Fruits for the Future 7

Ndjanssang

Ricinodendron heudelotii

Z. Tchoundjeu and A. Atangana

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Ndjanssang
Ricinodendron heudelotii (Baill.)

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The International Centre for Underutilised Crops (ICUC) is an autonomous, non-profit, scientific research and training centre. It was established in 1992, based at the University of Southampton in the UK, but has since moved to the headquarters of the International Water Management Institute, Sri Lanka. The Centre was established to address ways to increase the use of underutilised crops for food, nutrition, medicinal and industrial products. The enhancement of currently underutilised crops is a key to food security, to the conservation of biological diversity and to the preservation and restoration of fragile and degraded environments throughout the world.

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The World Agroforestry Centre (ICRAF), established in Nairobi in 1977, is an autonomous, non-profit research body supported by the Consultative Group on International Agricultural Research (CGIAR). ICRAF aims to improve human welfare by alleviating poverty, improving food and nutrition security and enhancing environmental resistance in the tropics.

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Table of Contents

List of Tables

List of Figures

List of Plates

Preface

Trees that produce edible fruits or seeds are important in tropical regions because they supplement and improve the quality of diets. Only a limited number have been fully domesticated and improved through selection and breeding, although a large number have been widely used and traded by local populations.

Many of the latter species are considered incipient domesticates and they remain genetically wild, even through they are protected by rural people, often around homesteads and their cultivated fields.

With limited resources for plant breeding in developing countries, many of the species considered to have potential for focused and relatively rapid improvement do not receive the attention they deserve. Plant breeders have little choice other than to place their limited resources on improving field crops.

Taking this into account, the International Centre for Underutilised Crops has developed a series of priority species on which it is felt more effort would be justified, because it would produce results in generating incomes, alleviating poverty and providing more balanced diets.

In the case of woody fruits of the tropical and subtropical regions, there are a number of these priority species considered as components of land use systems, where they can help to stabilise environments in agroforestry systems. *Ricinodendron heudelotii* is a prime example, and this monograph attempts to summarise what is currently known about the species.

The preparation and publication of this monograph has been funded by the Department for International Development (DFID), UK, as part of a project entitled “Fruits for the Future”.

The International Centre for Research in Agroforestry (ICRAF) is a partner organisation in this endeavour, as are numerous national programmes. This book is the 6th in a series of monographs; a parallel series of extension manuals is being issued.

For ndjanssang (and the related species known as mongongo or manketti), demand for seed kernels well outstrips supply, and if attention were given to marketing and trade, the species would have an assured place in rural development in Africa.

It will be noted that there are many gaps in our knowledge, and more basic as well as applied research needs to be carried out. It is hoped that making this monograph available to teachers, students, extensionists, policy makers, growers and others will promote further production and marketing, and will stimulate scientists to address some of the knowledge gaps.

We are grateful to Dr Zac Tchoundjeu and Alain Rene Atangana who produced the manuscript, and to Miss Rosemary Wise for the illustration of the plant; also to Dr N. Haq, Director ICUC, Miss Angela Hughes and Mr Berekhet Berakhy, former staff members of ICUC, for their efforts in seeing the manuscript through to finalisation. We thank Mr John Pratt for his review of the manuscript and helpful comments.

Editors 2005

Chapter 1. Taxonomy

1.1 Introduction

Ricinodendron heudelotti (Baill.) Pierre ex Pax. is a fast-growing tree, which produces edible seeds, traditionally used in many countries of Africa. It is called the ndjanssang tree and belongs to the family Euphorbiaceae.

The Euphorbiaceae is the largest family of the order Euphorbiales. The family contains over 300 genera and maybe over 7000 species. Not surprisingly, with so many species, many of them are of economic importance. They include rubber (*Hevea*), cassava (*Manihot esculenta* Crantz.), tung oil tree and related species (*Aleurites*), castor bean (*Ricinus communis* L.), purging nut (*Jatropha spathulata* Müll.-Arg.), and purging croton (*Croton tiglium* L.), all of which have been domesticated. In addition numerous other species are used by humans but are not truly domesticated. These latter include many medicinal plants, such as species of *Euphorbia*, *Hura*, *Pedilanthus* and *Phyllanthus*, and species for multipurpose uses, e.g. several species of *Jatropha* and *Schinziophyton rautanenii* Schinz.

The family shows wide diversity of plant forms, ranging from shrubs, trees and lianas to herbs or cactus-like succulents. All species accord with the characters of the order Euphorbiales in that they possess flowers, often in tight clusters, surrounded by bracts, and the group of flowers with their bracts superficially look like a flower itself. Nearly all species contain latex in special lacticiferous cells.

1.2 The family Euphorbiaceae and its divisions

1.2.1 Description of the flowers and fruit

Flowers are usually small or very small, unisexual, monoecious or dioecious, and usually regular. The perianth is occasionally absent in one or both sexes, simple, valvate or imbricate, calycine, rarely petaloid; or double, both outer and inner calycine and imbricate, or the inner petaloid and imbricate; rarely subvalvate, longer or shorter than the outer. Stamens are one to indefinite, free or united in various ways; filaments are free or connate; anthers are 2-(rarely 3–4)-celled; cells are usually parallel, adnate to the connective throughout, or free except at base or apex; erect, divaricated or suspended, rarely superposed; dehiscence is usually longitudinal, and rarely porous (Thiselton-Dyer, 1913). A rudimentary ovary may be present in male flowers. Females are flowers with sessile ovary, rarely shortly stipate. Gynoecium is usually tripartite (occasionally 2 or 4), with axile placentae and 3 loculi. Styles are usually as many as and continuous with the carpels, free or less connate, usually 2-lobed, with the inner face usually stigmatic. Ovules are similar throughout the family and are a characteristic feature: there are 1 or 2 in each loculus, they are pendulous from the inner angle, and the funicle is often thickened.

Fruits are usually capsular with 2-valved cocci separating from a persistent axis; or indehiscent and drupaceous, 1–3-celled; or 1, 2, or 3 connate nuts.

1.2.2 Tribe Crotoneae

Thiselton-Deyer (1913) classified the Euphorbiaceae into 5 tribes and *Ricinodendron* belongs to tribe Crotoneae.

Members of the tribe are characterised as follows. Sepals are usually small, closed or valvate or imbricate in bud, very rarely petaloid. Petals when present are free or connate, often longer than the sepals. Stamens are 1–2-seriate, the outer alternate with the sepals, or more usually central, and few to very many. Ovules are solitary in each cell. Cotyledons are much broader than the radicle. Inflorescence is various, often racemose or spicate or paniculate.

1.2.3 Alternative classification

Webster (1975) rearranged the Euphorbiaceae on the basis of embryology. He retained 5 tribes and *Ricinodendron* belongs in his system to Crotonoideae. It is to be expected that within-family taxa will receive different treatments when phylogenetically this large family appears to be made up of groups of genera derived from various different stocks that had bisexual flowers.

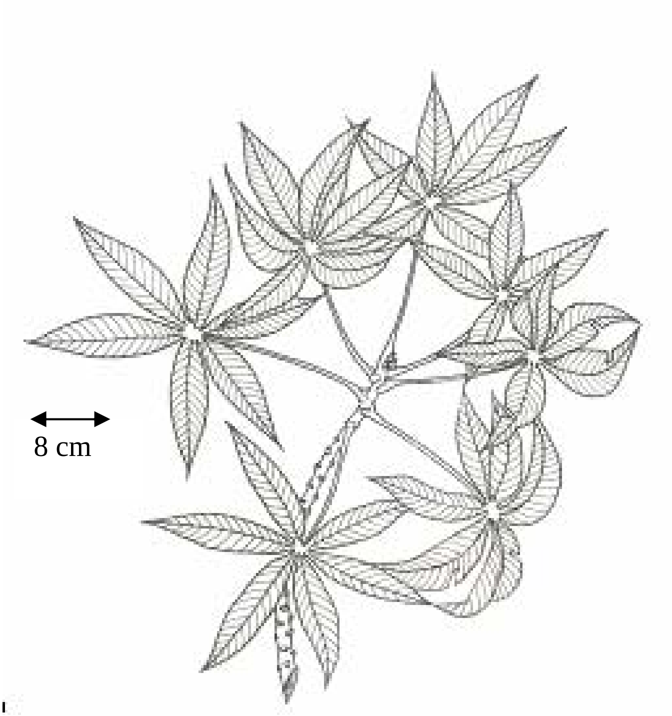
1.3 Genus *Ricinodendron*

The genus is now thought to be monotypic, containing only *R. heudelotii*.

1.3.1 Description of ndjanssang

(See also Figs. 1.1 and 1.2)

Ndjanssang is a large, deciduous, fast-growing tree averaging 20–30 m in height but being able to reach 50 m. The trunk averages 1.5–2.7 m diameter. The trunk is straight but the base is thicker due to short buttresses with big running roots (Vivien and Faure, 1985). Young trees have whorled branches, which arch upwards. The broad, spreading crown is candelabra-like, and broken branches can commonly be seen in the crown (Savill and Fox, 1967). Branches are often stubby and contorted. Branches are densely brown, hairy when young, and about 1 cm thick. The slash bark is red, densely mottled with scattered pits; the smooth bark is bright grey, becoming scale-like with age. The wood is white or pale yellow, darkening on exposure, and is very soft (Vivien and Faure, 1985).



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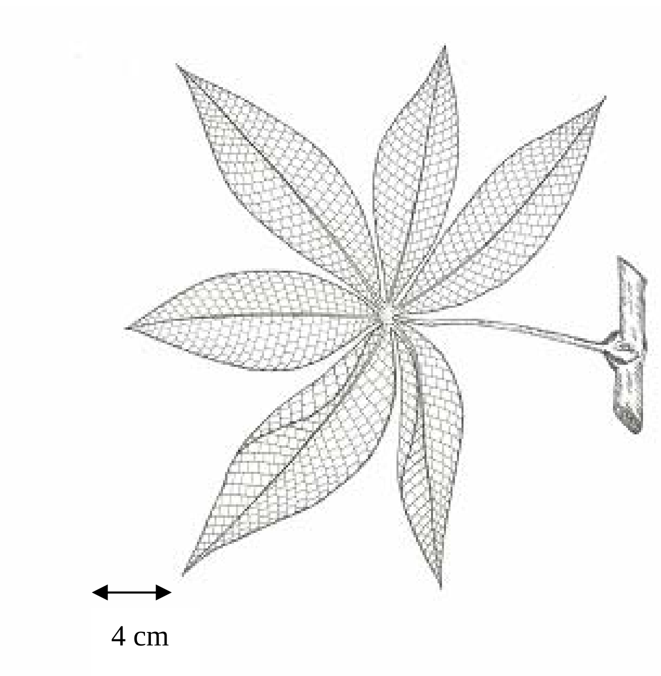

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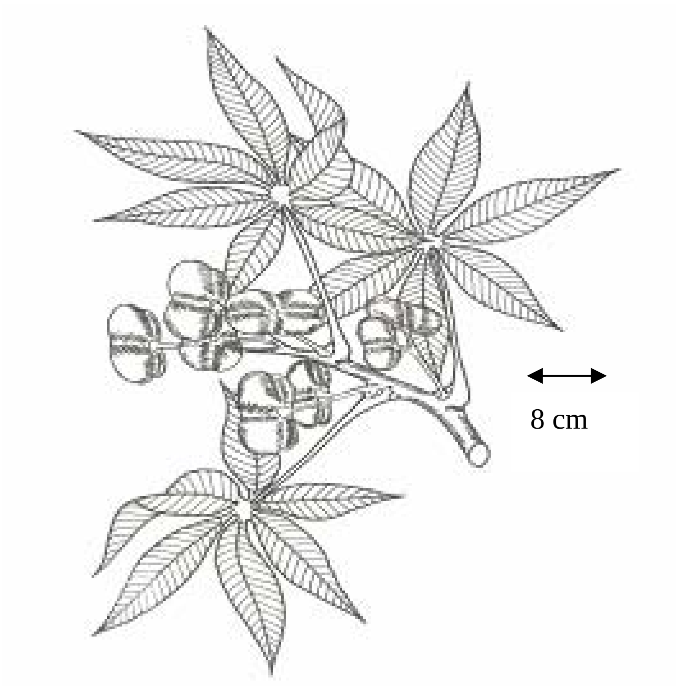

C

Figure 1.1. Leaves and leaflets of Ndjanssang:
A- Branch showing arrangement of leaves on stem.
B- Detail of leaf showing leaflet venation and stipules.
C- Stem containing mature fruits.

1.3.1.1 Leaves

The leaves are alternate and each leaf is divided into leaflets arranged digitately. The leaflets are elliptic from (6–)10 to 15(–20) cm long and (2.5–)3 to 10(–12) cm broad at the middle, with bases lengthily attenuated at the top of the petiole. Leaflet tips are acute and acuminate. In young leaves, the leaflets may be sessile or subsessile, or united at the base, so that the lamina is simply digitately lobed, with 3 to 6 lobes, sometimes 7.

There are generally (10–)12 to 15(–16) pairs of side veins per leaflet. Leaf margins possess small glands, as regular small projections. Young leaflets are covered with very fine spangled hairs, which can disappear when adult.

The petioles are 5 to 15(–20) cm long and two lateral glands can be found at the top. Stipules are toothed, leafy and persistent, and clasp the stem.

1.3.1.2 Inflorescence and flowers

The species is dioecious with flowers in a terminal panicle, the panicle becoming long and broad, 15 to 30(–40) cm long. The flowers are small and yellowish-white, of 4–5 mm in length. Flowering takes place in April and May. Male panicles tend to be larger and more slender (up to 40 cm long) than the female ones, which are somewhat condensed. The ramifications of the panicle are covered with dense spangled hairs. Male flowers have 5 sepals, with a 5-lobed corolla tube and 10 stamens. Female flowers have a stellate tomentose ovary with 2 styles, which are slender and bipartite.

1.3.1.3 Fruits

Fruiting occurs in September and October. The fruit is an indehiscent yellow-green capsule somewhat plum-like (2–)3.5 to 5 cm long and 2.5 to 4 cm wide (Ngo Mpeck *et al.*, 2003), and is generally spherical, with (1), 2 (or 3) seeded lobes (Fondoun *et al.*, 1999; Ngo Mpeck *et al.*, 2003). They weigh 19–47 g, and have a hard indehiscent, thin shell, although some fruits have been reported to be self-cracking (Ngo Mpeck *et al.*, 2003). The fruits smell of over-ripe apples. Young fruit is covered with fine hairs on the outer green skin; this turns brown on maturity.

1.3.1.4 Seeds

Each seed is reddish brown-black and usually consists of a testa with a yellow kernel inside. Inside the fruit shell is a soft spongy pulp layer making up about 20% of the fresh fruit, 10% being the fruit skin. Seeds make up the rest (Ngo Mpeck *et al.*, 2003). Five different types of seed numbers are known: single-seeded fruit with an aborted lobe; two-seeded fruit with two lobes; three-seeded fruit with three lobes; single-seeded fruit; and two- seeded fruit with unequally developed lobes (Fondoun *et al.*, 1999).

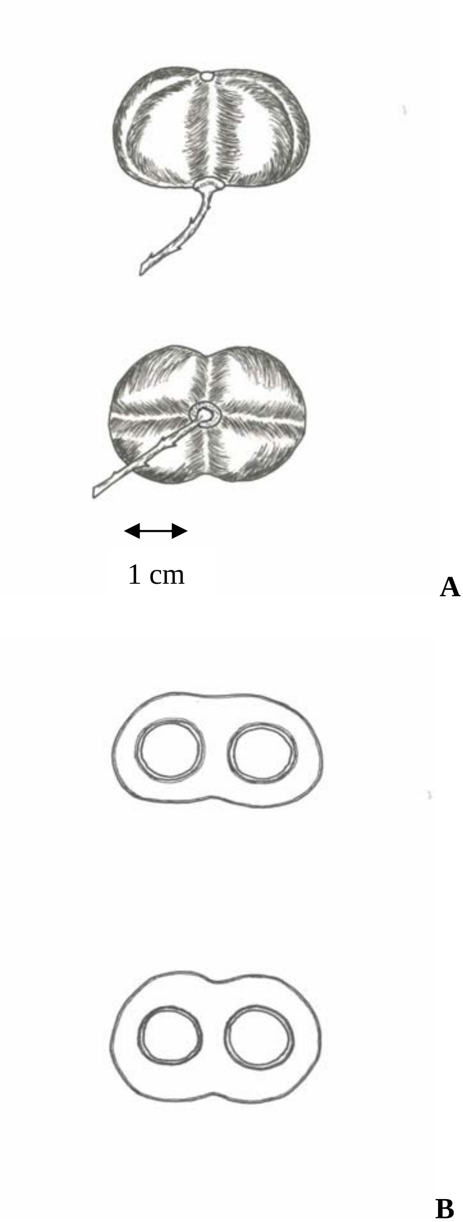

Figure 1.2. Mature fruits of Ndjanssang (2-seeded lobes):
A- Whole fruit.
B- Vertical section through mature fruits to show seed arrangement.

1.3.2 Nomenclature of *R. heudelotii*

Ricinodendron heudelotii (Baill.) Pierre ex Pax

1.3.2.1 Synonyms

Ricinodendron heudelotii (Baill.) Pierre ex Heckel
R. africanum Müll.-Arg.
R. gracilis Mildr. subsp. *heudelotii*
R. schliebenii Mildr.
R. tomentellum Hutch. and Bruce
Jatropha heudelotii Baill.
J. mahafalensis Jum. (see Heim *et al.*, 1919, and Maheu and Hussan, 1920)
Barrettia umbrosa Sim

1.3.2.2 Infraspecific taxa

Some authors believe there are two varieties: var. *heudelotii*, particularly centred on Ghana, and var. *africanum* particularly centred on Nigeria and westwards in other areas (ICRAF, 2004).

Other authors describe two subspecies: subsp. *heudelotii* and subsp. a*fricanum* (Müll-Arg.) J. Leonard. Subspecies *africanum* is further divided into two varieties:

> Var. *africanum*: leaflets subglabrous or densely stellate – tomentose on lower surface at first but becoming glabrescent.
>
> Var. *tomentellum*: leaflets densely fulvous stellate – tomentose on lower surface and persisting.

It is thought subsp. *africanum* extends from S. Nigeria eastwards through Sudan, Uganda, Tanzania, and Angola to Mozambique; and subspecies *heudelotii* extends from Guinea-Bissau to Ghana. Subspecies *heudelotii* has 3–5 leaflets per leaf, whereas *africanum* has (3–)5 to 7(–8), and respectively there are 3-locular ovaries and fruits and 2(3)-locular ovaries and fruits. For detailed descriptions of originally described taxa see Pieraerts (1917) and Berhaut (1975).

All forms of the species are found in drier forests, particularly secondary regrowth forests, usually in seasonal dry lands. It thrives as a successful coloniser of grasslands where farming has been abandoned.

According to past records, the nuts were wild-harvested and traded in local markets in two major areas of Cameroon and neighbouring places, and in Zaire, where it was a staple of forest people.

1.3.3 Other related species

R. rautanenii Schinz was originally included in the genus with *R. heudelotii*. This species is now referred to as *Schinziophyton rautanenii* (Schinz) Radl. Sm. In areas where the two species overlap, in southern Africa, there is some confusion about which species is meant. *S. rautanenii* is commonly referred to as the mongongo/manketti nut tree. It has a large straight trunk up to (9–)15(–18) m with a broad spreading crown. It has dark green digital leaves of 5 to 7 ovate to elliptical leaflets at the end of a petiole up to 5 cm long (www.natural/natural_good_guide_nuts_uncommon_Ricinodendron_rautanenii.htm). The branches are stubby and contorted, the bark grey and reticulate, and there are separate male and female trees. The species is native to Angola, Botswana, Democratic Republic of Congo, Malawi, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe. The species has been introduced in Israel and Australia and it produces edible kernels.

Another species was once described as *R. staudtii*, but this was based on a mixture of two other species on a herbarium sheet (Pax and Hoffman, 1911) and can be discounted.

1.4 Common names

In English the species is referred to as African nut tree, African wood-oil nut tree, Zambezi almond or Zambezi corkwood, but its promotion in Cameroon is leading to the adoption of the Bakweri name, ndjansanga. However, in Southern Africa the common name is more frequently mongongo or manketti, which can refer to *R. heudelotii* or to *S. rautanenii*.

Table 1.1. Local names of *R. heudelotii*

Country	Ethnic group	Local name
Angola		Munguella
Benin		Ookwe or Okwen
Cameroon	Bakweri	Ndjansanga
	Banka	Njansang
	Bassa	Njansang
	Bibaya	Gobo
	Bobilis	Ezol
	Boulou	Ezezang
	Douala	Nyansang
	Ewondo	Ezezang
	Ntumu	Ezang
	Maka	Zouol
Central Africa Republic		Musodo
Congo		Sanga-sanga
Democratic Republic of Congo		Bofeko
East Africa	Swahili	Muawa
Equatorial Guinea		Nsezang
Gabon	Fang	Essessang
Ghana		Asoma, Ekpedi, Wama, Okukurudu
Ivory Coast		Eho
Madagascar		Betrata
Nigeria	Igbo	Okwe
	Yoruba	Erinmado
	Hausa	Wawanputu kurmi
	Edo	Okhuen
	Urhobo	Eke
	Ijaw	Okengbo
	Itsekiri	Okue
Senegal	Diola	Bu mankurẽg, bu mankurèn, bu kẽnkaré
	Mandingue	Bon kuõforo
Sierra Leone	Mende	Gbolei, Kpolei
	Temne	Ka-Kino, Ka-Sigboro

	Kisi	Gbo, Kpo
	Kono	Gboe, Gbwoye
	Koranko	Gbore
Southern Africa	Afrikaans	Wild okkerneut
	Herero	Manketti, mongongo
	Kung	Mongongo
	Kwangali	Ngongo
	Lozi	Mungongo
	Shona	Mungongoma
	Tswana	Mongongo, mugonga
Tanzania	Kitongwe	Sitobaga
	Luguru	Mkungunolo
	Mwera	Mkangaula
	Ngindo	Nnjunju
	Nguu	Mtondoro
	Sambaa	Mtondoro
	Swahili	Muawa, Maua
	Zigua	Mtwatwa
Uganda		Kishongo

Source: Berhaut (1975), Fondoun *et al.* (1999), Muasya *et al.* (2000), Richter and Dallwitz (2000), Vivien and Faure (1985), Heim *et al.* (1919), Nishida and Uehara (1981), Savill and Fox (1967), Ruffo *et al.* (2002), and http://www.naturalhub.com/naturalfoodguidenuts(2003)

Chapter 2. Distribution

2.1 Distribution of the genus

The genus is endemic to tropical Africa (Good, 1964; ICRAF, 2004). The area where it is endemic is shown in Figure 2.1. ndjanssang occurs throughout this area.

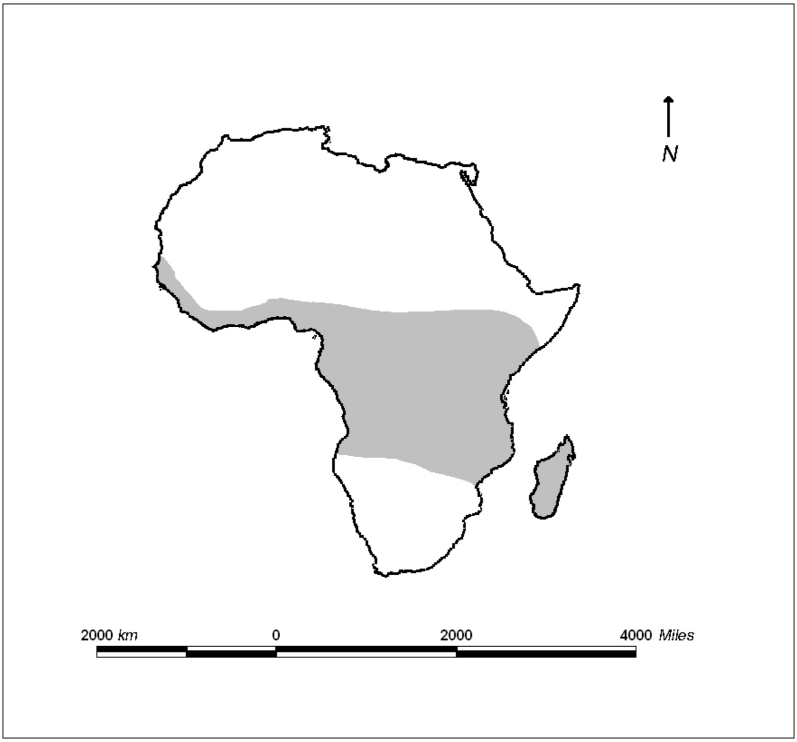

Figure 2.1. Distribution of ndjanssang

2.2 Distribution of ndjanssang

The species is found in central, western and southern Africa in Senegal, Guinea Conakry, Sierra Leone, Liberia, Ivory Coast, Ghana, Benin, Nigeria, Fernando Po, Cameroon, Central African Republic, Sudan, Gabon, Congo, Democratic Republic of the Congo, Uganda, Kenya, Angola, Zambia, Tanzania and Madagascar.

2.2.1 Occurrence within countries

Ndjanssang occurs generally in rain forests but is typical of secondary forests. Due to forest fragmentation, it has typically become a species of the fringing, deciduous and secondary forests common throughout the semi-dry, wooded savannah zone, where it is scattered in gaps at forest edges and in secondary scrub and thickets (ICRAF 2004).

The species is absent in older forest in Sierra Leone and is gregarious in older farm bush (Savill and Fox, 1967). In Nigeria, it is found in drier forests, and especially secondary regrowth (Keay, 1989) as well as in humid forest and transition zones to savannah (Anigbogu, 1996). In Tanzania, it is found in evergreen forests and secondary associations between 100–1200 m above sea level, and is common in gaps. Shaka *et al.* (1997) reported the species to be in the Semdoe forest of Tanzania. However, in the Mahale Mountains near Lake Tanganyika, the species has been recorded at high altitudes at more than 1600 m above sea level (Nishida and Uehara, 1981). In Democratic Republic of Congo, it occurs in secondary forests (http://clug.euronet.be/luc.pauwels/Habitata.pdf). In Senegal, *R. heudelotii* is found in mid-humid forests of low Casamance (Berhaut, 1975). In Cameroon it grows in secondary forests (Vivien and Faure, 1985) at altitudes ranging from 130 to 1030 m above sea level (Fondoun *et al.*, 1998). It is distributed especially in the forest zone (southern Cameroon), excepting mountain forests. No fruits were observed on trees at altitudes less than 130 m along the Cameroon coast (Fondoun *et al.*, 1999). It is also found on the plateaux of Uganda (1200 m and more above sea level).

2.2.2 Distribution of morphological variants

Three named morphological varieties are distributed in tropical Africa as follows:

> Var. *africanum* extends from southern Nigeria to Uganda, Sudan, Tanzania, Angola, Mozambique and Madagascar through Cameroon, Gabon, Equatorial Guinea, Central African Republic, Congo, Democratic Republic of Congo, Zambia (Ruffo *et al.*, 2002; Pax and Hoffman, 1911).
>
> Var. *tomentellum* is distributed in the eastern coastal zone of Kenya and Tanzania (Pax and Hoffman, 1911).
>
> Var. *heudelotii* occurs in Western Tropical Africa (Ghana, Ivory Coast, Guinea, Bissau-Guinea, Liberia, Sierra Leone, and certainly Togo and Cameroon).

2.2.3 Distribution in anthropogenic areas

Bush fallows, cacao (*Theobroma cacao*) plantations, home gardens and crop fields are common habitats of the species (Fondoun *et al.*, 1999), where it is used as a soil fertility improving species. This means the species is an incipient domesticate with great potential for further utilisation.

2.3 Distribution of *S. rautanenii*

Mongongo is found in southern Africa in Angola, Namibia, Botswana, Malawi, Mozambique, South Africa, Zambia, Zimbabwe and southern parts of the Democratic Republic of the Congo (Storrs, 1979).

The species' distributions overlap in Angola, Zambia, and Democratic Republic of the Congo.

Chapter 3. Production Areas

Despite the fact that ndjanssang is undomesticated, gathering, transportation and marketing systems have developed in several areas of tropical Africa. However, the system developed in Cameroon dominates all others.

3.1 The Cameroon production to consumption system

The humid forest zone of Cameroon is the main production area of ndjanssang, and it is traded to neighbouring countries Central African Repiblic, Gabon, Equatorial Guinea and Nigeria (Ndoye *et al.*, 1998), areas of Central Africa, and also to Europe (Sunderland and Obama, 1999; Tabuna, 1999). In 1995, a survey of markets showed that 35,952 kg of ndjanssang kernels were marketed in the humid forest zone of Cameroon, for a total value of 43,432,200 CFA, about US$ 78967 (Ndoye and Ruiz Pérez, 1997).

Lekie (central) and Manyu (south-west) are the largest production areas (Tchoundjeu, pers. obs.). This could be due to market incentives. For instance, Manyu Division is close to Nigeria, which is a large continuing market for ndjanssang. Lekie Division is the principal provider for agricultural products for Yaounde, the capital city.

Supply and demand has stimulated incipient domestication. In Manyu Division more than 66% of farmers have trees on their farms (31% on cacao farms and 33.6% on arable fields), whereas in Lekie Division 90% of farmers have trees on their farms (60% on cacao farms and 81.5% on arable farms) (Tchoundjeu, pers. obs.).

This incipient domestication has taken account of years of abundance and scarcity due to trees bearing fruit usually one year in every two or three.

3.2 Minor production areas

Ndjanssang kernels are also gathered in the rest of the humid forest zone of Cameroon and there is also local traditional gathering scattered through other parts of the distribution of the species.

Chapter 4. Ecology

4.1 Climate

The species grows wild in the tropical zone of Africa, characterised by an equatorial hot and humid climate. There are two rainy seasons per year or one long rainy season with a brief slackening, and two dry seasons (one hot dry season and one cool short dry season).

The rainy seasons vary between areas north and south of the equator and between countries. In Tanzania, the long rainy season occurs from mid-March through May and the short one during November. In Kenya, Cameroon (inland rainforest zone), Ivory Coast (Abidjan) and Ghana (south) the long rains occur later from April to June-July and the shorter rains in October-November. However, in Cameroon the rains are heavier in October. In all these countries, the coolest months are July-August. In Uganda, the Southern region has two rainy seasons beginning in early April and October, with little rainfall in June and December.

In Angola, the rainy season extends from September to April, with a brief slackening in January or February, while in Central African Republic it extends from April to October with a break in August (the coolest month). In Zambia, the main rainy season extends from the end of October to March, with a later one in April-May; dry season covers May-August.

4.1.1 Total rainfall

Ndjanssang grows in areas that receive a wide range of annual rainfall totals, from 1000 mm to over 3000 mm per year. At the lower end can be cited Uganda at 1000 mm, Yambio in Sudan at 1142 mm, and Kenya and Southern Togo at 1300 mm. At the higher end can be cited 3000 mm in Madagascar (east coast) or Cameroon (west coast). Many areas of West Africa experience 1500–2500 mm per year.

Ndjanssang trees lose all their leaves in the dry season (Mapongmetsem *et al.*, 1998). In Cameroon, this is November-March.

The fact that ndjanssang can grow under a wide range of annual rainfalls indicates the potential of the species in a wide range of environments.

4.1.2 Temperatures

The tree grows under a mean annual temperature ranging from 18º to 32ºC. It thrives in regions where the temperatures of the cooler months range from 18º to 23ºC and those of the hot months from 30º to 32ºC.

4.1.3 Light requirements

It has been recorded that regeneration from seeds is sparse under dense canopies (Vivien and Faure, 1985), and also that light enhances germination (Fondoun *et al.*, 1999). It was found to grow as a pioneer tree in the Gambari Forest Reserve in Nigeria by Riddoch *et al.* (1991). The tree is a light- demanding tree, and in areas where it has been preserved, e.g. on farmlands, it is fast growing, requiring no shading.

4.1.4 Wind

The tree is not resistant to strong winds, and branches usually break when there are strong winds. This characteristic makes seed collection by climbing potentially dangerous. In contrast with other fruit trees such as *Irvingia gabonensis*, bush mango, of value for its fruits and for its high quality timber, ndjanssang timber is a porous wood.

4.2 Soils

Ndjanssang grows best on medium textured and freely draining acidic soils. In Cameroon, it is found in areas where soil types are ultisols and oxisols (Ayuk *et al.*, 1999). The pH is usually 5–6. The cation exchange capacity is low and there is >40% aluminium saturation (Ayuk *et al.*, 1999).

4.3 Physiography

The species is a fast-growing, light-demanding tree and is a good coloniser of areas where farming has been abandoned. Hence, it is most widespread in fallows and secondary forests. The species is also found in deciduous lowland forests and wooded savannas, mid-humid forests (Berhaut, 1975), and mountain forests such as the Mahale Mountains of Tanzania.

In Cameroon, during land clearing for crop establishment farmers spare trees of the species and protect them so they appear in arable fields, cacao farms and home gardens (Fondoun *et al.*, 1999). In home gardens, the species is associated with banana, maize, African plum, *Irvingia gabonensis, Cola* spp., and many others (Tchatat, 1996).

When found in rainforest, it tends to be in association with forest trees as *Alstonia boonei*, *Pycnanthus angolensis, Triplochiton scleroxylon, Milicia excelsia, Ceiba pentandra, Terminalia superba, Cordia platythyrsa and Ficus exasperata* (Mapongmetsem *et al.*, 1999; Opoku *et al.*, 2002) in Cameroon and Ghana. In Nigeria in the Gambari Forest Reserve, ndjanssang has been found growing with other pioneer species *Ceiba pentandra, Pterygota macrocarpa, Milicia excelsa* and *Sterculia rhinopetala,* and the climax species *Blighia sapida* and *Strombosia pustulata* (Riddoch *et al*., 1991). In Cameroon, in evergreen forests there are high numbers of species of Caesalpiniaceae, and in deciduous forests there are high numbers of species of Sterculiaceae and Ulmaceae (Letouzey, 1958; 1968 and 1985).

Plate 1. Fruits of ndjanssang.

Plate 2. Fruits and leaves.

Plate 3. Ndjanssang cuttings in a non-mist propagator.

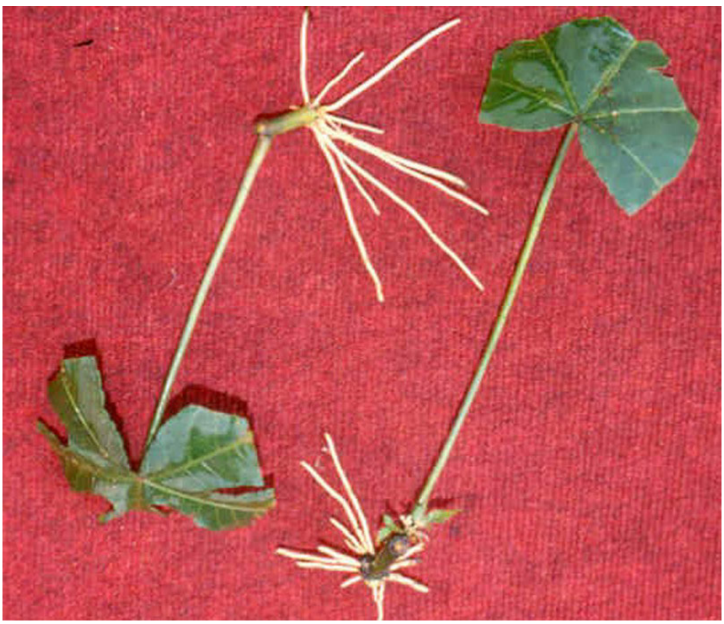

Plate 4. Rooted cuttings.

Plate 5. Planting out ndjanssang trees in Cameroon.

Plate 6. Ndjanssang kernels for sale at Mfoundi market, Yaounde, Cameroon.

Plate 7. Drying ndjanssang kernels for household consumption in Elig Nkouma.

Plate 8. Preparing kernels.

Chapter 5. Properties

5.1 Seed

The physio-chemical properties of dry kernels, defatted kernels and oil extracted from kernels have been studied in recent years in Cameroon and Nigeria. A summary of properties of dry kernels is provided in Table 5.1. (Tchiegang *et al.*, 1998, 2000; Tiki Manga *et al.*, 2000; Kapseu 1998; Dandjouma *et al.*, 2000 (Cameroon); and Ekam, 2003. Tane (1997) reported on a wider range of chemical properties and this data is included in Table 5.1 as is data from Tsware and Usman, 1998 (Nigeria)).

Table 5.1. Chemical composition of kernels

Constituent	Amount (%)
Water	3.1 ± 0.8
Fatty acid	47.4–55.30
Crude protein	24.3–65.2
Total carbohydrates	5.6–9.3
Digestible carbohydrates	5.6–9.3
Crude fibres	8.9–9.3
Ash	10.5–17.8
Nitrogen	8.6 ± 0.9
Dry extracts	97.8
pH	7.84

It appears that kernels are rich in crude protein, oils and also fibres. In relation to the lipids, tocopherol content is 0.45 ± 0.63 – 2.38 ± 0.12 mg / 100g; α-tocopherol is a lipid soluble antioxidant.

5.1.1 Fats

Tiki Manga *et al.* (2000) and Dandjouma *et al.* (2000) reported ndjanssang kernels to have very high fat contents, but these vary with the geographic origin of the tree (e.g. 49.2–63.5% and 47.4–

59.8% for two different locations). Oil density was also found to vary with the geographic origin of the tree (0.75–0.87).

The fatty acids have energy values of 495 kcal/100g (Tane, 1997). The fatty acids consist mainly of a high level of linoleic acid, a polyunsaturated fatty acid (60.32%), oleic acid, a monounsaturated fatty acid (14.66%), and two saturated fatty acids, stearic acid (12.95%) and palmitic acid (12.08%) (Tane, 1997). Linoleic acid is known to be the most important essential fatty acid, as it may help lower the amount of cholesterol in the blood and lessen the propensity for thrombosis. Its deficiencies are characterised by anaemia, scaly skin, decreased healing capabilities and permeation of fat into the liver. The high oil retention capacity of ndjanssang kernels shows that they are of great use to thicken soups and to incorporate into baby cereals and cakes.
The fats affect the functional properties of the kernels (Table 5.2).

Table 5.2. Functional properties of kernels

Properties	Amount (%)
Water retention capacity	287.2 ± 0.4
Gelling capacity	Least gelling concentration > 18
Emulsifying properties	33.1 ± 0.3
Emulsion stability	92.2
Foaming properties	5.1 ± 1.0
Moss stability:	
after 120 mn.	100
after 10 mn.	100
Oil retention capacity	54.2 ± 2.5

Source: Tchiegang *et al.* (2000)

5.1.2 Carbohydrates and proteins

Carbohydrates in kernels have energy values of 37 kcal/100 g, and the proteins have a comparative value of 97 kcal/100 g (Tane, 1997).

Ndjanssang defatted flour is rich in nitrogen (8%) and ash (16%) (Tchiegang *et al.*, 1998). In ndjanssang flour the percentage of essential amino acids in total amino acids is 35.5%, which is higher than the normal value for a well-balanced protein feed (Tchiegang *et al.*, 1998). This flour also has a high amount of minerals (Table 5.3). These characteristics make it useful in child nutrition.

Table 5.3. Chemical composition of defatted kernel flour

Essential amino acids	Amount (mg/g)
Leucine	30.6
Total lysine	14.7
Threonine	18.2
Tyrosine + Phenylalanine	41.7
Valine	32.3
Isoleucine	19.0
Tryptophane	6.2
Non-essential amino acids	
Asparagine	49.3
Serine	28.6
Glutamic acid	102.0
Proline	Traces
Glycine	25.6
Alanine	22.6
Arginine	51.4
Histidine	16.3
Crude fibres (g/100 g)	8.9 ± 0.2
Phenolic compounds	0.2 ± 0.11

Sources: Tchiegang *et al.* (1998, 2000)

5.1.3 Oil extracted

Processed kernels produce edible oil. This has been extracted out in laboratories (IUPAC, 1979, Tchiegang *et al.* 2005) and a degree of crude processing is sometimes carried out by farmers. The fatty acid composition of the resultant oil is shown in Table 5.4 and its properties in Table 5.5

Table 5.4. Fatty acid composition of ndjanssang oil

Constituent	Amount (% of weight)
Myristic acid C14: 0	-
Palmitic acid C16: 0	5.5
Stearic acid C18: 0	6.4
Oleic acid C18: 1	7.4
Linoleic acid C18: 2	28.3
Linolenic acid C18: 3	-
Elaeostearic acid C18: 3	51.1
Arachidic acid C20: 0	-
Gadoleic acid C20: 1	0.1
Lignoceric acid: C24: 0	1.2
α-tocopherol (mg/100 g)	2.4 ± 0.12
β-tocopherol (mg/100 g)	1.6 ± 0.24
γ-tocopherol (mg/100 g)	0.4 ± 0.63
Total of polyunsaturated acids	79.4%
Monounsaturated acids	7.5%
C 18: 1 n-9	7.4%
C20: 1 n-9	0.1%
Saturated fatty acids	13.1%

Sources: Tchiegang *et al.* (1998); Kapseu (1998); Tsware and Usman (1998)

Table 5.5. Properties of ndjanssang oil

Constituent	A	b
Density (g/mg)	0.753 – 0.873	-
Acid value	2.2 ± 0.17 – 9.2 ± 0.60	-
Iodine value	148.4 ± 1.39 – 169.8 ± 1.98	157
Saponification value	181.4 ± 0.71. – 198.0 ± 0.54	190
Peroxide value (meq/kg)	19.8 ± 0.03 – 114.1± 0.68	-

Sources: (a) Dandjouma *et al.* (2000), (b) Tchiegang *et al.* (1998)

5.2 Wood

Ndjanssang wood is white, grey or pale yellow and darkens on exposure. The sapwood, not differentiated from heartwood, is the same colour. It is very soft and weakly resistant to chipping and shocks (Richter and Dallwitz, 2000; Vivien and Faure, 1985). The grain is straight, without lustre, and its texture is somewhat coarse. The wood saws and works easily, and nails without splitting, but it is liable to decay and termite attack.

It has disseminated pores and its ring limits are absent or not distinct. The fresh density varies between 0.7 and 0.9 g/cm^3 and dry density (at 12% humidity) between 0.25 and 0.4 g/cm^3 (Vivien and Faure, 1985, Richter and Dallwitz, 2000). The shrinkage from green to oven dry is 2% (radial), 4.8% (tangential) and 7.6% (volumetric). The basic specific gravity varies between 0.2–0.4 c/cm^3.

5.2.1 Phloem

The secondary phloem was described in Nigeria by Lawton (1972). Its structure and composition was found to vary with seasons (Table 5.6). Two phases of cambial activity per year were reported. Dimensions of phloem elements were also found to vary with season (Table 5.7). The phloem forms a very narrow zone (one to six tubes wide) and the sieve plate is compound, oblique, mainly inclined to the tangential wall at an angle of about 30º, and bears a single row of five to seven areas with plastids containing starch accumulating around the pores. It also has irregular patches of sclereids formed from the phloem parenchyma between the rays in the non-functional phloem or from the tylosoids in the old sieve tubes. Starch is present in the parenchyma of the rays and the phloem, while cluster crystals are abundant in the phloem parenchyma nearest the cambium and infrequent in the older phloem.

Table 5.6. Seasonal variation of phloem elements in one year (1969)

	Feb.11th	Apr.16th	July1st	Sept.1st	Dec.2nd
N	104	172	174	173	471
M(μm) p	41.6±2.2	56.1±1.6	52.2±1.6	54.0±1.2	19.4± 0.7
a	45.1±3.2	49.9±1.7	48.7±1.4	49.4±1.8	20.3± 0.8
P_1 (%)	24	14	7	24	8
P_2 (%)	26 (20)	56 (48)	48 (44)	65 (46)	23 (18)
Source: Lawton (1972)					

N: number of sieve tubes per square millimetre of active phloem including the rays and fibre groups;
M: mean diameters of sieve tubes in active phloem (p: periclinal; a: anticlinal);
P_1: percentage of active phloem occupied by rays;
P_2: percentage transactional area occupied by sieve tubes of the active phloem, excluding the rays and the fibre patches where present. (Figures in brackets represent the area occupied by sieve tubes as a percentage of the total active phloem, including the rays and fibre groups.)

Table 5.7. Range of dimensions of phloem elements (μm)

Sieve tube elements			Fusiform	Fibres		Wall	Ray	
Width	Length	Pore	Initial length	Width	Length	Thickness	Width	Height
40–50	600–800	<1	300–500	50–80	50–80	20	10	800
Source: Lawton (1972)								

5.2.2 Vessels

The arrangement, diameter, number and length of vessels are given in Richter and Dallwitz (2000). Vessels are arranged in no specific pattern, in multiples, and are commonly short (2–3 vessels or more). The average number of vessels/mm^2 varies between 2 and 7, and the average tangential vessel diameter between 200–380 μm. Perforation plates are simple and intervessel pits alternate, with average diameter (vertical) varying between 10–17 µm. Vessel-ray pits have reduced borders or are apparently simple, round or angular (of the same type in adjacent or unilaterally compound). Tyloses are present in vessels (thin walled) and helical thickenings are absent.

5.2.3 Fibres, rays and parenchyma

Fibres are very thin walled, non-septate, and mainly restricted to radial walls, simple to minutely (or distinctly) bordered. Their average length varies between 1450–2050 µm (Richter and Dallwitz, 2000).

Rays are exclusively uniseriate and composed of a single cell type (or two or more cell types). Homocellular ray cells are procumbent, while heterocellular rays are square and upright cells restricted to marginal rows (Richter and Dallwitz, 2000).

The axial parenchyma is apotracheal and not banded, diffused in aggregates and as strands. Storied structures and tanniniferous tubes are absent, while prismatic crystals are present and located in axial parenchyma cells.

Not a great deal of analysis or pharmacological testing has been done. However, Kimbu *et al.* (1991) revealed the existence of two dinorditerpenoids (heudelotinone and 1,2-dihydroheudelotinol), and E-ferulic acid octacosylate, 3-methylmethylorsellinate and lupeol in the stem bark and root extract of ndjanssang trees. This particular extract was similar to that used for treatment of cough.

Chapter 6. Uses

Surveys of the use made by farmers of ndjanssang have been reported by Fondoun *et al.* (1999), Tiki Manga *et al*. (2000) and Mollet *et al.* (1998) and show that the highest priority use is for food, followed by medicinal use, cultural and soil fertility improvement.

6.1 Fruit and food products

The seed kernels constitute the edible part of the fruits. The kernels make up 31–33% of the seeds, which in turn make up a little over two-thirds of the indehiscent fruit capsule. The kernel is often referred to as the 'nut meat'. When seeds are extracted the pulp and shell are normally discarded. The kernels are usually dried for use as a flavouring agent in food dishes in West and Central Africa.

If oil is extracted, this is used in cooking whilst it is fresh. Tests on the properties, especially the iodine value, show that the oil is good for cooking purposes (Dandjouma *et al.*, 2000).

The paste of ground kernels is sometimes used as a thickening agent for soups and stews and incorporated in to baby cereals and cakes, due to their high oil retention capacity (Leakey, 1999; Fondoun *et al.*, 1999). Stews made with kernel extracts are reported to have a good taste and can substitute for the use of peanuts (Fondoun *et al.*, 1999). The paste is obtained by crushing dried, ground kernels with stones. Seeds may also be pounded to powder for use in making porridge in times of food shortage.

Fruit pulp is not yet used commonly in human diets across the geographic distribution of ndjanssang. The pulp, however, is dried for use as flavouring. Wood-ash from freshly felled trees is used as cooking salt.

6.2 Medicinal uses

6.2.1 Bark

The bark of the roots, bole and branches is used medicinally. Local preparations take many forms but are usually decoctions or other liquid extracts. Bark is variously used to treat leprosy, elephantiasis, gonorrhoea, dysentery, diarrhoea, coughs, hernia, rheumatism, abscesses, rickets, and smallpox (Abbiw, 1990; Ayuk *et al.*, 1999; Bokemo, 1984) in West and Central Africa. It is also used in southern Cameroon to cure yellow fever, anaemia, skin diseases, malaria, stomach pain, headache, toothache, worms; to provide easy child delivery (although in certain doses it can be an abortifacient); and as an aphrodisiac (Fondoun *et al.*, 1998; Mollet *et al.*, 1998). In Central Africa it is used as an anti-inflammatory.

6.2.2 Seed

The seed, seed shell and latex contain a resin, which along with the oil is used in West Africa as a remedy for gonorrhoea and diarrhoea.

6.2.3 Leaves

A decoction of leaves is used for fevers. The pulp of the leaves is used against mycoses, and to treat abscesses in Senegal (Berhaut, 1975).

6.2.4 Sap

The sap of the plant is used for eye infections and decoctions of leaves are used as a febrifuge. The latter is also used in cases of dysentery, oedema and female sterility.

6.2.5 Roots

The roots are used as aphrodisiacs in Ivory Coast; seed husks and latex of the plant are used in West Africa to cure gonorrhoea and diarrhoea.

6.3 Sociocultural aspects

Dried seeds of ndjanssang are used in the southern Cameroon for a popular game called ‘songho’, in Sierra Leone for rattles for bundu dances, and in Nigeria the Ibo people use them in a game called ‘okwe’.

Ndjanssang is a popular avenue tree in Uganda. Its wood is used for drum manufacture for traditional dances (Fondoun *et al.*, 1999). In Democratic Republic of the Congo, the wood is used for making drums, which are said to be very sonorous, and in southern Nigeria, Gabon and Angola, it is carved to make the whole or the resonant parts of musical instruments.

6.4 Agroforestry and land use

Ndjanssang trees are found in diverse land use systems such as fallow land, home gardens, natural and semi-natural forests, plantations and food crop fields (Ayuk *et al.*, 1999). The majority are to be found in plantations and arable fields. Trials to better incorporate ndjanssang into food crop systems are in progress at ICRAF-West Africa in Cameroon. The rate of destruction of the rainforest for shifting cultivation in Central Africa is estimated at 60% (FAO, 1997). *Ricinodendron heudelotii* was identified as a priority species for domestication under ICRAF’s Humid Lowlands of West Africa (HULWA) project, which includes assessing farmers’ and users’ needs, assessing the species currently grown, and ranking the importance of tree products according to food and nutritional security, market value and potential value (Tchoundjeu *et al.* 1999).

In southern Cameroon, ndjanssang is commonly used as a soil-fertility-improving tree (Fondoun *et al.*, 1999; Mapongmetsem, 1994) as well as a shade tree in cacao plantations. The large crowns of ndjanssang trees protect soils and crops from the sun, pounding rains and strong winds, especially in savannah zones (Anigbogu, 1996). Soil improvement might be due to the presence of arbuscular mycorrhizae (Re, 1960). Musoko *et al*. (1994) found a wide range of arbuscular mycorrhizae in the rhizosphere around ndjanssang in mixed forests, including 5 species of *Acaulospora*, 7 species of *Glomus*, especially *G. etunicatum*, and 2 species of *Scutellospora*. Natural leaf litter also contributes to soil fertility, and ash from burnt nutshells is rich in potassium, making it useful as fertilizer (Mapongmetsem and Tchiegang, 1996).

Residues from oil extractions contain a small amount of resin and this makes the residual cake unfit for use as cattle food; however, it is a useful nitrogenous fertilizer. Also, the waste from fermented leaf pulp is used as fertilizer (Mapongmetsem and Tchiegang, 1996), as is the wood ash (Abbiw, 1990).

There are other uses in agricultural systems. Ndjanssang trees in all areas are helpful in honey production. Leaves are a source of high-quality fodder for sheep and goats during the dry season (Anigbogu, 1996) in Nigeria.

Mushrooms associated with dead trunks or dying tree roots are relished in Gabon and Cameroon and in the Democratic Republic of the Congo. Caterpillars of the moth *Imbrasia ertli* are associated with the leaves and these are edible and prized.

6.5 Industrial uses

The oil obtained from dried kernels could be used for soap and varnish making (Ekam, 2003). The iodine and saponification values also point to the potential of the oil in paint and for cosmetic use. The oil is thick and pale yellow. Wood ash of the tree is locally used in soap making. Fibres of the tree are suitable for paper pulp.

6.6 Other uses

At the present time industrial applications are only possibilities. Due to its low resistance, ndjanssang wood is very little used in carving and furniture making. Nonetheless, currently the wood is used to manufacture boxes and crates, plywood, coffins, rafts, and fishing floats. It is considered to be a good balsa substitute. The wood is also used for fuel, poles and rough planks. It is also used in Uganda by Semliki and Unyoro forest dwellers for making the doors of their huts. It is carved into fetish masks, spoons, ladles, plates, platters, bowls, dippers and stools. In Ghana, it is currently recommended for use in insulation. The sawdust is suitable for use in sun helmets (ICRAF, 2004), and is used for filling lifebelts.

From studies of nutrient composition and digestibility (Asiegbu and Anugwa, 1991), ndjanssang could be used as a livestock feed during dry seasons.

Chapter 7. Genetic Resources and Genetic Improvement

Ndjanssang has only been actively under domestication since 1995, when ICRAF established experimental plots of the species in Cameroon. As a result, information on patterns of genetic diversity, identification of potential genetic resources to use in further improvement, and the establishment of germplasm collections are all rudimentary.

Any genetic improvement programme starts with the characterization of genetic variation in the natural stands, with the aim of identifying superior genotypes. However, much of the early work with tree species identifies superior phenotypes based on morphological traits, growth requirements, or desirable properties, and the heritability of these traits needs to be assessed.

Collection of genetic resources is usually coupled with conservation measures by storing specific stocks growing in field stands or stores seeds in genebanks (Lowe *et al.*, 2000; Asaah *et al.*, 2003; Smith *et al.*, 1992).

7.1 Variation in ndjanssang

Variation reported in the literature has been phenotypic and focused on fruit characteristics (Fondoun *et al.*, 1999; Tiki Manga *et al.*, 2000; Ngo Mpeck *et al.*, 2003). Fruit shape was classified into five different classes according to seed lobes. Ngo Mpeck *et al.* (2003) reported on tree-to-tree and provenance variation in fruit morphologies from the humid forest zone of Cameroon. Specific quantitative traits investigated were partitioning of mass between whole fruit, pulp, kernel and kernel shell, and fruit length and width. Fruit mass, which integrates all the other size-related variables (fruit length and width), was found to be more variable (241%) than fruit length (40%) and width (134%). The range in physical characteristics was, fruit mass (19.36 to 46.67 g), fruit length (37.26 to 52.10 mm) and width (28.82 to 38.71 mm), nut mass (3.17 to 5.98 g), nutshell mass (2.16 to 3.86 g) and kernel mass (1.01 to 2.12 g). As kernels are surrounded by a hard shell that is very difficult to crack, shell brittleness was investigated and found not to be related to shell mass. Fruit characteristics and nut characteristics were only weakly related.

Kernel oil contents varied according to provenance (49.25%–63.48% in 47 provenances) in southern Cameroon (Fondoun *et al.*, 1999), see Section 1.3.1.

Variation in other kernel traits (crude protein 49.9 to 65.2%; total carbohydrate 4.9 to 6.4%; crude fibre, total ash and energy values) of these samples was also reported by Tiki Manga *et al.* (2000).

Virtually nothing is known yet about the chromosome numbers and whether the species shows any polyploidy.

7.2 Identifying key traits

In many trees, there is an opportunity to identify a small number of key traits that together would form an 'ideotype' combining a number of highly desirable characteristics of potential commercial value (Dickmann, 1985). Ideotypes may vary according to purposes (users' perspectives), localities, cultural practices and environments. Users of non-timber forest products (NTFPs) from West and Central Africa can be classified in three categories: producers (forest dwellers who are mostly farmers), traders, and consumers. Forest dwellers are also the first consumers of NTFPs, and another category can be inserted between producers and traders or between traders and consumers: those involved in processing of the products. Each category has its own preferences.

In the case of indigenous fruit trees, farmers would value productivity traits (number of fruits per tree, fruit/nut size and mass, regularity of production, taste resistance/tolerance to diseases, number of vigorous branches bearing fruits, etc.,) while traders would focus on appearance (colour, freedom from disease) and preservation. Consumers would insist, for example, on product appearance, taste, size, and, to a degree, nutritional attributes. Participative rapid appraisal (PRA) and/or appreciative enquiry (AE) could identify each user category's requirements.

Farmers in Southern Cameroon have identified the characteristics of ndjanssang trees that they would like to see improved: yield, fruit size, reduced time to bearing, reduced tree height, a spread of fruiting time, regularity of production, and good taste (Ayuk *et al.*, 1999).

As ndjanssang is mostly used as a spice, the fragrance attributes of kernels would be greatly appreciated by consumers. An ideotype based on kernel phenotypes (visible traits) has been investigated by Ngo Mpeck *et al.* (2003) in Cameroon. Weak relationships were found between fruit and kernel characteristics, indicating that fruit size is not related to kernel size. This has led to a 'kernel ideotype' that would combine big kernel size and self-cracking seeds. However, the self-cracking trait was not found to be related to a thin shell, as some boiled seeds with heavy kernels were found to be self-cracking. Further studies are needed to investigate this aspect. When the factors controlling this trait are identified, studies on relationships between kernel mass/size and fragrance could be considered, along with high productivity and regularity of production (yearly), to identify the ideal kernel ideotype. However, preferences of traders and consumers will also need to be taken into account.

7.3 Germplasm collections

In spite of the important nutritive and commercial roles of ndjanssang in countries where it grows, no institutional germplasm collection has been attempted to date. As a high priority species for domestication, germplasm collections in Cameroon for trials on propagation have been made by ICRAF. On-station experiments are still in progress and trees are cultivated at Minkoameyos, near Yaounde. This collection was not targeted to any provenance or any source of variation. However, future collections may be based on plants with desirable characteristics.

At present there is no major threat of genetic erosion, because trees that colonise fallows are retained by farmers when they clear land for agricultural purposes. Sometimes, farmers also transplant wildlings growing in natural stands to their farms.

7.4 Constraints to genetic improvement

Major constraints include the difficulty in distinguishing male and female trees at young ages and seed coat inhibition of germination.

When the tree starts flowering, it is possible to do controlled pollinations. Marcots (air layering), which do not grow very high, could be used for this.

The germination rate of ndjanssang is less than 4%, due to seed dormancy. Hand scarification of seeds should significantly improve this (Mapongmetsem *et al.*, 1999).

Another constraint is the lack of characterisation data on a wide range of genetic resources, followed by targeted evaluation and selection of superior genotypes. The lack of knowledge on the heritability of desirable traits should also be stressed. Modern biotechnologies can be very useful in attacking these constraints.

Additional studies such as flowering phenology and pollination mechanisms are also needed. On the positive side, methods for propagating the species have been developed (Shiembo *et al.*, 1997; Ngo Mpeck, pers. comm.; Mapongmetsem *et al.*, 1999) and can be used to capture identified genetic variation. (See Section 8.1.)

Chapter 8. Agronomy

Research is ongoing on agronomy and most efforts have been focused on propagation techniques. Numerous aspects of husbandry such as spacing, pruning, nutrition and irrigation are yet to be investigated. Trials on intercropping and transplanting are in process at ICRAF-West Africa, and this chapter relies heavily on Cameroonian experiences.

8.1 Establishment

Work has been done on propagation by seeds (Mapongmetsem *et al.*, 1999; Ngo Mpeck, pers. comm.), leafy stem cuttings (Shiembo *et al.*, 1997), and air-layering (Ngo Mpeck, pers. comm.).

8.1.1 Seed and seed germination

Seeds consist of a smooth kernel surrounded by a hard endocarp, which may be responsible for the seed dormancy. Dormancy lasts for 6 months (Taylor, 1960). The germination potential of ndjanssang can be low, around 4%, when compared to other forest tree species from the Cameroon humid rainforest zone, such as *Cordia platythyrsa*, *Milicia excelsa*, *Terminalia superba*, *Ceiba pentadra*, *Pycnanthus angolensis*, *Tryplochyton scleroxylon* and *Alstonia boonei* (Mapongmetsem, 1994). This germination potential was found to vary (P = 0.05) from 23.7% in *T. superba* to 71% in *C. platythyrsa*. However, the germination potential of ndjanssang appears to vary according to provenance: it can reach 71% for some trees, when seeds are hand-scarified (Ngo Mpeck, pers. comm.). Much more information is needed on the effects of fruit maturity.

Germination is epigeal and starts three weeks after sowing (Mapongmetsem, 1994; Ngo Mpeck, pers. comm.). This germination delay is due to the impermeability of the seed coat, and hand scarification significantly improves germination.

8.1.2 Seed pretreatments

Amongst four pretreatments (soaking in boiling water, cold water, sulphuric acid, and scarification), scarification was found to improve the rate of germination to 61.6% (dry seeds) and 53% (fresh seeds) (Mapongmetsem, 1994). Scarification is more efficient when applied to the micropyl area; however, this is quite labour intensive.

8.1.3 Seed propagation

As seed germination can be very low, studies have focused on vegetative propagation techniques (Shiembo *et al.*, 1997; Ngo Mpeck *et al.* 2003). In rural areas, farmers transplant wildlings from seeds in natural stands onto their farms. After scarification, seeds are sown in a mixture of forest soil and river sand (2:1) at distances of 5 cm by 5 cm, and at 3 cm depth. Seedlings are then later transplanted into polythene bags.

8.1.4 Vegetative propagation

8.1.4.1 Cuttings

Ndjanssang is easy to root, providing the physiological state of the cutting is right and the humidity requirements within the propagator are fulfilled. A mixture of fine sand and sawdust was found to be the best rooting medium for leafy stem cuttings, and best rooting rate was achieved with cuttings with leaf areas of 80 cm^2, (Shiembo *et al.*, 1997). Auxin application (IBA: Indole Butyric Acid) was found not to affect rooting percentage but did affect the root number. With fine sand as a rooting medium, a leaf area of 80 cm^2 and IBA application at the base of the cutting, at least 80% of rooted stem cuttings can be obtained. The rooting ability and effectiveness of rooting was also found to be affected by tree source.

Juvenile cuttings from old stumps (coppice shoots) are used for rooting using non-mist propagation (Tchoundjeu and Leakey, 1996; Leakey *et al.*, 1990). The non-mist propagators are entirely made of local materials. Moreover they are well adapted to rural conditions where there is no electricity or tap water. They consist of a wooden frame enclosed in clear polythene sheet so that the base of the propagator is watertight (3 m x 1 m x 1 m), with the aim of minimising water stress. The base of the non-mist propagator is covered by a thin layer of fine river sand, then by successive layers of small stones and gravel overlaid by the rooting medium, to a depth of 10 cm on top of gravel. Sand, sawdust or gravel, or a mixture of sand and sawdust, or gravel and sand are used as growing media. Humidity and temperature in the propagator are maintained by the provision of a water table beneath the rooting medium, resulting in a permanently humid environment (RH = 80–90%).

8.1.4.2 Marcotting

Marcotting has not yet been standardised. However, in marcots set up on shoots 51–70 mm in diameter, 70% of rooting success can be achieved after two months with application of Seradix (0.03% IBA). This percentage of IBA is far higher than that achieved in other indigenous fruit species from West and Central Africa.

8.1.4.3 Grafting

Grafting can be achieved through simple side grafts (mean rate of success: 85%), which are better than top grafts (37.5% rate of success) (Nguele Oloa, 2000).

8.1.4.4 *In vitro* micropropagation

In vitro propagation of ndjanssang was investigated by Fotso Donfagsiteli *et al.,* 2004), using nodes with a single axillary bud, cultivated on Murasige and Skoog’s medium. The propagation rate was low. Using media with kinetin and NAA generated 36 rooted plants from 50 initial node explants. M&S medium with 2.5 mg/l supported the best development of axillary buds (71%). Transplanting onto medium with 2 mg/l NAA supported the rooting of 72% of these explants.

8.1.5 Field establishment

8.1.5.1 Direct seeding

Trees can be established through direct seeding, taking into account that seeds cannot germinate under a closed canopy. The planting hole size and the number of seeds/ha as well as planting hole spacing have not yet been investigated. A mixture of forest soil and river sand (2:1) seems to be a good substrate to use in the holes.

8.1.5.2 Transplanting

Seeds can be germinated in seedbeds and then transplanted into polythene bags filled with a mixture of forest soil and river sand in equal amounts, or forest soil alone. Seedlings are transplanted in the rainy season (when rains are stable) when they are 30 cm in height.

8.2 Management

8.2.1 Pruning and training

Ndjanssang seems to be self-pruning, corresponding to the growth cycle, because each tree develops one dominant branch every year. The main management practice applied, except to fight against aphids, is ring weeding, done around each tree.

8.2.2 Nutrition

At present fertilizers are used only on farms when the soil is poor. Application of NPK (nitrogen-phosphorus-potassium) at a ratio of 20–10–10 is suitable, at the rate of 25 g/tree/year, spread at the beginning of the rainy season.

Where fruit trees are being re-established on previously fallow land, the effects of fertilizer application have been shown to be of lesser importance on establishment of ndjanssang than shade (Norgrove *et al.* 2002). Mixed tree systems consisting of *Persea americana* (avocado), *Dacryodes edulis* (safou), *Terminalia* *ivorensis* (framiré), ndjanssang and *Theobroma cacao* (cacao) were planted under temporary shade crops of *Musa* spp., *Inga edulis* and *Chromolaena odorata* and four inorganic fertilizer regimes were tested, including N, P, K and Ca in different combinations. Growth and survival of 14 month old saplings was found to be not significantly affected by fertilizer regime.

8.3 Pests and diseases

8.3.1 Pests

Four types of caterpillars have been reported to defoliate ndjanssang in Democratic Republic of Congo (Latham, 2003). These defoliators, which have been described in the Bas-Congo region, are *Lobobunaea phaedusa* Drury (local name, in Kikongo: kaba), *Imbrasia petiveri* Guerin-Meneville (local name: bisu), *Imbrasia obscura* Butler, or probably *Imbrasia melanops* Bouvier (local name: minsendi), and *Imbrasia epimethea* Drury (local name: mvinsu). These caterpillars attack *R. heudelotii* leaves between December and January (*I. petiveri*), October to May (*L. phaedusa),* and October to February (*I. obscura* and *I. melanops*), while *I. epimethea* appears in November-December (Latham, 2003). Because these caterpillars are edible and constitute an important source of protein for local populations, no chemical fight against them was initiated or investigated.

In Cameroon, a psyllid, *Diclidophlebia xuani* (Physllidae sub-family Paurocephalinae), was reported to cause serious damage in nurseries. Adults and larvae attack young buds (Messi *et al.*, 1999). An inventory of arthropods was carried out by Alene *et al.* (2005) to identify natural enemies of the psyllid around Yaounde. Predators were found in the family Anthocoridae, Coccinellidae, Miridae, Syrphidae and unidentified spiders and parasitoids in the Encyrtidae, but their impact on the psyllid was weak.

Aphids also infest leaves in nurseries, and the leaves curl as a result of these attacks. This phenomenon is common in Cameroon, and could be a serious constraint to cultivation. The aphids attack the lower sides of leaves, and are easily observable. Systemic insecticides can be used to eradicate these attacks. The most used one is Cyperdim 220 EC (trade name), which contains 200g/l of dimethoat plus 20 g/l of cypermethrin. This is toxic (WHO classification: class II – fairly dangerous. Atropine sulphate acts as antidote). A concentrated emulsified solution made by Calliope (Nogueres, France) is spread using a knapsack sprayer (40–60 mg/15 l of water) on trees twice a trimester (1–1.5 l/ha) during the first 2 years of tree establishment in the field. Thereafter the treatment is optional, the older trees being relatively resistant, as they are in natural stands. Where possible cultural control of pests is preferable by removal of leaf litter from the base of the trees, adequate aeration of the canopy and removal of pests, or leaves with evidence of pests, at first sighting.

8.3.2 Diseases

No major diseases have been observed as yet. Shade trees, including *Ricinodendron heudelotii* are known to harbour the root pathogen *Phytophthora megakarya,* which causes black pod in cacao (Opoku *et al*. 2002). Shade trees act as alternative hosts for this fungus.

Chapter 9. Harvesting

9.1 Harvesting

Ndjanssang trees start bearing fruit at 8 to 10 years of age. Flowering is somewhat negatively influenced at low altitudes (Fondoun *et al.*, 1999).

The extraction of the seed kernels is time consuming due to the seed shells. Normally farmers allow the fruits to fall from the trees, gather them into piles, and leave them to rot. Once rotten, the seeds can be extracted by washing and boiling, and are then put into cold water and left for 24 hours. They are then subjected to further boiling to crack the seed shells, enabling the kernels to be extracted using a knife. The kernels are then dried (Figure 9.1). Most of this work is done by women.

9.2 Post-harvest handling

This is limited to transport from production areas to markets. There is no special packaging: jute bags or polythene bags are used. At the market, amounts are measured out by volume.

9.3 Production

Trees bear fruit usually once in a 2–3 year period, but some can fruit each year. Kernel yield varies between provenances and 100 fruit weight ranges from 165–275 g. An individual tree can produce up to 900 fruits in a fruiting year.

Domestication is in the early stages, so production per tree and yield per unit area have not yet been established.

9.4 Storage

Most traditional methods of storing kernels are based on avoiding excess humidity, such as by sun drying and storing them in a dry place.

In the humid forest zone of Cameroon, the following are recorded: sun-dried kernels in bags (the most practised method), sun-dried kernels in a calabash, kernels dried on the fireplace and bagged, sun-dried kernels in baskets, sun-dried kernels in a closed cooking pot, complete seeds previously washed and boiled, kernels dried on the fireplace and put in tins, sun-dried kernels in closed demijohns, and fresh kernels in plastic bags. The storage places reported by farmers range from bamboo racks hung over fireplaces to hanging from the ceiling. These traditional methods of storage are adequate for 1–2 years.

Stored kernels need protecting from rodents. In the field, seeds left uncollected are dispersed by hornbills, bats and rodents.

9.5 Processing

A very limited amount of local seed oil extraction is carried out. More scientific extraction has been worked out (IUPAC, 1979, Tchiegang *et al.* 2005). The γ-tocopherol content results in the oil being stable and prevents it from becoming rancid very quickly.

Chapter 10. Marketing and Trade

Ndjanssang fruits are mainly harvested from the wild. Since plantations are in their infancy, it is difficult to consider the economics of production.

Most trees are scattered in different land use systems in the humid tropics of Africa, mainly fallows, cacao farms, food crop fields, home gardens and forest, or in fairly substantial groves in parts of southern Africa. Quantities and values of traded seeds are not recorded in local official statistics.

Nonetheless, ndjanssang is one of the most traded non-timber forest products (NTFP) in the humid forest zone of Cameroon (Ndoye and Ruiz Pérez, 1997) and prices of kernels have been recorded in Libreville (Yembi, 1999) and even in specialised shops in France and Belgium selling NTFPs from Central Africa (Tabuna, 1999). Quantities and amounts traded in the humid forest zone of Cameroon from January to July 1995 by 271 traders from 31 markets were estimated at 35,952 kilos for a value of 66,000 Euros. However, the absence of any institutional framework, as well as the poor organisation of market networks of NTFPs, is the main constraint in assessing the trade.

In Cameroon, kernels are mainly sold in piles or in cups and the prices vary according to periods of abundance and scarcity, as well as the sizes of the piles and cups. For instance, piles in Yaoundé markets cost 50 to 100 CFA francs (0.0762 to 0.152 Euros) according to the sizes of piles in periods of abundance, and these prices go up in periods of scarcity. Cups cost 150 to 300 CFA francs (0.23 to 0.46 Euros), according to their sizes, in periods of abundance, and prices go up to 200 to 400 (0.30 to 0.60 Euros) and more in periods of scarcity.

The markets for ndjanssang kernels vary with their proximity to the urban centres. The net marketing margin in the Littoral province of Cameroon is 35-40% (Ndoye *et al*. 1998), twice that of the Centre province, due to the poorer supply in Littoral province. In addition fish is plentiful in Littoral province and ndjanssang is eaten as a flavouring with fish dishes.

Chapter 11. Developing a Medium-term Research Strategy

The limited past research on *Ricinodendron heudelotii* contrasts with the important role played by the seeds for both rural and urban populations of large areas of Africa. This situation is not unique; many high-value fruit trees have attracted little attention for research. It is hoped that the summary of information provided in this monograph will act as a spur to both scientific research and the development of appropriate technologies.

The innovative approach undertaken by ICRAF and ICUC (for addresses, see Appendix 1) and their international and national partners (Appendix 2) will capitalise on the wide range of fruit trees with hidden potential, the domestication of which could really contribute to the reduction of poverty in rural areas. This is because farmers are involved with participatory research, especially related to the production, processing and sale of the products, in contrast to commodities such as cocoa or coffee, which most rural people neither process nor contribute to the determination of their market prices.

Recent research has been conducted to determine the main factors affecting the selection and multiplication of ndjanssang, using simple and low-cost vegetative propagation techniques adapted to rural areas, and information gathered on the variation within and between different wild populations. Further domestication will involve more detailed assessment of patterns of genetic variation, the selection of ‘elite trees’ through simple, cheap and low-technology methods, the development of cultivars after ideotype identification (based on traits of high commercial and/or nutritive value), the integration of improved germplasm into existing land use systems, and the management of production.

Statistics on the quantities of seeds produced annually are still lacking, as well as on the maximum number of seeds that can be harvested per tree. The number of existing trees of the species in wild stands is also imperfectly known.

Productivity is irregular between years, so assessment of quantities available in years of abundance and scarcity is also needed for the establishment of programmes of cultivation. Market studies have been initiated and consumer preferences will be looked at.

11.1 Recent research results

Ndjanssang trees are found in various land use systems; they can easily be intercropped with a range of trees or arable crops. Simple, cheap and low-technology methods for propagation have so far been developed, using rooted leafy stem cuttings or air-layering. The nutritive properties of the seeds are now better known and studies on developing tools for easy kernel extraction are also under way.

11.2 Constraints

The major constraints to improving the species are twofold: first, the lack of ecogeographical surveying coupled with assessment of patterns of genetic variation; and second, the difficulty in distinguishing male and female trees at a young age. The latter hampers the production of propagules through leafy stem cuttings, since these are taken from young material.

The tree is also fast growing and self-pruning, and setting marcots when the tree is already flowering is difficult due to tree height.

11.3 Research strategies

A wide programme of improvement is needed, and this must start with the assessment of variability of wild stands in the species' natural distribution zone, from Madagascar to Senegal. This needs to be coupled with floral biology research and knowledge of cytology.

The establishment of suitable conservation methodologies for genetic resources is also needed. However, a suitable strategy has to be developed.

Current strategy for improvement is based on the propagation of ‘superior trees’ using agromorphological attributes, but this will have to shift to a genetic base linked to nutritive and commercial importance. Such traits are mainly based on chemical attributes (aroma and flavour, nutritive attributes), and the gene-ecological characterisation of provenances, coupled with chemical studies, is needed.

A synergy between industry, consumers, scientists and farmers needs to be established to define the strategies for the development of cultivars based on consumers’ preferences and taking into account farmers’ needs (association of this species with other food and cash crops, management on farm, cultivation and post-harvest constraints). Improvement objectives are, reduced time to bearing, reduced tree height, increased fruit size and greater spread of the fruiting period (Ayuk *et al*. 1999).

Clear characterisation of germplasm sources will need to be based on highly heritable attributes so that desired traits will be combined in stocks identified as suitable for cloning and widespread cultivation.

Immediate research objectives can be summarised as:

1. Investigation of genetic variability;
2. Establishment of germplasm collections;
3. Identification and development of desirable cultivars, with larger fruit and consistent chemical properties;
4. Quantifying production of useful plant parts, particularly the kernels;
5. Development of propagation methods, to shorten the juvenile stage of the tree and reduce mature tree height.

Chapter 12. *Schinziophyton* (formerly *Ricinodendron*) *rautanenii*

Schinziophyton rautanenii was previously referred to in Chapters 1 and 2. The common name mongongo or manketti can be used in southern Africa to refer to both *Schinziophyton rautanenii* and *Ricinodendron heudelottii*. *S. rautanenii* is a fruit that is also developing interest as a crop. *R. heudelottii* can be distinguished by the fruit, which tends to be smoother with a slightly thicker seed coat than *S. rautanenii*.

The pulp of *S. rautanenii* is eaten, but usually after it has been dried. San Bushmen make a porridge out of it. The seeds are also roasted and eaten or ground to a flour for cooking (http://www.naturalhub.com/natural_food_guide_nuts_uncommon_Ricinodendron_rautanenii.htm), (Phytotrade Africa – http://www.sanprota.com/products/mongongo.htm).

The agronomy of *S. rautenenii* in Southern Africa has been examined by various authors, including Botelle (1999) on yields of natural stands, Chimbelu (1983) on management, and Mwamba (1996) on growth in agroforestry systems.

Commercialisation needs and the economic potential of *S. rautanenii* seeds are recognised in Southern Africa (see for instance Mwamba, 1996). SDK Essential Oils of Kitwe, Zambia is a company which ships seeds worldwide and is involved in the development of pharmaceutical herbal balms. PhytoTrade Africa is a trade association of South African natural products. The association is currently working with this species, with particular reference to the use of its oil. The fat content of the kernels of *S. rautanenii* tends to be slightly higher than in *R. heudelotii*. In addition, the fatty acids of *S. rautanenii* differ somewhat: lower percentage of linoleic acid (43%), greater oleic acid (18%), and greater percentages of stearic and palmitic acids (both 17%) (BRI, 1988). A domestication process in partnership with local scientists is under way in Cameroon, Nigeria, Equatorial Guinea and Gabon, and in Botswana and Zambia for *S. rautanenii*. Chidumayu (2004) discussed the production capacity of mongongo in south-western Zambia. The potential area of cultivation of the species is very wide (from Madagascar to West Africa), as it colonises fallows and secondary forests.

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Appendix I. International institutions engaged in ndjanssang research and development

CAB International
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UNITED KINGDOM
www.cabi.org/

Centre for International Forestry Research (CIFOR)
Jakarta 10065
INDONESIA
www.cifor.cgiar.org

Food and Agriculture Organization (FAO)
Forest Product Division, Forestry Department
Rome
ITALY
www.fao.org/forestry

International Centre for Underutilised Crops
International Water Management Institute (IWMI)
127 Sunil Mawatha
Pelawatte
Battaramulla
SRI LANKA

World Agroforestry Centre
African Humid Tropics Region
P.O. Box 2067, Yaoundé
CAMEROON
www.worldagroforestry.org/aht

World Agroforestry Centre (ICRAF)
Trees and Markets Theme
P.O. Box 30677, Nairobi, 00100 GPO
KENYA
www.worldagroforestrycentre.org

Appendix II. Institutions and individuals with interests in ndjanssang

National Institutions

Institut de Recherche Agricole
pour le Développement (IRAD)
P.O. Box 2067, Yaoundé
CAMEROON

The University of Yaoundé I
Faculty of Sciences
P.O. Box 812,
Yaoundé
CAMEROON

Institut National Polytechnique
Félix Houphouet-Boigny / ESA
P.O. Box 1313
Yamoussokro
IVORY COAST

Federal University of
Technology
Department of Chemistry
P.M.B. 2076 Yola
NIGERIA

PhytoTrade Africa
www.phytotradeafrica.com

SDK Essential Oils
Kitwe, Zambia
www.naturalhub.com

University of Ngaoundéré
ENSAI, P.O. Box 455,
Ngaoundéré
CAMEROON

University of Dschang
Faculty of Agronomy and
Agricultural Sciences
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Dschang
CAMEROON

Centre Ivoirien de Recherches
Technologiques
P.O. Box 881
Abidjan 08
IVORY COAST

University of Maiduguri
Department of Food Science
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P.M.B. 1069 Maiduguri
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Individuals

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CAMEROON

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ICRAF-AHT
Yaoundé,
CAMEROON

Mr. A. R. Atangana
ICRAF-AHT
Yaoundé
CAMEROON

Aboubakar Dandjouma
ENSAI, University of Ngaoundéré
Ngaoundéré,
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Mr C. Facheux
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Dr C. Kapseu
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Ngaoundéré,
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Dr J. Kengue
IRAD/PGRP
Yaoundé
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Mezajoug Kenfack L.
University of Ngaoundéré
Ngaoundéré
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Dr P. M. Mapongmetsem
ENSAI, University of Ngaoundéré
Ngaoundéré
CAMEROON

Dr C. M. F. Mbofung
ENSAI, University of Ngaoundéré
Ngaoundéré
CAMEROON

Dr R. Ndjouenkeu
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CIFOR, Yaoundé
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CADDE,
Libreville,
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NIGERIA

Mr Nguele Oloa
Ministry of Agriculture
Yaoundé
CAMEROON

Mr J. H. Pratt (Manketti only)
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8 Hannover Avenue
Pvt Bag 20
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Dr Z. Tchoundjeu
ICRAF-AHT
Yaoundé
CAMEROON

Mr T. Tiki Manga
IRAD Njombé
Njombé
CAMEROON

Mr A. C. Tsobeng
ICRAF-AHT
Yaoundé
CAMEROON

Dr B. J. Tsware
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Index