Furthering the Domestication of African Pear (*Dacryodes edulis* (G. Don) HJ Lam)

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Abstract

Using both extensive field surveys and nursery germinated seedlings, the study tried to identify and characterise the intra-specific variations of genetic and horticultural interest in the African pear (*Dacryodes edulis*). In addition, the effects of auxin concentrations and rooting media on the rooting ability of the species were investigated using non-mist propagators. Two separate experiments conducted in both the dry and rainy seasons, tested the effects of (i) top soil, river-washed sand (RWS), sawdust and RWS + sawdust (1:1 by vol.); (ii) indole - 3- butyric acid (IBA) concentrations ranging from 0.0 to 0.8% and naphthalene-acetic acid (NAA) concentrations ranging from 0.0 to 4.0%. Fourteen representative D. edulis fruit types were identified. Of the 23 pomological and vegetative characters examined, only fruit length/breadth (L/B) ratio proved to a large extent reliable in categorisation of the species. The fruit L/B ratios ranged from 1.47 to 1.82, 1.33 to 1.36 and 1.12 to 1.28 for the large, medium and small fruit types, respectively. Leaflet length was significantly correlated with rachis length, with an R^2-value of 75%. A great deal of intra-specific variations of horticultural value exists in the African pear to warrant the initiation of a selection and improvement programme. Neither hormonal treatments nor rooting media was found to produce any significant effect in the rooting of the species` stem cuttings. Cuttings treated with 0.2% IBA had the highest survival rate of 3.44% compared to other hormonal treatments. Further studies in this area was recommended, in view of the numerous factors known to play a significant role in the rooting of stem cuttings.

Keywords: African pear, propagation, improvement and domestication.

Introduction

The African pear (*Dacryodes edulis* (G. Don) HJ Lam), formerly called *Pachylobus edulis* is one of the numerous indigenous African tropical fruit trees species (TFTS) that is little known by the outside world. It occurs in the Nigerian humid tropics between latitudes 4° 15´N and 8° N of the equator, extending eastwards to Cameroun and southwards to Zaire and Angola (Keay *et al*., 1964). The fruit, which is botanically a berry, serves as a very important and strategic food supplement, being normally available during the ´hunger periods` following the planting of most staple food crops. The seeds are fed to sheep and goats and its potential in animal feed formulation has been indicated (Okafor and Okolo, 1974). The chemical properties of both the pulp and seeds of this tree species has in recent times been studied and its industrial potentials highlighted (Obasi and Okolie, 1993; Kapseu *et al*., 1999; Black and Janssens, 1996). Different parts of the plant are locally used for the treatment of ailments such as toothaches (Maponguemetsen, 1994), stomach pains (Adjanohoun *et al*., 1988), dysentry, anaemia and various skin diseases (Dalziel, 1937; Bouquet, 1969).

In the Ibo speaking areas of South-eastern Nigeria, apart from the generic name for which the fruits are recognised, names are given to different cultigens of the fruit depending on its size, shape, colour, pulp thickness, taste, time of maturity, etc. (Okorie, 1985). The species had earlier been classified into two varieties - var. *edulis* and var. *parvicarpa*, based mainly on fruit size (Okafor, 1983). Most other pomological and vegetative attributes were discarded as being taxonomically unreliable. For purposes of genetic improvement and future development strategies, more detailed horticultural studies on the extent and nature of variability within the species are essential.

The peculiar germination and propagation problems of the African pear, which to a very large extent have limited the full domestication and utilisation of the species despite its multipurpose value had been discussed in an earlier paper (Okorie *et al*., 2000). Initial attempts at vegetative propagation of the African pear did not succeed and the species was considered unsuitable for this (Phillippe 1957; Okafor, 1983). Results from recent studies however indicate that many tropical woody species can be efficiently rooted from cuttings (Dick and East 1992; Offori *et al*., 1996; Teklehaimonot *et al*., 1996) using the low- technology non- mist vegetative propagation system developed by Leakey *et al.* (1990). The ability of woody stem cuttings to root has been shown to depend on a large number of factors. These include propagation medium (Leakey *et al*., 1994), nature of cuttings, i.e. whether old or juvenile tissue (Heuser, 1976; Hartmann and Kester, 1990), type and concentration of auxin used (Leakey *et al*., 1982; Komissarov, 1969); which interact with carbohydrates and phenolic co-factors (Haissig, 1974). The appropriate conditions and treatments for the vegetative propagation of each species must be experimentally determined. This study was therefore undertaken with the following objectives:

1. To identify and characterise the intra-specific variations of horticultural and genetic interest in the African pear (*D. edulis*).
2. To assess the effects of different auxin concentrations and rooting media using the low-technology non-mist propagation system (Leakey *et al*., 1990) for the vegetative propagation of the species.

Materials and Methods

Two series of experiments were conducted at Imo State University in Nigeria involving both extensive field and nursery germination/propagation studies. This part of the humid tropics is characterised by 6-8 months of wet season (rainfall 1800- 2260mm; temp. 21- 33°C; 05° 30´N, 07° 24´E).

Experiment 1:

Field study trips were undertaken to nine different states of Southern Nigeria where the species naturally occurs. African pear trees growing in the forests, distant and nearby farms, including homesteads were used for the field study. Photographs, line drawings, measurements and morphological observations were made on both the pomological and vegetative characters of the species. The measurements were taken at random from growing trees with a measuring tape and replicated 10 times for each attribute. Morphological studies and observations were made on 418 different African pear trees. Ten fruit samples of each type identified was collected and used for the nursery germination studies. The pomological characters studied are as follows:

- Fruit weight,
- Seed weight,
- Seed number,
- Pulp thickness,
- Cotyledon number,
- Overall fruit shape,
- Fruit stalk length,
- Shape of stem end,
- Colour of cut tissue,
- Fruit length/breadth ratio,
- Shape of stylar (blossom) end,
- Grooving number and location,
- Presence or absence of bottleneck,
- Colour of pulp before and after fruit darkening.

In the nursery germination studies, the seeds were first planted in pre-nursery in wooden germination boxes. The boxes were covered with a transparent polythene material. The pre-nursery media was composed of river-washed sand and sawdust (completely decomposed), in a ratio of 1:2 by volume, respectively. Both the pulp and endocarp of seeds were removed before planting. Germinated seeds were transplanted into medium sized polythene bags. The nursery medium was composed with top soil, river-washed sand and poultry manure (completely decomposed), in a ratio of 6:2:1 by volume or 7:4:1 by weight, respectively. Pre-nursery records were taken at intervals of 2 days and nursery records weekly. The vegetative characters examined were as follows:

- Seedling morphology,
- Branching habit,
- Leaflet length and mid-leaflet breadth,
- Days to 50% germination,
- Rachis length,
- Germination percentage,
- Leaflet number in a rachis,
- Seedling growth rate (measured as plant height).

Experiment 2: In the vegetative propagation studies modified low-technology, non- mist propagators were constructed following Leakey *et al*., (1990). A wooden frame was enclosed in clear polythene, making the base water- tight. The base was covered with successive layers of large stones (6- 10cm), small stones (3- 6cm) and gravel, and topped with an appropriate rooting medium to a total depth of approximately 25cm. The

basal 20cm was then filled with water. The propagators were placed under a nursery shade. Each propagator was subdivided into four compartments and one of the four rooting media - top soil, river-washed sand (RWS), sawdust and RWS + sawdust (1:1 by vol.) were randomly assigned to each compartment. The propagation media were treated with a fungicide (Diethane M. 45, Rohm & Haas, France) at a concentration of 25g in 10 litres of water, two days before cutting insertion. In the rainy season propagation studies (May- June), cuttings were taken from terminal shoots of seven- year old Africa pear seedlings. Each cutting had at least four nodes with a length of 5- 6cm. After trimming their leaflets to about half the normal leaf area, the cuttings were immediately treated with one of five hormonal treatments. These were obtained by dissolving the rooting hormones (indole-3-butyric acid and naphthalene-acetic acid) in industrial methylated spirit (IMS) at concentrations of 0.0% (IMS only), 0.2%, 0.4% and 0.8% for IBA and NAA, respectively. The IBA and NAA solutions were applied to the cutting base in a 10 µl droplet using a micro-pipette giving 0, 20, 40 and 80µg each of IBA and NAA per cutting, respectively. The alcohol was evaporated off before cutting insertion into the propagators (following Leakey *et al*., 1982). A total of 392 cuttings were used (7 cuttings per treatment), and laid out in 8 randomised blocks in the four different rooting media using two large propagation boxes.
In the dry season propagation studies, the same procedure as above was adopted but the treatments were made up of 0.0%, 0.2% and 0.4% for IBA, but 0.0%, 2.0% and 4.0% for NAA. The cuttings were taken from younger seedlings of 18 months old and there were 7 cuttings for each of the 5 treatments, giving a total of 280 cuttings. The number of green leaflets retained by cuttings in each treatment at the beginning of the experiment was recorded and subsequently, after every four days.

The data from the studies were subjected to analysis of variance (ANOVA), and standard errors and percentages calculated where appropriate following the procedure described by Snedecor and Cochran (1980). In addition, regression and correlation was also used for analysis of the field study data.

Results

Experiment 1:

A continuous and overlapping trend of variation was observed in most of the vegetative and pomological characters studied. This occurred not only between the different fruit types but also within individual trees. Fourteen representative fruit types were identified based mainly on fruit size and shape. The mean values for some important vegetative characters of the species are presented on Table 1. A total germination percentage of 86.1% was obtained 50 days after planting. The germination and growth rates (measured as plant height), were related more to the seed weight rather than fruit weight. Seed weights however, had no significant correlation with fruit size or its length/breadth (L/B) ratio. The seedling vegetative morphology of the species varied greatly between and within the various fruit types. While some had opposite set of seed leaves, the ´O-o` and ´U-J` fruit types were mostly whorled, the latter being frequently polyembryonic. The incidence of parthenocarpicity was so high in the ´U-H` fruit type that enough seeds could not be obtained for germination. The number of leaflets borne on the seed leaves ranged from 2 as in ´I-M`, to 7 as in ´U-F` fruit type and with variable phyllotaxy. The overlapping trend of variation observed in most of the characters studied is well illustrated by variations in mean fruit stalk length. This varied significantly ($p = 0.01$) from 4.3cm in ´U-G` fruit type to 30.8cm in `U-B` fruit type (Tab. 1). The latter however, has fruit stalks ranging from 5- 46cm in length.

Alternate fruit arrangement was associated with fruit stalks greater than 10cm in length, whereas fruit stalks less than 10cm had either opposite or single fruit arrangement. The leaflet length was significantly correlated with the rachis length with an R^2-value of 75%. The intra-specific variations in pomological characters of African pear are presented on Table 2. Like the vegetative characters, the continuous trend of variation observed not only between fruit types but also within individual trees, rendered most of the vegetative characters studied useless in the species categorisation.

Fruit colour before darkening (ripening) for example varies, even within trees, ranging from reddish pink to a greenish white or cream colour. Fruit weight also varied greatly within the species, being largely dependent on seed weight. Due to the high incidence of parthenocarpicity, fruit weight was not dependent on fruit size or fruit L/B ratio.

Table 1: Mean values for some important vegetative characters of the African pear (*D. edulis).*

Fruit Type	Days to 50 % germination	Seedling height (cm) at 14 weeks	Leaflet no. per rachis (cm)	Rachis Length (cm)	Fruit stalk Length (cm)	Leaflet Length (cm)
Large fruit types						
I-N s	18	21.8 3.4	16.5 1.2	61.5 4.8	6.4 1.4	23.5 6.5
U-F s	28	25.7 5.2	13.9 0.9	37.4 5.7	7.7 3.0	15.5 1.3
I-M s	36	16.1 4.0	16.7 1.4	34.5 3.1	17.2 1.1	16.5 5.5
U-K s	37	19.1 3.6	14.8 1.2	29.8 2.8	8.3 1.4	18.3 2.5
U-B s	27	24.8 3.0	16.3 1.4	51.6 5.6	30.8 16.5	20.8 5.8
Medium fruit types						
U-A s	22	22.7 2.2	18.4 1.8	55.5 6.7	6.4 0.8	21.2 5.1
O-o s	24	19.9 2.6	16.9 2.9	43.2 7.8	19.6 1.2	17.8 2.7
U-G s	17	20.7 10.0	14.1 1.4	27.7 2.5	4.3 0.8	13.8 0.4
U-H s	-	- -	19.9 1.5	40.9 3.6	7.6 1.3	20.1 4.1
U-E s	42	16.4 6.0	15.7 1.1	23.4 3.5	15.5 0.5	14.8 1.2
Small fruit types						
U-D s	49	8.7 1.7	13.4 1.8	20.4 3.1	8.6 0.9	15.8 4.6
U-S s	40	22.1 3.1	15.0 1.4	25.6 4.0	4.6 0.3	14.9 2.6
U-J s	38	7.7 2.7	13.8 1.9	39.5 5.3	18.0 3.9	22.1 4.8
U-C s	37	19.3 1.7	15.6 0.7	21.6 2.7	4.6 1.2	15.0 1.8

s = Standard deviation

Twin seeded fruits were observed in ´U-D`, ´I-M`, ´U-G`, ´U-E`, ´U-C` and ´U-J` fruit types. Except for ´U-J` which sometimes have fused cotyledons, all others had a constant cotyledon number of 10 per seed.

The size and shape of the stem and stylar (blossom) end of fruits is one of the few characters found to be relatively uniform within representative fruit types, although there may be gradations of such features like stylar end knobbing.
Except for ´U-H` fruit type, fruits without knobs either at the stem or stylar end are associated with the absence of grooves. The mean half-longitudinal fruit circumference (HLC) and the mean half mid-transverse fruit circumference (HTC) were found to be significantly ($p=0.01$) correlated in a linear fashion with an R^2-value of 82%. When this was plotted on a graph, three distinct categories emerged i.e.:

If $Y = a + bX$, where ´Y` is the HLC and ´X` the HTC;

Table 2: Intra-specific variations in some pomological characters of the African pear (*D. edulis*)

Fruit Type	Fruit shape	Mean L/B ratio	Pulp thickness (mm.)	Seed weight (g.)	Fruit weight (g)
Large I-N	Oblong	1.77	7-9	14.0 - 16.0	59.0 - 64.3
U-F	Elliptical	1.63	3-4	9.8 - 11.8	35.0 - 40.5
I-M	Oblanceolate	1.47	3-4	8.9 - 10.0	31.9 - 38.1
U-K	Disfig.-obclavate	1.78	3-4	4.2 - 5.5	26.2 - 37.9
U-B	Lanceolate	1.82	3-4	4.0 - 4.4	28.0 - 39.9
Medium U-A	Oblong-ellipsoid	1.36	5-7	8.1 - 9.0	49.0 - 59.1
O-o	Cordate	1.35	3-5	9.0 - 10.4	48.0 - 53.3
U-G	Obovate	1.36	7-8	9.9 - 10.9	42.0 - 52.3
U-H	Cordate-obovate	1.33	6-7	4.3 - 5.0	23.8 - 26.2
U-E	Emarginate	1.35	2-3	7.7 - 8.9	24.4 - 26.0
Small U-D	Oblong	1.70	2-3	8.4 - 10.0	14.6 - 17.5
U-S	Obclavate	1.22	4-5	3.1 - 5.0	18.2 - 24.4
U-J	Globulose	1.12	2-3	2.4 -4.1	13.8 - 15.9
U-C	Globose	1.28	2-3	6.2 - 6.8	13.3 - 14.4

For the large fruit types, $a = -0.039$ & $b = 1.215$;
For medium fruit types, $a = -0.498$ & $b = 1.436$ and
For small fruit types, $a = -1.220$ & $b = 1.935$.

In general, these three categories were also distinct in their germination and growth rates (Tab. 1). The large fruit types have higher L/B ratios ranging from 1.47- 1.82 with distortions in fruit shape at both ends, giving rise to continuous variations from oblong to lanceolate. In the medium fruit types, variations in fruit shape was more in the broadening of the stem end with a corresponding narrowing of the stylar end. Their L/B ratios varied only very slightly, ranging from 1.33- 1.36. Except for ´U-D`, the small fruit types have characteristically spherical shapes without grooves. Their L/B ratios ranged from 1.12- 1.28. The ´U-D` fruit type represents a cultigen that has very small fruits with an oblong shape and high fruit L/B ratio of 1.70, comparable to that of the large fruit types. In addition, their seedling growth rate and pulp thickness compares favourably to that of the small fruit types, and it was therefore classified as such. In general, the pulp thickness of the small fruit types is very thin (2- 3mm), a feature which lowers their horticultural appeal.

Experiment 2:

In both the dry and rainy season vegetative propagation studies, neither hormonal treatments nor rooting media produced any significant effect. The interaction effect was also non-significant. There were no visible symptoms of infection observed. The rate of stem tissue necrosis and leaf abcission was higher in the dry season trial with none of the cuttings retaining any green leaflet after the 12th day of cutting insertion. The effect of rooting media on the mean percentage survival and leaf retention of the cuttings in the rainy season trial is presented on Table 3.

After four weeks, the highest survival of 4.64% was recorded on cuttings planted in top soil, with 8.51% of their leaflets still being retained after 16 days of planting. Cuttings planted on sawdust had the lowest survival rate of 1.06%, with a higher leaf abcission rate 98.11% within the same period although these differences were not statistically significant (p=0.05).

Table 3: Mean percentage survival and leaf retention of African pear (*D. edulis*) leafy stem cuttings under different propagation media

Treatment	Survival (% +_SE)	Leaf retention (%) Time (days) 4	8	12	16
Top soil	4.64 +- 0.34	62.14	59.65	8.90	8.51
RWS	4.22 +- 0.36	63.00	59.62	9.10	8.49
Sawdust	1.06 +- 0.39	32.60	15.90	2.00	1.89
Sawdust/RWS	3.45 +- 0	58.30	50.00	3.12	3.01

The effect of IBA and NAA on the survival of the leafy stem cuttings in the rainy season trial is presented on Table 4.

Table 4: Mean percentage survival of African pear (*D. edulis*) leafy stem cuttings treated with different IBA and NAA concentrations

Treatment	Survival (%+- SE)	
Control	3.31	0.25
0.2% IBA	3.44	0.28
0.4% ,,	3.36	0.26
0.8% ,,	3.26	0.28
0.2% NAA	3.34	0.29
0.4% ,,	3.31	0.27
0.8% ,,	3.28	0.29

Cuttings treated with 0.8% concentration of either IBA or NAA had the lowest survival rate (3.26% & 3.28%, respectively) and the highest survival rate of 3.44% was obtained with 0.2% IBA. These differences were however, statistically not significant (p=0.05). Out of a total of 392 leafy stem cuttings planted in the rainy season trial, only 13 or 3.3% actually survived, producing some form of root primordia with neither hormonal application nor rooting media producing any significant effect.

Discussion

A great diversity of variation of genetic and horticultural interest exists in the African pear to warrant the initiation of a selection and improvement programme. Since African pear has been found to be cross-compatible (Rambaldi, 1984), the continuous and overlapping trend of variation observed could be attributed to several generations of natural crossing between the different fruit types. The expression of this high variability in the seedling growth and morphology of the identified fruit types suggests that these characters are to a large extent heritable. More studies are however required in the areas of the species genetics and pollination control if the useful variants already observed within the species are to be maximally exploited for its improvement.

The poor rooting success obtained in this study confirms the results of earlier works, following which the species was described as unsuitable for vegetative propagation (Okafor, 1983; Phillippe, 1957). The efficiency of the low-technology, non-mist vegetative propagation system for the rooting of tropical trees species have been proved by several studies to be very high (Mesen *et al*., 1997; Teklehaimanot *et al*., 1996; Ofori *et al*., 1996). In some cases, it even produced larger number of roots per rooted cutting when compared with the mist propagation system (Aminah *et al*., 1996). The importance of propagation medium for the rooting of vegetative cuttings is however, well known (Hartmann *et al*., 1990). In general, an appropriate rooting medium is described as one with an optimal volume of gas-filled pore-space and oxygen diffusion rate adequate for the needs of respiration (Andersen, 1986). The response of tree species to different media has been shown to differ. For example, in *Irvingia gabonensis* (Shiembo *et al*., 1996) and *Milicia excelsa* (Ofori *et al*., 1996), higher percentages were recorded in sawdust than in other media tested. But in *Cordia alliodora* (Mesen *et al*., 1997) and *Vochysia hondurensis* (Leakey *et al*., 1990) higher rooting percentages were recorded in fine sand and gravel, respectively. Contrasting rooting results recorded in different propagation media reflect variation in their physical and chemical characteristics, such as capacity for water retention (Loach, 1986). The more rapid leaf abcission rate observed on African pear cuttings in sawdust when compared with the other media used (although not statistically significant), suggest its unsuitability for the vegetative propagation of this species. The fact that the stems of African pear on injury produce a gummy and brownish exudate may to a large extent have aggravated the aeration and respiration problems within the propagation media. Since aeration and water holding capacity of the media are often negatively correlated (Loach, 1986), a very delicate balance of these within the propagation medium appears to be essential for the optimal rooting of this species.

Similarly, contrasting results have been obtained with respect to the effects of rooting hormones on tropical trees species. For example, whereas in *Cordia alliodora*, IBA concentrations of 1.6% produced the highest rooting percentage (Mesen *et al*., 1997) and cuttings without applied IBA failed to root (Mesen, 1993); in *Milicia excelsa*, a decline in rooting percentage with IBA concentrations greater than 0.2% was reported (Ofori *et al*., 1996). Successful rooting without applied auxin has also been reported in a number of other tropical tree species, such as *Shorea macrophylla* (Lo,

1985), *Nauclea diderrichii* (Leakey, 1990) and *Vochysia hondurensis* (Leakey *et al*., 1990). It is known that concentrations of auxins substantially higher than those normally found in plant tissues may cause cell death (Hartmann *et al*., 1990). Although we found no significant responses to IBA and NAA applied at concentrations of 0.2%, 0.4% & 0.8% respectively, and NAA at 2.0% & 4.0% in the rooting of leafy stem cuttings of African pear, more studies in this area is recommended. The numerous factors known already known to play a significant role in the rooting of vegetative cuttings such as seasonal effects, rooting medium temperature, nature tissue exudates, position and age of cuttings, etc. need to be thoroughly investigated in this species. Studies are also required in the areas of micro-propagation and post-harvest physiology of this valuable tree species.
The development of rapid and more efficient vegetative propagation techniques for important but neglected indigenous African tropical fruit trees species like the African pear would, to a very large extent, facilitate the full domestication and exploitation of their potentials. This would be a very efficient and effective way of combating the twin problems of hunger and environmental degradation in Africa.

Acknowledgements

´The Deutsche Akademische Austauschdienst` (DAAD) sponsored this study. We are also grateful to Professors Marc JJ Janssens, University of Bonn and TOC Ndubizu of Imo State University, Nigeria for their fatherly guidance and support.

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