AFRICAN INDIGENOUS VEGETABLES

An Overview of the Cultivated Species

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R. R. Schippers

Natural Resources Institute
University of Greenwich

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PREFACE

After living in Zambia, Kenya, Tanzania and Egypt for well over 20 years, working as a horticulturist, I would not have hesitated to cite tomatoes, cabbages, carrots, onions and other vegetables that are used by Europeans as being the main vegetables eaten by African people. It took me several more years and extensive travel in West and Central Africa to come to realize that this may not be entirely correct, and that there are many different vegetables which are commonly eaten by people in Africa's rural areas and not seen at the main city markets.

Since many local vegetable species are produced in the home garden as a relatively trouble-free and often abundant food source and only a few of these vegetables are considered as 'cash crops', policy makers have, in the past, neglected them and refer to them as 'minor crops'. They never serve as a staple food and are thus not given a high priority by the donor community. Urban people, especially in East Africa, have changed their eating habits and often consider their traditional food crops as old-fashioned and unfit for modern people. Despite the rapid urbanization that has taken place in recent years, there are still more people living in rural areas than in Africa's cities and many people still make use of their traditional food crops. However, little has been documented about indigenous African vegetables and since literature is lacking, African students cannot study such crops from existing books. As a result, most African lecturers now teach their horticulture students how to grow cabbages and other European types of vegetables and do not refer to African vegetables. A further consequence is that extension staff have no reference material to serve as a basis for assisting farmers.

Recent studies in Cameroon and Uganda, for example, have identified the value of Africa's indigenous vegetables for subsistence and income-generating opportunities and the recent strong reversal in consumption patterns of many African people; there is now much more interest in indigenous vegetables than there was only a few years ago. This has generated a call for information especially from students who wish to focus on such crops and from extension staff who are under pressure from farmers to advise them.

There is more information available on African vegetables than many people realize, especially from Nigerian authors. Unfortunately, such documentation is not easy to access and an effort has been made here to assemble published literature, together with some unpublished documents. These include papers from agricultural research stations, student dissertations from various universities and reports such as those from the Natural Resources Institute and the International Plant Genetic Resources Institute. Further information was generated through small student projects whereby students were asked to carry out specific surveys or to collect data on a particular commodity. Results from these student projects have contributed to this overview, which was complemented by personal observations in several African countries during recent years.

Out of the 126 African vegetable species mentioned, only the 25 most commonly cultivated crops have been covered in detail, depending on the information available. Less detail has been provided for 16 species which are only grown in limited parts of Africa, whereas a further 32 species are only briefly described because their cultivation is limited or because they have become quite rare. In addition, 53 species of related crops are mentioned out of several hundreds that are collected from the wild. Vegetables collected from trees are not covered even though several have been mentioned in the text.

For further information on African vegetables please contact:

R.R. Schippers
Natural Resources Institute
University of Greenwich
Medway University Campus
Chatham Maritime
Kent ME4 4TB
UK
Fax: +44 1634 88077
e-mail: r.r.schippers@gre.ac.uk

Introduction

Of late there has been a significant change in interest towards Africa's traditional sources of food and there is currently a reversal of an earlier decline in the use of indigenous crops. Vegetables grown in home gardens are becoming increasingly important to people and many of these happen to be indigenous vegetables. Traditional crops are valued in rural areas, but people in the cities are increasingly turning to traditional crops. Many people no longer have the money to buy expensive vegetables from the market, but still wish to add some form of relish to their starchy staple food.

Urban and peri-urban horticultural activities have created a dynamic source of food for many African cities and one can now find a much wider crop diversity than before, especially when migrants from different ecological zones bring their crop seeds with them. People's search for a higher income brings them to the cities, looking for good jobs. When they realize that this is not easy, many of the new migrants start to grow vegetables, first as a survival strategy and later for sale. This frequently turns out to be a highly lucrative business.

Also, traders have accepted the challenge to find cheaper commodities and now place more orders for African vegetables. Similarly, there are now more traders because the capital outlay required is lower for indigenous than for exotic crops (*see* also the section on socio-economics, p.3).

WHAT IS AN INDIGENOUS VEGETABLE?

There is a lot of confusion about the meaning of the word indigenous. Many people perceive it to relate to the food eaten by local people and will therefore include the leaves of cassava and sweet potatoes or the leaves and flowers of pumpkins, crops which all originated in South or Central America. These are some of the vegetables which are frequently eaten by villagers or by people with home gardens, but are not normally consumed by Europeans or by people from Asia. Similarly, people in Senegal appreciate the leaves of *Moringa oleifera*, a tree perceived to be indigenous, but in reality a native from Asia which has become naturalized in several places. Some names may be misleading, such as the gourd *Luffa aegyptiaca*, which does not originate in Egypt, but in India. Conversely, the tamarind, *Tamarindus indica,* has a tropical African origin. This tree is mainly known for the sweet-sour pulp found in its pods, but its young leaves, young pods and flowers can also be eaten as a vegetable.

The commonly cultivated *Amaranthus cruentus* found along Africa's warm and humid coastal regions is usually referred to as a typical African indigenous vegetable, but is it really? The species *A. cruentus* is now considered to have originated in the northern parts of Central America. However, *A. cruentus* is not only found in Central America but also in Africa and Asia and has become a pan-tropical crop.

The perception that plants with an American origin could only have been dispersed to other continents after the Columbus era is no longer given serious credit. There is increasing evidence that northern Europeans have paid regular visits to North America well before Columbus did. According to the *Washington Post* of 15 April 1997, a skeleton of a caucasoid man was discovered near Kennewick, Washington, during the summer of 1996 and radiocarbon dating revealed that he died about 9300

years ago. Further evidence that not all the original inhabitants of the Americas had an Asian origin, as has long been the assumption, can be found in Mexico and other Central American states, where there are several ancient statues depicting men with beards and otherwise distinctly Caucasian characteristics. Stone artefacts found in La Venta, a 3500-year-old site in Mexico, include several giant heads carved in granite, clearly depicting what can only be African men, next to statues depicting Caucasian men. (For further information reference can be made to HANCOCK, G. and FAIIA, S. (1998) *Heaven's Mirror: Quest for the Lost Civilisation.* London: Michael Joseph Ltd.)

These people must therefore have visited Central America at a time before the onset of the Maya and Aztec civilizations and at a time when the Pharaonic New Kingdom began in Egypt. There is further evidence of even more ancient global travelling by seafarers who probably originated in Polynesia (for further information *see* West African Okra, p.103). Also, the discovery of African bottle gourd seeds in Mexican soil strata which were dated 7000-5500 BC and similar discoveries in Peru dated 4000-3000 BC could probably better be explained in the context of recent findings and new interpretations which indicate that people must have travelled between continents since very ancient times.

The possibility that seeds of Mexican (food) plants found their way to Africa as early as 3500 years ago can no longer be excluded. African people who were brought to South and Central America as slaves did carry seeds of their food plants, so why not in the other direction several millennia earlier? *Amaranth* seeds are tiny, but can produce a leaf crop after just a few weeks, which could well have been of strategic interest to travellers seeking new and unknown territories. This could explain why *Amaranthus cruentus* and related species can be found in many tropical and sub-tropical regions around the world whilst their origin is considered to be in the Americas. The world-wide distribution of a number of fast-growing weeds that were once consumed as leafy vegetables or used as medicine, such as purslane, the nightshade group, waterleaf and others could have a similar explanation.

In the present context, indigenous is defined as 'originating in Africa'. There should be a clear link with wild species or one or more closely related species. This will immediately create some problems because there are several crops which are not known in the wild. These include the broad bean and the winged bean (*see* further under African Winged Bean, p.96), or those whose origin is much debated, such as the cocoyam *Colocasia esculenta* which was found in Ghana, whereas a Malaysian origin is more likely. With recent indications that of King Solomon's four gold mines one is located in Malaysia and another is most likely the present-day Ashanti gold mine in Ghana, it is not hard to imagine that there was some trade between these territories at that time, about 700 BC. *Colocasia* could have been carried as fresh food by travellers from South-East Asia and some may have been planted in Ghana.

There are other crops which are a taxonomic puzzle, such as the black nightshade group, the *Solanum nigrum* complex, which is often seen as a weed with global distribution. Crops which have a part-Asian and a part-African origin such as the common okra, but also the spiderplant and waterleaf, are considered here to be indigenous African crops.

African crops that originated in the forest zone include a wide range of vegetables such as the fluted pumpkin, bitterleaf and West African okra. The ecological zone between forest and savannah is the home of cowpeas and the Livingstone potato, whereas typical savannah crops include roselle and the common okra. Typical crops from semi-arid to arid areas are watermelon and sesame.

For the present publication, 73 cultivated vegetables from herbaceous plants or from shrubs have been included, together with a further 53 species that are frequently collected from the wild. Vegetables which could be collected from trees such as the baobab tree, *Adansonia* spp., the cabbage tree, *Moringa stenopetala,* various *Ficus* species and a wide range of others including *Myrianthus arboreus, Vitex*

doniana, Pterocarpus spp., *Hessia crinata* and *Triplochyton* spp. have been excluded. Leaves from most of these trees are collected and eaten as a vegetable, some of them reportedly with very high protein contents or otherwise of highly nutritious value. These species have not been included here, mainly because they are not cultivated and the leaves are usually collected from wild trees. The exception to this is the cabbage tree from South-West Ethiopia, which has been cultivated since ancient times and demands careful management. Another exception could be the cultivated seedlings of the wild borassus palm that are offered as a starchy vegetable in markets in Ghana.

To define what is and what is not a vegetable was found to be far from easy, so that rather than attempting to redefine the meaning of the word, reliance was made on what local people considered to be vegetables. In Africa, most vegetables are used as a condiment which accompanies the starchy staple food. Several leguminous crops mentioned are mainly used for their roots or for their seeds rather than for their green pods or leaves and should probably not have qualified as vegetables. Generally speaking, the term vegetable has been applied for those horticultural food crops which do not fall into the categories of dessert fruits, dry pulses, nuts, herbs, spices or large starchy root crops. Slimy sticks, which would otherwise be a borderline case, are now included by using this rather vague definition.

THE SOCIO-ECONOMIC IMPORTANCE OF INDIGENOUS VEGETABLES

Indigenous vegetables (IVs) play an important role in income generation and subsistence. Recent surveys carried out by the Natural Resources Institute in Cameroon and Uganda provided evidence that IVs offer a significant opportunity for the poorest people to earn a living, as producers and/or traders, without requiring large capital investments (*see* Figure 1). They are important commodities for poor households, because their prices are relatively affordable when compared to other food items.

Figure 1 Villagers offering wild and cultivated *Hibiscus* leaves at a roadside market in northern Ghana

IVs provide an important source of employment for those outside the formal sector in peri-urban areas of many African cities because of their generally short, labour-intensive production systems, low levels of purchased input use and high yields. The production of these vegetables is increasingly targeted as a livelihood strategy as the level of urban unemployment rises. African indigenous vegetables (AIVs) contribute to a more balanced diet for many people and a significant improvement in food security for the community at large. Commercial growers can make a lot of money from the fast-growing leafy vegetables now seen around many larger cities.

More exotic vegetables can usually be found in high-altitude areas with a temperate climate. In the humid lowland areas of West Africa and in hot, dry regions in other parts of the continent, exotic vegetables cannot grow well. A wide variety of AIVs are grown in these areas. AIVs remain popular in rural areas, where they are often considered to be more tasty and nutritious than exotic vegetables. They often play a ceremonial role and are an essential ingredient in traditional dishes.

Exotic crops are said to generate more profit for farmers than indigenous vegetables and are thus considered as cash crops. Cash crops usually require capital to purchase inputs such as fertilizers, seeds and pesticides, and often need the use of water pumps and other equipment. The smaller amount of cash needed to produce or trade IVs makes them more competitive, implying lower profits. However, this is not always the case. In Kampala, farmers reported that nakati was the most profitable vegetable crop. Farmers in Cameroon consider African nightshades to be cash crops. Both nakati and African nightshades require fewer purchased inputs, they mature faster and the total harvesting period is longer than for many exotics.

Women are key players in the production, processing and marketing (mainly retailing) of indigenous vegetables. The Yaoundé study found that in 14 satellite markets around the city, about 1000 women were engaged in selling AIVs (*see* Chart 1). For these women and their families, the meagre revenues earned are of the utmost importance.

Despite the geographical distance, the production systems for the many different AIV crops which may be found throughout the continent are very similar. Mixed cropping systems are the norm for all subsistence and semi-subsistence farmers, whereas most commercial production, especially under irrigation in the dry season, is monocropped.

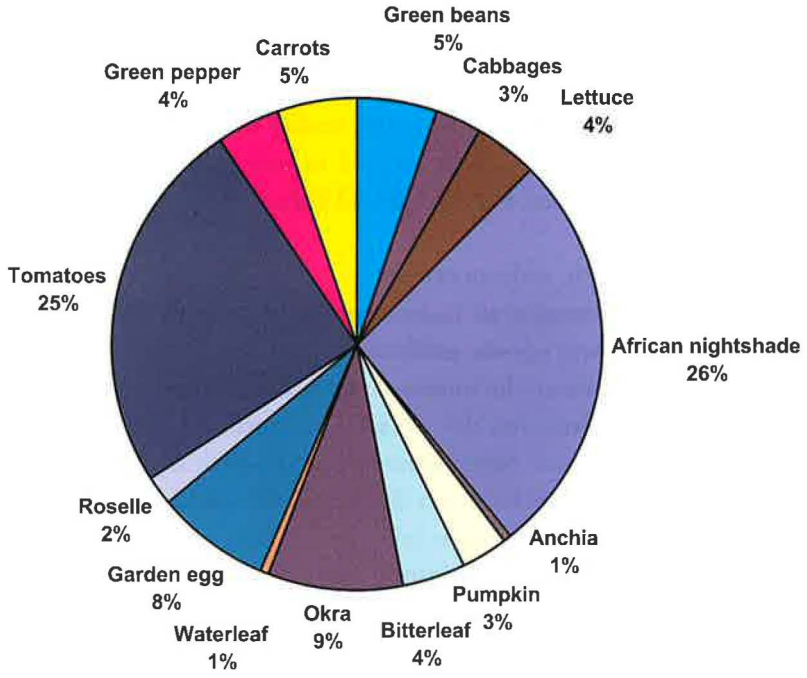

Chart 1 Sellers of vegetables by commodity: Foumbot market, Cameroon, January 1998

Source: BERINYUY, J.E. (1998) *Socio-economic survey on indigenous vegetables in The Foumbot area of the high plateau agro-ecological zone of Cameroon.* Report for NRI's project on indigenous vegetables in East and Central Africa.

The price for vegetables tends to fall in the wet season because it is the main production period and most rural households do not need to buy from the market. Retail prices remain constant, but the volume varies between seasons. The size of the bundles of leafy vegetables is reduced in the dry season.

In most countries, research has been focused on the major food crops or on cash crops with export potential. AIVs are invariably categorized as minor crops and are thus marginalized. This has initially resulted in AIVs becoming even more 'minor'. Fortunately, this trend is now reversing, despite lack of significant support from local authorities and a lack of support from the donor community.

CROP DEVELOPMENT AND PROMOTION

The process of domestication is continuous and it is often difficult to imagine that present-day crops belong to the same species as their ancestors, which look so different. The selection criteria of man are usually rather different from those of nature, for which multiplication and seed dissemination mechanisms are more important than food value and facility of harvest.

There are hundreds of landraces found throughout Africa which indicate their cultivation over a very long period. Their occurrence in often rather different agro-ecological zones has led to a great diversity and offers great scope for a plant breeder. The advancement through genetic enhancement as seen for the well-known 'western' crops has, to a great extent, bypassed African vegetables. There are significant opportunities to enhance indigenous vegetables, after which consumers will be able to get a much better-quality product and farmers will be able at least to double their yields. As shown by basic research on garden eggs carried out by Ghana's Ministry of Food and Agriculture jointly with the

Natural Resources Institute, the research impact can be significant. It could be argued that the value for money would be higher when investments are made in indigenous vegetables research rather than more money being invested in the well-established exotic vegetable crops. Most questions raised in connection with onions, cabbages or other exotics could readily be solved by a search of the internet or by a literature search. Research on AIVs is likely to lead to new findings and contributes not only to science, but also to people's food security and general well-being.

Steps to be taken towards genetic enhancement

1. **Collection of germplasm.** It is essential to make extensive collections of germplasm, especially from more isolated areas and from people's home gardens.
2. **Screening.** The germplasm needs to be screened by scientists with the help of producers and consumers to identify desirable characteristics. Selected material should then be purified, leading to the development of uniform varieties. Non-selected materials with distinctly different characteristics should be preserved in gene banks for later use. Such material could be of value when searching for tolerance or resistance to stress factors.
3. **Seed multiplication.** Multiplication of seed from a number of varieties, allowing farmers or traders to choose which ones suit them most.
4. **Development of new varieties.** Combining desirable characteristics or elimination of less desirable ones is usually possible by means of simple crossings. Since many of the crops are potentially self-pollinated and have a high level of inbreeding, there is a well-above-average chance of success, at least during the early stages of development.
5. **Agronomic research.** Identifying the major technical constraints facing farmers of indigenous vegetables and carrying out research to overcome these constraints.
6. **Technical package.** Development of appropriate technical advisory packages dealing with agronomic issues, e.g. nursery, spacing and fertilization, pest and disease control and with market and post-harvest related issues. Farmers will also benefit from the provision of reliable market information.

MAIN CONSTRAINTS FACING FARMERS WISHING TO GROW AFRICAN VEGETABLES

LACK OF TECHNICAL ADVICE

Extension officers may give advice on exotic vegetables but not on production systems for IVs because they have had no training to do so. Generally, improved agronomic packages provided to farmers are for staple and cash crops and often have little or nothing to do with indigenous vegetables. There is also a lack of published information about IVs. Therefore, most producers have to rely on traditional technologies.

LACK OF SEEDS/PLANTING MATERIALS

Most farmers grow their own seeds and some sell seedlings in their local markets. Other farmers obtain their seeds from specialists within their village. Farmers frequently express a desire to try out other varieties, but have no access to a good supply source for seeds. Uniform varieties hardly exist and most plots are planted with landraces which could be heterogeneous, but these landraces are able to withstand most of the local stress factors such as drought or very wet conditions, a low level of soil

fertility and pressures brought about by pests and diseases. The viability of seeds produced on-farm is not tested before planting so that farmers tend to reduce the risk of poor seeds by producing and sowing more than they actually need. Only a few seeds are kept for longer than one season.

MISUSE OF INSECTICIDES AND POLLUTED WATER ARE COMMON PROBLEMS

Many farmers need assistance on the choice and use of crop protection chemicals and on the dosage and appropriateness of the chemicals being used. Most of the problems of vegetable production are associated with pests, such as snails that eat the leaves of *Vernonia*, or aphids that cause the leaves of African nightshades to fold up. Flea beetles could destroy an early *Hibiscus* crop and cause a potential threat to the livelihood of people who depend on such crops in their semi-arid environment. This has resulted in the misuse of insecticides. In particular, the manufacturer's instructions as far as timing of applications is concerned are often overlooked. The misuse of pesticides has led to some consumers preferring to buy produce which shows evidence of insect damage, thus indicating the absence of toxic chemicals on the leaves.

Around Yaoundé, Cameroon, it was found that the irrigation water comes from small streams that are often used as sewers, resulting in uncooked vegetables such as lettuce becoming a health hazard. In Accra, Cairo, Dar es Salaam and other major cities, the irrigation water is often polluted with a range of chemicals which affects the taste and the health of the crops produced. Consequently, many consumers now prefer to buy leafy vegetables that have been produced in remote rural parts of the country, even though they appear less fresh.

Now that the decline in the use of traditional vegetables has been reversed and now that IVs are becoming more popular as a result of rapid urbanization, a major effort has to be made to offer a clean, healthy product that is not affected by misuse of insecticides or grown in soil contaminated with heavy metals or irrigated with water that can best be described as dirty.

To raise their profile, IVs should get the same treatment as exotics. If IVs are grown under less hygienic conditions, people will come to associate them with bad quality food that is only suitable for poor people.

AMARANTH

Amaranthus spp.

Figure 2 *Amaranthus blitum* in Uganda

INTRODUCTION

Amaranthus species are a group of highly popular vegetables, belonging to many different species. They are the most commonly grown leafy vegetable of the lowland tropics in Asia and Africa. The most frequently cultivated species in Asia, *Amaranthus tricolor*, is hardly ever seen in Africa. The taxonomy of the African species is still confused and much further work is needed. Several of these species are collected from the wild for subsistence and only a few are cultivated. All African species are used for their leaves. Amaranths can also be grown for their seeds and some varieties were introduced from the US for that purpose. Grain amaranth was not found to be very popular in Africa.

Amaranth is known for its C4 cycle of photosynthesis where the growth rate is optimized by high temperatures, bright light and adequate water and minerals. This is why amaranths perform so well in open areas when compared with a C3 plant such as *Celosia* which performs better under shade conditions than amaranths. C4 plants possess the so-called Kranz anatomy, where the endodermis consists of large, radially arranged cells which are not found in a C3 plant like *Celosia.*

THE SPECIES COMPLEX FOUND IN AFRICA

Several efforts have been made to unravel the taxonomic complex of amaranth, but this has often led to further confusion due to the many varieties, especially within the cultivated group of species. Since many species have become pan-tropical it is also difficult to state how many different truly African

species there are. This publication is restricted to the cultivated species, of which there are only a few. The most commonly grown amaranth in Africa, which is often cited as a good example of an African indigenous vegetable, *A. cruentus,* is probably of American origin.

Basic key to African amaranth species that are either cultivated or frequently collected from the wild

1. Inflorescence axillary only ..... *A. graecizans*
1. Inflorescence both terminal and axillary 2
2. Leaves rhombic to elliptic, not more than 3 cm, plants prostrate ..... *A. thunbergii*
2. Plant erect with leaves larger than 3 cm 3
3. At least some leaves emarginate at apex ..... *A. blitum*
3. All leaves entire at apex 4
4. Most nodes with a pair of sharp spines ..... *A. spinosus*
4. Spines absent 5
5. Inflorescence slender with racemes less than 8 mm in diameter ..... *A. dubius*
5. Inflorescence plume-like with raceme diameter of 10 mm or more ..... *A. cruentus*

The most widely grown 'African' amaranth is *A. blitum* L. (2n=34) (*see* Figure 2.). Its origin is considered to be the Mediterranean region (Stevels, 1990) from where the species has spread to Asia, Africa and southern Europe and, to a lesser extent, to the US. The cultivated varieties, and especially those from Asia, are classified under the cultivar group '*Oleraceus*' to which *A. lividus* L. belongs. *A. lividus* has been in cultivation in southern Europe for some 400 years and in the past it was also cultivated in West Africa, where it is no longer a common crop. In East Africa it is becoming increasingly popular (*see* Figure 3). There is therefore a need to collect germplasm from remnant plant populations in areas where cultivation took place in the past and also from the wild populations found throughout the continent. Such collections may become the base for new cultivars and for selected landraces with desirable characteristics like late flowering and large green leaves.

Figure 3 The broad-leaved form of *A. blitum* is also known as *A. lividus*

A. blitum is recognized by its ovate-elliptic leaves, which are usually obtuse or emarginate towards the tip. It is the main cultivated species in Uganda and western Kenya. In Uganda, it is much appreciated for its softer taste when compared to *A. cruentus,* although its yield is lower. The red-leaved forms are usually referred to as *bbuga,* whereas the more popular green-leaved varieties are called *dodoo.* The large, broad-leaved forms are frequently cultivated, for which the seeds are sown in prepared plant beds. The smaller-leaved, mainly green forms are usually found near homesteads where young plants from shattered seeds are retained rather than being removed as a weed. In Cameroon, it is sometimes referred to as 'horse amaranth' because it is much appreciated by animals and is occasionally grown as fodder for pigs. Its seeds are comparatively large (1-1.5 mm) when compared with those of *A. dubius* (1 mm or less) and this can also be observed by its seed weight, which is 1010 seeds for *A. blitum* and 3270 seeds for *A. dubius.* Both counts were made by Mayega Erisa from Makerere University. 2n=34.

The seeds are used to make an intoxicating drink in south-western Africa (Burkill, 1985).

The amaranth most commonly grown in Africa is *A. cruentus* L. (2n=32). This species is best recognized by its leaves that are twice or three times as long as wide and often have pointed leaftips (*see* Figure 4).

It has a large, widely branched inflorescence. A lot of attention has been given to this pan-tropical species which probably had its centre of origin in the northern parts of Central America (Guatemala and Mexico) and neighbouring regions of the US. According to Stevels (1990), the amaranths *A. hypochondriacus* L. and *A. hybridus* L. belong to this species. Black-seeded forms with dark-green stems and leaves, or forms with at least some red colour on the stems, leaves and inflorescences, are rather common as a weed and several of these forms are either collected from the wild or cultivated. In South Africa, this species, which can be up to 2 m high, is referred to as tree spinach. The Kiswahili name for amaranths in general, and this species in particular, is *mchicha.*

Figure 4 *Amaranthus cruentus*

Some light-green or yellowish forms, as often seen in cultivation, may have come from the yellow-seeded grain amaranth. Grain amaranths were first introduced in Africa for their seeds, to produce a protein-rich cake. This introduction of grain varieties has not been very successful and people started to use their leaves instead. Crosses between the leafy and grain forms are now rather common and most varieties grown for their leaves have black seeds and only a few have either yellow or brown seeds. The leaves have a high dry-matter content. 2n=32.

Amaranth seeds are occasionally used in Ethiopia to brew the alcoholic beverage *'tala',* a kind of beer.

Year-round cultivation of *A. cruentus* is practised in a number of locations such as around Dar es Salaam and the coastal regions of Nigeria, Congo (Democratic Republic) and Benin. This lack of crop rotation and continuous monocropping is possible because these amaranths are not, or hardly, affected by nematodes.

A. dubius Mart. ex Thell. is cultivated in several places in Africa such as the coastal areas of Kenya, but never on a large scale. It can be recognized by its long clusters of flowers in the axils of the lower leaves and a longer spike, branched or not, in the terminal part. Its leaves are ovate-elliptic which are pointed at the apex and not emarginate (*see* Figure 5). Its probable origin is South America and it is mainly cultivated in Asia. In Africa, it is found as a weed along roads and on waste sites. *A. dubius* is a tetraploid species with 2n=64.

A. graecizans L. occurs in drier areas of eastern and northern Africa where it is usually collected soon after the rains have started. Plants do not usually grow higher than about 40 cm and are prostrate with branches from the base. The species is rather diverse and several subspecies have been described. Plants found in southern Africa generally have narrow rhombic-to-elliptic leaves with a long petiole; in Kenya plants with a broader leaf are more common (ssp. *sylvestris)* (*see* Figure 6). These leaves are sparsely pubescent. The axillary cymes consist of green flowers.

Figure 5 *Amaranthus dubius*

Figure 6 *Amaranthus graecizans*

Because of the presence of these flowers people will not cook the whole shoot; they remove the leaves separately, which is one of the reasons why this amaranth species has a low market value. Their leaves are cooked like spinach and are much appreciated by older people because of their slightly bitter taste. In Mauritania, the seed is baked into thin cakes (Burkill, 1985). In Kenya, this species has its own name and is called *logatsi* by coastal people, whereas all other amaranth species are either called *mchicha* or *kiswenya.*

Amongst the species that are collected from the wild is the spiny amaranth or thorny pigweed, *A. spinosus* L., which resembles *A. dubius* and is frequently collected for home consumption, especially during periods of drought, and is only occasionally found for sale in the market in the form of loose leaves. It can be recognized by its short and often sharp spines found in the leaf axils. *A. spinosus* obtains a lower price on the market in Uganda, not only because of its spines, but also because people associate this plant with lavatories. *A. spinosus* is more tolerant to drought than *A. cruentus.* It is diploid with 2n=34.

A. thunbergii L. is common in southern Africa, where it originates. In Botswana, people collect it from the wild about 3 weeks after the rains have started, whereas the plants continue to grow throughout the summer. This species with small elliptic leaves and a long petiole is hardly cultivated at present. The Department of Agricultural Research of Botswana's Ministry of Agriculture has recently initiated research on this species and efforts are being made to cultivate it during the dry season. It is a popular vegetable amongst the Asian population living in South Africa. In Botswana, where it is called *thepe,* it is eaten with sorghum or maize. Its leaves are rather bitter when compared with other amaranth species. Cooked leaves are eaten with milk or fat to which some salt is added.

POLLINATION

The pollen of amaranth species is spread by the wind, but since there is a lot of pollen produced, much of it ends within the plant, leading to a high level of self-pollination (Grubben, 1977). For those species with a large panicle it is usually found that the higher-positioned flowers are staminate (male) and the lower ones pistillate (female). The axillary inflorescences are mainly pistillate. This information is based upon observations on *A. cruentus* and is likely to be the case for *A. blitum* as well since this species is also monoecious. The complete varietal range of yellow-green through dark-green and red forms of *A. blitum* (*see* Figure 7), with or without a dark-coloured centre, can easily cross with each other.

It is therefore necessary to isolate different varieties by at least 200 m when these are grown for seed. Interspecific crosses are usually sterile, whereas the difference in chromosome numbers between species constitute a further natural barrier in the hybridization process.

Figure 7 *Amaranthus blitum* in flower

AGRONOMY

There is a lot of information available on *A. cruentus*, but very little on *A. blitum* as far as cultivation in Africa is concerned. In Uganda and western Kenya, the most popular method is to sow the *A. blitum* crop in a plant bed and to harvest it directly by uprooting the whole plant. This method is mainly used for market gardening. The same method is used for *A. cruentus*, which is grown on a large scale in both West and East Africa. The crop can be harvested some 4-5 weeks after sowing. For subsistence, farmers collect side shoots from plants near their homes and allow the plants to produce seeds to be scattered for the next generation's crop.

In the case of a ratoon crop, the first harvest will be the main shoot, thereby allowing side shoots to develop which are plucked when needed. A low level cutting (20 cm from the ground) stimulates development of strong new shoots, whereas a high level will produce several weaker shoots that may start flowering at an early stage. When cutting too low poor regrowth can be expected. Transplanted seedlings are most commonly used for such crops, whereas direct sowing is the rule for a crop that is harvested by uprooting. In areas where stemborers are found, people harvest by uprooting the crop rather than by ratoon cropping.

The optimal spacing for plants to be harvested by uprooting is 10 x 10 cm, whereas for a ratoon crop the optimum spacing is about 20 x 20 cm. Considering the short duration from sowing to harvesting, which is usually about 4-5(-6) weeks, some commercial farmers opt for a mixed stand with nakati, whereby amaranths are harvested first, allowing the slower growing nakati more space at a time when the plants are large enough to need it.

Amaranths appreciate nitrogen and high levels of nitrogen will delay the onset of flowering, allowing a considerably higher yield. The crop also responds well to organic matter, which is applied at the rate of 2-4 t/1000 m^2. Chicken manure needs to be mixed well with the soil or diluted in water since its strength could scorch the plants. The use of well-fermented manure of whatever type would be the best. Amaranth grows well on town-generated waste or compost, which is one of the main reasons why it is so popular on waste-disposal sites in Cotonou, Benin and other urban and peri-urban areas. Trials in Benin with *A. cruentus* indicated that the crop also requires high potassium levels and best results were obtained with 400 kg/ha of compound fertilizers 10-10-20 N-P-K.

A shortage of water will result in early flowering. Frequent irrigation is therefore essential for a fast-growing crop that will flower late. Amaranth production has become very popular especially in (peri-)urban areas where the availability of tap water allows for a frequent and easy form of irrigation by using hosepipes. By far the most common species seen in such places is *A. cruentus*, which has become a real 'money-maker' for small-scale farmers with irrigation facilities located near the main cities of lowland tropical Africa (*see* Figure 8).

Figure 8 Seed crop of *Amaranthus cruentus*

There are no exact data on yields for the various African species. Records obtained from amaranth growers in the Dar es Salaam area (*A. cruentus)* indicate that 40 t/ha of shoots are quite possible. In Benin, the yield of 4-week old shoots of *A. cruentus* is about 30 t/ha. Similar yields have been recorded in Nigeria.

PESTS AND DISEASES

The principal diseases of amaranth are damping-off of seedlings caused by *Pythium aphanidermatum,* and leaf and stem rot caused by wetrot, *Choanephora cucurbitarum,* which is especially important in West Africa. The latter has been identified there as the most urgent breeding target in order to obtain resistance. In East Africa, a leafspot, tentatively identified as *Alternaria* sp., can be seen on *A. blitum.*

Caterpillars of *Hymenia recurvalis* can cause a lot of damage to the leaves. The stemborer *Lixus truncatulus* is an important pest in coastal areas of Tanzania even when the crop is only a few weeks old, producing wilting symptoms. Both pests can be controlled during the early plant stages by spraying with lindane. Aphids mainly cause problems during cool periods or in highland areas.

A. cruentus is known to be highly resistant to root-knot nematode, *Meloidogyne* spp. This may also be the case for other African amaranths, but further research is needed to confirm this. Such resistance would be highly useful for crop-rotation purposes which would benefit crops such as *Corchorus* or African nightshade.

NUTRITION

Amaranth has a high nutritional value because of the high levels of essential micro-nutrients like carotene and vitamin C, iron (an important element against anaemia) and calcium. It is especially rich in lysine, an essential amino acid that is lacking in diets based on cereals and tubers. The protein found in young plants can be important for people without access to meat or other sources of protein.

Amaranth leaves contain oxalates which can bind calcium and can thus be harmful when eaten in quantity on a regular basis. There should be no difficulties as long as the average daily intake does not exceed 100 g of leaves. The dry matter content of *A. cruentus* is about 16%.

Most amaranth species have forms that are rich in anthocyanin. Such red-leaved forms of *A. cruentus* can be seen in Cameroon and Tanzania, often together with their intermediates. They are harvested separately since there is a difference in consumer appreciation. People pay less for red-leaved types since they are said to have a sharper taste. In Uganda, where most varieties seem to have a dark centre in their leaves, preference is given to green types of *dodoo* (=*A. blitum* or *A. dubius*) (*see* Figure 9).

Figure 9 *Amaranthus blitum* plants are frequently collected from the wild or from homesteads where they are not removed as weeds. In West Kenya and Uganda they are sold on the market under the name *doodoo*.

LAGOS SPINACH

Celosia argentea L.

INTRODUCTION

Lagos spinach is a fast-growing crop, which is popular in south-west Nigeria owing to the soft texture of its leaves when compared with amaranth leaves. The most commonly cultivated vegetable species is *C. argentea,* which has its origin in West Africa, where it can be found as a weed in open, disturbed places. Outside Nigeria *C. argentea* is not cultivated as a vegetable on a large scale. It can be found in neighbouring West African countries, especially Benin and to a limited extent in the West Indies and the northern parts of South America. The only place where this vegetable is really common is in south-western Nigeria (*see* Figure 10).

The crop is highly susceptible to nematodes, which is the main limiting factor. A great deal of agronomic and breeding work has been carried out on its close relative, the cockscomb, an ornamental plant which has become an economic success story. What could happen to Lagos spinach with more research focused on finding germplasm with a tolerance to root knot nematodes is a matter of speculation.

Figure 10 *Celosia argentea*

A comprehensive overview on *Celosia argentea* has been prepared by Dr T. Badra who used the name Lagos spinach for this crop (Badra, 1991). For further details, the reader is advised to refer to his paper. According to Badra, the centre of origin of this plant lies between Senegal and Cameroon. The species can also be collected from the wild in the Red Sea area including Somalia and Ethiopia as well as Yemen. The Yorubas, who eat this crop more than anybody else, call it *sokoyokoto.*

Related species

Celosia isertii Townsend (=*C. laxa* Schum. and Thonn.) is a plant from riverbanks and swampy places, where it may climb on other vegetation with its long, thin vines. It has narrow, somewhat waxy leaves. This is the *Celosia* species that can be seen in Togo and the Volta district in Ghana. It is less common than *C. argentea,* but can be found over a wider area.

A third African species from the savannah and relatively dry areas, the diploid *C. trigyna* L., is mainly known in its weedy form with thin, weak stems and is much branched. It is rarely cultivated in Botswana and only occasionally in Nigeria. It has somewhat bitter leaves, which is why many people do not care for this species. Under cultivation, the small black seeds are broadcast, mixed with loose soil. Young shoots are harvested about 2 months from sowing prior to the development of the flower shoots, which can be spiny. This species responds very well to fertilizers. It is rich in saponins and is used as a traditional medicine in both East and West Africa. Van Epenhuijsen (1974) mentions a seed weight of 3200 seeds.

C. isertii and *C. trigyna* L. are used to treat tapeworm, especially in children.

The cockscomb, *C. cristata* L. from South Asia, which is closely related to Lagos spinach, is a well-known ornamental crop which is used as a garden plant and as a cut flower, but its leaves are not eaten as a vegetable.

Digera alternifolia is grown in home gardens and occasionally as a market gardening crop for sale to local markets in the Konso area of south-western Ethiopia. The local name for this leafy vegetable is *kogata.*

D. muricata (L.) Mart. is a popular leafy vegetable amongst the Giriama and other coastal tribes in Kenya, who cook it as a spinach. It has two distinct subspecies which are equally appreciated by people, although the large-leaved ssp. *patentipilosa* is less labour intensive to collect and to prepare. It has potential for further development, but since it can be found in the wild there is little incentive for cultivation by the Giriama people, although its distribution is limited to a small area along the coast. The Turkanas are known to eat it as a vegetable. It is similarly appreciated by livestock and elephants. In India, its seeds and flowers are used to treat urinary disorders.

BOTANICAL ASPECTS

The genus *Celosia* has about 60 members, found in South and Central America, Africa and South Asia. It is closely related to *Amaranthus* and can be distinguished by its ovary, since *Celosia* is multiovulate and *Amaranthus* uniovulate. Amaranth flowers are unisexual whereas the flowers of *Celosia* are bisexual.

C. argentea is a tetraploid species (4n= 36) with some varieties found to be octaploid.

C. trigyna is diploid. The vegetable *C. argentea* is very close to the ornamental *C. cristata* and its hybrids are fully fertile.

C. argentea flowers have five perianth segments of 6-10 mm long and the stamen contain five filaments which are fused at the base to form a cup. The long style has bilobed stigmas. The terminal spikes are densely packed with flowers. The species is rather polymorphous and generally has linear lanceolate leaves in the wild forms. The cultivated forms are mainly broad leaved. *C. trigyna* and *C. isertii* have perianth segments of 2-5 mm and spikes with short lateral clusters of flowers. They are further differentiated by their seeds.

VARIETIES

There are a number of varieties of Lagos spinach of which the most popular is Green soko. Green soko is erect with few prominent branches. Local green has the longest stems and heaviest roots. Another popular variety is Red soko with a large red spot in its centre. Red soko is generally taller than Green soko, growing up to 180 cm in height, with many branches and long lateral shoots up to 150 cm long. The young leaves are pink with a prominent dark-purple marking. The upper leaves of Red soko, when the plant is allowed to produce flowers and seeds, are about 28 cm long and 8 cm wide, while other leaves are about 17 x 8 cm. Green soko was developed in Benin from the red-leaved cultivars. The flowers are deep-purple, similar to the green form. The Nigerian variety Local white has a lower yield than Soko, but is less demanding as far as soil nutrients are concerned.

The International Institute for Tropical Agriculture (IITA) has released an early variety called TLV 8, which is also large-leaved and the most succulent of the three, outyielding the others. It is more tolerant to both low and high temperatures and is late-flowering.

Red-leaved plants are frequently used for their ornamental value and can be found in many countries. Their leaves can be consumed and are frequently harvested in the young plant stage prior to the onset of flowering.

More primitive landraces of *C. argentea* have long, narrow leaves that are green in colour. The wild *C. argentea* can be a troublesome weed, especially on clay soils that are relatively fertile.

AGRONOMY

The crop is usually sown directly for a once-over harvest by uprooting the crop. The small seeds are well mixed with dry sand or loose soil at a ratio of approximately 1 part seed to 20 parts sand. Germination can be expected in about 7 days. To accelerate the germination process and to increase yields later on, some people treat their seeds before emergence by placing the seeds in water at 70 °C for 2 h before sowing. Prolonged heat treatment will result in a reduced yield.

A nursery is used when harvesting is envisaged for an extended period. Seedbeds should consist of friable soil to which some well-decomposed cattle manure has been added. Soon after sowing, a grass mulch should be applied so that an adequate moisture level can be retained, but when the seedlings are about 1 cm tall this mulch should be carefully removed.

Transplanted seedlings were found to give a better yield for a ratoon crop than directly sown ones. Flat beds are better at retaining a high moisture level when compared with raised beds or ridges. The best performance was observed from flat beds which were first cultivated and in which some form of manure had been incorporated.

Such seedlings are transplanted at the 3-week stage when about 10-15 cm high and are spaced 15-30 cm apart each way. This spacing depends on the soil condition and the number of harvests envisaged, with a wider spacing for fertile soils and harvests over a longer period.

After the first harvest of a ratoon crop it is advisable to apply 50 kg NPK (15-15-15)/1000 m^2 around the plants or in between the rows.

As a weed *C. argentea* can grow both in very poor acidic laterite soils which are deficient in organic matter and in soils which are rich in nitrogen and potassium. Under poor conditions the weed will not grow much taller than about 30-50 cm, whereas when cultivated as a vegetable, with full attention, it could reach up to 2 m in height. A high level of organic material in the soil is required for optimum leaf production, especially for the green form.

It was found that burnt organic waste, compost, poultry and cattle manure significantly increased the green leaf yield of *Celosia*. The optimum rate of poultry manure for the large-leaved cultivars is 4 t/1000 m^2. As an alternative to manure, NPK fertilizers are recommended at a rate of 50 kg/1000 m^2.

The optimum rate of poultry manure for Local white is 20 t/ha. Local white has a higher crude protein percentage and vitamin C content than the broad-leaved Soko varieties, but its yield of edible leaf is lower.

When given adequate water and enough plant nutrients, Lagos spinach grows fast and after 4-6 weeks it may reach a size of about 30 cm, when it can be first harvested by uprooting the whole plant or, alternatively, the top can be removed, allowing new side shoots to develop.

When compared with amaranth *Celosia* is usually found to be growing faster and to have a higher dry matter content. *Amaranthus* is more popular than *Celosia* which is, however, more appreciated for its soft texture.

Climatic requirements

A high rainfall has no negative effect on plant growth. However, to overcome stresses caused by irregular watering or inadequate rains, a tillage of about 15 cm or more is recommended to support root growth and therefore shoot growth. A short period of drought may not be bad since this will induce axillary growth. A period longer than about 1 week of dry conditions will result in early formation of flowers which will be at the expense of the formation of new leaves. Red soko is more susceptible to drought than the green varieties.

Celosia grows well at low altitudes where temperature fluctuations are limited, although it has been recorded in Ethiopia at 1700 m. High light intensities are required to maintain regular leaf formation and development. The most favourable growth temperature during the day is between 30 and 35 °C with an optimum assimilation of CO_2. Temperatures above this range will not generate more leaf and stem production as seen in *A. cruentus*. Low night temperatures (20 °C or below) will retard growth. It is a short-day plant.

Celosia has a C3 cycle of photosynthesis which allows it to perform best under partly-shaded conditions, contrary to the C4 amaranth plants which perform better under fully exposed and warm conditions. *Celosia* is thus often a more suitable crop for home gardens with trees. To reduce the effect of natural heat stress, shading is recommended. Shade applied during the first week after sowing will have a positive effect on yields. These effects will diminish over time.

HARVEST AND POST-HARVEST

Harvesting can take place about 1 month after sowing by thinning out the tallest plants of approximately 20 cm in height. Uprooting continues until the last plants are about 40-50 cm tall. The green type is likely to start developing a flower head at this stage, whereas the red type will develop branches. The roots are removed from these crops before the bundles of shoots are brought to the market.

A second method of harvesting, the ratoon cropping method, is by first cutting the main stem at about 15-20 cm from the ground, thereby allowing lateral shoots to develop. The second harvest should again be taken about 15 cm from the node, to allow the plant to re-grow. Up to four cuttings can be obtained from the plant at 3-weekly intervals, after which the leaves start declining in size and quality. *Celosia*'s rate of regrowth is slower than for amaranth, which is one of the reasons why most commercial farmers prefer to re-sow rather than use the ratoon cropping system. The latter system is more popular with subsistence farmers.

An average yield of 16-28 t/ha can be obtained from Green soko and Red soko respectively. Maximum yields of 47 t and 58 t when harvesting by uprooting and by collecting shoots respectively were reported in the Nigerian Institute for Horticulture (NIHORT) Annual Report for 1983.

Steam-blanched and dehydrated vegetable leaves can be stored for 6 months without much loss in ascorbic acid content. Sodium sulphite and sodium metabisulphite significantly enhance the retention of ascorbic acid in processed leaves.

Celosia is a major vegetable in south-western Nigeria and can be found in local markets throughout the wet season. Substantial quantities are also collected from the wild and used both for subsistence and for sale at the market.

SEEDS

Lagos spinach has a high degree of self-pollination, but some natural cross-pollination occurs as a result of insect visits to the hermaphrodite flowers, leading to somewhat heterogeneous populations.

Farmers reserve a special corner for seed production. Seedlings are transplanted in rows 70 cm apart with 40-45 cm in a row. Seed plants can reach a height of 150 cm or more. It takes about 80-90 days from sowing to the first harvest of inflorescences with seeds. Inflorescences are ready when they turn silvery in colour and when the leaves are becoming yellowish. After the top shoot has been removed, secondary shoots will continue to develop and can be harvested up to 4 weeks later. The whole flowering shoot should be collected and dried on a tarpaulin or similar sheet to avoid losing too many seeds.

Figure 11 *Celosia* flowers can be very decorative

The lower part of the inflorescence has fully mature seeds at the time when the top part is just starting to flower (*see* Figure 11). Seeds shatter easily and seeds can only be collected from the ripe part. Therefore, although the seed yield is high, only part of the potential seed yield can be collected.

Red soko seed yields are higher than those of Green soko, but Green soko will go to seed faster than the Red soko variety. Seeds are less than 1 mm in diameter, biconvex and shiny black in colour. There are about 1000 seeds in 1 g.

One problem associated with seed production is a 4 mm-long black beetle with two light spots on the back, called *Baris planetes*, which feeds on the fruit. Similarly, the insect *Aspavia armigera* can be found on the inflorescence sucking the seed heads and young stems, resulting in a low seed yield.

PESTS AND DISEASES

C. argentea does not suffer much from pests and diseases apart from its susceptibility to the nematode *Meloidogyne incognita* and spider mites. The green variety is generally more susceptible to nematodes than the red type.

The Green soko variety is more affected by the white rust *Albugo blitii* which can be recognized by white pustules on the underside of the leaves and chlorotic spots above. White rust and crown blight are the most serious diseases affecting *Celosia.*

Crown blight *(Chonaephora cucurbitarum)*, a wet rot fungus, can become problematic in dense plots with insufficient aeration and can also cause rot on the stumps left after harvesting and after insect damage. Diseases of some importance in West Africa include the stem rot *Rhizoctonia solanii* which can also cause damping off just like *Pythium aphanidermatum* and *Thatatephorus cucumeris. Cercospora celosiae* causes grey spots on the leaves. Other diseases noticed on *Celosia* are the leaf spot disease *Alternaria* spp., collar rot *(Phytophthora cryptoge)*, charcoal rot (*Macrophomina phaseolina)* and *Curvularia* spp., which cause dark spots on the leaves.

NUTRITION

Boiled leaves and young shoots are used in soups and stews. Such leaves can be slightly mucilaginous. Consumers only retain the top and remove the lower leaves together with non-tender stalks. This is one reason why short branches of 15-20 cm are preferred over long ones of 40 cm and over. The red type is more bitter than the green varieties which are most preferred, although their yield is lower than that of the red type. There has been a selection for degrees of bitterness (of cooked leaves) and there is further potential in the available germplasm to create bitter-free varieties if so desired. Boiled shoots are served with starchy staples such as yam or yam flour, rice, etc.

Celosia leaves can be dried in the sun to be utilized during the dry season. Fresh leaves weigh about 11 times more than dry leaves whereas the dry weight ratio between leaves and stems is about 4:1.

The highest crude protein content and total vitamin C content were found in leaves harvested 5-7 weeks after sowing, whereas the highest total marketable yields, as well as total crude protein, are obtained 15 weeks after sowing. Green varieties contain more protein and Vitamin C than the anthocyanin-pigmented ones (*see* Table 1).

In India, the seed oil content of *Celosia argentea* was found to be 7.5%. This fatty oil is known under the name 'Celosia oil'. This oil and the seed cake could potentially be of significant additional value for this crop, given its high seed yields.

Table 1 Nutritional composition of the leaves

Water (ml)	84.0
Calories	4.4
Protein (g)	4.7
Fat (g)	0.7
Carbohydrates(g)	8.0
Fibre (g)	1.8
Calcium (mg)	260.0
Phosphorus (mg)	43.0
Iron (mg)	7.8

Source: FAO, 1968

Further data on nutrition can be found in Badra (1991).

MEDICINAL USES

C. argentea leaves are used to treat coughs and its roots have diuretic properties. The seeds are used as a remedy against diarrhoea.

BIBLIOGRAPHY

BADRA, T. (1991) Lagos spinach. pp. 131-163 In: *Pulses and Vegetables.* WILLIAMS, J.T. (ed.). London: Chapman and Hall.

BRENAN, J.P.M. (1981) The genus *Amaranthus* in southern Africa. *Journal of South African Botany* **47**(3): 451-92. (A key to and descriptions of the 15 native and introduced species of *Amaranthus* in Southern Africa are given.)

BURKILL, H.M. (1995) *The Useful Plants of West Tropical Africa.* Vol. 1. Kew, UK: Royal Botanic Gardens.

CHWEYA, J.A. and EYZAGUIRRE, P.B. (eds.) (1999) *The Biodiversity of Traditional Leafy Vegetables.* Rome: International Plant Genetic Resources Institute (IPGRI).

FAO (1983) *Traditional Food Plants.* Rome: FAO.

FAWUSI, M.O.A. and ORMROD, D.P. (1981) Response to temperature of *Celosia argentea. Scientia-Horticulturae* **15**(3): 215-221.

GRUBBEN, G.J.H. (1975) *La Culture de l'Amarante, Légume-feuilles Tropical avec Référence Spéciale au Sud-Dahomey.* Thesis, Wageningen Agricultural University.

GRUBBEN, G.J.H. (1977) *Tropical vegetables and their genetic resources.* Rome: IBPGR.

GRUBBEN, G.J.H. and van SLOTEN, D.H. (1981) *Genetic Resources of Amaranths—a Global Plan of Action.* Rome: IBPGR.

KOGBE, J.O.S. Effects of poultry manure on the yield components of *Celosia argentea* L. *Vegetables for the Hot Humid Tropics Newsletter (Nigeria).*

MNZAVA, N.A. (1997) Comparing nutritional values of exotic and indigenous vegetables. pp 70-75. In: *Proceedings of a Workshop on African Indigenous Vegetables, Limbe, Cameroon, January 1997.* SCHIPPERS, R.R. and BUDD, L. (eds.). Chatham, UK: IPGRI/Natural Resources Institute.

OMUETI, O. (1980) Effects of age on *Celosia* cultivars. *Experimental Agriculture,* **16**(3): 279-286.

STEVELS, J.M.C. (1990) *Légumes Traditionelles du Cameroun, une Étude Agro-botanique.* Wageningen, Netherlands: Veenman B.V.

VAN DER ZON, A.P.M and GRUBBEN, G.J.H. (1976) Les légumes-feuilles spontanés et cultivés du Sud-Dahomey. *Communication 65, KIT.*

VAN EPENHUIJSEN, C.W. (1974) *Growing Native Vegetables in Nigeria.* Rome: FAO.

SPIDERPLANT

Cleome gynandra L.

Synonyms: ***Gynandropsis gynandra*** **(L) Briq.**
Cleome pentaphylla **L.**

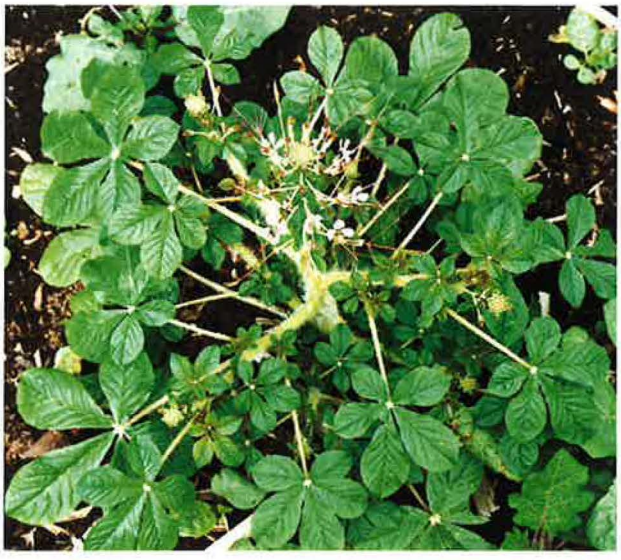

Figure 12 *Cleome gynandra,* the spiderplant

INTRODUCTION

In most African countries, the spiderplant is no longer considered as a weed, but is most welcome as a source of food and even income. It is rapidly becoming more popular, especially in Uganda and Zambia/Zimbabwe, where a change from a tolerated weed through the phase of a backyard garden crop into a fully-fledged cultivated crop has been seen. It is appreciated in regions with only a short rainy season such as South Matabelaland, Zimbabwe, where it is the most important vegetable. It is virtually unknown in West African high-rainfall areas. However, it is cultivated in the low-rainfall areas of West Africa such as around Garoua in northern Cameroon. It is scarce or non-existent in the cooler parts of southern Africa. Spiderplants are also used as a vegetable in several South Asian countries.

The most commonly used English names are spiderplant (*see* Figure 12), spider flower or African spider flower. Outside Africa the name cat's whiskers is frequently mentioned. The name spider flower is also used for ornamental *Cleome* species that are used either as border plants or as cut flowers. This is why the name spiderplant has been chosen rather than spider flower. No common name exists in

Africa, although there are very many local names for this traditional crop, which is used both as medicine and as a food crop. The Kiswahili name is *mgagani,* whereas it is known in Zimbabwe as *nyevhe.* For other names used in Africa reference can be made to Chweya and Mnzava (1997)

RELATED SPECIES

Cleome monophylla L. or spindle pod is mainly consumed in southern Africa even though it also occurs in East Africa. In Zimbabwe, where it is called *musemwasemwa,* efforts to cultivate this species are currently being made, but this crop is not likely to become important because of the small size of its few leaves. The leaves are simple and not compound in shape like *C. gynandra* or *C. hirta.* The spindle pod does not have a strong branching system. It is less bitter than *C. gynandra,* which is why many people prefer it. It can be distinguished from *C. gynandra* by its pink petals and lanceolate or oblong leaves which can be slightly hairy. Their stamens are not much longer than the corolla. Their leaves are used like *C. gynandra* and their pounded seeds can be used as a substitute for mustard (Tredgold, 1986).

Cleome hirta (Klotzsch) Oliv. is collected from the wild in Zimbabwe and no effort to cultivate this species has been found by the author. It is a weedy plant with 5-9 foliate leaves and linear-shaped leaflets. It has pink or purple-coloured petals which are paler towards the base.

BOTANICAL ASPECTS

There has been some confusion over the correct scientific name of this crop. Both *Gynandropsis gynandra* and *Cleome gynandra* are widely used. For simplicity, the latter has been accepted, in line with the name used in the recent International Plant Genetic Resources Institute (IPGRI) publication on this species and also because taxonomists currently consider *C. gynandra* to be the correct name. It is a member of the Capparaceae family (formerly Capparidaceae). A number of attempts have been made to establish the chromosome counts, resulting in diploid counts ranging between 2n=18 and 2n=34 with 2n=20 being most frequent, whereas polyploidy has also been observed (Chweya and Mnzava, 1997).

Advocates of a separate genus *Gynandropsis* use the presence or absence of an elongated stalk on which the stamens are inserted (androphore) as a distinction between the two genera. The spiderplant has a distinct androphore with stamens well beyond the corolla, which is why some authors place it under *Gynandropsis,* whereas *Cleome monophylla* and *Cleome hirta* do not have such an androphore (*see* Figure 13).

Leaves follow the direction of the sun, especially on warm days with a high light intensity. If water is available in adequate quantities, this sun-following phenomenon makes the plant's photosynthetic activities highly efficient. This is further enhanced by its C4 cycle of photosynthesis, just like the amaranths. The vegetative growth declines rapidly with the onset of flowering, which is the main reason why farmers remove the flowers.

Figure 13 The spiderplant has an androphore with stamens well beyond the corolla

The species flowers day and night and flowering may last for 2 months or more, depending on its access to water (*see* Figure 14).

Out of the more than 50 species of *Cleome* found in Africa, only three are frequently eaten.

Figure 14 Spiderplant flowers

VARIETAL SELECTION

A wide diversity in characters can be seen in the field, including:

- more or less hairy or glandular stems;
- more or less branched;
- small or large leaves;
- a vertical or horizontal plant structure;
- early or late flowering;
- white or purplish flowers;
- purple and/or green stems or petioles;
- short and thin or long and flabby pods;
- a range of bitterness.

Spiderplants from the Tanga district and the lowland parts of the Usambaras in Tanzania have distinct short and thin pods which are straight, whilst pods from plants found more inland are at least twice as large and variously shaped, mainly deflated and flabby when mature, but not thin and straight. Pods from Zimbabwe are less flabby than those from Uganda and central Tanzania.

Some people prefer the purple types because they are less attractive to insects and because they appear more drought tolerant. Other people prefer the green types because they are said to be more tender and less bitter. Research by Mnzava in Zambia has shown that green-stemmed types will regenerate better than purple types which may dry up or rot when the major shoots have been harvested once or twice.

PLANT BREEDING

The spiderplant can pollinate itself as shown by the occasional single plants that are found with pods and apparently viable seeds. When there are other spiderplants in the neighbourhood it can still be a self-pollinated crop, although a relatively high percentage of out-crossing is likely to be found. This will soon become evident when selection, for instance, for green-stemmed, large, late-maturing plants is attempted. In most cases the resulting crop will initially be a mixture again.

Observations in Zimbabwe (Chigumira, 1998) have shown that there are two different types of flowers.

1. Flowers which will facilitate cross-pollination where the anthers shed pollen before the stigma is receptive (protandry). Their stigmas are relatively short. Pollination can still take place within the same plant but not on the same flower.
2. Flowers with comparatively long stigmas which are receptive at the time when pollen is shed. Such flowers facilitate the self-pollination process.

Ideally, breeding has to be done in isolation, for which a lot of patience is needed. So far only limited research on this topic has taken place, mainly in Kenya. Results indicate that environmental factors, of which soil fertility and rainfall are the most important, play a more important role in the presence or absence of anthocyanin than genetic characteristics.

To improve the yield, breeders should select for late flowering and for tall, green-stemmed plants with many large leaves. When a uniform crop is desired, an effort should be made to mark a few similar-looking plants with desirable characteristics and to remove their flowers and fruit. These plants should be dug up carefully (they have long taproots) and replanted in a container (e.g. a plastic bucket) and carried to an isolated place without any other *Cleome* plants within at least 200 m.

Pollination can now only take place within and between those selected plants. The resulting offspring should be thoroughly screened and an early decision taken on what the desirable type should be. Controlled self-pollination of desirable plants will further offer the opportunity to regulate the percentage of certain characteristics within the target population.

All non-conforming plants should be removed before flowering. Once this process has been repeated four or five times there will be a plant population that is relatively uniform. As long as the multiplication can be in isolation and be controlled through a rogueing process, it should be possible not only to create, but also to maintain a variety that is desirable, distinct and uniform.

AGRONOMY

In most places, spiderplants are found in people's compounds and little or no attention is given to them other than occasional weeding. Seeds that drop at maturity will produce next season's crop. This is not, however, the case in arid zones. In Matebeleland, southern Zimbabwe, over 75% of the farmers interviewed mentioned that they collect and retain seeds for sowing. During dry years, *Cleome* will not appear spontaneously and farmers have to sow the seeds and irrigate the plants to obtain a crop.

Plants perform best when fully exposed and do not grow well in the shade. They thrive under warm conditions, but not hot and dry conditions and do less well when temperatures drop below 15 °C. In Zimbabwe, where it is a very popular vegetable during the summer months, the crop does not grow during the winter and people have to rely on the processed product.

Spiderplant responds well to an application of farmyard manure (Waswa *et al.*, 1996) with an optimal application of 30 t/ha. This results in delayed flowering and therefore a longer harvest period and a significantly higher yield of leaves and shoots. Fertilizer applications increase crude protein content but decrease β-carotene, ascorbic acid and iron (Chweya, 1997). When there is no farmyard manure available an application of 120 kg N/ha was recommended in Zambia. Higher rates of inorganic fertilizers often have an adverse affect.

In Uganda, spiderplant is often sown together with nakati (*Solanum aethiopicum*, Shum group), when the spiderplant can be harvested by uprooting the crop 1 month after sowing, at a time when the nakati is still small.

Planting is always by direct sowing, since transplanting is virtually impossible because of the taproots. The seeds germinate after 4-5 days. Germination can be rather uneven when some of the seeds are dormant. This dormancy will ensure that there will always be some seeds ready to germinate in a climate with unreliable rainfall patterns.

Figure 15 Bundles of spiderplant leaves at the market

The spiderplant may start flowering as early as 1 month after germination. The first harvest should take place before the flowers open. People will accept a shoot with buds, but pay a lower price for shoots with open flowers. Some people will eat those flowers, but most will remove them.

Only a few farmers grow spiderplants as a monocrop and harvest by uprooting the plants. Some farmers collect the leaves for market (*see* Figure 15). Ratoon cropping is more common, when the main shoot is harvested first and the side-shoots after 1 or 2 weeks. Farmers may apply a nitrogen topdressing after the first harvest to facilitate a rapid re-growth and to delay flowering. After a further 2 weeks, the secondary shoots can be harvested, but from then onwards yields will decline and continuous production will no longer be economical. Alternatively, the first harvest can consist of thinned plants, followed by a ratoon crop. Chweya and Mnzava (1997) mention a yield of about 30 t/ha of young shoots and up to 500 kg of seeds.

After harvesting several times the remaining plant will flower for an extended period until the rains stop. The fruit (capsules) take a long time to mature and dry properly, and at the end seeds are shattered through dehiscence. The easiest way is to collect yellow capsules before they are fully ripe and to dry them in a controlled way so seeds can be retained. Seed counts in Uganda averaged 140 seeds/pod (capsule) (*see* Figure 16). In the same trial, the number of seeds/g was 1244.

The Zambia Seed Co. promotes the crop through advisory leaflets and by making seeds available.

Figure 16 Each spiderplant pod contains 140 seeds on average

PESTS AND DISEASES

Figure 17 Purple spiderplant varieties are less affected by insects but are equally susceptible to diseases

Diseases recorded for spiderplant include *Sphaerotheca fuliginea, Oidiopsis taurica* and *Cercospora uramensis.*

The main pests on spiderplants appear to be aphids and flea beetles (*Phyllotea* sp.), which chew away at the margins of the leaves, making the product less attractive for human consumption. Spiderplants do not attract many pests, but it has been observed that when they are growing between other crops, pests coming from neighbouring crop species will attack them. The plant is a host for nematodes. Stemborers can infest *Cleome*, although the extent of the damage may vary considerably between landraces, indicating that some lines are less susceptible (*see* Figure 17).

In Zambia, hurricane bugs (*Bagrada* spp.) mainly attack young plants during the dry season. These insects can be controlled by spraying with an insecticide such as Ambush or Dimethoate.

Purple-coloured varieties were observed to be less affected by insects. In Botswana, tortoises have been reported to enjoy spiderplants.

Spiderplants are known for their insecticidal and insect-repellent characteristics and sprays of aqueous leaf extracts may cause a considerable reduction in aphid and thrips populations. Even though *Cleome* may repel certain species of aphids and other insects, this does not make them immune to attack by other species of herbivorous arthropods including some aphids. Intercropping with cabbages was found to have a profound effect on diamond-back moth, *Plutella xylostella,* considerably reducing its population when one row of cabbages was alternated with one row of spiderplants. When nakati is intercropped with spiderplants, as is common practice in Uganda, the incidence of thrips is much reduced.

NUTRITION AND USES

Spiderplants are a good source of calcium (Ca), magnesium (Mg) and iron (Fe) and also of vitamins A and C.

In many communities, cooked spiderplants are used by women before and after giving birth, and for as long as they breast-feed their children. It is believed that the plant restores the blood supply. For similar reasons, boys eat this vegetable just after circumcision. It is also known to help against stomach ailments. In West Africa, it is used as a medicine to treat headaches; the leaves are rubbed on the sufferer's head.

Figure 18 Many people dislike the smell of spiderplants, caused by a volatile oil found in the glandular hairs

There are data indicating that purple-stemmed varieties have a considerably higher crude protein and lipid content than green-stemmed plants, but further research is required to confirm this.

Many people dislike both the bitter taste of spiderplants and the smell, caused by an acrid volatile oil with a high phenolic content (*see* Figure 18). The phenolic compound binds proteins, thereby reducing the nutritional value of this vegetable. Proper cooking, replacement of cooking water and the use of additives will overcome this problem, even though a significant proportion of the ascorbic acid will be lost in the process. Some women will boil those vegetables for 2 h or longer, which may reduce the bitterness, but much of the nutritional value will be lost. Alternatively, milk can be added to the cooked product, which will further reduce its bitterness, especially when left overnight.

Spiderplants are beneficial to herdsmen because of their anti-tick properties. The essential oil extracted from the seeds is occasionally used as an insecticide, especially against ticks in livestock. Seeds from *Cleome monophylla* L. are said to have even stronger insecticidal properties.

The seeds are also used as a source of yellow dye.

POST HARVEST

Sun-drying of leaves is practised in several countries, after which the leaves are stored in a well-ventilated and dry place for up to 6 months. In Zimbabwe, buds of *Aloe greatheadii* are added to improve the flavour (Tredgold, 1986).

Some people in Kenya boil the plants for a few minutes to remove the bad taste before drying them. In Zambia, people boil whole or chopped leaves and mix them with groundnut paste. They preserve the leaves and shoots first by blanching them, followed by chopping into pieces and drying in the sun. Zimbabwean people cut the leaves into small pieces and dry these in the sun without first boiling them. People have observed that *Cleome* leaves taste better if they are left in the sun to wither partially before preparation. Other people in Zimbabwe pound fresh leaves in a mortar and roll the resultant mash into balls to be dried in the sun. It is claimed that this treatment preserves the product better. These balls must be stored dry to maintain their flavour. If they are stored under humid conditions they become musty and lose their good taste.

In Botswana, fresh leaves are cooked for 2 h with some salt added to remove the bitter flavour. The boiled leaves are kneaded into small balls which are then dried in the sun. These balls can be stored until the next rainy season. Soaking the balls in water will reconstitute the leaves, after which they can be prepared for a meal in the same way as fresh produce. In Namibia, the processed leaves are marketed locally as dried *omuvanda* cakes.

BIBLIOGRAPHY

CHIGUMIRA NGWERUME, F., MVERE, B. and MHAZO, M. (1998) Traditional vegetable improvement project agronomic trials. In: *Proceedings of a National Workshop on Traditional Vegetables and Underutilized Crops, Harare, Zimbabwe, September 1998.*

CHWEYA, J.A. and MNZAVA, N.A. (1997) *Cat's whiskers,* Cleome gynandra L. *Promoting the Conservation and Use of Underutilized and Neglected Crops.* Rome: IPGRI.

CHWEYA, J.A. (1997) Genetic enhancement of indigenous vegetables in Kenya. In: *Proceedings of the IPGRI Workshop, Traditional African Vegetables, on Genetic Resources of Traditional Vegetables in Africa. August 1995, Nairobi.*

SIEMONSMA, J.S. and KASEM PILUEK (1993) Vegetables. *Plant Resources of South East Asia (PROSEA),* Vol.8.

SITHANANTHAN, S. (1999) Recent research on biodiversity of African Indigenous Leafy vegetables in relation to insect pests and their management: an overview. *Paper presented at the IPGRI workshop, September 1998, Nairobi.*

TREDGOLD, M.H. (1986). *Food Plants of Zimbabwe.* Gweru, Zimbabwe: Mambo Press.

WAITHAKA, K. and CHWEYA, J.D. (1991) *Gynandropsis gynandra* (L.) Briq.—A Tropical Leafy Vegetable. Its Cultivation and Utilisation. *FAO Plant Production and Protection Paper No. 107.* Rome: FAO.

WASWA, P., OBIERO, H.M., OTUKHO, S. and EDAGWA, M.E. (1996) *Response of various local vegetables to different types/rates of manure.* Kakamega Research Station, Kenya (unpublished report).

BLACK JACK

Bidens pilosa L. and *B. bipinnata* L.

Bidens pilosa is frequently found as a troublesome weed which is difficult to eradicate. It grows very fast and people who like to eat it can harvest their first crop in about 3 weeks from sowing. In Tanzania's West Usambaras, villagers collect the plant for food as part of their weeding exercise. They do not collect the seeds for planting since the plant sows out so easily by itself. The young leaves and the tips of shoots of both *B. pilosa* and *B. bipinnata* (commonly known as Black Jack) are eaten since the older leaves have an unpleasant taste. Black Jack is frequently collected in Malawi and the eastern parts of Zimbabwe and eaten in both fresh and dried form. In South Africa, young shoots are dried for use during the cold season when no fresh plants can be found. Cooked and subsequently dried and stored, *Bidens* is said to taste much better in reconstituted form than as fresh material. It is also eaten in Nigeria during periods of general food scarcity and is made into soups. The strong flavour of the plant discourages people. In Nanyuki, Kenya, *B. pilosa* is collected for extraction of natural dyes.

Young leaves and shoots of *B. bipinnata* L. are not only collected from the wild, but also cultivated on a small scale in West Africa from Sierra Leone to Nigeria and in southern Africa.

Crassocephalum spp., *Solanecio* spp. and *Struchium* spp.

Crassocephalum spp. and *Solanecio* spp. are a group of related species mainly consisting of *Crassocephalum rubens* (Juss. ex Jacq.) S. Moore, *C. montuosum* (S. Moore) Milne-Redhead, *C. crepidioides* (Benth.) S. Moore and *Solanecio biafrae* (Oliv. & Hiern) C. Jeffrey are commonly consumed in south-western Nigeria and less in other parts of the humid zones of West and Central Africa. They are mainly collected from the wild and occasionally cultivated. This also applies to the water bitterleaf, *Struchium sparganophora* (L.) O.Ktze. from Nigeria. In Cameroon most of these species are becoming rare and are being replaced by vegetables that do not require support and that can grow in the open.

The climbing *Solanecio biafrae* and *Crassocephalum rubens* are cultivated in well-drained soil with a high proportion of organic material, usually under a tree or shrub for shade and support. They are frequently grown amongst cocoa trees. Propagation is mainly by taking pieces of stem of about 20-25 cm long, obtained from mature shoots. The leaves from these cuttings are stripped off. Propagation by seed is also possible and is the usual method for the non-climbing *C. crepidioides*. Mulching is found to be highly beneficial. When there is no natural support in the form of shrubs or trees, a form of staking is required for climbing species. They can also be grown on trellises or along a fence consisting of chicken wire or similar material and are usually spaced 40-60 cm apart. A frequently used cultivation method is the removal of flowering shoots to encourage leaf production.

Tender shoots can be harvested approximately 60 days after planting and harvesting may continue for 1 year or more depending on the vigour of the plants. The somewhat succulent leaves are mucilaginous and are usually used in soups in Ghana, Nigeria, Benin and Cameroon. In Sierra Leone, where *S. biafrae* is called *bologi,* it is eaten as a steamed vegetable in combination with okra and fish. It is said to have medicinal properties and its juice is applied to sore eyes. Disease is rarely serious. The name used for *S. biafrae* in Nigeria is w*orowo,* whereas the Nigerian name for *C. crepidioides* is *ebolo.*

WILD LETTUCE

Wild lettuces belonging to the genera *Lactuca, Launea, Emilia* and *Sonchus* include a number of species of which the leaves are frequently collected from the wild. Some species are cultivated, mainly belonging to the genus *Launea.* The well known lettuce, *Lactuca sativa* L. is derived from the prickle lettuce *Lactuca serriola* L., of eastern Mediterranean origin; lettuce was depicted on Egyptian tombs, 4500 years ago. Some authors consider the lettuce to be of hybrid origin in which *L. saligna* is involved. Since the latter species is also a native of Egypt, one could argue that lettuce has a part-African origin.

Launea spp.

***Launea cornuta* (Oliv. & Hiern) Jeffr.** is amongst the most popular of the leafy vegetables that can be found in the coastal zones of Kenya and also in the East Usambaras, Tanzania, where it is on offer at the local markets. Its local name is *mtsunga.* New shoots are produced from the subterranean rhizomes, even during the dry season. The long, narrow leaves are greyish-green with few irregular lobes and a slightly toothed margin. Since this crop can be found as a weed in sandy soils, no serious efforts have been made to cultivate it, other than ensuring that it is not removed as a weed (*see* Figure 19). Some limited market gardening now takes place in peri-urban areas to cater for the demand in coastal cities. Its leaves contain some milky white fluid and are generally bitter in taste. They are always cooked and usually eaten with amaranth, pumpkin or cowpea leaves. It is an important vegetable for the Kamba, Taita and other coastal tribes and has several ceremonial uses, especially amongst the Giriama. It is also used as an appetizer and is said to prevent and cure malaria (Chweya and Eyzaguirre, 1999).

Figure 19 *Launea cornuta* in Tanzania

***Launea taraxacifolia* (Willd.) Amin ex C. Jeffrey** is a species that is mainly cultivated in West Nigeria and collected from the wild in Senegal, Ethiopia and other parts of Africa. It has some tolerance to drought, but its leaves become very bitter. The leaves are much more tender and less bitter when plants are cultivated and adequate irrigation is provided. Balls of cooked leaves that are ready for use are occasionally sold at the market. Young leaves from the rosette are the largest and are less bitter when compared with the smaller leaves formed along the flowering stalk.

Van Epenhuijsen (1974) describes the main method of propagation as root cuttings, where the roots of old plants are cut into pieces approximately 10 cm long which then are planted horizontally and covered by soil at a spacing of about 40 x 40 cm. Plants will flower vigorously and produce many seeds which could become weeds unless they are well controlled. However, it is not easy to collect these seeds and their germination rate is low, which is why propagation is mainly through root cuttings.

BITTERLEAF

Vernonia spp.

INTRODUCTION

Figure 20 *Vernonia thomsoniana,* the country bitterleaf

The genus *Vernonia* is very large, and out of the more than 1000 known species over 300 can be found in Africa, of which roughly one third are in Madagascar alone. Several species are cultivated as a vegetable and others for their oils, extracted from seeds. *Vernonia* spp. have recently received a lot of attention because of their medicinal properties.

The two most commonly cultivated *Vernonia* species are the common bitterleaf, *V. amygdalina* Del. and the sweet bitterleaf *V. hymenolepis* A. Rich. The so-called country bitterleaf, *V. thomsoniana* Oliv. & Hiern. (syn. *V. pobeguini),* found in highland regions, has smaller leaves than the common bitterleaf and is the most bitter type (*see* Figure 20). It is either collected from the wild or from semi-cultivated plants near homes. A fourth species, which is frequently consumed in the drier parts of West and Central Africa, is *V. colorata* (Willd.) Drake (*see* Figure 21). The young shoots from this species are similarly collected from the wild or are grown in homestead compounds such as in northern Ghana where *V. colorata* is frequently offered in local markets. Here it is propagated by means of cuttings and is rarely collected from the wild. Several other species are only collected from the wild and are not or seldom cultivated, such as the annual crop *V. cinerea* (L.) Less. from the coastal areas of Kenya where it is called *chibudzi,* and *V. poskeana* from Zimbabwe.

Figure 21 *Vernonia colorata*

The oil crop, *V. galamensis,* an annual semi-arid herb from Kenya and Ethiopia, is now becoming an industrial crop in a number of countries, notably in Argentina and the US. Its oil is very rich in vernolic acid and can be used for the coating and plastics industry. There is limited cultivation in Zimbabwe and Kenya.

The species within the genus *Vernonia* can be highly variable and differences between species are not always easy to see, especially between *V. colorata* and *V. amygdalina.* Unfortunately, there is a significant overlap in leaf characteristics between the last two species and the best way to distinguish them is through their flowers or fruit/seeds. A short key for the four most important species found in West Africa, which are used as a vegetable, is as follows:

1. Flowerheads with sepal-like white to purple appendages to its phyllaries ..... *V. hymenolepis*
   Phyllaries without appendages..... 2
2. Florets widely spaced in a star-shaped arrangement ..... *V. thomsoniana*
   Florets packed closely together..... 3
3. Achenes (fruit) glabrous ..... *V. colorata*
4. Achenes hairy..... *V. amygdalina*

COMMON BITTERLEAF

Vernonia amygdalina Del.

Figure 22 *Vernonia amygdalina*, the common bitterleaf

The common bitterleaf, *Vernonia amygdalina* Del., is a shrub of up to 5 m high, with minutely toothed, obovate-oblanceolate leaves with the widest part below the middle. It is a perennial crop and some bushes are known which have been in continuous production for up to 7 years (*see* Figure 22). This species is frequently found in gardens. The similar-looking *V. colorata* is less frequently cultivated and is generally found in drier areas. To distinguish between the two species is not always easy since they have similar inflorescences. Both have glabrous phyllaries except for the hairy margin and the main difference is found with the small fruit (*see* Figure 23). A good magnifying glass is needed to see whether the achenes are glabrous (*V. colorata)* or minutely hairy *(V. amygdalina).*

Figure 23 Seed heads of *Vernonia amygdalina*

Their leaves are somewhat different, although these have overlapping characteristics which may create confusion. Generally, there is a gradual transition from the petiole to the attenuate base of the lamina in *V. amygdalina,* as opposed to the abrupt transition from petiole to leaf blade as seen in *V. colorata.* The latter species has more smooth leaf edges whereas *V. amygdalina* has more clearly dentate leaf edges (Stevels, 1990). The early leaves at the base of a shoot are markedly larger and lighter green in colour; the leaf blade is gradually tapering towards the petiole in contrast with the later more greyish-coloured leaves that are formed near the flowers. Such leaves are smaller and have longer petioles.

V. amygdalina is often planted as a hedge and can be used as a live fence in home gardens. *V. colorata* is more often cultivated as single shrubs in homesteads. It is rare to see these two species as a monocrop, unlike *V. hymenolepis.* Both *V. amygdalina* and *V. colorata* are called common bitterleaf since, as the name implies, leaves of traditional varieties are usually bitter. Varieties that are less bitter can be found, but are still not common. These cultivars are vegetatively propagated.

V. amygdalina is commonly found in Nigeria, Cameroon, Gabon and Congo (Democratic Republic) and to a lesser extent in their neighbouring states. The Luhyas in western Kenya use *V. amygdalina* as a vegetable, but do not cultivate it. This bitterleaf species can also be found in South-East Asia where it

is similarly grown as a vegetable. The Yoruba name for this crop is *ewuro* whereas the Igbos call it *onugbu*. In Nigeria bitterleaf is referred to as *ndolé*, referring both to common bitterleaf and country bitterleaf.

Substantial research has been carried out on nutritional status, but little on agronomic practices or genetic enhancement.

AGRONOMY

V. amygdalina is generally multiplied by planting shoots into the soil. These shoots should be placed at an angle of 45° to obtain faster regrowth and more side shoots. Shoots used as planting material are usually selected from shrubs that are known for their attributes, including a desirable degree of bitterness, leaf size and plant growth characteristics. Both mature and young stem cuttings can be used for planting. Some people grow more than one variety which is mainly based on whether a shrub is known to be bitter or somewhat sweet.

Most people who appreciate bitterleaf as a vegetable can collect them from their own gardens. It is possible to continue harvesting from the same plant throughout the year as long as the crop receives some water, such as waste water without detergents from households.

During the dry season bitterleaf is scarce and thus expensive at the markets. Some farmers deliberately prune their bushes back at the end of the rainy season and make sure that the plant receives adequate water. The young light-green sprouts with large leaves that emerge after about 3 weeks are very valuable at the market, since at that time most other leaves have turned greyish in colour, are much smaller and distinctly more coarse and bitter.

MARKETING AND POST-HARVEST TREATMENTS

For marketing, stems of various lengths are cut in the afternoon and tied into bundles. These bundles are kept overnight, placed upright, in a basin of water. Alternatively several bundles are tied together and sprinkled with some water ready to be brought to the market early in the morning. Sometimes these bundles are covered with jute bags to avoid desiccation.

Bitterleaf can be stored in a dry form for which the leaves are first washed and then dried in the sun. They are either preserved dry as a whole leaf or ground into a powder to be used later in soups. People have become careful when buying processed bitterleaf because some unscrupulous traders use other plants to increase the volume. Office workers in the main cities no longer have the time to prepare bitterleaf themselves and have become accustomed to a ready-made product offered at the local markets (*see* Figure 24).

PESTS AND DISEASES

Apart from a limited occurrence of leaf curl virus there are no major diseases of bitterleaf. Pests are not too problematic even though Misari (1992) lists 97 species of insects found on *Vernonia* spp. from northern Nigeria. Amongst the more frequent pests, the following were noted: thrips, cotton aphid, the white fly *Bemisia tabaci* and several others including *Empoasca* sp., *Sphaerocoris annulus, Fabricius* sp., *Ptyelus grossus, Polyclaeis* sp. and *Xanthochelus vulneratus.*

The bitterleaf weevil, *Lixus camerunus,* may damage stems and branches by making tunnels, causing branches to break and further growth will come to an end.

FOOD AND NUTRITION

Figure 24 Ready-made bitterleaf offered at the market is becoming very popular with office workers

The bitter types of *Vernonia* require a great deal of preparation before they can be eaten, since they need to be washed and macerated before further use. It is not common to eat this vegetable by itself and in Cameroon it is usually mixed with ground, cooked groundnuts to make up the famous *ndolé,* which is often served with prawns or various types of meat.

There are several methods of preparing bitterleaf. Sometimes the bitterleaf is pounded in mortars using a pestle until quantities of foam have emerged, often making it difficult to see what is happening. This foam will gradually disappear whilst the leaves are being washed and the water replaced and the leaves become less bitter. After thorough rinsing with fresh water until the colour of the water is no longer green, the produce is squeezed and allowed to dry in the sun. Sometimes salt is used in the above process, and rather than the mortar and pestle being used, the leaves are rubbed hard until the mixture foams and the bitterness is released. Less human energy is required when the sliced leaves are first boiled; limestone is often added to this process.

When the produce softens and foams it is put into a strainer and cooled in cold water, after which it still needs some rubbing and squeezing, but far less than using the cold method. The finished product can be divided into small bundles and stored in plastic bags in the refrigerator and, even better, in a deep-freezer.

Much of its ascorbic acid content will be lost in the foam as a result of the squeezing and rinsing process. Some people therefore suppress the foam by adding some palm oil, thereby retaining some of the bitterness and preserving more nutrients. Bitterness is partly caused by saponins, which can be poisonous.

The sweet *V. hymenolepis,* which is especially enjoyed in West Cameroon, is not used for the preparation of *ndolé,* but is more commonly fried or cooked like other leafy vegetables.

OTHER USES

Some studies have indicated that *V. amygdalina* can be a substitute for hop, to be used in beer brewing in Africa. The wood ash of *V. amygdalina* can be used as seed treatment for the control of seed-borne fungi. It is found to be fairly effective in the control of *Curvularia, Aspergillus, Fusarium* and *Penicillium* species. Consequently, seed viability and germination capacity were found to be better after treating seeds with this wood ash.

To celebrate the arrival of a newborn baby, it is customary in several tribes in Cameroon for the mother together with her visitors to eat bitterleaf. For this special occasion, the leaves and the soft parts of the stem are cooked whole; the stem together with the leaves must be eaten as one piece.

Vernonia amygdalina has many uses as a traditional medicine and concoctions of bitterleaves are used as medicine to reduce fever. It is used to treat stomach pains and a whole range of other disorders, as a fertility inducer, and as a laxative. In Uganda extracts of its roots are used as treatment for malaria. In Nigeria, leaves are placed on a wound as a substitute for iodine.

Of late, a great deal of research has taken place to investigate its pharmaceutical properties, the results of which go beyond the scope of this publication. The anti-microbial nature of its plant substances is not only useful for humans and for veterinary use, but also as a control agent against diseases in plants.

It is interesting to note that chimpanzees use *V. amygdalina* as a medicine to treat intestinal nematodes and especially *Oesophagostomum stephanostomum,* for which they swallow whole leaves and chew the bitter pith of the branches. This behaviour happens particularly during the rainy season and has been observed in Tanzania, and also in West Africa in the related pygmy chimpanzee. Presently, one of the most common medicinal uses of *V. amygdalina* is as a treatment against intestinal worms.

SWEET OR BAYANGI BITTERLEAF

Vernonia hymenolepis A. Rich.

Synonym: *Vernonia calvoana* Hook. f

INTRODUCTION

Vernonia hymenolepis can be found wild in mountainous areas in Cameroon, Uganda, Kenya, Tanzania and Ethiopia and is frequently cultivated in Cameroon where it is referred to as sweet bitterleaf (*see* Figure 25). It is also called *bayangi* bitterleaf because of its popularity with the Bayangi people in the Manyu division, South-West Cameroon. 'Sweet' refers to the low level of vernonine which causes the bitter taste associated with all species within the genus.

Figure 25 *Vernonia hymenolepis* flowers at the end of the season

Figure 26 Chief Mosasso, promoter of sweet bitterleaf

In West Cameroon, the crop was strongly promoted by Chief Mosasso from Lysoka Village, Buea subdivsion, who tried out different forms of cultivation and finally settled for a ratoon system, at which he has been successful for over 25 years (*see* Figure 26).

Sweet bitterleaf is grown as an annual crop which reaches a height of about 75 cm when grown as a kitchen-garden crop or in mixed cropping systems, whereas in the wild it can be either annual or perennial depending on the availability of moisture in the soil. In some places near streams, wild shrubs of 3 m high can be observed which are probably at least 2 or 3 years old.

Of the four frequently consumed *Vernonia* species in West Africa, *V. colorata* is most tolerant to drought and *V. hymenolepis* is by far the least tolerant. *V. hymenolepis* is therefore often found in marshy areas or at high altitudes and its cultivation during the dry season requires frequent irrigation. Both *V. thomsoniana* and *V. amygdalina* will survive a normal dry season and continue with the onset of new rains. All *Vernonia* species start flowering at the beginning of the dry season in West Africa, mainly in December and January. *V. hymenolepis* mainly flowers from December to February, but flowering plants may also be observed during the other months of the year.

PROPAGATION AND PLANTING

V. hymenolepis is virtually always propagated through seeds. Vegetative propagation by means of cuttings as used for *V. amygdalina* and *V. colorata* was not found to be practised. This is probably because most plants will have died by the time that the rains start and no fresh shoots will be available for planting, and besides, it has been noticed that cuttings do not form roots easily. Vegetative propagation would have the advantage that when a particularly desirable plant is found it would be possible to produce it on a larger scale. So far this is rarely practised for sweet bitterleaf.

The plant population from seeds is relatively uniform, although some plants have larger leaves than others and also the flower colour can change from white to pink to purple. No varieties have been selected so far.

Figure 27 Seed heads of *Vernonia hymenolepis*

When the sweet bitterleaf plant has dried completely, usually at the end of the dry season in February or early March, dried flower heads are collected. Seeds should be collected from plants specifically selected for that purpose, but this is not usually the case. Large plants may have several hundred flower heads each containing just over 100 fully developed seeds, in addition to some immature ones (*see* Figure 27). In practice, flower heads are picked from a dried commercial crop which has been selected earlier for its mild bitterness, in which case there are only about five developed heads available/plant. This number may rise to 35 when the farmer specifically wants to collect more seeds for sale or otherwise.

Seeds are collected by rubbing the heads to obtain a mixture of mature and immature seeds and chaff will be obtained. Sieving and/or winnowing will further separate the chaff and lightweight seeds from the good seeds. The 1000-seed weight is about 2.4 g.

Seeds are stored in a dry container such as a bottle until the onset of the rains or just before, when a new crop will be sown in the nursery. Alternatively, seeds are tied in a piece of cloth and placed in a rack above the fireplace in the kitchen where it is always dry. If such care is not taken, seeds can easily become mouldy, thereby losing their ability to germinate.

Seedlings are grown in nurseries. These nurseries are under the shade of a tree or under similar cover to reduce the heat and to avoid a too-fast drying of the soil. In addition, just after sowing, the seedbed will be covered with dry grass or palm fronds to reduce evaporation. Sowing is normally in the form of broadcasting, although sowing in lines at 15-20 cm spacing would be better to improve the flow of air and thus the quality of seedlings. It takes about 7 days for seeds to emerge. Care should be taken to avoid overcrowding either by ensuring that not too much seed is used, or by thinning at an early stage to a spacing of not closer than 4 x 4 cm. Overcrowding will cause rotting and will make it difficult to control snails and crickets at this stage.

Both seeds and young seedlings are offered at the market. Such seedlings can be either free rooted or offered for sale in black polythene bags (sleeves).

Before planting, care should be taken to prepare raised beds well in advance. The soil should be loose and friable and adequate amounts of manure or fertilizers applied. When transplanting, seedlings are often tested for their bitterness by using the tongue. Seedlings with a bitter taste are discarded and only 'sweet' ones are used. This process is unfortunately necessary since seeds are the final products of a cross-pollinated crop, which by nature can be highly variable. The advantages of using cuttings from a known plant are clear in this case.

Watering is essential soon after transplanting. During the first 2 weeks light watering is needed early in the morning (before the sun can scorch the leaves) and late in the afternoon. Once the crop is well established, watering once a day will be adequate, although when temperatures rise to over 30 °C, watering is required twice daily.

The seedlings are transplanted when they are 6 weeks old. Plants used in kitchen gardens during the rainy season are spaced at 75 x 75 cm or interplanted in a mixed crop with zom or other vegetables. In the dry season, they are most commonly grown as a monocrop and treated as a ratoon crop, for which they are spaced at about 20 x 20 cm. Some farmers even use a spacing of 15 x 15 cm, which results in more stems/area unit, but these stems will become more spindly and also, from the disease prevention point of view, this close spacing is not recommended.

Figure 28 Young bayangi plant, ready to be harvested

CULTURAL PRACTICES AND HARVESTING

In a ratoon crop, the first harvest takes place about 4 weeks from planting (*see* Figure 28) by cutting the stem about 5-10 cm above the ground when it is about 40-50 cm long. One or two new side shoots will soon develop which are ready to be harvested after 3 weeks. New side shoots will then develop both from the main stem and from the laterals. Harvesting can thus continue for 2-3 months. A total of six to eight harvests/plant is normal, with some farmers reporting 10 harvests/plant or more. For rapid regrowth, fertilizers need to be applied immediately after each harvest. Urea is a good fertilizer for

this purpose, but care should be taken to avoid contact with leaves. The plants should be watered immediately after fertilizer application.

Shoots are packed in bunches of about 20 stems during the dry season and 15-18 in the wet season (when the plant is stronger, having more heavy shoots). During the rainy season, the stem can be as long as 75-90 cm, with a bundle weighing about 1 kg. This weight and stem length are much reduced during the dry season. Bunches are tied together with plantain rope. For the wholesale market, individual bunches are packed together in large bundles, often weighing as much as 50 kg each, which are transported in bulk to the main market outlets.

In mixed farming systems, where plants can grow out, harvesting is mainly by pruning the tips of the branches. In kitchen gardens, only leaves are harvested. In the latter case, only a few side shoots are formed.

During the rainy season, mixed farming is the norm. The peak harvest comes from these mixed farms and the largest crop volumes can be seen at the market between the end of May and August.

Only young or newly sprouted leaves can be used since more mature leaves are too coarse. When the showy white or pinkish flower heads develop, usually as a result of drought or inadequate irrigation, the opportunity to harvest the leaves will be over.

Figure 29 Few plants may show signs of wilt, especially when planted close together

PESTS AND DISEASES

In ratoon cultivation of the sweet bitterleaf, an as yet unidentified wilting disease (*Fusarium* sp.?) can become a nuisance (*see* Figure 29). Pests found during the nursery stage, including aphids, snails and crickets, are usually controlled by applying methyl paraffin powder or manoxane powder. During the dry season grasshoppers are a problem, especially the variegated grasshopper, *Zonocerus variegatus*. As soon as the rains appear, these grasshoppers seem to disappear. Other pests and diseases are similar to those for *V. amygdalina*.

USES

Vernonia hymenolepis is a vegetable which not only plays an important role in nutrition because of its quantity and quality of nutritive elements, but also possesses a medicinal value. It is a typical example of a frequently used medicine becoming used as a vegetable. Some traditional uses are mentioned by Mbinglo (1998): taking a bath with many leaves, which are first squashed, is said to be able to cure pneumonia. A hot leaf placed against a wound is said to stop bleeding. It is also used to reduce hypertension. Further medicinal uses include treatment of jaundice. It is frequently used in the villages by mothers with babies suffering from diarrhoea. In the latter case, leaves are crushed and the juice is extracted; babies are given two spoons of these extracts per day until the diarrhoea stops.

So far its cultivation is mainly on a subsistence level, but it is increasingly becoming a crop for market gardening. In urban markets, it tends to be classified amongst the most prestigious vegetables during the dry season when high prices are offered for this crop, which is not as bitter as the other *Vernonia* species mentioned above.

Table 2 Chemical leaf analyses of four *Vernonia* species

Species	Mg/100 g dry matter			Ppm/100 g dry matter			
	Crude protein	Ash	Cellulose	Fe	Cu	Zn	Mn
V. amygdalina	24.94	16.6	11.36	350	34	83	700
V. colorata	26.50	19.60	10.50	200	16	82	885
V. hymenolepis	22.75	17.7	12.25	250	15	88	580
V thomsoniana	26.03	15.2	10.55	345	35	118	850

Source: Fube and Djonga, 1987

BIBLIOGRAPHY

ANON. (1994) *Etude de Quelque Pratiques Culturales et Value Nutritive du ndolé* (Vernonia calvoana, *Hook*). (Studies on some cultural practices and nutritive value of ndolé (*Vernonia calvoana*, Hook)). Yaoundé, Cameroon: Ecole Normal Supérieur Agronomique.

BESONG, B.F. and ABIA, C. (1998) *The production of Bayangi bitterleaf in south-western Cameroon.* Chatham, UK: Natural Resources Institute. (unpublished paper.)

CHWEYA, J.A. and EYZAGUIRRE P.B. (eds.) (1999) *The Biodiversity of Traditional Leafy Vegetables.* Rome: IPGRI.

CHIHANDE, D., ZINANGA, F. and MHEEN, J. van der (1997) *The Role of Indigenous Vegetables in Zimbabwe.* Report for Community Technology Development Trust, supported by IDRC, Canada.

FUBE, H.N. and DJONGA, B. (1987) Tropical vegetables in human nutrition: a case study of ndolé (bitterleaf) *Vernonia calvoana* (Hook). *Acta-Horticulturae,* **198**: 199-205.

KALANDA, K. and LISOWSKI, S. (1995) The genus *Vernonia* (Asteraceae) in the flora of Central Africa (Zaire, Rwanda, Burundi). *Fragmenta Floristica et Geobotanica,* **40**(2): 547-717.

MISARI, S.M. (1992) Further observations on the insects attacking bitterleaf in Samaru, northern Nigeria. *Savanna,* **13**(1): 1-13.

MBINGLO, S. (1998) *Survey on the production of bitterleaf, Vernonia spp. in Bamenda, north-western Cameroon.* An NRI/Dschang University student-project report.

STEVELS, J.M.C. (1990) *Légumes Traditionnels du Cameroun, une Étude Agrobotanique.* Wageningen Agricultural University Papers, 90-1, Wageningen, Netherlands: Wageningen Agricultural University.

TAGWIRA, F. (1996) Commercial development of *Vernonia galamensis* as an industrial crop. *SACCAR-Newsletter*, No. 35, 1-7.

VAN EPENHUIJSEN, C.W. (1974) *Growing Native Vegetables in Nigeria.* Rome: FAO.

ZEVEN, A.C. and ZHUKOVSKY, P.M. (1975) *Dictionary of Cultivated Plants and their Centres of Diversity.* Wageningen, Netherlands: Pudoc.

AFRICAN *BRASSICA* SPECIES

Cabbages, kale and related crops are amongst the most commonly cultivated vegetables found in Africa. *Brassica oleracea* L., the species to which the cabbage belongs, has many different forms, including the white-flowered Portuguese kale, var. *acephala,* syn. var. *costata,* or tronchuda, which is grown in Morocco, Algeria and Mozambique from where it has spread to Zimbabwe and Zambia. This heat-tolerant Portuguese kale with its loose leaves and lax flowerhead, does not require a cold period for flower initiation and is sometimes regarded as an African crop (*see* Figure 30). Although the Portuguese kale may have developed at least partly in Africa, the origin of the species to which it belongs is not African and therefore not considered as indigenous.

Figure 30 Portuguese kale

The various species within the genus *Brassica* are closely related which is one of the reasons for their taxonomic complexity. Several *Brassica* species originate in the Mediterranean region. *Brassica oleracea* L. has a shared northern Mediterranean and western European origin. The black mustard, *B. nigra* (L.) Koch., originates from central and southern Europe all the way to Central Asia. *B. rapa* L. (syn. *B. campestris* L.) is a ruderal weed in Europe and is also found in the Middle East and in Central Asia where it has developed into a group of vegetables including turnip and the Chinese cabbage. The oil-seed rape, *B. napus* L., of which the vegetable form is called swede or rutabaga, is likely to have originated in the Mediterranean region, but is not known in the wild. The Indian or brown mustard, *B. juncea* (L.) Czern., is a Western Asian species with a natural distribution extending to the African side of the Mediterranean. The Ethiopian kale or Abyssinian mustard, *B. carinata,* is probably the only species that can be considered as of African origin, although even here there is a clear connection with the Middle East and southern Europe.

Three natural *Brassica* species are found in the Mediterranean basin area: *B. nigra* (black mustard) with the basic chromosome number n=8; *B. oleracea* (cabbage, etc.) with n=9; and *B. rapa* (turnip) with n=10. Natural interspecific hybrids have formed where wild populations grow together. *B. carinata* can thus be considered as a natural hybrid between *B. nigra* and *B. oleracea. B carinata* is an amphidiploid and contains one genome of each parent and its basic chromosome number is thus 17. The Indian mustard, *B. juncea,* has n=18 whereas *B. napus* has n=19.

The large genetic diversity amongst the *Brassica* amphidiploid species is caused partly by multiple hybrids between different diploid parents, which themselves represent species known for their diversity, such as the *B. oleracea* complex. One of the consequences of this diversity is that it is rather difficult to separate the different species.

DIFFERENCES BETWEEN *BRASSICA CARINATA* AND *B. JUNCEA*

In Africa, the most relevant species that are used as a leafy vegetable are *B. carinata* and *B. juncea,* which are frequently confused with each other due to their similarity in plant characters and cultivation. *B. carinata* can best be recognized by its non-hairy, often glaucous leaves and distinctly flattened siliqua (pods) with a short beak. These fruit characteristics only become evident towards maturity of the pods and cannot usually be established before they have dried properly. Another important character is the pale-yellow flowers of *B. carinata,* although there are forms which show the characteristic deep-yellow colour of most other Brassicas. Both *B. juncea* and *B. carinata* have petiolate upper stem leaves without clasping auricles. *Brassica juncea* has non-glaucous leaves that are often somewhat hairy. Its pods are more or less round in diameter when dry, contrary to the distinctly flattened pods of *B. carinata.* The silique beak of *B. carinata* is about 5-7 mm or shorter.

ETHIOPIAN KALE

Brassica carinata L.

Synonym: *Brassica integrifolia* (West) Thellung var. *carinata*

Figure 31 Ethiopian kale

The oilseed crop Ethiopian mustard, or Abyssinian mustard, is the same species as the Ethiopian kale, which is used for its leaves (*see* Figure 31). Edwards (1991) mentions that weedy forms of *Brassica* species are found throughout the Ethiopian highlands, and are gathered to be eaten as a leafy vegetable. These probably represent different species including *B. carinata, B. juncea* and *B. nigra,* together with *Erucastrum* and *Eruca* species. Ethiopian kale is cultivated as a multi-purpose crop in the Ethiopian highlands at altitudes between 1500 and 2600 m. Several landraces exist that are used for their leaves, for their oilseed, or as fodder, or a combination of these. Its name in Amharic is *yabesha gomen.* The crop is still widely used for its young shoots and leaves and can be found in many homegardens and is frequently grown at the edges of fields. The seeds are crushed and the oil used for cooking or for oiling earthenware baking plates.

Records of this vegetable are scarce, probably because it is rarely grown as a vegetable outside Africa. Therefore there has been a lot of confusion about the correct name of the leafy *Brassica* species found near Lake Victoria and in the highlands of Tanzania and Malawi and also in Zambia and Zimbabwe. Local researchers had long suspected that their crops were *B. carinata* and its identity has only recently been confirmed, thereby considerably extending the known range of the species in Africa.

Ethiopian kale is currently grown on a moderate scale in Ethiopia, Malawi, Tanzania, Zambia and Zimbabwe and on a more limited scale in several other countries. They include West Africa, especially on hills in savannah regions near old trans-Sahara trading routes. One such site is near Foumbam in Cameroon, the former capital of a sultanate with extensive trading links with the Arab world. It is

locally referred to as native cabbage and resident scientists had earlier recorded it under the name *B. carinata.* The landrace found there is about 1.5-2 m tall, with a strong stem and widely spaced branches of the inflorescence. It has pale-yellow flowers and a distinctly flat silique, also in the young stage, of 37 x 9 mm with a beak 5 mm long. In Zimbabwe, Ethiopian kale is a traditional crop in Mashonaland and it is found particularly on anthills where the soil is fertile, allowing the plants to survive during periods of dry weather.

Figure 32 *Brassica carinata* flowers spontaneously, even in the hot season

Just after the first rains, *Brassica carinata* can be seen in a semi-wild form in the Lake Victoria basin area, especially near Busia in Kenya and across the border in Uganda. Luo and Abaluhya communities grow them in kitchen gardens. Plants either have green leaves and stems or show at least some anthocyanin. Their light-yellow flowers are in a long terminal inflorescence (*see* Figure 32). Plants are usually not much taller than about 50 cm, but may reach up to 120 cm. In Western Kenya, it is preferred over the thousand-headed kale and marrowstem, locally called *sukuma wiki* (*B. oleracea)*, which are generally found in cooler places. Most people appreciate the soft texture and its special mustard-like, sometimes sharp, taste when compared with kale or collards. The latter crops have stronger and much larger leaves.

The fact that it readily produces seed in these warm areas, which *sukuma wiki* does not, heightened interest amongst researchers, especially since the material is quite pluriform. It takes only just over 2 months to produce seed from seed. Birds appreciate the comparatively large seeds and Luo people often refer to this crop as cabbage for birds (*see* Figure 33). The potential for growing Ethiopian kale under irrigation exists, and out-of-season produce brought to local markets around Busia is eagerly bought by consumers. Further selection and research on its agronomy should receive high priority.

Figure 33 Ethiopian kale produces seed in Africa (Note the broad siliques with a short beak which are typical for *Brassica carinata*)

There is some speculation that the Luo people brought seeds of *Brassica carinata* with them when they left Abyssinia, hundreds of years ago. The crop is frequently found amongst Luo communities in both Kenya and Tanzania, who call it *kandhra.* People in Tanzania refer to this crop as *loshuu.* It is also found in Zimbabwe, where it is called *chembere dzagumana.*

Brassica juncea (L.) Czernjaew

Brassica juncea (L.) Czernjaew is a leafy vegetable grown in southern Africa under the name leaf mustard (*B. juncea* ssp. *rugosa)* or rape, although the latter name is rather confusing since it also refers to the leafy equivalent of the oilseed crops *B. rapa* and *B. napus.*

The species has been included here, based on records of Edwards (1991), but is not generally considered as indigenous to Africa. *B. juncea* is a more important crop in China and South-East Asia, where it is known in a wide variety of forms. Proper cooking of the leaves is essential because of the presence of the glucoside sinigrin, and the boiled water needs to be replaced with fresh water. Bitterness

caused by sinigrin increases with the age of the plant and is more pronounced as a result of water stress. Plant breeders in Asia have developed varieties that taste less bitter and contain fewer glucosides. In India, *B. juncea* is mainly used for its oilseed.

When the Scottish explorer David Livingstone reached Victoria Falls in 1855, one of the plants collected near the Falls was *B. juncea.* Therefore, this species is no recent introduction to Zambia and Zimbabwe, where it is now frequently cultivated, but was clearly established well before that time. Ndebele people in Zimbabwe call it *tsunga,* whereas the Shona give different names to the different varieties.

RELATED CROPS

Young seedlings of the related white mustard *Sinapsis alba* L. (syn. *Brassica alba* (L.) Boiss. (2n=24) are eaten in their countries of origin: North Africa and southern Europe where it is referred to as cress. Commercial mustard is made from a mixture of the seed flour of this species and that of the brown mustard, *B. juncea.*

POLLINATION

Most *Brassica* species, including *B. juncea,* are cross-pollinated. However, *B. carinata* is generally considered to be self-pollinating. It will set seed very efficiently without any pollinator. Where there are bees or other insects cross-pollination can be expected. An isolation distance of 200 m from other varieties or other flowering *Brassica* species such as rapeseed, is a minimum for seed production as long as there is another flowering crop or a tall crop in between. Otherwise the recommended isolation distance for a seed crop is 500 m.

VARIETIES

Several cultivars of the Ethiopian kale have been given local names such as Chitangankonde, Mulio giant and Figiri in Zambia and Mbeya green in Tanzania. Further work on the purification of these and other landraces is needed. Several local landraces of *Brassica juncea* can be found in Zimbabwe. These include Ndakupuka, Machembere and Marengenya.

AGRONOMY

Brassica carinata

The most common way of producing Ethiopian kale is similar to the way in which *Brassica oleracea* kale is grown. Seedlings are planted with a spacing of about 75 x 50 cm for varieties with larger leaves as found in West Africa and Tanzania and 50 x 35 cm for the small-leaved varieties found in Zimbabwe. Once established, frequent harvesting of leaves may take place. The smaller-leaved varieties are often collected in the form of shoots. Generally speaking, varieties with large leaves are tall and tend to have few sideshoots only, whereas varieties with small leaves are shorter, much more bushy and with many sideshoots. Such bushy varieties produce large amounts of seeds and are probably more closely related to the mustard group or oil crops. Young shoots from bushy varieties can only be harvested with a short stem, since the basal part is often woody and not tender. More frequent and

intense plucking of leaves tends to prolong the vegetative phase. Ethiopian kale has a longer vegetative phase than rape of both *B. juncea* and *B. napus,* but shorter than that of Portuguese kale (called *covo* in Zimbabwe) or other kales belonging to *B. oleracea.*

The total leaf yield varies considerably between cultivars of which Mbeya green is one of the best with a leaf yield of about 30 t/ha. Yields of up to 55 t have been obtained at experimental sites.

Ethiopian kale responds very well to manure, but this is not always available. Nitrogen fertilization is needed for a high leaf yield and an application of 100 kg N/ha is recommended. Frequent irrigation is needed for a good leaf yield. When the rains have stopped and irrigation is not available, plants will start to flower and produce seeds.

There is little difference in yield potential between the summer and winter months and temperatures do not have much influence on flowering. When compared with *B. juncea,* Ethiopian kale is far less prone to disease.

Flowering during periods of water stress, or the possible loss of a crop altogether is the reason why rural farmers broadcast seeds on anthills where the soil is more fertile. This system can be seen in Mashonaland, Zimbabwe, where this crop is regarded as traditional. The same treatment is also given to *B. juncea.* The two species used to be more common in Zimbabwe, but droughts have eliminated many crops with consequent loss in the diversity of germplasm.

To produce a crop for seeds, plants need to be selected for late flowering, large leaves and desirable consumption characteristics. Such a selection is likely to lead to a significant increase in crop yields.

Brassica juncea

The *B. juncea* crop takes some time to establish itself at the nursery and seedlings need up to 4 weeks before they can be transplanted. The most common planting method is similar to Ethiopian kale, with a plant spacing of 50 cm between rows and 30-45 cm in the row. Spacing has little influence on the yield, although a close spacing will result in smaller leaves. A wider spacing will result in fewer and larger leaves and less harvesting work. Organic manure was found to be better than inorganic and good results could be obtained by using a rate of 50 t/ha or 5 kg/m^2.

A second way is similar to the production of rape, *B. napus,* whose plants are usually grown close together in a plant bed. This system is frequently used in wet areas called dambos in Zambia. The seeds need to be mixed with sand and broadcast in such a way as to avoid removing too many seedlings later on. The first harvest can be in the form of thinned-out seedlings, collected after about 35 days from sowing. Leaves or shoots can be harvested at weekly intervals and farmers may collect those leaves over a 6-week period, after which flowers form and it becomes more economical to start a new nursery.

This crop performs better during the winter with average yields of 20-30 t/ha. Early bolting can occur during the summer with high temperatures inducing flowering. The rainy summer season is also conducive to disease. The irrigated crop planted during the winter will find a ready market from April onwards.

PESTS AND DISEASES

Generally speaking, Ethiopian kale is less prone to pests and diseases than cabbages and its near relatives, and farmers who produce this crop will be less dependent on pesticides.

Figure 34 Turnip mosaic virus can affect Ethiopian kale very badly

In India, Abyssinian mustard shows good tolerance to white rust, *Albugo candida,* but in Tanzania it was found to be one of the more serious diseases. Ethiopian kale is tolerant to *Phoma lingam,* black leg disease.

Some varieties have a thicker layer of leaf wax than others, and it was noticed that this leaf wax keeps aphids at bay to some extent. Leaf wax is also associated with the level of tolerance to *Alternaria brassicae,* the *Alternaria* leaf spot. However, the species is susceptible to blackrot, *Xanthomonas campestris,* black spot, *Alternaria brassicicola,* and to damping-off and seedling root rot, *Rhizoctonia solani.*

In Tanzania, it was found that Ethiopian kale is highly susceptible to turnip mosaic virus (*see* Figure 34). The green form with a thin wax layer was much more affected than the blue, waxy-leaved form. There is thus a clear association with the presence of aphids, the vector for this virus.

The main insect pests are aphids, caterpillars of the cabbage butterfly, *Pieris brassicae,* and the grubs of mustard sawfly, *Athalia proxima,* a pest which is particularly important at the seedling stage. Another pest is the diamond back moth, *Plutella xylostella.* This pest appears to be less troublesome on Ethiopian kale than on cabbages and cauliflower.

In Zimbabwe, hurricane bugs (*Bagrada* spp.) may attack *Brassica juncea* and cause serious damage. These can be controlled by spraying with an insecticide such as Ambush or Dimethoate.

NUTRITION AND ANTI-NUTRITION

The glucosinolates found in all *Brassica* species may cause enzymatic breakdown and result in goitre when cabbages, etc. are eaten frequently. When people only eat the leaves for a few weeks/year, harmful effects are barely reported. These glucosinolates also have anti-carcinogenic effects and are thus of medicinal value. Ethiopian kale is reported to have less glucosinolate than rape, *Brassica juncea,* which is one good reason for eating *B. carinata* rather than rape (Mnzava, 1997).

Abyssinian mustard (*B. carinata*) is a highly productive oilseed crop in the Ethiopian highlands, but its seed has a high erucic acid content, which is undesirable for human consumption and is the reason why the oil is mainly used for industrial purposes. Its seeds contain 32 - 40% oil.

GARDEN ROCKET OR ROQUETTE

Eruca vesicaria (L.) Cav.

Synonym: ***E. sativa*** **L.**

Roquette is a popular and frequently cultivated crop in the Sudan and in Egypt where it is called *girgeer.* Statistics for Sudan show up to 3000 ha under year-round cultivation with this crop. In India, it is cultivated for its seeds which are a source of jamba oil. It is also cultivated on a small scale in northern Ethiopia where young shoots are collected from the wild before the onset of flowering and eaten as a salad. Of late, this crop has become a popular salad crop and is frequently found in Western European supermarkets, sold as a component of mixed salad packs. It used to be mainly cultivated in Italy, but can now be found as a minor crop in several other Western European countries. The taste of its leaves resembles watercress and is similarly sharp with a mustard-like pungency. It is always consumed fresh and is used in Egypt and the Sudan as a salad, for example with roasted meat. The crop tastes best when grown in cool conditions. When it becomes too hot or when there is some moisture stress, it may start flowering and become bitter, rendering it unsuitable for consumption.

Roquette can grow in sandy and sandy loam soils, and, when available, farmers will apply manure and incorporate this into the soil. It tolerates salt reasonably well. Seeds are broadcast on raised beds. After about 5 weeks, the first harvest can be made by cutting the tops, leaving a stem of about 3-5 cm long to generate new side shoots. A total of 2-3 cuts are usually made before it gets too hot and flowering sets in. The leaf and shoot yield is about 10 t/ha. When the harvesting of shoots is over, the crop will be retained to produce seeds.

The variety used in Sudan is called Baladi.

Pests and diseases are not generally troublesome, but powdery mildew, *Erysiphe cichoracearum,* is one of the few diseases affecting this crop. Some pests observed on roquette in the Sudan are thrips (*Caliothrips* sp.), flea beetles (*Podagrica* spp.) and jassids (*Empoasca lybica).* Flea beetles could become a nuisance if proper rotation is not observed.

GARDEN CRESS

Lepidium sativum L.

Garden cress originates from a large area stretching from the Sudan to the foothills of the Himalayas and is frequently found in the Ethiopian highlands. The seedlings can be harvested when they are still in the cotyledon stage, about 10 days from sowing, or alternatively pieces of mature leaves are eaten as a salad, mainly by Arabs and Europeans. It is also called pepper-grass because of its pungency. It is an ancient crop which was already known to the Greeks as a spicy salad. It was used as a spice in Ethiopia before the introduction of *Capsicum* peppers.

Seeds are sold at the markets in northern Nigeria and these can be white, black or red in colour. The crushed seeds, especially the red variety, are used in West Africa as medicine, mainly for rheumatic pains and also for diarrhoea and dysentry. Crushed seeds mixed with water become mucilaginous and are made into liniments. Hausa people use the name *lafsur* for the crop and *algarup* for the seeds. Crushed seeds can also be used to dress sores in camels and horses (Dalziel, 1937).

WATERCRESS

Rorippa nasturtium-aquaticum (L.) Hayek

Synonym: Nasturtium officinale

Figure 35 Watercress

Watercress originates in southern Europe and western Asia and also occurs naturally throughout the highlands of Ethiopia (*see* Figure 35). It is not known whether the original range of the species extended to Ethiopia or whether it was introduced and subsequently spread naturally. It is now found as an urban agricultural crop, for example in the foothills of Mt. Meru and Mt. Kilimanjaro in Tanzania, and as a river weed in other parts of Africa.

It is easy to establish this crop wherever conditions are cool and wet, such as under a leaking tap in the garden. The crop is mainly established through cuttings rather than using seeds. It does not require much maintenance and it spreads rapidly. Shallow ponds can rapidly become covered with these plants and the species is frequently considered as an innocuous weed.

Farmers in Arusha, Tanzania, divert the water of local streams to flood small plots of land, which are covered with watercress. Frequent harvesting is possible and shoots should not be allowed to grow out and produce flowers, since such shoots cannot be sold.

Some people in Tanzania cook it for use as a relish. Marketing opportunities in Africa are limited and the pungent leaves are mainly sold in small bunches to expatriate communities as a garnish and eaten raw as part of a salad. Its market in the US and Europe is expanding since it was found to contain high levels of sulforaphane and indole-3-carbinole, which are used as treatment for cancer. It has high levels of iron and iodine and is also very high in vitamin C, but excessive use may lead to kidney problems. Watercress has a long history as a medicinal plant, used to prevent scurvy, and recent research has indicated that it is a health food that can be used as treatment against a wide range of ailments. It should not be used frequently. Watercress can host river flukes and its cultivation in uncontrolled water is not recommended, since these flukes can be serious and even deadly.

BIBLIOGRAPHY

BURGSTALLER, H., MAMOUN BESHIR MOHAMED and MAHMOUD S. HASSAN (1984) *A Handbook of Vegetable Production and Vegetable Pests and Diseases in the Sudan.* Khartoum, Sudan: Ministry of Agriculture and Irrigation, Plant Protection Department.

CHIGUMIRA NGWERUME, F. (1998) Response of two traditional *Brassica* vegetable species to spacing, organic and inorganic fertilisation. In: *Proceedings of a National Workshop on Traditional Vegetables and Underutilised Crops/plants, Harare, Zimbabwe, September 1998.*

CHIHANDE, D., ZINANGA, F. and MHEEN, J. van der (1997) *The role of Indigenous Vegetables in Zimbabwe.* Report for Community Technology Development Trust, supported by IDRC, Canada.

DALZIEL, J. M. (1937) *The Useful Plants of West Tropical Africa, an Appendix to the Flora of West Tropical Africa.* London: The Crown Agents for the Colonies.

EDWARDS, S.B. (1991) Crops with wild relatives found in Ethiopia. pp 42-74. In: *Plant Genetic Resources of Ethiopia* ENGELS, J.M.M., *et al.* (eds.). Cambridge: Cambridge University Press.

MINGOCHI, D.S. and JENSEN, A. (1988) Reaction of rape and Ethiopian mustard selections to blackrot and turnip mosaic virus in Zambia. *Acta-Horticulturae,* **218**: 289-294.

MNZAVA, N.A. and MSIKITA, W.W. (1988) Leaf yield response of Ethiopian mustard (*Brassica carinata* A. Br.) selections to defoliation regimes. *Acta-Horticulturae,* **218:** 77-82.

MNZAVA, N.A. (1997) Comparing nutritional values of exotic and indigenous vegetables. pp.70-75 In: *Proceedings of a Workshop on African Indigenous Vegetables, in Limbe, Cameroon, January 1997.* SCHIPPERS, R.R. and BUDD, L. (eds.) Chatham, UK: Natural Resources Institute/IPGRI.

MSIKITA, W.M. and MNZAVA, N.A. (1988) Comparative field performance of mustard, tronchuda and kale during mild winters in Zambia. *Acta-Horticulturae,* **218**: 59-64.

RICH, T.C.G. (1991) *Crucifers of Great Britain and Ireland.* Botanical Society of the British Islands Handbook No. 6.

SIEMONSMA, J.S. and KASEM PILUEK (1993) *Plant Resources of South-East Asia (PROSEA), Vol. 8. Vegetables.* Wageningen, Netherlands: Pudoc.

ZEVEN, A.C. and ZHUKOVSKY, P.M. (1975) *Dictionary of Cultivated Plants and their Centres of Diversity.* Wageningen, Netherlands: Pudoc.

The Cucurbitaceae are a large family found mainly in the warmer parts of all continents, and consist of 118 genera with about 825 species, many of which are eaten in one form or another. Some, such as cucumbers, pumpkins, various gourds, melons and watermelons, have considerable economic value. The leaves and sometimes flowers of several cucurbit species are eaten by villagers throughout Africa. The most important are the fluted pumpkin *Telfairia* and pumpkins belonging to the *Cucurbita* spp. which are common traditional vegetables. *C. moschata* is also one of the important types of 'egusi'. However, it is not indigenous to Africa, but has been introduced from Central America.

One of the main uses of cucurbits, apart from their fruit, leaves and flowers or occasionally their roots, is that of its seeds, which are frequently referred to as *egusi*. It may well be argued that these seeds are not vegetables, but they are certainly a horticultural food crop and are sometimes called pseudo-pulse crops.

EGUSI SEEDS

Figure 36 Seeds of different cucurbits are used as egusi. The real egusi, *Cucumeropsos mannii*, is at top right. Seeds at bottom right and top both belong to *Citrullus lanatus*. Seeds at bottom left belong to a variety of *Lagenaria siceraria*

Those seeds belonging to the cucumber family, which are used for extraction of oil, are grouped under the name *egusi*; a name used throughout West Africa (*see* Figure 36). Egusi seeds are a luxury and can be used to replace groundnuts in the preparation of *ndolé* (a favourite dish in Cameroon with bitterleaf as the main ingredient). They are also used in various forms of sauces and in south-eastern Nigeria 'egusi soup' is a favourite, together with leaves of fluted gourd. The 'palava' dishes from Ghana similarly contain egusi seeds.

The seed kernels of the Cucurbitaceae family found in markets throughout West Africa are important sources of oil used for food. These oilseeds are found in a range of genera of which the most important are (in decreasing order): *Citrullus* (watermelon), *Cucurbita* (pumpkins which originated in

Central and South America), *Cucumis* (e.g. melon and cucumber), *Cucumeropsis* (egusi melon), *Telfairia* (fluted pumpkin), *Lagenaria* (bottle or calabash gourds), *Luffa* (sponge gourds from Asia) and occasionally *Trichosanthes,* the snake gourd from Asia. Oilseeds are also found in genera belonging to other families such as *Parkia* spp., African locust beans and *Pentaclethra macrophylla,* the oil bean. These species which belong to the *Mimosaceae* are mainly collected from the wild and are thus beyond the scope of this publication.

WATERMELON

Citrullus lanatus (Thunberg) Matsum. & Nakai

Watermelons have been in cultivation for at least 4000 years, mainly for their seeds and for their watery, bitter fruit. The sweet fruit we know today are of comparatively recent origin. Modern watermelons, ssp. *vulgaris,* as first represented by citron melon-types and later developed in the Ukraine and Iran into sweet, often red-fleshed types, will not be dealt with in further detail. This is because watermelons are mainly considered a dessert fruit rather than a vegetable and they are already well covered in the literature.

Watermelons originate in the areas surrounding the two major African deserts, the Kalahari and the Sahara, where wild forms can still be found. It has three centres of diversity:

- the Kalahari Desert and surrounding areas, where fruit are mainly used as a source of water during periods of drought; these melons of ssp. *lanatus* may well represent the ancestral form of the modern watermelon;
- the southern Sahelian zones and neighbouring savannah areas where fruit of ssp. *mucospermus* Fursa are mainly used for their oilseeds; and
- arid regions in southern Ukraine where much larger fruit were originally selected for their water-holding capacity.

The Kalahari Desert melons are collected as young fruit in Botswana and are cooked as a vegetable. These young fruit are also dried and preserved for use in the dry season.

In the present context, emphasis is given to ssp. *mucospermus* Fursa, which is presently grown on a large scale for its seeds, mainly in West Africa. This is probably why the French name for this subspecies is *le melon à pistache.* These seeds have been used since ancient times for the preparation of a condiment or thick soup. The species has a long ethno-botanical history and its uses are highly diversified, ranging from the most important use of their seeds as protein-rich food to varied medicinal uses of the white, often bitter pulp.

Traditional varieties are cultivated by the Turkana from Kenya who call it *namunye.* Turkanas use the young fruit as a vegetable. They also feed them to their animals. In northern and western Sudan (especially around Kordofan) as well as in Chad, traditional varieties are used as a source of water, similar to its use in Namibia. Here, the use as a source of seeds is of secondary importance. The citronnel or citron melon, which is found in Sudan and in Egypt, is closely related to the watery type (white in colour, not sweet) and the rind of these fruit are drenched in a sugar solution and lightly cooked to be used as sweetmeats. There is a local cosmetic industry in Namibia which uses oil from watermelon seeds.

RELATED SPECIES

Watermelons are closely related to the colocynth, *Citrullus colocynthus* (L.) Schrader, a perennial species, which is bitter and even poisonous, and in the past the dry pulp has been used as gunpowder. This pulp, obtained from unripe fruit, is still used as a drug that causes a violent purging action. Extracts of the bitter peels of colocynth are used to keep camels away from water sacks. Oil extracted from seeds is used for illumination and many other uses could be mentioned. This species is found in north-eastern Africa, from northern Kenya where it is rare, to Egypt and neighbouring parts of Asia up to Pakistan. It is mainly found in lowlands and can be seen at altitudes up to 1300 m in Eritrea, Ethiopia and the Red Sea Hills of Sudan and southern Egypt. A slight roasting facilitates removal of the seed coat of the small-seeded colocynths. Their seeds are ground into flour and are, amongst other uses, used in the preparation of chapatis.

In South Africa and Namibia, young colocynth-like fruit, belonging to the very bitter *Citrullus ecirrhosus* Cogn., are eaten after boiling a few times then replacing the bitter water with fresh water (Sturtevant, 1919). In Botswana, roots of this crop are mixed with the larvae of *Diamphidia* beetles and used to prepare poison for arrows.

POLLINATION AND BREEDING

The different varieties and subspecies of *Citrullus lanatus* can easily hybridize since it is a cross-pollinated species. Therefore, farmers wishing to produce seeds of the sweet watermelon types must ensure that there are no 'egusi' melons within at least 200 m, since cross-pollination by bees and other insects can be expected. Genetic enhancement may well be feasible, making use of the green-seeded preserving varieties developed in Colorado, which produce up to 25 fruit/vine and utilize the large-fruited modern varieties in combination with Nigerian 'egusi' types.

When the temperature is more than 30°C, the crop will grow well, but the pistils in the flowers may not be able to retain the necessary moisture level for effective pollination. Flower setting is also impeded by high humidity because the pollen is not sufficiently freed. Bees are the main pollinators for this cross-pollinated crop. Self-pollination is possible when carried out by hand; the best time to do this is just before the female flower opens.

VARIETIES

There are a large number of *Citrullus* landraces in West Africa, many of which have been collected and are kept in gene banks, especially by NIHORT in Ibadan, Nigeria. Most of these were selected for their edible seeds which are important as a source of vitamin E, edible oil and protein. Although almost every cucurbit seed may be called *egusi,* care should be taken not to confuse this species with the real egusi melon, *Cucumeropsis mannii,* which is dealt with separately.

The main cultivars found in Nigeria are Bara, Serewe and Sofin. Bara, also known as Papa, has large brown seeds with thick black edges, especially thickened towards the apex, about 16 x 9.5 mm, common in northern and western Nigeria. The 100-seed weight is about 14 g. Serewe seeds are smooth light-brown with a light whitish edge that is not thickened, about 15 x 9 mm, mainly found in Eastern Nigeria. The 100-seed weight is about 12 g. Sofin has thick, white edges that are more thickened at the base.

A further variety is denoted as 'E' and has large light brown seeds with a white edge, about 16 x 10 mm and a 100-seed weight of about 16 g and found in Niger State. The variety 'N', which is mainly found in Bendel State, has small seeds of about 7 x 4 mm that are uniformly dark-brown with a blackish edge and a 100-seed weight of only 5 g. These are comparable in size to those of Sugar baby watermelon, although the latter has a hard seed coat.

For varietal choice, early maturity is important, especially for the dry areas with a short rainfall period. Also the shelling percentage is important. Seeds with a heavy seed coat are appreciated less than seeds that are soft and easy to shell.

In northern India, there is a group of varieties (*Citrullus lanatus* var. *fistulosus)* referred to as *tinda*, of which the green-fleshed fruit are cooked as a vegetable. Such varieties are also grown in Kenya, Zimbabwe and Ghana, mainly as an export crop for the Asian population living in the UK.

AGRONOMY

Citrullus can grow on a wide variety of soil types but sandy, free-draining soils are preferred.

Planting takes place at the beginning of the rains in dry regions and towards the end of the rains in areas with a high rainfall. Before sowing, 200 kg 15-15-15 N-P-K compound fertilizer/ha should be applied. Farmers usually sow 3-5 seeds/hole and retain the strongest plants. The spacing differs depending on variety, with 75 x 100 cm for single plants, to 2 x 2 m for a pair (2) of plants retained/station. This ground-covering crop is effective as a weed suppressor and is usually intercropped with a tall crop such as maize, millet (sorghum) or okra, and also with cassava or yams.

Seeds germinate after 4-7 days. The first flower can be expected after about 4 weeks and before the ground has been fully covered with the crop. Weeding is needed at an early stage to obtain a high yield. This crop is fairly drought-tolerant because of its deep root system.

Young watermelon leaves and young fruit are eaten as a cooked vegetable and sometimes immature fruit are eaten raw, but this use is of secondary importance to that of its seed (*see* Figures 37, 38 and 39). After 10-12 weeks, the crop will be ready to harvest when the fruit is fully mature and the crop has started to dry (*see* Figure 40). Fruit are collected and placed on a tarpaulin or similar sheet where they are broken into pieces. The remaining humidity and heat will cause the heaps of broken fruit to ferment. After about 1 week, seeds will have separated themselves from the flesh and a first separation of the rind and flesh remnants is now possible. The seed mixture can be taken away and washed in water and dried in the shade. In the dry season or in semi-arid areas, such as those in Sudan where water is not available, this 'washing' can be done with sand rather than with water. The seed to fruit

Figure 37 Young, tender leaves of watermelon can be eaten as a vegetable

Figure 38 Watermelon seed to be used as egusi

Figure 39 Watermelon and *Hibiscus* leaves being offered for sale at Navrongo market in northern Ghana

ratio, expressed in weight, is about 1 : 40. Seed yields can be up to 400 kg/ha, although most farmers do not usually obtain more than 250 kg of seeds.

Those seeds are widely traded on the market and this is where the involvement of most farmers ends. For subsistence use, however, seeds need to be dehulled. Fortunately, *Citrullus* seeds have relatively soft testas that can easily be removed by hand. There are now decorticators on the market for large-scale dehulling, so that women no longer need to spend many hours removing the seed coat before roasting the seeds. The proportion of shells ranges from 23-35% of the total seed weight depending on the variety (Omidiji, 1977).

Figure 40 Watermelon fruit used for seed are usually much smaller than those used as dessert fruit

The most common use of kernels is in ground form. The paste is rich in proteins and is used for the preparation of sauces. Seed kernels can be pressed for their oil, which is sold as a special commodity. In Nigeria, the oil of the Bara and Serewe varieties is traded on a large scale and is widely used for cooking and frying. The cake left over after extracting the oil is either made into balls and fried or steamed to produce *robo* and *monu* respectively. Both these products, which have a high protein content, are eaten together with maize or a similar starchy food.

PESTS AND DISEASES

Watermelons are very susceptible to a range of diseases, which is why they grow best under dry conditions. Under more humid conditions, downy mildew is the most important disease, caused by *Pseudoperonospora cubensis*. When the crop is planted during the rainy season damping-off, caused by *Macrophomina phaseolina*, can be a real difficulty at the seedling stage. The Nigerian varieties Bara, Serewe and Sofin are more tolerant to damping off than traditional varieties.

Anthracnose, which is seed transmissible, can be controlled by Benlate at the rate of 15 g/10 l of water, sprayed weekly. Care must be taken to select disease-free fruit for the selection of seeds for planting.

The major pest affecting young fruit is the melon fly *(Daucus* sp). It can be controlled by the use of Sevin, Malathion or other pesticides, whereas some farmers use a sugary bait with some chemical added to it. Major pests of stored seeds are the beetles *Trilobium casteneum* and *Lasioderma serricone.*

ANCHOTE

Coccinia abyssinica (W. and A.) Cogn.

Anchote is a perennial crop cultivated for its tubers in the western and south-western region of Ethiopia. It is grown at altitudes ranging between 1300 and 2800 m. Only the cultivated forms have edible tubers, whereas the tubers from wild plants are considered to be inedible. Such wild plants are generally found at lower altitudes. Tubers are eaten as a cooked vegetable. New shoots are produced from the tubers at the onset of the rains. Other cucurbits, of which the roots are eaten raw or cooked, include the perennial crop *Cucumis kalahariensis* A. Meeuse from Botswana, Namibia and South Africa. This species is called *mosumo* in Botswana.

EGUSI MELON

Cucumeropsis mannii Naud.

Synonym: *Cucumeropsis edulis* (Hook.f.) Cogn.

Cucumeropsis mannii Naud. is the real egusi melon, which is the most important cucurbit seed crop in the Côte d'Ivoire where its seeds can be found in most markets (*see* Figure 41). The Akan people in the Côte d'Ivoire call these seeds *nviélet.* In Cameroon, it used to be an important crop at a time when there was plenty of forest. Here, the crop is associated with shifting cultivation and is currently in a strong decline and cultivation now only takes place in the few remaining forest patches, often far from the main roads. After cutting branches of trees, the wood and other vegetation is burned during the dry season. The debris left over after burning serves as stakes for egusi melon, or *ngon* as it is called in Cameroon. The French name is *concombre amèr.*

Figure 41 *Cucumeropsis mannii*

In Nigeria and in Cameroon, *ngon* is planted in March at the start of the rains and harvested from September to November. It takes at least 6 months, but more often 7-8 months from sowing to harvest. This crop cannot grow well without support and does not do well in the open or on flat land. It is occasionally found at the edge of a garden, climbing into the shrubs or trees. It is also found in forest clearings where it may be interplanted with maize, for example, but here the yield is very low.

Stems of the egusi plant are pubescent and angular and have long tendrils which coil at the tip. The clustered male flowers and solitary female flowers are found on different parts of the plant. There are 5-7 male flowers on a cluster, each flowering on a different day. The light- to dark-green mottled fruit

can be found hanging from the tree branches or from the tree stumps and they turn creamy white towards maturity. The fruit flesh is white in colour and rather soft and jelly-like around the seeds. The seeds are large, long and distinctly white in colour and are embedded in a mucilaginous package. The Akan people in Côte d'Ivoire call these seeds *nviélet,* whereas in Nigeria they are called *itoo.* There are both long, narrow and large broad-seeded varieties and the kernels can be either white or green in colour. The green-coloured ones are preferred to the white ones.

When the vines have dried and fruit have changed colour, the fruit are collected and placed in a heap after being cracked or split open. They are left for a few days to ferment, causing a strong smell. This is one of the reasons why seed extraction is carried out at some distance from the homestead.

Figure 42 The real egusi seed

The seeds are removed and washed to remove the thick layer of mucus (*see* Figure 42). After washing, the seeds are covered in soil dust, which is needed to separate the seeds properly, since the mucus remnants effectively 'glue' the seeds together, making the dehulling process difficult. Proper drying of the seeds is essential before they are packed for sale in 80-100 kg bags. Improperly dried seeds may soon germinate inside the bag, especially if the bags are not properly covered against the rains or when the ambient humidity is too high. Such seeds become useless and represent a total loss.

The seed can be dried to a moisture content of about 9% and when stored in an airtight container can be kept in a good condition, both for consumption and for sowing. The sooner the seed is dried the better. Seeds offered for consumption need to be dehulled. Heating the seeds up to 60 °C will make the seed kernel shrink away from the hull. The hull will then become more brittle and eases the decortication process.

The seed yield depends on the growing system used. When seeds are mainly placed next to the remaining trunk of a tree about 30 kg seeds/1000 m^2 will be obtained. In a more intensive cropping system where the ash-covered land in between is used for cultivation, farmers may get about 90 kg/ 1000 m^2. The average plot is about 2000-2500 m^2.

Egusi is very labour intensive, not only because of the slashing and burning and/or the need to provide support, but also the considerable work entailed in extracting seeds from the fruit and their jelly-like coating and subsequent de-hulling process. It is therefore not surprising that seed kernels cost as much as US$ 3.00/kg which is very high for West African standards.

At the markets in Ghana, egusi kernels can be found which are imported from the Côte d'Ivoire and have already been decorticated. This may be explained partly by the assumption that people would like to keep this business to themselves, which they ensure by removing the seed coat so that seeds will no longer germinate.

Apart from grinding the kernels for oil and for their protein-rich cake, seeds are also roasted. This is a social form of eating together after the seeds have been cracked and the shell removed.

The oil of *Cucumeropsis* is not extracted on a commercial basis, contrary to that of *Citrullus,* probably because of its scarcity. The oil is highly saturated like the 'butter' extracted from the shea nut, *Butyrospermum paradoxum* (Family Sapotaceae), but unlike oils from the other cucurbit crops. Its oil ratio is comparatively low because of its heavy seed coat. Seeds have a protein content of 36% and a fat content of 44%. They are relatively rich in K, Ca and Mg.

Fruit flies can severely affect the production. It is therefore not recommended to plant again in the same area for at least another year. A severe damping-off disease was observed in Nigeria which was found to be *Macrophomina phaseolina.*

MELON

Cucumis melo L.

The melon (2n=24) probably originates in Africa, the continent where most of its wild relatives and some primitive varieties can be found. The melon itself is not known in the wild, although local people in Ethiopia consider some of the primitive varieties as wild and these can be found in open woodland or near river banks. Most African members of the genus *Cucumis* have a basic chromosome number of n=12, whereas most Asian members, such as the cucumber, *Cucumis sativus,* have n=7 as the basic chromosome number. It has probably been introduced to Asia where secondary centres of diversity can now be found in India, China and the Ukraine. No reference will be made to the use of melons as dessert fruit, mainly because they are not vegetables, but also because there is substantial literature available on such fruit.

Figure 43 Melons grown for their seed

The field melon (*Cucumis melo* ssp. *agrestis*) is used in a number of Sahelian countries for its rather watery fruit which are eaten as cucumbers. In the Sudan, these are called *tibish.* Young fruit are collected in northern Uganda and cooked. The so-called snake cucumber which is often seen in markets in Cairo and many other places in Egypt and the Sudan, where it is a popular crop during the summer months, is not a cucumber, but a subspecies of the melon (*Cucumis melo* ssp. *flexuosus* (L.) Greb.). It closely resembles the long cucumbers which are grown in greenhouses in Europe, but can be distinguished by the yellow parallel stripes along the fruit. Immature fruit are often pickled. Their flesh remains solid and fresh for a long time. It is eaten either fresh or cooked.

There are several varieties of snake cucumbers which are mainly named after their location, like Karrari and Jammoia. The highest yield can be obtained from November plantings, since later planting dates are often associated with powdery mildew diseases which have a serious effect on their yield. This crop responds well to high dosages of organic manure (up to 30 t/ha) and applications of urea at a time when the soil is not fully covered by leaves, or just after flowering. Fruit should be harvested every 2-3 days and less frequent harvests will result in reduced yields. Yields can be 25-30 t/ha.

Some people collect shoot tips or young leaves and occasionally consume the flowers, but the main use of melons in West Africa is for the seed (*see* Figure 43), which are used as 'egusi'. In Cameroon, children have to remove the seed coat of the various egusi types of which *C. melo* ssp. *agrestis* is amongst the most common. One child is usually given a daily task to fill a glass of 'kernels'. These fresh kernels are placed in the sun to dry and can then be preserved for about 2 months. Dehulling is a very important income-generating activity for the poorer members of society, who may hardly be able to afford these products themselves. Often a bag of unprocessed seeds is purchased from a trader who guarantees to buy the peeled product back at a higher price.

Melon seed kernels contain about 45% oil, which is sold as a commodity by itself. The cake contains 36% protein and this, together with the oil, is used to prepare sauces. Another way of consuming melon seeds is by frying or roasting them, which is popular in some parts of Nigeria. Alternatively, melon seeds are boiled in water and salt is added to improve the taste. In the latter cases melon seeds are eaten in the shell. Field melons are also important for their seeds in the Sudan and in Ethiopia and the extracted yellow oil is in high demand.

Melon cultivation and pest and disease problems are similar to those described above for the watermelon. Seed storage is a problem, since melon seeds will not stay fresh under moist conditions and can easily become mouldy, thus spoiling their taste. Proper drying after harvest is therefore essential, after which the seeds should be stored in an airtight container.

KIWANO

Cucumis metuliferus E.Mey. ex Schrad.

Cucumis metuliferus is a fruity vegetable popular in Botswana, Zambia, Zimbabwe and other southern African countries, where both young and old people collect the short, orange, spiny-looking fruit from the wild (*see* Figure 44). These juicy fruit are eaten fresh and taste like slightly sour cucumbers. They are especially important during the dry season when people use them as a source of water. The young leaves are cooked and used as spinach in Zimbabwe. Zimbabwe's Shona people refer to this crop as *mugaka* whereas people in Botswana call it *mogabala.* Since the fruit are relatively common and are also found as a weed on cultivated land, this species is either not or scarcely cultivated near its centre of origin. As far as the author is aware, efforts towards domestication in Africa have only been made in Zimbabwe's Chiredzi district.

Figure 44 Kiwano

The species was introduced to Australia and New Zealand in the 1920s where it turned into a weed. Domestication started in New Zealand, where it was noted that fruit could be kept for several months without losing their decorative value and flavour. It has been grown commercially there since the mid-1980s and, in order to promote the crop for export to Japan and the US, it was given the name kiwano. Today it is grown as a speciality fruit in California and Israel and, to a limited extent, in Kenya, whence it is exported to Europe.

C. metuliferus stands alone within the genus *Cucumis* and is not compatible with other species, so that cucumber or melon seed growers do not need to worry about outcrossing with this species. Its basic chromosome number is 12. Its vines are usually 2-3 m long with angular stems. The deeply cut five-lobed leaves resemble those of a watermelon rather than those of a cucumber, and are covered with sharp, stiff hairs. Most nodes have tendrils and 2-4 male flowers. Female flowers are much scarcer and only found on secondary branches. Male flowers appear about 3 days before the female flowers. Pollination only takes place when temperatures are high enough and parthenocarpic fruit are formed under cold conditions. Fruit are about 4 x 7 cm and some cultivated selections now approach twice that size. The fruit are covered with rather sharp thorns, hence the name African horned cucumber or horned melon.

The crop can be established either by direct sowing or by transplanting seedlings at the two true-leaf stage. The optimum temperature ranges between 20 °C and 35 °C. These high temperatures and fully exposed conditions are needed for the desirable orange-coloured fruit. Trials carried out in Israel indicated that the best plant density was 1 plant/m^2. It takes about 8 weeks from sowing to flowering and a further 6-7 weeks to the first harvest of ripe fruit. Fruit are ripe when the dark-green colour changes to yellow and it may take quite some time to change to its full orange colour. Treating the fruit with ethylene gas can enhance this colour change and this has become standard practice for export traders. Fruit with a weight of about 180-250 g are selected for export. Fruit can be stored for up to 3 months at room temperatures of about 20 °C.

The cultivated varieties now developed in New Zealand, Israel and the US have a rather bland taste that limits their potential as dessert fruit. This may offer an incentive for plant breeders in southern Africa to look out for fruit with more aroma and a pleasant sweet-sour taste. Other desirable characteristics could be larger fruit with fewer or less-sharp spines; these characteristics have been reported from Botswana. Bitterness is highly undesirable and caused by toxic cucurbitacines that can be present in small quantities.

RELATED SPECIES

The West Indian gherkin, *Cucumis anguria* L. (2n = 24), is mainly grown in South America (Brazil) and the Caribbean area, where it has probably arisen as a cultigen, but is hardly known as a vegetable in Africa. It is mainly collected from the wild and cultivated on a small scale in Zimbabwe, where people in the Chiredzi district appreciate both the young fruit and their leaves. The ripe fruit are used in Zimbabwe as medicine or as a pesticide. *C. anguria* is cultivated around Thiès in Senegal where the immature fruit are pickled green (Burkill, 1985). Its ancestor, *C. longipes* Hook., which can be found wild in West Africa, has bitter fruit (Purseglove, 1968).

Amongst the species collected from the wild for their leaves which are used as a spinach are *C. africanus* Lindl.f. and *C. myriocarpus* Naud., both from southern Africa. There are many other species in Africa which belong to the genus *Cucumis*, many of them being highly poisonous and used in traditional medicines. For the South African *Cucumis kalahariensis see* under *Anchote* (p.60).

Kedrostis pseudogijef (Gilg.) C. Jeffrey

In eastern and especially north-eastern Kenya, *Kedrostis pseudogijef* (Gilg.) C. Jeffrey is a woody climber with brown, corky stems and can be found on hedges and fences around houses. Its trifoliate leaves and young shoots are eaten with starchy food. The fresh leaves have an unpleasant odour which disappears after cooking. Food preparation takes a long time, which is one of the reasons why this crop is becoming less popular. It can be a fast-growing climber which is highly drought tolerant and remains green. Cultivation is limited to sticking a piece of stem in the ground at the start of the rains. It takes root within a short time and grows vigorously during the rains. No agronomic research has been carried out on this, for a dry area, interesting home-garden crop.

BOTTLE GOURD

Lagenaria siceraria (Molina) Standl.

The bottle gourd is one of the oldest crops known to be cultivated (*see* Figure 45). Remnants were found in Mexico in soil which was dated 7000-5500 BC and bottle gourd remnants found in Peru were dated 4000-3000 BC. Within Africa, the oldest remnants were in an Egyptian tomb, dated 3500-3300 BC (Purseglove, 1968). How this African crop could have found its way to America at such an early date has for long been a mystery. Recent evidence of ancient navigators who were capable of travelling over enormous distances may shed some light on this mystery (*see* also *Introduction*, p.2).

Figure 45 Young fruit of the bottle gourd can be eaten as a vegetable

The bottle gourd has also found its way to southern Asia, where it developed into a common fruity vegetable and is now a traditional crop in many parts of Asia. The Indian subcontinent has become a secondary centre of origin where many different varieties can be found, some of which are referred to as *doodhee.*

In Africa, the bottle gourd grows wild in semi-arid regions and is mainly used as a container called a calabash. Traditionally, such containers were used to store seeds, for example, okra, cowpeas and other food crops, and offered some protection against insect damage, since such containers could be closed effectively by sealing them with cow dung, for instance. These calabashes become very dry and are more or less waterproof during the rainy season. People cut the neck at its narrow part and scrape out as much flesh as possible, after which they will allow a natural fermentation to clean up the remaining pulp remnants. The fruit are dried well before they are used as a container.

There are also forms with edible fruit which are cultivated. Young and tender shoots and leaves and occasionally small fruit are eaten in Kenya, Tanzania and Cameroon. Young fruit are boiled or fried. The Zulus from South Africa boil young fruit or fresh leaves with milk to reduce the bitterness; when these are mixed with maize meal it is called *umqa.* The related *Lagenaria sphaerica* (Sond.) Naud. is collected from the wild in Zimbabwe's Chiredzi district and similarly used for its leaves and young fruit.

The bottle gourd is mainly cultivated in semi-arid areas and can be found in and around compounds, usually growing in a shrub with its fruit hanging, or grown on flat beds, depending on the purpose for which the crop is grown. There are different varieties, most with bitter, inedible fruit, which are grown as calabashes or gourds with their very hard rinds; some of these may also be used for their egusi seeds. There is an amazing variation in the size and sculpture of the seeds, ranging from smooth seeds to seeds with a very distinct ridge around the edges and other surface markings. One variety, or possibly a distinct species, has a smooth surface and lacks the ridges but has a flap-like appendage at the broad end of the seed. This variety is grown for its egusi seed in the north of the Côte d'Ivoire, northern Ghana and Burkina Faso. It has a soft rind and cannot be used as a calabash. In the Côte d'Ivoire this variety of egusi seed is second in importance, after *Cucumeropsis mannii* and more important than watermelon seeds or those of other cucurbits (Siemonsma, 1982).

Lagenaria oil is rarely traded. The ratio of the shell and the seed kernel is about 50% and the seed kernel itself consists of approximately 40% oil. In general, *Lagenaria* seed shells are very thick and hard to crack, which is one major reason why they are less popular than those of *Citrullus*, for example.

BITTER GOURD

Momordica charantia L.

The bitter gourd is commonly found as a wild plant in the high rainfall areas of West and Central Africa and is one of Africa's commonest cucurbits. It is, however, rarely cultivated and if so, it is mainly grown for use as a vegetable by the Asian community or grown for export. In the latter case, the seeds are brought from Asia where this crop is commercially important and where there are many varieties, including a range of hybrids. It is a common vegetable in South and South-East Asia where the immature fruit are used, mainly for curries and in pickles. The species has been domesticated in Asia where it has been in cultivation for thousands of years. It also grows wild in South-East Asian lowland rainforests and riverine forests and several authors therefore consider this to be an Asian species, which is also reflected in some synonyms for this species, such as *M. indica* L. and *M. chinensis* Sprengel. The genus *Momordica* is represented by close to 40 species from Africa and four to seven from Asia. The very bitter leaves of the closely related balsam apple *M. balsamina* L., from the drier parts of Africa, are used as a vegetable in the highlands of Jebel Marra in western Sudan and also in Mozambique and South Africa. Leaves of the related *M. foetida* Schumach. are similarly collected for consumption in Ethiopia.

In West Africa this species is mainly collected for medicinal purposes; its principal uses are as a laxative, for stomach ache and to treat fevers (Burkill, 1985). Leaves of *Momordica* spp. are also collected from the wild in Swaziland where they are used both as vegetable and as a medicine.

FLUTED PUMPKIN

Telfairia occidentalis Hook. f.

INTRODUCTION

The fluted pumpkin is no longer known in the wild, but most likely originated in West Africa's high-rainfall forest belt. The largest diversity in plant populations can currently be found in Imo State and surrounding areas in south-eastern Nigeria. The crop is found throughout the former forested areas

from Sierra Leone to Angola and up to Uganda in the east. For the Igbos it is the most popular leafy vegetable by far. Outside Nigeria, where it is frequently eaten by up to 35 million people, and apart from West Cameroon (*see* Figure 46), it is far less well known and, if so, then mainly for its immature edible seeds rather than for its shoots and leaves.

The term fluted refers to the shape of the female flowers, which resembles a flute. It is also called fluted gourd. In Nigeria, the Igbos call it *ugu* and the Yorubas use the name *ugwu*. In Cameroon it is referred to as *ekobon*.

Related species

The closely related oyster nut, *Telfairia pedata* (Sims) Hook., is found in Zanzibar and along the coast of Kenya, Tanzania and Mozambique, but also more inland such as the foothills of Tanzania's Usambara and Pare Mountains and the area around Lake Malawi; and to a limited extent in Rwanda and Uganda, and occasionally even in Zimbabwe. The oyster nut is called *mkweme* in Kiswahili and in Malawi it is called *matandu*. Oyster nuts and fluted pumpkins are also produced in India.

Figure 46 Fluted pumpkin in a home garden, Buea, Cameroon

Oyster nut seeds can be used as a substitute for almonds, but their main use is in ground form. The cake is highly valued as a protein food and the seeds are the source of the true 'oyster nut oil'. Its young vines have an unpleasant smell and are rarely eaten. For further information reference could be made to FAO (1988), since this crop is only rarely used as a vegetable.

There is a third African *Telfairia* species, *T. batesii*, which is not domesticated and is, by now, close to extinction. It was formerly found as a wild plant in Cameroon and Fernando Po, Equatorial Guinea.

BOTANICAL ASPECTS

Male plants flower about 4-5 months from sowing, whereas female flowers need another 3 weeks before the first flower is open. There is often a profusion of male flowers in inflorescences that are found at the end of a vine. Male flowers first open during the evening or night and often shed their pollen soon afterwards, even though the flowers remain open until the next evening. There is always enough pollen available from the many male flowers that open later. Female flowers also start opening in the evening, but open wider from mid-morning until early afternoon, when they have a strong scent and their stigmas are presumed to be most receptive. The female flowers are solitary, short stalked and are found in the axils of leaves, near the junction of a main side shoot, often screened by leaves. Only male flowers have nectar which attracts bees, *Diptera* flies and several other insects. Pollen grains are carried on the bodies of these insects.

Figure 47 The ratio of male to female flowers of the fluted pumpkin is 800 : 1

The fact that only about 20% of female flowers will set fruit shows that the pollination mechanism, with about 800 male flowers for one female, is not very efficient (*see* Figure 47). Pollination by hand is often more successful (Akoroda *et al.*, 1989). The fluted gourd is suspected by some researchers to be parthenocarpic, but female flowers that had their stigma cut failed to set fruit.

Plants are dioecious although monoecious plants are occasionally found. Most female plants have distinctly stronger shoots and larger leaves than male plants, which is one reason why most farmers prefer to have female plants. Unfortunately, it takes at least 3 months from sowing before this character becomes clear. It was found, however, that this method is not fully reliable, since some male plants may also have strong shoots and large leaves and some weaker looking plants turn out to be female. The ratio of male to female plants is difficult to establish because approximately 15% of the plants do not produce any flowers during the first year when the crop is needed either for its leaves or for its fruit. The number of male plants is probably somewhat larger than that of female plants, but to be accurate about that a large number need to be grown as a perennial crop, which is not the usual practice. A further likely cause for not flowering is the effect of Telfairia mosaic virus.

Only two to three fruit will develop on one plant, of which usually only one or two will be kept. The large, waxy, greyish-green fruit with 10 broad ridges weigh on average about 5-7 kg, but can reach 20 kg and sometimes more. The wax starts fading towards maturity, fruit appear to become darker green and the ridges become stiffer. Fruit may remain on the plant for some time after all the leaves have dropped. Each fruit contains 60 seeds on average with a normal range of approximately 30-110 seed/fruit. Approximately 15% of the fresh fruit weight consists of seed (increasing to 20% after being stored for 2 months or longer).

The fluted gourd is a perennial crop although it is cultivated as an annual crop. Leaves and young shoots dry and eventually drop when the dry season sets in and fruit are mature when the leaves senesce. At the start of the rainy season new shoots develop along the main branches, especially in female plants. Male plants do not live as long as females, which can live for about 4 years, when their main stem will have reached a diameter of up to 10 cm and its lianeous branches could be over 30 m long when found high up in trees. The size of fruit decreases over the years. Female plants can withstand dry conditions better than male plants and often develop some tuber-like thickened roots. Male plants drop their leaves about 3 weeks earlier than a female plant.

VARIETIES

Very limited research has so far been targeted towards genetic enhancement. The natural diversity is not very large, possibly because this crop is only known from just one ecological zone which used to be the rain forest. Selections have taken place for tolerance or resistance to Telfairia mosaic virus disease. In Nigeria, there is also a search for material with a higher proportion of female plants or plants with

stronger, more vigorous shoots. The Nigerian cv. Nsukka local, a landrace with large root systems, tolerates severe infection of the root knot nematode *Meloidogyne javanica* where top and root growth are not affected.

There is variation in pod colour (some being dark-green at maturity, others yellowish), in seed colour (ranging from yellow to brown to dark-red), the anthocyanin content of leaves and petioles or shoots, plant vigour and total size. Even the occasional monoecious plants have been observed. So far no material is known that is pure enough to have a proper varietal name. Any varietal purity will also be difficult to maintain since it is a 100% cross-pollinated crop. Therefore future selection and breeding work will need to be carried out by controlled pollination.

There is a need for researchers to find varieties that produce more fruit or more seeds/fruit to overcome the serious shortage of seeds for planting and for consumption purposes. Similarly, there is a need to develop varieties that are resistant to Telfairia mosaic virus since the disease is seed transmissible; it is the main reason why this serious disease is now rapidly expanding in most production zones, especially in south-western Cameroon.

Ideally, plant breeders should produce rooted cuttings from selected virus-free vines. In this way male plants can be selected based on their leaf size and plant vigour, whereas female plants can similarly be selected for desirable characteristics such as number of fruit and number/size of seeds. Controlled pollination could result in hybrids. Good record-keeping combined with plant maintenance can ensure a continuous supply of the best performing and successful material and thus a reliable source of seeds for sowing.

SEEDS

Fruit are physiologically mature 9-10 weeks after pod setting, usually about 8 months after planting. When the crop is grown for seed, 3000-5000 fruit/ha could be expected, representing about 3500 kg of seeds. With less attention to detail, farmers are not likely to get more than 2000-2500 fruit/ha, meaning 2000 kg of seeds or less. To plant a commercial, high-density leaf crop with a population of 30 000 plants/ha, about 400-500 kg seed will be needed, which demonstrates why seeds are so expensive.

Seeds are recalcitrant and will fail to germinate when kept dry. They also suffer from low temperatures. Seed quality is best when seeds inside the fruit are between 9 and 12 weeks old and seeds will slowly start their decline from about the 12-week stage from fruit setting onwards. This optimum quality refers to germination capacity and to oil and protein concentrations. The best way to keep them for up to 6 months is inside the fruit where the moisture is about 60% (*see* Figure 48). This also means that seed transport is only possible inside the large (about 50 x 20 cm) fruit. When seeds are left inside the fruit for too long they may start germinating and are then no longer suitable for any use apart from planting immediately. Fruit should be stored in a dry (but not cold), shaded place.

Figure 48 Cross section of a fluted pumpkin fruit showing the large seeds

Farmers usually leave seeds in the open for a few hours to reduce their moisture percentage to about 40-50%, which appears to provide the best germination conditions. If seeds are not then sown and watered immediately, they will die since this range equates the critical seed moisture content. When seeds are sown without being 'pre-conditioned', germination will be slow and irregular. The larger the seeds the better the chance of a good germination and strong plants. For a rapid growth and a strong rooting system, seeds of 15 g and above are recommended. Some people suspect that small seeds lead to male plants and large ones to female plants, but so far no real evidence has been shown to support this view.

To overcome the problem of the limited amount of seed available to produce the many seedlings required, Esiaba (1982) developed a technique where the germinated seeds with young seedlings approximately 7 cm long are carefully split in two cotyledon parts, each cotyledon with one or two plants and roots. From one seed up to four seedlings can thus be obtained, but only about two are likely to survive, thus enabling a farmer to double his/her plant population. Akoroda and Adejero (1990) have found that seeds germinate better and faster in sawdust than in soil or sand (7 days instead of 10-14 days). Such seedlings also split more easily than those grown in the field.

The highest germination percentages are found when it is relatively warm (25-30 °C) and humid. Germination will deteriorate rapidly when the moisture is below 40%, but also when the moisture content is above 70%.

Seeds usually weigh between 10 and 25 g, of which approximately 75% represents the seed kernel (growing point and two large cotyledons). These seed kernels contain at least 40% oil, depending partly on whether they are fresh or were first dried in the sun; this is higher than that of most oil seed crops. Seed kernels generally contain 20% water, 40% oil, and the remaining 40% can be used as seed cake.

AGRONOMY

Farming systems

Figure 49 Edible leaves and vine of fluted pumpkin plant

The most common production method in traditional farming systems is as a mixed crop together with a staple food, particularly yams, or, less frequently, with other vegetables. Some farmers utilize the stakes provided for yams to support fluted pumpkins. Of late, pure stands are becoming more common, especially in Nigeria for market gardening. Women mainly look after the crop whereas the men will tend the yams. Fluted pumpkins are not affected by the shade of trees and perform reasonably well in the open as long as there is adequate moisture available. During the dry season irrigation is required every 3 days.

Fluted pumpkins can be cultivated on flat land or on mounds. In home gardens, they are frequently grown along a fence or next to a tree, thus allowing the fruit to hang from a branch. They are also raised along stakes of various types including bamboo. Ideally they like well-drained, non-soggy soils with some shade. Full sunlight is less favourable for this crop. The high demand for this vegetable means that in practice it is grown on a wide range of soils, including poor, sandy soils (*see* Figure 49).

Planting

When planting for leaves, the usual spacing is 50 x 50 cm for a monocrop or occasionally even closer. Some farmers plant in the middle of a 1.20 m-wide bed at 40 cm intervals, and other farmers plant on a mound next to a stake. A series of stakes may form a fence. The spacing or planting method varies a lot, with some farmers insisting on the need for a very wide space. Spacing depends on soil fertility, the use of supports and the harvest frequency and also on the availability of seeds. There is thus a clear need for location-specific plant density trials.

Seeds should be placed flat and not upright, as some studies have shown that a vertical placement may result in cracked seed coats and irregular seedlings. When seed supply is not a limiting factor, farmers like to plant two (or three) seeds/hole just in case seeds fail to germinate. This is a more common practice for subsistence farming rather than for market gardening, where a failure of some seeds to germinate means that there is less to thin out and less to harvest for the first time.

It is grown both in the dry and the rainy seasons. When planting during the dry season, mulching is recommended to retain the moisture in the soil better. Mulching will also suppress weeds which can be troublesome during the early stages of growth.

Fertilization

Fluted pumpkins prefer a loose, friable soil with ample humus and a shaded position. These conditions are hard to find and fortunately this crop will grow in conditions which are far less favourable. Nitrogen is essential for an adequate vegetation and should ideally be given in the form of manure, applied before planting. The use of well-decomposed manure is essential for fruit production and in this case it is recommended that about 1 kg manure/plant be applied. For maximum leaf yields, it is advisable to topdress with a nitrogen fertilizer immediately after each harvest. Manure also contains phosphorous and other nutrients needed for seed production.

Planting for fruit production

When planting a monocrop for fruit or seed production the spacing has to be wide, usually about 1.50 x 2.00 m. Since fruit and not shoots are needed, about 90% of the male plants can be removed as soon as their flower buds can be recognized. When selecting and removing plants it is advisable to retain male plants with strong vines and large leaves. Also, all non-flowering plants should be removed since they serve no purpose in fruit production. One male plant for every 10 female plants is more than adequate. These male plants will produce ample pollen, especially since the best results are obtained through hand-pollination rather than natural pollination by bees or *Diptera* flies.

When fruit are produced to obtain seeds for planting it is essential to ensure that all plants with mosaic virus have been removed from the field, since this disease can be carried over by the seeds, thus affecting the next generation.

Efforts have been made to use cuttings of female plants instead of seeds, which are both expensive and have more than a 50% chance of being the less desirable male type. Unfortunately, the use of cuttings has not so far been very successful and further research is certainly warranted, for example, on rooting hormones. If cuttings could be used there is a possibility of selection for a desirable high leaf-yielding type, thus enhancing the genetic potential of its offspring.

Farmers who have been successful in obtaining a 90% female crop, and were able to control diseases, are well advised to retain their plants for a second growing season and to apply fertilizers prior to the onset of the new rains. Even though the fruit yield in the second year will be lower and seed sizes correspondingly smaller, the space created by removing male plants can be better utilized and the farmer will also save on the cost of establishing a new crop.

On the research side, it is common practice with cucurbit seed-producing companies to treat their plants chemically to influence the number of female flowers. It may well be possible to use similar hormone-like chemicals on fluted pumpkins, but as far as the author is aware, this has not been tested yet.

Harvesting

Harvesting of shoots of up to 50 cm long can begin 1 month after germination followed by 3-4 week intervals when new shoots are formed. There is evidence that female plants have a considerably higher yield than male plants, partly because their leaves are larger and because they have stronger vines. Also, they will keep growing once flowers have appeared, which is not the case for male plants. Thinning of plants may take place after 2 months, when a selection can be made between vigorous growing plants and slower growers with smaller leaves.

When planting for young shoots and leaves, it is wise to remove the flower buds at a very early stage, since flower formation will reduce the capacity for vegetative growth, especially for male plants. Harvesting should ideally be carried out by pruning shoots, rather than by hand-picking leaves. Hand-picking may damage the plants and hinder development of side shoots. Pruning with the use of a knife is better than picking by hand, but knives are NOT recommended when viruses are found in the crop.

Fresh shoot yields is usually about 500-1000 kg/harvest/ha, but could be more if the crop receives adequate manure or when fertilizers are applied after each picking. During the life of a crop, there will be approximately 4-6 pickings or occasionally more, depending on irrigation facilities and harvest frequency.

The productive life span depends basically on the rains, but even with adequate water most plants will cease production of new shoots after about 6-8 months. They will then require a rest period, provided for by the dry season, and the plants will sprout again with the onset of the new rains.

Marketing

For marketing, the shoots are sorted into lengths and tied into bundles. Care must be taken since the shoots break easily, and people prefer to have shoots with their tops intact, rather than a lower part which may be considered as a second choice since it is more mature and thus more coarse. The larger bundles are offered wholesale. To keep the product fresh, it is necessary to store the shoots in the shade with some water sprinkled on top to preserve them. Too much water will cause leaf rot.

Fruit are sold both at a mature and at an immature stage. Ripe fruit are identified by the senescence of the vine on which they grow. These ripe fruit are needed to obtain seeds for planting. Also, young, immature greyish-green fruit are sold for their unripe seeds that are much appreciated as food. Fruit can be found at the major markets during the dry season.

PESTS AND DISEASES

A serious problem, Telfairia mosaic disease, has badly affected production in Cameroon and has now spread to Nigeria. There has been some resistance breeding for this disease which has been only partially successful. This virus disease is recognized by stunting and a yellow mosaic on the leaves. Fruit may be twisted and remain small. This virus was found to be seed-borne and is also transmitted by *Aphis spiraecola.* Another virus disease in this crop is a strain of pepper veinal mottle virus, recognized by the yellow veins.

Generally, pests including nematodes and snails (*see* Figure 50), and diseases other than Telfairia mosaic virus, do not affect fluted pumpkins very badly. Cut worms belonging to *Noctuidae* spp. can be a nuisance, both in the nursery and in a newly planted field. One fungal disease is reported with some frequency, *Phoma sorghina,* or white leaf spot disease, which can be controlled by spraying with Dithane M-45. It is mainly found in older plants and it is not advisable to use seeds from affected plants for sowing next season's crop. *Colletotrichum* fruit rots such as *C. lagenarium* and *C. ordiculare,* which are occasionally seen as sunken black spots on the fruit and as irregular larger black spots on the leaves, could be a complication since they are likely to affect the seeds. Other diseases include the wilts caused by *Curvularia* spp. and *Fusarium* spp. and the stem rot *Didymella bryoniae.* In Cameroon Corynespora leaf blight (*Corynespora* spp.) and Alternaria leaf blight have been reported as relatively common. So far these diseases have not had a significant effect on yields and quality of shoots and leaves.

Figure 50 Snails are common on fluted pumpkin, but they cause limited damage

A number of fungal and bacterial pathogens have been identified on the fruit, of which the most important are *Rhizopus stolonifer, Aspergillus niger, Botryodiplodia theobromae* and *Erwinia* spp.

NUTRITION

Table 3 Trace elements in *Telfairia* seed flour: mg/100 g wet sample

Potassium (K)	1824
Magnesium (M)	535
Sodium (Na)	280

Source: Akintayo (1997)

Table 4 Nutritional value of *Telfairia* seeds and leaves

	Seeds	Leaves
Water (ml)	6.0	86.0
Calories	543.0	47.0
Protein (g)	20.5	2.9
Fat (g)	45.0	1.8
Carbohydrates (g)	23.0	7.0
Fibre (g)	2.2	1.7
Calcium (mg)	84.0	0.0
Phosphorus (mg)	572.0	0.0

Source: FAO (1988)

Food preparation

The young shoots and leaves are blanched or cooked for a short time and used in soups and sauces and are a favourite of Nigeria's Igbos. Occasionally, male flowers are picked for consumption together with the shoots and leaves. The tendrils are removed since these are too stringy. Leaves and the succulent shoots are cut or shredded and form the main ingredient of a 'soup' (which is not very liquid, but has a rather firm texture) to which palm oil and hot peppers are added, together with egusi seeds and other vegetables such as okra or cocoyam leaves. This soup is then added to the main course, pounded yams.

The more mature leaves found after the rains have stopped are more fibrous and, where possible, a mixture of old and young leaves are used. The crude protein level in the leaves was found to be higher during the first harvests than in subsequent harvests. The leaves have a high iron content.

The immature, large, fleshy seeds of the fluted pumpkin are shelled and the kernels are eaten boiled or roasted and used as a snack. To facilitate shelling, seeds are boiled whole, including the testa, for about 30-60 minutes. Boiled and shelled seeds can be added to the soup in ground form. Those seeds are an important food source for the Igbos as indicated by their separate name for the seed *ohi* from that for the plant which is *ugu*. When they are used as mature seeds they have to be washed first to remove the dye found around the cotyledon. Mature seeds are less tasty, but are a good source of edible oil and ground seeds make cakes which are high in protein.

Food preservation

The leaves are usually boiled first, after which they are sliced and washed in salt water, followed by further crushing and squeezing by hand. The resulting product will then be dried in the sun for use at a later date.

Properly shelled and boiled seeds can be wrapped in plantain leaves and left to ferment for about 3 days. These fermented cotyledons are then pounded and dried in the sun. The resulting product, called *ogiri,* is used as seasoning in soups and can be preserved for a few months as long as it is kept dry.

OTHER USES

The oily seeds are believed to have lactating properties and as such are in demand by women with young babies.

Telfairia roots can be very poisonous and root extracts are used to kill rats and mice; they can be lethal when consumed by people. They will also kill fish.

BIBLIOGRAPHY

ADENIRAN, M.O. and WILSON, G.F. (1975) *Egusi melon production in Nigeria: Seed Types and Major Growing Areas.* IITA (report).

ADETUNJI, I.A. (1997) Effect of time interval between pod set and harvesting on the maturity and seed quality of fluted pumpkin. *Experimental Agriculture,* **33**(4): 449-457.

AKINTAYO, E.T. (1997) *Chemical Composition and Physiochemical Properties of Fluted Pumpkin Seed and Seed Oils.* Nigeria: Chemistry Department, Ondo State University (report).

AKORODA, M.O., OGBECHIE-ODIAKA, N.I., ADEBAYO, M.L., UGWO, O.E. and FUWA, B. (1989) Flowering, pollination and fruiting in fluted pumpkin. *Scientia Horticulturae,* **43:** 197-206.

AKORODA, M.O. (1990) Ethnobotany of *Telfairia occidentalis* among Igbos of Nigeria. *Economic Botany,* **44**(1): 29-39.

AKORODA, M.O. and ADEJORO, M.A. (1990) Patterns of vegetative and sexual development of *Telfairia occidentalis. Tropical Agriculture,* **67**(3): 243-247.

AKORODA, M.O. (1990) Seed production and breeding potential of the fluted pumpkin. *Euphytica,* **49**(1): 25-32.

ANNO-NYAKO, F.O. (1988) Seed transmission of *Telfairia* mosaic virus in fluted pumpkin in Nigeria. *Journal of Phytopathology,* **121**(1): 85-87.

ASIEGBU, J.E. (1983) Effects of method of harvest and interval between harvests on edible leaf yield in fluted pumpkin. *Scientia Horticulturae,* **21:** 129-136.

BADIFU, G.I.O and OGUNSUA, A.O. (1991) Chemical composition of kernels from some species of *Cucurbitaceae* grown in Nigeria. *Plant Foods for Human Nutrition,* **41**(1): 35-44.

BADIFU, G.I.O (1993) Food potentials of some unconventional oilseeds grown in Nigeria: a brief review. *Plant Foods for Human Nutrition,* **43**(3): 211-224.

BENZIONI, A., MENDLINGER, S., VENTURA, M. and HUYSKENS, S. (1993) Germination, fruit development, yield and postharvest characteristics of *Cucumis metuliferus.* pp. 553-557. In: *New Crops.* JANICK, J. and SIMON, J.E. (eds.). New York: Wiley.

BURKILL, H.M. (1985) *The Useful Plants of West Tropical Africa.* Vol. 1. Kew: Royal Botanic Gardens.

CHIHANDE, D., ZINANGA, F. and MHEEN, J. van der (1997) *The role of indigenous vegetables in Zimbabwe.* Report for Community Technology Development Trust, supported by IDRC, Canada.

CHWEYA, J.A. and EYZAGUIRRE P.B., (eds.) (1999) *The Biodiversity of Traditional Leafy Vegetables.* Rome: IPGRI.

DEMISSIE, A. (1999). Potentially valuable crop plants in a Vavilovian center of diversity: Ethiopia. In: *Proceedings of a Conference on Crop Genetic Resources of Africa, Nairobi, September 1998.*

ESIABA, R.O. (1982) Cultivating the fluted pumpkin in Nigeria. *World Crops,* **34**(2): 70-72.

FAO (1988) *Traditional Food Plants.* Rome: FAO.

MAUNDU, P.M. and KABUYE, C.H.S. (1993) *Final Narrative Report on Indigenous Food Plants Programme.* National Museums of Kenya.

MBULI-LINGUNDI (1983) Studies on the chemical composition of the seeds of *Cucumeropsis manni* and their suitability as a food. *Zeitschrift für Lebensmittel-Untersuchung und Forschung,* **177**(1): 37-40.

MUTSAERS, H.J.W., MBOUEMBOUE, P. and BOYOMO, M. (1981) Traditional food crop growing in the Yaoundé area (Cameroon). Part 1. Synopsis of the system. *Agro-Ecosystems,* **6**(4): 273-287.

NIHORT (1984) Guide to the Production of Egusi Melon. *Extension Guide No. 6.* Ibadan: NIHORT Press.

NWUFO, M.I. (1990) Pod rots of fluted pumpkin in Imo State, Nigeria. *International Biodeterioration,* **26**(1): 63-68.

ODERINDE, R., TAIRU, O., AWOFALA, F. and AYEDIRAN, D. (1990) A study of the chemical composition of some members of *Cucurbitaceae* family. *Rivista Italiana delle Sostanza Grasse,* **67**(5): 259-261.

ODIAKA, N.I. (1997) *Aspects of seed quality in fluted pumpkin.* M.Phil. thesis submitted to the Faculty of Agriculture and Forestry, University of Ibadan, Nigeria.

OMIDIJI, M.O. (1977) Tropical cucurbitaceous oil plants of Nigeria. *Vegetables for the Hot, Humid Tropics,* **2:** 37-39.

OYEKAN, P.O. and OGUNREMI, E.A. (1978) Damping-off of melon (*Cucumeropsis edulis)* in Nigeria, caused by *Macrophomina phaseolina. Plant Disease Reporter,* **62**(2): 174-175.

PURSEGLOVE, J.W. (1968) *Tropical Crops. Dicotyledons.* London: Longmans, Green and Co. Ltd.

SIESMONSMA, J.S. (1982) *La Culture de Gombo* (Abelmoschus *spp.) Légume-fruit Tropical avec Référence Spéciale à la Côte d'Ivoire.* Thesis. Wageningen Agricultural University.

STURTEVANT (1919) *Notes on Edible Plants.* Report of the New York Agricultural Experiment Station.

ERU

Gnetum africanum Welw. and *G. buchholzianum* Engl.

Figure 51 *Gnetum* vines are packed in large bales for export from Cameroon to Nigeria

INTRODUCTION

Gnetum is the only genus of the gymnosperms of which the leaves are eaten by people. Other edible members of the gymnosperms include the stone pine *(Pinus pinea* L.) from southern Europe, cultivated for its edible seeds. Out of the approximately 30 *Gnetum* species, two are found in Africa, which are both eaten. *Gnetum gnemon,* which is found in Indonesia and in the Philippines, is cultivated as a tree mainly for its edible fruit and nuts. The two African species are lianas which have their roots in the ground and climb trees of 10 m high or more. It is usually found in the rain forests or gallery forests along rivers. The vines are evergreen. New leaves are formed throughout the year including the dry season, which is the time when most of the collection takes place. During this time, other crops are scarce, there is less work on the farm and the forest is more accessible during the dry season.

Collection from the wild currently takes place on a large scale, which has already resulted in a virtual disappearance of this species in many West African forests. Trade in this crop is extensive, partly because of its high value and because the leathery leaves are not so perishable and remain fresh for about a week. Also, dried leaves have a high value.

In Nigeria, *Gnetum* is still collected from the Oban highlands in the Cross-River State where it is now becoming rare. The large demand from Nigeria, together with a significant local appetite for 'eru' in Cameroon, now means that this formerly abundant species is also becoming scarce in Cameroon.

Likewise in Gabon, the Central African Republic and Congo (Democratic Republic), over-exploitation of this commodity is already leading to a strong decline of a crop that is similarly important to other forest inhabitants such as chimpanzees and gorillas.

The vines are collected from the wild in such a way that much of the plant is destroyed. Occasionally the tree on which it is found has to be cut as well, because it is too dangerous to climb to the top. The long vines are bundled and the bundles are put into large bales (*see* Figures 51 and 52). Traders take these large bales to the city markets or to Idenau, a coastal city in West Cameroon near the border with Nigeria, from where they are exported by ship. The present large-scale exploitation of wild resources is not sustainable and future demand for this crop can therefore only be met through cultivation and the first steps towards domestication have only recently been made.

Figure 52 The *Gnetum* vines are packed in bundles, ready to be sold at the market

In anglophone Cameroon, it is called *eru* and in francophone Cameroon the name *okok* is used, somewhat similar to the French name *koko*. In Gabon and the Central African Republic, it is called *okokok*. Names used for this crop in Nigeria include *okazi* and *afang*. In Congo (Democratic Republic), where it is similarly popular, it is called *fumbwa*.

BOTANICAL ASPECTS

Figure 53 Ripe fruit of *Gnetum africanum*

There are two different types of vines. Autotrophs are virtually leafless and rapidly grow vertically to reach tree branches and from there to the crowns of trees. The side shoots are called plagiotrophs which produce the leaves that are of value to consumers. *Gnetum* is dioecious with plants being either male or female. Flowers are very small and are found on catkins. Female plants are best recognized by their fleshy red fruit when mature (*see* Figure 53). These fruit contain a single seed (nut). Female plants often show more vigorous growth with stronger vines than male plants. However, this effect is less obvious in *G. buchholzianum* than it is in *G. africanum*.

- *G. africanum* has leaves which are relatively thin, pale-green and ovate to oblong in shape. The male catkins are of equal width from the base to their tip.
- *G. buchholzianum* has dark-green leaves which are thick and elliptic to oblong in shape. Their male catkins are widest at the base.

AGRONOMY

This crop performs best in the shade or near the edge of a forest and does not grow well under fully exposed conditions. Leaves of plants which are exposed to sunlight are much smaller and often more yellowish in colour than those grown in full shade; such small leaves have a low market value. Their different appearance under exposed conditions has led some people to believe that it is a different species.

A major investment for shade cover and supports is required for commercial farming to produce the large dark-green leaves required by the market. The alternative is to produce eru as mixed cropping with, for example, oil palm, rubber or similar tree crops. Trials are needed to establish the feasibility of such a production system. Such trials are, however, hampered by a further difficulty, which is that young plants are not easy to find owing to germination problems.

Seed germination is very slow and irregular; germination periods of 1 year or more are quite normal. Even so, the germination percentage is very low in a nursery and it is suspected that fruit need first to travel through the intestines of a bird, fruit bat or other animal before they can readily germinate. It has been observed that several species of birds, squirrels and other rodents eat the fruit even before they are completely ripe. Ripe fruit are therefore hard to find. Those fruit are normally found high in the trees and seed collection is far from easy.

This is the main reason why domestication efforts have not been successful, despite several efforts made in Nigeria, Cameroon and Congo (Democratic Republic) and possibly elsewhere. Instead, domestication efforts were made by the use of rooted cuttings. This was carried out by Dr Patrick Shiembo in Kumba, Cameroon, with assistance from the UK-based Darwin Initiative. A selection of the material is made where vines with broad, thick and dark-green leaves are given preference. Female plants were observed to have a stronger vine growth than male plants; selection of vines for cuttings should therefore ideally be made from female plants of *G. buchholzianum.*

Fresh stem cuttings are taken, for which a stem with a single pair of leaves is adequate. These cuttings are placed in well-decomposed sawdust as a rooting medium and care is taken to keep the leaves moist. A mist system is ideal for this purpose, although not essential, and other means of keeping the leaves wet with a fine spray of water can also be used. Evapotranspiration of the new cuttings should be minimized and it is recommended that the plant bed be covered with fine gauze nylon net or a loosely woven piece of cloth. Once rooting has taken place, which may take about a month, the new plantlets should be transferred to a proper growing medium with forest soil. Polythene sleeves filled with the soil can be used for this purpose (*see* Figure 54). Once side shoots have developed from the nodes, plants should be given more space to create an adequate flow of air.

Figure 54 Rooted *Gnetum* cuttings in polythene

Future propagation methods may include tissue culture, but so far no such experiments have taken place.

USES AND NUTRITION

The fresh leaves are rather leathery and are thus tough to eat whole. The leaves are therefore shredded into strips of about 2 mm wide. This product can be prepared directly or dried for later use after reconstitution by soaking in water. This shredding process, which is done by placing a number of leaves on top of each other and cutting them with a sharp knife, is a tedious job that is often done by market women. The dried shredded product is also exported, mainly to black communities of Nigerian and Cameroonian origin in the US and the UK.

Eru is often eaten as part of a mixture in a groundnut-based stew. It often replaces meat because of its high protein content and is thus much appreciated. To soften the otherwise rather tough product, people mix eru with waterleaf, *Talinum fruticosum,* and apparently these two vegetables are always eaten together.

The chemical analysis of *Gnetum africanum* is shown in Table 5.

Table 5 Chemical analyses of *Gnetum africanum*

Moisture	(% fresh)	37.39
Ash	(% dry)	4.72
Oil (fat)	(%)	14.2
Protein	(%)	10.18
Na	(ppm)	26
K	(ppm)	126
Ca	(ppm)	28.35
Mg	(ppm)	14.75
Fe	(ppm)	5.23
Zn	(ppm)	0.49
Cu	Ppm	0.06

Source: J.C. Okafor [1995]

In Nigeria, *Gnetum* is used for treatment of piles and high blood pressure.

BIBLIOGRAPHY

OKAFOR, J.C. (1995) Conservation and use of traditional vegetables from woody forest species in south-eastern Nigeria. In: *Proceedings of the IPGRI Workshop on Genetic Resources of Traditional Vegetables in Africa, August 1995, Nairobi.*

SHIEMBO, P. N. (1997) Domestication of *Gnetum* spp. by vegetative propagation techniques. pp.31-35. In: *Proceedings of a Workshop on African Indigenous Vegetables, Limbe, Cameroon, January 1997.* SCHIPPERS, R.R. and BUDD, L.(eds.). Chatham, UK: Natural Resources Institute/IPGRI.

LIVINGSTONE POTATO

Plectranthus esculentus N.E. Br.

Synonym: ***Coleus dazo*** **A. Chev.**

Figure 55 Livingstone potato, *Plectranthus esculentus*

The Livingstone potato is one of the earliest African crops to be domesticated and has now become a rarity after a long history of cultivation throughout the continent (*see* Figure 55). The Central African Republic is considered the primary centre of diversity for the Livingstone potato and this centre could stretch to include Niger, Chad and the Sudan (Harlan *et al.,* 1976). The crop can still be found in many countries as individual plants in a wide range of cultivated forms (Burkill, 1995). There is a strong likelihood that many of these remnants of earlier cultivation will disappear because of pressure for land, and because the present owners of the land may not be aware of the agricultural potential of the crop and are likely to remove these plants as weeds. A germplasm collection needs to be made with some urgency to safeguard these ancient cultivars from extinction and to preserve them as a valuable genetic resource.

This crop used to be referred to as the kaffir potato, but this name is no longer in use. It was known as finger potato in Zambia. There are several cultivars in Nigeria of which a large variety from Jos Plateau is called Akimik. The Tarok people of Nigeria call this crop *rizga* and this name is also used in neighbouring Chad. In Nigeria's Zaria and Kano provinces, there are also round and smooth varieties such as Aku. At the present time, the Livingstone potato is more common in southern Africa. Shona people cultivate it in the eastern districts of Zimbabwe and they call this crop *tsenza;* the Zulus from South Africa call it *ulujilo* whereas the Xhosa people call them *itapile.* It is also grown in Angola, northern Namibia and Swaziland (Allemann, 1998). Tubers are mainly collected from wild plants in Malawi where the crop is known but not cultivated. There is some confusion with the name Hausa potato, which is sometimes used for this crop species. The real Hausa potato is *Solenostemon rotundifolius,* which will be dealt with in the next section.

A related crop from south-western Ethiopia, *Plectranthus edulis* (Vatke) Agnew (syn. *Coleus edulis*) with purplish-blue flowers, is mainly grown in the highlands and requires much more rain. Its small and irregularly shaped tubers are boiled or roasted and eaten with their skins on; the leaves are eaten as a vegetable (Demissie, 1991). Its local name is *oromo dinich.*

Figure 56 Livingstone potatoes grow in a cluster at the base of a stem

Plectranthus esculentus is a shrub of approximately 60 cm to 1.20 m in height, although some straggling stems may reach 2 m in length. Like all other members of the *Labiatae* family, these stems are square when cut across. In southern Africa, the plant first produces its yellow flowers before the rains start, after which the leaves appear, whereas in Cameroon it does not produce flowers until the end of the season, after most of the leaves have dropped. The tubers are regarded as stoloniferous rhizomes and these will turn green when exposed and produce sideshoots with leaves. The primitive types have tubers, which are forked or split into many fingers, whereas cultivated varieties have soft, sometimes slightly hairy, unbranched tubers, which grow in a cluster at the base of a stem (*see* Figure 56). Tubers can also be formed at the nodes when prostrate stems are in touch with or covered by the soil. These roughly cylindrical tubers are usually 5-10 cm long and about 12-20 mm across, with some varieties in Cameroon reaching 25-30 cm.

Seeds are readily formed and can be used for sowing. However, their development is slow and the offspring is rather heterogeneous, which is why small tubers are used for propagation. These are stored in a cool place and after new sprouts have been formed they can be planted in mounds or ridges, which will facilitate drainage during the wet season. It is important that stones are removed from the plant beds. The crop can be found near water such as in the region of Lake Chad, and the Tenda, in south-eastern Senegal, select production areas near water. In southern Africa, however, Livingstone potatoes can be found in semi-arid or savannah areas with an annual rainfall of about 600-1000 mm.

Tubers are planted at a depth of 5-10 cm and are spaced at about 100 x 100 cm. Their cultivation is rather similar to that of the Hausa potato, *Solenostemon rotundifolius,* which grows in a similar environment. The growing season is about 6-9 months and in Cameroon they are planted at the end of May/early June after all the other crops are in the ground. Earthing up is especially important when new tubers are nearing the surface, as they turn green in colour and lose their value. Considering the low value of the Livingstone potato, however, this activity may be forgone, especially when the main food or cash crops require more urgent labour inputs. In Cameroon, harvesting takes place in February/March. The yield of Livingstone potatoes is recorded to range between 13 and 25 t/ha. Experimental work in South Africa has indicated that yields can be as high as 60 t/ha under optimal growing conditions.

The market for this crop is limited, which is the main reason why it is declining in favour of more 'modern' root crops such as yam, cassava and sweet potato. One of the few places where this crop is highly appreciated is the market of N'Djaména, the capital of Chad and there is now a government programme that aims at its rehabilitation through varietal improvements.

The farinaceous tubers taste like slightly bitter turnips and can be eaten raw as they are in Malawi and Zambia. Most people either boil the roots or roast them like potatoes. Some people cook the tubers with wood ash to reduce their bitterness. In the past, boiled and very soft Livingstone potatoes have

been popular in Cameroon as the first solid food to give to young children during the transition stage between breast feeding and the time when the children are able to absorb more solid starchy food such as yam or millet. Here, the crop can still be found at local markets in a boiled form, but rarely as a raw product. In the Plateau State, Nigeria, the crop is used for making special dishes during ceremonies in commemoration of ancestors. Fresh tubers can be dried and prepared together with arrowroot or cocoyam for special occasions such as funerals.

Pests appear to favour the Livingstone potato over the Hausa potato and nematodes can be particularly troublesome. Wild pigs and other animals dig up the tubers when they get the chance to do so. In contrast, very few diseases have been noted on the Livingstone potato and it is possible that it could have anti-fungal and/or anti-bacterial properties.

HAUSA POTATO

Solenostemon rotundifolius (Poir.) J.K. Morton

Synonyms: *Coleus dysentericus* Baker and *Coleus parviflorus* Benth.

Figure 57 The Hausa potato is usually grown on mounds or on ridges

INTRODUCTION

The Hausa potato has probably been cultivated since ancient times, considering that it is found in western, central, eastern and southern Africa and also in Madagascar and South-East Asia. It is likely to have originated in the savannah region between Togo and Guinea (Harlan *et al.*, 1976) and up to western Sudan, where it may have been domesticated some 6000 years ago. It probably spread to southern Sudan and adjacent areas from where it was carried to India (Murdock, 1959). There is some confusion with the crop found in India, Sri Lanka, Malaysia, the Philippines and China, which generally has a larger plant structure with larger tubers. Nowadays most authors consider plants from South-East Asia to be conspecific with the African material, whereas others see them as a different species for which the name *Coleus tuberosus* (Blume) Benth. or *C. parviflorus* Benth. is used.

Plants are small, usually about 20-30 cm high. The leaves have an aromatic smell. The small purple flowers are produced on an elongated terminal raceme. Despite the abundance of flowers, seeds are uncommon and these are not used for propagation purposes. The leaves and stems can be green or

dark-purple to red in colour. Stems can be prostrate or upright. Tubers can be found in a diversity of forms, sizes and colours. Forms with a grey to blackish-brown skin (*f. nigra)* are found in Mali, whereas Hausa potatoes with a skin colour ranging from light-yellow to dark-red (*f. rubra,* the most popular form) can be found throughout the continent. People occasionally collect wild, tuberous forms of the species. There are also forms without tubers.

Although the Hausa potato is becoming rare as a food crop in Africa, it is still popular in a few places, such as the Jos Plateau in Nigeria where it is called *tumuku*; it is also popular in northern Ghana, Burkina Faso and western Sudan. In South Africa, it is cultivated as a dryland crop where it is known as the Zulu round potato. In West Africa, the Hausa potato and the frafra potato (in Ghana) are the most common names used in English. Other names include Sudan potato, Madagascar potato, kaffir potato, Coleus potato, etc. In India, the crop is referred to as Chinese potato although Ethiopia is (incorrectly) considered to be the origin of the species rather than China. It is known under a number of different tribal names. In Wa, in Upper West Ghana, the local name in Dakari for this crop is *peiha* whereas in Bongo in Ghana's Upper East Region it is called *persa.*

Malawi and Zambia are now considered as secondary centres of diversity. In South Africa, it is mainly grown in coastal Kwazulu-Natal, the eastern Mpumalanga and north-western Cape and also in Angola and Swaziland. The species appears in the wild throughout sub-Saharan Africa, where it is found in many different forms, possibly including the remnants of cultivation of the past.

The Irish potato replaced the Hausa potato in cooler areas of Africa, whereas in the warmer parts yam became the favourite root crop, or alternatively cassava, sweet potato or bambara nut in the drier regions. The tuber yield is rather small when compared with those mentioned above. A major drawback is the labour-intensive nature of this crop.

Environmental conditions

In most places the Hausa potato grows in semi-arid conditions or the drier parts of savannah belts. This is a risky place to grow the crop, since when there is not enough rain, tubers will not form or will remain very small. Experimental work in South Africa has shown that the crop will grow in a wide range of climates, including humid zones, and also in somewhat cooler conditions. When there is too much rain, the tubers have a tendency to branch, which is disliked by consumers because they are then difficult to peel. Branching also occurs when much organic manure has been applied, often resulting in profuse vegetation, but poor-quality tubers. Soils should be well drained, but clay soils are unsuitable, as the plants are very sensitive to waterlogging.

Planting

In Ghana, only sprouted tubers are planted, with the growing end placed at the surface and therefore not buried by soil. The crop is planted either in loose, well-drained soil or on ridges or mounds (*see* Figure 57). Deep planting would mean a delay in sprouting, if the shoots even reach the surface. In South Africa, tubers are planted at a depth of 5-10 cm with a spacing of approximately 25 cm when planted on ridges spaced at about 75 cm. Allemann (1998) mentions a requirement of 25 000-60 000 tubers to plant 1 ha, depending on the size of the tuber and the planting distance.

When there is insufficient planting material, farmers may take cuttings from the sprouts and use these to increase the plant population. Cuttings root with some delay, especially when the weather is either too wet or too dry, although prolonged delays due to insufficient rains can be fatal. However, if successful, the crops are observed to produce larger (though fewer) tubers. Cuttings of up to 20 cm

long are placed horizontally at a depth of about 5 cm, but with their growing point above the soil surface. In South Africa such cuttings are planted in pairs with the growing points facing in opposite directions. The spacing is similar to that of the tubers. Propagation by means of seeds is not practised, because few seeds are produced despite the many flowers (*see* Figure 58).

Figure 58 The Hausa potato plant readily produces flowers, but seeds are rarely seen

Small tubers, which are left in the ground from last season, will become volunteer plants, which are not weeded out. However, since they do not normally grow in mounds, they will remain thin. A crop grown on mounds with loose soil usually has more rounded and larger corms. The planting season is at the beginning of the rains (May in Ghana) and harvest takes place when the shoots have dried up completely at the end of the season. In Ghana, this is usually in November. Weeding is recommended in the early stages, before the soil is fully covered with the crop. Prior to planting some farmers apply wood ash and diluted cattle urine.

Mixed cropping

Hausa potato planting is often associated with bambara nuts, which grow under the same conditions and often also on mounds or ridges. Bambara nuts have overtaken frafra potatoes in Ghana because of their more readily available market and because bambara nuts can be stored more easily. The average plot size is usually less than 1000 m^2. Larger plots are monocropped, whereas the smaller plots are intercropped with okra, cassava, millet, bambara nuts or yam. When yam are grown on mounds it is easy to put some frafra potatoes in since the mound is already there. Frafra potatoes require a great deal of sunlight so that the shade provided by the yam is a disadvantage. It is said that tubers grown in the shade taste less sweet and more watery.

Figure 59 Hausa potatoes are mainly eaten in rural areas and rarely reach urban markets

Yields

Most tubers found in Africa are between 2.5 and 4 cm long by about 10-17 mm, but some varieties are known to reach up to 8 cm. The tubers are formed in clusters of 3-7, either at the base of the stem or at the nodes below the soil surface. The best yields are obtained when planting small tubers. Total yields depend strongly on the amount and regularity of rains and usually vary from 5 to 15 t/ha. Experimental work carried out at Roodeplaat in South Africa has indicated that the potential yield could be up to 45 t/ha if agronomic practices are good.

Marketing

There is no ready market to grow the Hausa potato as a cash crop. People in northern Ghana know this crop very well and refer to its good taste, even though it is only found at the market during a short period of up to 2 months after the end of the rainy season (*see* Figure 59). There is a limited trade in these potatoes between the Upper East region of Ghana and Burkina Faso.

Storage

Small tubers (corms) are kept in a dry place or are left in the ground under a tree where it is cooler than in the open. Storage is difficult in hot areas, since the currently used method of burying them next to a tree will only allow the tubers to maintain their pleasant taste for about 2 months. The tubers develop green shoots towards the end of the storage period and will no longer be edible. Other methods, such as placing them in a basket to be hung on a tree branch to allow adequate ventilation often results in premature shrivelling. Consequently, many farmers sell their produce when they have a chance, often resulting in a shortage of planting material when the rains start. Storage is less of a problem in a cooler climate, and in South Africa, people pack them either in bags or in baskets which are stuffed with straw, to store well throughout the winter months.

PESTS AND DISEASES

The crop can withstand most pest problems even though a wide range of pests have been observed, including termites, centipedes and potato weevils. Millipedes which can bore a hole in the tubers are reported to be a nuisance in Ghana. The leafy part of the crop can be attacked by grasshoppers, stemborers, virus diseases, etc., but there is minimal harm, possibly because of the small plots concerned. There are indications that the leaves contain a chemical which repels insects, hence the limited damage usually noticed. In South Africa, it is believed that the crop suppresses nematode populations, but the Crop Research Institute in Kumasi, Ghana, has indicated that it is susceptible to nematodes, so that further research is needed. One major problem is pigs, which much appreciate these tubers. Unless they can be controlled there is little point in producing Hausa potatoes in areas where pigs are free-roaming.

RESEARCH NEEDS

Research is needed on basic agronomy, including the use of raised plant beds (ridges) and other yield-enhancing methodologies. Plant breeding efforts are required to increase the size of the tuber. Exchange of information between researchers based in Africa with specialists from Sri Lanka and Kerala (India) would probably make a significant impact.

NUTRITION AND USES

This crop is much liked for its taste which is better than that of the Irish potato. It is a delicacy when fresh tubers are cooked. The skins are usually removed after cooking, making them a snack to be eaten by hand. The tubers also taste good when fried in palm oil, but they will shrivel when roasted. It is a crop rich in carbohydrates, like most tuber crops (*see* Table 6). In India, where selected varieties are much larger and yields of up to 25 t/ha can be obtained, tubers are often baked or fried and may substitute for Irish potatoes. In India and Sri Lanka, the fleshy, aromatic leaves are consumed as a vegetable after being cooked.

Table 6 Nutritional value of Hausa potato tubers

Carbohydrate	(%)	23.4
Protein	(%)	4.7-5.2
Fat	(%)	0.8
Fibre	(%)	3.5
Calcium	(mg/100 g)	150
Iron	(mg/100 g)	29.2
Vitamin A	(mg/100 g)	3.4
Threonine	(mg/100 g)	0.38
Tyrosine	(mg/100 g)	0.30
Methionine	(mg/100 g)	0.13
Valine	(mg/100 g)	0.25
Phenylalanine	(mg/100 g)	0.36
Isoleucine	(mg/100 g)	0.22
Leucine	(mg/100 g)	0.38
Lysine	(mg/100 g)	0.24

Source: Alleman and Coertze (1979)

The tubers are used especially in Ghana during ceremonial occasions such as weddings or funerals. In the past, men used to eat a large meal of frafra potatoes before going out to hunt, to keep them fit, or before a long-distance journey. This custom is no longer practised. This is why few young farmers grow this crop today, since they value cash crops more than traditional crops.

POTENTIAL CONTACTS FOR RESEARCH ON HAUSA POTATOES:

Agricultural Research Council, Pretoria. Vegetable and Ornamental Plant Institute, Private Bag X293 Pretoria, South Africa.

Plant Genetic Resources Centre, Gannoruwa, Peradeniya, Sri Lanka.

Central Tuber Crops Research Institute, Trivandrum 695 017, India

BIBLIOGRAPHY

ALLEMANN, J. and COERTZE, A.F. (1997) *Indigenous Root Crops. A.2 Plectranthus.* Pretoria, South Africa: Vegetable and Ornamental Plant Institute.

ALLEMANN, J. and COERTZE, A.F. (1997) *Indigenous Root Crops. A.3 Solenostemon.* Pretoria, South Africa: Vegetable and Ornamental Plant Institute.

ALLEMANN, J., VILJOEN, J. and COERTZE, A.F. (1997) The Zulu round potato (root crop tolerant to marginal conditions). *Farmer's Weekly South Africa,* 30 May 1997, 14-17.

ALLEMANN, J. (1998) *Notes on the Livingstone potato.* (unpublished paper). Pretoria, South Africa: Vegetable and Ornamental Plant Institute, Agricultural Research Council.

BURKILL, H.M. (1995) *The Useful Plants of West Tropical Africa. Vol 3: Families J-L.* Kew: Royal Botanic Gardens.

DALZIEL, J.M. (1937) *The Useful Plants of West Tropical Africa.* London: Crown Agents for the Colonies.

DEMISSIE, A. (1997) Potentially valuable crop plants in a Vavilovian center of diversity: Ethiopia. In: *Proceedings of a Conference on Crop Genetic Resources of Africa, Nairobi, August 1995.* GUIRANO, L. (ed.). Rome: IPGRI.

HARLAN, J.R., DE WET, J.M.J. and STEMLER, A.B.L. (1976) *Origins of African Plant Domestication.* Mouton: The Hague.

IRVINE. F.R. (1969) *West African Crops.* Oxford: Oxford University Press.

KAY, D.E. (1973) *TPI Crop and Product Digest No.2 Root Crops.* London: Tropical Products Institute.

MURDOCK, G.P. (1959) *Africa, its Peoples and Their Culture History.* New York, Toronto, London: McCraw-Hill Book Company, Inc.

RAJAPAKSE, D.P., MENDIS, M.H. and GANASHAN, P. (1995) Tissue culture of innala (*Solenostemon rotundifolius*). High frequency plant regeneration from leaf explants. *Ceylon Journal of Science, Biological Sciences,* **24:** 1-5.

TETTEH, J.P. and GUO, J.I. (1993) *Problems of Frafra Potato Production in Ghana.* A dissertation. School of Agriculture, University of Cape Coast.

TREDGOLD, M.H. (1986) *Food Plants of Zimbabwe.* Gweru, Zimbabwe: Mambo Press.

VIMALA, B. (1994) Sree Dhara—a selection from Chinese potato (*Solenostemon rotundifolius*). *Journal of Root Crops,* **20:** 1, 31-33.

LEGUMINOUS CROPS

INTRODUCTION

There are many species of legumes that are used as vegetables, of which French beans, peas and groundnuts are probably the best known. The most well-known species with an African origin are probably cowpeas, which are grown mainly for their seeds, but also for their leaves. There are several species of which virtually the entire plant can be eaten in one form or another, including tubers, leaves and young vines and also the flowers, pods and mature seeds; any remaining plant parts can be used as fodder. There is extensive literature available on this family, so the main emphasis in this chapter will be on the less familiar African species that are used as vegetables. The leaves and young pods and seeds of a number of tree species belonging to this family can be eaten as well, but trees are beyond the scope of this book and will not therefore be covered. For the same reason, underutilized pulse crops like the bambara groundnut *Vigna subterranea* and Kersting's bean *Macrotylema geocarpum* are omitted.

Many legumes have the capacity to fix atmospheric nitrogen by converting it to ammonia, which is readily usable by the plant, thereby maintaining or improving soil fertility. The symbiotic arrangements with root nodules full of *Rhizobium* or related bacteria like *Bradyrhizobium* and *Azorhizobium* can especially be found in the subfamily *Papilionoideae.* This is why several species are useful in crop rotation and some are used as green manure such as the sun hemp, *Crotalaria juncea* L. Nitrogen fixation in the root nodules is far less evident in the subfamily *Caesalpinioideae.*

CROTALARIA

Subfam. Papilionoideae

The genus *Crotalaria* includes about 550 species of herbs and shrubs, of which over 400 species can be found in Africa, mainly in eastern Africa. Sun hemp, *Crotalaria juncea* L., is probably the best known and most widespread representative of the genus because of its use as a green manure and as a fibre crop for making strings. Two African species, *C. ochroleuca* and *C. brevidens,* are used as vegetables. Outside Africa, the only *Crotalaria* species cultivated as a vegetable is *C. longirostrata* from Central America.

CROTALARIA BREVIDENS BENTH.

Crotalaria brevidens Benth. is more drought tolerant than *C. ochroleuca* and its roots nodulate more profusely, which is why this species is also used as green manure. It is also used for its fibre. As a green manure, the whole crop is incorporated into the soil thereby improving both the soil structure and adding nitrogen through the activity of *Rhizobium* bacteria. In the wild, it is found throughout East Africa, whereas its distribution towards the west is limited to north-eastern Nigeria.

This species is mainly used as a vegetable in the Tarime district, Tanzania, and to a lesser extent in West Kenya, especially by the Luo community who call it *nyasamo*. *C. brevidens* is known as *mitoo* in Tanzania and the same name is used for both species in Kenya. It is both collected from the wild and cultivated as a vegetable. The Luo people use this plant as medicine against stomach pains and swellings. The Luhyas believe that it can cure malaria.

CROTALARIA OCHROLEUCA G. DON

Crotalaria ochroleuca G. Don can grow up to 120 cm high when undisturbed, but owing to regular harvesting of the shoots, the crop rarely exceeds 60 cm in farmers' fields (*see* Figure 60). Table 7 below may help to differentiate the two most popular edible *Crotalaria* species found in Africa.

Figure 60 *Crotalaria ochroleuca*

C. ochroleuca occurs wild from Senegal to Congo (Democratic Republic) in the west and throughout central and East Africa. It is cultivated to a limited extent in Cameroon and Congo where both the leaves and flowers are eaten, but is much more commonly grown as a leafy vegetable in northern and eastern Uganda and in western Kenya. In East Africa, it is mainly cultivated on small plots at altitudes from about 1000-2100 m, from the shores of Lake Victoria to Mt. Elgon and to the semi-arid zones of northern Uganda. It is also collected from the wild. *C. ochroleuca* is known as *marejea* in Tanzania and as *alaju* in northern Uganda.

Table 7 Differences between the two most important African *Crotalaria* vegetables

Characteristic	C. ochroleuca	C. brevidens
Leaf colour	bright-green	bluish-green
Leaf length x width in mm	55 x 20	70 x 15
Plant height	120 cm	210 cm
Standard of the flower	pale-yellow/ creamish	bright-yellow
Calyx	glabrous	puberulous
Pod length + diameter in mm	40-50 x 15-20	50-70 x 7-10 (12)
Seed colour	light-yellow	light-brown with some anthocyanin
No. seeds/pod	60-70(-100)	(80-)100-120
No. seeds/g	180	210

RELATED EDIBLE SPECIES FROM AFRICA

Uiso and Johns (1996) mention that *Crotalaria mucronata* Hochst is a food plant for the Sukuma people in Tanzania's Shinyanga district. This plant is collected from the wild and not cultivated, to the author's knowledge. Also the flowers of *C. polysperma* Kotschy are reported to be eaten by the Batemi of Tanzania's Ngorongoro district. A third species, *C. glauca* Willd., which can be found throughout East Africa, is occasionally collected as a famine crop.

FARMING SYSTEMS

The crop can be grown as a monocrop and be intercropped with finger millet or kenaf (*Hibiscus cannabinus)* and other indigenous vegetables as seen in Uganda. It can be intercropped with a range of other crops that benefit from the nitrogen fixation capacity and suppression of the nematode population. The soil fertility effect can still be noticed after 1 year. It is, therefore, an ideal plant for crop rotation. It is often grown on a small scale for subsistence and, less often, for market gardening. This is the main reason why this crop is planted after the staple food crops cassava, millet or maize have been established. It does relatively well in a semi-arid climate because of its long taproots and long lateral roots which can reach the soil moisture available at lower levels.

AGRONOMY

Most farmers collect their own seeds towards the end of a crop and seed is commonly available on local markets. Seeds are usually broadcast, and, less commonly, sown in rows 30 cm apart. The spacing within the row will start at about 5 cm and after being thinned and harvested once or twice will end at a spacing of between 15 and 20 cm. The seed germination capacity is usually good and it germinates in 3-4 days.

Currently there is no selection made to obtain the optimum variety and crops observed represent a mixture of landraces. However, there are clear differences in plant size and architecture, the branching capacity, the shape and size of the leaves and several other characteristics that may well warrant basic breeding efforts. It is mainly self-pollinating so that a good level of varietal purity could be obtained within a few generations.

As long as plants are cut for their shoots, no flowers and therefore no seeds can be formed. Most farmers stop harvesting with the onset of the dry season, thus allowing the plants to flower and to set seed. A seed yield of about 175-300 kg/1000 m^2 can be obtained when the plants are large enough and there is enough moisture left in the ground. Since seeds are rather expensive at the market, with a price of about Ksh 10 for 5-10 g, equivalent to about US$ 20/kg, small-scale seed production has good income potential.

Seeds store well and can be kept for a few years, since they are not attacked by insects or other pests. They must, however, be kept cool and dry to avoid deterioration by moulds and other storage fungi.

Despite its nitrogen-fixation capacity, *Crotalaria* shows a strong response to farmyard manure and somewhat less to artificial fertilizers (DAP and CAN). The recommended rate of (cattle) manure is 20 t/ha. Yields from plots without any fertilizers are found to be very much lower.

PESTS AND DISEASES

Generally speaking, this crop does not suffer much from diseases and even less from pests. Under very wet conditions the whole crop may be destroyed by fire blight just before the start of flowering. This is the only serious disease noted.

Aphids and thrips can be observed, but are rarely a serious menace. During pod development, pod borers may enter and interfere with seed development. The holes in the pods will allow rain to enter and destroy the seeds further through rots. Pod borers are more likely to attack *C. ochroleuca* than *C. brevidens,* probably because of the stronger pod wall of the latter species. The sucking activity of whiteflies may leave small whitish marks on the leaves during the dry season, making them less attractive for the market (*see* Figure 61). The leaf beetle, *Monolepta leuca,* may occasionally be a problem. Antelopes and other animals much appreciate this crop and can be a major difficulty for farmers.

Figure 61 Whitefly damage on *Crotalaria* leaves

A very different complication is caused by a parasitic companion crop, *Cuscuta suaveolens,* which may seriously restrict normal growth of *Crotalaria* by its thread-like mass of leafless vegetation that almost chokes the plants. This parasite from South America is presently a local nuisance but appears to be spreading in western Kenya.

HARVEST AND POST-HARVEST

Crotalaria can be uprooted just before flowering when the stems are about 40 cm high and the plants are about 2 months old. Sowing can take place four or five times/year, but most farmers will probably opt for crop rotation. The yield for a once-over harvest is about 1 kg/m^2, or possibly more when farmers apply enough manure before sowing, and irrigate when needed.

Alternatively, farmers can use the thinnings as a first harvest after about 6 weeks and use a ratoon system from there onwards. The ratoon system involves first plucking the main shoot at the 8-week stage and subsequent harvesting of the new side shoots. The main shoot can be cut to about 10-15 cm above the ground, as long as there are at least three true leaves left. New side shoots can be picked again after about 2 weeks; their growth will be enhanced by applying a topdressing of nitrogen fertilizer. A major advantage of this system is that at least some shoots can always be harvested, which is why this is the preferred method for subsistence farming. If there is enough rain, or when there is enough moisture left in the ground, harvesting may take place up to 15 times and some cases are known where a crop can be harvested for a full year. People who grow this crop for subsistence usually omit fertilizers and their total yield will be considerably lower.

Young shoots are plucked and made into bundles to be sold fresh at the market. Towards the dry season, only leaves are plucked and offered in the markets. The fresh product is highly perishable, which is why it is so expensive in cities far away from the production areas. Sprinkling the leaves with water is detrimental since the leaves will soon rot. Bundles should be loosely packed in bags, not tightly like most other crops.

Over 50% of *Crotalaria* growers in northern Uganda mentioned that they dry their crop and that they can get a substantial income from this product during the dry season. Drying takes 3-4 days during the dry season and 6-7 days during the rainy season; the whole plant or plucked leaves only are spread on a mat and dried in the sun. Flowers and young pods are plucked separately and dried (*see* Figure 62). These dried flowers retain their special flavour and are highly valued for use in soups.

Figure 62 *Crotalaria* seed pods are full of air

OTHER USES

Crotalaria is frequently used as livestock fodder and its seeds fed to poultry. However, care should be taken not to use too much because of slow acting pyrrolizidine alkaloids that may cause damage to lungs and liver. In Guatamala, it was found that people who regularly consume *Crotalaria* would become drowsy, which is attributed to these alkaloids.

A recent use for *Crotalaria* is as an agent to promote the germination of *Striga*, the highly troublesome parasitic plant which is a major cause of concern for maize and millet growers in Africa. When, as a result of the presence of *Crotalaria, Striga* germinates, it will subsequently die due to the lack of a suitable host plant. *Crotalaria* is also known to suppress *Meloidogyne* nematode populations and is used either in crop rotations or as a companion crop with nematode-susceptible vegetables such as tomatoes. Similarly, oil extracted from its seeds is sometimes used as an insect repellent.

C. ochroleuca is cultivated in the Sudan for its fibre, which is used to make nets for catching game.

NUTRITION

Crolataria leaves contain approximately 5000 µg/100 g fresh weight of β-carotene (provitamin A), and a high level of calcium and other micro-nutrients provides an important nutritional contribution to human diets (*see* Table 8). *Crotalaria* is also rich in proteins, which is probably why it is so popular with animals.

Table 8 Nutrient content of *Crotalaria brevidens*/100 g edible portion

Proteins (g)	4.2-4.9
β-carotene (mg)	2.9-8.7
Vitamin C (mg)	115-129
Calcium (mg)	270
Iron (mg)	4

Source: Imungi (1989)

C. brevidens is very bitter; this is caused partly by the presence of natural toxins such as pyrrolizidine alkaloids, diterpenes and phenolic compounds.

Two pyrrolizidine alkaloids have been identified in samples of *Crotalaria brevidens* leaves and flowers from Tanzania and Kenya. These alkaloids are not detoxified during cooking. Towards the end of the rainy season, when people eat *Crotalaria* on several occasions during the week, the weekly intake of these alkaloids was estimated to be about 300 mg/person. The toxicity of *Crotalaria* may thus outweigh its nutritional benefits when other foods, which could have a balancing effect, are scarce (Uiso and Johns, 1996).

Crotalaria ochroleuca has a much milder taste and is much appreciated by young people. This is especially so when compared with *C. brevidens*, said to be preferred by older people because of its bitter taste and also because of its medicinal properties that help reduce the effects of stomach ailments.

The Abaluhyas from western Kenya prepare this vegetable by boiling, followed by frying in fat or oil. It is usually eaten jointly with cowpeas or with pumpkin leaves; people in Uganda like it with jute mallow. It is less commonly consumed on its own. When cooking *Crotalaria* by itself the Luo people often add milk as a substitute for cooking fat to the cooking process. Milk reduces the bitterness.

CLUSTER BEAN

Cyamopsis tetragonoloba (L.) Taub

Subfam. Papilionoideae

Synonym: *Cyamopsis psoralioides* DC.

The cluster bean is also known by the name *guar* and is mainly used in India and Pakistan, where most crop improvement has taken place. This species developed from its probable ancestor *Cyamopsis senegalensis* Guill. & Perr., which still occurs in the wild in the semi-arid savannah zone from Senegal eastwards to the Arab peninsula. The young pods are collected in Ethiopia to be eaten as a vegetable. It is not found wild in India or Pakistan. In Africa, it is mainly grown as a vegetable for use by Indian people; small-scale export of young pods now occurs from Kenya, Zimbabwe and Ghana mainly to the UK-based Indian community. Guar can also be an industrial crop; in India, its seeds are used for the production of guar gum used in food processing and the textile industry. In Zimbabwe, the crop is mainly grown for its oil-rich seeds. The plant is also grown as fodder for livestock, for which tall varieties are used that can grow up to 1 m or more. Its nitrogen-fixing properties make it a good pasture crop.

Wild relatives of cluster bean are found in Namibia, Botswana and Northern Transvaal (Mushonga and Mafongoya, 1997). The Zimbabwean Department of Research and Specialist Services carried out some basic research and evaluated a number of varieties produced in south-eastern Zimbabwe. This drought-tolerant crop can be seriously affected by Alternaria leaf spot and by bacterial blight, and by a number of insect species of which stinkbugs, aphids, thrips and whitefly are amongst the more common. Seed yields range from 1.5 to 5 t/ha, depending on whether it is rainfed or irrigated.

HYACINTH BEAN

Lablab purpureus (L.) Sweet

Subfam. Papilionoideae

Synonyms: ***Dolichos lablab*** **L;** ***Lablab niger*** **Medik.**

Hyacinth bean *(Lablab purpureus)* is an important vegetable and pulse crop in southern Asia, but less so in East Africa (*see* Figure 63). The young pods and immature beans are popular in India, whereas in Africa they are mainly used as a by-product of the pulse crop, or they are grown to cater for the demands of Asian people. In West and Central Africa, they are occasionally grown for their young leaves, used similarly to those of cowpeas and *Phaseolus* beans. Other names used for this crop in Africa include lablab bean, Egyptian bean and bonavist bean.

Figure 63 *Lablab purpureus*

The wild forms of this species can be found in savannah areas of West, Central, East and southern Africa, where they are grouped under ssp. *uncinatus* Verdc., which are recognized by linear kidney bean-like pods. The cultivated forms, grouped under ssp. *purpureus,* have purple flowers and stems with characteristically flat pods at a young stage. The perennial forms that are found in north-eastern Africa can reach 3 m or more when they climb in shrubs. White-flowered forms with green stems and a broad suture can also be found, which may have derived from ssp. *bengalensis* (Jacq.) Verdc. Purseglove (1968) considers this crop to have an Asian origin because of its cultivation there since ancient times. Zeven and Zhakovsky (1975) dispute this, based on the wild subspecies that can be found in Africa and several related African *Dolichos* species and they see southern Asia as a secondary centre of diversity. Recent discoveries of apparently wild populations in Kenya's Cherangani Hills and on Mt. Mlanje in Malawi further support this view.

The crop is quite tolerant to drought and the leaves remain green during the dry season, which makes it a popular fodder crop for livestock. Hyacinth beans are often used as a soil-cover crop amongst plantations of young trees, or grown as a mixed crop with, for instance, maize. During periods of food scarcity, people eat the leaves and the flowers. It is also used as green manure, as in the Gezira in Sudan. The Kikuyus from Kenya traditionally consume hyacinth beans during wedding ceremonies. The Hausa people let the plants cover their fences as a kitchen-garden crop and eat the young leaves. Similar practices were noticed in south-eastern Cameroon. Since the crop's use as a vegetable is limited in Africa, no further information is provided here, especially since this crop is already well documented, as is the case for cowpeas.

AFRICAN WINGED BEAN

Psophocarpus scandens (Endl.) Verdc.

Subfam. Papilionoideae

The information below is based mainly on a paper given during a workshop on African indigenous vegetables in Cameroon (Jacques Paulus, 1997).

African winged beans can be found all over Congo (Democratic Republic) and Central Africa, from Cameroon to Angola, to Tanzania and Mauritius. In Kinshasa, the African winged bean is mainly known as *kikalakasa*, a traditional vegetable of which the leaves, pods, sprouts and seeds are edible. Local residents recognize the value of *kikalakasa* as a galactogene and this vegetable is thus popular with breast-feeding women.

The crop has been neglected for some time because some tribes consider it as food for poor people only, but this trend is now changing. *Psophocarpus scandens* was traditionally eaten in at least six of the 11 regions of Congo (Democratic Repbulic). In modern farming it is used as a cover crop in rubber and palm-tree plantations. *Kikalakasa* can still be found wild in many generally humid places, such as riverbanks and marshes, in and around Kinshasa.

The plant is climbing and perennial but, contrary to evidence from the literature, does not have tubers in this part of Africa. *Kikalakasa* is very rich in proteins and is easy to cultivate in kitchen gardens. The leaves are traditionally eaten as a vegetable and contain 7.1% protein when fresh and 39% when dried. They also contain 2.2% lipids when fresh and 12.1% when dried. The leaves are richer in proteins and in lipids before rather than during and after fructification. The seeds are very hard and require scarification before planting. Hard seeds contribute to their viability and seeds can be kept for many years.

More than 10 000 families in Kinshasa now cultivate *kikalakasa* in their kitchen gardens and there may be another thousand or so families who do the same in other towns in Congo (Deomcratic Republic).

The leaves can be dried, made into flour and mixed with other flours. Seeds can be roasted and good flour can be obtained. *Kikalakasa* had a competitive problem with eru *(Gnetum africanum).* Their tastes are quite similar but the former is cheaper.

Related species: *Psophocarpus grandiflorus* Wilczek. This is a perennial climbing herb, up to 5 m long, that grows wild in highland areas above 1750 m in East Africa from Congo (Democratic Republic) to Ethiopia. It is cultivated for its edible seeds in western and southern Ethiopia, possibly also in neighbouring countries.

The cultivated winged bean, *Psophocarpus tetragonolobus* (L.) DC., from South-East Asia is not known in the wild. All its near-relatives are African, so that an eastern Asian origin is disputed.

AFRICAN FOETID CASSIA

Senna obtusifolia (L.) Irwin & Barneby

Subfam. Caesalpinioideae

Senna obtusifolia is usually referred to as *Cassia tora,* which is an Asian species that does not occur in Africa. Unfortunately, the English name 'foetid' refers to the smell of the true *Cassia tora,* whereas the African material has a different smell. Its leaves are commonly eaten, often in large quantities, in semi-arid areas such as in Senegal and other countries bordering the Sahel. It occurs in many parts of Africa and is collected during periods of food scarcity. There is uncertainty about its origin and some claims are made indicating that this is an introduced species which originated in South America.

S. obtusifolia is one of the first crops to be harvested once the rains have started and it is also cultivated on a small scale in, for example, Cameroon, Ethiopia and Ghana (*see* Figure 64). It is used in Senegal to prepare a sauce that is added to the main course, couscous, eaten by people in rural areas. It is not a favourite crop in Senegal because people believe that when one eats too much it will bring poverty. Only young leaves are used; those that grow before the plant develops flowers. Fully grown plants can grow up to 1.50 m. Frequent consumption of especially the more mature leaves will cause diarrhoea, which is not surprising since the 'senna' pods of *S. angustifolia* and related species are used as a laxative. Related species that are collected from the wild during periods of famine include *S. occidentalis* and *S. auriculata.*

Figure 64 *Senna* as a cultivated crop in northern Ghana

AFRICAN YAM BEAN

Sphenostylis stenocarpa (Hochst. ex A.Rich.) Harms

Subfam. Papilionoideae

African yam beans are grown in several, mainly West African, countries for their seeds and tubers, but are not common and their cultivation is declining. Although African yam beans probably originated in Ethiopia where they are now grown on a small scale, it is presently mainly found in Côte d'Ivoire, Togo, Nigeria and other West and Central African countries such as Uganda. It is also reported in Malawi. In Nigeria the crop is known as *girigiri.* It can be seen in a variety of ecological zones ranging from fertile highland areas to sandy, leached-out areas in the lowlands, but also in swampy areas. The crop can grow on poor, marginal soils and rehabilitates nitrogen levels by using *bradyrhizobia* in its root nodules to fix atmospheric nitrogen. It tolerates high humidity, but does not like consistent shade. Stakes or similar support are needed for its vines which are usually about 2 m long, but may reach up to 4 m. It is easily recognized by its large (±25-40 mm) greenish-white to light-blue or purple flowers borne on strong axillary peduncles and by its trifoliate leaves of about 14 x 5 cm with lanceolate acute leaflets.

The fresh pods, which are 25-30 cm long and about 8-12 mm in diameter, are not eaten and are claimed to be poisonous. The round to oval-shaped seeds are considered a delicacy. They are rich in proteins (26-29%) and also contain about 8% lysine and 2.45% methionine plus cystine. The seeds require soaking in water for about 12 h before cooking (Burkill, 1995). Its leaves can be eaten like other legumes such as cowpeas and *Phaseolus* beans, but are not as popular. Seed production takes 4-5 months from sowing or planting small tubers to the first harvest and yields are quite high. It is often cultivated with yam to make better use of the stakes.

The tubers are harvested after about 8 months. These tubers taste somewhat similar to Irish potatoes and contain 11-19% protein, compared to the 5% found in Irish potatoes and sweet potatoes and even less in cassava. Their shape is like a spindle or a round sweet potato, although not as smooth. The tuber is about 5-8 cm long and weighs up to 300 g or occasionally up to 500 g but more often only about 50-100 g.

Some related species are collected from the wild during periods of famine. These include *S. marginata* ssp. *erecta* and *S. schweinfurthii.* The latter, rather woody, species is occasionally cultivated for its seeds and tubers and so is *S. stenocarpa,* which is sporadically grown for its seeds. The yam bean, *Pachyrhizus erosus* (L.) Urban., originates from Central and South America.

MARAMA BEAN

Tylosema esculentum (Burch.) Schreiber

Subfam. Caesalpiniaceae

Interest in the marama bean is developing in a number of southern African countries. This new crop, which can be produced in semi-arid regions, may be used for its roots and pulses and as a much valued fodder crop. It is also an excellent cover crop, providing protection against erosion and reducing growth of undesirable weeds, and could be used as a green manure to improve soil structure when incorporated into the soil. Marama beans are available as a fresh product from March to May and as a dried product from June to February.

The double-lobed leaves are red-brown when young and later become leathery and greyish-green. The leaves and vines are much appreciated by animals. The plant flowers in December and produces woody pods with 1–6 large, chestnut-brown seeds inside. Some people, for example in Zimbabwe, eat the young seeds straight from the pod, even though the taste is reported to be unpleasant and the fresh beans have a slimy texture. Once the seeds become older and turn brown they need to be boiled first. Boiled beans can be ground and then added to maize meal, or be used as a kind of porridge. The roasted seeds have a nutty flavour and are used as a snack. Roasted seeds are consumed in Angola, Botswana, Namibia, South Africa and Zimbabwe. It is possible to store marama beans for several years.

Seeds can be pressed to produce a clear-yellow cooking oil. Seeds contain 30-39% protein and 30-43% oil depending on the material used, allowing scope for selection of available germplasm. Other products include marama butter and biscuits made from the seed cake. After the oil has been extracted, the remaining seed cake consists of approximately 50% protein; this cake is in high demand as animal feed.

The large tubers are eaten either fresh or boiled in, for example, Namibia. The tubers can be stored like yams and have a similar use where they are ground or pounded and prepared as a starchy staple food. Some tubers can be 10 years old when they become woody and fibrous. The younger, succulent tubers contain a lot of water, which is important both for humans and wild animals during periods of drought.

Since marama beans belong to the subfamily Caesalpiniaceae where root nodules are not normally common, the high protein level found in the seeds, leaves and even tubers is surprising, especially since the plants are usually found on nutrient-deficient soils. Further studies to determine the mechanism of nitrogen fixation would be welcome, since its understanding would assist with the commercial-scale production envisaged for the near future.

Research on the development of varieties is currently (1999) taking place at the non-governmental organization (NGO) Thusano Lefatsheng in Botswana and by Veld Products Research of South Africa. Since there are wide variations in a number of characteristics, the potential for genetic enhancement is promising. Seed dormancy is one of the problems that needs to be resolved. Other research efforts are made by the department of botany of South Africa's University of Cape Town. Research in Namibia and South Africa has shown that wild populations are mainly found on dolomite and lime soils in relatively warm areas, indicating an interesting potential for production in otherwise unproductive low-nutrient soils in generally dry areas.

RELATED CROPS

Seeds of *Tylosema fassoglense* (Schweinf.) Torre & Hillc. are eaten by people in Malawi: its tubers are similarly edible. This plant has a distribution ranging from South Africa to the Sudan.

Vatovaea pseudolablab (Harms) Gillett can be found as a woody climber with a large tuber and is easily recognized by its long raceme of purple flowers. It is a real multi-purpose crop, of which virtually all parts can be eaten. The roots are a favourite snack, especially in roasted form. Fresh roots are fibrous and contain much juice. These roots differ in shape from long, slim and carrot-like, to round and potato-like. The leaves, the young pods and the seeds are eaten either raw or cooked.

Hadza women in northern Tanzania supplement their diet with these tubers, which can be dug out of the ground at any time of the year and are considered juicy and sweet. In Karamoja, in eastern Uganda, the crop is much appreciated and is becoming more difficult to find, but so far no attempts have been made to cultivate it. In Kajiado, Kenya, some people have planted seeds in a first effort to cultivate *V. pseudolablab* as a crop. It will be interesting to learn about their experiences and to see whether these efforts represent the first phase of a domestication process.

In the opinion of people who know these plants, the potential available in this species is eminently worthy of exploitation. To do so, a start needs to be made by collecting and evaluating germplasm. Preliminary selections could then be tested for their performance and promising material should be multiplied further; this should not be too difficult, assuming that it is basically a self-pollinated crop.

The species is found wild in the dry parts of Tanzania, Kenya, Uganda, Sudan, Ethiopia, Somalia, Yemen and Oman. It is commonly collected in all these countries, but is not or barely cultivated. It is now becoming rare in the Arabian Peninsula and becoming scarcer in East Africa, being a favourite of people and livestock alike. If no action is taken soon, the genetic pool of this valuable species is likely to shrink fast.

Vigna lobatifolia Baker from the drier parts of Angola, Namibia and Botswana is a similar species, which also has not been exploited. It has long, narrow roots, which swell to the size of a potato in certain sections. These are collected by Bushmen and are consumed fresh or cooked.

Tubers from other *Vigna* species that are currently collected from dry, infertile soils in the wild include *V. fischeri* Harms, *V. reticulata* Hook.f. and *V. vexillata* A. Rich.

COWPEA

Vigna unguiculata (L.) Walp.

Subfam. Papilionoideae

Cowpeas *(Vigna unguiculata)* are indigenous in several countries in Africa and have been in cultivation for a long time (*see* Figure 65). The Niger River basin is cited as the probable origin of the species, based on the very large diversity and presence of wild forms. Numerous varieties are known which are used for their seeds. Varieties that are prostrate with long vines are mainly used for their leaves (and occasionally their young green pods) and in many places the crop is a vegetable of major importance. These cultivars belong to the botanical variety *unguiculata.* It is often grown in between taller crops such as maize, cassava or okra and usually covers the ground. The crop is cultivated on a large scale and extensive literature on this pulse crop is readily available, such as that from the International Institute for Tropical Agriculture (IITA). It is the most important pulse crop in tropical Africa, although in a few places it ranks second, after groundnuts. Therefore, most research has been focused on cowpeas for seed production and only a few studies have been made on varieties that are primarily grown for their leaves.

Figure 65 Cowpea *(Vigna unguiculata)*

The leaf crop is especially important in arid or semi-arid areas, where it is deeply rooted and tolerant to drought. These leaf varieties are grown both for direct consumption and for drying, to be used in the dry season. The spacing for prostrate, indeterminate types that are used for leaf production is about 75 x 75 cm compared with the spacing for erect, determinate and low-branching types that are grown for seed, which is about 15 x 35 cm.

In northern Senegal, the variety Fuuta has been selected for the use of its leaves. This variety does not flower until 50 days after sowing. Also the Zimbabwean variety Chigwa has a long vegetative period, indicating that it is primarily used as a leaf crop. Most leafy varieties have dark-green leaves.

The most destructive diseases in areas where the crop is grown for its leaves are brown blotch (*Colletotrichum capsici*), Septoria leaf spot (*Septoria vignae*), stem canker (*Macrophomina phaseolina*) and the bacterial blight *Xanthomonas campestris.* A wide range of diseases may be encountered with rising humidity, of which the most important are Cercospora leaf spot (*Pseudocercospora cruenta*), scab, caused by *Sphaceloma* sp., brown rust (*Uromyces appendiculatus*) and web blight, *Rhizoctonia solani.*

The more important insect pests include the cowpea aphid, *Aphis craccivora,* various leafhoppers, larvae of African bollworm (*Heliothis armigera*) and the Egyptian leaf worm, *Spodopteris littoralis.* The cowpea leaf beetle *Ootheca mutabilis* can also be of concern although it is relatively easy to control with insecticides such as endosulfan.

Young leaves and occasionally young pods are offered at the market. Cowpea leaves can be rather coarse after cooking which is why leaves of more smooth or mucilagenous vegetables such as *Corchorus, Hibiscus sabdariffa, Sesamum* and others are added. Cowpea leaves can be dried in the sun and preserved as whole or broken leaves, or in powdered form for use during the dry season.

BIBLIOGRAPHY

BURKILL, H.M. (1995) *The Useful Plants of West Tropical Africa. Vol. 3: Families J-L.* Kew: Royal Botanic Gardens.

CHWEYA, J.A. (1997) Genetic enhancement of indigenous vegetables in Kenya. In: *Traditional African Vegetables, Proceedings of the IPGRI Workshop on Genetic Resources of Traditional Vegetables in Africa. August 1995, Nairobi.* GUARINAO, L. (ed.) Rome: IPGRI.

DAKORA, F.D. (1995) Agronomic and nutritional attributes of some underutilized legumes in e*astern and southern Africa. In: Proceedings of a Symposium held at the Institute for Tropical and Subtropical Crops, Nelspruit, South Africa, August 1995.*

DALZIEL, J.M. (1937) *The Useful Plants of West Tropical Africa.* London: Crown Agents for the Colonies.

HARDER, DANIEL, K., LOLEMA, O.P.M. and TSHISAND, M. (1990) Uses, nutritional composition, and ecogeography of four species of *Psophocarpus* (*Fabaceae, Phaseolae*) in Zaire. *Economic Botany,* **44**(3): 390-409.

IITA (1985) *Cowpea Research, Production and Utilization.* SINGH, S.R. and RACHIE, K.O. (eds.). New York: Wiley-Interscience.

IMUNGI, J.K. (1989) The Role of Indigenous Vegetables in Human Nutrition.

JACQUES PAULUS, S.J. (1997) The role of indigenous crops in home gardening and urban horticulture. pp. 42-45. In: *Proceedings of Workshop on African Indigenous Vegetables, Limbe, Cameroon.* SCHIPPERS, R.R. and BUDD, L. (eds.). Chatham, UK: Natural Resources Institute/ IPGRI.

KAY, D.E. (1973) *TPI Crop and Product Digest. No.2 Root Crops.* London: Tropical Products Institute.

KAY, D.E. (1979) *Crop and Product Digest. No.3 Food Legumes.* London: Tropical Products Institute.

MAUNDU, P.M. and KABUYE, C.H.S. (1993) *Final Narrative Report on Indigenous Food Plants Programme.* Nairobi: National Museums of Kenya.

MUSHONGA, J.N. and MAFONGOYA, P.L. (1997) Incorporating new crops into Zimbabwean farming systems. pp. 160-172. In: *Domestication, Production and Utilization of New Crops.* SMARTT, J. and HAQ, N. (eds.). Dhaka, Bangaladesh: Colorline Printers.

NATIONAL ACADEMY OF SCIENCES. (1979) *Tropical Legumes: Resources for the Future.*

OBIERO, H.M. (1998) *Notes on sun hemp,* Crotalaria *spp. in Western Kenya.* Kenya Agricultural Research Institute (unpublished paper).

PURSEGLOVE, J.W. (1968) *Tropical Crops, Dicotyledons.* London: Longmans, Green and Co. Ltd.

UISO, F.C. and JOHNS, T. (1996) Risk assessment of the consumption of a pyrrolizidine alkaloid containing indigenous vegetable *Crotalaria brevidens* (Mitoo). *Ecology of Food and Nutrition,* **35**(2): 111-119.

UISO, F.C. and JOHNS, T. (1996) Consumption patterns and nutritional contribution of *Crotalaria brevidens* (Mitoo) in Tarime District, Tanzania. *Ecology of Food and Nutrition,* **35**(1): 59-69.

ZEVEN, A.C. and ZHUKOVSKY, P.M. (1975) *Dictionary of Cultivated Plants and their Centres of Diversity.* Wageningen, Netherlands: Pudoc.

WEST AFRICAN OKRA

Abelmoschus caillei (A.Chev.) Stevels

and

COMMON OKRA

A. esculentus (L.) Moench

Figure 66 *Abelmoschus caillei* in Uganda

INTRODUCTION

Okra is a widely cultivated vegetable and can be found in almost every market in Africa. In Ghana it is the fourth most popular vegetable after tomatoes, capsicum peppers and garden eggs. In Sudan the common okra is the third or fourth most popular vegetable, whereas in Cameroon the two okra species, *Abelmoschus caillei* (A. Chev.) Stevels (West African okra) and *A. esculentus* (L.) Moench (common okra) combined represent the second most important vegetable in the market after tomatoes.

Common okra is mainly grown for market gardening in areas with a limited rainfall or under irrigation, whereas West African okra is found throughout the high-rainfall zones and is mainly grown for subsistence (*see* Figure 66).

In 1988, Stevels described West African okra as a separate species, based on her observations in Cameroon and on work carried out by Siemonsma in Côte d'Ivoire between 1977 and 1980. Siemonsma (1982) referred to this taxon as *type Guinéen. A. caillei* is mainly found in the humid coastal zones of West and Central Africa and more sparingly in its savannah belt. The area stretches from southern Senegal to southern Congo (Democratic Republic) and up to Uganda in the east. It is much more frequently found north of the equator than south. There is an overlap with the natural distribution of *A. esculentus* almost throughout the *A. caillei* area, with *A. esculentus* becoming common towards the east and towards the drier regions and rare towards the humid equatorial area.

West African okra is much appreciated because it continues fruiting during the dry season when few other vegetables can be found. In contrast, the common okra only fruits during the rainy season or under irrigation. West African okra plants remain green during periods of drought, thus allowing people to eat its young leaves when needed. It is by now mainly cultivated, but can easily grow semi-wild without any attention. The two species are often planted near to each other in order to have a continuous supply of fruit throughout the year.

Apart from the traditional *A. esculentus* types, there are also varieties introduced from Asia (e.g. Pusa sawani in Kenya) and from the US (e.g. Clemson spineless and others). These varieties are less mucilaginous than African landraces. The introduction of exotic varieties has led to a much reduced production of traditional okra cultivars, especially in East Africa, because of their higher yield and smaller, uniform plants, which can be harvested within 3 months and sometimes as early as 6 weeks from sowing.

The common okra has benefited from world-wide research over many years, resulting in many varieties adapted to specific needs. No similar genetic enhancement efforts have been made for *A. caillei,* which appears to be losing the competition for lack of a combination of desirable elements in one or more uniform varieties.

Since the identification of *A. caillei* as a second cultivated okra crop in Africa, there have been a number of germplasm-collecting missions and the characteristics of the new species have been studied in detail. There is little known about *A. caillei* as a crop that has probably been in cultivation for many centuries. There is therefore a need for further studies focused on genetic enhancement and agronomic aspects.

The Amharic name for okra is *bamia* and there are similar names in Arabic and other languages known from the early 13th century onwards. In French, okra is called *gombo. A. caillei* is called *ila* in Yoruba. In several vernacular languages the West African okra is referred to as 'the late *okro*'. In many anglophone African countries, the name *okro* is used rather than okra. The name *derere* is used for okra in Zimbabwe.

TAXONOMY

Okra used to be classified within the genus *Hibiscus,* from which it has been separated. The genus *Abelmoschus* may be easily distinguished from the closely related *Hibiscus* by its 5-toothed calyx, which splits longitudinally along a single suture at flowering. After flowering the whole bloom, consisting of calyx, petals and staminal column, which are adnate at the base, drops together, leaving the ovary and the epicalyx segments behind.

Abelmoschus is now considered to consist of nine or 10 species of which four are cultivated. There are five species in Africa, three indigenous and two that were introduced from Asia in the distant past (*see* Table 9).

Table 9 Main characteristics of okra species found in Africa

	A. caillei	***A. esculentus***	***A. ficulneus****	***A. moschatus****	***A. manihot***
Epicalyx segments					
Number	5-10	7-18	5-6	7-10	6-7
Length in mm	8-35	5-25	4-12	8-15	25-40
Width in mm	4-13	0.5-3	0.5-1.5	1-2	3-18
Persistence	drops at young fruit stage	throughout flowering only	drops when flower opens	up to dried fruit stage	up to dried fruit stage
Cytogenetics *					
Chromosome no.	184-200	(72) 108-144	72	72	60-68
Pedicel of fruit					
Length in cm	1-13**	0.5-3.5***	0.5-1.5	3-8	?

Notes: *source: Siemonsma (1991)
**often recurved
***mainly upwards, not recurved

A. ficulneus L. is found in tropical lowland areas with a long dry season, such as parts of the Sahel (Mali, Chad, Sudan) and East Africa (Ethiopia, Somalia, Tanzania, Uganda, Madagascar), but more so in South and South-East Asia as far as Irian Jaya and also in Australia. This species can be strongly branched and short, such as in the Sudan, or tall with few branches, reaching up to 2 m in height, such as plants found in the Selous Game Reserve in southern Tanzania. In Eritrea, it is found in grasslands on seasonally waterlogged black cotton soils. It has pink flowers of about 2-4 cm with a distinctly dark centre. Its hairy fruit, often with a round rather than a pointed apex, are best recognized by its divided, fig-shaped leaves. It is a wild species, of which both fruit and leaves are eaten in Sudan, during times of general food scarcity. *A. ficulneus* is one of the two ancestors of the common okra.

A. moschatus Medikus originates in South-East Asia and Melanesia, where it is mainly used for its leaves and also for the muscous oil extracted from its seeds. This oil is used in the preparation of certain perfumes. *A. moschatus* is occasionally found in humid locations in West Africa, for example, in Togo and Benin, where it plays a traditional role in local ceremonies. Both the leaves and pods are eaten. It has also been reported as a wild plant in South America, making it a pan-tropical species. *A. moschatus,* the musk mallow, could be used in breeding programmes when tolerance or resistance to jassids is required.

Figure 67 The semi-persistent epicalyx bracts of the spiny okra resembles those found in *A. manihot,* but can also be found in *A. caillei*

A. caillei is an allohexaploid species with the amphidiploid A. *esculentus* and the diploid *A. manihot* as suggested ancestors.

A. manihot (L.) Medikus is not indigenous to Africa, but was possibly brought to West Africa by Polynesian or South-East Asian navigators during ancient times, together with *A. moschatus.* It may still occur in Africa, although the search for this species has not been conclusive yet. *A. manihot* was earlier reported from Sierra Leone where it is no longer found (Hamon and Hamon, 1991). Some okra plants that can today be found in a few villages in Guinea (not far from Sierra Leone) show the typical reddish 'bloom' on the seeds and the prickly hairs on the pods which are characteristic of some varieties of *A. manihot.* Similar 'red-bloomed' seeds have also been collected from *A. caillei* plants in Côte d'Ivoire. The spiny okra from northern Ghana, a taxon within *A. caillei,* has fruit covered with sharp black spiny hairs and prominent spreading epicalyx segments which drop towards maturity (*see* Figure 67). This taxon has a number of characteristics in common with *A. manihot. A. manihot* is a potential source for resistance to yellow vein mosaic virus.

BOTANICAL ASPECTS AND MORPHOLOGY

The West African okra is cultivated as an annual or bi-annual crop. It may survive for 3 years and shrubs can reach 4 m or even higher, becoming woody at the base, strongly branched with a main stem of up to 7 cm in diameter. The horizontal or curved branches of *A. caillei* can sometimes be longer than the total plant height. Varieties found near 11° latitude and just above, for example, in northern Ghana, are annual and look much more like the common okra. Plants do not grow much taller than about 2 m with few, weak branches. They can then mainly be distinguished by their flowers, which have broad epicalyx bracts. Such varieties often have a cluster of fruit near the top and no flowers or fruit at the lower or middle parts of the main stem, which might be attributed to day length.

The main difference between *A. caillei* and *A. esculentus* is the width of the epicalyx segments (involucral bracts). There are (5)6-9(10) broad segments in *A. caillei* (*see* Figures 68 and 69) whereas *A. esculentus* has up to 18 narrow ones (*see* Figure 70). The pedicels of *A. caillei* are often longer than those of *A. esculentus* and consequently *A. caillei* can frequently be found with pendant fruit whereas *A. esculentus* fruit are virtually always upright.

Figure 68 Segments of *A. caillei* are broad

Figure 69 Broad epicalyx segments of *A. caillei*

Figure 70 *A. esculentus* has many narrow epicalyx segments

It should be noted that both *A. caillei* and *A. esculentus* are highly polymorphic species, especially in West Africa, and not all characteristics as tabled above are consistent. It is, for instance, possible to find common okra with green bracts on fruit sold in the market. Some *A.esculentus* types have curving pedicels. Therefore a combination of characters should be used to distinguish between the species. The two species can also be identified by their seeds, with a dense marking seen on *A. esculentus* seeds and a wider marking for *A. caillei* seeds.

West African okra is becoming rare at latitudes above 11° North and below 11° South because of its short daylength requirement. *A.caillei* will not produce flowers under conditions of more than a maximum of 13 h of sunlight (sometimes not more than 12.5 h) whereas *A. esculentus* is much more daylength-neutral. This can be noticed, for example, in northern Ghana, where *A. caillei* does not produce flowers and fruit before October and is thus referred to as dry season okra. West African okra continues to produce fruit in the dry season, unlike common okra, which only produces fruit during the rainy season, or under irrigation. The timing of harvesting has little to do with the dry season, but much to do with day length. In fact, *A. caillei* does not really like dry conditions and will lose most of its large leaves. With the onset of the rains, new leaves appear, giving this crop its bi-annual or perennial characteristic. When sowing in June/July, a first harvest will be obtained at the same time as the April crop. *A. caillei* usually requires a longer time from seed emergence until flowering than *A. esculentus.*

Figure 71 Okra can have green, yellow or red fruit. The red variety is Late red finger from Ghana

The fruit colour of both species is varied, with *A. caillei* fruit generally being darker but there are clear exceptions (*see* Figure 71). Fruit colours may range from dark purple-red to reddish-green, greyish dark-green and from light-green to yellow. Many *A. caillei* fruit are hairy or somewhat spiny. Farmers are aware of the difference between the two and treat them as different crop species, even though they may be found growing in the same compound.

The origin of *A. esculentus* is not certain. One theory favours a Sahara region origin, where this species has been in cultivation for thousands of years. Of the African taxa, one genome comes from *A. ficulneus,* but the other is uncertain and could represent a presently extinct species or possibly a diploid form of *A. esculentus.* Today a range of primitive landraces can still be found in Sudan, where people collect fruit from wild plants for drying purposes. These wild plants are collected during the short rainy season in the southern Blue Nile, Kordofan and Darfur districts.

Other theories favour a northern Indian origin for *A. esculentus* where it could have been derived from *A. tuberculatus* (2n=58) and *A. ficulneus* (2n=72). As an amphidiploid, *A. esculentus* may well have absorbed genes from the above two species, given the most common chromosome count of 2n=130. However, there may also be other, presently unknown species involved, considering the range of chromosome counts for different varieties. The offspring from the many African and Asian varieties of *A. esculentus* are fully fertile. It should be noted that there is a far greater diversity in *A. esculentus* in Africa than in Asia.

BREEDING

Owing to the absence of a self-incompatibility system, the two okra species are generally autogamous. Outcrossing does however occur, with bees of different species acting as pollinators.

Figure 72 *Mycabris* beetles feed on okra flowers and also act as pollinators

There are indications that *A. caillei* has a higher rate of cross-pollination than *A. esculentus*. Up to 27% cross-pollination has been reported from Nigeria (Chheda and Fatokum, 1990) when compared with a maximum of 20% as reported for *A. esculentus* (Charrier, 1984). The usual level of outcrossing is, however, much lower. When putative pure lines are multiplied, some heterogeneous offspring can occasionally be found which could be explained by earlier cross-fertilization by pollinating insects of parent plants. Also beetles such as *Mycabris* sp., which usually eat the petals, may act as pollinators (*see* Figure 72).

Outcrossing between the two species is rare and hybrids are usually infertile. The chance of a natural hybrid between them is slim because of the difference in chromosome numbers. Crosses have been made between *A. caillei* and *A. esculentus* which gave viable hybrids with distinct hybrid vigour. In turn, these hybrids are scarcely fertile and thus do not produce viable seeds.

A consequence of the possibility of cross-pollination within the species is that it is not advisable to use seeds obtained from variety comparison trials where lines are planted adjacent to each other. In the latter case, when no additional seed is available, it may be wise to take cuttings from desirable lines, grow these out and multiply these lines in isolation. When a particular plant is appreciated, or when collecting germplasm, it is advisable to take the lowest fruit from such a plant since chances of cross-pollination are limited and the offspring are likely to be uniform.

Figure 73 The pale yellow okra flower will soon open and will turn pink after pollination

Flowers open early at dawn and self-pollination takes place from 06:00 until noon. Young flowers are light- to bright-yellow in colour (*see* Figure 73) and change to a pink colour after pollination has been completed. The anthers are dehiscent at the time of anthesis.

Okra flowers are very sensitive to emasculation, making cross-pollination by hand rather difficult when it involves removal of approximately 100 etamins found on the staminal column, which is a tedious operation. Fortunately, however, it is easier to remove the staminal column altogether, which has to be done the day before the flower is expected to open. Prior to that, the epicalyx, the calyx and the petals have to be removed. To avoid accidental pollination, the remainder of the flower should be covered with a sachet or similar cover. Fresh pollen should be collected just before hand pollination is attempted early next morning, preferably before 07:00, when the best results will be obtained.

A new technique, that has recently been tried in India, is that of induced male sterility through mutation breeding using gamma rays. Once there is access to a male sterile line of okra, hybridization becomes much easier since emasculation is no longer required. The resulting hybrid varieties now on offer by seed companies are uniform and, because of their hybrid vigour, have a high yield potential.

For a mainly inbred species, like okra, the pedigree method is ideal. This involves selfing by bagging individual plants, thus ensuring that no foreign pollen can enter by means of insects or in other ways. This is a good working method for maintaining lines.

Selections can be made amongst the early *A. caillei* types which produce flowers only 10 weeks from sowing and are rather similar to *A. esculentus* in plant shape and productivity. Many also have the desirable dark-green fruit with a high mucous content.

Future work might include the incorporation of genes for two or three fruit at each node, as can now be seen with modern varieties of the common okra (*see* Figure 74).

Figure 74 Some okra plants have two fruit per node

VARIETIES

Common okra

Most plant populations consist of landraces or remnants of earlier introduced varieties such as Clemson spineless from the US. These can be seen in East and southern Africa and remain the most popular okra cultivars in Côte d'Ivoire and southern Ghana. In Ghana these are given their own name: *asontem,* 'early maturing'. They usually take about 10 weeks from sowing to produce the first fruit. The Clemson spineless variety is no longer uniform in West Africa, but is still very popular because it is early. It is less mucilaginous than the West African okra or common okra. Mutations can be found in coastal Tanzania which are 3-4 m tall with strong branches at the base. The southern Asian cv. Pusa sawani has been introduced to East Africa where it has become very popular. Other varieties that have been introduced into Africa are Green emerald and Dwarf long green.

Only minimal research has been undertaken on truly African varieties. Recently, research in Senegal and Tanzania has produced a number of varieties, including several high-yielding hybrids (*see* Figure 75).

Figure 75 Modern okra variety developed by AVRDC in Tanzania

In Sudan, there are a number of varieties available from local seed houses which include a spiny type called Khartoumia. Other local varieties include Momtaza, Karrari, Kassala, Medani, Sinnar and others, which are named after the location where they are grown. The same applies to the variety Kariba from Zambia. In Zimbabwe, Botswana and Namibia there are early-maturing dwarf varieties such as Rechiindia, and late-maturing tall varieties, for instance, Derere refu to spread availability throughout the year. There are several landraces, all with names in local languages. These include varieties with itching hairs that are not liked by people, such as those from Hurungwe in Mashonaland, western Zimbabwe. Primitive landraces can still be found in the Gambella area in Ethiopia and the coastal areas of northern Kenya.

West African okra

The Spiny okra, a taxon within *A.caillei* from northern Ghana, has fruit covered with sharp black spiny hairs and prominent spreading epicalyx segments which drop towards maturity. This taxon has a number of characteristics in common with *A. manihot.* Ripe dried fruit are black in colour as compared to the greyish-brown usually seen in *A. caillei.* Pedicels of the fruit are 5-8 cm long and pendant. A prominent characteristic is the spreading calyx segments, 25-35 mm long, which remain on the fruit for much longer than other okras, but drop when the pods become more mature. The comparatively small seeds are somewhat kidney shaped and brownish in colour rather than the greyish round seeds of the common okra. This taxon is grown on several farms in the region between Navrongo and Bolgatanga in Ghana's Upper East region (nearly 11° latitude) and near Wa in the Upper West region. In Kursal, one of the dialects of northern Ghana, the spiny okra is referred to as *kpaseya,* whereas all other okras are called *mana.* Farmers mainly use the spiny fruit for drying rather than for fresh consumption. Although their dried fruit are preferred over the other okra varieties, harvesting is difficult and people have to protect their fingers from the spines by wrapping rags around them, otherwise sores will develop which cause prolonged stiffness.

Varietal names are often descriptive, such as 'the early one', 'the late one' or 'the dry season type', etc. Apart from the common biannual types, there are also annual types of West African okra, such as those found in northern Ghana, which are sown during the rainy season in June and produce flowers and fruit from October to December. Earliness, expressed by the lowest leaf axil in which flower buds appear, is partly a varietal characteristic and partly due to day length. West African okra may therefore produce its first flowers and fruit in, say, October, regardless of the time of planting, whether at the start of the long rains in April or during the short rains in August.

One perennial variety is called Late red finger (*see* Figure 71). Most varieties in this group have short, pyramidal-shaped fruit which are often curved downwards. One of these is called Buropo, 'the late one'.

Observations

Fruit shapes of both species vary from short and triangular to long straight or long curved. The length of a mature fruit can vary from 4 to 40 cm and the width may vary from about 1.25 cm up to 7 cm (*see* Figure 76).

Figure 76 Variously shaped seed pods representing the mixture that can be found in landraces

In traditional farming systems and home gardens, people prefer plants with a long production season and many branches so that there is always something to harvest. West African okra is therefore more popular for subsistence use. For market gardening, the preference when growing commercial *A. esculentus* varieties is for earliness with flowers appearing from the fifth leaf onwards. Farmers do not want these plants to produce long branches and would rather opt for more plants/area unit. Short branches with flowers are, however, welcome. Also, a short internode length is appreciated.

Any recommendations derived from varietal performance trials on West African okra will only be valid for a zone with similar daylength. This means that results obtained in, for example, Upper West Ghana cannot be used in the Ashanti region or southern parts of the country. Plants with the shortest critical day-length requirement are found near the equator, such as in Cameroon and Gabon.

SEEDS

Most farmers collect their okra seed from the remnants of a commercial or subsistence crop and rarely produce seed from a crop which is specifically grown for seed only. Few farmers buy their seed from the market. Seed dealers will stock mainly imported okra seed and only very few companies, such as those in Senegal, will offer seeds from locally selected varieties. The Asian variety Pusa sawani is multiplied in Kenya and offered by the East African Seed Co., but no research is being carried out to develop local varieties.

Farmers usually collect mature ripe pods that have turned brown or, for some cultivars, grey, and show symptoms of splitting. Pods can be spread on sheets of cloth or similar material to dry further. Excessive drying of okra may cause hard seed. Seeds from both species can be dormant for at least 2 months, especially those found in the drier regions. This is not usually a drawback because of the time lapse between the growing seasons.

In most areas, farmers traditionally extract the seeds just before planting. This method, where seeds are stored inside the pods, is said to give the best germination. Such pods are tied together with a piece of rope and hung in such a way that rodents will not have access to them. Seeds can be stored for up to 5 years, as long as they are well dried (moisture content of 10% or less) and moisture is kept out. Seeds are not significantly affected by high temperatures, but high humidity will ensure rapid deterioration.

The pods should be threshed when dry and brittle. Within a single pod there are seeds at various stages of ripening. Young and immature seeds should be removed during the seed cleaning process.

Okra fruit can be attacked by insects, especially the cotton pine bollworm, *Pectinophora gossypiella,* which attack the fruit when they are ripening. In places where such pests are a major hazard, it is wiser to open the pods soon after harvest to collect the seeds. Some farmers place mothballs between the seeds or pods to prevent or reduce further insect damage.

Most varieties have about 15-25 seeds/g and some small-seeded varieties may have as many as 50 seeds/g. No exact data are available on seed yields for West African okra. The number of seeds/pod varies from about 20 to about 150, depending on the fruit volume, with an average of about 80 seeds/pod (*see* Figure 77). Seed yields for common okra in Kenya are about 600 kg/ha. In Senegal, seed yields range from about 500 to 1300 kg/ha with an average of 800 kg/ha.

Figure 77 The number of seeds per pod varies from about 20 to about 150 seeds

Some seed-borne diseases, such as *Ascochyta* pod spot, are common on okra seeds. Seed treatment with Thiram or Capstan mixed with 2% Actellic dust will help control these pests and pathogens. Treated seed should be stored in suitable containers

such as varnished earthenware pots, gourds or plastic or glass bottles with tight-fitting covers. To keep the seeds as dry as possible, they should first be placed in a polyethylene bag before being placed in the container.

AGRONOMY

Crop requirements

A well-drained sandy loam with a pH of 6-6.8 is ideal for growing okra. It does not grow well on clay soils, in swampy areas or on acid soils (*see* Figure 78). Okra is moderately tolerant to salinity, particularly *A. esculentus,* which originated in a semi-arid environment where salt is often encountered at the soil surface, and more so than *A. caillei* which is found in the humid forest belt. The crop does not grow well when temperatures drop below 20 °C, especially *A. esculentus,* which likes plenty of sunshine and does not do well in the shade. It can tolerate high temperatures, but heat coupled with low humidity slows down growth considerably.

Figure 78 A crop grown on soil with a low pH

Land preparation

The crop should be planted on prepared ridges when it is to be irrigated; alternatively seeds can be sown on flat beds to make maximum use of available rains. Growing okra on the same piece of land where okra or other members of the Malvaceae family, such as cotton, roselle or kenaf, have recently been grown, should be avoided.

Okra requires a lot of nutrients to perform well. Therefore, prior to sowing, the land should be tilled and it is recommended that manure be applied at the rate of 20 t/ha and worked into the soil. Alternatively, and depending on the initial soil fertility, 250 kg/ha of NPK 15-15-15 fertilizer should be applied prior to sowing. Since *A. caillei* takes a longer time before the first flowers appear, nitrogen in the form of urea is needed during this vegetative phase in the form of a topdressing at the rate of 100 kg/ha. Potassium can be applied at the same time. Once flowers have been formed topdressing with an NPK 15-15-15 compound fertilizer is recommended.

Sowing

Okra is sown directly. Germination may take about 5 days in the more humid areas (*A. caillei)* whereas it only takes 3-4 days in the savannah belt (*A. esculentus*). In dry and warm areas farmers may soak their seeds in water overnight for up to 24 h during the cooler season to speed up germination. Any seeds that float or seeds that do not swell should be discarded to ensure a more even germination. Seeds should then be sown, or when that is not possible, surface dried with a cloth or dried in the shade. The seed cannot be preserved and should be sown once the growing point (radicle) has emerged. If the soaked seed is properly dried and not wetted again it can be stored for a week or even longer. This so-called priming induces biochemical changes in the seed which will result in more rapid germination and a stronger root system. These changes persist during the dry storage period. Once sown, these seeds will germinate more rapidly and develop a stronger root system than non-primed seeds. A good seed-soil contact is essential for an even crop establishment and it is thus important to cover the seeds with soil and to press the soil slightly. This is especially important under warm

conditions when the soil surface may become so hot that fragile young roots collapse unless they are able to reach lower, cooler levels. Rapid germination is also important for crops raised in an area with a low rainfall, to ensure better crop establishment and few gaps in the rows.

The spacing depends on the variety and duration of the crop. Early varieties which are not, or scarcely branched, could be spaced at 25 x 75 cm, whereas clearly branched varieties are usually spaced at 45 cm in the row. The taller biennial varieties are often found on their own, as a group of a few plants, or intercropped in a mixed farming system. They may be found growing spontaneously from seeds which have dropped out of pods which were not harvested. When planted in a controlled way, two or three seeds are sown per station, spaced at 75 x 100 cm. After germination, only one plant should remain and the others pulled out at the three-leaf stage. Traditional farmers may place as many as 10 seeds in a hole and expect two or three plants to germinate, which are subsequently reduced to only one or two.

Mulching

Mulching ensures that the young roots will not dry out and it will also induce the cool micro-climate that is required during the early stages. Mulching with grass or other plant material reduces evaporation and run-off after rain or irrigation. It suppresses weed development, although care should be taken not to use a mulch which includes weed seeds. It is not recommended that a mulch be applied on loamy soils or during the main rainy season, since this could cause fungal problems at the base of the stem.

Irrigation

It is most important to retain good moisture levels in the soil at the early stages of development, since it has been shown that the first month of growth determines the crop's yield potential. The more green matter that can be produced during this period the better. Plants that suffer from water stress may drop their young fruit and total yield will therefore be reduced. For high-quality fruit, irrigation should take place at least twice a week when there are no rains.

Topdressing

Okra plants need to develop strong vegetation prior to flowering. Therefore 125 kg/ha of ammonium sulphate or urea can be applied 3 weeks after sowing and again after the first harvest. Nitrogen generally favours leaf production and may delay the onset of flowers appearing.

Topping

The growth habit of tall and bushy *A. caillei* plants can be modified by removing (pinching) the apical bud when the plants are about 40-50 cm tall. Topping encourages axillary shoot production, which increases the number of fruit/plant and therefore increases yield. Such pruning also limits the height of the plant, making harvesting easier on normally tall varieties.

HARVEST AND POST-HARVEST

Fresh pods

Fruit are picked either at a very early stage of about 3-4 days from flowering, when they are tender, or when they are close to their maximum size but not yet fibrous, which is after about

6-7 days (*see* Figure 79). A good way to judge the freshness of a commodity is by snapping the tips of a few fruit. They are all right as long as they snap, but once they bend, they have probably become tough or may have developed some fibre. Fruit quality increases up to the sixth day from fruit setting before it begins to decline and the fruit becomes tough and fibrous. Most farmers opt for the larger pods because of their greater weight, but 3-day-old small immature pods may command a premium price; these are the ones that are normally used for export purposes.

Figure 79 6-7 day-old fruit of *A. caillei*

There is a distinct difference in growth rate between *A. esculentus* and *A. caillei.* The latter starts to grow slowly from the fourth day and reaches its maximum length on the sixteenth day, whereas *A. esculentus* continues to grow fast and reaches its maximum size after 10 days. Crude fibre develops much faster in *A. esculentus* than in *A. caillei,* making the latter more suitable for a later harvest. For both species it takes about 5 weeks for fruit to mature with fully grown seeds.

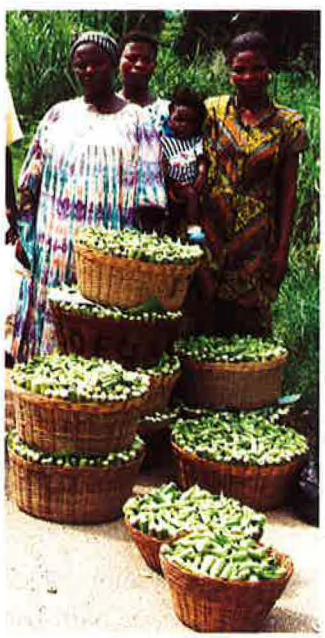

Figure 80 Okra for sale at a roadside market in Ghana

To obtain high yields a farmer will need to pick fruit regularly, since the plant will direct its energy towards seed production at the expense of new growth. When young fruit are removed, the plant will produce new flowers leading to more fruit. The optimal frequency of picking is twice or even three times a week for large plots and when there is a regular market (*see* Figure 80). Since flowers are produced on the main stem at an interval of 2-3 days, there is little point in picking fruit more frequently than three times/week.

Little damage will be done to the plant when young and snappy fruit are picked. However, when more mature fruit are ripped off the plants as a way of harvesting, serious damage can occur either by broken stems or by infection with fungi or bacteria. Therefore, it is recommended that pruning scissors or a knife be used to harvest such fruit properly.

There is little information available on yields of *A. caillei,* mainly because it is not usually monocropped. The general impression is that yields are lower than those of common okra, but since *A. caillei* often produces out of season, farmers are able to command a better price. Yields for common okra are about 4-7 t/ha when grown in the traditional way. With improved farm management and by using improved varieties such as those available in Senegal, a farmer may get 25-40 t/fruit/ha.

Leaves

Although okra fruit are by far the most commonly collected products, there are places where the leaves are at least as important as the fruit. This is the case in the Bongor region in western Chad. People mainly collect the small, young leaves or new sprouts after the fruit have been collected. The leaf yield in this area is 3-6 t/ha.

Figure 81 Okra used as a leaf crop in Uganda

Leaves are picked from both *A. caillei* plants (for example, in Benin, the north-western Côte d'Ivoire and Burkina Faso) and *A. esculentus* plants (for example, in Chad, Senegal, Sudan and northern Uganda,

see Figure 81). In northern Ghana, where fully-grown young okra leaves can be seen at the markets, people will also collect the small shoots found along the main stem, which are formed towards the end of a crop after the fruit have been harvested. Leaves may be picked as a by-product of fruit production or, alternatively, a crop is primarily grown for its leaves and young shoots. In the latter case, a first harvest consists of the main shoot, which promotes side shoot development as a ratoon crop. Thus mainly young and tender leaves will be harvested.

The leaves are cooked as for spinach and eaten as a condiment with starchy food. They are not as mucilaginous as the fruit. Villagers in Zimbabwe mix okra leaves with pods and cook these together.

Processing

Leaves can be collected for drying and these are preserved for use in the dry season. Large leaves are broken into small pieces to remove the stalks and main veins.

Older fruit are normally used for slicing. When okra cannot be sold at the market and has been left for more than 2 days, it tends to become tough and unsuitable for direct use. Processing allows these fruit to be preserved for later use. In rural areas, farmers preserve part of their harvest for use in the dry season. Fruit are sliced and dried on a rack or mat in the sun. Drying continues for several days until the okra rattles when the racks are moved. The dried okra is then put into plastic bags or gourds for storage in a cool dry place in the house. The dried product can further be ground into powder. It is possible to store both dried sliced okra and powdered okra for a long time, but most people prefer to grind the product just before use. Powdered okra is used for soups and sauces, especially to eat with meat and fish.

Young, tender fruit of 2-3 days old are dried whole. These entire pods shrink considerably and fresh fruit of 2-3 cm will turn into a dried product of just over 1 cm. These products are highly valued when compared with the sliced or ground product. In Sudan, where people collect young pods from the desert for drying, the dehydrated product is called *waika.*

PESTS AND DISEASES

Pests

Okra is host to a range of pests which can also be found on cotton, roselle and kenaf. These four crops, all of which belong to the Malvaceae family, are frequently found in each other's neighbourhoods, since they can all withstand dry and warm conditions. It is therefore important to avoid okra production near these other crops and proper crop rotation should be maintained. It is also important to weed out other members of the Malvaceae family since these can act as host for several pests and diseases.

The most common pests are flea beetles of the *Podagrica* group. These can be devastating in the early growing stages when leaves can be reduced to a mere skeleton; they will also damage the fruit (*see* Figure 82). In such a case, flea beetles should be controlled with a soil treatment of a recommended systemic carbamate. Flea beetles are especially problematic for an irrigated crop and their population is normally reduced by heavy rains.

Figure 82 *Podagrica* flea beetles do not only attack okra leaves but they will also damage the fruit

Figure 83 Okra fruit can be attacked by many different insects, including the coreid bug

Other pests include crickets, *Brachytrupes membranaceus*, jassids (*Empoasca* sp.). coreid bugs and cotton stainers (*Dysdercus* spp.) which can be a menace, especially for young plants (*see* Figures 83 and 84). Various chemical sprays can be used against these insects until flowering time, when the only recommended spraying is with pyrethroids.

The cotton bollworm, *Heliothis armigera,* is frequently found on okra and can be a serious pest when its caterpillars invade the fruit, making it unsuitable for sale. Chemical control is difficult because of the short period between fruit formation and harvest and is often more expensive than the loss of a few fruit. If necessary, spraying with carbaryl or pyrethrum-based insecticides is recommended. If available, the baculovirus *Heliothis* is a safe and effective pathogen which can be sprayed as for conventional insecticides. Other chemicals should not be used.

Many other caterpillars are found on okra, most of which are not serious. One of these is the leaf roller *Sylepta derogata,* which is usually found on the underside of a leaf (*see* Figure 85). Another more serious pest is the stem borer *Earias biplaga.* Caterpillars of fruit borers damage flower buds and young fruit which may drop prematurely. As long as these caterpillars are not serious, they can be picked off by hand or, in the case of leaf-rollers, the curled part of the leaf can be removed.

Figure 84 The cotton stainer is a common pest on okra

Root-knot nematodes of *Meloidogyne* spp. can cause stunted growth. In severe cases the roots can be badly damaged and the plant may die. Rotation with crops such as groundnut or millet or the application of manure can be used in place of artificial fertilizers.

Figure 85 The leaf roller *Sylepta derogata* on okra

Fungi

Powdery mildew, *Oidium abelmoschii,* is probably the most common fungus found on okra. White spots can cover the whole leaf, which dries out and drops as a result. Pods will be similarly affected. In high rainfall areas, premature leaf fall and dieback may result. Control may be possible with sulphur.

The leaf spot, *Cercospora abelmoschi,* another major okra disease in West Africa, is recognized by its round or angular spots of up to 1 cm in diameter which are yellowish-green in colour and later dark-brown. The underside of the leaf becomes greyish, changing to black. It is mainly found under humid conditions. It appears that some varieties are much more tolerant to this disease than others. Cercospora leaf spot can be controlled by spraying Benlate or Bavistin. Avoid splashing water when irrigating since this disease may also be transmitted by rains.

Fusarium oxysporum f. *vasinfectum,* identified by a brown discoloration of the stem when cut across, may cause serious wilting. It is a soil-borne disease and should be controlled by crop rotation. It is not recommended that seeds be collected from such plants since these may transmit the disease. Acid soils are more conducive to this disease, especially when potassium is also in short supply.

There are a number of other fungi and bacteria associated with okra that are known to be seed transmissible. The most important include *Ascochyta abelmoschi*, pod spot, and *Macrophomina phaseolina*, charcoal rot, frequently found to affect seedlings at an early stage. Also *Pseudomonas syringae*, bacterial blight, can be transmitted by means of seed.

Virus diseases

West African okra is far less susceptible to okra leaf curl virus (transmitted by the whitefly *Bemisia tabaci*) and yellow vein mosaic virus, than varieties of common okra. The okra mosaic virus, which is transmitted by *Podagrica* flea beetles, is not very important.

Generally speaking, West African okra can withstand diseases much better than common okra, which may be one of the reasons why *A. caillei* is more frequently found in high rainfall areas. This crop also requires fewer pesticides and is therefore more popular for subsistence and homesteads.

NUTRITION

In most urban markets, people prefer common okra to West African okra mainly because it is more tender and its relatively long fruit are easier to cut. Also, people tend to prefer 'modern' *A. esculentus* to the 'traditional' *A.caillei.* Interestingly, the reverse trend is now being observed, for example, in Yaoundé, where *A. caillei* is now more valued than the 'modern' types. Since *A. caillei* fruit are generally more mucilaginous than those of the common okra, they are in demand, particularly in rural villages and in the drier regions where a slimy vegetable is needed as an accompaniment to the often coarse staple food such as millet. *A. caillei* is especially popular for its ability to dry well and to retain its mucilaginous characteristics. The fruit of *A. caillei* are supposed to have more flavour than *A. esculentus*, but are considered to be rather solid.

Most okras are eaten in cooked or processed form, whereas young fruit may also be eaten fresh. People who prefer a more solid and less glutinous okra texture can add some lemon juice to the dish.

Table 10 Nutritive value of okra/100 g edible portion

	Fruit	Leaves
Dry matter (g)	10.4	10
Energy (Kcal)	31	33
Protein (g)	1.8	2.0
Calcium (mg)	90	70
Phosphorous (mg)*	56	
Magnesium (mg)*	43	
Iron (mg)	1.0	1.0
Carotene (mg)	0.1	0.99
Thiamine (mg)	0.07	0.10
Riboflavin (mg)	0.08	0.10
Niacin (mg)	0.8	1.0
Vitamin C (mg)	18	25

Source: Grubben (1977) **Note:** *from Hamon and Charrier (1997)

Okra is a good source of calcium (*see* Table 10) and a secondary use is the oil from its seeds, whose oil content is about 20%. Amino acids found in *A. caillei* seeds compare favourably with those in poultry, eggs and soya beans.

OTHER USES

Okra is also used as a source of gum and its fibres were traditionally used to make rope. The ground pulp of *A. caillei* stems is used as a stabilizer when making Pita beer in northern Ghana. Okra flowers themselves can be most attractive and can be used to decorate the home (*see* Figure 86).

Figure 86 Okra flowers can be most decorative

HIBISCUS AS A VEGETABLE

INTRODUCTION

The genus *Hibiscus* consists of some 400 species which are divided into a number of sections. The edible species found in Africa all belong to the section *Furcaria,* of which there are some 40 representatives. More than half of these originate in Africa and the remainder can be found in tropical America, Asia and Australia. The *Hibiscus* species dealt with below originate from the warmer parts of central and eastern Africa where these and related species can still be found in the wild. Both kenaf and roselle are ancient crops which are thought to have been domesticated in the headwaters of the river Niger and western Sudan some 6500 years ago (Murdock, 1995) when the rainfall in that part of Africa was much higher than it is today. The false roselle comes from south-western Africa. Roselle, kenaf and false roselle are all cultivated for their leaves (*see* Figure 87), and roselle is becoming an increasingly popular crop, particularly in peri-urban areas.

Figure 87 *Hibiscus* is frequently grown as a boundary crop. Kenaf (left) and roselle (right) can then be used for their leaves and their fibre

False roselle is comparatively easy to identify by its showy dark-pink flowers and reddish leaves, although there are forms with green leaves and yellow flowers. The difference between kenaf and roselle is less clear, because both species have highly variable leaf forms and colours. They can both have yellow flowers even though most kenaf varieties have creamy-white flowers. A short key for the three most important species that are used as a vegetable is as follows:

1. Bracteoles divided near the tip in an upper part and a lower, spoon-shaped, part. ... *Hibiscus acetosella*
1. Bracteoles (epicalyx bracts) not or not clearly forked 2
2. Calyx fleshly, often enlarged. The apex of the bracteole is channelled. Immature fruit lacking a woolly white cover. Prickly hairs absent. Seeds with a conspicuous brownish-red hilum. Calyx nectary not swollen..... *H. sabdariffa*
2. Calyx not fleshly. The apex of the bracteole is entire. Fruit with a white woolly or waxy cover. Stems with prickly hairs. Seeds with an inconspicuous yellow-brown hilum. Calyx nectary swollen ..... *H. cannabinus*

FALSE ROSELLE

Hibiscus acetosella Welw. ex Hiern

Synonym: *Hibiscus eetveldianus* De Wild. & Th.Durand

Figure 88 *Hibiscus acetosella* in Tanzania

False roselle (*Hibiscus acetosella*) is most readily recognized by its comparatively small red leaves and dark-pink blossoms (*see* Figure 88). The lower leaves are three- or five-fingered, the middle ones three-fingered and the top leaves are undivided. Some varieties have green leaves and yellow flowers, which are best recognized from similar looking roselle or kenaf plants by the spoon-shaped terminal part of the epicalyx segments and their vertical appendages. Flowers are open from early in the morning until noon, when they close.

The ancestor of *H. acetosella* is likely to be the spiny plant *H. noldeae* Baker f. *H. noldeae* and *H. acetosella* originate from south-western Africa (Angola and southern Congo (Democratic Republic)) where false roselle is a minor vegetable. It is also found as a minor vegetable in Zimbabwe, Zambia and Tanzania. This species tolerates shade, cloud cover and frequent rains much better than kenaf and roselle, which do better under fully exposed conditions.

False roselle is more popular in Central and South America than it is in Africa. Leaves can be eaten raw or cooked and have a pleasant sour taste and are also somewhat mucilaginous like roselle. It is occasionally offered as a vegetable mixed with roselle, for example, in Cameroon and other Central and West African countries. In most places roselle has taken over as the more favoured leafy vegetable because people consider the leaves of false roselle to be too sour (*see* Figure 89). Nowadays false roselle is mainly grown in south-western and Central Africa as an ornamental crop or as medicine to treat anaemia. The red juice extracted from the leaves resembles blood and is probably rich in iron. This juice is also used as a medicine to suppress fever. People in Tanzania use the leathery leaves of the local variety to make a juice. The varieties in West Africa generally have a softer leaf texture than those found in East Africa.

H. acetosella is resistant to collar canker (*Phytophtora parasitica)* and could be used for interspecific crossing with roselle. It also has a good genetic resistance to root-knot nematodes.

Figure 89 False roselle is becoming less popular because its leaves are considered to be too sour

KENAF

Hibiscus cannabinus L.

Figure 90 Kenaf, *Hibiscus cannabinus* in Ghana

Roselle and kenaf are closely related and they are both cultivated for their fibre and their leaves. Contrary to the edible fleshy calyces of roselle, the calyx of kenaf is not enlarged and the whole fruit is rather flattened and not edible. It is an annual crop of which some forms become 3 m tall and are practically unbranched, whereas others remain a low bush with many branches. Wild plants found in East Africa are tall and clearly branched with deeply divided leaves.

The tall forms with undivided leaves as seen in West Africa originated from the fibre crops which were grown there in the past. At present, kenaf jute is mainly grown in Bangladesh, India and southern China and is nowadays hardly produced in Africa. In West Africa kenaf is mainly seen as a kitchen garden crop or is used as a boundary marker. People collect the leaves for home use and sometimes include the flowers (*see* Figure 90). Shoots or young plants with their roots attached are a market gardening product as can be seen in peri-urban gardens outside Accra in Ghana.

The more bushy forms, known as *malakwang* in the Acholi language of northern Uganda are certainly not used as a fibre crop and are mainly cultivated for their fresh shoots and leaves and occasionally for their seeds (*see* Figure 91). They are called *amalakwang* in Lango.

Most Malakwang cultivars have a lamina with 3-5 shallow palmate lobes and some have a deeply cut leaf with five to seven finger-like lobes. Mature plants have small prickly hairs on the stem and petioles, but these are hardly developed in the early stages when the fresh leaves are consumed. These prickly hairs serve to distinguish them from roselle, which usually has smooth stems, although some can be hairy but not prickly. Kenaf flowers can be creamy-white, pink, light-yellow or bright-yellow. Some varieties have small flowers of about 3-4 cm in diameter and others can be as large as 7 cm. Varieties with red, finger-shaped leaves usually have pinkish flowers and pink-coloured fruit at maturity. Such pink-flowered varieties may show a tolerance to root-knot nematodes, contrary to most other kenaf varieties which are highly susceptible to nematodes.

Figure 91 Shallow-lobed Malakwang from Uganda

In northern Uganda, some Malakwang varieties are described as the white type and the green type. At present most of these cultivars are landraces, growing together in a mixture. There is a need to study the diversity presently available and to make selections from amongst the desirable types.

Kenaf grows faster than roselle which could be an advantage when it is produced as a market gardening leaf crop (*see* Figure 92) whereby it is uprooted as soon as it has reached a certain length. It is however much more sensitive to nematodes which is a major limiting factor.

Figure 92 In northern Uganda kenaf is a major vegetable sold in local markets

ROSELLE

Hibiscus sabdariffa L. var. *sabdariffa*

Roselle is used for many different purposes, the most common of which are as a fibre crop, a refreshing beverage and a leafy vegetable (*see* Figure 93). As a vegetable crop it is mainly known from the savannah and semi-arid areas in Africa. In the savannah areas of Côte d'Ivoire, Ghana and Burkina Fasso it is the most important leafy vegetable and is extensively cultivated. Its use as a fibre crop is mostly in southern Asia where it is referred to as *mesta.*

In Asia it is used as a substitute for jute and its pulp is suitable for the manufacture of newsprint. The dried red calyces are commonly used as a tea, drunk either hot or, more commonly, cold, after adding some sugar. This beverage is rather sour, hence its refreshing taste. It is very popular especially in north-eastern Africa, but also in the Caribbean area. The crop is gaining in popularity in the Americas, where the calyx is used for making jelly, jams and beverages and for making food colorants and chemical dyes. The fresh succulent calyces can also be used to make a kind of chutney, together with ginger, pimento and other spices. In Chad, one of the reasons for growing this crop is for oil. This oil is mainly used for cooking purposes, but can also be used as an ingredient for making paints. Further uses are in the medicinal field where Karkadé tea is used to suppress high blood pressure. The plant's leaves are a source of mucilage used in pharmacy and cosmetics. Of recent interest is its ornamental value; farmers in Israel are trying to promote it as a cut flower.

Figure 93 Roselle grown for its leaves

Roselle is rarely encountered near the equator because as a day length-sensitive crop, flower initiation only takes place during periods when the day length dimishes. This is the principal reason why kenaf and the false roselle are the main *Hibiscus* species that are used there as leaf crops. Roselle is far less commonly grown south of the equator, for example, in Congo Kinshasa, Zimbabwe and South Africa, and is hardly found as a vegetable in East Africa where several related species can be found in the wild. Some African names are: *beri* in the Dagari language, *isapa* in Yoruba and as *sour-sour* in Sierra Leone. In a number of Sahelian countries it is called *dah,* whereas in Senegal and surrounding countries it is referred to as *bissap.* The French name is *oseille de Guinée* or roselle. In the Caribbean area the crop is known under the name of Jamaican sorrel or Florida cranberry.

For this section, emphasis has been placed on its food value, specifically its use as a vegetable, both for its leaves and for the edible calyces of the cultivar group Sabdariffa. Plants of this cultivar group are usually branched and do not grow much higher than about 2 m; the calyces are glabrous. The calyx of var. Altissima, the group of varieties that are mainly used for fibre production, is not edible and often hairy or even spiny. This group of varieties is usually much taller and is not or barely branched.

The species *Hibiscus mechowii* Garcke, which can be found from Angola to West Tanzania is thought to be a primitive form of *H. sabdariffa* (Edmonds 1991). Angola is likely to be the primary centre of dispersal for this species and therefore also for roselle. *H. mechowii* is collected from the wild and eaten in Zambia and Zimbabwe.

VARIETIES

There are many different varieties of roselle, although only a few vegetable types have been given a specific name, possibly because of the mixtures in plant populations which can better be called landraces. Considering the high level of self-pollination, it should be relatively easy to produce a uniform crop.

Figure 94 Some roselle varieties have finger-like leaf shapes

It is very hard to distinguish between kenaf and roselle during the early, non-flowering, stages. Shoots of kenaf, roselle and even false roselle, are frequently offered as one bunch, especially when there is a mixture of leaf types, as will often be the case.

Varieties can be distinguished by three different colour groups: green, green and red and dark-red. There are also significant differences in the plant structure including plant height, although these are influenced by the spacing between plants. There are two leaf groups: the shallowly incised 3-lobed ones and the deeply 5 (or 7) lobed finger-like ones (*see* Figure 94). Also the petal colour will allow differences to be recorded which range from creamy-white through yellow to orange. Most varieties have yellow flowers with a distinct dark-red staminal column, but the staminal column of some cultivars is light yellow (*see* Figure 95).

Figure 95 Roselle variety with a yellow staminal column

According to Stevels (1990), roselle plants with anthocyanin pigmentation are able to withstand the harsh Sahelian environment better than plants with a yellow-green colour. Red types are more drought tolerant than green types and suffer less from *Oidium abelmoschi,* powdery mildew. Under these conditions they are generally more vigorous than the green types, which are, however, more appreciated for their leaves. Green types do better under more humid conditions, but suffer more from powdery mildew.

Roselle varieties may differ in the colour of the calyces, which range from green to red and even purple. Shapes of the calyx can be long or short, conical or not conical, etc. In Senegal the most commonly grown red calyx variety is called Koor. The dried calyces of this variety are mainly used for *bissap* production.

RELATED SPECIES

Leaves of the wild sorrel, *Hibiscus asper* Hook.f., are collected from the wild by those families who do not grow roselle on their farms, for example, in northern Ghana (*see* Figures 1 and 96). It is frequently offered at roadside markets at a reduced price in comparison with the cultivated roselle. The taste is rather similar. In Senegal, people have selected one variety with narrow leaves which is now being cultivated. This species is likely to be one of the parents of the allotetraploid *H. sabdariffa* and is also referred to as the false roselle.

Figure 96 *Hibiscus asper*

Figure 97 Dried roselle capsules used for seed extraction

SEED

For roselle, seeds can be a by-product of the collection of calyces. When the calyx is removed, a 5-loculed capsule may be left to dry so that seeds can be extracted at a later stage. However, this will produce poor-quality seeds. It is better to concentrate on the production of calyces and to leave seed production to the seed specialists. Some farmers will remove the calyces as late as possible to obtain both products. Resulting seeds may not be properly filled and are likely to have a low germination capacity. Since a farmer is able to produce a large quantity of seeds this is not necessarily a problem. Roselle capsules are spread to dry in a thin layer on a sheet, on a cement floor, mat or similar place, preferably in the shade, to avoid over-heating of the seeds (*see* Figure 97). The capsules are crushed by hand to separate their seeds, followed by a simple winnowing process.

Figure 98 Fruit of the pink-leaved kenaf

Kenaf fruit (*see* Figures 98 and 99) are plucked and dried in the shade for a limited period to avoid insect damage; after which the fruit are put in a bag and the bag is beaten until the seeds are freed. Calyces strongly adhere to the capsule and it is therefore less easy to crush these by hand, so that a mechanical device is preferred. A winnowing process ensures further separation. The 5-locular capsules contain 3-4 seeds/locule. There are about 75-80 seeds/g.

Figure 99 Similar fruit of the green-leaved kenaf

The capsules of false roselle often have needle-like stiff hairs on the outside, making seed extraction by hand a tedious job. There are 1–3 seeds in each of the 5 locules. Since there are often several flowers and fruit/node, the potential seed yield can be very high.

When it rains towards the end of a cropping season or when the humidity is high, there is a chance that seeds will germinate within their capsules. Seeds need to be stored in a dry container, to prevent them from regaining humidity from the air or otherwise. Care must also be taken to avoid exposing the dark-coloured seeds to direct sunlight, especially when the temperature is high, to avoid 'cooking' the seeds. If stored well, seeds will maintain their germination capacity for at least 3 years. Dormancy can be a difficulty and as a result it is not always possible to use fresh seeds. This is especially the case for the red varieties of roselle; less so for the green ones.

It is possible to obtain between 400 and 600 kg of roselle seed/ha for the green calyx varieties, whereas the red-calyx variety Koor can easily produce 1000 kg/ha, equivalent to 300 l of oil. Some roselle varieties have very large capsules, each with well over 100 seeds.

In the Plateau region of Nigeria people ferment roselle seeds to make a cake to be used as 'sorrel meat' or *iyu* as it is called by Tarok people.

Kenaf seeds are used as food in northern Uganda. Here seeds are first roasted and then ground with a grinding stone, followed by a pounding process. The fine powder is then put into water where, after a while, the skin parts float and the flour settles at the bottom. The floating skin parts are collected and further separation is effected through stirring. Only the skin parts can be used and the flour is thrown away, since it is considered as too coarse for human consumption. The skin parts are used to make a special paste which is a local delicacy. This paste is mixed with boiled pigeon peas to which smoked fish and some green vegetables are added.

BREEDING

Hibiscus species are highly self-pollinating and the landraces consist of a wide range of varieties, allowing ample scope for the breeder (*see* Figure 100). According to Seck (1997) chances of cross pollination for roselle are only about 0.3%. The pollen is only viable for a short period beyond anthesis, whereas the stigma is receptive shortly before and for a full day after the opening of the flowers. The five capitate stigmas found at the end of a staminal column are red or occasionally yellow in colour. Flowers open early in the morning at dawn. At anthesis, pollen is freed and may contact the stigma. The pollen tube grows rapidly and reaches the embryo sac after about 1.5 minutes and fertilization can be completed within a few hours.

Hibiscus species can be improved through a pedigree method and by backcrossing.

Figure 100 *Hibiscus* landraces consist of a wide range of varieties, allowing ample scope for a breeder

Pedigree method

The pedigree method is generally used when a certain number of dominant characters are to be combined from two parents into a new variety. Generally speaking, an F1 is selfed to obtain the F2. Plants from one F2 compose a line or family. Each F2 plant will then be selfed again and selections made between and within the different families. This process is followed with selfings until the Fn generation, at which time varieties are stable enough to be tested for release.

Backcrossing

The backcrossing method is more appropriate when a limited number of dominant genes (1 or 2) are involved. The variety to be improved is called the recurrent parent, with the second variety called the donor parent. The two genotypes are crossed to obtain the F1 which is backcrossed with the recurrent parent as many times as needed, resulting in a series of backcrosses (BC1, BC2, BC3, ..., BCn). At each generation, plant selection will be based on the useful characters of the recurrent parent and the trait(s) to be transferred. If the latter is controlled by a recessive gene, recognizing plants with the new character will be difficult unless backcrossings are associated with the selfing of each plant. Eventually, when some new lines are very close to the recurrent parent, selection can proceed through a pedigree method to stabilize them.

Some notes on inheritance

Narrow-lobed leaf shapes are dominant over the shallowly incised, broad-lobed leaf shape of most edible types. Each leaf type is monogenically inherited. For roselle, glabrous calyces are dominant over hairy ones. Acidity and anthocyanin content are not correlated.

Cytogenetics

The basic chromosome number of *Hibiscus* is n = 18. Both *H. cannabinus* and *H. asper* are diploid (2n = 36), whereas *H. sabdariffa* and *H. acetosella* are tetraploid with 2n = 72. Diploid, tetraploid, hexaploid, octoploid and decaploid taxa are found amongst related wild species.

Crosses between species

It could be useful to incorporate the genes for resistance to root-knot nematodes as found in the tetraploid *H. acetosella* into the nematode-susceptible diploid kenaf, *H. cannabinus.* Hybridization between these species was found to be relatively easy, but the resulting triploid plants are sterile. These hybrids could be developed further into a fertile allohexaploid although this has been found to be agronomically unsatisfactory (Wilson and Menzel, 1964).

AGRONOMY

Leaf crop

The crop can be sown at any time of the year as long as there is water available. For drier regions or in places with a short rainy season it is advised to prime seeds prior to sowing by placing them in water overnight before sowing. See further under *Sowing (okra)* (p.112). Roselle crops which are only grown for their leaves are found as a monocropped market-gardening crop and not usually as a home garden

crop. The latter does not apply to kenaf. In Uganda, Malakwang is often intercropped with sesame, peanuts or finger millet. Malakwang is usually sown with the first rains in March and a second sowing takes place in August. It is important to plant early to make maximum use of available water. However, many subsistence farmers give priority to their starchy staple crops and will only attend to their vegetable crops when their main food crop has been established.

The crop is either broadcast or seeds are sown, two or three at a time, with spacings of about 15 x 15 cm. Alternatively the crop is sown in lines which are 30 cm apart. After a first thinning the spacing in the line will be about 5-7 cm. The spacing for seed plants is 60 x 60 cm. *Hibiscus* does not respond well to transplanting because of its tap roots.

Figure 101 Young *Hibiscus* plants

Germination takes 7 days, longer than most other vegetables. It takes 3-4 weeks from germination to the first harvest (*see* Figure 101). As a first thinning, plants of about 20 cm are pulled out and marketed with their roots attached. When ratoon cropping is practised, the second harvest is at the 6-week stage (2-3 weeks after the thinning round) when the top will be plucked about 6-8 cm from the soil or just above the third leaf. Two to three side shoots will then develop which are collected during the third harvest after another 2-3 weeks. There can be a total of four harvests of shoots or even five when conditions are favourable. After that, only loose leaves are collected, mainly for home consumption, since loose leaves are highly perishable and thus are not appreciated at the market. These leaves come from plants that are reserved for either their calyces or for seed production.

A far more common method is to uproot young plants altogether to sell at market with their roots attached. Such harvests are less perishable because it is easy to keep the plants fresh by placing the roots in water. When the roots have been removed it is less advantageous to place the bundles in water since they are likely to rot. The uprooting method is the most common and is especially seen as a commercial activity in peri-urban market gardening.

The crop is sold as bunches with a shoot length of up to 50 cm long. A total yield of shoots can be about 2 kg/m^2. A bunch has about 25-50 stems during the rainy season, whereas during the dry season, with inadequate irrigation, a bundle may contain up to 100 stems.

In cultivation, the Malakwang crop does not get a chance to grow taller than about 50-70 cm. However, when left totally undisturbed, it grows to over 2 m and the prickles become strong. Kenaf varieties with undivided leaves can easily grow to 2 m high and are frequently seen taller than that. The top leaves of kenaf plants with shallow or deeply-lobed leaves and also those of the false roselle are no longer lobed, but are long or ovate in shape. When the leaves grow old they become tough and fibrous.

Roselle crop grown for its calyces

When grown mainly for its fleshy calyces, roselle is usually found either in long rows as a plant marking the border between plots, or as individual plants in kitchen gardens. In home gardens, people use roselle as a multi-purpose crop; the leaves are plucked in the early stages and the calyces later on.

The crop is sown at a spacing of about 50 x 70 cm, with a wider spacing resulting in shorter plants with more branches and more fruit/plant. However, a narrower spacing will give a greater fresh calyx weight/unit area. Some farmers plant in double rows and thin out to have two plants/hole rather than one.

Sowing dates may vary from early June to mid-August, depending on the location, with the earlier dates closer to the equator (such as in Cameroon) and later dates closer to 15° latitude. The crop is not much grown south of the equator but, where this is the case, the sowing dates are in the opposite direction, for example, in Zimbabwe it can be sown from February onwards to coincide with the critical day length requirement. In Sudan, large monocropped plots may be found where the calyces are used for processing.

Figure 102 The fresh roselle calyx is the most sought-after part of the plant

The ring-shaped calyx bracts are the most favoured part of the crop (*see* Figure 102). The green or fresh calyces can be collected from about 2 weeks after flowering, or about 100 days from sowing. It is better to wait a bit longer with the first harvest until the capsules are more developed, so that their seeds can be used as well. The yield of fresh calyces can be about 4 t/ha and sometimes more. In Senegal the average yield of dried calyces is about 500 kg/ha for the variety Koor.

Seed treatment before sowing

A common disease encountered is *Phytophtora parasitica* which can be controlled effectively by dry seed treatment with Dithane M-45 at a concentration of 3 g/kg seed. Few farmers use this method, which is one reason why so many seeds are needed to establish a crop. The number of seeds required can be further reduced by soaking the seeds in water, 24 h before planting. Floating seeds and those seeds that do not swell up adequately can be discarded. After the selected seeds are sown, a uniform stand can be expected. It is essential to sow such seeds on pre-irrigated land or immediately after the rains. Alternatively, the planting holes should be given water soon after sowing, otherwise the crop will be lost.

Fertilization

Hibiscus responds well to manure or fertilizers, but few farmers, other than those growing for the market, are prepared to invest in this crop. Where possible, manure is preferred at the rate of 10-20 t/ha because manure also contains nutrients like sulphur, magnesium and calcium which are required above the NPK found in artificial fertilizer compounds. If there is no manure available, an initial application of 250 kg compound fertilizer/ha is recommended. When growing a leaf crop an additional application of 100 kg nitrogen/ha is needed as side dressing. To obtain a good yield of calyces, it is further recommended that a compound fertilizer be applied at the 6-week stage.

Environmental requirements

Both kenaf and roselle perform best in soils with a pH of 6.5–7; acid soils do not suit them (*see* Figure 103). Neither do they flourish in poorly aerated or swampy soils; sandy loam soils are the best. Pure sand with only a low humus content will not adequately retain water and is therefore not suitable unless irrigation facilities are available.

A leaf crop requires a higher rainfall than a calyx crop and responds well to regular irrigation. A rainfall of 600-800 mm is enough for the vegetative phase of a calyx crop, but at least 1000 mm will be needed for a leaf crop which is to be ratoon harvested.

Figure 103 Acid soils cause a discoloration of *Hibiscus* leaves

Both crops need high temperatures of about 25-32°C for an optimum performance and they can tolerate very warm conditions. During experiments carried out in India, roselle was found to be sensitive to low temperatures at all growth stages. Plant growth stopped at 14°C and death occurred after 15 days. At 10°C the plants only survived for 2-3 days.

Roselle is day length sensitive. Flower initiation starts at a critical minimum day length and continues when the day length gets shorter. When flower buds are formed too early they will abort when the critical minimum day length has not been met. Roselle does not flower when the day length increases, such as in spring. For this reason the crop can only produce calyces in the Caribbean area in the months of November to January. These calyces are considered a delicacy for Christmas. In the southern hemisphere, for example, in Zimbabwe, roselle can be seen flowering from March to May. The photoperiod is variety specific.

Roselle and kenaf are annual crops, although some plants in home gardens seem to be able to survive for at least 2 years when the main stem reaches 4 cm in diameter and looks woody.

PESTS AND DISEASES

There is considerable similarity in pests and diseases of roselle and kenaf, and to some extent also with those of the two okra species and with cotton (*see* Figure 104). When pests and diseases are encountered which are not mentioned below, reference could be made to the literature on these crops. However, care should be taken with the safety period for pesticides, which are recommended for cotton but may well be dangerous to use on a leafy vegetable crop.

Figure 104 Malakwang is prone to pests and diseases

Hibiscus appears to be highly attractive to different species of *Podagrica* beetles which attack the leaves and are particularly troublesome in the early stages, when mere skeletons of leaves can often be seen. Traditional control measures include a dusting of wood ash over the leaves. *Podagrica* beetles are mainly found on a monocrop and when inadequate care has been taken, such as faulty proper crop rotation. *Podagrica* infestation is most serious when crop growth is retarded by, for example, inadequate soil moisture or insufficient rains (*see* Figure 105).

Figure 105 *Podagrica* beetles are a major nuisance on *Hibiscus*

The incidence of jassids, *Amrasca biguttula* and *Jacobinsca lybica,* is more serious when cotton or okra crops are present and the same applies to diseases like the okra mosaic virus or another okra disease, *Colletotrichum abelmoschii.* Pests found in cotton such as *Pectinophora gossypiella* will leave the cotton when their boll surface gets too hard and they will move over

to roselle or okra (they actually prefer the softer fruit of okra). *Earias insulana* is a major pest of cotton and also appreciates roselle capsules.

In Senegal, leafhoppers are a particularly serious problem during the months of June to October when it is hot and dry. Also cotton aphids, *Aphis gossypii,* can be a major problem for both the leaf crop and the calyces.

An important disease during the rainy season is *Phytophthora parasitica* which can be effectively controlled by dry seed treatment with Dithane M-45, followed by soil drenching twice at 0.2% at an interval of 15-20 days. Kenaf is resistant to *Phytophtora* sp. and hybrids between kenaf and roselle are possible, allowing a transfer of these resistance genes from kenaf to roselle.

In poorly drained soils, or in otherwise damp conditions, damping off caused by *Pythium aphanidermatum* is common. The mildew disease *Oidium abelmoschi* is mainly found on leaves when the calyces are nearly ready to be harvested. The powdery mildew *Leveillula taurica* causes small white spots on the underside of leaves. These diseases are of little concern to most farmers since they hardly affect the calyces and are not often seen on an early crop grown for its leaves.

Cercospora abelmoschi and *Cercospora hibiscina* show indefinite yellow spots which first appear on the upper leaf surface followed by a browny-black mould on the lower surface. Leaves then roll, wilt and drop. *Cercospora* mainly occurs in the more humid areas or during the long rains. It can be seed borne and is also transmitted by splashes of rain. *Colletotrichum hibisci* mainly affects kenaf.

Charcoal rot, *Macrophomina phaseolina* is another disease affecting roselle.

A virus disease found mainly in the more humid areas is the small vein thickening virus which is transmitted by the whitefly *Bemisia tabaci.*

Purple or pink-flowered kenaf varieties have been found to be resistant to root knot nematodes (*see* Figure 106).

Figure 106 A cross between kenaf and false roselle is resistant to nematodes

NUTRITION

Calyx bracts are used as a vegetable in only two, unrelated, species: globe artichoke and roselle. Whereas for globe artichoke the bracts of young flower buds are used, for roselle the whole older fruit are plucked including the succulent calyx and the capsule. The bracts should be detached from the base of the calyx on the same day that they are harvested. If this manually tedious process is delayed, there can be difficulties after plucking, since separation becomes difficult when the product is no longer fresh and brittle. Care must be taken to ensure that the calyces are whole, since broken produce is difficult to sell. The bracts are often dried for use in the dry season when there are no green vegetables available. They can be reconstituted when placed in water. Calyces are cooked in water with palm oil and some groundnut paste or shea butter to make a delicious sauce which is somewhat sour in taste. This sauce is added to the starchy staple food.

The red dried calyces of related varieties are used as a refreshing drink in the Sudan, in Egypt and in similarly hot central and northern African countries where it is referred to as *karkadé*. In Sudan, there is a bottling plant where this *karkadé* is processed into a carbonated beverage. A syrup can be prepared from the very sour red calyces by placing them in boiling water together with a relatively large amount of sugar and cooling the drained product. A refreshing beverage is made from this syrup by adding cold water. Traditionally, calyces were chewed on to alleviate thirst during long desert trips.

When preparing leaves as food, the leaves are either lightly cooked as a spinach, or finely cut and used in soups and sauces, where *Hibiscus* is appreciated for its pleasantly sour taste. For nutritional content of fresh roselle leaves, *see* Table 11. Leaves are also used to make 'draw soup' which is rather mucilaginous in texture. The green *Hibiscus* types are more appreciated for use as a 'spinach' than the red types, which are more often used in sauces. Some varieties have very sour leaves, in which case the cooking water is discarded and replaced with fresh water. Alternatively, people may add sodium bicarbonate to the leaves as a neutralizer.

Table 11 Nutritional content of fresh roselle leaves (per 100 g)

Water	85 g
Protein	3.3 g
Fat	0.3 g
Carbohydrate	9 g
Fibre	1.6 g
Calcium	213 mg
Phosphate	93 mg
Iron	4.8 mg
ß- carotene	4.1 mg
Vitamin B1	0.17 mg
Vitamin B2	0.45 mg
Niacin	1.2 mg
Vitamin C	54 mg

Source: PROSEA (1993)

The calyces have much lower protein and vitamin content when compared with the leaves and contain about 4% citric acid. The young leaves are known to be rich in digestible protein.

The leaves and flowers of kenaf are used as vegetables and seeds are used both for their oil and to prepare a delicious paste which is used when eating fish or meat. The powdered leaves are used medicinally to treat Guinea worm sores.

The oil content of roselle seeds may vary from 25% to 35%. The oil is used for cooking and to prepare sauces, or occasionally for industrial purposes. It has similar properties to cotton seed oil and contains 30% to 35% protein.

In Uganda, kenaf leaves are often dried in the sun and the dried product can be preserved for a long time. The dried leaves are a valuable commodity and are sold at the market, especially during the dry season, when there are no fresh leaves available.

BIBLIOGRAPHY

BLENCH, R. (1997) *Agriculture within the cultural system of the Tarok people of East Central Nigeria.* London: ODI.

BRAUN, M. (1990) *Probleme des Pflantzenschutzes im Kleinbauerlichen Gemusebau des Zentralsudan, unter besonderer Berucksichtigung Soziookonomischer Aspekte.* Thesis, Hohenheim University.

BOULANGER, FOLLIN, J. C. and BOURELY, J. (1984) *Les* Hibiscus *Textiles en Afrique: Première Partie: Conditions Particulières de la Production de Kénaf et de la Roselle Coton et Fibres Tropicales.* Paris: CIRAD/IRTC.

CHARRIER, A. (1984) *Genetic resources of the genus* Abelmoschus *Med.* Rome: IBPGR.

CHHEDA, H.R. and FATOKUM, C.A. (1990) Studies on okra germplasm in Nigeria. pp. 21-23. In: *Report of an International Workshop on Okra Genetic Resources, New Delhi India, October 1990. International Crop Network Series No.5.* Rome: IBPGR.

CRITCHLEY, B.R. (1988) *Pests of Vegetable: their Identification and Control in Ghana.* Chatham, UK: Natural Resources Institute.

DENTON, L. and NATH, P. (1978). *Vegetative Growth and Fruiting Pattern in Okra.* Ibadan: NIHORT.

EDMONDS, J.M. (1991) *The Distribution of* Hibiscus *L. Section* Furcaria *in Tropical East Africa.* Rome: IBPGR/IJI.

GRUBBEN, G.J.H. (1977) *Tropical Vegetables and their Genetic Resources.* Rome: IBPGR.

HAMON, S. and HAMON, P. (1991) Future prospects of the genetic integrity of two species of okra cultivated in West Africa. *Euphytica,* **58:** 101-111.

HAMON, S. and CHARRIER, A. (1997) *Les Gombos.* in: *L'amélioration des Plantes Tropicales.* Montpellier, France: CIRAD-ORSTOM.

IBPGR, (1991) *Report of an International Workshop on Okra Genetic Resources.*

M'BAYE, F. (1994) *Contribution a l'étude des Possibilités deCréation et de Production de Varieties Commerciales Hybrides de Gombo.* Memoire de fin d'études pour l'obtention du Diplome a l'ingénieur des Travaux Agricoles. Dakar, Senegal: ENCR.

MURDOCK, G.P. (1995) *Africa, its Peoples and their Culture History.* New York, Toronto, London: McCraw-Hill Book Company, Inc.

NDOUR, C. (1997) *Contribution a l'étude des Possibilites d'amelioration Genetique du Bisaab.* Mémoire de fin d'étude pour l'obtention du diplome a l'ingénieur des travaux agricoles. Dakar, Senegal: ENCR.

OYOLU, C. (1981) *Patterns of Chemical Composition in Vegetable Species with Special Reference to Okra.* Ibadan: NIHORT.

ROZI, A.I. (1993) *Etudes des Possibilites d'amelioration Genetique et de Diversification du Materiel Vegetal de Gombo, Cultive au Sénégal.* Memoire de fin d'études pour l'obtention du diplome a l'ingénieur des travaux agricoles. Dakar, Senegal: ENCR.

SECK, A. (1997) Seed production and storage of indigenous vegetables. pp. 81-87 in: *Workshop Proceedings, NRI African Indigenous Vegetables Workshop, Limbe, Cameroon, January 1997.* SCHIPPERS, R.R. and BUDD, L. (eds). Chatham, UK: Natural Resources Institute.

SIEMONSMA, J.S. (1982a) West African okra—Morphological and cytogenetical indications for the existence of a natural amphidiploid of *Abelmoschus esculentus* and *A. manihot. Euphytica,* **31:** 241-252.

SIEMONSMA, J.S. (1982b) La Culture du Gombo *(Abelmoschus* spp.) *Légume-fruit tropical avec référence spéciale a la Côte d'Ivoire.* Thesis, Wageningen Agricultural University.

SIEMONSMA, J.S. (1991) *Abelmoschus*: a taxonomical and cytogenetical overview. 16 pp. in: *Report of an International Workshop on Okra Genetic Resources, New Delhi, India, October 1990. International Crop Network Series No. 5.* Rome: IBPGR.

SIEMONSMA, J.S. and KASEM PILUEK (1993) *Plant Resources of South-East Asia (PROSEA), Vol.8: Vegetables.*

STEVELS, J.M.C., (1990) *Légumes Traditionnels du Cameroun, une Étude Agrobotanique.* Wageningen Agricultural University, Wageningen.

WILSON, F.D. and MENZEL, M.Y. (1964) Kenaf and Roselle. *Economic Botany,* **18:** 80-91.

van der ZON, A.P.M. and GRUBBEN, G.J.H. (1976). *Les Légumes-Feuilles Spontanés et Cultivés du Sud-Dahomey.* Amsterdam: KIT.

SESAMUM

Sesamum spp. and *Ceratotheca* spp.

INTRODUCTION

In Africa, there are approximately 25 *Sesamum* and four *Cerathoteca* species, many of which are used for their leaves or for seeds. They are mainly collected from the wild and only cultivated to a limited extent. They are often found as 'undisturbed weeds' near villages. The genus *Cerathoteca* has fruit with two lateral horns at the apex, which open into four horns, whereas *Sesamum* has capsules with a single terminal beak.

Figure 107 *Sesamum angustifolium*

Three species: *Sesamum radiatum* Thonn. ex Hornem., *Sesamum angustifolium* Oliv. (*see* Figure 107) and *Ceratotheca sesamoides* Endl. are frequently cultivated in savannah or semi-arid areas throughout the continent. The crop is mainly grown for its leaves and young shoots, contrary to the related simsim, *Sesamum orientale* L. (=*S. indicum* L.), which is almost exclusively grown for its oilseeds in semi-arid regions. *Sesamum orientale* L. can still be found in the wild.

S. radiatum is collected from the wild and is occasionally cultivated in the middle belt and northern Nigeria, but also in Ghana, Cameroon and in drier parts of East Africa such as northern Uganda and Kenya. It is much appreciated by the Hausa people and the Muslim population. It is very tolerant of dry conditions.

S. angustifolium is more common in southern Africa and is called *renyanguru* in Shona (Tredgold, 1986). *Ceratotheca sesamoides* is frequently cultivated in northern Cameroon, Chad and the drier parts of Nigeria and also in the Sahelian zone. In Zambia, leaves of *Cerathoteca sesamoides* are collected from the wild from November until the following April, some of which are dried for use in the dry season from May till October. The Fulani people use the mucilage of this crop for plastering their walls (Harlan *et al.*, 1976). In Zimbabwe, leaves are used from the larger *Cerathoteca triloba* (Bernh.) Hook. f., which is also collected from the wild.

In Zimbabwe, people prefer to dry leaves of *Ceratotheca* spp. in the shade or inside the house to avoid direct sunlight. The reason for this is that the hot sun affects the flavour and taste and also the colour of the dried produce.

There are indications that *Sesamum* and *Ceratotheca* species have been more frequently cultivated in the past, but it is presently on the decline as a leaf crop, partly because of increased production of the sesamum oil seed crop and the availability of other mucilaginous crops such as *Corchorus* and okra.

AGRONOMY

Pollination and varieties

Attempts have been made to select varieties which have a more pleasant odour and are more suitable as a vegetable. The pollination of these species is similar to that of simsim. At anthesis, when the flower opens at sunrise, the bifid stigma separates and becomes receptive to pollen (Purseglove, 1968). These stigmas are covered with pollen, which is simultaneously released during anthesis, resulting in self-pollination. There is a limited amount of cross-pollination caused by insects, probably resulting in an outcrossing percentage of no more than 1%. If breeding is attempted, early emascualtion is essential, since it has been observed that the first pollen can be shed before the flowers are open. Pollination needs to be done by hand.

Seeds

Pods are collected at physical maturity, but before they open, and are left to dry on a plastic sheet or similarly large surface from which the seeds will not disappear when they shatter from their pods. This drying takes about 2 weeks. The seeds will then be stored in a container until just before the rains. These seeds can be used for sowing or sold at the market as food. Seeds can easily be stored for longer, provided they are kept dry, and will still germinate after 1 or 2 years.

Nursery

Seeds are broadcast in a nursery and selected seedlings are then transplanted about 2 months after sowing. Seedlings may grow faster when some manure has been applied to the soil. Transplanting is usually in a mixed farming system and monocropping is uncommon.

Land preparation

Sesame responds well to manure and crops are often grown in areas where there have been goats, sheep, pigs, donkeys, guinea fowl, chicken or other livestock. A sesame leaf crop is rarely established as a monoculture and for that reason neither fertilizers nor manure are applied specifically for this crop. People are still able to collect sesame from the wild, so that prices for the product are usually low during the rainy season and there is thus no incentive to spend money on manure or fertilizers.

Harvest

The first harvest takes place about 6 weeks from transplanting. The first shoots will not have any flower buds. If the shoots are allowed to grow tall they may become woody and no longer succulent, rendering such shoots useless as a vegetable. Later harvests may have flowers or even small pods unless the crop is irrigated. Such bunches are less desirable and a lower price is offered for them.

It is possible to obtain up to six pickings of leafy shoots when the crop is irrigated and when fertilizer or manure are applied. The crop usually forms new shoots at the base of the plant and is therefore very suitable as a ratoon crop. Without regular picking of new shoots, flowers will soon form, which means the end of the crop. The flowers and young pods are not eaten.

USES

The leaves are used as a substitute for okra and are similarly slimy. Leaves may have a strong odour which is not always appreciated, but most of the smell disappears after cooking, when the leaves become mucilaginous. In Uganda, the leaves are always consumed with cowpea leaves and those two vegetables are usually sold together at the market. When preparing this food, sesame leaves and shoot tips are placed in boiling water, sometimes with some salt, and will be cooked for a time, after which cowpea leaves will be added. Sesame leaves alleviate the somewhat coarser cowpea leaves.

In Sahelian countries, leaves and shoots are collected during the rainy season and dried and ground to powder to be used in soups and sauces during the dry season.

Their seeds are not used for oil extraction, but are used directly in a sauce after being heated and ground.

BIBLIOGRAPHY

HARLAN, J.R., DE WET, J.M.J. and STEMLER, A.B.L. (1976) *Origins of African Plant Domestication.*

MAUNDU, P.M. and KABUYE, C.H.S. (1993) *Final Narrative Report, Indigenous Food Plants Programme,* National Museums of Kenya.

PURSEGLOVE, J.W. (1968) *Tropical Crops, Dicotyledons.* London: Longman, Green.

TREDGOLD, M.H. (1986) *Food Plants of Zimbabwe.* Gweru, Zimbabwe: Mambo Press.

STEVELS, J.M.C. (1990) Légumes Traditionnels du Cameroun, une Étude Agrobotanique. *Wageningen Agricultural University Papers 90-1,* Wageningen.

PURSLANE

Portulaca oleracea L.

Purslane is a weed with a global distribution and its primary origin is unknown. It is believed to be one of the earliest vegetables known to mankind. In Africa, this species can either be collected from the wild, where it is mainly found with prostrate branches (var. *oleracea*) (*see* Figure 108) or from cultivation where the branches are more upright and the leaves are often larger (var. *sativa*).

Figure 108 *Portulaca oleracea*

Cultivated crops are usually found in hot, semi-arid regions like Sudan where several cultivars are grown. Purslane is cultivated for its young shoots and leaves and also for its medicinal value. A few cultivars are named such as Rumi and others are referred to as 'local'. Outside Sudan it is often considered to be a weed and only a few people in sub-Saharan Africa recognize it as a potential vegetable. In northern Africa, it is much more appreciated for its slightly acid taste and here it is often consumed fresh as a salad. It is also cultivated to a limited extent in Europe, Asia and the Americas. In the Sudan, where an estimated 3000 ha are grown, yields of about 20 t/ha can be obtained, mainly under irrigation. During December and January, purslane is scarce because of the low temperatures. Its name in Arabic is *rigla.*

RELATED CROPS

In the warmer, mainly semi-arid lowland areas of Africa the related *Portulaca quadrifida* L. can be found, which is also edible, but not cultivated. It is recognized by its much narrower, pointed leaves and a ring of hair-like stipules at the base of the leaves. It has similar medicinal properties.

PESTS AND DISEASES

One disease found on purslane is the white rust *Cystopus portulaceae,* which does not affect the crop in a serious way. A common and serious pest found on purslane is the larvae of the stem weevil *Baris lorata,* which causes conspicuous galls. Other insects include larvae of the lesser armyworm, *Spodoptera exigua,* which attack the new leaves when they unfold. Whiteflies and jassids can also affect purslane.

PURSLANE AS A WEED

Since purslane is an important host plant for root-knot nematodes, any farmer will uproot it as a weed and destroy it to ensure that the seeds will not be dispersed. Seeds of *P. oleracea* and especially those of *P. quadrifida* may float on the surface of water and are not normally blocked by sieves because of their small size. As a consequence, the two species are dispersed through the irrigation system and many farmers consider them as a serious weed, despite their shallow rooting systems which make them easy to remove.

NUTRITION AND USES

Purslane has a very high water content of about 92%, comparable to the 94% of waterleaf. The calcium content is also high with 331 mg/g of the edible portion. The leaves are rich in Vitamins A and C, especially when they are collected prior to the flowering stage. The plant has a high oxalic acid content and therefore large intakes of this vegetable are not recommended. Purslane is occasionally used as a fodder plant. When sheep graze on this crop for an extended period oxalates can cause kidney blockage. The leaves have a high sodium content and, in the past, dried leaves or their ash were used as a form of salt (FAO, 1988).

Purslane is collected in South Africa for subsistence and the whole plant, including flowers and even their seeds, are consumed after being cooked, when the relish formed becomes mucilaginous. It is eaten with boiled eggs, and breadcrumbs or something similar are added. In Botswana, purslane is available in fresh form from November to March when plants are collected for drying in the sun; such dried vegetables are sold at the village markets during the dry season.

The Pokot and Turkana people from Kenya collect purslane seeds and grind these into flour, which is used to prepare a special type of porridge. This porridge has a characteristic smell, which is much appreciated.

Purslane used to be important for its medicinal value and presently is a well-recognized health food and is included in the WHO's list of most-used medicinal plants. It has anti-viral, anti-bacterial and anti-fungal properties and is used to treat a range of disorders (Siemonsma and Piluek, 1993). One of its main drawbacks is its high oxalate content (*see* further under Waterleaf, p.145). It also contains the alkaloid norepinephrine.

WATERLEAF

Talinum fruticosum (L.) Juss.

Synonym: ***Talinum triangulare*** **Willd.**

Figure 109 *Talinum fruticosum*

INTRODUCTION

Waterleaf is commonly found as a weed throughout Africa or, for that matter, throughout the tropics of the world. It may not necessarily be indigenous to Africa even though the species concerned is a common weed in most African countries. It is sometimes claimed to have a South American origin and has spread around the world during the last 300 years, but this is disputed by others. An African origin may also be possible, based on other species on the continent including the closely related *Talinum cuneifolium* (Willd.) DC, but also based on the names in different languages which do not appear to be related. Further investigations are needed. It is not considered to be a serious weed because of its shallow rooting system. The plants are common in cultivated or disturbed land, including roadsides and places near people's homes.

The most frequently cultivated species in Africa is *T. fruticosum,* usually referred to as *T. triangulare,* which occurs mainly in the wetter parts of Africa, or as a weed in irrigated crops (*see* Figure 109). *T. paniculatum* is usually encountered in savannah areas or other dry regions (see below). As the name *triangulare* implies, *T. triangulare* (or more correctly *T. fruticosum)* is best recognized by its triangular peduncles. *T. fruticosum* and the virtually indistinguishable *T. cuneifolium* are frequently cultivated.

The French name for waterleaf is *grassé.* The Yorubas call it *gbure* whereas Igbos call it *nti-oke* or *mgbolodi.* In Sierra Leone, it is referred to as *bologi* and in Cameroon it is called *elok-sup.*

RELATED SPECIES

Talinum paniculatum (Jacq.) Gartner is a biannual plant which can tolerate drought quite well. It can grow in poor soils and can be found in places such as gravel footpaths in both West and East Africa. The main distinguishing features from waterleaf are its long inflorescence of about 30-60 cm long and the dark-purple coloured stems and peduncles. The peduncles are round and not triangular as in *T.*

fruticosum. The flowers and capsules resemble those of waterleaf, but are distinctly smaller. Its leaves are thicker and darker-green in colour and are acute towards the apex, whereas *T. fruticosum* is more obtuse.

Its shoots and leaves are collected from the wild, although the crop is occasionally cultivated in Nigeria. It is propagated by means of cuttings and rarely by seed; its cultivation is similar to waterleaf. The spacing is twice as wide because the plants are larger and can remain in the plot for 1 year, after which they become too woody; then it is time to replace them. Their yield is reported to be twice that of waterleaf. Their seeds are very small, with a seed count of 4900 seeds/g (van Epenhuijsen, 1974).

BOTANICAL ASPECTS OF WATERLEAF

Flowers are bisexual, with the 3-lobed styles elevated well above the anthers. Yet it is recorded as being mainly self-pollinating with a limited degree of outcrossing. The showy pink flowers are open during the morning. It takes about 2 weeks from flowering until fruit ripening. The terminal inflorescence consists of approximately 15 flowers and sometimes more. A large proportion of these will develop into a fruit (capsule) with many seeds (*see* Figure 110). The ripe capsules shatter when touched. The plants have a tendency to 'sleep' during the night, with the leaves lowering. The sub-surface part of the stem is often tuberous.

Figure 110 Flowers and fruit of *Talinum*

T. cuneifolium cannot readily be distinguised from *T. fruticosum* in the field since the reported difference in leaf apex between the two species was not found to be consistent. The only way to differentiate between these two species, which are both found in the wetter parts of West Africa, is by studying the seed surface and pollen characteristics, for which a microscope is needed. For further information the reader is referred to Nyananyo and Lowokudejo (1986).

The chromosome number for *T. fruticosum* has been reported as 2n=24, 48 and 72. The higher numbers were mainly reported from Asia where plants are usually taller and bear the name *T. triangulare*. Cytological studies may be warranted and there appears to be scope for plant breeders in this respect. In Nigeria, the chromosome number of both *T. cuneifolium* and *T. fruticosum* has been reported as 2n=24.

AGRONOMY

Waterleaf can be sown, planted or collected from the wild. The crop seeds profusely as a weed, which is why few people like to plant it during the rainy season. The crop grows well in the shade and appreciates a good cloud cover, although it can grow in fully exposed places where the plants remain smaller. Waterleaf grows most profusely when the soil's water content is close to its field capacity. Under natural conditions, plants will live for about 4 months before they perish, mainly due to drought.

The common way of growing waterleaf as a commercial crop is by using cuttings of about 10 cm long, which are normally planted during the dry season when there is no competition from the wild. It is advisable to remove the lowest pair of leaves before planting. In Cameroon and Nigeria, the first planting usually takes place by about 15 November.

Another method, other than collecting material from the wild, is by sowing seeds. Seeds are mixed with roughly 10 times the volume of dry sand and are broadcast in a well-prepared nursery bed. Germination can be noticed after about 5 days and from there onwards growth will be rapid. A farmer can use thinned plants as a first harvest and leave the remainder for later harvests. Alternatively, the nursery can be used as a seed bed from where 3 week-old seedlings of about 12-15 cm high can be transplanted. Waterleaf is frequently planted with other vegetables in a mixed cropping system.

Nursery beds are sometimes prepared by collecting grass and other green material which will be burned. Occasionally farmers may add some manure or fertilizers, but this is often considered too costly for a relatively low-paying crop. Household waste is often more appropriate. Waterleaf needs nitrogen; lack of nitrogen can be indicated by yellowing of the leaves.

The spacing is about 15 x 15 cm, rather at random, in plant beds produced as a monocrop. Soon after planting the crop needs to be watered; this is required daily during the first week, but only three times a week when the plants have covered the soil completely. Planting is a continuous process whereby one person usually plants between 25 and 50 m^2/day. This also means that harvesting can be on a daily basis (or adapted to market days).

The close spacing is possible because of limited pressure from diseases. Limited space also allows for less competition from weeds. If there are many weeds, they need to be removed, which often means that a wider spacing becomes essential to allow space for tools. If the soils are fertile or when manure is used, meaning that plants develop rapidly with large leaves, the spacing should be increased to 25 x 25 cm.

Most waterleaf plants found in a mixed cropping system appear to have started spontaneously and have not been planted deliberately. This natural occurrence as a welcome weed, which is also found on wasteland near people's homes, is used as a subsistence crop, but during the rainy season it is also the main source of supply to the market.

Growth is fast during the rainy season when temperatures are about 30°C, but will slow down considerably with the onset of the dry season. The crop is, however, quite tolerant of drought. It prefers shade rather than the full sun. The onset of flowering does not appear to affect production of leaves or new side shoots. There is therefore no need to remove such flowers.

SEEDS

Although there are normally about 40 fruit on a plant and each capsule is packed full with tiny shining black seeds (65 seeds/capsule on average), seed collection is a specialist's job. Collection of seeds from ripe, yellow capsules is often difficult because ripe capsules shatter once they are touched. Ripe capsules can be identified by their size and often (but not always) by their recurved pedicels. Some people prefer to harvest the large but not fully ripe capsules which are still properly closed. Seeds from such capsules (which should be completely dried, then winnowed) have a lower germination capacity, which most people do not consider as a drawback because there will be enough seeds left that do germinate.

Seed dormancy has been reported which is especially important for *T. paniculatum* in the savannah areas. Some seeds have a much stronger seed coat than others, resulting in a variation in seed emergence.

PESTS AND DISEASES

Waterleaf appears to be one of the few crops that does not seem to be seriously affected by either pests or diseases, although it is a host of root-knot nematodes. This is why some farmers do not appreciate this species as a vegetable in their crop rotation. The most common disease is white leaf spot (*Pleospora* sp.).

There is a so-far unidentified disease which is referred to as blight. At first, dark-green spots appear on the underside of the leaves, which at a later stage show as brown or reddish spots on the upper side. Eventually they become black, rendering the produce unsuitable for sale. There is no known treatment other than by removing affected plants at an early stage.

The leaves may fold, probably caused by a virus that is transmitted by flies. Farmers try to scare away the flies by spreading some wood ash on the plants.

HARVESTING

The best way of harvesting a crop which starts as seed is by cutting the stem just above ground level, which allows a faster regeneration when compared with harvesting the upper portion and side shoots. If the first harvest is delayed and the lower parts of the stem are thus becoming brown and dropping their leaves, it is still advisable to cut just above the ground in order to obtain a better quality for the next harvest. In the latter case, it may be necessary to remove the brown stem parts prior to bringing the crop to the market. For a crop for which cuttings were planted, the best way is to harvest the new side shoots.

It takes only 3 weeks from planting before the first harvest can take place. From then onwards, harvesting can continue at 1-2 week intervals for a total of 2 months, or until just after the start of the new rainy season. On average farmers can harvest four times from a plant before its growth starts to decline. Waterleaf is one of the fastest growing vegetables in Africa. Once the rainy season crop becomes available, prices drop to a level when it is hardly worthwhile collecting it, especially when labour has to be paid for.

MARKETING

Waterleaf has long been considered as a crop for the poor and was thus not highly valued. Since the increased popularity of eru (*Gnetum* sp.) from around 1990 onwards, the demand for waterleaf has steadily risen. Waterleaf has the property of softening the otherwise tough eru, making it more palatable. Since eru is normally available during the dry season, prices for waterleaf in this period have become attractive to farmers, making it economical for them to raise this crop on a commercial basis.

In Ibadan, waterleaf can be seen in large quantities at Apata farmers' market, where produce is brought in as early as 05:00, but after 08:00 the produce is usually sold and can no longer be seen. In Nigeria, there is also significant production in Akwa Ibom State from where the produce is transported to markets in Calabar and Port Harcourt.

Waterleaf is highly perishable and the crop may start withering only a few hours after being harvested. This is not a problem when people wish to dry the product, but it will no longer be suitable as a fresh product. It is possible to remove the leaves and keep them fresh inside a plastic bag in a refrigerator for up to 48 h.

NUTRITION

The name waterleaf is most appropriate when it is realized that the moisture content of its leaves and young stems is as high as 94%. Once this crop is cooked it releases a lot of water and only a limited amount is available to be eaten. Therefore, it is often dried before cooking. The vegetable is rather slimy and is therefore appreciated by many people, especially in West Africa, but also in northern Uganda where it is eaten with starchy staple foods such as finger millet, sorghum or maize meal. It is also eaten as a raw vegetable in salads.

Waterleaf is a mucilaginous vegetable with a high oxalate content. The presene of oxalate, which is also found in purslane, is one of the drawbacks to these vegetables, especially since most of it is in soluble form and can induce oxaluria (stones in the urinary tract) if taken in excess. Amaranth has a similarly high oxalate content, but only about 40% of this is soluble, as opposed to the more than 90% for *Talinum* and *Portulaca.* Fortunately, blanching or cooking will remove nearly half of the soluble oxalic content.

Waterleaf also contains hydrocyanic acid, which is a further reason why this vegetable should be consumed in small quantities only and why it is not recommended for livestock. Caution must be exercised in the use of this vegetable in infant foods, the more so since it also contains nitrates and nitrites and cooking will not significantly reduce these anti-nutritional elements. On the positive side, it has a high calcium and phosphorus content.

Waterleaf is also used as a colouring agent in okra soup and is the basic ingredient in waterleaf sauce. The latter is a mixture of tomatoes, onions and waterleaf to which palm oil and salt are added to make a sauce which is complementary to starchy food such as yams, cassava or rice.

Akachuku and Fawusi (1995) have established the nutritive value of 200 naturally grown waterleaf plants in Nigeria, of which the average values are shown in Table 12.

Table 12 Nutritive value of waterleaf on dry weight basis (expressed as a percentage)

	Leaves	Green tender stems
Protein	29.4	13.4
Fat	1.0	2.0
Fibres	1.2	2.1
Ash	1.6	2.0
Nitrogen	4.45	2.03
Phosphorous	0.31	0.30
Potassium	4.43	3.60
Calcium	0.30	0.40

Source: Akachuku and Fawusi (1995)

In Cameroon, another use for waterleaf is as a treatment for measles. In South Asia it is used as an aphrodisiac.

BIBLIOGRAPHY

AKACHUKU, C.O. and FAWUSI, M.O.A. (1995) Growth characteristics, yield and nutritive value of waterleaf, *Talinum triangulare* (Jacq.) Willd in a semi-wild environment. *Discovery and Innovation,* 7(2): 163-172.

AKWA ADE, I. (1997) *The cultivation of waterleaf,* Talinum triangulare. Student report, Dschang University, Cameroon.

BURGSTALLER, H., MAMOUN BESHIR MOHAMED and MAHMOUD S. HASSAN. (1984) *A Handbook of Vegetable Production and Vegetable Pests and Diseases in the Sudan.* Ministry of Agriculture and Irrigation, Plant Protection Department. Khartoum. 73 pp.

EPENHUIJSEN, C.W. van (1974) *Growing Native Vegetables in Nigeria.* Rome: FAO.

FAO (1988) *Traditional Food Plants.* Rome: FAO.

NYANANYO, B.L.O and LOWOKUDEJO, J.D. (1986) Taxonomic studies in the genus *Talinum* in Nigeria. *Willdenowia.* **15**(2): 455-463.

SIEMONSMA, J. S. and PILUEK, K. (1993) *Plant Resources of South-East Asia: No. 8 Vegetables.* PROSEA.

STEVELS, J. M. C. (1990) *Légumes Traditionelles du Cameroun, une Étude Agro-botanique.* Wageningen, Netherlands: Agricultural University

TOLKEN, H.R. (1969) The genus *Talinum* in southern Africa. *Bothalia,* **10**(1):19-28.

GARDEN EGGS, JAKATU AND NAKATI

Solanum aethiopicum L.

INTRODUCTION

Solanum aethiopicum (garden eggs, jakatu or nakati) can be seen in almost every market in West and Central Africa where it is one of the five most important vegetables, together with tomatoes, onions, peppers and okra (*see* Figure 111). In Ghana, garden eggs occupy second place after tomatoes, whereas in Senegal their economic importance equals that of tomatoes. The fruity forms are less important in East Africa, even though they are a common feature of markets in Kampala and Dar es Salaam. The Shum group seen in Kampala's markets, called *nakati,* represents the most common and popular leafy vegetable there. Garden eggs are also found in South America and the Caribbean.

Figure 111 Garden egg

Since the domestication process has probably been going on for thousands of years, selective pressures have adapted the species to a range of climatic zones. For the wetter areas in Africa, there is the leafy Shum group. In the semi-arid zones of the western Sahel up to northern Nigeria, *jakatu,* belonging to the Kumba group, can be found, which is enjoyed for its large, multilocular fruit and sometimes for its leaves. For the zones with a more average rainfall, garden eggs belonging to the Gilo group are most commonly found.

The egg-shaped or round fruit of the Gilo group, referred to as garden eggs, are also called scarlet eggplants when distinction needs to be made between them and the brinjal eggplant from Asia. In Uganda, they are called *ntula,* whereas in Tanzania they are called *ngogwe* and also *nyanya chungu,* meaning bitter tomatoes. Nigeria's Yorubas call it *ikan* and the Igbos call it *anara.* In the Côte d'Ivoire, it is mainly referred to as *ndrowa.* In Cameroon, Gabon and Congo (Democratic Republic), it is called *aubergine de village.* There are many other names for this crop in local vernaculars. The names *jakatu, jaxatu* or *njakatu* are used in several francophone African countries, but also in Sierra Leone and the Gambia and mainly refer to the multilocular types.

TAXONOMIC ASPECTS

There has been a lot of confusion on the taxonomy of African eggplants. Botanists have for years named different cultivars of *S. aethiopicum* as many separate species and found it difficult to accommodate the intermediates between these 'species'. Work done by Dr R.N. Lester from Birmingham University, Dr M.O. Omidiji from Nigeria and others has led to the conclusion that there is one pluriform diploid species only (2n = 24). *S. aethiopicum* can thus be compared with the pluriform *Brassica oleracea,* with its many forms ranging from kohlrabi to kale to broccoli, brussels sprouts, cabbage, etc. A similar pluriform species is *Beta vulgaris,* with its distinctly different forms of Swiss chard, sugar beet, beetroot, etc.

Both *S. aethiopicum* and *S. anguivi* belong to *Solanum* subgenus *Leptostemonum* section *Oliganthes.* The brinjal, *S. melongena,* and the gboma eggplant, *S. macrocarpon,* belong to the same subgenus but a different section, *Melongena.* Crosses can be made with relative ease between *S. aethiopicum* and *S. anguivi.* As a point of interest, the non-edible Aculeatum group was the result of a cross between *S. anguivi* and the Kumba group. Aculeatum plants are now used as rootstock for brinjal eggplants and other crops, including tomatoes, for their resistance to a number of soil-borne diseases.

Crosses between *S. aethiopicum* and *S. melongena* or *S. macrocarpon* are possible, although difficulties are encountered, since the F1 hybrids are often relatively infertile (Daunay *et al.,* 1991).

The main differences between brinjal eggplant, scarlet eggplant and gboma eggplant are as follows

Brinjal eggplant, *Solanum melongena*: leaves hairy, flowers purple, ripe fruit yellow.

Scarlet eggplant, *Solanum aethiopicum*: leaves hairy or glabrous, flowers white and less than 25 mm, ripe fruit orange to red.

Gboma eggplant, *Solanum macrocarpon*: glabrous leaves, flowers large, purple or, rarely, white (*see* Figure 112). Ripe fruit yellow or brown.

Figure 112
Gboma eggplant flower

Cultivated plants with small, white flowers and orange or red fruit have previously been described as separate species, but mainly as *S. zuccagnianum* Dunal, *S. aethiopicum* L., *S. gilo* Raddi (and *S. olivare* Paill. S. integrifolium Poir. These four taxa are completely interfertile (Lester and Niakan, 1986) and are now treated as four cultivar groups: the Shum group, the Kumba group, the Gilo group and the Aculeatum group respectively, of a single species, *S. aethiopicum* L.

Within this species there are three groups of edible cultivars plus one non-edible group, the Aculeatum group.

The various white-flowered plants can rapidly be identified as below.

Leaves glabrous

Shum group: Fruit with 2-3 locules, small, 12-18 mm. Flowers 12-15 mm with 5-6 petals. Leaf tips pointed to round. Leaves comparatively small.

Kumba group. Large, flattened, multilocular fruit. More than five sepals, flowers 18-22 mm. Obtuse leaf tips. Leaves large.

Gboma eggplants. Smooth round fruit, not multilocular. Flowers >22 mm. Petals fused.

Leaves hairy

Gilo group. Leaves not or only slightly prickly. Fruit oval to round, less often somewhat flattened; medium to large sized. Fruit with 2-3 (-5) locules, smooth or slightly lobed. Few fruit per inflorescence.

Aculeatum group. Not normally encountered in Africa. Leaves and stems prickly. Medium sized fruit very bitter, 4-10 loculed, with distinct furrows. Fruit in clusters of five to eight, round to flattened.

S. anguivi. Several to more than 10 flowers per raceme. Fruit 8-15 mm, light-orange to red. Wild populations often have prickly leaves and stems.

Note: The above distinctions are for the main groups, but intermediates between these groups occur, such as Kumba group with hairy leaves or Gilo group with many fruit/cluster.

GARDEN EGGS

Figure 113 Young garden eggs in Uganda

The Gilo group

Garden eggs used to be referred to as *Solanum gilo,* hence the Gilo group. This is by far the most commonly cultivated group of cultivars and can be found in many different forms, depending on local selection criteria.

They usually have 1-3 fruit per node. Fruit sizes range from 2-8 (-12) cm and are white to green (to purple) in colour when immature (*see* Figures 113 and 114). When fully mature they are orange to dark-red or shiny-brown in colour. Some types have clusters with more fruit which are usually small (2-3 cm) and bitter. Such varieties may be close to the ancestor *S. anguivi.* Some varieties have grooved fruit, but most have a smooth surface. Most fruit have 2-3 locules, but some grooved types like the

ones found in Cameroon can have up to 5 locules. In Ghana, people prefer fruit with 2 or 3 locules since it is more difficult to remove the seeds when there are many locules. Fruit shapes vary from long and cylindrical to flattened, but most varieties are ovoid to spherical in shape.

Figure 114 Green garden eggs from Cameroon

Figure 115 Different colours of garden eggs on one truss

The large leaves are hairy and sometimes spiny and are not normally eaten. The hairs are stellate (star-shaped) with a short base and with 8 radial cells. Plants are bushy and can reach a height of 2 m, although most commercial varieties range in height from 65 to 110 cm. The woody forms as seen in Cameroon can grow for 3 years, whereas most commercial crops last for only one season of about 6 months. There is little point in keeping the plants alive for much longer than 6 months, since the yields will be low and the quality will be poor when compared with young plants.

S. gilo was first described in Brazil where it is called *jilo*. The plants concerned were traced back to their origin in Mozambique where they are called *ngilo*.

JAKATU

The Kumba group

Plants belonging to the Kumba group are found in the savannah and semi-arid zones of West and north-western Africa such as in Mauritania, Niger, Senegal, Mali, Burkina Faso and also in northern Ghana up to northern Nigeria. In Senegal, jakatu is a major cash crop like tomatoes or onions and produced throughout the year under irrigation, minimizing price fluctuations. Fresh fruit are now being exported to France, mainly for West African people living there.

Jakatu has ribbed fruit which generally taste sweeter than the Gilo group fruit. The multilocular character is already expressed in the flowers, where many stamens can be seen and a larger number of carpels, petals and sepals. The large-fruited types usually have two layers of locules. Fruit can be as wide as 20 cm, but most varieties are much smaller than that, with some as small as 3 cm.

Figure 116 The variety Soxna from Senegal

When the fruit become too heavy, they can make the plant fall over. Staking plants is rather expensive, which is why varieties with very large fruit are no longer popular. Fortunately, many jakatu varieties have fruit that are

concentrated on the lower parts of the plant or near the main stem. Most varieties do not grow much taller than about 40-50 cm, although some can reach 70 cm in height.

Until recently, all Kumba group plants had glabrous leaves and some varieties were primarily grown for their leaves. Since such plants are attacked by spider mites and thrips, and their yields have become very low because of these pests, plant breeders have crossed them with the Gilo group. The resultant crops have hairy leaves which are a natural defence mechanism against spider mites and nowadays most varieties are primarily used for their fruit. Leafy types are still produced and eaten, for example in northern Ghana, but here and elsewhere there is a shift towards production of *Solanum macrocarpon,* which is also produced for its leaves but appears to be resistant to spider mites.

Fruit belonging to the Kumba group have few seeds and these often show seed dormancy (Seck, 1992) which can be a major difficulty. Farmers are therefore prepared to buy seeds from recognized seed companies to ensure that seeds will germinate soon after sowing. A number of non-dormant varieties are now available. To overcome dormancy, researchers can use gibberellic acid (GA) in a solution of 500 ppm for 24 h but GA is too expensive for farmers and not easy to use. Seeds germinate after about 3 days, which is much faster than the usual 5-8 days for Gilo group cultivars. Also, flowering can be as early as 40-50 days after sowing.

There is less variation between Kumba group cultivars than those of the Gilo group, possibly because of the Kumba group's lower percentage of cross-pollination. The Kumba group cultivars have short peristyles and their stigmas do not protrude as much beyond the anthers as Gilo group cultivars. Also, the location of flowers on the lower or middle parts of the plant is an indication that fewer insects will visit those flowers.

As mentioned, members of the Kumba group are primarily grown for their leaves in Ghana and Burkina Faso where one of the leafy varieties is called Kombi-oree. Its leaves are large, glabrous and have obtuse leaf tips. They can only be consumed in the early stages before they mature and toughen. There are several distinct varieties that are used for their fruit, which are mainly white or green in colour. Some people in remote villages of Senegal prefer purple types over the white or green ones. The most important variety in Senegal is Soxna (*see* Figure 116).

The ripe orange fruit of jakatu can be stored for several months, even in hot conditions. Young fruit can be rather sweet and these are eaten raw in northern Ghana and in Burkina Faso.

Jakatu is susceptible to root knot nematodes and to *Verticillium dahliae.*

NAKATI

The Shum group

Plants of the Shum group used to be referred to as *Solanum zuccagnianum.* The name Shum is derived from *ndschum,* used in Cameroon, and from the somewhat similar *osun,* used by the Yorubas in south-western Nigeria. The Shum group can be found in the higher rainfall zones of most West and Central African countries. It is of local importance especially in Uganda and south-eastern Nigeria and to a lesser extent in Cameroon, Gabon, the Congo, Togo, Congo (Democratic Republic), etc. (*see* Figure 117). Ugandan people call it *nakati* and this is the most abundant leafy vegetable found in the

Figure 117 Nakati grown as a monocrop can be highly rewarding

Kampala markets. For this reason the vernacular name nakati is used here rather than the scientific name *S. aethiopicum* Shum group. In south-eastern Nigeria, where the crop is also common, its name is *anara.*

Figure 118 Nakati flowers and fruit

Nakati plants have small fruit, borne either singly or in clusters of up to eight fruit. These are generally bi- or trilocular like those of *S. anguivi.* The fruit are rarely eaten (*see* Figure 118).

The leaves are glabrous, although some less densely hairy varieties are also eaten. The plants are not able to grow out because of repeated harvesting of their leaves or shoots. Large, unharvested plants can reach about 80 cm. Nakati plants soon develop a much-branched architecture with weak stems and many small leaves. Many varieties have somewhat rounded or even pointed leaf tips, although forms with oak-like, blunt-edged leaves have also been noticed. A form with laciniate leaves has been recorded from Togo.

There are forms that are close to *S. anguivi,* although nakati fruit are usually somewhat larger (12-20 mm). Purple-stemmed types, which frequently show some anthocyanin on their leaves as well, perform better during a dry spell and are reported to have less trouble from aphids when compared with green types. The purple varieties are more bitter than the green ones, but this bitterness disappears when they are well cooked. Some customers prefer the green-stemmed varieties because they tend to be sweeter.

The crop requires a high humidity or regular irrigation and will drop its leaves when it is getting dry. In Uganda, nakati is usually grown in the swamps during the dry season. It is often intercropped with early-maturing leafy vegetables or grown underneath banana or plantain. Traditionally, nakati grew well on land where trees were burned. Even today some farmers dig shallow pits and fill these with branches of trees, grass and cow dung. This is then covered with soil and left for a year to break down before planting or sowing a nakati crop.

Plants are raised in a nursery and seeds are mixed with sand or loose soil. In the case of mixed cropping, which is common, many farmers mix nakati seed with seeds of either amaranth or the spiderplant *Cleome gynandra.* These crops can be harvested 1 month before nakati is ready. Alternatively, nakati seedlings are transplanted for production as a ratoon crop at a spacing initially of 10 x 50 cm. Other farmers broadcast their seeds; this is the common method when there are no irrigation facilities.

Thinned-out plants are used as a first harvest, which is usually 2 months from sowing during the rainy season. First harvesting may take 2-3 weeks longer during the dry season unless adequate irrigation is provided. After 1 week, the second harvest (or first real harvest) can take place by cutting the plants about 10 cm from the ground, allowing side shoots to develop. After 3 weeks, the next harvest will consist of those side shoots, which by then have grown to about 35 cm. It is possible to have up to five harvests, depending on soil fertility and moisture. Market gardeners harvest when the plants are about 40-50 cm high, which is usually at a time when the first flowers are about to open. The average yield is about 3 kg/m^2 during the rainy season.

Figure 119 A ratoon crop from a subsistence farmer in Cameroon

The ratoon cropping system is commonly used for subsistence farming where a regular supply is essential (*see* Figure 119). Ratoon cropping on a commercial scale will guarantee a more regular supply, spread over a longer season, thus reducing the risk of low prices during gluts in the market. The disadvantage is that it requires more labour and there are no opportunities for a supplementary income from fast-growing crops such as amaranth.

A farmer will divide the plants into large bundles which will weigh between 30 and 40 kg during the rainy season, but only about 25 kg in the dry season. The weight/stem is usually lower during the dry season than during the rainy season. A farmer can expect about 75 bundles/1000 m^2 and is able to harvest three to four crops/year. This often means three crops of nakati plus three crops of amaranth and spiderplant/year.

Before they are marketed, the bundles are kept with their roots up and left in the shade, or left with their stems or roots in water to keep them fresh. The leaves should not touch the water, otherwise they may start rotting. The bundles should be removed from the water during the night. At that time, the bundles are usually placed in the grass where they may collect dew and remain moist.

In order to be in the market early, before the new rainy season crop comes in, some farmers prune their old crop back and wait. Soon after the rains have begun, following a period of drought, fresh shoots will appear, allowing a first harvest after 2-3 weeks.

The crop needs a lot of nitrogen and may rapidly deplete nutrients from the soil. Hence there is a need for regular fertilizing or use of manure. It is advisable to apply a top dressing of nitrogen to get a sufficiently heavy flush for the fourth and possibly fifth harvest.

Nakati faces a range of diseases that are usually associated with tomatoes and *S. scabrum,* but also those found in garden eggs. Such diseases include early and late blight which are not often seen in the Kumba or Gilo groups. One problem in Uganda is that monkeys like to eat nakati.

Housewives remove most flowers before cooking, although the flower buds can be left. Some people appreciate some young fruit on the stems, which add some bitterness to the dish. Others prefer to remove such fruit. When cooking, only the tops are used, with leaves plucked from the coarser parts of the stem. To overcome the problem of bitterness, which is found in some varieties or in older crops, the vegetables are washed with hot water, or the cooking water is replaced with fresh water before serving the dish.

In Nigeria, nakati is frequently used in egusi soup, a popular dish, for example, in the Enugu area, based on cucurbit seed kernels. In Uganda, nakati is mostly steamed rather than boiled and is often eaten as a supplement to *matoke* bananas. Some Ugandan people prefer to fry it. It is said to control constipation.

In Uganda, boiled nakati leaves are dried and later pounded into a powder which can be stored for a long time. This powder is normally used in the preparation of a sauce, for example by adding it to a groundnut stew. The boiled and salted fruit of *S. anguivi* and the red nakati fruit are dried in the sun and ground into powder to be used in soups or used as medicine for high blood pressure.

Solanum anguivi Lam.

Solanum anguivi, which can still be found in many places throughout the non-arid parts of Africa including Madagascar, is considered to be the ancestor of the *S. aethiopicum* complex. In the older literature it was referred to as *S. indicum* or *S. anomalum*. The Yoruba name for this plant is *igba yinrin* and in Ghana, where it is rare, it is called *nsusua*. It can cross with relative ease with all groups within the *S. aethiopicum* complex, although resulting plants may not survive naturally, which is why they are still considered as two separate species. The more primitive varieties of nakati and some Gilo group cultivars are considered to be close to *S. anguivi*.

Figure 120 *Anguivi* berries are very decorative

Fully wild or weedy plants can have very prickly leaves and stems; such plants are usually weeded out and are thus not often encountered in gardens. *S. anguivi* is more often found in a semi-cultivated state. The crop is dispersed with the help of birds which drop the seeds after eating the berries. Plants are woody, usually about 70-150 cm high with spreading branches. Such bushes can be found in gardens; they are not removed as weeds since the fruit can be used in soups, etc., or as medicine. Also, the masses of red berries are appreciated for their ornamental value (*see* Figure 120). The small berries of about 7-10 (-15) mm which are very bitter, are found in small to large clusters of up to 20 fruit (*see* Figure 121). Most plants survive just one rainy season and die once the dry season starts, but large bushes of up to 3 m in height can be seen in Uganda which, according to their owners, are at least 2 years old.

Figure 121 *S. anguivi* with many fruits per cluster. Note the long style in the flower

S. anguivi is highly polymorphic and variable in its plant structure, fruit and leaf characters and some taxonomists see *S. anguivi* as a species complex consisting of different taxa. In Uganda, where *S. anguivi* is relatively common, plants with white and dark-green coloured immature fruit were found in addition to a whole range of intermediates, sometimes striped. Some fruit are yellow, turning to light-orange when fully ripe. The species is of interest to eggplant breeders because of its resistance to *Ralstonia solanacearum* and other diseases.

S. anguivi can be used in a breeding programme to increase the number of fruit in a truss of garden eggs (*see* Figure 128). The more primitive Gilo group cultivars with 5-7 bitter fruit are probably the result of a natural cross. One of the drawbacks is that the resulting hybrids are far too bitter and the fruit have the wrong shape and colour. A number of back crosses with the parent that has desirable fruit characteristics is likely to overcome this.

Their small bitter fruit (*see* Figure 122) are an important ingredient of a dish called *nkwi* which is popular in Cameroon (*see* also under *Triumfetta*, p.204). Fruit are frequently used medicinally, to control high blood pressure. Fruit of the semi-domesticated form, found in gardens, are used in both fresh and dried or even ground form for this purpose. Such fruit are also used as a condiment to add taste to soup. In the past it used to be a substitute for salt.

Figure 122 *Anguivi* fruit for sale at a market in Kampala. Compare the pea-sized fruit with the small cucumber

Figure 123 Fruit of *S. torvum* at a market in Ghana

Related species

S. anguivi should not be confused with the large and prickly *S. torvum* which can reach up to 3-4 m in height and has large clusters of green fruit. This common bush originated in South America and is found as a pantropical weed. Fruit of *S. torvum* are frequently seen in the markets of Ghana (*see* Figure 123) where they are virtually always offered as a truss rather than as individual fruit as *S. anguivi* is in Uganda. *S. torvum* is becoming more popular as a bitter ingredient in soups and sauces.

BREEDING

Pollination

All African eggplant species are pollinated by bees which carry pollen from stamens of one flower to the stigma of another. The major pollinators are bees belonging to the genera *Exomalopsis* and *Apis*. Bumblebees, which occasionally break into flower buds before they are opened, can act as the earliest pollinators. As long as flowers from one plant (or one pure line plant accession) are visited, the plants can be said to be self-pollinating, whereas cross-pollination will occur when pollen is carried to a flower on a different plant.

Unlike tomatoes, where the flower structure will allow pollen from its own anthers to reach the stigma, in garden eggs this is not possible, since the pollen is shed from terminal pores of the anthers which do not touch the stigma. The anther dehiscence is poricidal (tomatoes dehisce longitudinally). When the

Figure 124 Large-flowered *S. aethiopecum*

pores open at anthesis, some pollen will shed upwards and reach the stigma, thus causing self-pollination. The most certain way to control pollination is by carrying out hand pollination. Alternatively, a group of plants from one accession derived from seeds from a single plant can be used, or even better, a single fruit. In the latter case, when there will be a plot of virtually identical plants, insect pollination will probably take place between these plants. In this case, seeds should only be collected from the inner circles of plants and not from the outer rows, where 'contamination' with 'foreign' pollen is more likely.

Crossing

Most varieties maintained by farmers are virtually pure-bred lines. When farmers wish to maintain or introduce a new variety they often start with seeds from a single fruit only. Inbreeding is thus a common phenomenon. The high level of autogamy found in African eggplants can be a major asset when attempting to produce F1 hybrids which are likely to show the heterosis effect. However, Omidiji (1983) noticed that in the F2 and further generations this heterosis effect soon disappears.

When attempting to make a cross between two varieties, fresh pollen needs to be collected. This can be rather difficult since bees are competing for the same limited supplies. One way of overcoming this problem is by bagging buds which are about to open from the donor plant and collecting the pollen the following morning by tapping the pair of tweezers by which the flower is held. Ideally the pollen should be collected onto a dark (black) surface (paper, plastic, etc.) so that it is more clearly visible. Pollen is only viable for 1 day from anthesis.

Some plants show floral heteromorphism where the first flowers are hermaphrodites with styles protruding beyond the anthers. Later flowers with short styles are functionally male and often smaller in size. Consequently, later flowers serve as a pollen source but do not produce fruit.

It has been noticed that when attempting to cross a variety with large flowers (*see* Figure 124) with another with small flowers (*see* Figure 125) there is a great difference in the success rate between the male parent and the female parent. The best results will be from using the large flower as the male parent and the small flower as the female. The other way round is often unsuccessful, possibly because the pollen tubes of the small-flowered variety are unable to grow out long enough to cover the distance of the long styles to the ovary of the large flowers. If the flowers of the offspring are also small in size there is an additional advantage, since small flowers help in the biological control of the flower borer *Scrobipalpa blapsigona.*

Figure 125 Small flower of *S. aethiopicum*

Once enough pollen has been collected from one or several flowers of preferably the same selected plant, buds of the recipient plant which are nearly open need to be selected. These buds should be opened and the anthers removed by a pair of tweezers with a sharp point before pollination can begin (*see* Figure 126). Hand pollination is carried out by dipping the stigma into the pollen directly or by bringing the paper with the pollen to the stigma. Next, the flower needs to be isolated to avoid further pollination by bees or other insects. This can be done by surrounding the flower with sticky tape which should not touch the stigma directly. Another possibility is to place a bag around the pollinated

Figure 126 Removing the anthers is tedious work

flower and to remove this after 3 days. The stigma is receptive 1 day before the flower bud opens until 1 day after it has opened. Receptivity is indicated by a light green-colour of the stigma, but once this changes to yellow there is no danger of additional pollination.

The flower should be identified by tying a label to the stem next to it or by marking it with a coloured piece of string (for example, a piece of wool), which represents a particular crossing. It is essential to make adequate records of this work, mentioning the male and female parents, the pollination date, etc.

The best plants to be used for a breeding programme are young ones which have just started to flower rather than old ones with mature fruit. It is advisable to water the plants the evening before pollination so that the flowers are fresh and turgid. For further information about garden egg breeding see Seck (1998).

Important elements for varietal improvements are:

- bitterness of the fruit;
- fruit skin toughness (post-harvest feature, shelf life);
- colour and colour pattern;
- fruit shape and size (and its uniformity within a plant or over time);
- yield potential;
- earliness and duration of the harvest season;
- plant architecture, plant size and location of fruit; and
- tolerance to soil-borne pathogens and/or diseases.

CULTIVARS AVAILABLE

In places like Senegal, research has centred on jakatu and a number of varieties have been released of which Soxna is the most popular. In most other places in Africa varietal selection work has mainly been carried out with Gilo group cultivars. In Côte d'Ivoire, local landraces of the Gilo group were screened and one variety, Sodefel was selected which became the standard. There have been several success stories in Nigeria and Omidiji (1983) and researchers from NIHORT have developed new varieties. In Ghana there are many local forms grown in various parts of the country. Some forms are bitter and others more sweet. Some research work has been carried out by the University of Ghana. The Crops Research Institute, jointly with NRI from the UK, has recently been working on a garden egg varietal enhancement programme (*see* Figure 127).

Figure 127 A promising new garden egg variety developed by CRI in Ghana

Figure 128 Cross between Gilo and *S. anguivi*

Figure 129 A Nigerian garden egg cultivar

Most farmers still produce a mixture of landraces or their local selections especially for subsistence use. Ghanaian traders often control the main markets by supplying seeds of their favourite variety to the farmer. These varieties are all white, whereas most traditional varieties are either green or striped. In Nigeria, the favourite is a white variety with light-green mottling towards its base (*see* Figure 129). Tanzania's main variety, Tengeru white, is also white in colour. Some varieties have been collected which have a lot of anthocyanin on their stems and even leaves whilst their fruit are partly purple in colour. Similar purple fruit and branches have also been observed in the Shum group, whereas in Senegal there are several Kumba types which are totally purple in colour.

The main cultivars of the Gilo group in Ghana are:

cv. Ansrowia 'does not fear the sun': a small-fruited type which grows in clusters of up to seven light-green fruit, often with dark-green stripes. The first fruit are larger than the later ones. It is locally preferred for its bitter taste and can be sold even when there is a glut;

cv. Aworoworo: pale-green to white, egg-shaped fruit, 4-6 cm long with a slight extrusion towards the pistil end. This is probably the most common garden egg found in the Brong Ahafo region. High yielding and preferred by traders, but it takes a long time to mature, the harvesting period is short and the fruit become smaller at the tail end of the season (due to lack of nutrients?). The cv. Abesim is a selection from Aworoworo which is smoother and lacks the extrusion. Its yields are higher than those of Aworoworo;

cv. Dwomo: named after a village in Brong Ahafo (*see* Figure 130) and is a selection by the Integrated Food Crops Systems Project. A dwarf variety with branches close to the ground, a characteristic which is not popular with harvesters. Its yield potential of over 2 kg of good quality fruit/plant, or approximately 50-70 t/ha, is considerably more than that of traditional varieties which may produce 0.5-1 kg per plant. It is distinctly earlier and sweeter than other varieties; and cv. Legon prolific: a variety with oblate to global-shaped fruit, developed by Dr Bley from the University of Ghana, Legon (*see* Figure 131). A short perennial type that produces for as long as there is enough moisture in the soil.

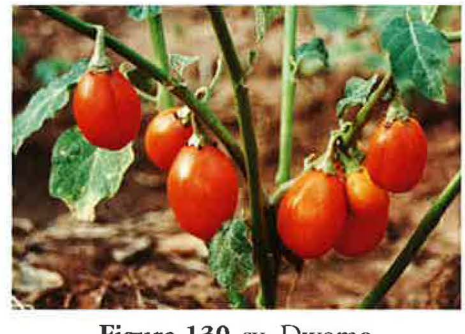

Figure 130 cv. Dwomo

Figure 131 cv. Legon prolific

SEEDS

Garden egg seeds are rarely sold by seed companies (e.g. Alpha Seed Co. in Arusha, Tanzania; Aglow Agricultural Produce Ltd in Accra, Ghana; or Tropicasem in Dakar, Senegal), but can be obtained at vegetable markets. Also seedlings can be purchased at local markets. Often it makes good sense to obtain seeds or seedlings from a farmer who has made his own selection and who knows which variety is in demand.

Traditionally, garden egg seeds were preserved within the fruit rather than as loose seeds. This practice, which applies equally to many other vegetable crops, can still be seen in Nigeria and Cameroon and possibly elsewhere. Fruit are either sliced or broken open to facilitate proper drying in the sun. At market stalls (for example, at the main market in Yaoundé, Cameroon) farmers can buy these shrivelled fruit, which can be 1 year old, and remove the seeds for sowing. When these fruit are kept dry properly, a large percentage of seeds will germinate.

Alternatively, seeds can be extracted from ripe, orange or red fruit, collected from selected disease-free plants. When an attempt is made to extract seeds from unripe fruit the germination capacity is likely to be low or zero. A common method is first to dry the orange fruit for a few days and rub them by hand to loosen the seeds from the flesh. Then the fruit should be put in water to soften up. After about 1 day, the fruit can be broken easily and the seeds removed inside the water; the seeds will drop to the bottom and most of the fermenting flesh will float, allowing for an easy separation.

The seeds are dried in the shade on a piece of cloth or similar material. After drying, the seeds should be placed in a jar or similarly closed container and some silica gel added to remove excess moisture. When silica gel is not available, some oven-dried rice or similar grains can be placed at the bottom of a container with some cloth separating the seeds from the rice. The container should be airtight if possible. If seeds are not well dried they lose their germination capacity in about 3 months.

Seed yields vary according to variety. It was found that 1 kg of garden egg fruit from Uganda yielded 31 g of seed with a seed count of 580/g. Therefore about 18 000 seeds can be extracted from 1 kg of Ntula variety fruit. The Ghanaian variety Dwomo has about 15 g of seed/kg of fruit with a seed weight of about 250-300 seeds/g. The variety Soxna, a Kumba type from Senegal, was found to have 12 g seed/kg of fruit. Kumba group cultivars have comparatively large seeds. The seed yield from 1 kg nakati fruit was 127 g, whereas fruit from *S. anguivi* often contain even more seeds/kg of fruit.

AGRONOMY OF GARDEN EGGS, JAKATU AND NAKATI

Climatic requirements

The three main groups have different humidity requirements. The Kumba group tolerates relatively dry conditions, the Shum group need high humidity and the Gilo group, the most common, thrives best in between these ranges. It is clearly a tropical crop, with optimal night temperatures between 20°C and 27°C and day temperatures between 25°C and 35°C. Fully exposed conditions are preferred; production in the shade may result in tall plants that are unsteady, especially under windy conditions.

Land preparation

S. aethiopicum can be produced on a wide range of soils, but does not perform well on clay. Soils should be fairly deep and well drained. The optimum pH is 5.5-6.8. If the pH is lower than 5, lime should be applied. The crop may occupy the field for 6 months or sometimes more, so that a well-fertilized soil is required for optimum growth. The field should be prepared in advance by adding compost or well-decomposed manure at the rate of 5 t/1000 m^2 and working it well into the soil. If a green manure crop is used it should be ploughed or dug into the soil 4-6 weeks before planting to allow adequate time for decomposition. An application of 50 kg of 15-15-15 NPK compound fertilizer/1000 m^2 is recommended prior to planting.

Nursery practices

Figure 132 Seed boxes should be filled with sterile soil

Seeds are sown thinly in rows, broadcast in a well-prepared nursery bed with friable soil, or sown in seed boxes (*see* Figure 132). The seeds are covered with a thin layer of soil that should be slightly pressed. This cover is needed to distract birds, mice or ants and to provide a growing medium. Germination of garden eggs takes 5-7 days, whereas some Kumba group cultivars may emerge as early as 3 days after sowing. The plants will be in the seed-bed for about 5 weeks after sowing. The young seedlings are protected from the hot sun and heavy rain by covering the compacted soil with grass or palm fronds, which will need to be raised after germination when the cotyledons expand. Thinning may be required so that the plantlets will be spaced at least 2 cm apart. The cover can be removed altogether when the leaves reach a size of about 4-5 cm to harden off the plants prior to transplanting.

Transplanting

When seedlings are 12-15 cm high (about 5 weeks after sowing) they are ready for transplanting. Young seedlings of 3-4 weeks old may establish easily, but their tenderness attracts crickets and subsequent losses could be considerable. Seedlings should not be allowed to become too long and spindly. The seedlings should be watered adequately for maximum uptake before transplanting and to facilitate uprooting. This also increases the amount of soil that remains attached to the roots and will thus assist uninterrupted growth.

Ideally, transplanting should take place late in the afternoon or during an overcast day. The seedlings should not be planted deeper than they were in the nursery. The seedlings should be watered immediately after transplanting and the whole field irrigated the next day.

Spacing

Spacing depends on the variety and the cropping period, with 90 x 90 cm for the more vigorous or strongly branched cultivars and 90 x 60 cm or even 75 x 60 cm for less widely branched types. The spacing of 60 x 60 cm, as used by many farmers, is considered too close since air cannot circulate well, thereby allowing *Cercospora* and other diseases to develop. Yields of unmarketable fruit increase with closer spacing. For the smaller Kumba types like Soxna, double lines could be used, as for tomatoes. A plant population of about 25 000/ha is the optimum density for Soxna, but some farmers plant as many as 40 000 seedlings/ha. For double lines, the space between double rows should be 100 cm, giving a spacing between pairs of plants (10 cm separation) of about 60-75 cm.

Fertilizers and topdressing

Supplementary fertilization is required, especially when the crop remains in the field for a long time. The recommended rate in Ghana is 125 kg/ha of 15-15-15 NPK fertilizer to be applied about 10 days after transplanting and a further 50 kg at the first flowering stage. This may be repeated monthly. Where no additional fertilizer is given, the fruit tend to become smaller after a few harvests and may consequently fetch a lower price at the market.

The leafy types such as nakati and Kumba group varieties will need extra nitrogen inbetween harvests of their leaves. Depending on the pH of the soil, this is in the form either of ammonium sulphate or calcium ammonium nitrate. The latter is mainly used on soils with a pH of 6 or less. For garden eggs, additional nitrogenous fertilizers should not be applied before the first harvest has taken place to avoid extra leaf development at the expense of the fruit. Phosphates are needed to stimulate flowering and fruit formation, whereas potash is needed for seed setting. Both potash and phosphates are needed for a good seed yield.

Mulching

Mulching is mainly done during the dry season to reduce evaporation. The surface of the soil is covered with dry grass to keep the soil moist and to reduce temperature fluctuations in the soil. Mulching should not be carried out too close to the stem as this encourages collar rot. There is no need to remove the mulch when the plants have developed since the decomposed grass will become part of the soil by the next season.

Irrigation

Adequate moisture in the soil is needed for optimum growth and yield (*see* Figure 133). The frequency of irrigation should be increased after fruit setting otherwise flowers and developing fruit may abort. Soils with high organic matter content hold moisture better. Yields are generally higher under controlled irrigation in the dry season than during the main rainy season.

Figure 133
Distorted fruit caused by drought

HARVESTING

The earliest varieties belong to the Kumba group such as Soxna, which can be harvested about 85 days from sowing. Early garden egg varieties such as Dwomo are ready for picking in 90-95 days, but most garden egg varieties take about 110-120 days.

Figure 134 Sweet variety of garden eggs from Cameroon that can be eaten fresh when the fruit have turned orange in colour

Fruit must be collected before their seeds ripen, that is, before the skin becomes tough and changes colour from whitish to pale-yellow (or from light-green to light-orange) (*see* Figure 134). The fruit should be cut off with a knife or pruning scissors rather than pulled from the plant. A short piece of the fruit stalk should remain attached to the fruit. Harvesting should be regular even when there is no ready market; it is needed to encourage subsequent fruit development. Seeds will ripen in the fruit that are left on the plant, rendering them useless for sale and few new fruit will then be formed.

Average garden egg fruit weigh from about 25-45 g. The market does not appreciate the larger types of 50 g or more. Most traders prefer fruit of 30-40 g, but during periods of shortage smaller fruit are liked, so that there are more fruit in a heap when sold to a customer with a limited budget.

Garden eggs and jakatu may produce around 12-20 t/ha, but often much less for the traditional varieties grown without supplementary irrigation (5-8 t/ha). When recommended varieties are used, together with good farm practices, a yield of 50 t/ha is feasible. Yields obtained on experimental sites in Senegal and Ghana have shown a potential of up to 70 t/ha.

NUTRITIONAL VALUE

Studies by Ore-Oluwa Taylor (1983) in Nigeria indicated that the leaves from the two *Solanum* species mentioned below provide all the nutritionally important amino acids in adequate quantities (*see* Table 13). The level of crude protein in the leaves was found to be 39% and 36% respectively for *S. aethiopicum* and *S. macrocarpon.* The soluble oxalate (2.70% and 2.47%) and total oxalate (8.89% and 9.34%) were found to be high.

Table 13 Amino acid composition of leaf protein concentrates

Amino acids	***S. aethiopicum* Shum group**	***S. macrocarpon***
Lysine	6.64	5.7
Threonine	4.16	4.32
Valine	4.67	3.72
Methionine	1.71	1.39
Cystine	1.89	1.35
Isolencine	4.67	5.83
Leucine	6.96	7.56
Tyrosine	4.62	4.06
Phenylalanine	5.35	6.30
Histidine	3.11	2.86
Arginine	5.08	6.64
Aspartic acid	8.54	13.30
Serine	3.64	4.62
Glutamic acid	14.95	14.01
Proline	6.27	6.49
Glycine	3.86	4.32
Alanine	4.47	5.58

Source: Taylor, 1983

It should be noted that *S. aethiopicum* plants contain spirosolane alkaloids which are poisonous when taken in excess. For further information on this see the paragraph on nutrition for *S. macrocarpon*, p.175.

COMMON DISEASES

Bacterial wilt *(Ralstonia solanacearum)*

Bacterial wilt is a soil-borne disease that can appear at any stage of development of the crop, causing rapid wilting of the leaves followed by death of the whole plant. The severity of the disease may be increased by the presence of root-knot nematodes in the soil. These damage the roots and provide ready means of entry for the bacteria. Garden eggs have a much higher level of natural resistance to bacterial wilt than the brinjal eggplant (*S. melongena)* or tomatoes. Planting a solanaceous crop such as tomatoes or garden egg on the same piece of land more than once in 2 years is not recommended. Along some river banks where garden eggs can no longer be produced due to bacterial wilt and other soil-borne diseases, it is possible to use the wild, disease-resistant *S. torvum* as rootstock on which garden eggs (and tomatoes) can be grafted.

Damping off *(Thielaviopsis basicola)*

Damping off causes the stems of young seedlings to rot at soil level thus killing the seedlings. The disease is severe, especially in damp soil and when overcrowded seedlings are heavily watered in the nursery. It is recommended that well-drained soil in the nursery and raised beds in the rainy season be used. A traditional method of control is to apply powdered charcoal to the soil surface. The related *S. macrocarpon* is resistant to damping off.

Angular leaf spot *(Cercospora melongenae)*

Angular leaf spot is distinguished by the presence of angular or irregularly shaped spots on the leaves which are usually confined within the veins (*see* Figure 135). This disease can cause serious loss when uncontrolled and when it affects the flower pedicels. It is especially problematic during the rainy season or in shady places. It can be controlled by spraying with a fungicide; removing and burning infected leaves; picking and disposing of diseased fruit; and avoidance of overwatering and splashing on the leaves.

Figure 135 Leaf spot

Grey leaf spot *(Stemphylium floridanum)*

Grey leaf spot causes small round-to-angular spots on the leaves; they are greyish-brown and usually not larger than about 4 mm. The spots have a clear, dark purplish-brown circle and the area between the spots is yellow. Leaves will drop prematurely. It is a common disease during the rainy season and can be observed in the nursery. The best control can be achieved by applying Thiram at 100 mg/l of water. Maneb is also effective.

Collar rot (*Sclerotium rolfsii)*

Sometimes wilting plants are found that have a clearly visible white mycelium at the base of the stem near the soil. Sometimes greyish-black sclerotia can be seen in the mycelium. These are characteristics of collar rot. Such plants together with their roots should be removed and destroyed by burning. If the field is badly affected, care should be taken to avoid growing garden egg and tomatoes on this land for at least 3 years.

Various rots on the fruit

Phytophthora nicotiana is a fungus that primarily attacks the fruit, causing dark, water-soaked spots to develop on the surface. Mature fruit then brown rapidly and rot.

Figure 136 Black mummy, caused by *Phomopsis*, is mainly found in the Kumba group

Phoma spp. and *Phomopsis* spp. are a group of related fungi that can affect both the plant and their fruit. Spots that appear on the leaves are circular, brown to grey, with a light centre. The plant may show blight and cancer symptoms. The large spots on the fruit may lead to dry rot, which transforms them into a black mummy (*see* Figures 136 and 137). This *Phomopsis* is mainly seen on the Kumba group. These diseases are seed transmissible so care should therefore be taken not to select fruit from affected plants for seed extraction.

Some further diseases affecting garden eggs are:

Leveillula taurica- a powdery mildew with yellow spots on the upper surface and a white mould below. Mainly confined to the dry season;
Puccinia substriata- yellow rust. Usually found only when pearl millets are present; it is more frequently found on the Kumba group than on the Gilo group; and
Alternaria solani- early blight (especially on the Shum group).

Figure 137 *Phomopsis* fruit rot

There are a number of viruses that affect both leaves and fruit. There is little information about the virus types and methods of control.

Disease tolerances in garden egg

A relatively high level of resistance to bacterial wilt, *Ralstonia solanacearum,* is available in *S. aethiopicum* and the same applies to anthracnose, *Colletotrichum gloeosporioides.*

The Aculeatum group (used as rootstock for brinjal eggplant in Japan) has a good resistance to *Ralstonia, Fusarium solani* and *Phytophthora parasitica.* The Gilo group is resistant to *Phomopsis* blight, but is not always resistant to bacterial wilt. Several garden egg varieties are resistant to aphids.

PESTS OF IMPORTANCE TO GARDEN EGGS

Flower borer *(Scrobipalpa blapsigona)*

Figure 138 *Scrobipalpa blapsigona*-infected bud (r.) and normal flower bud (l.)

The flower borer is a serious pest which appears to be on the increase, especially in irrigated crops. In Senegal, losses of 70-100% have been reported. Young buds are attacked by the larvae of the small flower borer moth. These buds will swell up and become yellowish in colour. Affected buds are round rather than oval-shaped, are larger than others and will soon drop (*see* Figure 138). It has been noticed that

flower borers have a strong preference for large-flowered varieties and leave the small-flowered ones alone. This provides a good argument for the breeder, since flower size and fruit size are not necessarily correlated. Small wasps act as natural predators so that there is no need to spray the crop with chemicals. Conversely, when sprays are used, these tend to kill the wasps and allow the pests to spread, thus worsening the situation.

Fruit borer *(Leucinodes orbonalis)*

The larvae of small (13 mm) fruit borer moths bore into developing fruit, leaving noticeable holes on mature fruit which may then start rotting, thus destroying their market value. They also bore into young shoots, preventing further growth. As soon as larvae are seen, they should be sprayed, then fortnightly with Actellic 25 EC or Karate. Karate should not be used during the fruiting period. Fruit borers are a significant problem in Uganda.

Leaf miners *(Liriomyza trifolii)*

Leaf miners mainly attack the glabrous-leaved types such as the Kumba group. Damage is most serious during the nursery stage. There are natural predators such as *Chrysonotomya* sp. in the rainy season and *Hemiptarsensus semialbiclava* which can be found during the dry season. The best way to control leaf miners is by using these natural predators, thereby avoiding the use of pesticides.

Root-knot nematodes *(Meloidogyne* spp.*)*

Eggplant is highly susceptible to root-knot nematodes which make galls (swellings) on the roots. Absorption of water and nutrients is reduced and plants wilt and die in severe cases. Research is taking place to suppress nematode populations by biological control agents like *Pasteuria penetrans* and *Verticillium chlamydosporium*, which parasitize the eelworms. Crop rotation is at present the best approach to minimize nematode problems. Sandy soils close to rivers are known to have more nematodes than heavier soils away from rivers.

Stem borer *(Euzophera villora)*

The stem borer is an insect that infests the stem at ground level and may girdle the plant, which eventually dies. The plants should be sprayed as for fruit borer, but care should be taken to direct the spray to the base of the stem.

Thrips (probably *Thrips tabaci*)

Thrips can be especially troublesome on glabrous leaves, where they scarify the surface. They create a silvery web on the underside of the leaves, which remain stunted. Sometimes they produce an effect that looks like a virus (*see* Figure 139). Thrips will also feed on the flower buds and many can be found inside the buds even before they open, thus causing the buds to drop prematurely.

Black aphids (*Aphis fabae)*

Black aphids can cause a severe reduction in yield. It has been observed that there are varieties of garden eggs which appear to have a tolerance to aphids. This needs further investigation.

Spider mites *(Tetranychus* sp.*)*

Figure 139 Leaves appear to have a virus but in reality have been attacked by thrips

Yield losses of over 50% caused by spider mites have been reported in the Kumba group found in the drier parts of north-western Africa. The glabrous leaves of the Kumba group are a favourite for the two-spotted (red) spider mite *(Tetranychus urticae).* Leaves turn yellow and fruit growth declines rapidly. In a serious infestation, the whole plant becomes covered in a web. Another species of economic importance is *Polyphagotarsonemus latus* which can also cause leaf and fruit deformations. Chemical control is difficult due to building up of resistance.

Varieties with stellate hairs, like the Gilo group, are far less susceptible.

For further references on pests and diseases see the various publications by van Epenhuijsen (1974), Critchley (1998) and Suglo (1998).

OPPORTUNITIES

Figure 140 *Solanum torvum*

Solanum torvum, (in Ghana called *kwahu nsusua* or *susruba*), which is commonly found as a shrub with many small green berries in a cluster, is known for its resistance genes effective against *Meloidogyne* nematodes and resistance to several other soil-borne pests and diseases (*see* Figure 140). These include *Verticillium, Thielaviopsis, Ralstonia, Phytophthora parasitica* and *Fusarium solani.* Unfortunately crosses with *S. aethiopicum* are not successful and it is therefore not possible to incorporate these genes into garden eggs. It is possible to use *S. torvum* as a rootstock and this technology could probably be of interest to those farmers who used to grow garden eggs on river banks near main roads, but can no longer do so because of pest and disease infestation.

POST-HARVEST HANDLING

Packaging

Garden eggs are marketed locally in baskets or packed into jute sacks for transportation to distan markets. This form of packaging material contributes to bruising of the fruit. Wooden boxes ar suitable containers for garden eggs, but these are rather expensive.

Storage

Garden eggs are not usually stored except whilst awaiting transportation, when there is a bumper harvest, or when prices are expected to rise within 1 or 2 days. For these reasons the storage area should preferably be cool and in the shade. Harvesting should take place during the coolest part of the day, preferably towards the evening or early in the morning. If produce has to be stored during the dry season a pan of water should be kept in the storage area to maintain the air humidity and to reduce shrivelling.

Drying

In Cameroon, ripe orange garden egg fruit are preserved by smoking. The fruit are boiled and, when cooled, cut into a few pieces; these are placed on a stick and hung above a wood stove or similar place where there is a lot of smoke, such as in a bakery. The smoking could last for a whole week, after which the pieces will have shrunk to only one-third of their original size and the product will have become very solid. It can be kept for a long time at this stage. When needed it is soaked overnight in water, after which it can be used in stews and for thickening soups. A somewhat similar method has been reported from Côte d'Ivoire where fruit are skewered on sticks and dried in the sun.

The high temperatures found in Ghana during October and November are favourable for drying garden eggs at a time when the price for the fresh produce is low. Solar drying, as used for drying cayenne peppers, takes about 8 days, compared with a traditional drying period of 12 days and is most effective. With solar drying the final weight is reduced to just 25% of the original weight and the moisture content will range between 7.5 and 9%. The produce can either be sliced or cut into cubes, depending on what the market requires. White fruit that were selected were found to turn to a yellow or orange colour when dried. Drying of garden eggs is not normally practised in Ghana, but it was found to be technically feasible and the end product was found to be suitable for use in soups.

Red nakati fruit are sun dried and ground into a powder which can be used in soups or as medicine for high blood pressure (*see* Figure 141).

Figure 141 Dried nakati fruit can be ground and sold as a medicine for high blood pressure

GBOMA EGGPLANT

Solanum macrocarpon L.

Figure 142 Gboma eggplants at a roadside market near Mankesim, Ghana

INTRODUCTION

The two horticulturally important eggplant species with an African ancestry are the scarlet eggplant, *Solanum aethiopicum* L., of which garden eggs are the best known representatives, and gboma eggplant, *Solanum macrocarpon* L. Both species can be found throughout the warmer and non-arid parts of Africa where they are often important fruity or leafy vegetables (*see* Figure 142). Several fruity cultivars of gboma eggplants can also be found in South America, the Caribbean and South-East Asia. The eggplant species usually referred to as aubergine or brinjal, *Solanum melongena* L., has its origin in South Asia, although it is closely related to the East African *Solanum incanum* L. The latter species has fruit that are poisonous when mature, but less so in the young stages when they are occasionally eaten, for example, in Tanzania.

The name gboma means leaf-fruit in the Ewe language, in which garden eggs are called *agbitsa.* The Yorubas of south-westwen Nigeria refer to it as *igbagba.* In south-eastern Nigeria the Igbos call it *mafowo-bomonu* and in Cameroon it is called *anchia* or *nkeya.*

In most African countries, gboma eggplant is generally considered to be a minor crop and, except in Nigeria, virtually no research has been carried out to enhance the germplasm potential or to study its agronomic requirements. The horticultural institute at Porto Novo in Benin has selected and distributed one cultivar. Specific research on this crop is not known from other places where this crop is relatively common, such as Côte d'Ivoire or the Zaire River Basin area. Agronomic research and

variety development work which started in 1998 in both Cameroon and Ghana is expected to contribute towards a better understanding and use of this potentially valuable and nutritionally important crop.

BOTANICAL ASPECTS

Figure 143 *S. macrocarpon*

Figure 144 The white-flowered form of *S. marcrocarpon* is rare in Tanzania and Ghana

Figure 145 *S. aethiopicum*

The easiest way to distinguish *S. macrocarpon* from *S. aethiopicum* is by its flowers; these have fused petals which are mainly light-purple in colour and have a diameter of 25-45 mm (*see* Figure 143). Plants with white flowers and/or more deeply cut petals can occasionally be seen, but are quite rare (*see* Figure 144). The flowers of *S. aethiopicum* are always white with free petals and their diameter is 12-18 (-22) mm (*see* Figure 145). *S. macrocarpon* usually has 2-6 (-10) flowers/inflorescence of which the lower 1-3 (-5) are hermaphrodites and the top ones are functionally male only. The lower flowers have a larger corolla than the higher ones. The leaves of the various forms and cultivars vary widely in size and in shape. The leaf blade runs down almost to the base of the petiole. Most leaves are shiny and glabrous, although some varieties can be slightly hairy or distinctly prickly. The large, often clasping calyx and sub-spherical, white-to-green (or, less commonly, purple) fruit which turn yellow or brown when physiologically ripe, are clearly distinct from Gilo or Kumba group garden eggs with their orange-to-scarlet fruit when ripe.

S. dasyphyllum Schum. is the ancestral species, commonly found in East Africa and less so in West Africa. This is a weedy species, usually with hairs and prickles on the stems, leaves and calyces. In East Africa, *S. dasyphyllum* is a common thistle-like weed and is often considered a nuisance because of its prickles (*see* Figure 146). Some people in Ghana collect the seeds of *S. dasyphyllum* to chew on for its intoxicating effect that can last for up to 2 days. This deleterious effect, caused by steroid glyco-alkaloids, is dangerous and can even cause death.

Figure 146 *S. dasyphyllum*

S. dasyphyllum and *S. macrocarpon* can be crossed easily, producing fully fertile hybrids, showing that together they comprise a single biological species. Intermediates are frequently encountered, especially in places where both the wild form and the cultigen can be seen.

The domestication process of *S. dasyphyllum* has involved loss of hairs and prickles (even if some are only partially without them), and a selection for tenderness of the leaves is frequently seen to be linked to a smaller leaf size and reduced lobing. Landraces that were selected for their fruit often show a reduction in bitterness and an increase in fruit size. There are thus two distinct groups within *S. macrocarpon,* of which the group used for its leaves is the most common throughout West and Central Africa. The fruity group is mainly restricted to the humid coastal areas of West Africa. In the coastal zones of East Africa, *S. macrocarpon* is far less common, but can still be found, for example, near Malindi in Kenya and near Dar es Salaam in Tanzania. The distinction between the two groups is not rigorous and leaves of the varieties selected for their fruit are often eaten. People who know both types mention that fruity varieties often have coarse leaves.

Figure 147 Mature fruit of the leafy group of *S. macrocarpon* often have a cracked surface

The leafy group is characterized by its mature yellow, brown or sometimes orange-brown fruit of about (22-) 30-45 (-60) mm in diameter, often but not always with a cracked surface (*see* Figure 147). Fruit are usually solid and packed with seeds and therefore are not eaten or only eaten at a very young stage. Fruit of the leafy types are not popular because of their bitterness. The leaves are comparatively small and not or only slightly lobed. They are glabrous or have few hairs on the veins or on the leaf margin and are rarely prickly.

The fruity group usually has much larger fruit of 5-8 (-12) cm in diameter, mainly oblate in shape and remaining yellow at maturity with a smooth, non-cracked surface (*see* Figure 148). The calyx is soft, rather wide and edible (when it is not prickly). Immature fruit can be white, green or purple. Fruit are soft and contain comparatively few seeds. The large, often lobed leaves can be eaten at a young stage and occasionally have prickles, usually on the midrib or larger veins. Some leaves have hairs, especially along the veins and on the lower surface. Such hairs can be both simple and stellate and they often drop towards leaf maturity.

There is considerable variation in plant characters, including pigmentation in the leaves ranging from shades of green to purple, size and shape of leaves, presence and shape of hairs, rate of leaf re-growth, fruit size, seed content, plant height, etc. Apart from the cultivars that are used either for their fruit or for their leaves, there are plant types that are not eaten, but used for medicinal purposes only, for which the roots are also used. Such varieties often have either short hairs (both stellate and slender simple hairs) or prickles.

Figure 148 The fruity group of *S. macrocarpon* usually has much larger fruit with a smooth, non-cracked surface

POLLINATION

The gboma eggplant, *S. macrocarpon,* has a low level of outcrossing, but is otherwise a self-pollinating crop since there are no incompatability barriers. Bees and other pollinating insects usually visit flowers within one plant before going to the next. The stigma is receptive some hours before the flowers open and remains receptive for about 2 days after. Flowers start opening very early in the morning when it is still dark.

Figure 149 Flower of *S. dasyphyllum*

Flowering starts about 50-60 days after transplanting, depending upon the variety. Plants grown in dry areas are observed to flower earlier than those in humid areas. The pollen is ripe from anthesis. Some segregation in the population may occur when there are several varieties planted close to each other, or when the wild *S. dasyphyllum* is present (*see* Figure 149). It is a diploid plant with 2n=24.

VARIETIES

Bukenya (1994) carried out a study on the morphology of the *S. macrocarpon* complex in Ghana and was able to describe some cultivated varieties which are mainly grown for their fruit and less so for their leaves. The names given are either those under which they were known by farmers or named after the village where they were found:

cv. Gboma: this variety is close to the type specimen for the species. It has small flowers and a calyx of 15-18 x 4-6 mm. Leaves are very shallowly lobed with medium-sized fruit, white to light-green at the young immature stage, turning to purple later, before becoming yellow at maturity;

cv. Mankessim: medium-to-tall plants, sometimes prickly. Calyx very wide. Leaves fairly deeply lobed, the middle lobe 40-60 mm, with few persistent hairs. Fruit 40-50 x 50-60 mm, white at the young stage (*see* Figure 150). Frequently cultivated.

Figure 150 cv. Mankessim

cv. Akwaseho: a version of Mankessim with more deeply-lobed leaves and larger, ivory-coloured fruit up to 50 x 90 mm.

cv. Kade has long but narrow calyxes, up to 30-60 mm long. Its leaves are narrow and deeply-lobed with a middle lobe of 80 mm. Its fruit are irregular in shape, ranging from 30-70 x 40 mm, green or green with whitish patches when immature;

cv. Sarpeiman: a primitive variety which is close to *S. dasyphyllum* with prickles 6-10 mm long. It is also fairly hairy and has petiolate leaves. Fruit green when young; and

cv. Bui: similarly primitive, prickly plants with subsessile, deeply-lobed, somewhat hairy leaves. Immature fruit green.

SEEDS

Fruit take about 10 weeks to mature from setting to full maturity. Seeds should ideally be collected from physiologically ripe fruit, identified by their cracked surface or dull colour. To facilitate removal of the sugary mucilage surrounding the seeds, it is advisable to ferment the fruit in water for about 24-36 h (depending on the temperature) after the fruit have been squashed. When foam appears on the surface of the water, the seeds will have settled at the bottom of the container and are ready for collection.

One gram contains approximately 250-350 seeds, depending on the variety. Seeds of the fruity types are almost twice as large as those of the leafy types. Most varieties have yellow seeds, but some are brown in colour.

AGRONOMY

The leafy group

Seeds are sown in a nursery and are spaced at 20 cm between the rows. The seedlings can be transplanted after 4-6 weeks. The spacing depends on the variety and optimum leaf yields were obtained in Nigeria at a spacing of 50 x 50 cm. Soil fertility is important and when preparing the beds, 15-15-15 NPK fertilizers should be applied at a rate of 80-100 kg/ha.

Figure 151 The favourite small-leaved type of *S. macrocarpon* from northern Ghana

The most favoured varieties have small leaves of about 15 x 10 cm (such as a white-flowered variety that can be found in northern Ghana) (*see* Figure 151). Such plants remain low when harvested frequently. Other cultivars are much larger and can have leaves of 35 x 25 cm that are often more coarse. The most preferred are young leaves from dark varieties.

The first harvest of leaves usually takes place about 1 week after flowers have appeared. The whole shoot including the terminal bud, and occasionally flowers, is picked. Subsequent harvests can be made once a fortnight and will consist of sideshoots in a form of ratoon cropping. An average yield of 2.9 kg/m^2 can be obtained in Nigeria with a crop spacing of 50 x 50 cm.

Varieties with rapid early re-growth will be most suitable for a high vegetative yield. Leaves can be harvested over a number of seasons and sometimes for more than a year when not interrupted by a dry season. This is not always economic, with yields being low when plants are getting older; better yields are obtained from a new crop. The crop found at markets early in the season is usually from re-growth. If plants are left undisturbed they can grow to a height of about 1.20 m and even up to 2.20 m. The average height of mature and regularly harvested plants is about 40-60 cm, whereas the frequently branched small-leaved types, which stay close to the ground, will not grow much taller than about 30 cm.

Leafy gboma eggplants are produced both in the high-rainfall or humid coastal zones of West and Central Africa and also in semi-arid and savannah areas (*see* Figure 152). Varieties coming from savannah areas may flower about 9 weeks from sowing, whereas the first flowers of varieties from high-rainfall areas will not produce flowers in less than 14 weeks.

Figure 152 In humid areas gboma eggplant fruit ripen whilst new leaves and flowers are formed

The savannah crop is mainly used for subsistence purposes and its availability is restricted to the rainy season. These dryland varieties are more tolerant to drought than the Kumba group of *S. aethiopicum* found in the same area. Apart from being drought

Figure 153 Gboma eggplants may sprout again after a fire

tolerant they also have the ability to sprout again after a fire (*see* Figure 153). The crop from coastal areas is grown both for the market (for example, in Benin) and for subsistence.

The leaf crop is of significance in the traditional farming system for the Yorubas in Nigeria. In most places such as Benin, south-western Nigeria, Cameroon and elsewhere in West and Central Africa, gboma eggplant is mainly grown for its leaves.

The fruity group

A plant can produce up to 50 fruit during its lifetime of 2 years on average, after which it is usually removed. Fruit are ready for picking about 3-4 weeks after fruit setting. At this stage they are still soft and not filled with seeds. The fruity group of varieties produces its first flowers before the leafy group, although the difference is not much more than about 2 weeks. The fruity group is restricted to the high-rainfall zones and is not known in savannah areas.

Some fruit can be very large, weighing up to 750 g each, with a size of up to 115 mm wide and 85 mm high. Most fruit, however, are about 80 x 60 mm in the immature stage and weigh about 200-250 g when they are offered for sale. They are mainly sub-spherical and only a few varieties are round or ovoid/heart shaped. The preferred colour is ivory white, but there are several varieties with different shades of green (*see* Figure 154) and some that are, at least partly, purple in colour. Clustered varieties are rare, and could be used in a breeding programme (*see* Figure 155).

Figure 154 Different cultivars of the gboma eggplant fruity group

Figure 155 Clustered varieties are uncommon and could be used in a breeding programme

In Côte d'Ivoire and in Sierra Leone, gboma eggplants are a popular and expensive fruity vegetable. Fruit are usually sold individually. Their price is two to three times higher during the dry season than it is during the rainy season.

Fruit varieties require more frequent watering than the leafy group. Once plants are affected by drought, seeds will develop faster, making the fruit unsuitable for consumption.

The spacing for fruity varieties is about 1.00 x 1.00 m.

The toughness of the skin varies between varieties and this toughness can be a disadvantage when cooking the fruit. There are, however, some varieties with a softer skin, but such varieties do not travel well and cannot be stored for long. Tough-skinned varieties can be stored for up to 2 weeks, but when the calyx has turned black and has dried out, the fruit is difficult to sell.

In Ghana, fruity types, for example Mankessim and Winneba, are only popular in the warm and humid coastal area and further to the west. There are some varieties that are quite bitter but most people prefer the non-bitter types. The fruit crop appears to be on the decline in most countries and it is important that germplasm collections are made to preserve the present diversity (*see* Figure 156). *S. macrocarpon* fruit are becoming a luxury vegetable in the Caribbean for export to the US and Europe, and are also becoming more popular in South-East Asia and it would be unfortunate to lose potentially valuable germplasm due to lack of proper conservation.

Figure 156 Small-leaved, white-flowered varieties of gboma eggplant are uncommon

PESTS AND DISEASES

A study was carried out in Nigeria on pests affecting *S. macrocarpon,* resulting in the following list:

Empoasca flavescens	leaf hopper
Epilachna hirta	leaf beetle
Epitrix cucumeris	flea beetle
Epitrix parula	flea beetle
Heliothis armigera	fruit borer, bollworm, corn earworm
Meloidogyne sp.	root knot nematode
Psilliodes balyi	—
Psilliodes splendida	cut worm
Spodoptera litttoralis	—
Proderia litura	—
Tetranychus truncatus	red spider mites.

S. macrocarpon is known to be resistant to the whitefly *Trialeurodes vaporariorum.* It is highly tolerant to the spider mite *Tetranychus urticae* and only minimal infestation is observed.

The following diseases were recorded (in the same study):

Puccinia penniseti	yellow rust (can be severe)
Geotrichum candidum	rusty brown leaf spot
Fusarium sp.	
Verticillium dahliae	wilt
Gloesporium melongenae	anthracnose
Leveillula taurica	powdery mildew
Phomopsis vexans	phomopsis rot
Phytophthora parasitica	fruit rot
Pseudomonas solanacearum	bacterial wilt
Leaf curl virus	the exact species and its vector are not known.

Generally, *S. macrocarpon* is not very susceptible to diseases and is resistant to *Thielaviopsis basicola* (damping off disease). Gboma eggplants require warm conditions and are therefore not or only rarely found at high altitudes. At high altitudes, plants are sturdy and their growth rate is slow. Otherwise rare diseases of gboma eggplant, such as *Alternaria solani* and *Phytophtora infestans,* may be found under such circumstances.

NUTRITION AND ANTI-NUTRITION

Fruit consist of: 89% water; 8% carbohydrates; 1.4% proteins and 1.5% fibre. The leaves consist of: 86% water; 6% carbohydrates; 4.6% protein; 1.6% fibres and 1% fat. The leaves are rich in calcium. For the amino acid composition of leaf protein concentrates *see* p.162 where a comparison has been made with amino acids found in leaves of the Shum group.

One negative aspect, which needs to be addressed, is the presence of a number of spirosolane alkaloids, including solanine and solanidine, which are bitter tasting, found in all *Solanum* species. These substances are potentially poisonous when eaten frequently. This is especially so when the food is not properly cooked, for example, when people merely blanch the leaves or steam them lightly to present them as being fresh. Leaves should therefore not be eaten raw as a salad. Unfortunately, the cooking or frying process does not remove these alkaloids, but discarding the water in which the vegetables have been cooked can reduce them. If people do eat *Solanum* species frequently, and especially bitter-tasting leaves or fruit, toxicity symptoms such as vomiting and diarrhoea may well be noted. One of the difficulties is that the liver is able to retain and accumulate alkaloids over long periods. It is therefore possible that by consuming too much *Solanum,* people may become confused or, more seriously, become delirious, leading to a coma and death. A further possible consequence of ingesting too much solanine is that mothers may give birth to a child suffering from *spina bifida,* a disease where some of the bones in the spine have not joined properly.

Plant breeders should take the problems associated with spirosolane alkaloids into consideration and aim for cultivars with considerably less than 20 mg alkaloids/100 g fresh weight of the edible plant part, which is the upper acceptable limit.

Food preparation and peoples' preferences

In Uganda's Buganda region, *S. macrocarpon* leaves are wrapped in banana leaves and placed on top of the main starchy dish, therefore becoming steamed. This will reduce the loss of vitamins which would occur when they are cooked. Another favourite method is to fry the leaves in cooking oil with onions.

In Cameroon, Benin and Nigeria, *S. macrocarpon* leaves are appreciated more than the Shum group of *S. aethiopicum,* since they are less coarse (*see* Figure 157) and, accordingly, *S. macrocarpon* leaves fetch a much higher price than other leafy vegetables in the market at Yaoundé. In Uganda, where nakati is popular, people consider gboma eggplant leaves to have a flat taste. In Nigeria, the leaves are highly appreciated for their quality when made into soup. The soup remains acceptable for consumption for about 3-4 days, as long as it is re-heated twice daily.

Figure 157 Large gboma eggplant leaves can be coarse

The leaves can be preserved by sun drying. The dried product is broken into small pieces or ground to a powder and subsequently used in soups. Varieties with small spines can be used for drying. Some people shred the leaves before cooking them and the small spines will then be of no consequence, which may explain why there are still so many landraces left that have spiny leaves. Many people consider the fruit skins of gboma eggplant to be rather tough and the soup made out of gboma eggplants is thought to be too heavy, which is why they are generally less popular than garden eggs. On the other hand, garden eggs are generally more bitter than gboma fruit; this is why the sweet taste and soft structure of gboma fruit are sometimes preferred.

OTHER USES

According to Dr Bukenya (1994) pregnant women in Uganda eat the leaves of one gboma eggplant variety to ease delivery. The leaf extract can be used as treatment for boils. Extracts from the roots are used to treat abdominal worms. Fruit of the wild form, *S. dasyphyllum,* are used in treating the side effects of measles. Cooked young fruit of *S. dasyphyllum* are used in Cameroon as a medicine for fever in babies. The fruit are ground into a paste and this paste is also used to treat stomach-ache in small children.

S. macrocarpon fruit are not eaten by people in Uganda because of their resemblance to the poisonous weed *S. incanum.* Even the consumption of leaves in Uganda is restricted to the southern part of the country.

AFRICAN NIGHTSHADES

Solanum scabrum, S. villosum and others

Figure 158 Farmer in Foumbot, Cameroon. Note the line of amaranth plants in between the nightshades

INTRODUCTION

The two most frequently cultivated African nightshade species are the dark-purple-berried *Solanum scabrum,* which can be found mainly in West Africa and the orange-berried *S. villosum,* which is cultivated in East Africa. There are several species with black berries that are cultivated to a limited extent, of which the most important is *S. americanum.* All these species belong to the *S. nigrum* complex, which are here referred to as the African nightshade group of species. Further research is needed to establish the correct identity of the black-berried species. Their cultivation is on a much more limited scale than those of *S. scabrum* and *S. villosum,* whereas most black-berried types are collected from the wild and are thus beyond the scope of this section.

S. scabrum is mainly known from Africa and the wide range of diversity found in Nigeria and Cameroon suggests that its origin is likely to be in the warm humid forest belt of western Africa. *S. villosum* is known from a much larger area, but is mainly found in eastern Africa, southern Europe and the Middle East. Its indigenous status for Africa is therefore probably correct. Both *S. nigrum* and *S. americanum* have a global distribution and it is therefore more difficult to make a similar claim for these two species.

S. scabrum, or garden huckleberry as it is also referred to, is cultivated in several locations in Africa's humid highlands and somewhat less in its lowlands, such as in Congo (Democratic Republic) and Gabon. It is an important subsistence crop in southern Nigeria. In Cameroon, it is one of the most popular cash crops and especially in the western and north-western provinces it is found to be the most commonly grown traditional vegetable (*see* Figure 159). *S. scabrum* is also seen in East Africa and its cultivation is on the increase in both Kenya and Tanzania.

Figure 159 African nightshade, *S. scabrum*

There are two subspecies of *S. villosum*. The first has short hairs and can be found in relatively dry areas such as in Ethiopia, northern Uganda and the eastern part of Kenya. The second subspecies, which appears to be glabrous, is relatively common in the northern highlands of Tanzania and less so in its southern highlands. *S. villosum* is not as popular in East Africa as *S. scabrum* is in West Africa. However, observations over the last 10 years have shown that *S. villosum* is rapidly establishing itself as an important and expensive leafy vegetable, especially in Tanzania, where it now ranks behind amaranth in popularity as a leafy vegetable; this popularity is increasing at the expense of cabbage.

The generally smaller black-fruited nightshades can be seen growing in the same areas and appear to be less domesticated and closer to the wild or weedy species. The black nightshade group is also cultivated as a minor crop in tropical Asia and in South and Central America.

Naming African nightshades

There is confusion about names and reports from Nigeria often refer to *S. nodiflorum*, which is a synonym for *S. americanum*, when probably the plant referred to is *S. scabrum*. Also the name *S guineense*, a synonym for *S. scabrum*, is frequently used in Nigerian literature. There are many local names for these vegetables and different names may be given for the tall *S. scabrum* or garden huckleberry and for the smaller black-berried nightshade species which are all called *la morelle noire* in French. Yoruba-speaking people call black-berried nightshades *odu* and give the name *ogunmo* to *S. scabrum*. In East Africa, the whole group is called *mnavu* in Kiswahili whether the berries are black or orange. In south-eastern Nigeria, *S. scabrum* is called *ewa*. In Uganda, African nightshade is called *nsugga*, which mainly refers to the non-cultivated black-berried species. In Cameroon, people use various names, of which *jamajama, zom* and *bitossa* are most frequently used for *S. scabrum*.

S. scabrum is one of the most popular leafy vegetables in south-eastern Nigeria and Cameroon and is often called huckleberry or garden huckleberry, which is confusing because of the reference to a berry. The true huckleberry is a very different species, a shrub with edible berries belonging to the Ericaceae family.

Most African nightshade species are difficult to identify but *S. scabrum* can be recognized with relative ease by its strong stem with more-or-less toothed wings. There are both small- and large-leaved cultivars with different leaf shapes and the leaf colour can be either green or dark-purple. The flowers are either white or light-purple and have brown or dark-yellow anthers. Its berries are sub-spherical, dark-purple in colour and 10-15 (-17) mm broad. In contrast to most other members of the *S. nigrum* complex, these berries remain on the plant at maturity. The stems can be green or purple in colour. The tall type with green stems is sometimes referred to as the Foumbot variety and is grown on a large scale as a monocrop in and around Foumbot. In Nigeria this annual herb is reported as growing up to

1 m in height and 1.20 m in width when left undisturbed. *S. scabrum* is by far the most common species in West Africa and many different cultivars can be seen, often of local importance only (*see* Figure 160).

Figure 160 The various cultivars of *S. scabrum* appear to be very different

The complexity in the *S. nigrum* group is partly caused by different levels of ploidy. When both the genetic diversity and the plasticity found in other *Solanum* species such as *S. aethiopicum* and the possibility of hybrids between species are considered, it is understandable that there is much confusion about the delimitation of the species. Fortunately, *S. scabrum* is quite distinct, even though there is a lot of variation. Chances for crosses with related species other than *S. nigrum* are limited, because these two species are hexaploid, whereas six of the eight most common related species found in Africa are either diploid or tetraploid (Edmonds and Chweya, 1997). Taxonomic details for the four major African species within this group are provided at the end of this section.

Aspects of breeding

S. scabrum and other African nightshades are predominantly self-pollinating, although there are differences between the species, considering the variable lengths of their styles. *S. americanum* is often noticed with styles well beyond the anthers, indicating a higher level of cross-pollination.

The lack of a self-incompatibility system, which applies to all African nightshades, is a very useful tool, since it will help to stabilize any crossings made, whereby after only two or three generations the new population will be sufficiently uniform. It will assist a genetic enhancement programme through purification of landraces where a selected accession could be multiplied quite rapidly and the offspring would have a high degree of uniformity. Varieties could thus be created within a short period.

Small bees and black syrphid flies can affect pollination (*see* Figure 161). Therefore, when a crop is grown for seed production care must be taken to avoid cross-pollination. It is recommended that the seed crop be planted in blocks (and not in lines); the outer rows will be discarded and berries should only be collected from the inside of the block. The block should be exclusively made up of plants grown from seeds extracted from one selected plant. The planting distance for a seed crop should be about 50 x 50 cm to 100 x 100 cm, depending on species and variety.

Figure 161 Pollination of African nightshade by bees

Seed production

Seeds can either be produced on the farm or purchased at the market (in Cameroon for about $ 0.40/ 20 cl glass). Some farmers make an effort to produce *S. scabrum* seeds for sale. Some of the seed producers also specialize in the production of seedlings for sale to others.

Strong plants with desirable characteristics are normally selected after the third or fourth harvest when no further shoots will be plucked and the plant is allowed to produce flowers and berries. Other farmers are less selective and designate one corner of their farm to be used for seed production. They do not just avoid paying for seed, but mainly wish to ensure that they will obtain the desirable variety and especially that the germination capacity will be good.

Figure 162 The berries from *S. scabrum* are easy to collect

Figure 163 Berries of *S. villosum* are collected before they drop

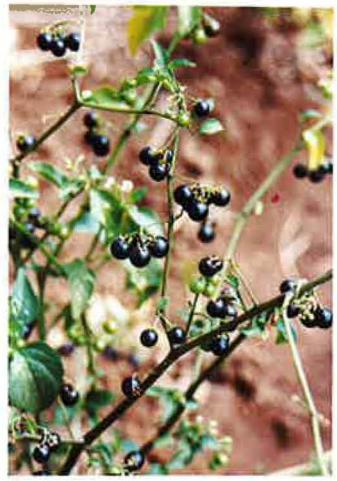

Figure 164 Black-fruited berries of *S. americanum* usually drop and are difficult to collect

S. scabrum berries are easy to collect (*see* Figure 162) since they remain on the plant, whereas the berries from most black-fruited types drop to the ground. The orange berries of *S. villosum* only drop when the fruit is over-mature and could be collected from the plant (*see* Figure 163).

Collecting berries from black-fruited African nightshades, mainly carried out by children, for example, in Kenya, takes a lot of time (*see* Figure 164). For this reason seeds from 'black' nightshades are far more difficult to obtain than seeds from *S. scabrum* and this is frequently mentioned as a major constraint to their production. Seeds of *S. villosum* can be bought from the Alpha Seed Co. in Moshi, Tanzania, for about $ 35/kg compared to amaranth, which is offered for about $ 4/kg, indicating the difference in cost of collection and seed extraction. The Kenya Seed Co. has also started to sell *S. villosum* seeds.

A popular way to extract *S. scabrum* seeds in Cameroon is for farmers to put the berries in a bag with a few small holes in the bottom. The bag is hung so that there is plenty of air circulation. The fruit will start rotting and the juice will leak out through the holes. After some time, the produce will have dried completely. By storing dried fruit with their seeds inside there is less chance of damage by rodents. A winnowing process separates the seeds just before sowing.

In the fermentation process, fruit are squashed inside a container with water and left for several hours up to 1 day to separate the fleshy parts from the heavy seeds which will settle at the bottom of the container. These seeds can be collected by pouring the water with the floating material out of the container; once this has been repeated, say, three times, most seeds are left which may then be dried in the shade on a piece of cloth. Some farmers do not take this trouble and simply squeeze the seeds out of the over-ripe berries, wash the seeds and dry them. The latter method is also applied for *S. villosum.*

Alternatively, as noticed in Yaoundé's seed market, the ripe berries are spread on a sheet of plastic or cloth placed on concrete where they will be dried by the sun. The dried berries will then be collected after about 1 week and the seeds are sold inside the berries. It is said that seeds will keep longer inside the dry berry than as extracted pure and clean seeds.

From 1 kg of *S. scabrum* berries, farmers will obtain about 40 g of seeds. The number of seeds/berry varies from about 20-60 depending on the variety and conditions. There are about 1000 seeds in 1 g of the larger varieties of *S. scabrum,* whereas there are up to an estimated 3500 seeds/g for the smaller-fruited African nightshades. For the large Foumbot variety, 150-300 berries/plant can easily be obtained and sometimes more.

S. scabrum seeds can remain viable for several years when kept dry, but will rapidly lose their germination capacity when kept in humid conditions. This viability can be extended for up to 10 years when seeds are kept under cold conditions (assuming that the cooling system is not frequently disrupted by a lack of electricity, causing a rise in ambient temperatures and high humidity which will have an adverse effect). Seeds can be kept dry by keeping them in an airtight container, ideally with a desiccant such as oven-heated rice placed at the bottom, separated from the seeds by a piece of cloth.

AGRONOMIC ASPECTS

Propagation

Figure 165 African nightshades' flowering occurs earlier when seeds are sown directly than when seedlings are transplanted

Direct sowing

African nightshades produced for subsistence are mainly sown at the beginning of the rainy season. Nurseries are used to grow a commercial crop, mainly in the dry season and for monocropping. When sowing directly, a few (3-10) seeds are used per location, for example, next to the companion crop in a mixed cropping system. The strongest plants will be kept and the others removed as a first harvest or for planting in a different place. To avoid seedlings from becoming too spindly, sowing should not be too dense. Direct sowing during the rainy season results in taller plants and, when there is adequate room, in more and larger leaves and branches and a better dry-matter content when compared with transplanting. Flowering occurs earlier when the seeds are sown directly than when seedlings are transplanted (*see* Figure 165).

Nursery practices

It has been noticed both in Kenya and in Nigeria that African nightshade seeds require manure to germinate well. In Uganda, they were found to germinate very well on land where there had been recent fires (such land being rich in plant nutrients such as potash). Germination is often poor and was found to be significantly lower when seeds were sown on non-fertilized land. Given these observations it is clear that proper nursery practices are needed. A piece of land should be prepared by digging the soil and by working in some well-decomposed manure, leaving a well-drained structure with fine particles. The burning of a layer of grass or similar material placed on top of this bed will sterilize the soil and avoid both soil-borne pathogens and weeds. It will also provide a layer of ash that is full of nutrients, especially potash. The nursery bed is now ready to be sown with lines about 20 cm apart or, alternatively, seeds are broadcast. Seeds are either mixed with dried poultry manure and/or sand. Some farmers mix seeds with ash to spread the seeds more evenly. After sowing, the bed should be covered with a thin layer of soil which also helps to prevent ants from carrying the seeds away. The germination time is usually 5-7 (-10) days.

Figure 166 Stem cuttings can be used for propagation of *S. scabrum*

Seeds sown for a commercial crop will be in the nursery for about 1 month from sowing to transplanting. One farmer in Yaoundé was seen sowing *S. scabrum* berries rather than sowing seed. First, he turned the plant over with the roots in the air, thus allowing the berries to ripen faster and to soften. The berries do not fall off, but need to be picked from the plant. This ripening process is said to hasten germination. Those soft berries will be sown and the resultant bunches of young plants used as seedlings.

Using stem cuttings

An alternative propagation method is occasionally used in Nigeria where *S. scabrum* is propagated by stem cuttings (*see* Figure 166). When using this method the spacing is normally 40 x 40 cm or even 40 x 60 cm, considering that the variety concerned can reach 100 cm in height (if not trimmed). The advantage of this method is that it only takes about 3-4 weeks before the first harvest can take place, but the total yield is lower compared to transplanted or directly sown seedlings. Similar trials carried out in Kenya also showed a significantly lower yield from vegetatively propagated plants, mainly due to their limited branching. Furthermore, when leaves from such crops were studied in the laboratory, it was found that they contained more glycoalkaloids than leaves obtained from seedling plants.

Transplanting and spacings

Seedlings are selected for their strength and freedom from diseases and planted late in the afternoon. Seedlings should be at least 8 cm tall and have about 5-6 true leaves. Adequate water is needed just before and immediately after transplanting since roots are sensitive to drought. Whilst transplanting, it is essential to ensure that there is a good root-to-soil contact by covering the roots with soil and by applying a slight pressure to it. Replacement of plants to avoid an irregular crop is then hardly necessary.

The spacing may differ, depending on the variety and on the intended crop duration but poor transplanting practices lead to a loss of revenue (*see* Figure 167). It is usually wider during the rainy season than during the dry season. Spacing is normally somewhere in between 15 x 15 cm and 25 x 25 cm (16-40 plants/m^2) with staggered planting or occasionally 25 x 10 cm when planted in rows on beds about 10 m long and 110 cm wide. Spacing can be even wider (25 x 40 cm) when the crop is to be kept for a long period, encouraging stronger branches and an extended harvest period for which additional fertilizers will be needed. Large-scale commercial farmers in Foumbot, Cameroon, use a 20 x 20 cm spacing during the dry season. The spacing for *S. villosum* in Tanzania is currently about 25 x 40 cm, but further studies are likely to indicate that closer planting will be possible. The argument used for this wide spacing is the avoidance of diseases, especially in the rainy season.

Figure 167 Open space left because of poor transplanting methods will not bring in any revenue

The higher yields obtained during the dry season are attributed to the generally wider spacing used and thus less disease pressure. Branching is stronger at a wider spacing, making up for the lower number of plants.

Cultivation practices

Daily irrigation is needed for the first week after transplanting, especially during the dry season. The irrigation interval can later be reduced to three times/week, depending on temperatures, cloud cover or possible rains. Watering can be through the paths (gravity irrigation) in between the raised beds or by using a hose or watering can. Overhead irrigation should be avoided because of the potential spread of diseases.

Plants tolerate some shade, but thrive when exposed to full sun during the cool season. They do not do well during the hot season unless they have adequate access to water.

Weeding is needed during the early stages of development. Once the lower branches have spread out, weeds are generally suppressed.

Fertilization

Nightshades require large amounts of nitrogen and other nutrients and therefore do well in soils that are rich in organic matter. They also grow well on land covered with ash from recently burned vegetation. Fertilizers were found to be effective and farmers mainly use 20-10-10 NPK, urea or sulphate of ammonia when there is no poultry or farmyard manure available. Side dressing is practised after every second harvest. Extra nitrogen may appeal to the farmer because of increased yields. However, high nitrogen levels make the crop more vulnerable to diseases unless there is a proper balance with potassium. It will also have an impact on the level of nitrites in the leaves, which could become a human health hazard that could eventually turn customers away.

PESTS AND DISEASES

Figure 168 The small holes in nightshade leaves caused by ants are appreciated since they indicate that no insecticides have been used

Nightshades are frequently eaten by insects, but apparently people do not mind buying leaves with holes and see it as proof that insecticides have not been used (*see* Figure 168). Such small holes can be caused by ants. Black aphids may cause (*see* Figure 169) leaves to curl and affect further growth of the plant. In some areas, aphids appear to have taken over altogether and, even when they are subsequently controlled by chemicals, the characteristic curly leaves remain.

Caterpillars and occasionally grasshoppers, including *Zonocerus variegatus,* can be a nuisance. Small black beetles (possibly flea beetles) found on the underside of African nightshade leaves cause those leaves to twist and fold, making them unattractive for sale. Commonly found beetles include *Lagria* sp., *Podagrica* sp and *Epilachna* sp. Black aphids, millipedes and snails have been reported on *S. americanum* in Kenya. Aphids are also the most important pest problem for *S. villosum* in Tanzania.

A traditional cure for pests is wood ash spread onto the leaves. People do not like the resulting grey colour of the leaves and prefer dark-green leaves, which is rather difficult unless the holes caused by

Figure 169 Aphids are a serious pest on African nightshades

Figure 170 Root-knot nematodes are common in African nightshades

insects are accepted. Farmers use a lot of insecticides such as Sevin 85 or Decis. Some farmers use Actellic in the nursery. Spraying is carried out once or twice a month depending on the gravity of the infestation. Chemicals are not always effective against insects that are hiding underneath the leaves.

Many farmers do not follow the instructions given on the label of the insecticide container, which may state that, say, 1 week has to pass before harvesting can take place. Instead they believe that the effects of chemicals last only 24 h and such farmers will harvest 1 day after spraying. This lack of knowledge and lack of proper advice have resulted in a lot of people with stomach complaints or worse and have given leafy vegetables a bad name.

Many of the pests of tomatoes or Irish potatoes can also be seen on African nightshades. Nematodes are no exception (*see* Figure 170) and it is therefore important to stick to a crop rotation in which the various members of the *Solanaceae* family should not follow each other. A rotation with amaranth is recommended.

During heavy rains diseases can be troublesome, especially when plant spacing is close. A major disease in *S. scabrum* was found to be *Phytophthora infestans,* the late blight which is also common on tomatoes and Irish potatoes. This causes a greyish rot of leaves and stems and subsequent drop of leaves (*see* Figure 171). It is said to be particularly problematic during the rainy season when temperatures are low; the three most profitable crops all happen to be affected by late blight. According to Edmonds and Chweya (1997), *S. nigrum* and *S. villosum* are resistant to late blight, thus offering opportunities for the plant breeder.

A second important disease is *Alternaria solani,* the early blight.

Other diseases recorded include:

- *Cladosporium oxysporum,* which can be recognized by a greyish-green mould on the lower side of the leaves and a light green-yellow colour above;

Figure 171 *Phytophtora infestans*

Figure 172 *Cercospora nigrescens* eye spot

- a species of downy mildew, the eye spot, *Cercospora nigrescens* (*see* Figure 172); and
- the powdery mildew *Leveillula taurica,* with yellow spots on the upper surface and a white mould below;

In Kenya, a 5% plant loss due to *Ralstonia solanacearum,* bacterial wilt was recorded. Wilting has also been observed in Tanzania on *S. villosum.* In this case the pathogen has not been identified.

During the dry season there may be a slight difficulty with leaf curl virus in Cameroon. In Nigeria, a yellow vein virus was reported in the rainy season which is probably transmitted by the whitefly, *Bemisia tabaci.*

Disease-spraying programmes are similar to those for tomatoes and Irish potatoes. This will, however, only be feasible when the resulting products can be sold at a profit.

HARVEST AND POST-HARVEST

It takes about 5 weeks from transplanting to the first harvest for *S. scabrum,* when stems are cut down to about 15 cm from the ground, allowing new side shoots to develop. The shoot length of *S. scabrum* varies from 15-50 cm, depending on the variety. Large-leaved varieties usually have long stems. Further harvests take place at roughly 7-14 day intervals, on average 3-4 times/plant if there is no additional manure or fertilizers, but large-scale commercial farmers will harvest 10 times and occasionally more. Most farmers keep the plants until February/March when the land is needed again for other rainy season crops or staple crops.

It was found in Cameroon that optimum yields are obtained during the third (second-fifth) harvest, which is about 2 months after planting. Yields are 7-13 t/ha for the first harvest to up to 12-20 t for the third harvest, especially when the more densely planted crop has its peak. Yields decline significantly after the sixth harvest unless adequate fertilizers are applied. A commercial farmer can thus obtain 50 t/ha and, with good management, even more from his dry-season crop of the green Foumbot variety. For the dark, small-leaved type, which is very popular in West Cameroon, the average yield/1000 m^2 is about 50 large bundles (of about 20 kg each) per harvest. The smaller plant types have a shorter harvest season than the large-leaved tall types, because when the small plants grow older, their shoots become thinner. Total yields are about 40 t/ha for small-leaved varieties and 50-70 t/ha for the large-leaved types.

For *S. villosum,* harvesting may take place on a weekly basis and thus 8-10 harvests can be obtained from the crop. In this case, side shoots of about 10-20 cm long are harvested. Complete harvesting is practised when the spacing is as close as 10 x 10 cm and plants are uprooted. This method is sometimes used when there is suitable land available, but less than 2 months before the main staple-food crop will need to be planted. Roots of the harvested crop can be kept in water to keep it fresh and the flowers should be removed before the crop is taken to market (*see* Figure 173).

Figure 173 *S. villosum* flowers should be removed before the crop is taken to market

In Kenya, the early crop is brought to market with the roots attached. Subsequent harvests are usually short shoots which are sold in a loose heap. Yield data from Kenya and Tanzania show about 20-25 t/ha, but many of these data were based on small plots and not commercial-sized fields. Yields for a mixed cropping system are very hard to establish and no accurate data are available.

Actual harvesting may take place twice a week, depending on the market day of the village or nearby town, but the plucking of shoots will not be from the same plant. Harvesting takes place very early in the morning and the produce is sold the same day. Alternatively, it is collected late in the afternoon and the produce is placed on plastic sheets or banana leaves, after which they will be tied in small bunches and brought together in large bundles. Wholesale consignments will go to assembly markets where trading takes place from 05:00 to 06:00. When left overnight the bundles are placed vertically. If the stems are placed in a horizontal position the heads may turn upwards, making them less attractive.

Yaoundé retail price statistics show that *S. scabrum* prices are lowest from May to October and rise to a peak price towards the beginning of the rainy season in March, when farmers can obtain a price which is twice the main-season price or more. The price/bundle remains constant, but the quality and quantity may vary considerably. This practice where the price remains constant, but the volume differs, is used in most African countries for traditional vegetables.

In the markets in Arusha, Tanzania, *S. villosum* was found to be by far the most expensive leafy vegetable, offered at roughly twice the price of amaranth.

In Kenya, where African nightshades are rarely seen outside the rural areas, there is a demand in Nairobi which can scarcely be met by farmers from the surrounding areas. Now farmers from as far away as the Kisii and South Nyanza districts have made arrangements to transport their produce to the capital.

USES AND NUTRITIONAL VALUE

Especially in Nigeria, *S. scabrum* leaves may be dried for use in soups or sauces during the dry season. Drying in the shade where temperatures are relatively low was found to be better for the retention of ascorbic acid. The levels of crude protein and mineral nutrients were not much affected by drying.

In western Kenya, African nightshade is used to produce a substitute for meat. People first boil the nightshade in water, after which the cooking water is replaced with milk and boiled again for a short time. The resulting product is compressed and left to dry and ferment for a few days, when it solidifies and turns almost black in colour. This 'cake' is now ready and the slices cut from it are said to be high in proteins. It is served together with cassava or similar food and can be accompanied by freshly prepared leafy vegetables.

The nutritive value of African nightshades depends on many factors, including crop species, whether it was grown during the rainy or the dry season, soil fertility, etc. The age of the crop is also important and leaves collected during the vegetative stage have a higher protein content than those harvested from flowering onwards.

The leaves contain an appreciable amount of methionine. A major consideration is the fact that about 60% of the vitamins and many other micro-nutrients (*see* Table 14) can be lost in the cooking process, especially when the water is replaced several times. This is one of the reasons why the less bitter *S. scabrum* is possibly a better vegetable than the bitter *S. americanum* and similar black-fruited species,

since the cooking water can be used in soups and sauces. The shorter the cooking process, the fewer nutrients will be lost and the Ugandan method of steaming may be the best. However, many people in Uganda do not like *nsugga* because it is too bitter, suggesting that the steroid glycoalkaloid content is too high.

A favourite dish in Cameroon's forest zone is *sanga,* which is prepared from fresh maize and African nightshades. People in Uganda occasionally use the dark-purple or black fruit as a source of ink.

Table 14 Nutritive value of 'black nightshade'/100 g fresh shoots/leaves

Nutrient	Range of Values
Water	83-91 %
Crude protein	2.8-5.8 g
Crude fibre	0.6 -1.4 g
Fat	0.8 g
Carbohydrate	3.3-5.0 g
Calories	38 Kcal
Total ash	3.3-8.8 g
Iron	1.0-4.2 mg
Calcium	90-442 mg
Phosphorus	75 mg
Beta-carotene	1.7-11.6 mg
Ascorbic acid	20-158 mg
Oxalate	58.8-98.5 mg
Nitrate-N	29-400 mg
Total phenolics	68.3-73.4 mg

Source: Edmonds and Chweya (1997)

Toxicity

People with ready access to *S. scabrum* eat it two or three times a week on average. When people eat it more frequently, they may develop stomach-ache and then change to other vegetables such as *Colocasia* or *Xanthosoma* leaves, amaranth, bitterleaf or cabbages during the rest of the week. The stomach-ache is caused by the toxic glycoalkaloids solanine and solanidine that are usually associated with *Solanum* species.

To the author's knowledge, no green or black berries are eaten in Africa, but East African children frequently eat the orange berries of *S. villosum.* Most people also remove the flowers and inflorescences. The inflorescence with buds, flowers and small fruit are removed in south-western Nigeria before cooking. Van Epenhuijsen (1974) mentions that these very bitter-tasting inflorescences can subsequently be used in soups for flavouring, which is mainly appreciated by older people. People have noticed that when they eat immature berries they may develop problems which could be serious. Green berries contain more of the poisonous alkaloid solanine and the less poisonous solanidine. The effect of solanine poisoning includes vomiting and dizziness, mental confusion and loss of speech and can even result in blindness.

Most leaves contain only low levels of these alkaloids, which are associated with the bitter taste. Cooking will reduce some phenolic compounds that may be present in the leaves, whilst bitterness will be reduced after the cooking water is discarded. Heating will unfortunately not reduce the toxic effects of solanine and solanidine.

See further under *Nutrition and anti-nutrition* in the section on *Solanum macrocarpon*, p.175.

Consumers' likes and dislikes

The cooking water, particularly of the dark-stemmed varieties, can be black (the cooking water of most African nightshades is green). People may or may not change the water once or several times, to reduce the dark colour and to reduce the bitterness and toxins. Unfortunately, vitamins and other micro-nutrients can be thrown away with this water, thereby much reducing the nutritious value. When *S. villosum* is cooked in northern Uganda, people usually replace the cooking water, thereby reducing the bitter taste. However, when it is cooked with a paste of sesame seeds, this bitterness is appreciated and the water will not be replaced. Tender, fresh shoots are eaten with the leaves. Older shoots or shoots left overnight produce a foam when cooked. This is not appreciated.

Both *S. scabrum* and *S. villosum* are relatively mild in taste when compared with other African nightshades. There are large differences between varieties and this aspect requires further study.

In Cameroon's western province, *S. scabrum* is enjoyed in combination with corn fufu. *S. scabrum* is a spinach-like vegetable which is not mucilaginous, unlike *Corchorus, Hibiscus* and others.

MAIN CHARACTERISTICS OF THE MOST COMMON CULTIVATED SPECIES WITHIN THE AFRICAN NIGHTSHADE COMPLEX*

*Adapted from Edmonds and Chweya (1997).

Solanum americanum Miller

Plants glabrescent to slightly pilose
Stems with inconspicuously dentate ridges or edentate
Leaves 3-6.2 (-11) cm long x 1.1-4 (-6.6) cm broad; lower surface moderately pilose; margins entire to sinuate
Inflorescence simple, umbellate cymes, 3-6 flowered
Calyces 1.1-2.4 mm long, **Sepals** reflexed away from mature berries
Corollas stellate, white (or with purplish tinge). Basal star, translucent or yellow-green in colour, 2-4 (-6) mm
Anthers yellow. 0.7-1.5 mm
Styles 1.2-3.5 mm, usually exerted beyond anthers
Berries globose, dark-green or black, 4-8 mm. Falling from calyx when ripe
Cytology: diploid, 2n = 24

Note: morphologically rather variable; common throughout Africa and found throughout the world. It is occasionally cultivated in home gardens (*see* Figure 174).

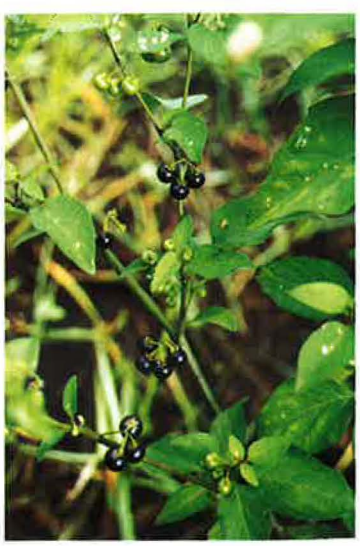

Figure 174 *S. americanum* L.

Solanum nigrum L.

Plants: decumbent to erect, up to 70 cm high
Leaves 2.5-7 cm long x 2-4.5(-6) cm broad; subglabrous, margins entire to sinuate-dentate
Inflorescence simple, often extended cymes, 5-10 flowered.
Calyces 1.2-2.5 mm long, **Sepals** usually ovate, adherent to base of mature berries
Corollas stellate, white with translucent basal star, 5-7 mm, usually 1.5-3 times as long as calyx
Anthers yellow. 1.5-2.5 mm
Styles 2.8-3.5 mm, not exerted beyond anthers
Berries broadly ovoid, dull purple to blackish (or yellow-green), 6-10 mm. Remaining on plants or falling from calyces when ripe.
Cytology: hexaploid, 2n = 72

Note: There are two subspecies: ssp. *nigrum* has only slight pubescence and the non-glandular hairs are appressed; ssp. *schultesii* has long, soft hairs with a glandular head. Not, or rarely cultivated.

Solanum scabrum Miller

Synonyms: *S. guineense* Lamarck
S. melanocerasum All.

Plants erect, glabrescent to subglabrous, lateral branches sparse, usually spreading horizontally. Plants can reach 1 m in height and become 1.20 m wide when undisturbed
Stems large, prominently ribbed, ridge with distinct teeth.
Leaves large 10 12 (-16) cm long and 6 8 (-14) cm wide, with entire to sinuate margins. Apices acute to obtuse.
Inflorescence simple or forked, often extended cymes, 6 14 (-27) flowered.
Calyces 1.9-3.5 (-4.5) mm, **Sepals** usually reflexed away from berry.
Flowers stellate, white (or with purplish tinge). Basal star, yellow-green, 7-9 mm
Anthers brown or purplish-brown, 2.5-3.3 mm
Styles 2.9-4.5 mm long, not exerted beyond anthers
Berries broadly ovoid, dark-purple, 15-17 mm broad, remaining on plant and adhering to erect pedicels at maturity.
Cytology: hexaploid 2n = 72

Note: commonly cultivated (*see* Figure 175).

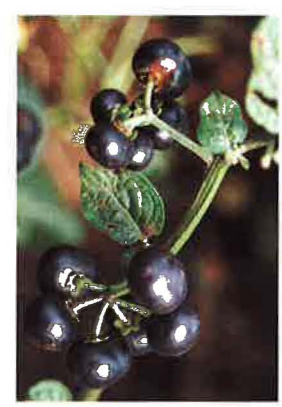

Figure 175 *S. scabrum*

Solanum villosum Miller

Synonym: *Solanum pseudo-nigrum.* This name is mainly used in Kenya and Tanzania
Plants subglabrous to hairy, up to 70 cm high. With glandular hairs
Leaves 2-7 cm x 1.5-4 cm, rhombic to ovate-lanceolate, margins entire to sinuate-dentate. Cultivated forms of ssp. *miniatum* usually have larger leaves.
Inflorescence simple, umbellate or small cymes with 3-5 (-7) flowers.
Peduncles short, erect but long pedicels deflexed in fruit
Calyces 1.2-2.2 mm, deflexed or adhering to mature berry
Corollas white 4-8 mm, 3-5 times as long as the calyx
Anthers yellow, 1.5-2.5 mm
Styles 2.9-5 mm long, rarely beyond anthers

Berries elliptic or oval-shaped, less commonly round. 6-10 mm broad, falling when ripe. Berries orange to red
Cytology: tetraploid 2n = 48

Note 1: The berries range in colour from yellowish-orange to red, with orange the most common (*see* Figure 176). Children frequently consume the berries.

Note 2: The hairy subspecies *villosum,* which is eaten in northern Uganda, tolerates drier conditions than the subglabrous subspecies *miniatum,* which is especially cultivated in Tanzania, Kenya and Ethiopia. This crop is rapidly gaining in popularity especially in Tanzania.

Figure 176 *S. villosum*

BIBLIOGRAPHY

(This list includes published papers and unpublished NRI reports and other grey literature)

AGONG, S.G. (1993) Seed extraction procedures for long term conservation of *Solanum nigrum. Seed Science and Technology*, **21**(2): 447-51.

BEDIGA, J.M. (1992) *Time of Picking and the Yield of Two Leafy Vegetables (Black Nightshade* Solanum nigrum *and Jew's Mallow* Corchorus olitorius). University Centre of Dschang, Cameroon: INADER.

BUKENYA, Z.R. and HALL, J.B. (1987) Six cultivars of *Solanum macrocarpon* in Ghana. *Bothalia,* **17**: 91-95.

BUKENYA, Z.R. and HALL, J.B. (1988) *Solanum* in Ghana. *Bothalia,* **18**: 79-88.

BUKENYA, Z.R. and CARASCO, J.F. (1994) Biosystematic study of *Solanum macrocarpon- S. dasyphyllum* complex in Uganda and relations with *Solanum linnaeanum. East African Agricultural and Forestry Journal,* **59**(3): 187-204.

BUKENYA, Z.R. (1994) *Solanum macrocarpon,* an under-utilised but potential vegetable in Uganda. pp. 17-24. In: *Proceedings of XIIIth plenary meeting AETFAT, Malawi.* SEYANI, J.H. and CHIKUNI, A.C. (eds.).

BUKENYA, Z.R. and CARASCO, J.F. (1995) *Solanum* in Uganda. *Bothalia,* **25**: 1

BUSSON, F. (1965) *Plantes Alimentaires de l'Ouest Africain: Etude botanique, Biologique et Chimique.* Marseille: Ministere de la Cooperation. 568 pp.

CHWEYA, J.A. (1985) Identification and nutritional importance of indigenous green leaf vegetables in Kenya. pp. 99-108. In: *Ninth African Symposium on Horticultural Crops, July 1983.* TIDBURY, G.E. and TINDALL, H.D. (eds.). Wageningen (Netherlands): ISHS.

CHWEYA, J.A. (1997) Genetic enhancement of indigenous vegetables in Kenya. In: *Traditional African Vegetables, Proceedings of the IPGRI International Workshop on Genetic Resources of Traditional Vegetables in Africa, Nairobi, Kenya, August 1995.* GUARINO, L. (ed.). Rome: IPGRI.

CRITCHLEY, B.R. (1988) *Pests of Vegetables, their Identification and Control in Ghana.* Chatham, UK: Natural Resources Institute.

DALZIEL, J.M. (1937) *The Useful Plants of West Tropical Africa, an Appendix to the Flora of West Tropical Africa.* London: The Crown Agents for the Colonies.

DAUNAY, M.C., LESTER, R.N. and LATERROT, N. (1991) *The Use of Wild Species for the Genetic Improvement of Brinjal Eggplant and Tomato.* pp. 349-412. In: *The Biology and Taxonomy of the Solanaceae.* HAWKES, I.G., LESTER, R.N. and SKALDING, A.D. (eds.). London: Academic Press.

DENTON, L. and AYODELE, F.A. (1996) *Notes on selected indigenous vegetable crops in Nigeria.* (Unpublished report) Chatham, UK: Natural Resources Institute.

EDMONDS, J.M. and CHWEYA, J.A. (1997) *Black Nightshades,* Solanum nigrum L. *and Related Species.* Rome: IPGRI-IPK.

EPENHUIJSEN, C.W. van. (1974) *Growing Native Vegetables in Nigeria.* Rome: FAO.

FOMBIN, V.A. (1995) *The cultivation of huckleberry* (Solanum scabrum) *in Foumbot area, Western Province of Cameroon.* Field study report, FASA, University of Dschang.

FAWUSI, M.O.A. (1983) Nitrogen fertilization and storage temperature effects on the nutritive value of *Solanum nigrum. Journal of Plant Foods,* **5**(3): 161-7.

GBILE, Z.O. (1979) *Solanum* in Nigeria. In: *The Biology and Taxonomy of the Solanaceae.* HAWKES, J.G., LESTER, R.N. and SKALDING, A.D. (eds.). London: Academic Press.

GBILE, Z.O. 1986. Epidermal studies in the *Solanum nigrum* complex in Nigeria. In: *Solanaceae: Biology and Systematics.* D'ARCY, W.G. (ed.). New York: Columbia University Press.

GOCKOWSKI, J and NDUMBE, M. (1997) The transformation of leafy vegetable cropping systems along the humid forest margins. In: *Proceedings of the Indigenous Vegetables Workshop, Limbe, Cameroon, January 1997.* SCHIPPERS, R.R. and BUDD, L. (eds.). Chatham, UK: Natural Resources Institute.

IMUNGI, J. G. (1989) *The role of indigenous vegetation in human nutrition in Kenya.* Nairobi: Nairobi University (unpublished paper).

JAEGER, P.M.L. and HEPPER, F.N., (1986) A review of the genus *Solanum* in Africa. pp. 41-55. In: *Solanaceae: Biology and Systematics.* D'ARCY, W.G. (ed.). New York: Columbia University Press.

LESTER, R.N. and NIAKAN, L. (1986) Origin and domestication of the scarlet eggplant, *Solanum aethiopicum* L., from *S. anguivi* Lam. pp. 433-456. In: *Solanaceae: Biology and Systematics.* D'ARCY, W.G. (ed.). New York: Columbia University Press.

LESTER, R.N. (1986) Taxonomy of scarlet eggplant, *Solanum aethiopicum* L. pp. 125-132. In: *Acta Horticulturae 182, Taxonomy of Cultivated Plants.* VAN DER MAESEN, L.J.G. (ed..).

LESTER, R.N., JAEGER, P.M.L., BLEIJENDAAL-SPIERINGS, B.H.M., BLEIJENDAAL, H.P.O. and HOLLOWAY, H.L.O. (1990) African eggplants-a review of collecting in West Africa. *FAO/ IBPGR Plant Genetic Resources Newsletter,* **81/82**: 17-26.

LESTER, R.N.and NIAKAN, L. (1990) Descriptors for Eggplant. Rome: IBPGR (unpublished notes).

LESTER, R.N. (1996) Report on a visit to Ghana, July 1996. (NRI unpublished report).

LESTER, R.N. (1996) Identification of some African eggplants and allied *Solanum* species (unpublished report).

LYON, F. (1996) Vegetable varieties, seed selection and supply in Brong Ahafo, Ghana. (NRI unpublished report.)

NGEPI, G. (1991) La morelle noire *(Solanum nigrum)*: techniques de production paysannes et tentative d'amélioration. (Huckleberry: farmers' production practices and tentative improvements). INADER, University Centre of Dschang. Cameroon (student report).

OLYMPIO, N and SCHIPPERS, R.R. (1995) Eggplant and garden egg production: a joint NRI and UST publication for the Integrated Food Crops Systems Project in Ghana. Chatham, UK: Natural Resources Institute.

OMIDIJI, M.O. (1983) Evaluation of some F1 hybrids and cultivars of *Solanum gilo* in south western Nigeria. *Acta Horticulturae,* **123**: 91-98.

ONAYEMI, O. and BADIFU, G.I.O. (1987) Effect of blanching and drying methods on the nutritional and sensory quality of leafy vegetables. *Plant Foods and Human Nutrition,* **37**(4): 291-8.

ONYANGO, M.A. (1993) Effect of plant density and harvesting frequency on the yield and vegetable quality of four variants of black nightshade *(Solanum nigrum* L*)*. MSc thesis, University of Nairobi.

RODDICK, J.G. (1986) Steroidal alkaloids of the Solanaceae. pp. 201-222. In: *Solanaceae: Biology and Systematics.* D'ARCY, W.G. (ed.). New York: Columbia University Press.

SCHIPPERS, R.R., (1996) *Domestication of Indigenous Vegetables for Sub-Saharan Africa.* pp. 201-222. Chatham, UK: Natural Resources Institute (technical report).

SCHIPPERS, R.R. (1996) Cash cropping study in Enugu, Nigeria - preliminary overview of field studies conducted in March, April and May 1996. Chatham, UK: Natural Resources Institute (technical report).

SCHIPPERS, R.R. (1994-1999) Various NRI reports for the Integrated Food Crops Systems Project, Bong Ahafo, Ghana.

SECK, A. (1984) *Contribution a l'Amélioration Génétique du Jaxatu pour la Culture en Saison Chaude et Humide.* Camberene, Dakar: ISRA-CDH.

SECK, A. (1992) *Etude de l'Influence de la Période de Culture et de la Variabilité Génétique sur la Dormance des Semences du Jaxatu.* Senegal: Ecole Nationale des Cadres Rureaux.

SECK, A. (1997) *Genetic Studies on Resistance of African Eggplant* (Solanum aethiopicum *ssp. Kumba) to Spider Mites.* Camberene, Dakar: ISRA-CDH.

SECK, A. (1997) Developing new varieties of indigenous vegetables. pp. 76-80. In: *Proceedings of the African Indigenous Vegetables Workshop, Limbe, Cameroon, January 1997.* SCHIPPERS, R.R. and BUDD, L.(eds.). Chatham, UK: Natural Resources Institute.

SECK, A. (1998) Varietal improvement and breeding procedures of African eggplants. Chatham, UK: Natural Resources Institute (technical report).

SIEMONSMA, J.S. and PILUEK, K. (1993) *PROSEA, Plant Resources of South-East Asia, No. 8. Vegetables.*

STEVELS, J.M.C. (1990) Légumes traditionnels du Cameroun, une étude agrobotanique. Wageningen Agricultural University Papers 90-1, Wageningen.

SUGLO, E.K.J. (1998) Review of pests and diseases of African eggplants in Ghana. Chatham, UK: Natural Resources Institute (technical report).

SUGLO, E.K.J. (1998) Review of Socio-Economic studies on African Eggplants. Technical reports for the Integrated Food Crop Systems Project.

TAYLOR, O.-O. (1983) The nutrient composition and nutritive value of the leaf protein concentrate from two solanaceous vegetables. *Acta Horticulturae,* **123**.

TETIO-KAGHO, T. and ZANFACK, E. (1990) Etude de quelques légumes *(Amaranthus hybridus, Corchorus olitorius,* et *Solanum nigrum)* traditionnellement cultives au Cameroon. II. Valeurs nutritives a different stades de recolte. *Proceedings of the Biosciences Conference, Ngaoundere.*

WESTPHAL, E. (1981) L'Agriculture autochtone au Cameroun. (Traditional agriculture in Cameroon). *Miscellaneous papers 20.* Landbouwhogeschool, Wageningen, The Netherlands.

ZONFAC, J.C. (1984) Techniques culturales et valeur nutritive de quelques légumes locaux *(Amaranthus hybridus, Corchorus olitorius and Solanum nigrum).* Cultural techniques and nutritive value of some indigenous vegetables *(Amaranthus hybridus, Corchorus olitorius and Solanum nigrum).* Dschang University paper.

JUTE MALLOW

Corchorus olitorius L.

Figure 177 *Corchorus tridens*

INTRODUCTION

The genus *Corchorus* consists of some 50-60 species, of which about 30 are found in Africa. *Corchorus* is mainly known for its fibre product jute and for its leafy vegetables. Jute is mainly extracted from *C. olitorius* L. and *C. capsularis* L., a species from India. Several species of *Corchorus* are used as a vegetable, of which *C. olitorius* is most frequently cultivated. There has been a debate on the origin of *C. olitorius* as being from South China and India/Myanmar or from Africa. Because of its ancient cultivation in both Asia and Africa, it is difficult to be sure, but because of the much wider diversity within this species in Africa and the occurrence of several related species in Africa, an African origin for *C. olitorius* is more likely. North India, Bangladesh and Myanmar are now considered as secondary centres of diversity.

C. olitorius, called Jew's mallow or jute mallow in English and *corète potagère* in French, is popular as a vegetable in both dry or semi-arid regions and in the humid areas of Africa. In many West African countries, the crop is referred to under names similar to *keren keren,* like *krin krin, crain crain* or *kelen kelen.* It is called *mlenda* in kiswahili, *tege* in Cameroon, *derere* in Zimbabwe and *otigo* in Uganda. Some Nigerian names include *ewedu* in Yoruba, *ahuhara* in Igbo, whereas the Hausa people call it *malafiya,* somewhat similar to *molukhia* as used by Arabs in north-eastern Africa.

Considerable research attention has been given to this crop in the Sudan, where it is much appreciated in '*malachia*' soup. In Egypt farmers occasionally grow the crop in greenhouses during the winter months to cater for its out-of-season demand. It is a very old vegetable that was mentioned in early Greek literature. The cultivation of *C. olitorius, C. tridens* L. and *C. trilocularis* L. (*see* Figure 177) is similar. The last species is least frequently cultivated for its leaves.

BOTANY

African edible species of *Corchorus* are annual or short-lived perennial crops, up to 2 m high. Their stems are well developed with abundant fibres in the phloem tissue, which is why they are also used as fibre crops. The leaves of the three cultivated *Corchorus* species have serrated leaf margins, they are alternate and show the characteristic 'swallow tails' or setae at the base of their lamina. The 1-3 yellow flowers are opposite the leaves and 8-17 mm in diameter. The fruit is a straight or slightly curved capsule that terminates in a beak, the shape of which is an important characteristic for species identification.

Corchorus olitorius is the most frequently cultivated and most common species in Africa. It is highly variable in size, branching and the shape of its fruit and leaves. The leaves are generally dark-green and glossy. This species can be recognized by its 5 7-valved capsule and a straight beak of up to 12 mm long. Forms with thick capsules, virtually no beak or forms with short spreading horns can also be found. Plants are often more than 1 m high at maturity. In South Asia, *C. olitorius* is sometimes referred to as 'tossa' jute.

C. tridens L. (=*C. trilocularis* auct. non L.) is more woody and mainly seen in the warmer and drier areas. This species is recognized by its oblong to lanceolate non-shiny leaves and a thin 3-valved capsule with 3 small, spreading horns at the apex. The leaves are often light to yellowish-green and its stipules are glabrous. It tastes more bitter than *C. olitorius.* Plants generally do not exceed 1 m in height. The Yorubas from south-western Nigeria call *C. tridens* '*senujaga*', whereas *C. olitorius* is referred to as *ewedu* or *oyo,* as well as the more general *keren keren.*

C. trilocularis L. looks rather similar to *C. tridens,* but its leaves are often broader. The long capsule splits into three, or less often four, valves when dry. Its capsules have a straight beak without horns. The stipules of the leaves are pilose. It is more common in East than in West Africa.

All African species that are collected or grown as vegetables happen to be diploid with 2n=14.

Wild species collected for food

Species that are frequently collected from the wild or only cultivated to a limited extent include:

C. aestuans L., which can be recognized by its short capsules with thick horns, spread at the apex. The small (up to 30 cm) plants are close to the ground. It is eaten as spinach in several African countries, but not known to be cultivated;

C. asplenifolius Burch. This is a popular wild species from southern Africa, with long and narrow, deeply serrated leaves which lack the 'swallow tails'. It has a woody rootstock; and

C. fascicularis Lam. This much branched plant, often with reddish stems and elliptic leaves without setae and with a group of 2-5 small capsules, found throughout Africa, is mainly weedy and occasionally semi-domesticated and collected for sale at local markets in, for example, Cameroon.

In addition to the species listed above, others may also be collected from the wild during periods of general food shortages. The habitat for most of these species varies widely and the same species that can be found in wet highlands, marshland or riverbanks can equally well be found in dry thornbush country. *Corchorus* species appear to be able to adapt themselves to harsh conditions.

Many species are sought after by livestock and also by antelopes and other game animals. *Corchorus* is still collected from the wild in many places such as in Kenya's Homa Bay region, where it is a popular vegetable during the rainy season. People see no need to pay specific attention to its cultivation and are thus not able to enjoy it during the dry season.

VARIETIES

At the various markets in Nigeria a mixture of different species can be seen and a wide range of varieties within the main species, *C. olitorius*. Different taxa are not only seen in the same market stall, but are frequently mixed together within the same bunch. This habit of mixing different morphotypes was earlier observed by Akoroda (1985) and van Epenhuijsen (1974). It is, however, interesting to note that the different types are identified locally under different names. They are readily distinguishable by their leaf characters that can differ in form of serration, shape and leaf colour and whether this is dull or shiny. A further distinction can be found in the degree of hairiness of the stem.

The two most common types in Nigeria are Oniyaya, growing to 150 cm in height and widely branched with broad, deeply serrated leaves and Amugbadu, a plant growing even taller with large, finely serrated leaves that are oblong in shape. There are several other minor local morphotypes, for example Eleti ehoro with small ovate leaves like the ear of a hare, oblong and with fine serration, and Eti eku with a leaf shape like the ear of a rat. Another Nigerian variety is Yaya. Similar varieties are also found in Benin and Togo. In Ghana, the small-leaved varieties are most popular and are offered at the markets in small heaps, especially in the northern and eastern parts of the country. These small leaves are often found as short sideshoots along the main stem of varieties that were formerly grown for their fibre.

In both Benin and Cameroon, the variety with deep lobe-like incisions is named Incisifolius, which is more deeply lobed than the Oniyaya variety (although there are overlaps). A large, broad-leaved variety from Cameroon with shorter 'swallow tails' that is commonly cultivated near Yaoundé is called Géant de Bertoua. Its leaf tips are more round than those of Amugbadu, the most common one in Nigeria which resembles the Cameroonian Ewondo (*see* Figure 178).

Figure 178 The variety Ewondo from Cameroon

Among the Yoruba-speaking group of south-western Nigeria there is a preference for Oniyaya because of the belief that it is more mucilaginous. The common practice in Nigeria is to plant unselected and generally quite heterogeneous local cultivars. Varieties similar to Oniyaya are found in Ghana (*see* Figure 179). In Cameroon, uniform plantations with Géant de Bertoua (*see* Figure 180) or Ewondo can be found.

Figure 179 A Ghanaian variety similar to Oniyaya

The diversity is expressed in many vegetative and physiological characteristics such as leaf size, shape and colour; size and shape of the capsules, seed yield, plant height, branching pattern, days to flowering and tolerance to diseases and pests.

GENETIC ENHANCEMENT

As mentioned above, a considerable diversity of *Corchorus* species can be found in the markets, which reflects the diversity found in the field. Such observations can partly be explained by the phenomenon of volunteer crops, caused by dormancy and irregular germination patterns. Viable seeds remain in the soil until their dormancy is broken, which could be a long time. These volunteers grow up together with a newly sown crop and cause admixtures, whereas crosses with the cultivated crop could produce recombinants for the next generation.

Figure 180 cv. Géant de Bertoua, a common variety, Yaoundé, Cameroon

Generally speaking, farmers pay little attention to variation in plant characters when selecting cultivars for planting. When selections are made people look for characteristics considered useful for better yields and rapid revenue earnings. Therefore, selections are made for rapid early growth, large leaf size, deep-green and glossy leaf colours and late flowering. When smaller leaves are preferred, farmers like a variety with profuse branching.

The rich genetic variation found in the many landraces has so far hardly been exploited, leaving ample room for development of improved varieties. In Nigeria, one of the few countries where *Corchorus* has been given research priority, the genetic improvement programme is undertaken at NIHORT in Ibadan. NIHORT maintains a large germplasm collection of local landraces and considerable variation amongst different accessions was noted when these were characterized and evaluated. The breeding programme is directed towards the production of improved and pure lines/varieties of the four major morphotypes.

C. olitorius is basically self pollinating, but levels of 10-13 % outcrossing have been reported (Grubben, 1977; van Epenhuijsen, 1974). Deliberate crossing by hand was found to be particularly difficult due to flower drop after emasculation. Natural crossings are found, but these are rather difficult to control.

Germplasm of *C. olitorius* L. has also been collected in some other African countries. The number of improved lines which have been produced so far is not large and not distributed enough to cause a noticeable erosion of the rich local genetic resources. Although there is currently no serious danger of genetic erosion from introduced improved cultivars, collection and conservation of local germplasm is essential to create a large enough genetic base to be used for future improvement programmes. As farmers' production methods become more sophisticated, local varieties may gradually be replaced with improved ones, of which some may yield up to 80 -90% more than many traditional varieties.

ECOLOGICAL REQUIREMENTS

C. olitorius is produced over a wide range of climatic zones, extending from sea level up to about 1200 m. There are a few places where production takes place at 1400 m, but plant growth there is very slow. It is poorly adapted to cold conditions and will not perform well during the dry but cold harmattan period (January-March) experienced in areas north of approximately 8° latitude up to the Mediterranean. The ideal conditions are a moist climate with a temperature range of 25-32°C.

The crop performs well in areas with rainfall of between 600 mm and 2000 mm/year. In its natural environment it is often found near swamps (*see* Figure 181) or wet areas nearby rivers and lakes throughout tropical Africa. It also thrives near rivers in otherwise dry regions such as Sudan.

Figure 181 Farming *Corchorus* near the edge of a swamp

Jute mallow is susceptible to drought at different stages of growth and especially during the flowering stage. High vegetative yields can therefore be obtained with increases in water application. *Corchorus* thrives on sandy loam soils rich in organic matter and with abundant moisture. The soil should be well drained. Clay soils are not suitable. .

Temperature and daylength effects

Studies carried out in a controlled environment concluded that dry weights increased with rising temperature and that the largest leaf area was observed with 30°C during the day and 25°C during the night. Both lower and higher temperatures had a negative effect on leaf development. Plants stop growing when temperatures fall below 15°C.

Similar studies in Nigeria concluded that a daylength of 12.5 h resulted in greater fresh and dry weights of shoots, longer stems, more roots and increased leaf areas when compared to a day length of 11.5 h. The growth rates declined with plant age. Stomatal density was found to be greater when the photoperiod was longer. Conversely, researchers found that fruit production is highest when plants are grown under short-daylength conditions with 10 h of natural light, followed by 14 h of darkness.

AGRONOMIC ASPECTS

Planting

In most traditional cropping systems, farmers plant on flat land, on ridges, or on raised beds. Only a few farmers sow or transplant in lines and most broadcast their seeds (*see* Figure 182). The broadcasting method is often wasteful, especially when the seed is not mixed with sand and many seedlings of poor quality are produced. For the traditional mixed-cropping system, farmers sow directly.

Plants about 15 cm tall are used for transplanting and spaced at 10 cm within rows, with 30 to 50 cm between rows, depending on the variety used. Alternate plants can be pulled out during the first harvest, thus leaving a space within the row of 20 cm. Research in Ghana showed that transplanting is not always successful, but when plants survive they produce more and stronger side shoots.

Dormancy

Seed dormancy constitutes a major difficulty as mentioned above. A general solution to seed dormancy is to parboil the seed, placing them in simmering water for 5-10 seconds. This gives the best seed germination and uniform seedlings. Treated seeds need to be sown immediately since they cannot be stored.

Cropping systems

When *Corchorus* is grown as a cash crop, as frequently seen around Yaoundé in Cameroon, monocropping is the rule, with individual plots of about 100-300 m. Here a series of plots can be found, planted at fortnightly intervals to spread the marketing risks. However, in most places in Africa ,production for subsistence is far more common.

Figure 182 *Corchorus* seedlings being raised in a nursery

Over 80% of production takes place during the rains, and irrigated production during the dry season is limited, even though it attracts higher market prices, which are about 60-70% above those of the wet season.

The combination of *Corchorus* with staple food crops is considered by most farmers as a profitable means of early revenue generation whilst waiting for other crops to mature. *Corchorus* is compatible for planting with many staple crops, but it has a low competitive ability when combined with vegetables. Intercropping watermelon and okra with *Corchorus* in Nigeria did not reduce the vegetative yield of *Corchorus*. *Corchorus* may be found together with many different species of vegetables in peri-urban gardens and combinations with staple crops are uncommon. Companion crops are selected without any consideration for disease and pest reactions and the crop's nutrient demands. Farmers may plant tomato, *Celosia* and *Corchorus* together, all of which are highly susceptible to nematode attack.

Labour requirement and division by gender

Jute mallow is a labour-intensive crop. Labour is needed for land preparation, weeding, watering, harvesting and seed processing. Land preparation and weeding are mainly carried out by men, whereas women and often children take care of harvesting, marketing and seed processing operations. All culturing operations are carried out manually.

Cultivation

Plants can be topped to give stronger side shoots, although such action may reduce fruit and seed yields. Broadcasting usually results in a high plant population with limited space in between, making weeding and fertilizer applications difficult. Transplanting is the norm in peri-urban gardens, thus overcoming this constraint.

Fertilizers

Application of manure or fertilizers significantly influences the vegetative yield. Well-decomposed poultry manure applied at the rate of 20 t/ha is ideal. Alternatively, a fertilizer application at the rate of 75 kg N, 20 kg P and 40 kg K/ha will provide optimum yields. For the more readily available

15-15-15 compound fertilizer, an application of 250 kg/ha is recommended.

SEED PRODUCTION

Most farmers produce their own seed, mainly by beating the dry stems and branches with sticks, followed by winnowing. Plants are frequently left in the field for too long, resulting in contamination of the fruit with diseases. When fruit are left on the plant for too long, some fully ripe capsules will shatter their seeds (*see* Figure 183). The overripe, black capsules collected from dry plants at the end of the season were found to contain more seeds with dormancy symptoms than yellow or brown capsules. Ideally, yellow/brown capsules should be picked by hand and left to dry on a canvas or similar sheet and be shelled in a controlled way, such that any shattered seeds will drop onto the sheet, allowing for effective recovery. Seeds need to be dried to a 9% moisture content to retain their viability until the next season.

Figure 183 Ripe *Corchorus* capsules will spring open and shatter their seeds

Flowers can develop well during the dry season. The best period for seed production is at a time with reducing daylength and preferably with limited rainfall. Yields of about 100 g/seed/plant are possible. Plants need to be spaced at 50 x 50 cm and well fertilized. Seed yield is higher from plants that have not been stopped to induce side shoot production. Rainy season crops which are closely spaced usually give no more than 2 g/seeds/plant.

Figure 184 The best *Corchorus* seeds are extracted from fruit at the top and middle parts of the plant

In Yaoundé's seed market, *Corchorus* seeds are sold as bundles of long stems with dry capsules. It is the farmer's responsibility to extract the seeds. Extracted seeds can be stored for up to 1 year, after which the germination capacity will rapidly deteriorate. Seed germination is partly affected by seed size. Bigger seeds germinate faster and produce larger seedlings than small ones. There are indications that the position of fruit on the plant affects the germination capacity since seeds extracted from capsules at the top and middle of the stem are better than those from the base (*see* Figure 184).

As long as the seeds are kept dry they can be stored for a long period. Experiments in Zimbabwe with *C. tridens* showed that 25-year old seeds had a germination percentage of 70%, whereas fresh seeds did not germinate well because of dormancy problems (student project by Ms V. Machakaire).

The number of seeds/capsule depends on the number of locules and their length. For *C. olitorius* there are usually 5-8 locules, each with 15-30 seeds. The average is about 100 seeds and large ones may contain up to 230 seeds. There can be up to 500 seeds/g. Seed yield of 600 kg/ha have been recorded from Kenya (Onyango, 1992).

PEST AND DISEASES

Major pests of *Corchorus* in West Africa include leaf-eating grasshoppers, *Zonocerus variegatus,* and caterpillars belonging to *Acraea* spp. and the armyworm *Spodoptera littoralis.* Nematode infection of *Meloidogyne* spp. can greatly reduce yields and cause up to 100% plant loss. Its symptoms are chlorosis, reduction in the numbers and sizes of leaves and stunted growth. Pure poultry droppings are reported to be a good nematode control. It is advisable to rotate the crop, for example, with amaranth, to control the nematode population.

A further difficulty may be caused by flea beetles, *Podagrica* spp. Farmers hardly ever use chemicals for pest control, but traditional methods involving the use of wood ash on the leaves are at times adopted. Sometimes, red spider mites (*Tetranychus cinnabarinus)* can be a nuisance, especially during the dry season. In Sudan the small black beetle, *Epithrix torvi,* feeds on the leaves, creating holes which render the crop unsaleable.

Diseases do not affect *Corchorus* very severely. Collar rot, *Sclerotinia rolfsii,* with a white mycelium on the stem is occasionally found. Plants will wilt and the disease can be recognized by the brown tissue and sometimes by the small black corms found between the mycelia. Black leafspot, *Curvularia* sp., is occasionally found, but no action is taken against it; the same applies to stemblight, *Macrophomina phaseoli.* Powdery mildew, *Erysiphe* sp., can be more serious, especially during the dry season. In Sudan, the main disease found is leafspot caused by *Cercospora* sp.

HARVESTING

Figure 185 The rolled leaves are not caused by disease, but by salt. This *Corchorus* crop grown in peri-urban Accra is almost ready to be uprooted for sale

Harvesting can be by uprooting (*see* Figure 185) or by pruning and cutting. Traditional farmers uproot plants over three to four consecutive periods, then take the shoots from the remaining plants before they are left for seed production. In a ratoon cropping system, the first harvest is usually by a thinning of plants, thus creating more space, followed by cutting the remaining plants. New side shoots will then develop which can be removed; this process will be repeated three or four times. Studies of both methods showed that repeated pruning/cutting (= ratoon cropping) produced a higher number of branches and shoot + leaf yield than uprooting.

Different varieties have different growth habits. Cultivars with rapid early growth are suitable for harvesting by uprooting, while the late-maturing cultivars may be more amenable to ratoon cropping. The plants can be harvested 40-60 days from sowing. Very early varieties, when given the right conditions, could be ready for harvest after 4 weeks.

Extensive trials carried out by Mbah-Ngami (1998) indicated a yield of 38 t/ha for the Ewondo variety, using 20 t/chicken manure/ha, which was found to be the optimum. Without manure, a yield of about 15 t can be obtained, whereas a higher dose of manure did not give higher leaf yields.

The crop attracts a high market price during the dry season and the first weeks of the rainy season and there is a glut with corresponding low prices during and immediately after the rainy season. The market value of *Corchorus* is relatively low in terms of unit cost when compared with, for example, *Amaranthus, Celosia, Telfairia* and *Vernonia* sp. However, the quantity marketed is usually higher. Both the leaves and seeds are good sources of income.

Studies on the profitability of *Corchorus* seed production for sale indicated 75-85% returns above production cost (NIHORT, 1986).

POST-HARVEST HANDLING AND PROCESSING

Most leafy vegetables are highly perishable and *Corchorus* is no exception. Post-harvest losses can be serious when the crop is handled poorly during harvesting or thereafter. A shelf life of 1 or 2 days is possible when moist conditions are maintained, together with low temperatures where feasible. This can be achieved by wrapping produce in wet cloth, leaving plenty of room for aeration and by ensuring that the cloth remains moist.

Experiments have been carried out which have extended the shelf life for up to 6 days using locally designed evaporative cooling structures; these have the effect of lowering the temperature of the container by water evaporation. The shelf life can also be extended by using perforated polythene pouches. Similar studies in the Philippines have shown that the shelf life of harvested *Corchorus* shoots, when stored in polyethylene bags without diffusion holes, was increased almost four-fold compared to those held in the open air.

PROCESSING

Traditionally, leaves are preserved by steam blanching, followed by drying in the sun. It is essential to store them in a dry environment, in which case leaves can be kept for about 6 months without any serious damage to the quality. However, if the produce is kept at ambient conditions, there could be a range of fungal problems. The microflora associated with sun-dried *Corchorus* in storage in Nigeria were recorded as *Rhizopus* sp., *Penicillium oxalicum, Rhizomucor* sp. and *Fusarium equiseti.* Storage losses were also attributed to *Aspergillus flavus, A. niger* and *A. fumigatus* (Adebanjo and Shopeju, 1993).

There is a great difference between blanching treatments. Steam blanching followed by dehydration will retain most ascorbic acid (Vitamin C) even after 6 months. An application of sodium sulphite or sodium metabisulphite further enhances this retention. Much poorer results can be expected when using hot water rather than steam blanching and when the leaves have not been properly dehydrated.

In savannah areas *Corchorus* leaves are frequently sun dried and preserved for use during the dry season. The dried leaves are also found in powdered form, as seen in the markets of Côte d'Ivoire (Siemonsma, 1982).

NUTRITIONAL IMPORTANCE

See Table 15 for the nutritional value of *Corchorus olitorius* leaves.

Table 15 Nutritional value of *Corchorus olitorius* /100 g fresh leaves

Water (ml)	84.1	Phosphorus(mg)	122.0
Calories	43.0	Iron (mg)	7.7
Protein (g)	5.6	ß-carotene, equiv.(mg)	7850
Fat (g)	0.3	Thiamine(mg)	0.13
Carbohydrates	7.6	Riboflavin (mg)	0.26
Fibre (g)	1.7	Niacin (mg)	1.10
Calcium (mg)	266.0	Ascorbic acid (mg)	53.0

Source: FAO, 1972

The protein content of young leaves of Kenyan plants was found to be 25.4% for *Corchorus tridens* and 22.5% for *C. olitorius* (Imbamba, 1973). *Corchorus* leaves are a rich source of folic acid. Folacin deficiency results in megaloblastic anaemia, which is prevalent amongst pregnant women in many developing countries. The anaemia of kwashiorkor is also megaloblastic, whereas anaemia caused by iron deficiency is not (Mnzava, 1997).

Cooked *Corchorus* leaves form a mucilaginous substance comparable to okra soup. This mucilaginous character is highly appreciated, especially in areas where people depend on rather coarse food such as millets or similarly starchy staple food. It aids the swallowing of such solid food products. The soup is cheap and easy to cook. In Zambia and elsewhere in southern Africa, soda and salt are added to the cooking process to further enhance the slippery consistency of the final relish.

Experiments showed that application of nitrogen fertilizer increased the ascorbic acid, nitrogen, calcium and phosphorus content of the leaves. The dark-green leaves have varying proportions of calcium, iron, carotene, vitamin C and protein required for good health. It was noticed that many of the useful micro-elements are lost in the cooking process, especially when the water is thrown away. It is best to boil the 'soup' for as short a time as possible. From the nutritional point of view, steaming, as done in Uganda, is best.

Immature fruit are referred to as 'bush okra' in West Africa. Bush okra can be dried and ground into powder for use in soups during the dry season.

Corchorus is also used as a laxative.

SLIMY STICKS

Triumfetta spp.

INTRODUCTION

A number of *Triumfetta* species are used for the preparation of a mucilaginous sauce called *nkwi* or *nkui,* for which the bark from green shoots is employed. In Nigeria and Cameroon these species are *Triumfetta pentandra* A.Rich., *T. cordifolia* A.Rich. (*see* Figure 186), *T. annua* L. and *T. rhomboidea* Jacq. The last two species are also used in southern Africa for their leaves, which are cooked as a mucilaginous relish. The roots of *T. rhomboidea* are boiled and eaten as a vegetable, for example, in Zimbabwe.

Triumfetta has clusters of small, yellow flowers which are found in leaf axils or in terminal cymes. Their fruit are globose or ovoid capsules of 8-25 mm diameter, covered with stiff, strong, often hooked bristles; this is why they are also known as burweed.

Shrubs may reach 3-5 m in height, although the cultivated forms will usually not be more than 1-1.5 m in height. The crop is cultivated in the grassland areas of Cameroon's highlands where it may have a dual function both as a boundary and a subsistence crop and is usually grown on a small scale. There is a limited demand at the market, since most people interested in preparing nkwi usually grow some plants near their homesteads. The sticks are tied into bundles and brought to the market in the main cities.

Figure 186 *Triumfetta cordifolia*

CULTIVATION

For cultivation, the top 15-20 cm are cut from a stem, to be used as a cutting. Such cuttings can be obtained from the wild or from a neighbour. Usually, about five cuttings are planted upright in a circle with a spacing of between 10 and 15 cm. They need to be planted in the shade of a tree since they do not perform well under direct sunlight. If the stem is not planted straight upwards, but bends and touches the ground, adventitious roots may develop which have an adverse affect on the quality of the stem and reduce the capacity to produce slime. Sometimes cuttings are tied to the stem of a plantain to ensure that they remain upright.

HARVESTING

Figure 187 *Triumfetta* sticks ready to be harvested

The crop grows very fast, is brittle and is easily damaged. Stems are cut at the nodes when they are about 75 cm to 1 m long, then the leaves are removed (*see* Figure 187). New shoots continue to develop, allowing farmers to harvest throughout the rainy season. Most plants wither during the dry season and only the roots remain fresh but dormant. As soon as the rains start new shoots are formed.

PREPARATION AND USE

Nkwi soup prepared from *Triumfetta* shoots is especially used to encourage people's appetites and to provide more energy. It is often the first dish given to a woman who has delivered a child. The highly mucilaginous sauce is also for young children when they change from breast feeding to eating the much firmer starchy staple food.

Nkwi soup is not easy to make and farmers often make more money by selling the soup than by selling the stems, since these could be harvested from the wild. Women wash the stems and place them over a fire to facilitate easy peeling. The peeled bark is placed in boiling water for about 15 min. and allowed to cool down. The bark is then squeezed by hand in lukewarm water to extract the sap, which reacts with the water and produces the characteristic nkwi slime. The stems are thrown away, together with remaining bits of bark that are removed after all the sap has been squeezed out. The mixture now needs to be whisked continuously to obtain an homogenous product which is highly viscous. Once an homogenous slime has been obtained, spices and other ingredients can be added. These ingredients must be prepared beforehand. The Bamilike preparation of nkwi requires basic ingredients such as salt, pepper and crayfish and is accompanied by various spices such as:

the dried fruit of *Tetrapleura tetraptera;*
the dried fruit of *Piper guineense;*
the dried root of *Varbrazzeana* sp.;
the dried bark of *Scorodophloeus zenkeri;*
the dried bark of *Hypodophnis zenkeri;*
the dried rhizome of *Scleria striatinux*; and
dried capsicum peppers.

Limestone may be added to the nkwi mixture to give it a reddish and attractive colour.

This spicy slime is eaten with a coarse staple such as yam or corn fufu, accompanied by nightshades, cocoyam leaves or similar green vegetables. Care must be taken not to include vegetable oil, since this will spoil the product.

In Zimbabwe the fibrous stems are used as string.

BIBLIOGRAPHY

ADEBANJO, A. and SHOPEJU, E. (1993) Sources and mycoflora associated with some sundried vegetables in storage. *International Biodeterioration and Biodegradation*, **31**(4): 255-63.

AKORODA, M.O. and AKINTOBI, D.A. (1983) Seed production in *Corchorus. Acta Horticulturae* 123.

AKORODA, M.O. (1985) Morphotype diversity in Nigerian land-races of *Corchorus olitorius. Journal of Horticultural Science*, **60**(4): 557-62.

AKORODA, M.O. (1988) Cultivation of jute (*Corchorus olitorius* L.) for edible leaf in Nigeria. *Tropical Agriculture*, **65**(4): 297-9.

CHIHANDE, D., ZINANGA, F. and MHEEN, J. van der (1997) *The role of indigenous vegetables in Zimbabwe.* Report for Community Technology Development Trust, supported by IDRC, Canada.

CHWEYA, J.A. and EYZAGUIRRE, P.B. (eds.) (1999) *The Biodiversity of Traditional Leafy Vegetables.* Rome: IPGRI.

DENTON, L. (1997) A review of *Corchorus olitorius* in Nigeria. In: *African Indigenous Vegetables Workshop Proceedings, Limbe, Cameroon, January 1997.* SCHIPPERS, R.R. and BUDD, L. (eds.). Chatham, UK: IPGRI/Natural Resources Institute.

DENTON, L. and FAJINMI, A.A. (1996) Notes on selected indigenous vegetable crops in Nigeria, prepared for NRI.

EDMONDS, J.M. (1990) Herbarium survey of African *Corchorus* L. species. *Systematic and Ecogeographic Studies on Crop Genepools 4.* Rome: IBPGR/IJO.

EL TAHIR, M.E. (1976) *Variability and biological studies on Jew's mallow* (Corchorus olitorius). Sudan: Khartoum University Faculty of Agriculture.

EPENHUIJSEN, C. W. van (1974) *Growing native vegetables in Nigeria.* Rome: FAO.

FAWUSI, M.O.A. and ORMROD, D.P. (1981) Effects of temperature on the growth of *Corchorus olitorius. Journal of Horticultural Science,* **56**(4): 353-6.

FAWUSI, M.O.A. (1983) Quality and compositional changes in *Corchorus olitorius* as influenced by N fertilization and post-harvest handling. *Scientia Horticulturae,* **21**(1): 1-7.

GRUBBEN, G.J.H. (1977) Leaf Vegetables. *Tropical Vegetables and their Genetic Resources.* Rome: IBPGR.

IMBAMBA, S.K. (1973) Leaf protein content of some Kenyan vegetables. *East African Agricultural and Forestry Journal,* **38**(3): 246-51.

LUCAS, E.O. (1988) The potential of leafy vegetables in Nigeria. *Outlook on Agriculture,* **17**(4): 163-8.

MBAH-NGAMI, A.G. (1998) *Couts de Production des Legume-feuilles Laitue, Amarante, Corète potagère et Morelle noire) dans la zone peri-urbaine de la ville de Yaoundé.* Student report, Dschang University, Cameroon.

MBINGLO, S. and NTANGTI, L. (1998) *The cultivation of slimy stem (nkwi),* Triumfetta pentandra. Student reports, Dschang University, Cameroon.

MNZAVA, N.A. 1997. Comparing nutritional values of exotic and indigenous vegetables. In: *African Indigenous Vegetables Workshop Proceedings, Limbe, Cameroon, January 1997.* SCHIPPERS, R.R. and BUDD, L. (eds.). Chatham, UK: IPGRI/Natural Resources Institute.

NATH, P. and DENTON, L. (1979) Vegetable germplasm in Nigeria. *Plant Genetic Resources Newsletter,* (39): 24-5.

NWOKE, F.I.O. (1980) Effects of number of photoperiodic cycles on induction and development of flowers and fruit in *Corchorus olitorius* L. (var. *oniyaya* Epen.). *Annals of Botany,* **45**(5): 569-76.

ONYANGO, M.O.A. (1992) *Viability, growth and seed production study of six indigenous vegetables.* Student report, Nairobi University.

SCHIPPERS, R.R. (1996) *Domestication of indigenous vegetables for sub-Saharan Africa.* Technical report, Natural Resources Institute Project A0515.

SECK, A. (1997) Developing new varieties of indigenous vegetables. In: *African Indigenous Vegetables Workshop Proceedings, Limbe, Cameroon, January 1997.* SCHIPPERS, R.R. and BUDD, L. (eds.). Chatham, UK: IPGRI/Natural Resources Institute.

SIEMONSMA, J.S. (1982) *La culture du gombo (Abelmoschus spp.) Légume-fruit tropical avec référence spéciale a la Côte d'Ivoire.* Thesis, Wageningen Agricultural University.

STEVELS, J.M.C. (1990) Légumes traditionnels du Cameroun, une étude agrobotanique. *Wageningen Agricultural University Papers 90-1.* Wageningen, Netherlands: Wageningen Agricultural University.

TREDGOLD, M.H. (1986) *Foodplants of Zimbabwe.* Gweru, Zimbabwe: Mambo Press.

WESTPHAL-STEVELS, J.M.C. (1986) Local vegetables in Cameroon: *Corchorus* species used as a vegetable. In: *Proceedings of the First International Symposium on Taxonomy of Cultivated Plants.* Wageningen, Netherlands: ISHS.

CROPS OF LESSER IMPORTANCE AS A VEGETABLE AND CROPS WHICH ARE OF LOCAL SIGNIFICANCE ONLY OR MAINLY COLLECTED FROM THE WILD WITH LIMITED CULTIVATION

Fam. Acanthaceae

Asystasia spp.

Asystasia species are commonly found throughout sub-Saharan Africa on roadsides or disturbed places near houses. The two species *Asystasia gangetica* (L.) T. Anders. and *A. mysorensis* (= *A. schimperi* T. Anders.) and possibly other related *Asystasia* and *Justicia* species are used as a leaf crop towards the end of the rainy season when other vegetables are scarce. They are mainly collected from the wild and are usually left undisturbed to produce seeds when found in home gardens. *Asystasia* does not normally grow higher than about 40 cm, but can be harvested once it is about 20 cm high. It produces many sideshoots and regenerates fast, allowing several harvests as a ratoon crop. Its cultivation is localized in western Kenya and northern Tanzania. In West Africa, *A. gangetica* is a local vegetable, grown during the rainy season and is also used medicinally to prevent dysentery.

Fam. Lobeliaceae

Cyphia glandulifera A. Rich.

Cyphia glandulifera, a crop with large dark-green succulent leaves and pretty pink flowers, is found and consumed in the Kitui area of Kenya where it is called *ngomo*. It is one of the few crops that will grow well on clay soils and even on black cotton soils. Both the leaves and the grey-white tubers, which are about 4 cm across, are eaten. The juicy tubers taste like raw potatoes and are peeled and eaten especially by herdsmen. Kitui people consider the fried product as a delicacy. It is a fodder plant for livestock. Plants are also collected from the wild in Ethiopia where people appreciate the young shoots and tender roots but make no effort to domesticate them.

There is significant variation in the germplasm, offering scope for genetic enhancement. However, virtually no research has taken place on this interesting species, which is still mainly collected from the wild. *Cyphia glandulifera* is known from grassland or wet depressions in warm areas of Somalia, Ethiopia, Kenya and Tanzania. The species is highly variable in leaf shape and growing habit and also in the taste of its tubers and it is possible that there is a species complex rather than a single taxon.

Fam. Musaceae

ENSET

Ensete ventriculosum (Welw.) Cheesm.

Synonym: *E. edule* (Horan.) Cheesm.

Enset is also known as false banana or Abyssinian banana. It can be found wild in many parts of sub-Saharan Africa, often on steep slopes or along rivers. There are six species within the genus, three in Africa and three in China.

There are many different landraces and enset is considered to be one of the most ancient cultivated plants of Ethiopia and was possibly grown over 15 000 years ago. It is still an important traditional food source for Ethiopia's people, but is hardly used outside that region. It is mainly cultivated for the flour obtained from the large lower part of its pseudo-stem and corm. This 'flour' consists of fermented small pieces of pseudo-stem pulp and pulverized corm. This starchy food can be stored for several years in large clay pots, or in a well-covered hole in the ground. The flour is used to prepare large flat pancakes which have a characteristic smell.

The corms can also be cooked in an unfermented form, but this is not common. The young inflorescences are also edible when cooked, but are not often eaten. People in South Africa cut the stalks of young, unfolding leaves which they boil and eat like celery. Enset is also consumed as a leafy vegetable in Ethiopia, particularly young plants of the sweet varieties that are used during times of grain shortages.

In Ethiopia, the cultivated forms of enset can often be found at fully exposed sites at high altitudes in places where there are no wild plants present. There are very many clearly different varieties and sideshoots are used for propagation rather than seeds, which are not necessarily true to type.

The false banana is frequently grown for ornamental purposes in high-altitude gardens where bananas or plantains will not grow. Enset species, some of which have showy dark-red leaves, are also used as ornamental pot plants. Enset may be used as a fibre crop and its twine used for weaving.

BIBLIOGRAPHY

AGNEW, A.D.Q. (1974) *Upland Kenya Wild Flowers. A Flora of the Ferns and Herbaceous Flowering Plants of Upland Kenya.* Oxford: Oxford University Press.

MAUNDU, P.M. and KABUYE, C.H.S. (1993) Final Narrative Report Indigenous Food Plants Programme, National Museums of Kenya.

ACRONYMS

AIVs	African Indigenous Vegetables
AVRDC	Asian Vegetables Research and Development Centre
CDH	Centre pour le Developpement de l'Horticulture
CIRAD	Centre de Cooperation International en Recherche Agronomique pour le Developpement
CPRO	Centre for Plant Breeding and Reproduction Research
cv.	cultivar
DFID	Department For International Development
DLO	Directoraat Landbouwkundig Onderzoek
ENCR	Ecole Nationale des Cadres Ruraux de Bambey
FAO	Food and Agriculture Organization
IBPGR	International Board for Plant Genetic Resources
IDRC	International Development Research Center
IITA	Interrnational Institute for Tropical Agriculture
INADER	Institut National de Developpement Rural
IPGRI	International Plant Genetic Resources Institute
ISHS	International Society for Horticultural Science
ISRA	Institut Senegalese de Recherches Agricoles
IV	Indigenous Vegetable
KARI	Kenya Agricultural Institute
KIT	Koninklijk Instituut voor de Tropen
NGO	Non-Governmental Organization
NIHORT	Nigeria Institute for Horticulture
NRI	Natural Resources Institute
ODA	Overseas Development Administration
ODI	Overseas Development Institute
PROSEA	Plant Resources of South-East Asia
SACCAR	Southern Africa Centre for Cooperation in Research and Training
sp.	species (singular)
spp.	species (plural)
ssp.	sub-species
var.	variety

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Until the beginning of the 20th century, people in Africa depended to a significant extent on food which had its origins in Africa. A diverse range of originally wild African species was domesticated a long time ago and included rootcrops, cereals, legumes and many different vegetables.

Popular food crops from outside the region were introduced into Africa and these exotic crops soon started to dominate the traditional crops. This trend was enforced with the arrival of European settlers and has resulted in most African vegetables becoming minor crops.

However, most exotic crops are not successful in either dry or very humid regions and do not do well in the warmer parts of Africa; in these regions indigenous African crops are still important and indigenous vegetables are much in demand because many people no longer have enough money to buy the more expensive exotic crops. Consequently there is now a reversal in the trend away from exotics and towards traditional vegetables.

This has generated a call for information, especially from students who wish to focus on such crops, and from extension staff who are under pressure from farmers to advise them.

African Indigenous Vegetables, an Overview of the Cultivated Species describes over 100 African vegetable species and covers the 25 most common crops in detail. Where possible, information is provided on the origin of the species and on some botanical aspects. The main emphasis is on their agronomy, providing as much detail as is currently known about these crops.

It is to be hoped that this book will contribute towards knowledge of African vegetables and their further advancement.