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Methodological approaches for the selection of genotypes in a progeny trial of *Dacryodes edulis* (G. Don) H. J. Lam in Cameroon

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ABSTRACT

The World Agroforestry Centre (ICRAF) initiated a program in Cameroon for the selection of improved genotypes of *Dacryodes edulis* for domestication. There are major challenges in such selection because superior performance of individual trees may be based on site conditions rather than on genetic differences. Open-pollinated seeds were collected from mother trees in four provenances in Cameroon and planted in a progeny trial at Minkoameyos, Cameroon. Progeny from the same mother tree are referred to as family. After one year of growth in the field, growth traits were measured annually for five years and fruit traits were measured in two successive years. Three methodological approaches were investigated: family and within-family selection (combined selection), ranking for phenotypic selection and correlation for multi-trait and early selection. Variation in growth and fruit traits among families was not significant for most provenances, indicating that family selection would not be effective for the selection of genotypes in the trial. Phenotypic selection resulted in the retention of a small number of individuals of all families in the trial. There were strong positive correlations between fruit traits and between fruit and growth traits, while negative correlations were found between fruit traits and yield. The correlations indicate that selecting for one fruit trait may also improve the other fruit traits but reduce fruit yield. Positive and significant juvenile-mature correlations for growth were also found in this trial, indicating that early selection may be possible based on growth. Based on these results, phenotypic selection is recommended in the progeny trial for the domestication program in Cameroon and further research on early selection is needed as the trial advances in age.
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Keywords: Domestication, tree growth, fruit traits, family variation, correlations, early selection

INTRODUCTION

The World Agroforestry Centre (ICRAF), in collaboration with national agricultural research institute in West and Central Africa Regions have been domesticating the high-value indigenous fruit and medicinal trees for the last decade (Tchoundjeu et al., 2006). Five species were selected based on farmers' preferences and the market potential of the species. *Dacryodes edulis* (G. Don) H. J. Lam (Burseraceae family) was ranked second amongst species

that farmers selected for the domestication program after *Irvingia gabonensis* (Aubrey Lecomte ex O'Rorke) Baillon (Franzel et al., 1996). *D. edulis* is known as African plum or safou in Cameroon and bush butter in Nigeria. It is a dioecious, small to medium-sized tree up to 20–25 m tall. It is an important fruit tree at the national and international levels, because the fruit has high nutritional value and plays an important role in the rural economy (Awono et al., 2002; Mbofung et al., 2002; Schreckenberg et al., 2002a). The species originated from Central Africa and the Gulf of Guinea and is presently cultivated from Sierra Leone to Angola along the Atlantic coast and further inland as far as Uganda (Leakey et al., 2002). It has also been recorded in northern Zimbabwe.

A progeny test of safou was established in Minkoameyos in 2001 from four provenances. The trial was planted for the selection of superior genotypes to be used in the on-going domestication program. There are major challenges in such selection as superior performance of individual trees may be based more on environmental than on genetic differences. Furthermore, reliance on only a few trees as a basis for future expansion will narrow the genetic base and make the material vulnerable to changing disease pressures and/or climate change (Cornelius et al., 2006). In any selection the expected gain in performance must thus be weighed against the risk of future costs due to higher vulnerability.

A number of selection methods are available for improving gain. Combined index selection is employed based on the breeding values, whereas phenotypic selection ranks the individual based on its phenotypic value without any knowledge about the genetic parameters (Falconer and Mackay, 1996). Shelbourne (1992) found that phenotypic selection in unpedigreed stands, resulted in lower genetic gain than elaborate strategies, but was favorable when possibilities for faster generation turn-over and lower cost were taken into account. Furthermore, as demonstrated experimentally, if the selection intensity is relatively low (e.g., 20% selected) then phenotypic selection based on tree growth traits can produce genetic gain without significantly reducing genetic variation in the growth traits in the next generation (Weber et al., 2009). Genetic improvement of several traits simultaneously is often needed in a breeding program and this requires that information about several traits be included in the selection procedure. Trait-trait correlations have been estimated for many trees and used for developing a domestication strategy (e.g., White et al., 2007; Sotelo et al., 2010).

Domestication of most trees species is a slow process due to their long life span. Developing techniques to select at an early age would speed up the process, but this requires that the traits are at least moderately heritable at an early age and juvenile-mature correlations are strong and positive.

This paper presents methodological approaches for the selection of genotypes in the progeny trial of safou based on tree growth and fruit traits. The specific objectives are to (a) determine if there is significant genetic variation within provenances for family and within-family selection, (b) use a ranking procedure to phenotypically select progeny based on their growth and fruit traits, and (c) determine if the correlations between traits at the same age and if the correlations for the same trait at different ages are sufficiently strong to allow multiple-trait selection at an early age.

MATERIALS AND METHODS
Selection of candidate plus-trees

Field visits to identify candidate plus-trees in terms of desired fruit traits were conducted by ICRAF technical staff and farmers in 2001 (Tchoundjeu et al., 2002). In Cameroon, *D. edulis* is cultivated and marketed in the humid lowland zone (Isseri, 1998). Four populations (Boumeyebel, Makenene, Kekem and Ongot, hereafter referred to as provenances) were identified for collection and represent the two agro-ecological zones in Cameroon (i.e. with one or two annual rainy seasons). These zones are

located between latitude 2º6′-6º12′ N and longitude 8º48′-16º12′ E. Altitudes ranged from 500-2000 m, mean annual rainfall ranged from 1500-2500 mm and soil pH was 4-4.8. The maximum distance between provenances was 200 km. Five candidate plus trees were selected in each provenance, with at least 100 m between each selected tree in each provenance. The trees were selected based on fruit size and flavor, mesocarp colour, fruiting season, frequency of fruiting and resistance to pests and diseases. The selected trees were located in household gardens, farmlands and secondary forests. Information on the geographical location was recorded for each selected tree.

Fifty seeds were randomly sampled from each tree, sown and grown in polythene bags at ICRAF's research nursery in Yaoundé, Cameroon. Seedlings were transplanted in the progeny trial after six months growth in the nursery. The progeny trial includes four provenances, five families per provenance and 30 progeny plants per family, and was established in Minkoameyos, located near Yaoundé. Minkoameyos is in the humid lowland zone, with two rainy seasons per year. Each provenance was established at a different site, but the maximum distance between the four sites was only about 100 m, so the sites had similar environmental conditions (latitude = 3°51-58' N, longitude = 11°25-27' E, altitude = 813 m, mean annual rainfall = 1295 mm, soil pH = 4-5.5). Each site included 15 replications, and in each replication there were two-tree row plots for each of the five families (30 seedlings total per family). Seedlings were planted in manure-filled holes at a spacing of 5 by 5 m. Border trees of safou from unknown provenances were planted around each site at the same spacing.

Data collection

After one year of growth in the field, growth parameters were measured annually for five years and fruit traits were assessed at the onset of fruiting following a standard procedure (Leakey et al., 2002; Waruhiu et al.,

2004). Growth traits included height (Ht), root collar diameter (CD) and crown diameter (CR) of all living trees at the end of the growing season. The number of fruits was recorded in each fruiting season for trees with fruits, and 30 fruits were randomly selected from the four cardinal quadrants of the canopy for measurement of fruit variables. These included fruit length, width and pulp thickness (mm); total fruit weight, kernel weight and pulp weight (gm); and pulp weight as a percentage of total fruit weight.

Data analysis

Variables studied included survival, growth traits, fruit traits and fruit yield (i.e. the number of fruits produced). Due to fire damage and the low percentage of trees with fruit, many trees were not included in the analyses. Because the provenances were not replicated on the same site, data were analyzed separately by provenance (site).

Using the SPSS statistical package, one way analysis of variance (ANOVA) was used to determine if there were significant differences among families within provenances. The ANOVA model was $Y_{ij} = \mu + F_i + \varepsilon_j$ where, μ = overall mean, F_i = effect of family and ε_j = the experimental error.

The Krustal Wallis test was used to rank the genotypes based upon their phenotypic values and determine if ranked values were significantly different. The top 20% of genotypes for each trait were then selected.

Spearman non-parametric correlation coefficients were used to determine if there were significant relationships between different traits at the same age and between the same trait at different ages.

RESULTS
Survival

Survival rate in the provenances was 73%, 81%, 89% and 92% for Ongot, Boumyebel, Makenene and Kekem, respectively after six years. Mortality was caused by accidental fire and loss during weeding at the first year of growth.

Variation in tree growth and fruit traits

Mean tree height was 4.8 m in each provenance after six years. The values for height, root collar diameter and crown diameter of individual trees ranged from 1.8 to 8.1 m, 1.3 to 16.2 cm and 0.43 to 18.0 m, respectively across the four provenances in the sixth year. Except for all the families in Ongot provenance and a few families in Boumyebel provenance, ANOVA indicated that the differences among families within provenances were not significant (Table 1). There were significant differences in most fruit traits among families of the Boumyebel and Kekem provenances in the sixth year (Table 2). However, most fruit traits did not differ significantly among families in the Makenene and Ongot provenances.

Ranking genotypes based on tree growth traits

In this trial, the best 20% of the genotypes based on the three growth traits (tree height, root collar and crown diameters) represented all families from the four provenances. The number of selected genotypes was 27 from Kekem, 25 from Ongot, 22 from Makenene and 16 from Boumyebel. Since all 20 families from the four provenances are represented in the selected group, there is a relatively broad genetic base for the improvement program. Since the growth traits were highly correlated (discussed below and details in Table 3), the majority of the selected genotypes in each provenance were in the top 20% for at least two of the three growth traits: 23 from Kekem, 18 from Ongot and from Makenene, and 13 from Boumyebel.

Ranking of genotypes based on fruit traits and yields

Among genotypes selected based on fruit traits, eight genotypes from Boumyebel, one from Makenene, two from Kekem and three from Ongot provenance were in the top 20% for all five fruit traits. In addition, most of the genotypes were in the top 20% for three or four of the five fruit traits. This reflects the positive correlations among the fruit traits (Table 4), and indicates that selection of genotypes with multiple-trait superiority is possible. Concerning yields, very few genotypes were in the top 20% for both fruit traits and yield because of the negative correlation between the fruit traits and yield.

Correlations among tree growth and fruit traits

There were strong, positive and significant correlations among growth traits in years two through six (Table 3), Correlations indicated that trees with larger root collar diameter had significantly larger crown diameter in all the provenances. Correlations were low between height and root collar diameter and between height and crown diameter for the Makenene provenance. There was no obvious trend between the magnitude of the correlation and the age of the trees.

Correlations among fruit traits (fruit length, fruit width, pulp thickness, fruit weight, pulp weight and percentage pulp) were strong and positive in most of the provenances in the sixth year (Table 4). The strongest correlation was between pulp weight and fruit weight in all the provenances. Correlations between fruit traits and yields (number of fruits) were weak, but negative in all the provenances.

Some fruit traits were significantly correlated with growth traits (Table 5): negative correlations with height (except in Ongot provenance), and; - positive correlations with tree collar diameter (except in Kekem provenance) and crown diameter in all the provenances. Furthermore, correlations between yield and growth traits were positive in most provenances.

Juvenile-mature correlations

In general, there were significant, positive correlations between growth traits at different ages (Table 6) and the correlations were generally stronger between two consecutive years (e.g. year 2 and 3) and weakest between the first and the last measurement year.

Fruit production started in the fifth year and increased notably in the sixth year. The percentage of trees with fruits was 12% for Boumyebel, 15% for Kekem, 18% for Makenene, and 9% for Ongot in year 5; and 46% for Boumyebel, 48% for Kekem, 38% for Makenene and 22% for Ongot in year 6. Correlations among fruit traits were positive but not significant between the two years (not tabled). Trees had many flowers during the flowering season but only a few fruits at the end of the fruiting season: strong winds and early rains during flowering and onset of fruit probably knocked off the flowers and young fruits.

Table 1: Mean and significance of family variation for tree growth traits in four provenances of *Dacryodes edulis* in years two through six.

Provenance/year	2	3	4	5	6
Mean					
Tree height (m)					
Boumyebel	1.2	1.7	2.7	3.7	4.7
Kekem	1.2	1.7	2.6	3.7	4.8
Makenene	1.3	1.8	3.9	4.8	4.8
Ongot	1.2	1.6	2.6	3.6**	4.8***
Root collar diameter (cm)					
Boumyebel	2.5	3.8	6.3	9.0	10.6
Kekem	3.9	3.8	6.8	-	11.0
Makenene	2.8	4.0	6.9	9.4	10.6
Ongot	2.5	3.6	5.9**	8.5*	10.2***
Crown diameter (m)					
Boumyebel	87	1.14	1.56	2.36	3.63
Kekem	1.0	1.1	1.6	2.6	4.0
Makenene	0.93	1.12	1.6	2.3	3.7
Ongot	0.8***	1.1**	1.5***	2.1	3.5***

Significance: * P < 0.05, ** P < 0.01, *** P < 0.001, NS P > 0.05. Sample size: 71-79 for Boumyebel, 130-138 for Kekem, 113-121 for Makenene, 97-105 for Ongot. - = data not available.

Table 2: Mean and significance of family variation for fruit traits in year six in four provenances of *Dacryodes edulis*

Trait/Provenance	FL	FW	PT	FWGT	KWGT	PWGT	P%	NF
Mean								
Boumyebel	82.8***	40.2**	6.6***	65.9***	12.7*	53.2***	78.5**	248.6
Kekem	71.7**	36.9***	6.3**	50.3*	11.6	38. 7*	75.7	238.2
Makenene	73.8*	38.4	6.7	54.5	12.2	42.3	76.6	197.2
Ongot	70.8	35.0	5.1**	43.9	12.2	31.8	71.1**	295.3

Variables: FL = fruit length (mm), FW = fruit width (mm), PT = pulp thickness (mm), FWGT = fruit weight (gm), KWGT = kernel weight (gm), PWGT = pulp weight (gm), P% = pulp percentage, NF = number of fruits.
Significance: * P < 0.05, ** P < 0.01, *** P < 0.001.
Sample size: 50-67 for Boumyebel, 66-73 for Kekem, 48-56 for Makenene, 27-30 for Ongot.

Table 3: Correlations among tree growth traits in four provenances of *Dacryodes edulis* in year two to six.

Boumyebel				**Ongot**			
	Ht2	CD2	CR2		Ht2	CD2	CR2
Ht2	1			Ht2	1		
CD2	0.860**	1		CD2	0.792**	1	
CR2	0.869**	0.835**	1	CR2	0.806**	0.776**	1
	Ht3	CD3	CR3		Ht3	CD3	CR3
Ht3	1			Ht3	1		
CD3	0.899**	1		CD3	0.849**	1	
CR3	0.822**	0.877**	1	CR3	0.784**	0.820**	1
	Ht4	CD4	CR4		Ht4	CD4	CR4
Ht4	1			Ht4	1		
CD4	0.871**	1		CD4	0.748**	1	
CR4	0.633**	0.759**	1	CR4	0.597**	0.829**	1
	Ht5	CD5	CR5		Ht5	CD5	CR5
Ht5	1			Ht5	1		
CD5	0.834**	1		CD5	0.844**	1	
CR5	0.663**	0.827**	1	CR5	0.653**	0.782**	1
	Ht6	CD6	CR6		Ht6	CD6	CR6
Ht6	1			Ht6	1		
CD6	NS	1		CD6	0.825**	1	
CR6	NS	0.712**	1	CR6	0.647**	0.821**	1

(**Table 3** con't)

Makenene				**Kekem**			
	Ht2	CD2	CR2		Ht2	CD2	CR2
Ht2	1			Ht2	1		
CD2	0.234*	1		CD2	0.799**	1	
CR2	NS	0.754**	1	CR2	0.689**	0.758**	1
	Ht3	CD3	CR3		Ht3	CD3	CR3
Ht3	1			Ht3	1		
CD3	NS	1		CD3	0.869**	1	
CR3	NS	0.668**	1	CR3	0.741**	0.770**	1
	Ht4	CD4	CR4		Ht4	CD4	CR4
Ht4	1			Ht4	1		
CD4	NS	1		CD4	0.833**	1	
CR4	NS	0.588**	1	CR4	0.700**	0.776**	1
	Ht5	CD5	CR5		Ht 6	CD6	CR6
Ht5	1			Ht6	1		
CD5	NS	1		CD6	0.584**	1	
CR5	NS	0.713**	1	CR6	0.444**	0.836**	1
	Ht6	CD6	CR6				
Ht6	1						
CD6	NS	1					
CR6	NS	0.737**	1				

Variables: Ht = height, CD = root collar diameter, CR = crown diameter in years 2, 3, 4, 5 and 6.

Significant: * P < 0.05, ** P < 0.01, NS P > 0.05

Sample size: 71-79 for Boumyebel, 130-138 for Kekem, 113-121 for Makenene, 97-105 for Ongot.

Table 4: Correlations among fruit traits in four provenances of *Dacryodes edulis* in year six.

	FL	FW	PT	FWGT	KWGT	PWGT	P %	NF
Boumeyebel								
FL	1							
FW	0.720**	1						
PT	0.760**	0.786**	1					
FWGT	0.852**	0.924**	0.877**	1				
KWGT	0.322**	0.337**	NS	0.330**	1			
PWGT	0.840**	0.913**	0.884**	0.992**	NS	1		
P %	0.769**	0.785**	0.828**	0.815**	NS	0.862**	1	
NF.	NS	-0.307*	NS	NS	NS	-0.262*	-0.374**	1
Kekem								
FL	1							
FW	0.308**	1						
PT	0.433**	0.840**	1					
FWGT	0.660**	0.867**	0.888**	1				
KWGT	0.454**	0.351**	0.436**	0.597**	1			
PWGT	0.639**	0.890**	0.895**	0.986**	0.456**	1		
P %	0.474**	0.699**	0.676**	0.656**	NS	0.756**	1	
NF.	NS	NS	NS	NS	NS	NS	NS	1
Makenene								
FL	1							
FW	0.341**	1						
PT	0.486**	0.761**	1					
FWGT	0.747**	0.760**	0.839**	1				
KWGT	NS	NS	NS	0.264*	1			
PWGT	0.737**	0.798**	0.855**	0.975**	NS	1		
P %	0.468**	0.657**	0.616**	0.551**	-0.601**	0.707**	1	
N F.	NS	NS	NS	NS	0.352**	NS	NS	1
Ongot								
FL	1							
FW	0.640**	1						
PT	0.624**	0.793**	1					
FWGT	0.678**	0.846**	0.702**	1				
KWGT	0.570**	0.551**	0.462**	0.764**	1			
PWGT	0.652**	0.859**	0.711**	0.983**	0.633**	1		
P %	0.373*	0.648**	0.612**	0.612**	NS	0.733**	1	
NF.	NS	NS	NS	NS	NS	NS	NS	1

Variables: FL = fruit length, FW = fruit width, PT = pulp thickness, FWGT = fruit weight, KWGT = kernel weight, PWGT = pulp weight P% = pulp percentage, NF = number of fruits.
Significance: * $P < 0.05$, ** $P < 0.01$, NS $P > 0.05$.
Sample size: 50-67 for Boumyebel, 66-73 for Kekem, 48-56 for Makenene, 27-30 for Ongot.

Table 5: Correlations between tree growth and fruit traits in four provenances of *Dacryodes edulis* in year six.

	FL	FW	PT	FWGT	KWGT	PWGT	P %	NF.
Boumeyebel								
Ht	NS	NS	NS	NS	NS	NS	NS	NS
CD	0.308*	0.280*	0.330**	0.339**	NS	0.330**	0.285*	0.252*
CR	NS	NS	NS	NS	NS	NS	NS	NS
Kekem								
Ht	NS	NS	NS	NS	NS	NS	NS	NS
CD	NS	NS	NS	NS	NS	NS	NS	NS
CR	NS	NS	NS	NS	NS	NS	NS	NS
Makenene								
Ht	NS	-0.289*	NS	NS	NS	NS	NS	NS
CD	0.284*	NS	NS	0.333*	NS	0.292*	NS	0.442**
CR	NS	NS	NS	NS	NS	NS	NS	0.392**
Ongot								
Ht	0.422*	NS	0.354*	0.358*	NS	0.385*	NS	NS
CD	0.535**	NS	NS	NS	0.415*	NS	NS	0.477**
CR	0.343*	NS	NS	NS	NS	NS	-NS	NS

Variables: Ht = height, CD = root collar diameter, CR = crown diameter, FL = fruit length, FW = fruit width, PT = pulp thickness, FWGT = fruit weight, KWGT = kernel weight, PWGT = pulp weight P% = pulp percentage, NF = number of fruits. Significance: * $P < 0.05$, ** $P < 0.01$, NS $P > 0.05$. Sample size: 71-79 for Boumyebel, 130-138 for Kekem, 113-121 for Makenene, 97-105 for Ongot.

Table 6: Juvenile-mature correlations for tree growth traits in four provenances of *Dacryodes edulis* in year two to six.

A. Tree height

Year	2	3	4	5	6
Boumyebel					
2	1				
3	0.956**	1			
4	0.873**	0.904**	1		
5	0.617**	0.588**	0.642**	1	
6	-0.235*	NS	NS	-0.236*	1
Kekem					
2	1				
3	0.818**	1			
4	0.457**	0.611**	1		
5	0.302**	0.420**	0.506**	1	
6	0.304**	0.437**	0.368**	NS	1
Makenene					
2	1				
3	0.933**	1			

4	0.828**	0.898**	1		
5	0.360**	0.418**	0.560**	1	
6	NS	0.230*	0.269**	NS	1
Ongot					
2	1				
3	0.860**	1			
4	0.718**	0.760**	1		
5	0.358**	0.402**	0.622**	1	
6	0.532**	0.492**	0.540**	0.464**	1

B. Root collar diameter

Year	2	3	4	5	6
Boumyebel					
2	1				
3	0.891**	1			
4	0.816**	0.945**	1		
5	0.623**	0.646**	0.650**	1	
6	0.709**	0.740**	0.843**	0.640**	1
Kekem					
2	1				
3	0.834**	1			
4	0.580**	0.627**	1		
6	0.645**	0.710**	0.623**	-	1
Makenene					
2	1				
3	0.906**	1			
4	0.830**	0.912**	1		
5	0.532**	0.589**	0.686**	1	
6	0.665**	0.732**	0.870**	0.671**	1
Ongot					
2	1				
3	0.734**	1			
4	0.661**	0.867**	1		
5	0.237*	0.431**	0.526**	1	
6	0.498**	0.565**	0.655**	0.299**	1

C. Crown diameter

Year	2	3	4	5	6
Boumyebel					
2	1				
3	0.795**	1			
4	0.605**	0.738**	1		

5	0.504**	0.512**	0.547**	1	
6	0.613**	0.582**	0.565**	0.467**	1
Kekem					
2	1				
3	0.699**	1			
4	0.421**	0.662**	1		
5	0.256**	NS	0.226**	1	
6	0.544**	0.649**	0.547**	0.217*	1
Makenene					
2	1				
3	0.709**	1			
4	0.542**	0.768**	1		
5	0.405**	0.551**	0.614**	1	
6	0.558**	0.688**	0.814**	0.644**	1
Ongot					
2	1				
3	0.757**	1			
4	0.595**	0.765**	1		
5	0.239*	0.316**	0.448**	1	
6	0.599**	0.631**	0.684**	0.391**	1

Significance: * $P < 0.05$, ** $P < 0.01$, NS $P > 0.05$. - = data not available. Sample size: 71-79 for Boumyebel, 130-138 for Kekem, 113-121 for Makenene, 97-105 for Ongot.

DISCUSSION

This study investigated methodological approaches for the selection of genotypes from experimental trials of safou in Cameroon for a domestication program. Family variation was insignificant for most fruit traits in two of the four provenances, indicating that family selection in the sixth year would not be very useful for all provenances in this domestication program. The few studies that have been undertaken in safou suggest the presence of continuous tree to tree genetic variation in fruit traits from natural populations (Leakey and Ladipo, 1996; Leakey et al., 2002; Waruhiu et al., 2004; Anegbeh et al., 2005). Phenotypic selection of all families with a few individuals in each family can provide both genetic diversity and gain for the sustainability of the domestication program. This method has been recommended in most tree improvement programs, especially when early turn over and low cost is required.

The positive correlations between growth traits, between fruit traits, and in some cases between growth traits and yield, suggest that selection for one trait could lead to indirect positive responses in the other traits that are positively correlated with the trait under selection. The positive correlations in this trial could have resulted from common environmental effects, pleiotropy (i.e., the traits have common genes) and/or genetic linkage between genes that affects both traits giving linkage disequilibrium (White et al., 2007). Research on correlations between fruit traits of younger and older trees and heritability of fruit traits are needed in order to assess the potential for early selection based on fruit traits.

This is the first time that correlations have been reported in this species, so comparisons can only be made with other perennial species. For example, Sena et al. (1994) reported a positive correlation between nut weight and yield of *Anacardium occidntiale* L; and Atangana et al. (2002)

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found strong positive relationships among fruit weight and dimensions of *Irvingia gabonensis* in Cameroon and Nigeria. In contrast, Leakey et al. (2004) reported weak negative correlations among kernel, fruit and nut length of *I. gabonensis* from Cameroon and Nigeria. In addition, Abasse et al. (2011) found that correlation between fruit and kernel weights differed among natural populations of *Balanites aegyptiaca* (L.) Delile. in Niger: i.e. it was positive, negative or not significant depending on the population.

Positive correlations between growth traits at different ages suggest that early selection based on growth could be effective in this species, assuming of course that the growth traits are moderately heritable (Sotelo Montes et al., 2006; Weber et al., 2011). As others have reported (Lambeth, 1980; Riemenschneider, 1988; Matheson et al., 1994), correlations were generally stronger between two consecutive years (e.g. year 2 and 3) and weakest between the first and the last measurement year.

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