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Domestication of *Irvingia gabonensis*: 2. The selection of multiple traits for potential cultivars from Cameroon and Nigeria.

A.R. Atangana[1], V. Ukafor[2], P. Anegbeh[3], E. Asaah[1], Z. Tchoundjeu[1], J.-M. Fondoun[4], M. Ndoumbe[4] and R.R.B. Leakey[5,6,*]

*[1]IRAD/ICRAF Project, International Centre for Research in Agroforestry, B.P. 2067, Yaoundé, Cameroon; [2]Rivers State University of Science and Technology, P.M.B. 5080, Port Harcourt, Rivers State, Nigeria; [3]International Centre for Research in Agroforestry (ICRAF/IITA Onne), PMB 008, Nchia-Eleme, Port Harcourt, Rivers State, Nigeria; [4]Institut de la Recherche Agricole pour le Développement (IRAD), B.P. 2067, Yaoundé, Cameroon; [5]Centre for Ecology and Hydrology (CEH), Bush Estate, Penicuik, Midlothian, EH26 0QB, Scotland, UK; [6]current address: Agroforestry and Novel Crops Unit, School of Tropical Biology, James Cook University, Cairns, Queensland 4870, Australia; *Author for correspondence (e-mail: roger.@jcu.edu.au)*

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Abstract

Ten fruit and kernel traits were assessed in 24 fruits of each of 152 *Irvingia gabonensis* trees in three distinct populations in west and central Africa [2 populations of non-planted trees in Cameroon: Nko'ovos II (21 trees) and Elig-Nkouma (31 trees) and 1 population of planted trees in Nigeria: Ugwuaji (100 trees)]. Strong relationships were found between fruit weight and other fruit traits (e.g. flesh weight [$r^2 = 0.99$: $P < 0.001$], fruit length [$r^2 = 0.74$–0.83: $P < 0.001$], fruit width [$r^2 = 0.77$–0.88: $P < 0.001$]). In contrast, relationships between kernel weight and other kernel/nut traits (e.g. shell weight and nut weight) were found to be weak [$r^2 = 0.009$–0.37, $P = 0.058$–0.001], with the exception of nut weight at Nko'ovos II ($r^2 = 0.65$, $P < 0.001$). Relationships between fruit and kernel traits (fruit mass *v.* kernel mass, fruit mass *v.* shell mass, flesh mass *v.* kernel mass, nut mass *v.* fruit mass and flesh depth *v.* kernel mass) were found to be very weak. This indicates that domestication through the selection and vegetative propagation of multiple-trait superior phenotypes is unlikely to be able to combine good fruit characteristics and good kernel characteristics within cultivars. Consequently, domestication activities should independently focus on ideotypes representing: 'fresh fruit' traits, and 'kernel' traits, that combine high values of the different fruit and kernel characteristics respectively. Evidence from this study indicates that selection of the three trees closest to the fruit ideotype per village as the mother plants for vegetative propagation and cultivar development, should give village level gains of 1.3 – 2-fold in fruit mass, and up to 1.5-fold in taste. Similarly for the kernel ideotype, selection of the three trees with the best fit would give potential gains in kernel mass of 1.4 – 1.6-fold.

Introduction

Domestication of indigenous fruit trees within agroforestry practices offers important 'Win-Win' opportunities for the transformation of land use in Africa (Sanchez and Leakey (1997); Leakey (2001a, 2001b)). Consequently, the International Centre for Research in Agroforestry (ICRAF) and its partners have launched an Agroforestry Tree Domestication Programme (Leakey and Simons (1998)). This programme is based on the vegetative propagation of trees identified as 'elite-trees' by collaborating farmers developing nurseries at the village level (Tchoundjeu et al. 1998). To be successful, tree domestication should provide farmers with both food security and opportunities for cash generation.

Irvingia gabonensis (Aubry Lecomte ex O'Rorke) (Bush mango/Dika nut) is an indigenous tree of west

Table 1. Location of *Irvingia gabonensis* populations used in this study

	Elig-Nkouma (Cameroon)	Nko'ovos II (Cameroon)	Ugwuaji (Nigeria)
Latitude (°N)	4° 07′	2° 56′	6°25′
Longitude (°E)	11°24′	11° 21′	7°32′
Altitude (m)	461	610	175
No. of trees collected	31	21	100

and central Africa, found from Nigeria to Congo, which produces commercially important non-timber forest products. Okafor (1975) identified two varieties, *I. gabonensis* var. *gabonensis* and *I. gabonensis* var. *excelsa*. These were recently named *Irvingia gabonensis* and *Irvingia wombulu* respectively, by Harris (1996). The main widely consumed products from *I. gabonensis* are kernels (Ndjouenkeu et al. 1996; Ndoye et al. 1997) and fresh fruit. In a recent survey of farmer's species priorities for agroforestry, *I. gabonensis* was identified as the top priority species for domestication in the humid lowlands of West Africa (Franzel et al. 1996). Leakey (1999) reviewed the nutritional and the commercial values of *I. gabonensis* fruits and kernels.

Prior to this study, phenotypic variation in fruit traits in *I. gabonensis* has only been descriptive (Ladipo et al. 1996). However, recently, within a project to examine the biophysical and socio-economic constraints to domestication in indigenous fruits Atangana (2000) and Ukafor (2001) have quantified the morphological variability of fruit and kernel traits in Cameroon and Nigeria respectively. In addition, kernels from these studies are being analysed for variation in their food-thickening properties and fat content. Together, these studies are indicating that in *I. gabonensis* there is considerable opportunity for the selection of elite trees for multiplication as cultivars (Atangana et al. 2001), using air layering, grafting or cuttings (Shiembo et al. 1996). Recent studies in *I. gabonensis* indicate that the best approach may be the selection of ideotypes that express desirable combinations of traits for either fresh fruit or for kernel production (Leakey et al. (2000)). The present study examines in more detail the opportunities for multiple trait selection, which can also take into account the different preferences of men and women, even within a village (Mbosso 1999), as well as the preferences of farmers from different villages. A future paper will examine the extent to which the trees in this study have been subjected to genetic selection (Leakey et al. 2001).

Methods and materials

The study was conducted in two villages in Cameroon and one in Nigeria (Table 1). These sites were separated by 100–350 km and hence are clearly different populations. The use of three geographically distinct sites should reduce the chance of finding correlated traits that may be due to random non-general associations that can occur in a single isolated population. Two of the sites (Nko'ovos II in Cameroon and Ugwuaji in Nigeria) were in fact within the two genetic diversity hotspots identified by Lowe et al. (2000), using DNA markers. These sites were also genetically distinct. The *I. gabonensis* trees occurred naturally on the farms in Cameroon (Atangana 2000), but were planted in home gardens in Nigeria Ukafor (2001). Twenty-four fruits were collected from each tree as they ripened over the fruiting season (May–August) in 1999 as described by Atangana et al. (2001).

The 24 collected fruits were weighed fresh in the villages using small portable kitchen scales graduated to 2 g. They were then measured (length and width) using calipers graduated to 0.1 mm. A spike attached to the same caliper was used to measure fruit flesh (mesocarp) depth in fruit thickness dimension. After the measurements, 2–3 fruits per tree were assessed for taste (scored 1 [bitter] – 5 [sweet]) and for fibrosity (scored 1 [non-fibrous] – 5 [fibrous]). At the same time, skin and flesh colours were assessed using the Methuen Code of Colour (Kornerup and Wanscher (1978)). Fruits were then taken to the laboratory for depulping. The washed nuts (endocarp and cotyledons – see Figure 1) were then dried in the sun for 2–3 days and weighed using an electronic balance (Mettler Toledo PB 3002). The kernels were stored for chemical analysis. Since the ease with which nuts can be cracked to allow kernel extraction is seen as an important trait, shell weight was derived (fruit mass − nut mass).

Data were collated using Microsoft Excel 97. Statistical analyses were done using Genstat 5 (3.2). This study particularly examined the relationships between