A REVIEW OF THE SILVICULTURE AND RESOURCE POTENTIAL OF A MIOMBO FRUIT TREE: *UAPACA KIRKIANA* (EUPHORBIACEAE)

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NGULUBE, M.R., HALL, J.B. & MAGHEMBE, J.A. 1996. A review of the silviculture and resource potential of a miombo fruit tree: *Uapaca kirkiana* (Euphorbiaceae). *Uapaca kirkiana* Mull. Arg. is a multipurpose tropical fruit tree indigenous to the miombo woodlands of southern Africa and widely distributed in Angola, Zaire, Burundi, Tanzania, Malawi, Mozambique, Zambia and Zimbabwe. The tree is particularly valued for its fruit which is a source of food and cash throughout its natural range. The wood is useful for timber, fuelwood, charcoal, agricultural implements and general carpentry. A brief account of its taxonomic position, botany, ecology and distribution is outlined. A major part of this review centres on the silviculture and resource potential of *Uapaca kirkiana* in southern Africa. The discussion draws attention to existing gaps in knowledge and research needs to support and enhance conservation and development of *Uapaca kirkiana* as a resource. Constraints to the realization of its full potential are identified as incomplete knowledge of the reproductive biology and breeding systems, lack of detailed propagation and cultivation procedures, insufficient data on the market potential of the fruit and its products, and lack of appropriate processing and storage technologies.

Key words: *Uapaca kirkiana* - taxonomy - botany - silviculture - resource potential - fruit tree - conservation - management - miombo woodlands - southern Africa

NGULUBE, M.R., HALL, J.B. & MAGHEMBE, J.A. 1996. Satu ulasan mengenai potensi silvikultur dan sumber pokok buah-buahan miombo: *Uapaca kirkiana* (Euphorbiacea). *Uapaca kirkiana* Mull. Arg. adalah pokok tumbuh-tumbuhan asli tropika pelbagai guna bagi kawasan hutan jarang Afrika Selatan dan taburannya adalah meluas di Angola, Zaire, Burundi, Tanzania, Malawi, Mozambique, Zambia dan

Zimbabwe. Pada keseluruhannya pokok tersebut khususnya bernilai bagi buahnya yang menjadi sumber makanan dan wang. Kayu tersebut berguna untuk balak, kayu api, arang, alat-alat pertanian dan pertukangan kayu. Satu keterangan ringkas mengenai kedudukan taksonomi, botani, ekologi dan pengagihannya telah dirangka. Bahagian utama ulasan ini menumpukan kepada potensi silvikultur dan sumber *Uapaca kirkiana* di Afrika Selatan. Perbincangan memberikan perhatian kepada perbezaan-perbezaan yang wujud dari segi pengetahuan dan keperluan penyelidikan untuk menyokong dan meningkatkan pemuliharaan dan perkembangan *Uapaca kirkiana* sebagai satu sumber. Hambatan-hambatan bagi merealisasikan potensi sepenuhnya telah dikenalpasti iaitu pengetahuan yang cetek mengenai pembiakan biologi dan sistem pembiakbaikan, kekurangan prosedur-prosedur terperinci mengenai pembiakan dan penanaman, data yang tidak lengkap mengenai potensi pemasaran buah-buahan dan keluarannya, dan kekurangan teknologi pemprosesan dan penyimpanan yang sesuai.

Introduction

The genus *Uapaca* consist of 60 species of which 49 are restricted to tropical Africa and the rest occur only in Madagascar. In tropical Africa, *Uapaca* species are found in both woodland and moist forests of west and southcentral Africa. The most widespread and best known of them, *Uapaca kirkiana* Muell. Arg., is a typical miombo woodland species of the Zambezian Regional Centre and adjacent transitional centres (White 1983). It occurs naturally in Angola, Burundi, Malawi, Mozambique, Tanzania, Zaire, Zambia and Zimbabwe.

Uapaca kirkiana is one of the few recognised important African fruit trees with economic potential which is extensively locally utilised within the natural range (Maghembe *et al.* 1994). Its fruits have high nutritional values and play an important dietary role (Carr 1957, Sufi & Kaputo 1977, Malaisse & Parent 1985, Saka & Msonthi 1994), while the wood is useful for general purposes: timber, fuelwood and charcoal, posts and agricultural implements (Goldsmith & Carter 1981). The bark and roots are used for treatment of various stomach disorders (Storrs 1979). Despite its abundance in the miombo region of southern Africa, accelerating deforestation (Hyde & Seve 1993) and the rarity of domesticated stands underline the need for active conservation.

Around the many expanding centres of population within its natural range, extensive replacement of forest by arable and tree crops has been responsible for substantial reductions in *U. kirkiana* populations. Currently farmers are interested in *U. kirkiana* only to the extent that they can harvest edible fruits, wood and other products. Beyond that, the only effort made is to select trees with good fruiting characteristics like heavy fruit load, regular fruiting, big fruits with good flavour and leave them uncut during woodland clearing prior to cultivation or settlement. Data from ethnobotanical and socio-economic studies (Maghembe & Seyani 1991, Kwesiga & Chisumpa 1992, Grundy *et al.* 1993) reveal that local farmers have strong interest in the domestication of *U. kirkiana* as a multipurpose fruit tree to eventually yield fruit to supply the growing local market and cater for domestic needs. However, available data which could guide and support cultivation of *U. kirkiana* as a resource in southern Africa remains scattered in the published and the grey literature for any effective use. This paper

therefore attempts to provide a unified pool of the existing data on the silviculture and resource potential of *Uapaca kirkiana.*

Distribution and environmental requirements

Existing information on the ecology of *Uapaca kirkiana* has been assembled and a distribution map prepared (Ngulube *et al.* 1995). The species is reported from most countries within the Zambezian centre of endemism and adjacent transitional phytochoria (White 1983): Angola, Burundi, Malawi, Mozambique, Tanzania, Zaire, Zambia and Zimbabwe between latitudes 2°S and 21°S (Figure 1). Within the natural range, occurrence is related to unimodal rainfall regime with an annual rainfall range of 500-1400 mm occurring over a 4-5 months period followed by a long dry season lasting 5-7 months. Over the range, the mean day time temperature regime is 18-29°C in the hot season and 12-24°C in winter. Typically, *Uapaca kirkiana* grows in well-drained escarpments, mostly at altitudes of 500-2000 m, with infertile sand or gravelly soils of acidic reaction. Frost-free sites are most ideal. Associated woody species include *Albizia, Anisophyllea, Brachystegia, Burkea, Isoberlinia, Julbernardia, Monetes, Parinari, Protea, Pericopis, Pterocarpus, Ochna* and other *Uapaca* species of the miombo ecozone.

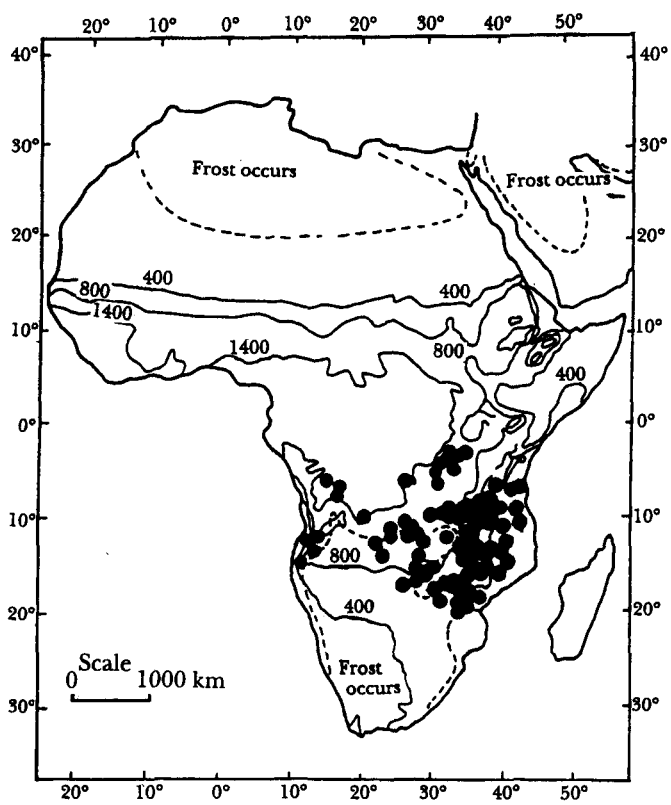

Figure 1. *U. kirkiana* distribution

Taxonomy

Uapaca is a member of the family Euphorbiaceae, subfamily Phyllanthoideae in tribe Antidesmeae, and the sole representative of the subtribe Uapacinae (Webster 1975, 1987). *Uapaca* is a Malagasy name for the genus 'Voa-paca' and was used for the Madagascar species, *Uapaca thouarsii*, described by Henri Baillon (1827-1895) in 1858.The genus currently has 60 species assigned to it (Radcliffe-Smith 1988, 1993), but there has been no recent revision on a continental scale and the number of distinct species is probably less. Racdliffe-Smith's (1988) revision of the East African members was the first major taxonomic account of the genus for over 50 years. The greatest diversity is in the Zaire Basin and further south in the miombo region. Many species names are used in ecological and floristic publications from this area but are now considered synonyms of the older names. Thus reference to *U. albida* De Wild., *U. dubia* De Wild., *U. benguelensis* Muel. Arg., *U. goetzei* Pax, *U. homblei* De Wild., *U. greenwayi* Susseng., *U. munamensis* De Wild., *U. neo-masuku* De Wild. and *U. teusczii* Pax, all signify *U. kirkiana.*

Uapaca kirkiana was named by Jean Mueller of Aargau (1864) after Sir John Kirk (1832-1922) who collected the type specimen of the species on 8 March 1862 in the Soche Hills of southern Malawi (Kirk s.n.-holotype, K). As *U. kirkiana* occurs in eight southern African countries, it has many vernacular names, the most common being wild loquat (English), msuku (Malawi, Tanzania and Zambia), nkusu (Tanzania), umhobohobo or muzhanje (Zimbabwe), matu or nt'junku (Mozambique) and mumbola (Angola).

Botany

Botanical descriptions of *Uapaca kirkiana* are provided by several authors (Pardy 1951, Drummond 1981, Palgrave 1981, FAO 1983), but perhaps the most comprehensive is the recent review by Radcliffe-Smith (1988). The tree is evergreen or semi-deciduous with spreading multiple branching forming a dense rounded crown. The trunk is short, attaining heights of 5-12 m and diameters of 5-25 cm at DBH. The bark is dark grey or grey-brown, thick and deeply fissured. Leaves are simple, 12-36 cm long and 4-24 cm wide and alternately arranged in clusters at the tips of the branches (Figure 2).

Knowledge of the phenological aspects, reproductive biology and breeding systems is incomplete. The species is dioecious and therefore outcrossing. The unisexual inflorescence originates from axillary positions among the leaves or more often below them on the previous season's wood of the branchlets in both male and female trees. Male flowers occur in dense masses, whereas female flowers are solitary. Only casual mentions indicating either insects (Hans & Mwamba 1982a) or specifically bees (Storrs 1979) and wind (Seyani 1991) as possible pollination vectors are encountered in the literature.

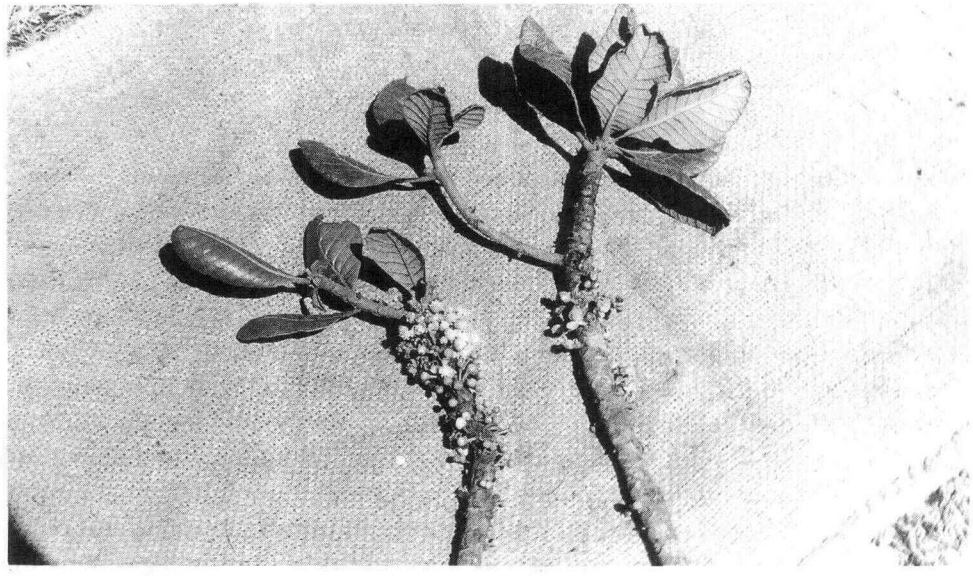

Figure 2. *U. kirkiana* branchlets with flowers

Several sources (White 1962, Storrs 1979, Palgrave 1981, FAO 1983) and herbaria records indicate September to April as the flowering period throughout the natural range. There seems to be a south to north time lag in flowering and fruit ripening, with fruits in the southern range maturing first and the northern range last. The rains follow a south to north trend; the flowering and fruit ripening is thus timed to coincide with the rainy season of the individual locality. This is especially important because the seed is in effect a small seedling at fruit ripening with the cotyledons already developed into premodial leaves with chlorophyll. The seed has characteristic short shelf life (Maghembe *et al.* 1994) requiring immediate germination after fruit ripening.

Fruit-set occurs between January and April, attaining maturity between August and November. Most sources (Drummond 1981, Palgrave 1981, FAO 1983) indicate fruit ripening taking place between September-December, but this may extend up to February (Seyani 1991) or March depending on the locality and prevailing climatic conditions. Mature fruits are globose, yellow-brown, about 2-4 cm across and lengthwise, with a tough skin enclosing 3-5 seeds. Human beings, monkeys and baboons are the most important dispersers, the fleshy fruit pulp being eaten and the seed discarded. Although elephants, bush pigs, warthogs and cattle also eat the fruit, it is not known whether they play any role in seed dispersal following defecation.

Silviculture

Natural stands

Uapaca kirkiana has not been developed through applications of purposeful management. In natural stands (Figure 3), the species coppices well after cutting or pollarding and can regenerate easily from seed. Regeneration through root suckers has been reported (FAO 1983). Fruit is the major product in *U. kirkiana* and as such, pollarding and coppicing may only be employed as a management operation for obtaining wood products. *Uapaca kirkiana* is fire-sensitive (Trapnell 1959, Lawton 1978, Kikula 1986). Therefore, in protected stands, management exclusively involves controlled early burning to stimulate regeneration and reduce the intensity of dry season bush fires. Preliminary results reveal improved fruit productivity and quality following canopy opening through thinning applications (Mwamba 1994). A spacing of 3.5 × 3.5 m seems the most ideal in this respect.

For common property resources such as village forest areas, management entails established rules controlling access to areas where *U. kirkiana* occurs (Coote *et al.* 1993, Makuku 1993, Gumbo 1993). In some communal forest areas in Zimbabwe, for example, cutting of *U. kirkiana* trees is prohibited and collection of fruits is governed by rules (Gumbo 1993). Protection is ensured by a standing penalty system enforced by the chief and his lineages (Makuku 1993).

Figure 3. *U. kirkiana* trees in a natural stand in Malawi

Propagation and cultivation

Seed supply

For good quality seed, fruit collection should be done prior to natural fall (Ngulube & Kananji 1989). Seed processing involves manual removal of the fruit skin and seed separation from the mesocarp by hand cleaning in water before air or sun drying. Small samples can be processed manually by hand, but large quantities may require a depulping machine. The seed of *U. kirkiana* is short-lived and cold storage does not prolong viability (Hans 1981, Ngulube & Kananji 1989, Maghembe *et al.* 1994). Once processed, the seed should be dispatched for sowing. Where temporary cold storage is necessary, it should not exceed four weeks for best germination results.

Nursery activity

Fresh seed germinates readily, but prospects are improved by effective scarification, manual nicking, complete endocarp removal or 24-h soaking in water at ambient room temperature (Hans 1981, Ngulube & Kananji 1989, Maghembe *et al.* 1994, Prins & Maghembe 1994). In natural stands, *U. kirkiana* forms an association with mycorrhizae which is an important feature of forest and woodland ecology (Högberg 1982, Högberg & Piearce 1986).

The importance of ectomycorrhizal inoculation to achieve successful establishment of planted stands of *U. kirkiana* has already been demonstrated (Mwamba *et al.* 1992, Maghembe 1994, Maghembe *et al.* 1994). As such, soil with mycorrhizal inoculum containing spores and pieces of roots from existing *U. kirkiana* stands should be included in nursery soil. Direct sowing into prefilled polythene tubes with the hilum facing downwards is advisable.

Germination is epigeal and takes 2-6 weeks. In natural populations, *U. kirkiana* seedlings grow in partial shade of the mature trees. Seedlings should therefore be raised under partial shade for the first few months to avoid high temperatures and direct insolation. Afterwards, however, they require full exposure to the sun. The seedlings are water-sensitive, with a permanent wilting point of about 11% (Hans & Mwamba 1982b). Therefore, for best results, maintenance of appropriate moisture levels during the entire nursery phase is necessary. Root initiation following pruning or wrenching is rapid (Mwamba *et al.* 1989) and appropriate root pruning procedures should be applied to avoid roots from firmly penetrating the nursery bed soil.

Vegetative propagation using stem cuttings has been undertaken (Kumar 1979, Hans 1981) with little success. Air-layering has potential (Kumar 1979, Sambo 1992), although survival of the rooted cuttings following planting have so far revealed poor results (Mwamba 1989a).

Performance in planted stands

Conventional plantations are non-existent, but planting of small stands for research purposes (Mwamba 1989a, Mwamba *et al.* 1992, Maghembe 1994) or single trees within land devoted to other activities (Grundy *et al.* 1993, Okafor 1993) has been undertaken. Survival figures following field planting are variable, ranging from 28-100% (Maghembe *et al.* 1994, Mwamba *et al.* 1992). If the seedlings are inoculated with ectomycorrhizae in the nursery, 100% survival in field planting is possible (Maghembe *et al.* 1994). Planting seedlings from natural regeneration has also demonstrated better survival over uninoculated nursery-raised seedlings (Mwamba *et al.* 1992). Direct field seeding is not advisable due to low germination success and subsequent survival (Mwamba *et al.* 1992).

Uapaca kirkiana is a slow growing tree under poor or no management conditions, but growth rate improves tremendously following suitable inoculation and clean weeding (Maghembe *et al.* 1994). Although exposure of *U. kirkiana* seedlings to X-rays and gamma rays prior to field planting improved growth (Hans & Lingumbwanga 1982), the results were inconclusive. Development of multiple stems occurs in early stages, attaining 2-6 stems per plant in less than three years (Mwamba *et al.* 1992, Maghembe *et al.* 1994). The tree architecture of *U. kirkiana* seedlings or coppices indicates existence of a weak apical dominance.

Harvesting

Uapaca kirkiana, being widely utilised as a multipurpose resource, supplies products throughout the year. However, the only product harvested on a consistent and predictable basis is the fruit. In planted stands, fruiting occurs within 9-10 years (Mwamba 1989a), but yield figures are not available. However, fruit loads exceeding 600 fruits per tree (about 18 g per fruit) have been recorded in some natural stands in Zambia (Mwamba 1992).

Mature and ripe fruits fall naturally from the trees and these are easily collected from the ground. Collection of fruits from short trees or trees with lower branches is done directly. For tall trees, fruit collection may involve climbing, shaking the tree using a stone or some such instrument as a way of dislodging the fruits. Breaking of branches or branchlets to collect fruits is prohibited as this may adversely affect subsequent yield, fruits being borne only on previous season's wood of the branchlets.

Protection

No serious pests and diseases have so far been reported attacking *U. kirkiana* in natural populations or planted stands. Necrosis, linked with *Pestalotiopsis versicolour,* leaf spots caused by *Cercospora* species, mildews and sooty moulds such as *Cladosporium cladosporioides,* have been recorded on *U. kirkiana* foliage without any serious consequences (Parker 1978). Phytophagous insects: *Cercoplastes uapacae,*

Ledapis spp., *Microsyagrus rosae* and *Euphoria* spp. may cause 10-20% foliar damage in *U. kirkiana* (Parker 1978). *Carpohilus fumatus* and *Deudorix* spp. attack mature fruits to feed on the pulp, followed by *Drosophila enanasse* and *Ceratitis cosyrae* which rapidly degrade the ripe fruits (Parker 1978). The economic importance of these insects, however, remain unassessed, and prescriptions for their control undeveloped.

In natural stands or on the farm, branches of *U. kirkiana* trees are sometimes attacked by hemiparasites (family Loranthaceae), mainly *Agelanthus subulatus, Phragmanthera cornetii, Tapinanthus dependeus* and *Viscum congdonii.* The effect of these parasites on the fruit load is still unassessed and procedures for their control unavailable. Removal of attacked branches has proved ineffective as other branches are subsequently attacked by the parasites. Mature fruits are eaten by elephants (*Loxodonta africana*), baboons (*Papio cynocephallus*), blue monkeys (*Cercopithecus mitis*), velvet monkeys (*Cercopithecus aethiops*), thick tailed galago (*Galago crassicaudatus*), lesser galago (*Galago senegalensis*) bush pigs (*Potamochoerus porcus*), warthogs (*Phacochoerus aethiopicus*) and squirrels (*Sciurus* species).

Animal damage through browse and trampling is critical during the juvenile phase. In the wild, elephants (*Loxodonta africana*), eland (*Taurotragus oryx*) and zebra (*Equus burchelli*) are some of the main browsers of *U. kirkiana* (Jachmann 1989, Shorter 1989). Fire damage is also critical at the early stage. Vegetation growing close to planted *U. kirkiana* seedlings must therefore be eliminated through clean weeding to provide optimal conditions for establishment and reduce the hazard of dry season fire. Total fire-protection of planted stands of *U. kirkiana* is mandatory for successful establishment, after which, the use of fire as a management tool could be applied as appropriate.

Resource potential

Food

Throughout its natural range *Uapaca kirkiana* plays a useful and valuable role in the economy of the local inhabitants. The fruit is so far the only part used as a food source throughout the range. The fleshy pulp of the ripe fruit is edible and eaten fresh. The pulp is also processed into a wide variety of refreshments, including juices, squashes and wines (Hans *et al.* 1978, Storrs 1979, Hans 1981, Fox & Young 1982, Pullinger & Kitchin 1982, FAO 1983, 1990, Campbell 1987, Mwamba 1989a, Seyani 1991, 1994, Lovette 1993, Maghembe *et al.* 1994). In Malawi and Zambia, popular brands of *U. kirkiana* wines, "Mulunguzi" and "Masuku", respectively, are commercially produced and sold in city supermarkets (Mwamba 1989a, Seyani 1991). In Malawi, the fruit is also used in brewing an opaque local beer "Napolo Ukana" and distillation of a local gin "Kachasu". The fruit pulp is also used as a sweetener in the preparation of jam, sweet beer, porridge and cakes.

Nutritionally, the fruit pulp is a source of carbohydrates, energy, fibre, mineral elements, proteins and vitamins (Sufi & Kaputo 1977, Malaisse & Parent 1985, Saka *et al*. 1992, Saka & Msonthi 1994). Among the 90 species analyzed for fruit nutrition (Malaisse & Parent 1985), *U. kirkiana* is recorded among the five with the highest content of carbohydrates. Among the related *Uapaca* species, *U. kirkiana* ranks highest in carbohydrates, fibre, phosphorus, iron and dry weight (Table 1). Sufi and Kaputo (1977) recorded seven types of sugars in the fruit pulp of *U. kirkiana*: 4.1% glucose, 2.7% fructose, 1.5% sucrose, 0.2% xylose and traces of raffinose and ribose. Saka *et al*. (1992) recorded 16.8 mg per 100 g ascorbic acid, 27.4% dry matter and a pH of 5.05 for the pulp. Hans (1981) indicated a 22% oil content in the seed without any other details.

Wood

The wood of *U. kirkiana* has diverse uses. Reports consistently indicate the wood as useful for domestic utensils, furniture and joinery, carvings and boxes. The round wood is also locally used in house or fence construction as poles (Cunningham 1993). The wood is also a useful source of good quality firewood and charcoal, although specific comments on product quality are unavailable.

Table 1. Nutritional composition of the fruit pulp of *Uapaca* species.

Component	*U.bengelensis*[1]	*U.kirkiana*	*U.nitida*	*U.pilosa*	*U.robynsii*
Energy (Kj)	1378	1420	1462	1482	1462
Energy (cals)	330	340	350	355	350
Dry weight (g)	33.0	42.0	30.4	25.2	17.0
Water (g)	67.0	58.0	69.6	74.8	83.0
Proteins (g)	2.7	0.02	8.0	2.6	2.0
Fats (g)	0.1	1.0	2.9	3.4	1.8
Ash (g)	6.0	2.5	2.8	3.2	3.1
Fibre (g)	2.2	4.3	3.4	2.5	1.9
Carbohyd. (g)	89.0	92.0	82.9	88.3	91.2
Calcium (mg)	60	40	-	90	-
Phosphorus (mg)	100	112	-	50	-
Iron (mg)	20	275	-	5	-

[1]Originally regarded as a separate species under *Uapaca benguelensis*.
Source: Malaisse and Parent (1985).

Heartwood and sapwood are not clearly differentiated, the wood being uniform, pale pink-red when fleshly cut, changing on exposure to deep pink-red with brownish tinge (Goldsmith & Carter 1981). The texture is medium and fairly even. Rays are straight, prominent and highly figured in radial section. Tangentially, ray ends appear regular and symmetrical, forming a plain unfigured pattern with fibre. Vessels are few, small to large sized, solitary and surrounded by parenchyma. Growth rings are poorly defined. Tyloses and gum deposits are absent.

The wood shows no serious seasoning defects or degrade if properly stacked and dried slowly under cover. Durability is moderate, having low susceptibility to insects (termites and wood borers) and fungal attack. Impregnation with preservatives is, however, difficult (Goldsmith & Carter 1981), but the wood saws cleanly and easily to true edges, planes without difficulty to a smooth finish. It also glues firmly, paints well and takes a clear vanish finish. It works well with both hand and machine tools, firmly holding nails after nailing. Reports on mechanical and shrinkage (radial and tangential) properties of the wood are unavailable. For wood density, Goldsmith and Carter (1981) recorded 670 kg m^{-3}.

Medicinal values and other uses

The leaves, bark and roots of *U. kirkiana* are widely used in preparation of traditional medicines. An infusion of the roots is used to cure indigestion and dysentery (Fanshawe 1968, 1972, Storrs 1979, Hans 1981, Palgrave 1981, Seyani 1991, 1994). The leaves are an effective cockroach repellent in households. Information on the chemical extracts and the effectiveness of these treatments is, however, unavailable. A local blue dye is made from the roots of *U. kirkiana* and a salt for seasoning food is also obtained from the wood ash. The thick-broad leaves are used as wrappers for storage of processed food. The fleshy fruits contribute a substantial amount of animal feed, albeit for a short period (Walker 1980). The flush of *U. kirkiana* leaves appearing at the end of the dry season is utilised by cattle as fodder in the absence of more palatable alternatives (Rees 1974, Lawton 1980, Walker 1980, Kwesiga & Chisumpa 1992).

Services and other benefits

Uapaca kirkiana provides good shade in homesteads and in farms during the dry and hot season. As a dominant or co-dominant tree of the miombo vegetation in hilly sites, it is useful in watershed management. *Uapaca kirkiana* also provides ideal faunal and plant habitats. It serves as host to a hemipterous bug, *Encosternum delegoruri* during winter (Makuku 1993). These bugs benefit from the protective shelter and the microclimate (morning dew) generated by the dense crowns of the trees. In Malawi and Zimbabwe, these bugs are sold for cash in markets and are therefore an important source of protein and cash for the rural communities. Flowers of *U. kirkiana* are a source of bee forage with a good honey flow (Storrs 1979) and thus plays an important role in apiary within the miombo woodland vegetation.

In natural stands, *U. kirkiana* forms an association with mycorrhizae which is an important feature of forest and woodland ecology (Högberg 1982, Högberg & Piearce 1986). *Amanita, Cantharellus, Lactarius* and *Russula* constitutes the major commonest genera of fungi which typically form ectomycorrhizas within the miombo woodland vegetation (Williamson 1975, Pegler & Piearce 1977, Morris 1987). These fungi belonging to the basidiomycetes are widely collected and

consumed or sold in markets during the rainy season. Some are dried and stored for later use or sale and a limited export market for freeze-dried ones also exists. The fungi supply the trees with phosphorus and other nutrients, most of the nutrients being utilized by the plants and recycled, but some are left to enrich the soil. As natural sources of phosphates are finite, *U. kirkiana* may be an important agroforestry tree in the maintenance of soil fertility in degraded sites as mentioned in some reports (Kwesiga & Chisumpa 1992, Minae *et al.* 1994).

Discussion

Uapaca kirkiana has great potential for domestication as a source of food and other products and services within the miombo ecozone of southern Africa. Within its natural range, sale of *U. kirkiana* fruits in local markets and along road sides for consumption or to industries for processing into refreshments and alcoholic drinks is a flourishing business. Thus it is an integral part of regional economic systems. Despite its importance as a source of food, cash and wood products, its future is threatened by extinction due to the ever-increasing pressures on the miombo woodlands caused by increasing population, intensification of various land use practices, infrastructural development and associated environmental problems.

Uapaca kirkiana is an important agroforestry tree being deliberately retained in farm fields or around the homesteads for its fruit (Hans *et al.* 1978, Campbell 1987, Maghembe & Seyani 1991, Kwesiga & Chisumpa 1992, Grundy *et al.* 1993, McGregor 1994). In the absence of details of any form of management of the planted trees natural regeneration seems much more significant than schemes involving planting. Efforts to support the domestication of *U. kirkiana* are, however, already being made by National Tree Seed Centres within the Southern African Development Community (SADC) through organised collection and sale of the seed to the public. In the absence of knowledge of the seed biology, an extended nursery phase (>8 months) of *U.kirkiana* increases costs. Such an extended nursery phase may not be appealing to the rural public wishing to raise their own planting stock. As a dioecious species, selection of the male and female individuals at an early stage is ideal. At present, this can only be done at the flowering stage, making early selection of the individuals to retain problematic. Detailed data on seed biology, seedling characteristics (which would facilitate early sex identification) and nursery procedures are therefore required to bridge these knowledge gaps.

Little work has been done to develop appropriate vegetative propagation procedures for securing planting stock of *U. kirkiana.* Vegetative propagation techniques developed for several other tropical trees (Leaky 1990, Leaky & Coutts 1989) have great potential as tools for rapid multiplication for domestication and conservation strategies of *U. kirkiana.* The potential of tissue culture in this respect is currently under investigation at the University of Malawi (Kwapata 1994) and in Zambia at the Tree Improvement Centre of the National Council for Scientific Research.

Considering the likely high degree of genetic variation implied by its wide distribution within the miombo woodlands of southern Africa, much has to be done to select superior genotypes with regard to fruit size, pulp and nutrient contents, palatability and resistance against pests and diseases. Occurrence of intermediates between *U. kirkiana* and *U. sansibarica* (Radcliffe-Smith 1988) suggests that hybridisation within the *Uapaca* species is possible. Available literature draws attention to the variability in size, yield and quality of the fruits of *U. kirkiana* (Mwamba 1989b, 1994, Hans 1980, 1981). Breeding improved varieties of *U. kirkiana* will, however, depend on a well organised programme of provenance surveys and trials as well as detailed studies of the reproductive biology, breeding systems and the pollination ecology. Investigations should also be conducted into other *Uapaca* species, both from the point of view of this breeding programme and in their own right.

U. kirkiana has great potential for development as a tree crop producing food and other products within the miombo ecological zone of southern Africa (Hans *et al.* 1978, Hans 1981, Campbell 1987, Mwamba 1989a, Seyani 1991, Lovett 1993, Kwesiga & Mwanza 1994, Maghembe *et al.* 1994, Minae *et al.* 1994, Temu & Msanga 1994). However, this will not be possible in any efficient fashion if the market potential upon which the crop is ultimately dependent is undeveloped. Considerable market opportunities already exist in Malawi and Zambia following the development of winery industries whereas, for most other countries, the fruits are still largely collected for domestic consumption and small scale sales in markets or along the road side. Therefore, in order to obtain maximum benefit from the productivity of the fruit, careful evaluation of available markets and a solid research base for storage and processing of the fruit should be established.

Apart from direct nutritional contribution, a significant potential for developing cottage industries based on the *U. kirkiana* fruit exists. For example, a number of food products, including jam and jellies, juices, cakes and beverages could be produced commercially from the fruit. Such industries could enhance the improved use of the edible products, as well as promote the development and conservation of *U. kirkiana* for the large-scale supply of raw materials. Chemical characterisation of the roots, bark and leaves which are reportedly used in administering traditional recipes to cure stomach disorders should receive scientific attention. Similarly, the reported dye properties of the bark and the ash properties of the wood should be explored in some detail.

The natural distribution of *U. kirkiana* cuts across national boundaries and is widespread throughout the Zambezian region of endemism (Figure 1). It is therefore important that international agricultural research centres, in particular, the International Centre for Research in Agroforestry (ICRAF), Southern Africa Development Community (SADC) Regional Tree Seed Centre Network Project, Southern Africa Centre for Cooperation in Agricultural Research (SACCAR) and SADC Regional Gene Bank, should take the lead with the national institutions to develop research into domestication of this valuable multipurpose tree resource. A multidisciplinary approach should be adopted in the implementation of a more dynamic and intensive development programme which would generate and draw

together knowledge of the biological features, ecological character and utilisation potential as a firm basis for management, conservation and improvement of *Uapaca kirkiana* as a multipurpose tree crop of the miombo ecological zone of southern Africa.

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