Chapter 3
Cassava in Africa

Rory J. Hillocks
Natural Resources Institute, University of Greenwich, Chatham Maritime, Kent ME4 4TB, UK

Origins of Cassava in Africa

South America, probably the Amazon region, may have been the centre of origin for species that gave rise to *Manihot esculenta*. While there is some controversy regarding the exact botanical origins of the progenitors of modern cultivated cassava, the archaeological evidence points to the Amazon region as the centre of domestication (see Chapter 1).

In the 16th century, Portuguese navigators took cassava from Brazil to the west coast of Africa (Jones, 1959) and later to East Africa through Madagascar and Zanzibar (Jennings, 1976). Although cassava appears to have been grown in Fernando Po in the Gulf of Benin and around the mouth of the Congo River by the end of the 16th century, it did not spread much in West Africa until the 20th century. Cassava was unknown north of the river Niger before 1914 (Purseglove, 1968). Some local spread seems to have taken place along rivers by Africa traders and travellers in the 17th century.

Cassava was taken from Brazil to Reunion off the East African coast in 1736 and was recorded in Zanzibar in 1799 (Purseglove, 1968). With the exception of the coastal region, cassava was not widely grown in East Africa until the late part of the 18th or early 19th century. The explorer Speke found no cassava on the western shore of Lake Victoria when he went there in 1862, but Stanley recorded it in Uganda in 1878. Cassava may have reached Lake Victoria along trade routes from the east (Jameson and Thomas, 1970) or from the west (Purseglove, 1968). The crop became established in Uganda during the 19th century and its value as a food security crop was soon realized. Records show that in 1963/64, around 175,000 ha were grown in Uganda, where the drier regions to the east and north were the largest producers (Jameson and Thomas, 1970).

Most of the spread of cassava in Africa away from the coast and riverside trading posts took place during the 20th century due to the colonial powers encouraging its cultivation as a reserve against famine and the ability of the crop to survive locust attack. Cassava is now grown in all African countries south of the Sahara and north of the Limpopo River. In 1972, the International Institute of Tropical Agriculture (IITA) was inaugurated with its headquarters in Ibadan, Nigeria, under the auspices of the Consultative Group on International Agricultural Research (CGIAR). IITA shares the global mandate for cassava with the Centro Internacional de Agricultura Tropical (CIAT) in Colombia and is responsible for developing the crop in Africa.

Production Trends

Africa now produces more cassava than the rest of the world combined (see Table 3.1) and the

Table 3.1. Mean yield and production statistics for cassava-producing countries in Africa 1996–1998.

	Yield (kg ha^{-1})	Production (1000 million t)		
Country	1998	1996	1997	1998
Angola	5,573	2,500	2,326	3,211
Benin	8,747	1,452	1,625	1,625
Burkina Faso	2,000	2	2	2
Burundi	8,882	549	603	622
Cameroon	16,667	1,700	1,700	1,500
Cape Verde	11,538	3	3	3
Central African Republic	3,046	526	579	579
Chad	6,111	268	250	275
Comoros	5,556	50	50	50
Congo Democratic Republic	7,500	16,800	16,800	16,800
Congo Republic	7,191	791	780	791
Côte d'Ivoire	5,075	1,653	1,699	1,700
Eq. Guinea	2,579	49	49	49
Gabon	5,000	210	215	215
Gambia	3,000	6	6	6
Ghana	11,389	7,111	7,000	7,172
Guinea	5,800	667	732	812
Guineabissau	16,200	17	16	16
Kenya	9,286	880	900	910
Liberia	6,527	213	283	313
Madagascar	6,678	2,353	2,418	2,404
Malawi	2,778	190	200	200
Mali	7,273	1	1	1
Mozambique	5,556	4,734	5,337	5,639
Niger	7,667	230	225	230
Nigeria	11,274	31,418	30,409	30,409
Reunion	7,200	2	2	2
Rwanda	6,250	250	250	250
Sao Tome	10,714	3	3	3
Senegal	2,336	36	37	47
Sierra Leone	4,992	281	310	310
Somalia	10,000	50	52	52
Sudan	1,800	10	10	10
Tanzania	8,933	5,992	5,704	6,193
Togo	5,184	548	596	579
Uganda	6,681	2,245	2,291	2,285
Zambia	4,951	620	702	817
Zimbabwe	4,231	150	160	165
Africa	8,223	84,559	84,326	85,945
World	9,798	164,711	164,045	158,620

Source: FAO Production Yearbook, Vol. 52 (1998).

largest producing nations are Nigeria (35% of total African production and 19% of world production), Democratic Republic of Congo (DRC; 19% of African production), Ghana (8%), Tanzania (7%) and Mozambique (6%). The four largest producers have increased their share from about 70% to 80% of total African production over the last two decades. The biggest increase has been in Nigeria which increased its share from 22% to 35%, and Ghana which increased its share from 4% to 8% (IITA, 1997). The share of other producers has declined, and DRC has moved from being the largest to the second largest producer in Africa, after Nigeria. However, it is in the DRC, Tanzania and Zambia (possibly also Mozambique [northern], but no figures available) that cassava is the most important crop to the largest proportion of farming households (Table 3.2).

Total production of cassava in Africa increased from *c.* 35 million t in 1965 to over 80 million t in 1995 (Fig. 3.1), an annual growth rate of 2.9%. This is roughly the same as the population growth rate, so that average per capita production did not increase during the period. However, during the last decade, per capita production has increased as total production has grown faster (3.8%) than in the preceding decade.

Increases in the cultivation of cassava during the 1990s occurred, at least partly, in response to declining soil fertility and increased cost of inorganic fertilizers. Although Malawi for example, is not one of the major producers of cassava, national production increased from 20,000 million t to over 80,000 million t in the decade between 1989 and 1999 (Teri *et al.*, 1999). This increase in cassava production was probably achieved, at least to some extent, by replacing maize with cassava.

Most of the increases in cassava production in Africa have been due to increases in area under cultivation, rather than increases in yield per hectare. Average yields have only increased by 33% over the last two decades, but area under production has increased by about 70%. While the annual rate of growth in area under production has increased to 3.2% from 1.3% during the previous decade, that of yield has declined from 1.2% to 0.6%. Only in Ghana has yield increased significantly between 1990 and 1995 (Fig. 3.2). As cassava production is expanding in Africa, the crop is to a large extent replacing fallow, confirming that most of the production increase has been due to increase in crop area. Cassava is often planted just before land is allowed to go into fallow, indicating that the crop is also being used to increase land use intensity. Cassava is replacing other root crops, especially yam in the humid zone, maize in the non-humid zone, and other food crops in the sub-humid zone (IITA, 1997).

Results from surveys conducted with funding from the Rockefeller Foundation; the 'Collaborative Study of Cassava in Africa' (COSCA), show that for farmers across all agroecological zones, the main reason why cassava production is increasing is in response to famine, hunger and drought. The second most important reason is the resistance of the crop to pests and diseases. These findings confirm that cassava is planted as a food security crop. Increases in production as a consequence of population growth, higher prices and increased market access, as well as increasing yield of cassava, are more important in the humid than in other zones (except for high yield in the highland-humid zone). This points to the importance of these market-related factors in driving farmers to increase cassava production. This is significant, as such factors are expected to increase in intensity over the next two decades, as a result of further urbanization.

Production Constraints

Shortened fallow periods and declining soil fertility

In Africa the predominance of various fallow systems differs between villages, depending on soil fertility status and on pest/disease, market and demographic pressures. It is often reasoned that as fallow periods decline, cassava will increasingly replace crops which require higher soil fertility and production labour. However, although cassava is well adapted to growing under continuous cultivation, it is not as frequently grown under that system as other major staples.

The farmers' ability to respond to declining fallow periods, due to demographic, market, pest/disease and other pressures by replacing more demanding crops with cassava, is constrained by its long cropping cycle. Cassava can be harvested from 6 months after planting, but most of the available local varieties do not attain maximum yield before 18 months. Currently, improved varieties attain their maximum yield at 12–15 months. Under intensive cultivation, where the fallow period is often less than 1 year, long-duration varieties are not ideally suited because they are usually harvested before they attain maximum yield. However, early-bulking varieties are not likely to reduce this pressure unless they are combined with agronomic practices for greater water and nutrient-use efficiency. Shortening fallow periods require varieties selected for efficient nutrient

Table 3.2. Percentage distribution of villages in which farmers reported that selected crops are the most important crop in cassava growing areas of sub-Saharan Africa, by country, 1991.

Important crop	Côte d'Ivoire	Ghana	Nigeria	Tanzania	Uganda	DRC	Zambia	Malawi	Burundi	Kenya	Weighted mean
Cassava	8.4	35.0	20.5	51.6	42.5	80.0	60.6	12.4	9.6	7.6	32.8
Yams	17.8	21.3	35.8	–	–	–	–	–	–	–	7.5
Cocoyam	–	–	–	–	–	–	–	–	2.9	–	0.3
Potato	–	–	–	–	–	–	–	–	5.8	–	0.6
Plantain	–	16.3	–	–	–	–	–	–	–	–	1.6
Bananas	–	–	–	5.7	1.9	–	–	–	–	–	0.8
Maize	–	12.5	15.3	21.7	13.2	12.1	12.1	82.8	31.7	68.2	27.0
Rice	16.8	–	3.2	2.8	–	3.6	–	–	–	4.6	3.1
Other food crops	–	3.8	25.3	12.3	34.9	4.3	27.3	4.8	50.0	4.6	16.7
Cash crops	57.0	11.3	–	5.7	7.6	–	–	–	–	15.2	9.7

Source: IITA (1997).

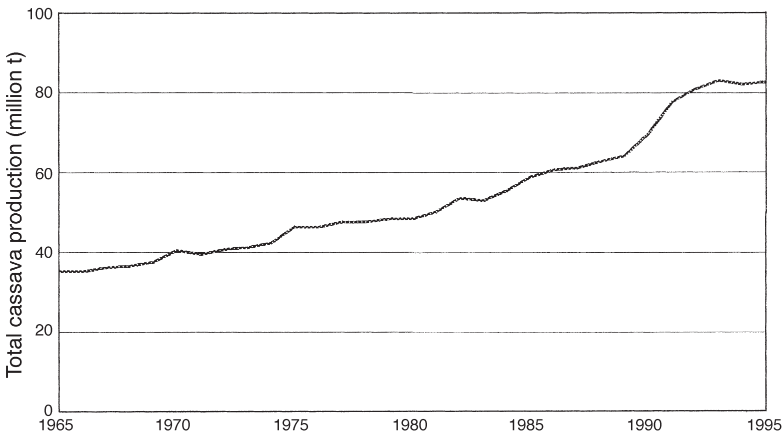

Fig. 3.1. Trend in total cassava production in Africa 1965–1995. *Source*: IITA (1997).

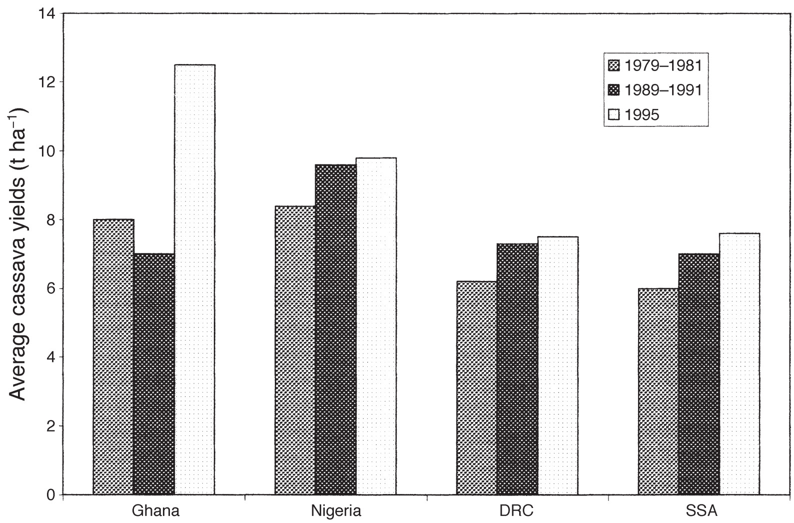

Fig. 3.2. Average cassava yields in three of the top producing countries in Africa compared to the average for sub-Saharan Africa (SSA). DRC, Democratic Republic of Congo. *Source*: IITA (1997).

assimilation, and for better ability to be intercropped with legumes.

Access to good quality planting material

Cassava production is dependent on an adequate supply of vegetative propagules (i.e. stem cuttings). The multiplication rate of these materials is very low in comparison with crops grown from true seed. In addition, cassava planting materials are bulky and highly perishable as they soon dry after harvest, unless carefully stored. Multiplication and distribution of cassava planting material are expensive therefore, relative to conventional seed services. The yield stability and environmental development of cassava is highly dependent on the quality of planting materials, and there is evidence that the initial use of healthy cuttings is an important factor in the subsequent attainment of good yields. Conversely, cuttings with low vigour, and which are infested/infected by pests and pathogens, often limit cassava production. However, there is insufficient knowledge concerning criteria appropriate for selection of vigorous and clean cuttings, and on the optimal conditions for their propagation and maintenance. Pests and diseases, together with poor cultural practices, combine to contribute to yield losses that may be as high as 50%.

In dry agroecosystems, where biomass production is usually low in comparison with more humid areas, and in areas where new materials such as improved varieties are being introduced for the first time, the production of planting material in sufficient quantities is a major restriction to the widespread and rapid adoption of the crop or a new variety.

Lack of well-adapted varieties

In the countries included in the COSCA survey, representing around 80% of cassava production in Africa, farmers are continually abandoning old cultivars and introducing new ones. For instance, among the 20 most popular local cultivars grown in southern Tanzania during the 1970s, only eight of these could be identified 20 years later (R.J. Hillocks, unpublished). This indicates farmers' need for better varieties, but also highlights the danger of loss of genetic diversity. While it is increasingly evident that cassava is expanding into the semi-arid and mid-altitude zones, the available improved germplasm is mostly adapted to the lowland humid tropics. Therefore, germplasm adapted to other agroecological zones is needed. Moreover, expansion of the utilization of cassava for new industrial uses requires germplasm with high yield as well as quality that is suited to specific end-uses.

Plant pests and diseases

As cassava cultivation in Africa intensified, indigenous pests attacked the crop and exotic pests were introduced. Although it is now widely accepted that cassava in Africa is attacked by a number of serious pests, few in-depth studies of the ecological and economic importance of any of these species have been carried out. The major cassava pests in Africa include relatively few phytophagous arthropods, pathogens and weeds, compared to the pest complex found in the neotropics. The most severe pests are the exotic species accidentally introduced into areas where the local germplasm is susceptible to attack, where effective natural enemies/antagonists are absent and where a tradition of practices to cope with the introduced pests had not had sufficient time to evolve. In addition, pest problems are being created where intensification of cassava production erodes the environmental stability inherent in balanced agroecosystems.

The major pests are cassava green mites (CGM; *Mononychellus* spp.), elegant grasshopper (*Zonocerus elegans* L. and *Zonocerus variegatus* Thunb.), cassava mealybug (CM; *Phenacoccus manihoti* Matile-Ferrero), root mealybug (*Planococcus citri* Risso) in the rainforest ecozones, cassava mosaic viruses (CMVs), cassava bacterial blight (CBB; *Xanthomonas axonopodis* pv. *manihotis* Berthet and Bondar), cassava anthracnose disease [CAD; *Colletotrichum gloeospoioides* f. sp. *manihotis* Henn. (Penz.) Sacc.], and root rots in the humid lowlands. The role of termites, nematodes and certain weed species particular to specific ecozones, has been reported as constraints but have not received adequate attention. See chapter 10 for more detailed information on insect pests and chapters 11 and 12 for diseases.

The appearance of CM and CGM as introduced pests in the 1970s in Africa had a devastating effect in farmers' fields. In particular, CM attack was so severe that it threatened the future of cassava in Africa. Massive efforts spanning several continents and involving numerous international and national research institutions under the leadership of IITA, led to the development of a successful continent-wide biological control programme. Natural enemies of CM were identified in South America, and the parasite *Apoanagyrus lopezi*, has been released in many countries in Africa. Biological control, along with improved varieties and cultural practices, provides a cost-effective, sustainable and environmentally friendly technology for the control of CM without using insecticides. The widespread establishment and documented impact of exotic predatory mite species offers good prospects for biological control of CGM as well.

The trend towards increasing the shelf-life of fresh cassava and an extended storage of dried cassava (chips/flour), will aggravate the problems caused by postharvest pests. These include the devastating larger grain borer (LGB;

Prostephanus truncatus) and a number of root rots. LGB can consume as much as 74% of cassava chips within only 4 months of harvest. Fungi are also known to infest cassava chips during processing and handling, in the field or during storage; they may lead to the formation of mycotoxins, making the chips unable to meet trade and health standards.

Variety Improvement and Adoption

Since the initial cassava germplasm introductions by the Portuguese, subsequent introductions and breeding programmes have generated high-yielding, disease-resistant genotypes. The early challenge for improvement was to produce varieties resistant to cassava mosaic disease (CMD) and later to CBB. During the 1970s, building on work done earlier in East Africa, improved cultivars incorporating resistance to these diseases were developed. Genotypes resistant to CMD and CBB are available at IITA as virus-indexed plantlets, ready to be shipped to any institution.

Several clones that combine good levels of resistance to CGM in addition to the other diseases and pests, and have low cyanogenic potential, have been developed at IITA. Many cassava improvement programmes in Africa have received these materials in tissue culture and true seed forms. These clones are tested under local environmental conditions and those that outperform local varieties are released to farmers. For example, in West Africa, over 25 improved cassava varieties have been released, or, are recommended by the National Programme in Nigeria. In Sierra Leone up to eight varieties have been released by the Institute of Agricultural Research and four in Ghana. In Central and East Africa, Cameroon has released seven varieties, Democratic Republic of Congo five, Uganda nine, Tanzania ten, and Zimbabwe four. At least three varieties have been released by each of the other cassava-producing countries in Africa (IITA, 1997).

Procedures for meristem culture and virus indexing for CMD in cassava have been established. Since the early 1980s, an agreement has been reached with African phytosanitary regulatory agencies to permit the movement of *in vitro* virus-tested cassava germplasm in Africa. The meristem culture technique has been used successfully to transfer cassava germplasm from the field gene banks at IITA, and in Ghana and Republic of Benin to the *in vitro* gene bank at IITA, and from IITA to a number of countries in Africa and to CIAT, in Colombia.

Despite these achievements, adoption of improved varieties of cassava was not widespread by 1991, except in Nigeria (Nweke, 1994a,b). However, more recent evidence points to increased adoption rates in Ghana, Uganda and Sierra Leone. During COSCA surveys, the most frequent reason given by farmers for discarding varieties was ‘late bulking’ (Table 3.3). The implication is that in villages where the cultivation of those genotypes was abandoned, the farmers were selecting for early bulking. Where farmers were selecting for high root yield, weed suppression, good in-ground storability, disease and pest tolerance, good processing qualities, desirable branching habit, low cyanogenic potential, good cooking qualities, good planting material yield, etc., the varieties that did not have those desired traits were abandoned (Table 3.3).

Crop Production Systems

Cassava in Africa is usually grown in mixed stands with other crops. The most frequent companion crops are maize, sorghum and pigeonpea. Results from COSCA show that individual farmers grow an average of six to seven different companion crops, with a range of one to 15 crops. Only about 25% of the fields were planted to a single crop. Rice, yam and cassava were the crops grown most often as sole crops (IITA, 1997).

The amount of labour used in field production of cassava differs between African countries, with the highest in Nigeria and lowest in Côte d’Ivoire. Farmers allocate more labour to all farm operations, except land clearing, in high- than in low- population density areas (Tshiunza, 1996). The total amount of labour allocated to the production of cassava is highest under recurrent cultivation and statistically the same between shifting and continuous cultivation systems. The amount of labour allocated to each farm operation under recurrent cultivation is greater than that under shifting cultivation. The difference in total field production labour between recurrent

Table 3.3. Reasons given by farmers in Africa for abandoning cassava varieties.

Reason	% of farmers
Late bulking of roots	20
Low yield	16
Weed competition	11
Poor in-ground storability	10
Susceptible to pests and diseases	8
Poor processing quality	7
Undesirable branching habit	5
High cyanide content	5
Poor cooking quality	2
Poor yield of planting material	1
Introduction of better varieties	1
Susceptible to drought	1
Low leaf yield	1
Others	12

Source: COSCA and Nweke (1994a).

and continuous cultivation systems, and between shifting and continuous cultivation is due to land clearing and weeding operations. More labour is allocated to land clearing operations in shifting and recurrent than continuous cultivation. The opposite holds for weeding operations.

Hired labour is the external input used most frequently in cassava production systems in Africa. The COSCA showed that labour was employed for use in one or more farm tasks in 41% of the fields of the major food crops including cassava (Nweke, 1994b). The proportion was highest for yam (67%), lowest for sweet potato (13%) and close to the overall average for cassava (40%). Hired labour is used in various combinations with family labour for land clearing, seedbed preparation, planting, weeding, harvesting and field-to-home transportation operations. It is used most often in land clearing and seedbed preparation.

In some countries, farmers may use machinery in cassava production. In Africa, only three operations are likely to be mechanized: land clearing, land preparation and field-to-home transportation. Of the three farm operations, transportation is the most frequently mechanized, with transport of cassava from 30% of the fields being by motorized means (Tshiunza, 1996). Pingali *et al.* (1987) also report that transport is usually the first farm operation to be transferred from human to animal power and the second is ploughing. Primary tillage and transport are extremely energy demanding and are usually transferred to a new source of power even when wages are low.

Generally, the cultivation of cassava is thought to require less labour per unit of output than most other major staples (Goering, cited in Berry, 1993). In Sierra Leone for instance, cassava requires less labour per unit of output than upland rice and maize. Expansion of cassava production in Africa seems to be leading to greater labour productivity in the region.

Cassava can grow and give reasonable yields in soils of low fertility but fertilizer is often required for the crop to reach its maximum production potential. Cassava requires relatively little nitrogen to achieve high yields, so that it responds to no more than 100 kg ha^{-1} of nitrogen, after which there are diminishing returns (Tshiunza, 1996). Phosphorus is the most important nutrient for obtaining yield increases in cassava, with yield response to applications of as high as 400 kg ha^{-1}, although levels of 100 to 150 kg ha^{-1} are frequently recommended. Cassava extracts more potassium from the soil than any other element. A high-yielding crop extracts 100 kg ha^{-1}, or more of K. To maintain high yields when cassava is grown in an area continuously, potassium fertilization is essential. Potassium availability also affects tuberous root quality, since its deficiency leads to lower dry matter and starch content, and a higher cyanogenic potential.

Despite the potential benefits, chemical fertilizers are applied to only about 3% of cassava fields, and manure to about 7% of the fields. This compares to 2% of banana/plantain, 11% of rice, 15% of maize, 20% of yam and 5% of crops overall (Nweke, 1994b). Lageman (cited in Tshiunza, 1996), observes that, in the densely populated village of Umuokele in Nigeria, farmers applied mulch and manure to their outer fields. While fallow periods decline as population density increases, the use of organic manure, livestock grazing and other agricultural land-use intensification cultural practices become more frequent in the cassava-producing zones of sub-Saharan Africa.

Crop Utilization

Cassava plays a food security role in areas prone to drought, famine and in periods of civil disturbances. The crop's ability to provide a stable food base is a function of its flexibility in terms of planting and harvesting strategies and because of its relative tolerance of poor soil and pest/disease problems. It is also widely appreciated as a low-cost carbohydrate source for urban consumers, especially where it is available in convenient forms for working urban housewives.

Cassava is a major source of dietary energy for low income consumers in many parts of tropical Africa, including major urban areas (Dahniya *et al.*, 1994; Berry, 1993; Nweke, 1994a,b). Table 3.2 shows that farmers in a third of villages in the cassava growing areas of Africa rated it as the most important crop. In half of the countries covered it was rated as the most important food crop. Maize was chosen as the most important crop in three countries (Malawi, Burundi and Kenya), while yam was rated as most important only in Nigeria. Cash crops as a group were chosen as most important only in Côte d'Ivoire (IITA, 1997).

Cassava makes a greater contribution to total calorie intake in Africa than maize or sorghum. FAO statistics indicate that cassava makes a much smaller contribution than cereals to protein supplies, partly because they do not consider cassava leaves a food item, and consequently a source of protein. Nevertheless, the growth in supplies of protein between 1990 and 1995 has been the same for cassava and rice (20%). Only maize had a higher growth rate (28%), while sorghum and millet increased their contribution to protein supplies by only 8% (IITA, 1997).

One of the main obstacles to the expansion of cassava has been the limited understanding of cyanogenesis in cassava. Recent studies have clarified much of the confusion around the toxic potential of cassava and have clarified the mechanisms of the removal of cyanogenic compounds from cassava during processing (see Chapter 14).

Most cassava in Africa is used domestically, so cassava has played little role as a foreign exchange earner or in import substitution. However, there now appears to be an opportunity to export cassava products, as the traditional Asian exporters appear to be having difficulties in satisfying demand, particularly in the European Union market, due to changes in the relative costs of production. Some African countries are already taking advantage of this trend. For example, exports of cassava chips from Ghana which commenced with 500 t in 1993, reached 29,000 t in 1996 (IITA, 1997).

Thirty per cent of the cassava root produced in Africa is for fresh consumption. In addition, cassava leaves are a preferred vegetable in many countries. 'Shelf-life' of fresh cassava roots rarely exceeds 2 days. Storage and packaging technologies to extend shelf-life will contribute to increasing cassava root availability and reliability, stabilizing prices and facilitating export. However, there is little reported research on ways of extending shelf-life and reducing postharvest losses.

The highly perishable nature of harvested cassava and the presence of cyanogenic glucosides call for immediate processing of the storage roots into more stable and safer products. The extent to which the potential market for cassava may be expanded depends largely on the degree to which the quality of various processed products can be improved to make them attractive to various markets, local and foreign, without significant increases in processing costs.

Traditionally, cassava roots are processed by a variety of methods into many different food products, depending on locally available processing resources, local customs, and preferences (see Chapters 14 and 15). Processors are mainly located in rural areas and obtain their supplies of cassava roots in the same way as itinerant traders. Less than 2% of cassava is processed through factories that are sometimes owned by cooperatives.

Ugwu and Ay (1992) classified cassava products in Africa into nine groups as follows:

- cooked fresh roots;
- cassava flours: fermented and unfermented;
- granulated roasted cassava (*gari*);
- granulated cooked cassava (*attieke*, *kwosai*);
- fermented pastes;
- sedimented starches;
- drinks (with cassava components);
- leaves (cooked as vegetable); and
- medicines.

Flours are the most widely used cassava product in Africa and are processed in a variety of ways. Drying and milling are the most essential steps. Flours from unfermented cassava roots are more common in areas where sweet cassava varieties dominate.

Over 50% of all villages in the COSCA survey had some form of cassava processing centre, and the use of processing machinery, particularly mills, was found to be widespread, except in Central African countries. Mechanized processing has been found to be positively associated with population density. Also, as access to market improves, cassava processing tends to become more mechanized (Ugwu and Ay, 1992).

Improved cassava processing equipment has been designed and tested by research institutions for use at farm and village levels with the objective of reducing postharvest losses, increasing labour productivity and improving product quality. The equipment includes a peeling tool, manually operated chipping, grating and grinding machines, an efficient multiple fuel-type frying stove, a de-watering device and a tray-type dryer. Simple processes, allowing farmers to convert the highly perishable cassava roots into dry, easily stored and freely traded commodities such as chips and flour, are available. They make it possible for high-volume users, such as agro-industries, to develop cassava-based operations.

High labour requirements appear to be the only resource constraint in cassava processing, which none of the traditional techniques can circumvent. Evidence from eastern Nigeria shows that high root yields attained through the adoption of improved cassava varieties would not have substantial economic advantage using manual processing technology (Nweke *et al.*, 1991). The economic advantage of yield-increasing technology may not result in expanded production, and hence into expanded cash income opportunities, if there is no matching investment in cost-saving technology at the processing stage. Some Nigerian farmers using IITA's high-yielding TMS 30572 variety to produce *gari*, have been observed during certain seasons to cut back drastically on planting because they were unable to process the previous season's plantings (Nweke *et al.*, 1991).

There are some possibilities for import substitution of cassava flour and industrial starch. For example, Ouraga-Djoussou and Bokanga (1998) report that around the city of Ibadan in Nigeria, cassava flour produced by a new method is in high demand by four large biscuit manufacturers. A high premium price has been put on the flour compared to the traditional '*lafun*' type of flour. Women's groups that were processing cassava into *gari* have organized themselves to take advantage of this new market, particularly since the price offered by the biscuits factories is high and the returns much better than those obtained from *gari*. Results of an economic analysis by Ouraga-Djoussou and Bokanga (1998) show that with a 15% substitution rate of wheat flour with cassava, Nigeria could save up to US$14.8 million in foreign exchange annually, with US$12.7 million going to cassava processors and US$4.2 million to cassava farmers.

The potential of cassava as a foreign exchange earner in Africa needs to be assessed carefully. Preliminary indications are that the average cost of production of pellets and chips may be too high to allow West Africa to compete with Asian countries in the international market. For example, a survey of 11 cassava pellet producers in southwest Nigeria in 1996 showed that their mean production cost for dry pellets was 22,500 Naira t^{-1} (80 Naira was at the time approximately US$1). Only about 10% of establishments produced at less than or equal to the monthly mean world market price (FOB) of 13,000 Naira t^{-1} for January and February 1996 (F.I. Nweke, J.K. Lynam and S.A. Folayan, unpublished).

Research and Extension

The International Agricultural Research Centres (IARCs), National Agricultural Research Systems (NARS) and regional networks conduct research on cassava in Africa. The most active IARC is the IITA which is funded through the CGIAR. The CIAT, the other CGIAR centre active in Africa, operates through the IITA. Smaller international programmes are executed by the French Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) and the Natural Resources Institute (NRI) of the UK.

IITA conducts a full research programme on cassava, from breeding and pest management to farming systems and postharvest technology. CIAT mainly provides germplasm to IITA's breeding programme and collaborates on biocontrol programmes. CIRAD and Institut de Recherches Scientifiques pour le Développement en Coopération (ORSTOM) have programmes for genetic improvement and physiology.

National programmes for cassava research exist in most African countries in which cassava is grown. There are particularly strong programmes in Cameroon, Congo, Côte d'Ivoire, Malawi, Nigeria, Sierra Leone, Tanzania, Uganda and DRC. All these national programmes are linked together through networks or regional organizations, the most important of which are the Eastern Africa Root Crops Research Network (EARRNET), the Southern Africa Root Crops Research Network (SARRNET), the conference of the African leaders of agricultural research (Conférence des Responsables de Recherche Agronomique Africains; CORAF), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the Southern African Centre for Cooperation in Agricultural Research and Training (SACCAR), and the Institut du Sahel (INSAH).

Many of the NARS face constraints due to human resource problems, shortage of funding and problems of management and coordination of research programmes. The Special Programme for African Agricultural Research (SPAAR) has developed four Frameworks For Action (FFA) in order to provide guidelines and outline strategies that will enable NARS to fulfil their role. These frameworks are based on the building of coalitions between national and regional institutions in technology generation and transfer. The key features are strengthening of the NARS in order to make them more responsible to their clients and to develop their capacity for policy and economic analysis. Implementation of the FFAs generally calls for a number of principles including:

1. Preparation of a national agricultural research strategy or master plan.
2. The establishment of adequate, sustainable, stable and timely funding through transparent and accountable funding mechanisms that pool the collective efforts of donors to address priority national and agricultural research.
3. Enhancement of institutional and management capacity of NARS.
4. The strengthening of research – extension – farmer linkages.
5. The formation of research advisory groups consisting of coalition of all the major research partners.
6. Effective regional collaboration among national, regional and international research institutions.

The FFAs are to be implemented through regional coordinating mechanisms, which include CORAF for West and Central Africa, INSAH for the Sahel, ASARECA for East and Central Africa and SACCAR in South Africa.

Future Needs

Variety improvement

Cassava genetic resources in Africa are under the threat of erosion. The COSCA survey indicates that farmers in Africa are abandoning old cultivars in favour of new ones. While this is a necessary part of agricultural development, traditional cassava cultivars must be collected to prevent further loss of desirable genetic diversity. Additional variability should be sought, particularly if adapted to harsh environments. Moreover, the potential contribution of wild relatives of cassava should not be ignored. The early cassava introductions were limited and not sufficient to transfer the wide genetic base existing at the centre of origin of the species.

Further introductions from Latin America hold promise to broaden the germplasm base of cassava, by providing unique sources of variability not currently available in Africa.

The search for, and utilization of, new sources of resistance to each of the major pests and diseases need to be intensified, with the aim of diversifying resistance that would prove difficult for pathogens and pests to circumvent. Problems, which are recalcitrant to conventional methodologies, need to be addressed using the tools of biotechnology.

Protocols for identifying and eliminating pests, diseases and poor plant vigour in cassava cuttings are needed by NARS involved in plant quarantine and plant protection activities, and for selection, propagation, and management of pathogen-free cuttings by extension agents and farmers in a sustainable manner. The objective would be to develop and implement a strategy to produce and maintain clean and vigorous cassava planting material, given the specific requirements of the major cassava-growing ecozones in Africa.

Information from COSCA has provided much valuable information on the characteristics of improved varieties most sought after by farmers in SSA. Prominent among them are high yield, early bulking and high dry matter content. Breeding programmes need to develop varieties, which reach maximum bulk around 9 months, rather than the current average of 15 months.

Integrated pest management

Pests and diseases still take their toll on cassava production. Cassava brown streak disease (CBSD; caused by *Cassava brown streak virus*) and insect pests are increasingly becoming problems of economic importance. Plant protection research needed to address these issues can broadly be grouped into characterization and adaptive/strategic activities. The major characterization themes include yield loss due to grasshoppers, green mite, mealybug and plant diseases such as CMD, CAD and root rots in specific ecozones, resistance screening, and soil nutrient trials. These investigations should provide a quantitative basis for deciding whether or not to develop specific pest intervention technologies.

Another area of plant protection in cassava that is often ignored concerns the ecosystem-specific pests. During extensive plant protection diagnostic surveys carried out by Ecologically Sustainable Cassava Plant Protection, a number of important pest constraints were identified as being associated with specific ecozones, but not exclusively on cassava. These include the variegated grasshopper in the transition forest and moist savannah, termites in the moist and dry savannah, nematodes in all ecozones, and vertebrate pests and root rots in the rain and transition forests.

Adaptive/strategic research themes for cassava plant protection and production should include the classical biological control of LGB and CGM, and the identification and integration of sustainable control methods for CMD, CBB, CAD, weeds, termites, nematodes and vertebrates. The development of packages of integrated control methods for root rots (including CBSD) will have a direct impact on the quantity and quality of marketable tuberous roots. Methods to protect cuttings from infection by root and stem rot pathogens would be part of the development of protocols for producing and managing clean and vigorous cuttings. Integrated participatory on-farm trials, where appropriate, and the elucidation of indigenous knowledge systems should also be pursued.

Improved postharvest management

To be competitive and to increase their income, cassava farmers need to sell high-quality processed products with a long shelf-life. One of the major advantages cassava has over other starchy crops is the variety of uses to which the roots can be put. In addition to being a major staple food for humans, it also has an excellent potential as livestock feed, and in textile, plywood, paper, brewing, chemical and pharmaceutical industries. The major constraint, however, is that cassava deteriorates rapidly. Fresh roots must be transformed into more stable products within 2 or 3 days from harvest. This transformation requires technology for peeling, grating, boiling, fermenting, drying, frying and milling.

Timely harvests and efficient postharvest operations play a crucial role in the lives of farmers. Appropriate equipment to carry out these operations reduces crop waste and enables more complete utilization of the food crops grown. This is especially true of farmers who are moving from subsistence agriculture to large-scale commercial production. IITA has devoted attention to designing and fabricating improved processing equipment. While the primary goals of these technologies have been to minimize crop losses and improve labour productivity and product quality, activities that have evolved recently include on-farm testing and demonstration of the equipment, training of manufacturers and networking to promote the use of improved equipment. It should be borne in mind that by improving the quality of farm products, incomes and standards of living are also raised for farming families who use these technologies.

High labour requirement appears to be the main resource constraint in cassava processing. Cassava processing is most often the responsibility of women. High root yields attained through the adoption of improved cassava varieties would not have substantial cost saving advantage under manual processing technology. Consequently, there is a need to give greater attention to cassava processing technologies in Africa. A better understanding of the distribution of marketing margins in the cassava chain from producers to middlemen to processors to end-users will point the way to better targeting of technology dissemination.

Industrialists and entrepreneurs often shy away from using cassava in their applications because of the absence of a local example to follow and the uncertainty of success. Therefore, product development research needs to be strongly promoted and the private sector should be encouraged to participate. Issues that need to be addressed include raw material import substitution, promotion of a positive image for cassava, development of products for existing and new markets, identification of the functional characteristics of cassava genotypes in relation to various end uses, utilization of cassava plant parts (e.g. leaves, peel, etc.) for livestock feeding and the leaves for human consumption.

References

Berry, S.A. (1993) Socio-economic aspects of cassava cultivation and use in Africa: implications for development of appropriate technology. COSCA Working Paper No. 8. Collaborative Study of Cassava in Africa, International Institute of Tropical Agriculture, Ibadan, Nigeria.

Dahniya, M.T., Akoroda, M.O., Alvarez, M.N., Kaindaneh, P.M., Ambe-Tumanteh, J., Okeke, J.E. and Jalloh, A. (1994) Development and dissemination of appropriate root crops packages to farmers in Africa. In: Ofori, F. and Hahn, S.K. (eds) *Proceedings of Ninth Symposium of the International Society of Tropical Root Crops*, 20–26 October 1991, Accra, Ghana. International Society for Tropical Root Crops, Wageningen, The Netherlands, pp. 2–9.

FAO Production Yearbook (1998) FAOSTAT database. http://apps.fao.org/cgi-bin/nph_db.pl

IITA (1997) Cassava in Africa: past, present and future. Report prepared for IITA by Dunstan Spencer and Associates. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Jameson, J.D. and Thomas, D.G. (1970) Cassava. In: Jameson, J.D. (ed.) *Agriculture in Uganda*. Oxford University Press, Oxford, pp. 247–251.

Jennings, D.L. (1976) Cassava, *Manihot esculenta* (Euphorbiaceae). In: Simmonds, N. (ed.) *Evolution of Crop Plants*. Longman, London, pp. 81–84.

Jones, W.O. (1959) *Manioc in Africa*. Stanford University Press, Stanford, Connecticut.

Nweke, F.I. (1994a) Cassava distribution in Africa. COSCA Working Paper No. 12. Collaborative Study of Cassava in Africa, International Institute of Tropical Agriculture, Ibadan, Nigeria.

Nweke, F.I. (1994b) Farm level practices relevant to cassava plant protection. *African Crop Science Journal* 2, 563–582.

Nweke, F.I., Ugnu, B.O., Asadu, C.L.A. and Ay, P. (1991) Production costs in the yam based cropping systems of southeastern Nigeria. *Research Monograph No. 6*. Resource and Crop Management Program, International Institute of Tropical Agriculture, Ibadan, Nigeria.

Ouraga-Djoussou, L.H. and Bokanga, M. (1998) Cassava and wheat consumption in Africa: new opportunities for cassava in the 21st century. In: Akoroda, M.O. and Ekanayake, I.J. (eds) *Proceedings of the Sixth Triennial Symposium of the International Society for Tropical Root Crops – Africa Branch*. Lilongwe, Malawi, 22–28 October 1995. International Society of Tropical Root Crops, Wageningen, The Netherlands, pp. 328–333.

Pingali, P., Bigot, Y. and Binswanger, H.P. (1987) *Agricultural Mechanisation and the Evolution of*

Farming Systems in sub-Saharan Africa. Johns Hopkins University Press, Baltimore, Maryland.

Purseglove, J.W. (1968) *Tropical Crops: Dicotyledons*. Longman, London.

Teri, J.M., Sandifolo, V.S., Kaeya, E.H., Moyo, C.C., Chipungu, F.P. and Benesi, I.R.M. (1999) Root crops revolution in Malawi: lessons learned. *Roots* 6(2), 24–39.

Tshiunza, M. (1996) Agricultural intensification and labour needs in the cassava-producing zones of sub-Saharan Africa. Doctoraatsproefschrift No. 326 aan de Faculteit Landbouwkunfige en Toegpaste Biologische Wetenschappen van de Universeteit Leuven.

Ugwu, B.O. and Ay, P. (1992) Seasonality of cassava processing in Africa. COSCA Working Paper No.9. Collaborative Study of Cassava in Africa, International Institute of Tropical Agriculture, Ibadan, Nigeria.