 ± 1.0	28 ± 2.1	20 ± 0.0	31 ± 3.1	20 ± 0.7	20 ± 1.1	0 ± 0.0	-	20 ± 0.0	23 ± 3.6	40 ± 1.1	21 ± 2.7	20 ± 0.1	34 ± 3.6	40 ± 0.6	20 ± 0.0	40 ± 2.3	22 ± 1.1	0 ± 0.0	-
20	40 ± 0.3	26 ± 2.7	40 ± 0.0	22 ± 0.0	40 ± 1.7	30 ± 2.6	40 ± 0.9	26 ± 2.1	40 ± 0.6	26 ± 2.6	0 ± 0.0	-	40 ± 0.0	23 ± 2.1	40 ± 2.0	24 ± 2.7	0 ± 0.0	0 ± 0.0	40 ± 0.4	23 ± 2.1	40 ± 0.0	25 ± 0.0	0 ± 0.0	-

- = There was no germination 60 days after sowing

Key: G% = Germination Percentage; GT = Germination Time (days)

Table 6: Effect of D - manitol on percentage germination of fruits of *irvingia* varieties *plucked* from forest floor (Mean ± S.E)

	Var. gabonensis												*Var. excelsa*											
	Concentration (g/l)												Concentration (g/l)											
	1.5						3.0						1.5						3.0					
Harvest	Hours of Soaking												Hours of Soaking											
Period	24		48		72		24		48		72		24		48		72		24		48		72	
(WK)	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT
10	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-
12	20 ± 1.7	31 ± 1.1	20 ± 1.3	27 ± 2.6	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	20 ± 2.0	31 ± 3.5	20 ± 0.0	29 ± 1.1	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-
14	20 ± 0.0	34 ± 3.0	40 ± 1.7	27 ± 0.0	20 ± 2.3	36 ± 4.1	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	20 ± 0.1	26 ± 1.7	20 ± 1.3	24 ± 0.7	20 ± 0.9	24 ± 1.2	0 ± 0.0	-	0 ± 0.0	-	20 ± 0.0	25 ± 2.3
16	40 ± 2.1	22 ± 2.1	20 ± 0.3	26 ± 2.0	20 ± 2.1	20 ± 1.0	20 ± 0.1	20 ± 0.7	20 ± 0.7	32 ± 2.4	20 ± 0.0	22 ± 2.1	20 ± 1.1	22 ± 0.3	20 ± 0.4	24 ± 2.1	40 ± 2.3	19 ± 2.1	20 ± 0.0	22 ± 2.1	20 ± 0.0	29 ± 3.6	20 ± 0.0	20 ± 2.1
18	40 ± 2.1	16 ± 0.0	40 ± 3.0	22 ± 3.0	20 ± 1.1	26 ± 0.0	40 ± 0.0	29 ± 3.6	20 ± 0.0	31 ± 2.1	20 ± 1.1	36 ± 3.4	40 ± 0.0	26 ± 3.8	40 ± 1.1	30 ± 2.7	20 ± 2.1	36 ± 3.7	40 ± 0.0	21 ± 2.7	40 ± 2.0	21 ± 0.0	0 ± 0.0	-
20	40 ± 1.1	17 ± 1.1	40 ± 1.3	20 ± 1.2	20 ± 2.0	34 ± 1.3	40 ± 0.0	27 ± 2.1	40 ± 0.0	29 ± 1.1	20 ± 0.7	31 ± 3.0	40 ± 0.0	24 ± 0.7	40 ± 2.1	31 ± 3.1	20 ± 2.0	30 ± 2.7	40 ± 0.0	30 ± 3.6	40 ± 2.0	23 1.1	0 ± 0.0	-

- = There was no germination 60 days after sowing

Key: G% = Germination Percentage; GT = Germination Time (days)

Table 7: Effect of polyethylene glycol (PEG) on percentage germination of fruits of *Irvingia* varieties *plucked* from standing trees (Mean ± S.E)

Harvest Period (WK)	*Var. gabonensis*												*Var. excelsa*											
	Concentration (g/l)												Concentration (g/l)											
	5.0						10.0						5.0						10.0					
	Hours of Soaking												Hours of Soaking											
	24		48		72		24		48		72		24		48		72		24		48		72	
	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT
10	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-
12	20 ± 1.2	-	0 ± 0.5	-	0 ± 0.0	-	0 ± 0.0	-	20 ± 0.0	43 ± 0.0	0 ± 0.0	36 ± 2.1	0 ± 0.0	-	20 ± 1.3	31 ± 6.7	0 ± 0.0	-	0 ± 0.0	-	20 ± 0.3	34 ± 0.6	20 ± 0.4	20 ± 1.6
14	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	20 ± 1.3	43 ± 3.6	20 ± 0.4	31 ± 1.6	20 ± 1.3	26 ± 2.2	0 ± 0.0	-	20 ± 0.5	22 ± 2.1	0 ± 0.0	-	20 ± 1.3	40 ± 9.6	20 ± 0.4	37 ± 2.7	40 ± 1.6	18 ± 0.7
16	20 ± 0.3	33 ± 2.1	20 ± 0.0	29 ± 3.4	20 ± 0.7	33 ± 2.6	40 ± 1.3	36 ± 3.4	20 ± 0.0	25 ± 2.6	40 ± 2.1	28 ± 3.6	20 ± 0.0	26 ± 2.6	20 ± 0.3	24 ± 1.4	20 ± 0.0	34 ± 2.0	20 ± 0.0	32 ± 3.0	40 ± 0.5	30 ± 2.7	40 ± 2.3	25 ± 2.0
18	20 ± 1.1	30 ± 4.1	20 ± 0.0	29 ± 3.1	60 ± 2.0	33 ± 3.0	40 ± 0.0	36 ± 4.0	60 ± 1.3	28 ± 2.5	60 ± 2.0	29 ± 2.0	20 ± 0.0	30 ± 2.0	40 ± 1.1	27 ± 2.3	60 ± 0.0	26 ± 2.4	20 ± 0.0	36 ± 3.1	40 ± 0.0	26 ± 3.6	60 ± 2.6	24 ± 4.4
20	40 ± 2.1	37 ± 1.1	20 ± 1.1	33 ± 3.6	60 ± 2.3	30 ± 3.6	20 ± 0.0	31 ± 2.7	60 ± 1.2	26 ± 2.4	60 ± 2.0	30 ± 3.6	20 ± 0.0	30 ± 3.6	40 ± 1.1	23 ± 2.9	60 ± 1.6	41 ± 4.6	20 ± 0.0	25 ± 3.6	60 ± 1.1	27 ± 3.6	60 ± 2.6	26 ± 2.5

\- = There was no germination 60 days after sowing

Key: G% = Germination Percentage; GT = Germination Time (days)

Table 8: Effect of polyethylene glycol (PEG) on percentage germination of fruits of *Irvingia* varieties *plucked* from forest floor (Mean ± S.E)

Harvest Period (WK)	*Var. gabonensis*												*Var. excelsa*											
	Concentration (g/l)												Concentration (g/l)											
	5.0						10.0						5.0						10.0					
	Hours of Soaking												Hours of Soaking											
	24		48		72		24		48		72		24		48		72		24		48		72	
	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT	G%	GT
10	0 ± 0.0	-	0 ± 0.0	-	20 ± 0.0	34 ± 1.6	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-	0 ± 0.0	-
12	20 ± 0.4	35 ± 2.4	20 ± 0.6	27 ± 3.6	20 ± 1.1	36 ± 2.1	20 ± 0.6	31 ± 2.3	20 ± 0.7	40 ± 4.6	20 ± 2.1	37 ± 3.6	20 ± 0.0	29 ± 2.3	20 ± 0.1	21 ± 2.1	20 ± 0.0	43 ± 4.6	20 ± 0.0	21 ± 3.1	20 ± 0.0	23 ± 2.0	20 ± 1.1	31 ± 2.1
14	20 ± 0.1	24 ± 2.6	40 ± 0.0	24 ± 2.0	40 ± 1.3	27 ± 1.1	20 ± 0.0	31 ± 3.1	40 ± 1.2	29 ± 2.1	40 ± 0.0	24 ± 2.6	20 ± 0.0	33 ± 0.7	20 ± 0.0	36 ± 3.6	40 ± 1.1	23 ± 2.8	20 ± 0.0	29 ± 3.6	20 ± 0.0	28 ± 2.8	40 ± 0.0	24 ± 2.0
16	20 ± 1.2	27 ± 2.6	40 ± 2.0	28 ± 2.0	40 ± 1.4	25 ± 1.9	40 ± 0.1	28 ± 2.0	60 ± 0.6	21 ± 3.1	60 ± 0.0	22 ± 0.9	20 ± 0.7	28 ± 0.6	40 ± 1.2	31 ± 3.9	60 ± 0.0	37 ± 2.6	40 ± 1.2	24 ± 2.5	40 ± 0.0	26 ± 2.6	60 ± 0.0	46 ± 0.7
18	20 ± 0.0	26 ± 0.7	20 ± 2.3	29 ± 3.6	60 ± 1.7	18 ± 1.0	40 ± 0.0	29 ± 2.3	60 ± 2.1	18 ± 0.6	60 ± 1.1	21 ± 1.3	20 ± 0.0	28 ± 2.1	40 ± 0.0	31 ± 0.9	60 ± 0.0	34 ± 3.1	20 ± 0.0	23 ± 2.6	40 ± 0.0	26 ± 2.2	60 ± 0.0	16 ± 1.6
20	20 ± 0.1	24 ± 1.6	60 ± 1.6	21 ± 0.0	60 ± 0.1	20 ± 0.2	60 ± 2.1	21 ± 3.1	60 ± 1.1	18 ± 0.7	60 ± 0.9	19 ± 1.1	20 ± 0.6	21 ± 2.0	40 ± 0.0	28 ± 2.1	60 ± 0.0	25 ± 3.0	40 ± 1.0	20 ± 0.7	60 ± 0.0	16 ± 0.0	60 ± 0.0	14 ± 0.0

\- = There was no germination 60 days after sowing

Key: G% = Germination Percentage; GT = Germination Time (days)

and hypocotyl length in green-grams seeds. Decrease in germination of seeds soaked for 24 hours was probably due to less penetration of PEG solution into the internal part of the seed. Similar result was obtained by Black (1972) who reported that hard testa of many seeds acts as hindrance to water penetration. The significant increase in the germination capacity with KNO_3 and PEG was similar to the report of Thompson and Horn (1944) who reported that some chemicals and growth regulators can improve the germination of lettuce seeds.

Mannitol decreased the percentage germination of *Irvingia* seeds with increased concentrations. The none germination recorded in seeds soaked for 72 hours in 3.0g/l mannitol was as a result of inducing drought condition to the seeds. Similar reports were made by Roberts and King (1980) and Deijode (1983) who noted that treatment of recalcitrant seeds with high percentage Mannitol result in the lost of viability. Khan (1980) and Esenowo (1995) also noted similar reduction in germination and growth with Mannitol.

This work has shown that seed maturity is positively related to moisture content, viability and germination, and viability can be determined by means of TZ staining. Since fruits harvested from standing trees and forest floor attain viability between the 14th and 20th week after fruiting and maximum germination potential of the seeds could be enhanced with use of p etreatments, it is recommended that nursery operators should explore these methods as a source of seedling regeneration after determination of physiological maturity by using TZ staining.

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