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Provenance and fruit colour effects on seeds quality traits of sweet wild mango [*Irvingia gabonensis* Aubry-Lecomte ex (O Rorke)] seeds.

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ABSTRACT

Irvingia gabonensis (sweet bush mango) is one of African orphan crops with high potentials that has not be fully utilized and improved on due to poor germination and seedling establishment as well as unavailability of seeds, therefore the need to find the effect of provenance and fruit maturity on emergence and seedling vigour of *Irvingia gabonensis* with the aim of determining which fruit colour and source to base seed collection for improvement purpose. Five colour groups which include green, yellow, yellowish green, greenish brown and dark brown were sourced from Edo, Delta, Anambra and Cross River. These were arranged in a completely randomized design factorial with three replications. Data on seed germination percentage, plant height, Seed Vigour Index (SVI), collar diameter and number of leaves were subjected to Analysis of variance (ANOVA) and significant means were separated using Duncan Multiple Range Test at 5% level of probability. Results shows that significant differences ($P<0.05$-$P<0.01$) were observed in the five quality traits observed due to differences in provenance and fruit colour. The interaction effect of provenance and fruit colour was significant ($P<0.05$) for all the traits. Edo provenance had the highest seed germination (51.01%), collar diameter (11.6mm) and leaf production (13.88) while Delta provenance had the highest plant height and seedling vigour index. Fruit colour of dark brown recorded the best in terms of seed germination (54.22%), plant height (19.41) and collar diameter (10.97) while yellow fruit seeds had the highest seedling vigour index (3.80) and leaf production (12.12). Seeds from the dark brown and yellow colour which indicate the fully ripe fruit of *Irvingia gabonensis* should be used in the improvement of *Irvingia gabonensis*. Edo and Delta could serve as better sources of seeds of *Irvingia gabonensis*.

Keywords: *Irvingia gabonensis*, fruit colour, provenance, improvement, seedling vigour index.

Introduction

The African forests are rich in various indigenous fruits that have tremendous benefits for human existence particularly those that provide food and many other useful products. The sustainability of these useful resources is of great concern (Ladipo, 2000), particularly with the continued clearing and selective exploitation of forests (Leakey, 1999), because most of them are gotten from the wild, and they are highly important to the local populace who depend on them directly or indirectly for their livelihood.

Irvingia gabonensis (Aubry-Lecomte ex ORorke); Bail (bush mango) is one of the African orphan crops. Orphan crops or neglected crops are crops that are important to local diets, developed by the African Orphan Crops Consortium (AOCC) with the objectives of developing genomics resources for economically important as well as socio-culturally relevant crop and tree species grown in Africa. *Irvingia gabonensis*

produces edible fruits which are widely marketed (Leakey, 1999; Ladipo, 2000) and form an important diet providing carbohydrates, oils and proteins to enhance health and nutrition (Fajimi *et al.*, 2007). The fruit pulp is eaten and the kernel is also used for medicinal purposes and as a source of oil for making soap (Nya *et.al*, 2000, 2006 and Shiembo *et al*., 1996).

In spite of its importance in providing economic and livelihood benefits to the local populace most importantly, the subsistence farmers, it is still not widely cultivated as most of the edible fruits and kernels are still gotten from the wild, hence and they are becoming increasingly difficult to collect due to deforestation and old age of tree (Ladipo 2000). There is need to established this in plantation by the use of improved seedlings. The survival of forest plantation, growth performance, volume and quality of forest produce harvested over time in a given plantation is influenced by the quality of seed sown (Moss, 1995) which is to a larger extent dependent on the source from which seeds were collected (Elmabgoul *et. al.,* 2014, Ehandor and Ayodele, 2014). Poor germination and seedling establishment are major problems in *Irvingia* production (Ladipo,2000). Good source of seeds could reduce the risk of planting poorly adapted tree crops that pose a great threat for sustainable forest growth (Hamann *et al*., 2000).

Provenance is the geographical source or place of origin from where a given lot of seeds or plants (propagules) are collected. Information on morphological variation in seed characteristics amongst the provenances of a species has been reported to be useful for tree improvement programs (Singh *et al.,* 2010; Shu *et. al.,* 2012). Variations in seed morphological characteristics, germination and seedling growth among different provenances have been reported for many forest trees but not in *Irvingia gabonensis* in Nigeria. Variation among the provenances has been attributed to genetic differences caused by the adaptation of different provenances to diverse environmental conditions (Ginwal *et al.*, 2005) and soil types (Elmagboul *et. al*., 2014). Seed is the common propagation material for most tropical tree species (Bowes, 1999). Propagation from seed is inexpensive and usually effective, and is therefore a viable method for their ex-situ conservation (Abirami *et al*., 2010). The production of good quality seedlings with good vigour requires the use of good quality seeds which can withstand the adverse weather conditions.

An understanding of seed physiology is also important as this could expectedly contribute to the effort of seed-based in-situ conservation as well as ex-situ cultivation as well as tree improvement programme (Sharma and Sharma, 2006). *Irvingia* fruits change from green to yellow as fruits ripen. The major pigments responsible for fruit colours are chlorophyll, carotenoids and anthocyanins. The chloroplasts in green immature fruits generally lose chlorophyll on ripening and increase other pigments. I*rvingia* fruit are found in five colours (Ladipo, 1999), this immense variability in colour is a resource that can be utilized for colour selection. The proper handling of seed through the processes of ripening or maturation, collection processing and germination is required for success in producing improved seedlings.

The need for expansion and tree improvement for improved tree and fruit quality and success in breeding programme will depend on the broad genetic base of crop and also for achieving the goals of improving the crop and producing high yielding and better resistant

varieties (Lowe *et. al*., 2000). Therefore, there is the need to diversify the genetic base of improved *Irvingia gabonensis*, and the first step towards this is to evaluate the germplasm or genotypes from various provenance. This is because the evaluation and selection of plants at phenotypic level usually reveals important traits of interest to plant breeders (Singh, 1989).

Very little information exists on the effect of fruit color as well as provenance in Nigeria on seed quality of this African orphan crop. It will be necessary to determine which fruit colour as well as provenance to collect seeds of *Irvingia gabonensis* that will yield good viable seeds and seedlings of good vigour. Therefore this study was carried out to evaluate the possible effect of provenance and fruit colour on germination and seedling vigour performances *of Irvingia gabonensis* seeds with the aim of broadening genetic base for selection and improvement..

Materials and Methods

Seeds collection and processing

Matured fruits of *I. gabonensis* were collected from phenotypically superior mother plants at the peak of fruiting season from four (4) identified states in Nigeria namely: Anambra, cross river, Delta and Edo. In each state, a total number of five (5) locations were identified based on abundance and fruits were collected from five (5) trees. These were labelled and kept for further assessment. The collected fruits from each provenance were divided into five categories bases on color as: green, yellow, greenish brown, yellowish-green and dark brown according to (Ladipo *et al.*, 1996 and Bowes 1999).

The five colour categories were made up of 100 fruits each per provenance making a total of 500 seeds for the experiments. The fruits were extracted manually and air dried for three days.

Experimental site

The experiments were carried out at the Physiology and Tree Breeding Nursery of Forestry Research Institute of Nigeria (FRIN). Headquarters, Jericho, Ibadan. Nigeria. FRIN is located on the longitude 070 23'18"N to 070 23'43"N and latitude 03051'20"E to 03051'43"E. The climate of the study area is the West African monsoon with dry and wet seasons. The dry season is usually from November through March and is characterized by dry cold wind of harmattan. The wet season usually starts from April to October with occasional strong winds and thunderstorms. Mean annual rainfall is about 1548.9 mm, falling within approximately 90 days. The mean maximum temperature is 31.9^{o}C, minimum 24.2^{o}C while the mean daily relative humidity is about 71.9% (FRIN 2015).

Experimental design

The factorial experiment was laid down in a Completely Randomized Design (CRD) with five replications. There were two factors: provenance (4) and fruit maturity colour (5).
Five colour groups were green, yellow, yellowish green, greenish brown and dark brown.
The four provenances were Edo, Delta, Anambra and Cross River

Experimental procedure and maintenance of Seedlings

Nursery pots were filled with top soil and one seed sown directly at a uniform depth of 5cm into the pots. The seedlings were watered regularly to avoid water stress. A nursery shed were provided to avoid excessive water from the rain and also to protect the seeds

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from direct sunlight. Weeding was carried out as at when due.

Seed Quality Assessment

The following seeds quality traits were assessed:

1. Seed germination: this was assessed at the commencement of seed germination until no further germination was noticed.

$$\%\ Seed\ germination = \frac{Number\ of\ seed\ germinated}{Number\ of\ seed\ sown} \times 100$$

2. Seedling height : this was assessed fortnightly after two weeks of seed germination

4 Seed Vigour Index (SVI): Seedling Vigour Index was calculated by multiplying percentage germination by the average of plumule length after seven days of germination (Kim *et al.*, 1994) and divided by 1000 (Adebisi, 2011).

5 Collar diameters was observed fortnightly with the aid of digital veneer caliper

6 Leaf production: Physical count of leaves was done fortnightly.

Statistical Analyses

Data collected were subjected to Analysis of Variance (ANOVA) and significant treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Results

Table 1 shows the summary of result of analysis of variance showing the effect of provenance and fruit colour on seed quality traits of *Irvingia gabonensis*. The effect of provenance on all traits measured were significant ($P<0.05$). The effect of fruit colour were also significant ($P<0.05$) on all the traits except seedling vigour index. The interaction effect of provenance and fruit colour was highly significant for all the parameters examined.

Table: 1 Summary of Analysis of variance (ANOVA) showing the effects of provenance and fruit colour on seed quality traits of *Irvingia gabonensis* seeds.

Source of variation	DF	Seeedling germination	Seedling height	Seedling vigour index	Collar diameter	Leaf production
Provenance (P)	3	532.22**	2052.48**	881.08**	51.48**	111.09**
Fruit colour (F)	4	558.32**	373.99**	28.81^{NS}	5.03**	4.59*
P x F	12	267.35**	84.75**	32.61**	4.18**	11.52**

* Significant at 0.05 probability level

* * Significant at 0.0 1 probability level

Table 2 shows the main effects of provenance on seed quality parameters evaluated in *Irvingia gabonensis* seeds. It indicated that seeds sourced from Edo had the highest seedling germination (51.01%), collar diameter (11.76mm) and leaf production (13.88) which was significantly different from other sources. Seeds collected from Delta had the highest plant height and seedling vigour index which were different from other sources statistically. Seeds from Cross River had the least value for all the seed quality traits measured.

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Table 3 shows the main effect of provenance and fruit colour on seed quality parameters evaluated in *Irvingia gabonensis* seeds. It shows that there were significant differences in seed quality parameters among the fruit colours. The yellow seeds had the highest seedling germination of 55.39% while seeds from green fruit colour had the lowest germination value of 40.65%. Seeds from yellow fruit had the highest plant height/seedlings (20.32cm) closely followed by darkbrown seeds with plant height value of 19.41 cm, which was closely followed by yellowish green seeds with plant height of 19.7cm which are not statistically different from each other. The seeds from green fruit had the lowest plant height of 13.5 cm. In term of seedling vigour index, all the colour categories had the same effect which was not statistically different from each other. The diameter of all the fruit colours except seeds from green colour fruit had similar and higher stem diameter values.

Leaf production\seedling was highest in yellow fruits (12.92) which was significantly different from values recorded for seedlings from yellowish-green (12.63) and dark-brown (12.61), greenish brown (12.03) fruits whereas seedlings from green colour fruits had the lowest leaf production (11.08).

Table 4 shows the interactive effects of provenance and fruit colour on germination percentage of *I. gabonensis* seeds. The interactive effects were significant. The result showed that darkbrown seeds from Edo (62.65%), Delta (60.86%) and Anambra had higher similar effect with yellow seeds from Anambra (60.27%) and greenish brown seeds from Anambra (60.22%). Green seeds from Cross river had the least germination of 33.91% which was not significantly different from green (37.53%) and yellowishgreen (33.97) seeds from Edo

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Table 2: Main effects of provenance on seed quality parameters evaluated in *Irvingia gabonensis* seeds.

Provenance	% Seed germination	Plant height	Seedling vigour index	Collar diameter	Leaf production
Edo	51.01[a]	21.52[b]	3.64[b]	11.76[a]	13.88[a]
Delta	44.02[b]	22.72[a]	3.89[a]	10.81[b]	13.55[a]
Anambra	44.58[b]	18.93[c]	3.37[d]	9.58[c]	9.53[b]
Cross River	42.74[c]	18.32[c]	3.05[c]	7.92[d]	8.21[c]

Means followed by the same alphabet in a column under each column are not significantly different from each other by the Duncan's Multiple Range Test at 5% level of probability

Table 3: Main effects of fruit colour on seed quality parameters evaluated in *Irvingia gabonensis* seeds.

Fruit colour	% Seed germination	Plant height	Seedling vigour index	Collar diameter	Leaf production
Green	40.63[c]	13.35[c]	3.78[a]	7.74[b]	11.08[c]

Yellow	55.39 [a]	20.32 [a]	3.80 [a]	11.39 [a]	12.92 [a]
Greenish brown	50.47 [b]	16.79 [b]	3.69 [a]	10.32 [a]	12.03[bc]
Yellowish brown	50.50 [b]	16.87 [b]	3.76[a]	9.12 [b]	12.63[ab]
Dark brown	54.22[a]	19.41[a]	3.66[a]	10.97[a]	12.61[ab]

Means followed by the same alphabet in a column under each column are not significantly different from each other by the Duncan's Multiple Range Test at 5% level of probability

Table 4: Interactive effects of provenance and fruit colour on germination percentage of *Irvingia gabonensis* seeds

	Provenanve			
	Edo	**Delta**	**Anambra**	**Cross River**
Green	37.53[d]	40.26[c]	54.33[b]	33.91[d]
Yellow	53.09[b]	52.77 [b]	60.27[a]	53.26[b]
Greenish brown	40.55[c]	40.48[c]	60.22[a]	47.08[c]
Yellowish green	33.97[d]	43.32[c]	47.92[c]	60.63[a]
Dark brown	62.65 [a]	60.86[a]	60.38[a]	52.64[b]

Means followed by the same alphabet in a column under each column are not significantly different from each other by the Duncan's Multiple Range Test at 5% level of probability

Table 5 shows the effect of provenance and fruit colour on plant height of *Irvingia gabonensis*

The result showed that seeds from brown fruits sourced from Edo had the highest plant height of 32.03 cm whereas the lowest plant height of 8.64cm was recorded for green fruit sourced from Cross river.

Seeds from dark brown fruits from the entire provenance had similar higher effect. The seeds from the green fruits across the entire provenance had the poorest plant heights. The seeds from yellow fruits from Delta also had higher effect of plant height.

Table 6 shows the interactive effect of provenance and fruit colour on collar diameter of *Irvingia gabonensis*. The result showed that seeds from yellow (11.77), dark-brown (11.63) and greenish brown (11.61) collected from Edo had higher collar diameter which are not significantly different from each other. In the same vein, seeds from green (11.15), greenish brown (11.33) and yellowish green from Delta had the same effect. In Anambra, seeds from darkbrown had the highest collar diameter whereas seeds from yellowishgreen recorded the highest collar diameter in Cross River.

Table 5: Interactive effect of provenance and fruit colour on plant height of *Irvingia gabonensis*

Fruit colour	Provenance			
	Edo	Delta	Anambra	Cross River
Green	18.17^{e}	19.50 ^{b}	12.32^{d}	8.64^{d}
Yellow	28.50^{b}	24.83 ^{a}	18.22^{c}	22.67^{a}
Greenish brown	25.17^{c}	15.63 ^{c}	22.35^{b}	16.30^{c}
Yellowish green	21.55^{d}	24.37 ^{a}	22.06^{b}	16.20 ^{c}
Dark brown	32.03^{a}	24.40 ^{a}	25.28^{a}	23.77^{a}

Means followed by the same alphabet in a column under each column are not significantly different from each other by the Duncan's Multiple Range Test at 5% level of probability

Table 6: Interactive effect of provenance and fruit colour on collar diameter of *Irvingia gabonensis*

Fruit colour	Provenance			
	Edo	Delta	Anambra	Cross River
Green	10.88^{c}	11.15^{a}	8.16^{c}	11.37^{b}
Yellow	11.77^{a}	10.20^{b}	10.26 ^{b}	7.84^{c}
Greenish brown	11.61^{a}	11.33^{a}	10.55 ^{b}	7.133^{c}
Yellowish green	11.34^{b}	11 .55^{a}	10.29^{b}	12.05^{a}
Dark brown	11.63^{a}	10.27^{b}	11.25^{a}	8.06^{c}

Means followed by the same alphabet in a column are not significantly different from each other according to Duncan's Multiple Range Test at 5% level of probability

Table 7 shows the interactive effect of provenance and fruit colour on number of leaves of *Irvingia gabonensis.* Seeds from Yellowishgreen fruits from the entire provenances except Delta had high leaf production whereas seeds from green fruit from all the provenance except Delta recorded low values of Number of leaves. In Anambra, all the colour categories except green fruit had high values of number of leaves which was not significantly different from each other. In Cross river, seeds from yellow, yellowishgreen and darkbrown had high values of leaf production which was significantly different from grrenishbrown and green fruits.

Result in table 8 shows the interactive effect of provenance and fruit colour on seedling vigour index of *Irvingia gabonensis* seeds. The result revealed that seeds from dark-brown fruits collected from Delta had the highest seedling vigour index whereas seeds from greenishbrown fruits gave the lowest seedling vigour index.

In Edo, seeds from green and dark brown fruits had high values of Seedling vigor index 16.80 and 16.29 respectively while greenish brown recorded the least value of seedling vigour index11.86.

In Delta, seeds from dark brown had the highest of seedling vigour index 17.39 which was significantly different from others whereas, seeds from yellowish green had the

least of seedling vigour index 2.27 which was not significantly different from that of yellow fruits.

In Anambra, seeds from green fruits had the highest of seedling vigour index 15.37 which was significantly different from others whereas seeds from yellow fruit had the least of seedling vigour index 8.36.

In Cross River seeds from darkbrown fruits recorded the highest value of seedling vigour index 9.24 which was significantly different from others. The least value from Cross river (1.18) was recorded in seeds from greenishbrown fruits.

Table 7: Interactive effect of provenance and fruit colour on Leaf production of *Irvingia gabonensis* seeds

Fruit colour	Provenance			
	Edo	Delta	Anambra	Cross River
Green	11.13^{c}	13.67^{a}	7.67^{c}	7.13^{c}
Yellow	12.17^{b}	10.68^{c}	11.62^{a}	11.33^{a}
Greenish brown	12.22^{b}	7.32^{e}	11.33^{a}	8.87^{b}
Yellowish green	13.08^{a}	12.67^{b}	11.00^{a}	11.30^{a}
Dark brown	13.33^{a}	12.33^{b}	11.67^{a}	11.00^{a}

Means followed by the same alphabet in a column under each factor are not significantly different according to Duncan's Multiple Range Test at 5% level of probability.

Table 8: Interactive effect of Provenance and fruit colour on seedling vigour index of *Irvingia gabonensis* seeds

Fruit colour	Provenance			
	Edo	Delta	Anambra	Cross River
Green	16.80^{a}	16.96^{ab}	15.37^{a}	6.17^{b}
Yellow	13.39^{b}	9.71^{c}	8.36^{d}	5.06^{c}
Greenish brown	11.86^{c}	2.27^{d}	13.50^{b}	1.18^{d}
Yellowish green	8.53^{d}	9.73^{c}	11.88^{c}	5.73^{c}
Dark brown	16 .29^{a}	17.39^{a}	11.89^{c}	9.24^{a}

Means followed by the same alphabet in a column under are not significantly different from one another according to Duncan's Multiple Range Test at 5% level of probability.

Discussion

This study revealed that significant differences were observed among the provenance for seed germination, seedling vigour index, plant height, stem diameter and number of leaves of *I. gabonensis*. The effect of fruit colours was also significant for all the traits except seedling vigour index. The interactive effects of provenance and fruit colours were also significant for all the seed quality traits examined. This implies that seed quality parameters of *Irvingia gabonensis* is affected by fruit colours and sources of collection. Consequently, improvement in seed and seedling vigour could be achieved by giving due consideration to fruit colour from which seeds of *Irvingia gabonensis* are obtained as well as factors such as sources of collection. The study revealed that the effect of provenance was highly pronounced as

seeds sourced from Edo have the superior seed germination collar diameter and number of leaves. In the same line, seeds sourced from Delta recorded the highest plant height and seedling vigour index. Therefore there is potential for selection from source on which to base seed collection for the improvement of *Irvingia gabonensis*. This finding agrees with the works of Oyun (2003) who observed a significant difference in growth performance of *Parkia biglobosa* collected from different seed sources. According to Oyun (2003), the differences observed were attributed to environmental adaptation and some genetic components from the mother plants and their locations. Variation among plant performances due to differences in provenances has been reported for most tree species (Charity *et.al.*, 2015) which include *Faidherbia albida* (Dangasuk *et al*., 1997), *Cordia africana* (Loha *et al*., 2006), Pine species (Lopez-Upton *et al*., 2005), *Jathropha carcus* (Ginwal *et. al.,* 2005) and *Magnolia officinalis* (Shu *et al*., 2012). According to Mkonda *et al*., (2003) and Loha *et al*., (2006), in most plant species, seeds vary in their degree of performance between and within populations and between and within individuals, causes of such variability is generally attributed either to genetic characters of source population/plant (Shu *et al*., 2012), or impact of mother plant environment (Singh *et al.*, 2010). Gutterman (2000) further added that such environmental factors include day length, temperature, light quality, water availability and altitude.

On the effect of fruit colour, seeds from dark brown had the highest seed quality in terms of seed germination, plant height and collar diameter whereas seed from yellow fruits had the highest in terms of seedling vigour index and number of leaves. The differences in the performance of various colour group could be attributed to the level of maturity of the fruits of *I. gabonensis* since colour changes from green to yellow and subsequently to dark brown when deteriorating, this offer opportunity for selection in the improvement of this species. This is in line with Adebisi *et al*., (2011) who observed that seeds obtained from yellow fruits of *Gmelina arborea* tree gave superior seed germinating performance as well as seedling growth parameters. The non significant effect of fruit colour on seedling vigour index is in line with the findings of Alaje *et. al.*, (2019) who observed that the fruit colour has no effect on seedling vigour index of *Irvingia wombolu.*

Conclusion

Significant differences were observed in seedlings germination, plant height, stem diameter and number of leaves of *I. gabonensis* observed due to differences in fruit colour and provenance. However, fruit colour does not have effect on seedling vigour index of *Irvingia gabonensis.*

Edo provenance had the highest seed germination collar diameter and number of leaves while Delta provenance had the highest plant height and seedling vigour index therefore there is potential for selection among the provenance used

Fruit colour of dark brown recorded the best in terms of seed germination, plant height and collar diameter while yellow fruit seeds had the highest seedling vigour index and number of leaves. This offers opportunity for selection for the improvement of *I. gabonensis* among the various fruit colours as well as different provenances used in this study.

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