COLA NITIDA

&

COLA ACUMINATA

A State of Knowledge Report undertaken for
The Central African Regional Program for the Environment

by

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1 TAXONOMY

1.1 The genus *Cola*

Cola, a tropical African genus of the family Sterculiaceae, comprises about one hundred and twenty five species. *Cola* species are evergreen, mostly small or moderately sized trees although a few grow to 25 metres. A number of species are widely cultivated in tropical countries, especially in Africa. The most commonly used are *C. verticillata* (Thonn.) Stapf, *C. acuminata* (Pal. de Beauv.) Schott and Endl. and *C. nitida* (Vent.) Schott and Endl., with the latter two having the greatest economic importance (Lovejoy, 1980).

The following description of the genus is given in (Opeke, 1992):

> *Trees or shrubs with alternate leaves; stipules present although sooner or later dropping. Male and hermaphrodite flowers grouped into a panicle of cymes, or in fascicles on the branches or on the trunks. Five sepals; male flower: the anther loculi are placed laterally at the top of the androecium in one or two superimposed rings; hermaphrodite flower, style short, stigma fleshy, more or less recurved, a vestigial androecium at the base of the gynaecium. Fruit: five to ten follicles, placed perpendicularly on the peduncle, radicles directed towards the hilum. After germination of the seedling the cotyledons are subhypogynous.*

The leaves of *Cola* species are simple, entire and narrowed or rounded towards the base. The arrangement of the leaves on the stem is alternate in some species and verticiliate, in whorls of 3 or 4, in others.

The flowers of both *C. nitida* and *C. acuminata* have a white or coloured perianth. Typically, trees bare two types of flowers; male, with anthers fused into a single column or hermaphrodite with one or two rings of anthers at the base of the superior ovary. After fertilisation, the ovary divides forming separate fruiting carpels or follicles, usually five to ten in number. Fruits are sessile, placed at the end of a short peduncle, from which they radiate in star-shaped fashion. As the fruit increases in weight, the stem hangs vertically and the follicles are borne horizontally or ascending in recurred fashion, containing one to ten seeds.

The nuts of a small number of *Cola* species, including *C. nitida* and *C. acuminata*, are good to eat though most species produce seed that is hard and inedible. Some *Cola* species are

polycotyledonous, e.g. *C. acuminata*. The seed of the edible species is ovoid or ellipsoid, or angular by compression, varying in size up to 5 cm long and 3 cm in wide. Most of the seed consists of cotyledons to which the minute embryo is attached. In *C. nitida* there are two cotyledons and the seeds readily split into half whilst in *C. acuminata,* where there are three or four cotyledons, sometimes as many as six, the seed splits into a corresponding number of pieces (Irvine, 1956; Keay, 1958; Russell, 1955).

1.2 Botanical history of *Cola* species

Kola nuts were widely used in West and Central Africa long before the arrival of European voyagers (Russell, 1955). Leo Africanus referred to a bitter nut with the name *'goro'* which he encountered during a visit to western Sudan in 1556. This is the name that is used to refer to kola in Nigeria. However, the first definite description of kola nuts was made by Edouado Lopez, a Portuguese traveler, who saw seeds with four cotyledons in 1593 (Chevalier and Perrot, 1911).

In 1805 Palisot de Beauvois published an account of specimens that he had collected during a visit in 1786 to parts of what is now Nigeria. Among the species he described was the local kola tree, named by him as *Sterculia acuminata* (Russell, 1955). In the same year Ventenat described a species he was sent from Mauritius as *Sterculia nitida*. Both species subsequently became part of the genus *Cola* when Schott and Endlicher created it in 1932.

According to Russell (1955), the systematics of kola species was in a state of "indescribable confusion" by the beginning of the Twentieth Century as a result of a profusion of new species, named on the basis of very meagre evidence. It was not until the French botanists Auguste Chevalier and Emile Perrot's (1911) taxonomic account that clarity was restored. Chevalier created the subgenus Eucola to contain the five species of edible kola nut: *C. nitida* (important for trade), *C. acuminata* (important for socio-cultural values), *C. ballayi, C. verticillata* and *C. sphaerocarpa*. The latter three species are not known to be cultivated, but their seeds are sometimes use to adulterate the produce of the commercial species when it is scarce.

1.3 *Cola nitida* (Vent.) Schott and Endlicher

Synonyms
Sterculia nitida Ventenat
Cola vera Schumann
Cola acuminata (Beauvour) Schott and Endlicher
Cola acuminata Engler

Listed by Hutchinson and Dalziel (1958).

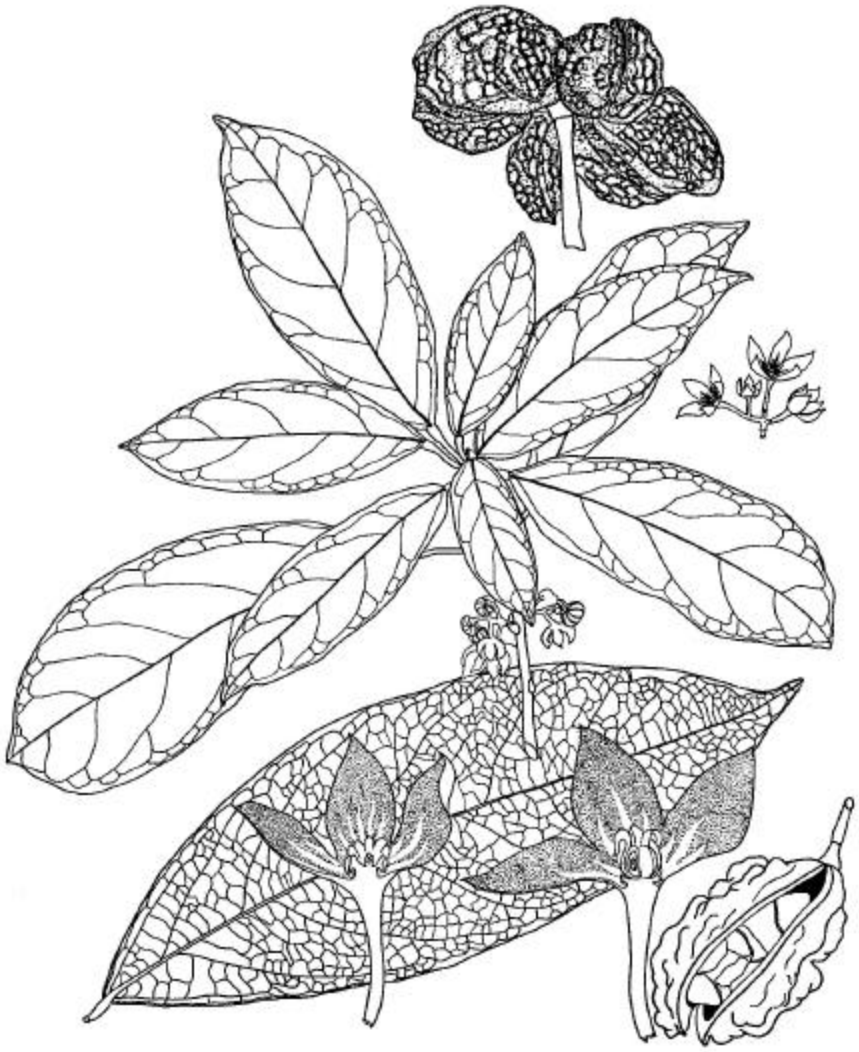

Figure 1: *Cola nitida* (Vent.) Schott & Endl. (Purseglove, 1968).

Description

Cola nitida is a medium sized (<25m) evergreen forest tree. The bole is usually unbranched reaching to 8-20 m in height and sometimes attaining 24 m. The trunk may grow to 50cm in diameter with, in old trees, narrow buttresses extending to about 1 metre. The bark of the tree is grey with longitudinal fissures (FAO, 1995; Keay, 1958; Russell, 1955)

The dark green leathery leaves are usually sparse and confined to the tips of branches. The leaves are simple up to 33 cm long and 13 cm in width with apex abruptly and shortly acuminate with long petioles often swollen at the top (Fig lB). Measurements of two hundred leaves from various sources gave the following mean dimensions: lamina length 16.3 cm,

width 5.6 cm, petiole length 4.1 cm (Russell, 1955)

Reproductive ecology

The flowers have a faint smell and are borne in inflorescences of axillary cymes, non-verticilate, flowers male or hermaphrodite, apetalous, cream or white coloured usually with a small dark red markings within. There is however, great variation in the proportion of male and female flowers between racemes and from tree to tree. Typically the hermaphrodite flower has a five lobed calyx, five curved fleshy stigmas lying over the ovaries which in turn rest on a plate-like structure round the edges of which are two rows of ten rudimentary stamens. In the male flowers the anthers develop fully and yield yellowish, slightly sticky pollen; the gynoecium is absent (Keay *et al*, 1960).

The number of carpels may vary from one to six. The green, warty carpels are arranged as a star and are borne on a short, pendant peduncle (1-10 cm), and are up to l3 cm long and 7 cm wide, usually horizontal or in a recurved position. Each carpel contains 4-10 seeds, usually with two cotyledons, arranged in two rows, surrounded by a thin but tough membranous white skin. The nuts are generally pink or red depending on the variety though sometimes they are white (FAO, 1982; Keay *et al.*, 1960; Russell, 1955; Voelcker, 1935).

Species and cotyledon colour within C. nitida

Chevalier and Perrot (1911) recognised a number of sub-species within *Cola nitida.*. In their publication the sub-species were described as *alba, rubra, mixta* and *pallida* all of which are cultivated in Nigeria. The main difference between these sub-species lies in the colour of the seed. The sub-species *alba* is distinguished by the absence of red coloration in the flower. Chevalier further observed that *C. rubra* trees produce only red nuts; *C. alba*, pink and white, and *C. pallida* trees producing small pale pink or white and pink nuts mixed and that the colour of the nuts of any one variety may alter from year to year.

Russell (1955) believed that the criteria that Chevalier's used to differentiate sub-species within *Cola nitida* were too slight to justify their formation. Two distinctive kinds of *Cola nitida* were therefore described merely as 'white flowered' and 'red flowered'. Chamney (1927, cited in (Voelcker, 1935)), in his publication of *Distribution of white and pink seeds of kola nuts plants in Ghana* concluded that cotyledon colour is a function of age. However, Voelcker (1935) summarised his findings from the experiments at Moor Plantations in Ibadan, Nigeria as below:

- The colour of the cotyledon of *C. nitida,* may be red, white or intermediate shades of

pink. The red is the most common; white is rare in Nigeria.

- The colour of the nuts may vary from follicle to follicle, from tree to tree, and, on the same tree, from year to year.
- The colour has been shown to be determined by the genetic constitution of the tree on which the flowers are borne and of the tree, which yields the fertilising pollen.
- Trees grown from white nuts produce only white nuts when the flowers were self - fertilised.
- Trees grown from white nuts produce red, pink or white when the flowers are fertilised by pollen from trees grown from red nuts.
- Crossing flowers from trees grown red nuts with white pollen gave red and white fruits.

Voelcker proposed that his findings indicated that the inheritance of cotyledon colour is purely Mendelian, and is determined by the interaction of a number of genes.

1.4 *Cola acuminata* (Beauvoir) Schott and Endlicher

Synonyms
Sterculia acuminata Beauvoir
Cola pseudoacuminata Engler

Listed by Hutchinson and Dalziel (1958).

Description
Cola acuminata is a slender tree which can grow up to a height of 30 m, but usually 10 - 20 m with diameter of about 30 cm. The trunk commonly branches close to the base with the leaves almost reaching the ground. The branches are many, frequently divided, slender and crooked, markedly ascending. The bark of the old trees is rather rough and corky, grey in colour and often split into squares. On the larger branches the bark is smooth, corky warts and an olive colour are frequent and are distinctive characters of this species when present.

The foliage is simple, sparse and confined to the tips of the branches. They are very dark green, rather fleshy, often curled with lateral veins, which is not prominent. In shape they are elliptic or slightly obovate, rounded at the base and with long petiole which is as long as one metre. The leaf is not flat but often curved, keeled at the mid-rib and twisted at the tip. Russell (1955) gave mean dimensions of a large number of leaves from different: lamina length 16.3 cm, maximum width 5.6 cm, petiole length 4.1 cm.

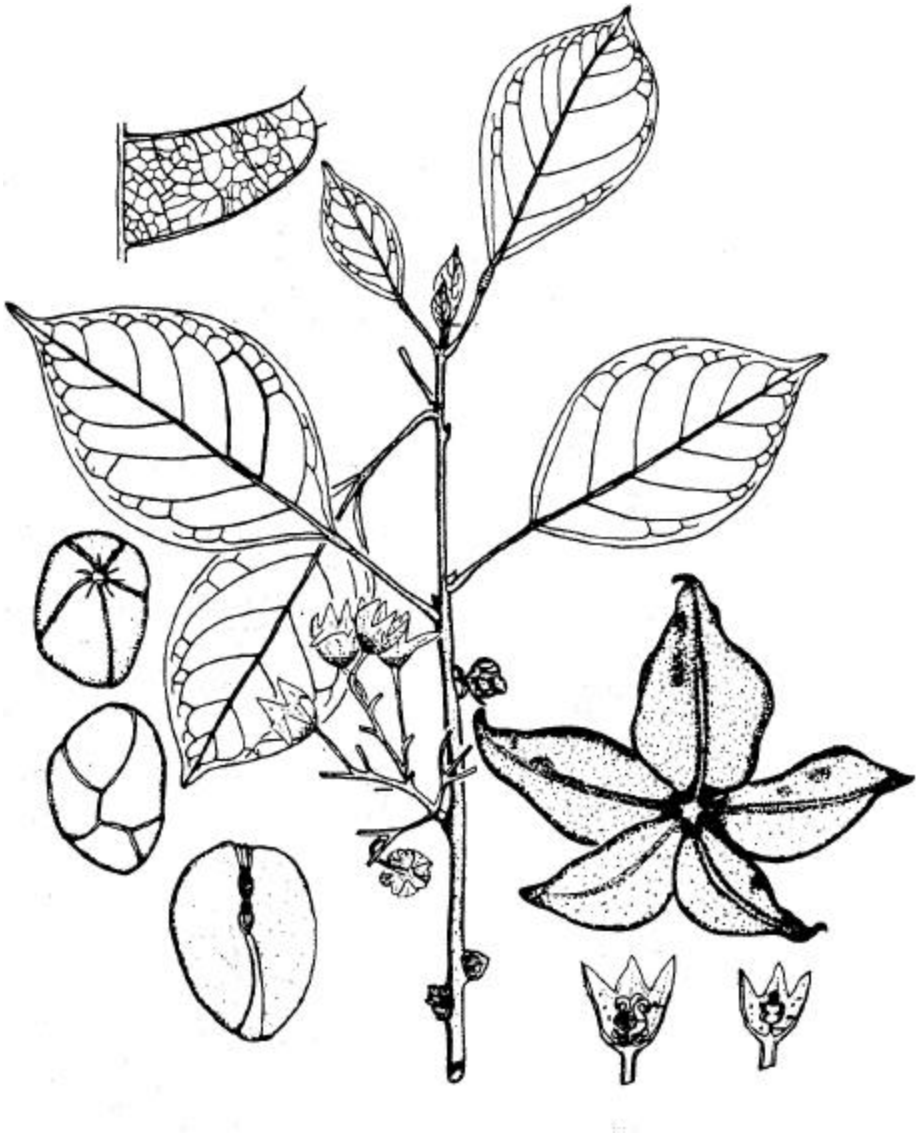

Figure 2: ***Cola acuminata*** **(P. Beauv.) Schott & Endl. (Nkongmeneck, 1985).**

Reproductive ecology

The inflorescence has several to many flowers, which are not arranged in whorls. The perianth is joined for nearly half its length and often forms an open cup up to 2.5 cm, with white or cream colour and small dark-red coloration at the base of segment inside, being most marked along the veins. Both hermaphrodite and male flowers are found on a single tree, with male flowers being smaller. The perianth is glabrous inside or with scattered stellate hairs. The anthers are borne on a short, but distinct column (Keay, 1958; Opeke, 1992; Purseglove, 1968; Russell, 1955).

The fruits are borne on young branches and form a star-shaped cluster of pods, usually

numbering five, with each carpel bearing 4-10 seeds (Fig. 3C). Most of the fruits are harvested from April to June and hence making it markedly different from *C. nitida*. The carpels are sessile, brownish in colour, straight or slightly curved with a prominent straight point or tip, the whole up to 20.3 cm long and 6.4 cm wide, the surface is rough to the touch, russet or olive-brown.

The seeds in each carpel are arranged in two rows covered with a thin white skin. The seeds are commonly pink or red, but occasionally white, up to 4 cm long and 2.5 cm wide (Fig. 3D). The cotyledons are distinctively three to five and even six, pink, red or sometimes white in colour and more viscid than those of *C. nitida* (Keay *et al.*, 1960; Purseglove, 1968; Russell, 1955).

Tree parts	***Cola nitida***	***Cola acuminata***
Leaves	Leaves abruptly acuminate, flat, with nerves prominent,	Leaves remain acuminate curved and twisted.
Fruits	Fruits curved, with prominent keel extended to form a curved beak, rugose or tuberculate, green, smooth to the touch.	Fruits straight or slightly curved not rugose or tuberculate, resset, rough. to the touch.
Seeds	Seeds with two cotyledons.	Seeds with more than three cotyledons, usually four or more.
Germination	The two cotyledons remain closed, and the plumule arises outside them	Four cotyledons spread open and the plumule grows up between them.
Harvesting season	October to December.	April to June.

Table 1: Key distinctions between *C. nitida and C. acuminata*

2 DISTRIBUTION

Cola nitida was originally distributed along the west coast of Africa from Sierra Leone to the Republic of Benin with the highest frequency and variability occurring in the forest areas of Côte d'Ivoire and Ghana (Opeke, 1992). Chevalier and Perrott (1911) and Warburg (1902) both quoted in (Opeke, 1992) stated that cultivation of *C. nitida* was carried eastwards

through Nigeria towards Cameroon and the Congo around 1900, and spread westwards as far as Senegal (Opeke, 1992). *C. nitida* is planted through Senegal, Guinea, Liberia, Côte d'Ivoire, and Ghana towards the western part of Nigeria (Voelcker, 1935).

Southern Nigeria is considered the center of occurrence of *C. acuminata*, with its original area of distribution stretching from Nigeria to Gabon. *C. acuminata* also occurred spontaneously in the mountainous areas of Angola, Zaïre and Cameroon, and it has long been in cultivation on the islands of Principe and São Tomé (Opeke, 1992). It has also been cultivated in Angola, Fernando Po and Tanzania. (Fereday *et al.*, 1997).

West Africans took the seed with them when they traveled, even in the days of the Slave Trade. Kola has therefore been extensively cultivated in tropical South and Central America and the West Indies. It has also spread eastwards to Mauritius and Malaysia (FAO, 1982; Purseglove, 1968; Russell, 1955). Seeds were distributed from Kew Royal Botanic Gardens for planting in Calcutta, Singapore, Sri Lanka, Java, the West Indies and United States of America (Moloney, 1887).

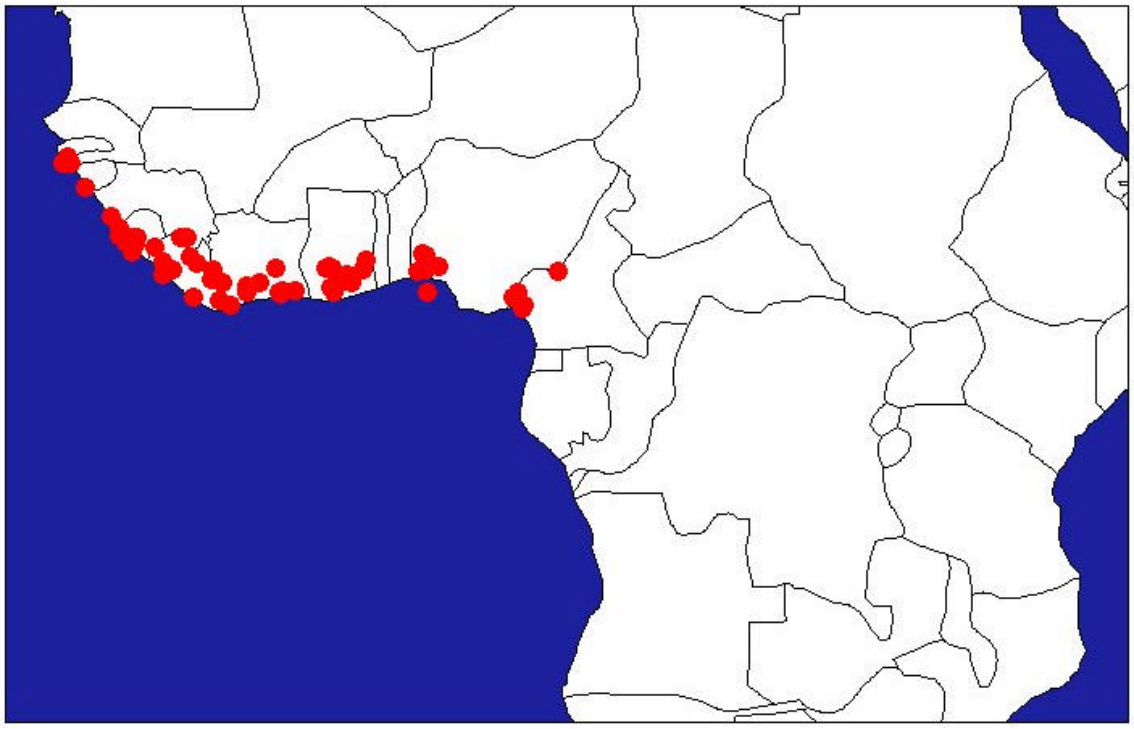

Figure 3: Collection locations of 130 herbarium specimens of *C. nitida* from Meise, Wageningen, Kew and Missouri herbaria. Specimens taken from cultivated trees have not been plotted.

Cola species have been cultivated in tropical South and Central America, the West Indies,

East of Mauritius, Sri Lanka and Malaysia. The trade in slaves from West Africa was often the vector for the spread of this species (Russell, 1955).

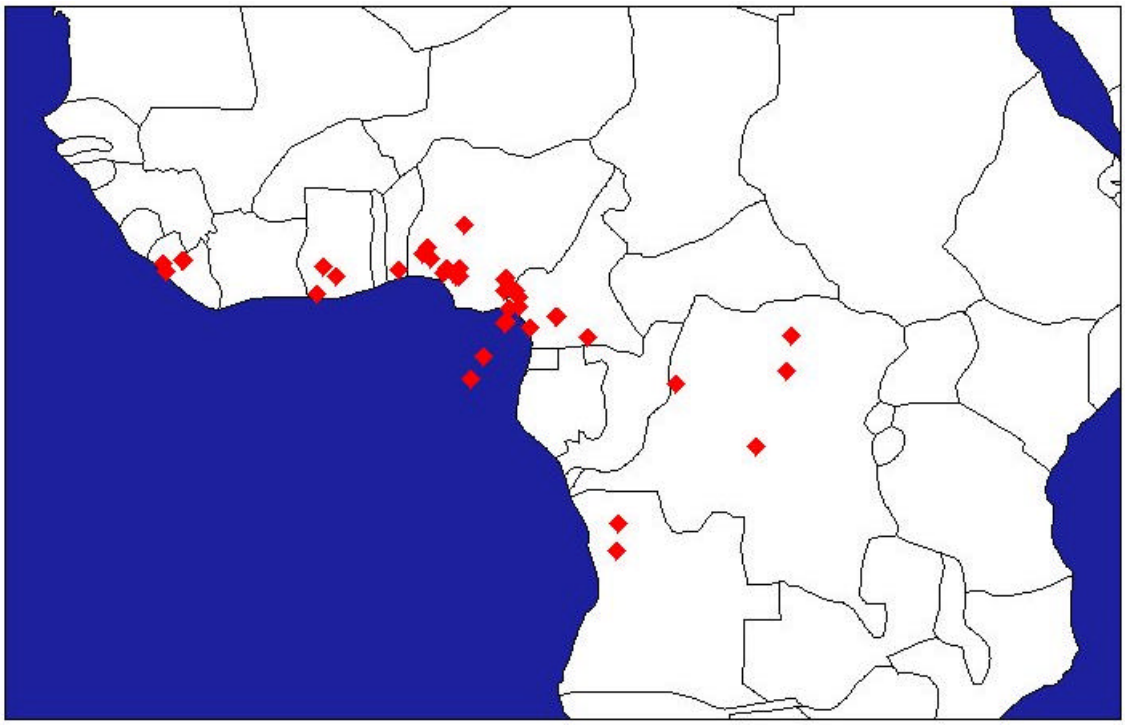

Figure 4: Collection locations of 83 herbarium specimens of *C. acuminata* from Meise, Wageningen, Kew and Missouri herbaria. Specimens taken from cultivated trees have not been plotted.

3 ECOLOGY AND PHENOLOGY

3.1 Ecology and Climatic zones

Cola species occur in the hot tropical lowland forest with rainfall extending over a period of 8 months or more and a temperature of between 23°C and 28°C (Ekanade, 1989). Species have also been cultivated in the transitional zones where the forest gives way to the savanna (Opeke, 1992). It is mainly grown between 6° and 7° north of the equator, but has also been found up to 10° N on the West Coast of Africa. The species requires a hot, humid climate with well-marked wet and dry seasons, and it is capable of withstanding three or more months of dry season (Keay *et al.*, 1960).

The preferred annual rainfall for *Cola* species is about 1700 mm. However, further inland towards the moist deciduous forest and the savanna, where the dry season extends up to seven

months or more, kola can grow with annual rainfall of about 1200 mm. It is also relevant to note that small patches of *Cola nitida* could be cultivated far beyond the drier areas to the north where growth could only be made possible by the occurrence of wet land with a high water-table (Russell, 1955).

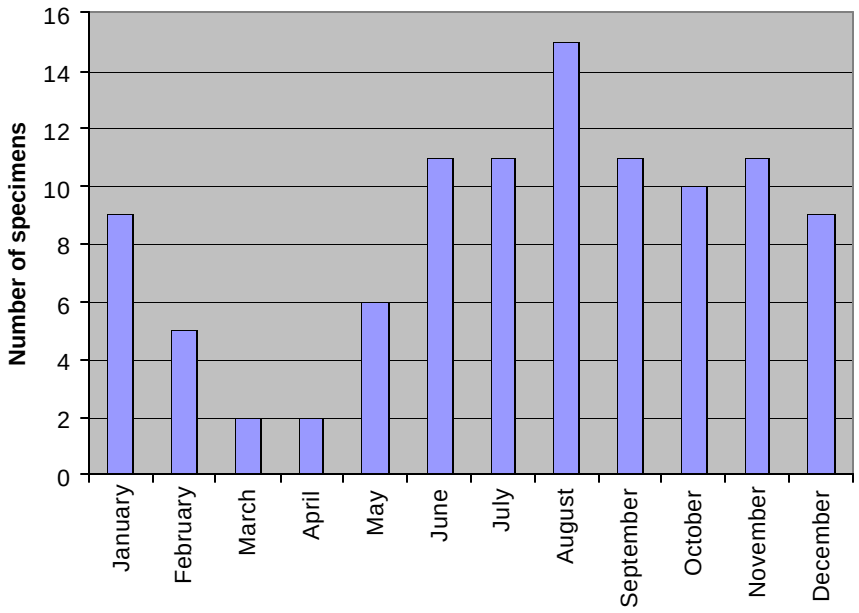

Figure 5: Collection month of 108 flowering herbarium specimens of *C. nitida*

Unlike *Theobroma cacao*, which grows in soils with good moisture retaining capacity, *Cola* species flourish in both heavy and light soils as long as they have good depth. In well-drained, fertile soils containing much humus vigorous growth and early fruiting is favoured (Bucher, 1909). The root system of the kola tree ramifies profusely in the top layers of the soil with the taproot typically reaching a depth of 120 or 150 cm.

Russell (1955) records a profusion of flowers on most trees of *C. nitida* in July and August and sporadic bursts of flowers thereafter. According to Voelcker (1935), flowering of *C. nitida* takes place sporadically throughout the year unless drought occurs.

The main flowering flush commences in the middle of the wet season between July and August, but sometimes May-January (Keay *et al.*, 1960) and gives rise to the crop which is harvested four or five months later. Analysis of 108 herbarium specimens of *C. nitida* showed that flowers had been collected through most of the year across this species' range. Few flowering specimens were collected in March-April (see Figure 5).

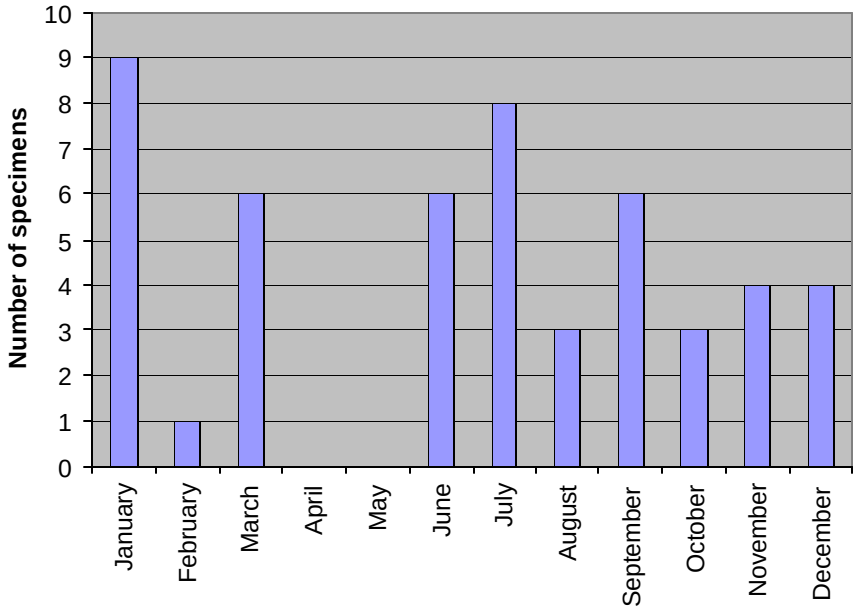

Figure 6: Collection month of 53 flowering herbarium specimens of *C. acuminata*

In Nigeria *C. acuminata* flowers abundantly in the dry season from December to February, and to a lesser extent in August and September. Fruits are harvested from April to June (Russell, 1955). Not one of 53 flowering herbarium specimens of *C. acuminata* had been collected during April-May (see Figure 6). Two peaks of flowering were found, one in January, the other in July.

3.2 Kola nut composition

The seed of kola comprises 13.5% water, 9.5% crude protein, 1.4% fat, 45% sugar and starch, 7.0% cellulose, 3.8% tannin and 3% ash. The seed is also rich in caffeine (2.8%) and theobromine (0.05%) (Purseglove, 1968).

Moloney (1887) compared the nutritive constituent of kola nuts to other species used as stimulants such as cocoa (Sterculiaceae) and coffee (Rubiaceae). He stated that kola contains more caffeine than coffee, and has an appreciable quantity of theobromine and considerable quantity of glucose. It has a quantity of starch three times greater than contained in cocoa, but relatively little fat. He found it also to contain a special form of tannin.

Most fruits are rich in polyphenolic compounds which play an important role in determining colour and flavour. Chromatogram analysis of kola nuts has indicated the presence of phenolic constituents in quantities that are higher than those typical for many fruits. Apples for instance contain 0.1 – 2.0 g / 100 g fresh weight of polyphenolic compounds (van Buren,

1970), compared with in excess of 4.0 g/ 100 g fresh weight in kola nuts. Many polyphenolic compounds are highly reactive with human body constituents and have an impact on metablic processes. Kola nuts have long been highly valued in both the traditional and industrial pharmacopoeia (Heckel and Schlagdenhauffen, 1884). Analyses by Odebode (1996) showed that the two species differed markedly in the amount of total phenol and that differences also existed between different colour variants (Table 2). The total phenol content was greater in *C. nitida* than *C. acuminata* . In *Cola nitida,* the quantity of total phenol in red nuts was up to three times that of white and pink nuts; but in *Cola acuminata* the difference was not significant. This investigation supports the general view that *Cola nitida* is more astringent than *Cola acuminata,* because astringency is related to the phenolic content of fruits (Odebode, 1996).

Colour	***Cola nitida***	***Cola acuminata***
White	4.45	3.37
Pink	6.12	4.17
Red	9.09	-

Table 2: Total phenolics in two *Cola* species (mg/l00g fresh weight). Source: Odebode, (1996)

Atawodi *et al.* (1995) analysed both *C. acuminata* and *C. nitida* for their content of primary and secondary amines, and assessed for their relative methylating potential. Seeds of both species contained high quantities of both primary and secondary amines. Methylating activity was significantly higher in kola nuts (170-490 µg/kg) than has ever been reported for a fresh plant product. The authors urge that the possible role of kola nut chewing in human cancer aetiology should be explored in countries where kola nuts are widely consumed as stimulants.

Ibu *et al.* (1986) reported that both species of cola induced significant increases in gastric acid secretion. They advise sufferers from peptic ulcers to avoid eating kola nuts.

4 MANAGEMENT AND USES

4.1 Uses

Kola nuts are widely cultivated in West Africa because they contain two alkaloids, caffeine and theobromine, which are powerful stimulants that counteract fatigue, suppress thirst and

hunger, and are believed to enhance intellectual activity (Nickalls, 1986; Sundstrom, 1966). Due to their unique bitter taste, kola nuts are effective for refreshing the mouth, and the twigs are used as " chewing sticks" to clean the teeth and gums (Lewis and P.F., 1985). Kola nuts are also used as a source of alkaloids in pharmaceutical preparations (Opeke, 1992).

Large quantities of the nuts are exported to Europe and North America, where they are used chiefly for flavouring cola drinks such as Coca-Cola, which are refreshing or stimulating substitutes for tea or coffee (Irvine, 1956). Beverages such as kola wine, kola cocoa and kola chocolate – a type of chocolate containing cacao and kola powder in cocoa butterfat (Opeke, 1992) – and one interesting sounding concoction called "Burroughs and Wellcomes Forced March Tabloid" were once tried in Britain, but they were short lived (Tindall, 1998).

Medicinal uses

Traditionally, the leaves, twigs, flowers, fruits follicles, and the bark of both C. *nitida* and C. *acuminata* were used to prepare a tonic as a remedy for dysentery, coughs, diarrhœa, vomiting (Ayensu, 1978) and chest complaints (Irvine, 1961). The nuts have considerable potential for the development of new pharmaceuticals and foods (Fereday *et al.*, 1997). Extracts of *C. nitida* bark have been tested on various pathogenic bacteria (*Staphylococcus aureus, Klebsiella pneumoniae, Proteus mirabilis, Pseudomonas aeruginosa* , beta-haemolytic streptococci, *Escherichia coli* and *Neisseria gonorrhoeae*) (Ebana *et al.*, 1991). All the extracts showed inhibitory activity against these organisms.

Benie *et al.* (1987) report that stem bark extracts of *C. nitida* inhibited the release of luteinizing hormone (LH) from rat pituitary cells and may therefore regulate gonadotropin release. This has potential to be used as a natural fertility regulator.

Socio-cultural values and uses

Chewing of kola nuts is a widespread habit in the Sub-Saharan countries of Africa, especially in northern Nigeria and Sudan. Kola chewing plays a similar social role to tea and coffee drinking or cigarette smoking in Western countries (Purseglove, 1968; Rosengarten, 1984; Russell, 1955). *C. acuminata* is widely used ceremonially and socially by the people of West and Central Africa. At a birth a kola tree may be planted for the new-born child. The child remains the lifelong owner of the tree. A kola tree is also often planted at the head of a grave as part of local death rites (Tindall, 1998).

Russell (1955) described cultural uses of kola in the Yorubaland of western Nigeria. He reported that the seed is normally kept in the house and an offering of kola forms part of the

greeting to an honoured guest. The older the kola the more highly it is regarded, and white and pink nuts are kept for particularly favoured guests. The gift of kola and especially the splitting and sharing of kola nuts between two or more people signifies a special bond of friendship. Similarly, the sharing of kola nuts is a necessary prerequisite to business dealings that involve a strict etiquette in presenting, dividing, and eating of the fruits. Proposals of marriage may be made by a young man's presentation of kola nuts to the prospective bride's father and her acceptance or refusal may be conveyed by a reciprocal gift of nuts, with the meaning depending upon the quality and colour. Kola nuts presented by the bride's family signify fertility, productivity, prosperity, contentment and desire for the union (Johnson and Johnson, 1976; Sundstrom, 1966).

Kola figures prominently in religion and magic. It is used in divination and to learn the mind or intent of a god for healing the sick or against barrenness. In some areas it is a component of an oath-taking process. The possession and use of kola nuts may be a symbol of wealth and prestige (Hauenstein, 1974; Lovejoy, 1980).

4.2 Propagation

Kola was traditionally propagated from seed, but today cultivation by cuttings has become very common. In southern Nigeria seeds are germinated in boxes or polythene bags filled with top soil and lined in equal parts with sand or sawdust (Oludemokun, 1979; Opeke, 1992) or raised in nursery beds. Germination is slow, but under favourable conditions *C. nitida* germinates within 80 days and *C. acuminata* within 60 days. Seedlings are usually planted out when six to eight months old at a depth of 7 to 10 cm. Soil sterilisation is important in nurseries. Over-watering should be avoided since the seedlings are liable to various fungal and other pathogenic infections (Oludemokun, 1979; Opeke, 1992). This method costs more in material and labour than sowing directly on the field, but where valuable seed is being used the additional cost is justified (Russell, 1955). Propagation by cuttings is preferred as a means of multiplying the white-seeded strain of kola nuts that is favoured by the market. Vegetative reproduction is a relatively straightforward means to multiply, test, select and utilise the wide range of genetic diversity that is present in the *Cola* species. This is the most promising method to produce highly productive clones that could be used locally and for industrial purposes (Tchoundjeu *et al.,* 1998).

It would seem that, at present, there is little selection by farmers for varieties with improved performance (Russell, 1955). Farmers should therefore be encouraged to plant highly productive improved seeds.

The time for transplanting the young seedlings is ideally during the rainy season when enough moisture and nutrients are available for plant growth. In West Africa, the suitable time for kola transplanting is April in the southern kola belt, and June in the transitional zone (north of the kola belt).

Cola species are tolerant of a wide range of environmental conditions and have few cultural requirements are therefore needed once the tree is established, yet more careful treatment, suitable technical packaging and advice on pruning, fertiliser application and other cultural practices would be desirable (Ekanade and Egbe, 1990; Fereday *et al.*, 1997).

Initial growth is slow, with the young plants only reaching three meters in four years, during which period they should be kept clear of weeds. Flowers may occur in the fifth year, but it is not usually until the seventh year that any fruit is seen, and this is scanty. By the eleventh year a fair crop should be obtained, and peak production begins after twelve years. Full production is normally reached about the twentieth year, and trees may continue to bear fruits until they are seventy to hundred years old (Russell, 1955). Productivity mainly depends on environmental factors like excessive drought, or changes in weather pattern that alter the period of flowering and fruiting of the species.

4.3 Management of kola on and off-farm

Among the various non-wood forest products in the sub-region, *Cola nitida* and *Cola acuminata* are extensively cultivated because they contribute greatly to the social, economic and cultural life of the people in West and Central Africa. However, scientific research on domestication of *Cola* species in the sub-region is still in its very early stages (Tchoundjeu *et al.*, 1998). Of the many *Cola* species *C. nitida* is cultivated on a large-scale because of its commercial importance, while *C. acuminata* is planted for its socio-cultural importance.

Kola trees can also be found in large reservoirs of out-lying farms in West and Central Africa. These trees arise from natural regeneration having been protected during bush clearance in and around compound farms or in relatively nearby out-lying farms. However, many *Cola* species have been under regular cultivation. Okafor (1980) cited *C. acuminata* as one of the most extensively cultivated indigenous plants in Southern Nigeria and Central and Ghana

Species	Forest	Secondary forest	Abandoned farmland	Farmland
Kola				
Bush mango				
Njangsang				
Eru				

Table 3: Extent of cultivation of kola in South West Province of Mount Cameroon

In most cases, the impetus for off-farm protection is farmer driven, with no outside pressure – such as from government institutions or market traders – encouraging preservation or domestication (Fereday *et al.*, 1997). The status of cultivation within forest or farm systems is therefore related to kola's various uses and roles in providing food, revenue, and particularly, in the social life and religious customs of the local people living along the forest fringes (Okafor, 1980; Russell, 1955). The importance of protecting regenerated kola seedlings on farmland may not be perceived by the farmers themselves. This only becomes evident in the longer term, and may be of greater benefit to the wider community than to individual farmers. Despite the multi-purpose functions of planting kola trees, like providing shade and income etc., few farmers protect regenerating kola seedlings, preferring to focus on annual crops which bring more tangible and immediate benefits. Questions of land tenure also have an impact on other sustainable agriculture, agroforestry and community forestry programmes, and many kola trees are destroyed by shifting cultivation and inappropriate management because of ownership problems.

Furthermore, most kola trees, either in forest or farmlands, are considered an open-access resource and sustainable management is often lacking. While most farmers view growing kola trees on farmland as a means of assuring regular supply, secured access and ownership, insecurity of tenure is also considered as a disincentive. Resource managers should therefore seek to change this because it is very difficult to manage an open-access resource sustainable and equitably.

4.4 Kola as an agroforestry tree crop

Regeneration/coppicing

Unlike other tree crops, such as cacao and coffee, kola trees are capable of producing coppice resprouts when the trunk of a mature tree is cut. Coppicing could therefore be a means to

replace a dying, overgrown or diseased tree with young material from the old trunk. When used in combination with replanting of new stock this is a useful method for respacing a closely planted stand to produce a new orchard from the coppiced outgrowth whilst selectively removing crowded trees. Experience has shown that the optimum height for coppicing kola trees is 120 cm (Opeke, 1992). Coppicing at this height produces abundant young regrowth that branches out very rapidly but shoots should be thinned to two or three shoots to ensure healthy regrowth and strong junction. Mostly, the shoots develop from sub-orbicular outgrowths on the stump forming a sort of cushion or swelling, carrying many buds at the apex. However, shoots rarely develop without health problems; the profuse shoots attract insects and need be protected by regular spraying with insecticides like DDT or BHC.

It is usually advisable to coppice at the beginning of the rainy season. Though the amount of rainfall does not influence the number of cushions formed, the young shoots can develop in a humid environment enabling the leaves to become hardened before the dry season sets in. According to Opeke (1992), growth from shoots is rapid, and production may be resumed in the second or the third year after coppicing.

Inter-cropping kola and agricultural crops

Traditional farmers in West and Central Africa frequently inter-plant food crops and other tree crops like cacao with kola, but this practice was thought to deplete the stored surface soil fertility and to be too competitive (Russell, 1955). Farmers' main reasons for intercropping young kola trees are, to give overhead shade, keep young kola trees free from weeds, and provide the farmer with some form of living (food and/or cash) from the land while the juvenile kola is unproductive. In southern Nigeria, an average of 55% of kola farms in Ogun State were inter-cropped with cacao alone, while 16% were inter-cropped with both cacao and robusta coffee, *Coffea canephora* L. Only 29% of the kola farms were under monoculture (Oladokun and Egbe, 1990).

However, a comparison of yields of kola and cacao in cacao/kola inter-cropped plots in south-western Nigeria over a period of ten years, demonstrated that it requires approximately 1.75 ha of monoculture to produce the same crop yield (kg/ha) as 1.0 of a mixed culture (Oladokun and Egbe, 1990). For many farmers, the principle reasons for inter-cropping cacao and kola trees are not simply in an attempt to increase productivity. Labour inputs, for weed control and other maintenance activities are invariably shared by the crops. Kola is known to fruit erratically, and an intercrop of cacao can provide an important insurance against kola crop

failure. Juvenile kola trees can provide the light shade that is necessary for productive cacao cultivation. Oladokun (1990) observed that the copper sulphate used to control the fungus *Phytophthora palmivora* that causes black pod disease in cacao, benefited kola trees which have a high copper requirement.

Appropriate planting patterns ensure sustained soil fertility and higher productivity. The proper combination of tree crops is therefore a prerequisite for an effective economic and biological method of sustaining soil productivity in tree crop production (Ekanade, 1989; Ekanade *et al.*, 1991). Dublin (1965) also observed that inter-planted kola with robusta coffee grew and yielded well in the Central African Republic. Hence planting kola with tree crops like cacao, coffee, or food crops such as plantain, offers improved chances of adequate soils as well as immediate and diversified economic benefits (food and/or income) for the prospective peasant farmer.

Incorporating domesticated trees like kola into agroforestry schemes therefore has many shared benefits among the agricultural crops. Financially, therefore, the net income from the mixed culture plantations would be higher than that obtained from monoculture farms, and on a per unit area basis the yields in the former are almost double of the latter (Oladokun and Egbe, 1990).

Inter-planting kola and timber species/woodlots

Woodlots have also been tried in agroforestry systems with kola. Farmers, planting kola trees in forest zones, usually provide overhead shade by retaining some forest trees. This practice is very important for the livelihood of the local farmers because some of the shade trees also serve as sources of firewood, wild fruits, and building materials. Farmers may therefore prefer inter-planting timber yielding species to an agricultural crop for income generation. Current research related to inter-planting kola trees with timber yielding trees and/or woodlots such as *Gmelina arborea* and *Tectona grandis* proved to be high yielding and efficient (Ojeniyi and Oweto, 1986; Ojeniyi and Agbede, 1980). Inter-planting kola trees with scattered shade trees such as *Albizia , Erythrina,* or *Inga* species also provides overhead shade and helps to create an appropriate microclimate for desirable soil conservation as well as providing firewood.

Planting arrangement

Dublin (1965) suggested a spacing between 5 x 5 m and 8 m x 8 m for commercial groves in monoculture plantations, but for agroforestry combinations with other tree crops, differing appropriate planting patterns may be needed to ensure optimum yield. In fact, no ideal spatial

arrangements for intercropping kola and other tree or food crops have been developed. The planting patterns listed below have been tried, and proved most beneficial for the crucial topsoil properties and optimum yield. The recommended spacing for agroforestry systems are;

Kola /cacao - *7.5* m x *7.5* m, Cacao/cacao - 3.0 m x 3.0 m. One row of kola between two rows of cacao

Ekenade and Egbe (1990) emphasised that all arrangements in which the kola trees are close and adjacent to two cacao trees in a row appear to be beneficial to the soil.

Kola/cacao - *5.3* m x *5.3* m, Cacao/cacao — *2.5* m x *2.5* m. One row of kola between three rows of cacao

Inter-cropping and soil fertility status

Mixed cropping of kola/cacao and other timber yielding species has proved to maintain and enhance soils far better than monocultures (Ekanade *et al.*, 1991; Oladokun and Egbe, 1990). Various soil properties and macronutrients, including pH, organic matter, available phosphorus, calcium, magnesium, potassium, zinc and copper, are made available for plant use. This practice is of particular importance for developing an appropriate agroforestry system for tropical agricultural since it does not involve application of chemical fertilisers so it is well-suited to the peasant farmer.

Ekanade (1990) indicated that inter-planting cacao and kola could enhance soil fertility since the mixture of their litter materials results in the release of crucial nutrients to the topsoil. This is possible because cacao and kola do not continue to bear fruits throughout the year, and nutrients withdrawn during the harvesting period are therefore replenished during the off-season through the rapid decomposition of litter (Ekanade, 1987).

However, not all soils may be suitable for mixed cropping. For instance, kola is far more hardy and tolerant of a wider range of soils environments than cacao which requires more fertile soil. Soil maps or site analysis is therefore necessary for intercropping to ensure sustainable crop yield.

Soil nutrient disparities have been found to occur in kola and cacao intercrops. When kola is interplanted with cacao, soil properties tend to improve under kola over time while the converse is the case under cacao (Ekanade *et al.*, 1991). These differences are not significant within the first fifteen years; thus, as these trees advance in age soil macronutrients under kola, and between kola and cacao, are significantly higher in value than under cacao. In South

Western Nigeria this pattern was found to occur after forty years of intercropping. The soil nutrient differences under kola and cacao were considered to result from differences in growth habits, but further research would be necessary to examine the possible effect on each of the species with time.

Shading

Cacao is more shade-tolerant than kola and planting it under tall kola trees gives it the required overhead shade. Current publications have shown that kola yields in comparison with cacao were much depressed in a mixed culture (14-19%) than cacao (3-15%). The need for light shade over cacao or coffee in Nigeria can be safely and economically met by intercropping cacao or coffee with kola trees (Oladokun and Egbe, 1990).

Pollination

It has been found that, fewer kola trees flower in kola/cacao intercrops than in monocultures, but a high relative yield of kola is eventually obtained in the mixed culture. Oladokun (1990) suggested there was a higher efficiency of pollination within the mixed-intercrop, as the final yield was not significantly affected.

4.5 Pests and diseases

C. nitida and *C. acuminata* were believed to be resistant and biologically robust species and to have no important diseases associated with them (Russell, 1955). On the contrary, current publications have shown that *Cola* species are vulnerable to a host of fungal diseases that can attack all parts of the crop (Oludemokun, 1979). He emphasised that, many fungi are capable of infecting kola fruits at an early stage of development, but the disease symptoms will only develop when conditions are favourable.

Many diseases that kola is susceptible to can easily attack related agriculture crops or other tree species. For instance, *Fomes lignosus* (Klotzsch) Bres. and *Fomes noxius* (Corner) may affect kola, cacao, rubber, coffee and other tree crops (Adebayo, 1975). Care should therefore be taken with a suitable combination of crops to minimize disease attack as well as for optimum yield.

Fruit and seeds

Kola nuts are vulnerable to various fungi diseases. *Botryodiplodia theobromae* Pat has been found to be the most common single species of pathogen associated with kola (Oludemokun, 1979). It has been identified infesting the follicles, which develop a black rot and

subsequently affect the nuts. Rusty brown spots develop on the nuts, which later turn black and become hard and dry. The tissues may fall out, living small pits in the surface. *Botryodiplodia theobromae* can also attack other parts of the kola tree. Recent publication have shown that, storage of kola nuts in baskets lined with fresh leaves at a high temperature and high humidity provokes development of various parasitic fungi, especially wet rots caused by *Fusarium* and *Penicillium* species (Oludemokun, 1979; Opeke, 1992). Besides these pathogens *Aspergillus niger* has also been found to cause black, hard rot and pink soft rot respectively on kola nuts (Oludemokun, unpublished).The extent of loss in storage assessed in northern Nigeria was estimated as high as 30% (Oludemokun, 1979).

Olunloyo (1979) found that the rate of development of fungi actively growing on nuts of *C. nitida* depended more on the ambient relative humidity than on nut moisture content. The principal postharvest pathogens were found to be *Botryodipbdia theobromae* and *Fusarium* spp. Milton (1% sodium hypochlorite) sol. was slightly fungicidal at 0.5 and 0.75% and highly so at 0.95 and 1%, depending on exposure period. Substantial reduction of postharvest rot (particularly in nuts stored in baskets lined with polyethylene sheet over banana leaves) was achieved when the nuts were soaked in 1% Milton for 30 min before storage.

Agbeniyi (1999) tested the efficacy of Milton solution (containing 1% v/v sodium hypochlorite) and wood ash in controlling storage rot of kola nuts (*C. nitida*). The effects of the nut treatments on microbial contamination caused principally by *Botryodiplodia theobromae* and *Fusarium pallidoroseum* were also investigated. Both the Milton solution and ash treatments (at a rate of 3 g/kg of kolanuts (dry powder)) gave a significant reduction in percentage incidence of storage rot. This suggests that kolanut treatment with wood ash should be a cheap, alternative preservative for the control of storage rot of kolanut.

Balannogastric kolae is one of the most common weevils to attack kola nuts, though many other species occur. Prevention of kola weevils is very important during harvesting and storage. Field losses have been estimated up to 50 and 70 percent (Opeke, 1992). A careful farmer ensures regular and thorough harvesting of fruits before they reach the point of splitting, as well as avoiding damage to the seeds through breaking of kola pods in order to avert weevil infection.

Eggs are laid into the nuts, or on other parts of the fruits, and the adult weevil emerges within one month. *Balannogastric kolae* have an average lifespan of 53 days, and 20 days for *Sophrorhinus imperata.* They can breed throughout the year if conditions are favourable (high

humidity) (Opeke, 1992). Storing the kola nuts at the appropriate temperature and relative humidity could prevent nut rot diseases. Oludemokun and McDonald (1976) reported that a temperature of 20ºC and relative humidity of 75-100% were the most favourable conditions for storage of kola nuts. Spraying storage rooms with DDT could also prevent the kola weevil.

Both *C. nitida* and *C. acuminata* seeds are vulnerable to attack from the curculionid kola weevil, *Sophrorhinus gbanjaensis*. The oviposition and development of larvae on nuts of *C. nitida*, *C. acuminata* and the wild species *C. verticillata* were studied by Daramola (1980). Significantly higher numbers of eggs were laid in nuts of *C. nitida* and *C. verticillata* than in those of *C. acuminata* when mated females were caged with 35 nuts of each species separately for 35 days. *C. nitida* and *C. verticillata* were preferred to *C. acuminata* as oviposition sites when nuts of the three species were offered together.

An assessment of the effect of weevil infestation on the caffeine content of red and white cultivars of *C. nitida* was carried out in Nigeria (Lale and Okunade, 2000). Results showed significant decreases in the amount of caffeine with increasing levels of infestation, especially in the red cultivar. Mean reductions in caffeine content ranged from 8.8 to 62.6 % in the red cultivar and from 18.8 to 25 % in the white cultivar.

Leaves and twigs

Leaf disease is very common in young leaves and usually occurs in the latter part of the rainy season, seriously affecting many of kola shoots, and leaving them leafless (Opeke, 1992). The infected leaves turn brown, and start to die back from the tip to the petiole and from the margin to the midribs before they finally drop. *Phomopsis* species have been observed to cause tip dieback diseases of kola. *Guignardia citricarpa* Keily is associated with yellow or orange discoloration of leaves while *Botryodiplodia theobromae* causes a twig blight and a brown coloured blight of leaves (Adebayo, 1975). The diseased twigs die and turn black with leaves remaining attached. *Glomerrella cingulata* causes greenish spots with a mouldy appearance on kola leaves (Oludemokun, 1979).

The larvae of kola, *Ceretitis colae* and the stem borers, *Phosphorus virescens* and *P. gabonator* have been found to cause serious losses in kola plantations in both Ghana and Nigeria (Ghana, 1917; Opeke, 1992).

The ant species *Crematogaster buchneri* Forel is known to attack the flowers, leaves, young branches and pods of *C. nitida* in Nigeria. The ants scrape off the epidermis, so that affected leaves fall and pods become shriveled (Eguagie, 1973).

Roots

In nurseries, seedlings are often infected with fungal diseases. Common among them are *Botryodiplodia theobromae* and *Fusarium* species that cause the roots of the infected seedling to rot and turn their leaves brown. Aldrex T, pesticides containing 25% aldrin and 50% thiram, have been reported to reduce incidence of fungal infection in nurseries (Adebayo, 1975; Oludemokun, 1979).

In the field, infected roots often cause yellowing of leaves before eventually killing the plant. *Rigidoporus lignosis* (Klotzsch) Imazeki, *Fomes lignosus* (Klotzsch) Bresodola and *F. noxius* Corner commonly cause this type of problem in both *C. nitida* and *C. acuminata* in Nigeria and Sierra Leone (Adebayo, 1975; Opeke, 1992). Adebayo (1975) reports that collar inspection was found to be more reliable method of detection than foliage inspection.

4.6 Selection for greater productivity

The average annual production of kola nuts has been estimated to be about three hundred seeds per tree (FAO, 1982). Commercial kola nut farms have typically rather low productivity. Russell (1955) pointed out that a striking feature of kola plantations in western Nigeria was that there was a great difference in productivity between individual and adjacent trees. Purseglove (1968) recorded nut production from 246 trees over 4 years in Nigeria with the following results: 46 trees gave no nuts at all; 79% of all the trees gave mean annual yields of 0-300 nuts while the remaining 21% produced 72% of the total yield of the plot. The average was 210 nuts per annum, while the 10 best trees averaged 1,415 nuts peaking at 2,209 nuts per annum. The size of the nuts varied from 16.9-40 nuts/lb of fresh seed after removal of the testa, with an average of about 27.7 nuts/lb. These result suggest that there is considerable potential for the production of improved varieties of these trees.

Sanwo (1998) examined individual tree performances in Nigeria. Annual pod and nut yields per tree exhibited substantial scope for success in selection. The number of nuts per pod was less variable. Both high and low yielding trees exhibited considerable annual variation in productivity. Approximately 7.3% of the selected trees gave nut yields that were over 250% of the Nigerian recorded annual yield. One tree naturally combined annual consistency in

yield and high yield traits. It would appear that although the two traits are distinct and appear independently controlled they could be combined via breeding.

4.7 Harvesting

A careful farmer cuts the fruit from the tree before the follicle splits open ensuring that fruits is free from pest attack. The approach of maturity can be predicted by a change in colour from deep green to a light brown. At the beginning of the harvest period undergrowth beneath the kola trees is cleared to reduce the risk of infestation by the larvae of the kola weevil, *Ceratitis colae* and infection by the fungus *Botryodiplodia theobromae* (Opeke, 1992; Russell, 1955).

The harvesting practices of kola have been considered sustainable. In contrast to other similar non-wood forest products such as *Garcinia kola,* where the bark of the tree is also harvested for sale, little immediate damage is inflicted on the tree and there is little risk that the sustainable use of the resources could be impaired (Peters, 1994).

However, harvesting commercial quantities of fruits can affect not only the species regeneration, but also genetic composition and quality of the resource especially, if only "inferior" fruits and seeds are left to regenerate (FAO, 1995). Sustainable harvesting of kola nuts therefore depends on the size-class distribution of the tree population (Peters, 1994), preferably with regard to differences in exploitation intensities. Due to inadequate information on management of the wild resource with respect to productivity and population dynamics, sustainable harvest of the wild resources seems very difficult. All efforts therefore need be encouraged to enhanced domestication of *Cola* species and incorporate them into suitable agro forestry systems. These could contribute both to preserving biological diversity and improving the lot of local communities through income generation and equitable distribution of benefits.

Kola nuts are harvested twice a year either by collecting the fallen fruits or with a curved knife-blade attached to the tip of long poles. Farmers usually climb the tree with this harvesting equipment and scramble amongst the branches cutting all the fruits they can see approaching ripeness. This practice is repeated monthly during the fruiting season from September to January. The greatest production is usually from October to December for cultivated species in Nigeria with smaller harvest period in March and April (Fereday *et al.*, 1997; Keay, 1958; Russell, 1955).

In most part of West and Central Africa women and children who live in forest-fringe communities usually gather and extract kola nuts. In western Nigeria, kola harvesting and

sales are an important income source for women traders. Ndoye (1997) reported that, in Cameroon about 94% of the traders (gathering and sales) are women of whom 84% can read and write. Sales from the nuts therefore, serve to supplement the household income of many of the forest dwellers and comprise 5% - 35% of household's cash revenue in western Cameroon (Champaud, 1983). About 258,000 people or 20% of the economically active population derive their part of their income from the NWFP collection in Ghana (Falconer, 1990).

Post harvest treatment

Harvested fruits are usually heaped on the ground at a convenient place under trees and the follicles are split open. The large green kola pods are cracked under the tree and the nuts carried back to villages where the thin outer skin is removed to reveal the nuts. In order to facilitate removal of the testa, the nuts are either soaked in water or by heaping them into a large basket where they are left to ferment for about five days The nuts are then rinsed in water and the softened testa wiped off. The cleaned nuts are transferred to baskets, often of enormous size and without lining, and kept here for three or four days with frequent stirring. Defective nuts are picked out during this stage and the process is known as curing. A lot of sweating occurs here with the purpose of gently reducing the water-content of the seeds. The seeds are then graded and may be stored to wait a favourable market, wrapped in green leaves and deposited on the ground or in a cool corner of a hut and regularly checked for weevil damage (Russell, 1955). Periodically the nuts are examined and fresh wrapping leaves applied to keep it moist. The leaves used are of various species but some Marantaceous plants are preferred including *Marantochloa* and *Thauma tococcus,* whose large leaves show resistance to rotting. The quality of the nuts depends greatly on the care with which the harvesting, cleaning, and curing was carried out. Under the best conditions the seed may be stored for many months without decline in quality (Masefield, 1949). Kola can be stored for up to two years usually in baskets or old fertiliser bags if kept dry (Fereday *et al.*, 1997). Oludemokun and McDonald (1976) reported that, a temperature of 20°C and relative humidity of 75 — 100% were the most favourable conditions for storage of kola nuts.

Quality of products

Unlike other non-wood forest products kola nuts are often graded. Retailers inspect the nuts by setting aside anyone showing insect damage and then grade them according to colour and size. The most careful and repeated examination is for weevil infestation (Opeke, 1992;

Russell, 1955). The quality of the product is very important for the value and determination of market price. Right from the harvesting, the farmer makes sure to prevent the harvest of immature fruits as the nut becomes thin and shrunken after drying. Post-harvest attack from insect pests can seriously affect products market acceptability. Apart from weevil damage, environmental factors such as high humidity and temperature can affect the rate at which the quality of the nuts decline (Oludemokun and McDonald, 1976), usually discolouring the nuts and prone to fungal attack *(Botryodiplodia theobromae).* Mechanical damage to the nuts especially during extraction of nuts with machetes also reduces quality significantly (Ladipo, 1997). In most cases, appropr iate variations in prices are applied to justify farmers' efforts during the curing process and storage to ensure good flavour. However, customer's preference depends on colour, size, flavour, and level of adulteration and keeping quality (Ladipo, 1997). Usually, white nuts are preferred to pink or purple in both traditional and commercial markets.

5 MARKET TRENDS AND DEVELOPMENT

5.1 The kola trade

Kola is traded in three stages (Opeke, 1992): unprocessed wet nuts; the bulk sale of processed nuts; and the retail trade in both unprocessed and processed nuts. *Cola nitida* is the main commercial species traded world wide, whereas *C. acuminata* is of local trading importance, especially among the Yoruba tribes in West Africa. Fresh nuts are only exported to countries within or neighbouring West Africa. Only dried nuts are exported beyond the region.

In southern parts of West Africa, the most commonly consumed species is *C. acuminata* and *C. nitida* is preferred in northern parts. For example, *C. acuminata* is the preferred species in western Cameroon and its trade is limited to this region. *C. nitida*, however, is produced though generally not consumed in this region; what is collected is traded to the North.

Activities involved in harvesting/gathering and sales of kola nuts in the humid forest of the sub-region can be categorised into:

- Farmers, who harvest or gather products for sale;
- Assemblers/ retailers, who buy from village markets or direct door-to-door from farmers, and sort and package them in large baskets or units of a bag.
- Wholesalers, who conduct their transactions in bags and export to neighbouring

countries, Europe or America.

5.2 Domestic market

Farmers mostly sell all produce immediately after gathering or harvesting due to lack efficient storage facilities and lack of transport. The price is usually determined by the farmer's effort in maintaining a high quality product. The quality of the nuts depends greatly on the methods used to extract the nuts from the pod, and in curing and cleaning and storage (Masefield, 1949; McIlroy, 1963). Unlike other non-wood forest products there is a well-established protocol applied in marketing kola nuts. For instance, in the trans-savanna trade within West Africa nuts are sorted according to colour and size, and each class commands its own prices according to quality (Ladipo, in press). As with most non-wood forest products in west and central Africa, marketing of kola is typically informal, conducted usually through verbal agreement.

A recent Tropenbos survey of the collection of kola nuts by family households of the Bipindi-Akom II region in the South Province of Cameroon recognised that income from kola nut sales is very important, and also that nuts are sold in high quantities. This survey noted that there was a decline in production within the period studied (two years) (Table 4).

Species	Number of families	Number of families involved in trade	Percentage of harvest sold	Total revenue in CFA (4 months)
Cola nitida / Cola acuminata	8	3	30%	2,500

Table 4: Household involvement in collection and sales of kola nuts surveyed by Tropenbos Cameroon Programme (TCP)-September 1997 to January 1998

Many farmers view marketing in general as a secondary activity, carried out to supplement income earned from farming activities, especially during off-farm seasons. Acworth (1993) reported that collecting non-wood forest products represents to a household a valuable supporting income enabling them to balance income and subsistence needs for little resources other than their own labour. Further publications emphasised that the income of non-wood forest products in some rural household in south-western province of Cameroon was even higher than coffee, with kola nuts contributing between 5% and 37% of the household cash revenue (Laird *et al.*, 1997).

5.3 Local market

During the main harvesting season many kola nuts traders, especially the Hausa traders from Nigeria, tour a number of villages and towns buying stocks of kola. They usually hire a

storeroom where they keep their produce. Their major marketing problems are high transport costs (which consume about half of the value of the purchase) and storage losses (about 10%). Their main focus is the local markets in the humid forest zones of Cameroon, Ghana, Sierra Leone and other nearby countries, including the Central African Republic (CAR), Equatorial Guinea and Gabon (CIFOR, 1997) as listed in Table 5.

Cameroon	Mfoundi (Yaoude), Bafia, Ombessa, New Bell (Douala), Mbalmayo, Edea, Kenzou
Ghana	Kumasi, Tachiman, Tamale, Bolgatanga
Nigeria	Lagos, Ibadan, Kassa Marire(Kane)
Sierra Leone	Freetown
Democratic Republic of Congo	Benin, Kisangani
Sources: Ladipo, in press; CIFOR, 1997	

Table 5: Major local markets for kola products

In 1995 and in 1996, the local markets of Mfoundi, Bafia and Qmbessa in Cameroon accounted for 82% of the total quantity of *C. acuminata* sold [SOURCE?]. While in 1996, New Bell market became more important and accounted for 22% of the actual quantity marketed as against 2% in 1995. According to CIFOR (1997) in the *C. acuminata* trade from 1995 to 1996, the actual quantity marketed and the value of sales decreased relatively by 61% and 34% respectively. The decline in quantity was explained by a drastic reduction in production, which may be due to physical, biological and ecological factors.

Most of the retailers/farmers sell their products in smaller units such as cups and bowls and only through verbal agreement. The price therefore varies with the size, keeping quality and the colour of the nuts. In Nigeria, the Owode and Labozhi crops contain a high proportion of the more valuable pink nuts, while in Ghana and Sierra Leone kola maintains a high price partly on account of its good keeping quality (Voelcker, 1935). However, in most of the markets only large nuts are sold. Apart from farmers and local traders, most of the retailers are Hausa people from Nigeria who always scramble for new market sources in the sub-region in response to increases in demand. Most of these kola nuts traders have higher gross profit margins and are more likely to depend solely on them for their livelihood.

In Nigeria, kola is distributed along the railway line linking Lagos and Kassa Marire market in Kane in the north. Most trade transactions are made with retailers through verbal agreement. A feature of most villages in parts of the Yoruba country is a group of huts outside the village, occupied by Hausa traders from the north who are engaged in buying kola nuts

from the farmers, packing them and sending them to their home-country.

Problems associated with local markets are:

- Price formation
- Storage of the product
- Increase in demand
- Transport cost.

5.4 Kola trade within the Sub-Saharan countries

In Cameroon, for example, Nkongmeneck (1985) reports that approximately 22,500 tonnes were produced in 1981 (of which, 20,400 tonnes entered commerce). An estimated 1,100 tonnes were exported in 1980 (worth approximately 182.6 million FCFA), primarily to Nigeria and Chad. Nkongmeneck adds that there are many gaps in government data, and thus these figures are, at best, only indicative. He adds that the price of kola for the export market appears to be lower than those for internal markets. He postulates that this is because of poor internal market organisation and problems associated with kola nut conservation. In Ghana, the Forestry Department estimated the value of kola exports to be 3.4 million cedis in 1975, the majority (83%) of which was sold to Nigeria (Forestry Department Annual Report 1983).

As mentioned above, *C. acuminata* commonly tends to occur naturally to the east from Nigeria to the Central African Republic, while *C. nitida* to the west from Sierra Leone through to Nigeria. Both species are more highly valued in their native land but are traded across the region. While *C. acuminata* is very popular within its natural region of occurrence for socio-cultural value, *C. nitida* is extremely popular throughout West and Central Africa for its stimulant effect because of its higher caffeine content (Lovejoy, 1980).

C. acuminata is highly valued by the people of northern Nigeria and Sudan who are the chief buyers. In Cameroon, Nkongmeneck (1985) estimated the quantities of *C. acuminata* in trade to be 24,400 tons of which most are exported to Kane in northern Nigeria. Nigeria's annual production is estimated at 100,000 tons and that of the Cote d'Ivoire at 30,000 tons while export was about 6,000 tons annually in Ghana to Nigeria. The vast majority of kola production is utilised within the African continent, particularly in Sub-Saharan Africa (Tindall, 1998).

C. nitida is a better species also for internal trade. It has long served as an important crop for Ghana, Sierra Leone, Northern Nigeria, Burkina Faso, Cote d'Ivoire and Sudan in the Trans-Saharan Trade. The Hausa kola traders have followed fixed caravan routes through West Africa for many centuries to Timbuktu, Sokoto, Kane and elsewhere. Today extensive trade to

Burkina Faso continues on one of the old routes, where kola nuts from Ghana and Sierra Leone are conveyed first by lorry and then by donkey to the frontiers of Sudan and further travel to north or east (Purseglove, 1968).

Large quantities of kola nuts are shipped from Sierra Leone and Ghana to Lagos where they are then conveyed by rail linking Lagos and Kane and further north to Sokoto and Congo. The railway carries between 50,000 and 60,000 tons of kola nuts annually to the markets of the northern Nigeria. Exports of kola nuts from Ghana were estimated at 6 million tonnes and 7,482,602 tons in 1988 and in 1989 with a value of US$ 1,031,952 and US$ 1,476,135 respectively (Laird and et al., 1997).

5.5 International trade

Large quantities of kola nuts have been traded both among the countries of West and Central Africa and the Sub-Saharan Africa for centuries. Until the establishment of kola nut plantations in South and Central America, the West Indies, Sri Lanka and Malaya, there was considerable export from this region to the rest of the world. Exports from Lagos to Brazil were valued at £2,949 in 1878 and £3,560 in 1882 (Moloney, 1887). Exports to Western Europe were very small. In 1887 exports to Britain and France were valued at £20 and £40 compared with a total value of local consumption of £32,400.00 (Moloney, 1887). Exports declined drastically once kola plantations were established elsewhere. Yet this never caused severe competition with African production since vast majority of the kola production is utilised within the African continent, particularly in Sub-Saharan Africa (McIlroy, 1963).

Today, kola nuts are exported to Europe and North America for flavouring kola drinks and for use in the manufacture of pharmaceuticals. Industrial exploitation is mainly for the caffeine. Beverages like kola wine, kola cocoa and kola-chocolates and assorted medicinal products have been derived from kola nuts. Oyedade (1973) stated that a few hundred tons annually are exported for these purposes. At any rate, off-continent exports appear to absorb only a minor part of the world production estimated at 180,000 tonnes of which 120,000 tonnes are produced by Nigeria and used either internally or in neighbouring countries (FAO, 1982; Lovejoy, 1980; Rosengarten, 1984). *C. nitida* is preferred in international trade because of its high caffeine content and the white strain is most valued.

A recent publication by United Nations' Food and Agriculture Organisation (FAO, 1982) estimated that from a total West and Central African production of kola nuts of 180,000 tons only 60,000 are exported; the rest are consumed internally. Thus, it is clear that the product

remains virtually unknown in other part of the world (FAO, 1995).

6 INSTITUTIONAL POLICY AND SUSTAINABLE EXPLOITATION OF *COLA* SPECIES

6.1 Current legislation governing the management of kola resources

Unlike other non-wood forest products *Cola* species are widely domesticated and predominantly grown on farmlands. The resource is therefore renewable and managed sustainably in both private and government lands. However, vast quantities of wild kola also occur in state forests, communal forest estates and open access areas. In Ghana, a number of policies have been instituted to regulate exploitation of non-timber forest resources to ensure sustainable use and conserve their genetic diversity. These regulations therefore apply to wild kola:

- The government manages and regulates exploitation of kola products in both States and communal forest estates in interest of the community.
- The local communities and private individual may exercise their rights of ownership of their forest/tree establishments based on the governing land tenure system of the State.
- Commercial exploitation proceeds with procurement of written permit and equivalent royalties are paid to the State.
- The resources are assigned in accordance with the Master plan of the regional forestry development.
- Clearing/development of projects on State/communal land is subject to prior study of the environmental hazards.
- No person may use States or communal forests scientific, commercial or culturally without prior authorisation.
- The use of kola resources is restricted in areas declared as ecologically fragile.

(Ministry of Lands and Forestry, 1996)

6.2 Constraints to sustainable management

Land and resource tenure

Land tenure problems are major issues for sustainable management of forest resources throughout West and Central Africa (Ambrose-Oji, 1997; Jeanrenaud, 1991). In Ghana, for instance, the landholding communities own the products from the forest with their chiefs as representatives while the government manages the land. Land tenure systems and the rights of

land ownership therefore determine to a large extent the scope of tree cultivation, management options and sustainability (FD/IIED, 1994). However, recent policy and legislation aims at substantially enhancing the rights of farmers and local communities to the off-reserves resource (CFMU, 1995; Smith, 1997).

Fereday *et al.* (1997) during their field study in Cameroon also observed that land rights are very complex in the region. Many farmers rent their land out and only traditional landowners have permanent farms. It is therefore not logical to plant or protect trees on rented land, unless the land is leased for a long periods, because the trees will become the property of the landowner once the tenancy expires. Insecurity over land tenure naturally reduces a tenant's planning horizons and hence most farmers plant crops that can generate quick returns. Even where farmers have secure access to land, few may be prepared to take a sufficiently long-term view especially on products that seem to occur naturally in abundance in the forest.

Cultural beliefs

Some of the cultural beliefs in the sub-region also pose a problem to sustainable management. Chevalier and Perrot (1911) recorded that, in some parts of French Guinea where *C. nitida* is native, it is held to be most inauspicious to plant a seed of kola since the person doing so will assuredly die as soon as the seedling comes into flower. However, this belief has not accompanied *C. nitida* into Nigeria as the farmers cultivate kola trees without any ill after-effect.

Also in Nigeria, most farmers continuously slash the trunk of their kola trees with cutlass to enhance production of the tree crop. Though wounding the bark of the tree has been shown experimentally to result in a significant increase in yield of mature fruits it is also believed to have a long-term effect on the production of the tree (Russell, 1955).

Shifting cultivation

Shifting cultivation has always been a major problem in protecting coppiced and regenerated *Cola* species throughout the region of West and Central Africa. Very often cultivation of farmland involves clearing, slashing and burning of forests together with all the valuable tree species. This is more common with the tenant farmers who do not recognise the value of tree because they do not have long-term control over the land. Though some farmers may retain *Cola* species for seasonal subsistence most of the trees are destroyed as they are believed to cast too much shade on annual crops. FAO (1995) reported that, the practice of shifting cultivation accounts for 60% of the forest losses in this region each year.

Effect of seasonality

The main harvesting season of kola is from October to December for *C. nitida* while that of *C. acuminata* is April to June. Unless a farmer has trees of both species or has intercropped with cocoa or coffee, income from the nuts is highly seasonal. Most farmers therefore prefer cultivating a mixture of annual crops where benefits are spread more evenly throughout the year.

6.3 Opportunities for sustainable management

There is considerable potential for further development of *Cola* species as a commercial crop under sustainable management. As a traditional crop in West and Central Africa, the cultivation, harvesting and processing of kola is widely known. Although prone to a number of pests and diseases experience has shown both *C. nitida* and *C. acuminata* to be tolerant of a wide range of environmental conditions. The crop is easily cultivated and these species appear to be more resistant to pest and disease attack than other plantation crops of the region. *Cola* species are suitable for agroforestry combinations with both agricultural crops and timber yielding tree species/woodlots. Kola nuts have a high market value and there is considerable potential for expanding markets outside Africa.

7 RECOMMENDATIONS

The following recommendations are based on the findings of this review:

- The current significant decline in kola productivity highlights the need for a selective breeding programme. This will require provenance trials and the establishment of seed orchards for the supply of improved stock to farmers.
- There is a need for expansion of the international market in order to encourage exports and boost the income of kola farmers. This may require the development of new processing technologies and the dissemination of information on the potential food and medicinal products that can be manufactured using kola nuts.
- Greater research is needed into kola diseases and how they may be effectively controlled.
- More research should be initiated on the optimum densities and configurations of kola inter-crops for suitable agroforestry systems including the consequences for pollination efficiency for *Cola* species .

- There is a need for the development of quality control measures in order to produce a crop of consistent quality for export and to ensure that high quality products are able to attract premium prices. This will provide an incentive for the planting of improved stock.
- Appropriate storage methods should be installed to ensure kola products are available throughout the year and do not deteriorate in storage. This will ensure that producers are able to store their crop to give better price determination and sustained income.
- Individual countries may need to review legislation governing land tenure to encourage a longer term view of production amongst farmers in which slow growing tree crops such as kola will once again be valued and to ensure the sustainable management of the wild resources.

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