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TECHNICAL GUIDE FOR THE PRODUCTION AND CONSERVATION OF YAMS (*Dioscorea spp)*

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ABBREVIATIONS AND ACRONYMS

CIRAD: International Co-operation Center of Agricultural Research for Development

FAO: Food and Agriculture Organisation

IFAD: International Fund for Agricultural Development

FAS: Faculty of Agronomic Sciences

g: gram

GTZ: Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation)

Ha: hectare

Kg: kilogram

NPK: Nitrogen, Phosphorus, Potassium

PNDRT: National Programme for the Development of Roots and Tubers

R&T: Roots and Tubers

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INTRODUCTION

Before the introduction of cereal crops to West Africa, yam provided the main source of hydrocarbons. Nowadays, with a production of 30[1] million tons per year, yam comes second among the root and tuber crops.

Within this sub region, (Nigeria, Togo, Benin, Ghana, Cote d'Ivoire, etc.), yam is either consumed boiled, as chips or as fufu. It greatly contributes to food security, plays an important social and cultural role and constitutes an important source of agricultural income.

Much as yam is considered a luxury food, its increasing demand in urban areas leads us to think that in future, it shall eventually become an alternative for the ever increasing food needs resulting from galloping urbanisation, and position itself as a substitute for imported instant food.

Contrary to other West African States, the importance of yam in Cameroon is secondary. With an annual production of 722 509 tons in 2002-2003[2], that is, a yield of 11.6 tons per hectare, yam, in volume terms, represents the third root and tuber crop produced in Cameroon after cassava (2 349 171 tons) and cocoyams/taro (1 156 919 tons). It is generally consumed boiled and rarely processed into chips.

The main domesticated and cultivated species are Dioscorea rotundata, Dioscorea cayenensis, Dioscorea alata and Dioscorea dumetorum. Each of these species comprises several varieties each adapted to well specified soils. Yam is cultivated in association or as a sole crop in all the agro-ecological zones of Cameroon. However, its total production varies from zone to zone. High production zones (see map) are II, III, IV, V as well as the Mayo-Rey and Faro Divisions in the North Province.

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[1] Nigeria alone accounts for more than 20 million

2 Rapport de synthèse "Etude de base", page 25, NPRTD, 2005

However, it is mostly cultivated extensively and almost always, traditionally. Moreover, it is almost exclusively cultivated by women, either singly or grouped in producer organisations which are structurally weak and consequently unable to generate convincing results. If we add to the above shortcomings the serious storage problems that yam faces, one can start understanding the lack of zeal for yam cultivation.

All the same, yam production still has several development opportunities in Cameroon. Its productivity, processing, consumption and its profitability can still be improved upon.

In order to improve on the performance of this sub sector and enable households to have more access to yams, the Government of Cameroon initiated, within the framework of the poverty reduction strategy, the National Programme for Roots and Tubers Development (NPRTD)

NPRTD is a programme supervised by the Ministry of Agriculture and Rural Development (MINADER), implemented with support from the International Fund for Agricultural Development (IFAD), in accordance with loan agreement No 606 CM of July 23, 2003.

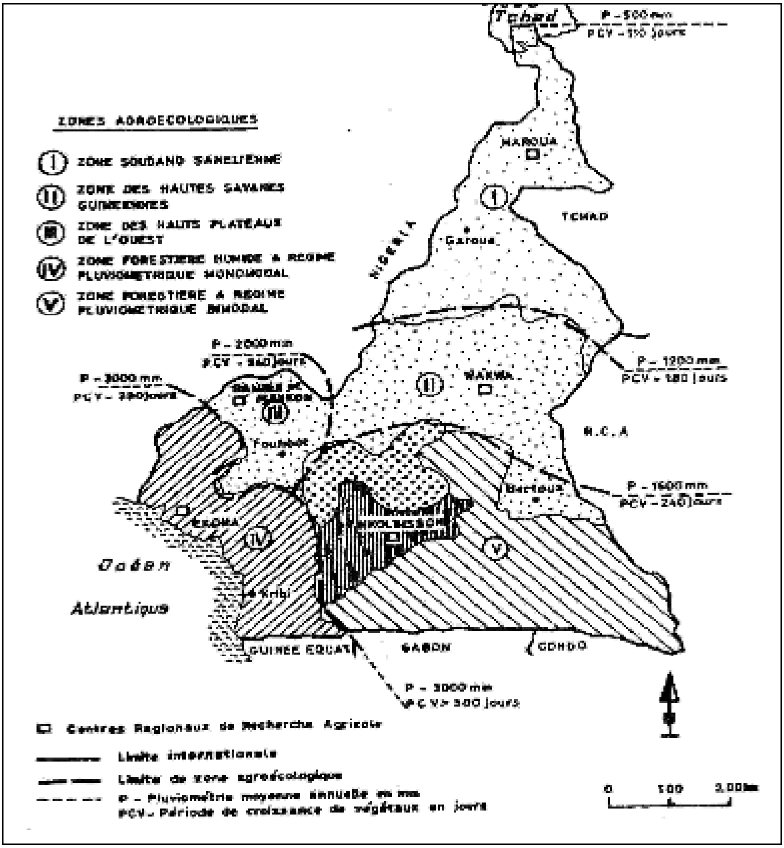
The main goal of NPRTD is to contribute to the improvement of food self sufficiency and of the livelihood of rural population, through the development of root and tuber crops. By the end of the programme (2012), 120 000 rural households (about 6 000 villages) would have become members of organisations, should have acquired capacities for the sustainable development of the roots and tubers sub sector, and would have effectively adopted improved technologies and management strategies. The income they shall generate from this sub sector should have increasing by 50% and the National Root and Tuber Inter-professional Organisation should have been effectively put in place.

During its whole duration, NPRTD shall deal mainly with five root and tuber families represented by the following crops: cassava, cocoyams/colocassia, sweet potato, solanum (Irish) potato and yam.

Its beneficiaries shall be the rural poor, mostly women and under privileged youths.

The present Guide[3], while trying to avoid replacing the technicians present in each of the regions, is destined to get the necessary practical information to them.

Map 1: The agro-ecological zones of Cameroon



Source : IRAD

[3] Elaborated with the assistance of Jean Claude MEDOU, Christopher NGONG and Emmanuel NJUKWE.

I. AGRO-CLIMATIC CONDITIONS

Yam grows and develops well between the altitudes of 0 to 1500 meters above sea level and at an average temperature range of 23 to 25°C. Rainfall above 1500 mm is conduisive to its growth. In fact, the best yam development is obtained in zones with a rainy season of at least five months. The transition zone between the tropical rain forest and the savannah is most suitable for its production.

II. STAGES OF PRODUCTIOIN

II.1 Land Preparation

This takes place before the first rains and consists of:

- Clearing the plot
- Tilling the soil and making ridges or mounds. Mounds could be 20 to 45 cm high with a diameter of 1.2 to 1.5 m
- Applying well decomposed manure to the ridges or mounds (organic residues, fowl droppings, etc.), if necessary.

N.B.

- Deep soils that are permeable and rich in humus are recommended.

- A natural fallow of five years enables the soil to regain its fertility for good yam production. Conversely, if the fallow is improved with green manure such as Mucuna spp., the fallow period can be reduced to 3 years.


Fig1.Yam plot showing average-sized mounds

- Large mounds (0.8-1 m high) favour tuber development, but large tubers, because of their high water content, do not store well. Large mounds also entail a lot of labour and extra means.


Fig2.Yam plot showing ridges

- It is recommended to cultivate yam on ridges so as to economize space for other crops or increase the planting density. Moreover, ridges enable the crop to benefit more from rain water retained in the furrows. It is also difficult for rodents to destroy average-size tubers produced in ridges because they store better

II.2 Planting

Planting material comprises whole tubers or fragments of tubers (4 to 6 fragments or 6 to 8 fragments).

Fig3: Phyto-sanitary treatment of Yam setts by soaking

Fig4. Yam setts and mini-setts

It is recommended to soak the planting material in a water +fungicide (Manebe or benlate) solution and dry for 24 to 48 hours under shade before planting. One can equally rub the minisetts with wood ash immediately after cutting.

Box 1: Yam multiplication by minisetts

This technique consists of producing small whole yam tubers from mother- tubers that are cut into small fragments of 15 to 30 g. To produce the necessary minisetts, the following procedure is followed:

1. Choose good, healthy and whole tubers that have started germinating.
2. Cut the tubers transversally, in discs with a thickness of about 3 cm.
3. Further cut the discs longitudinally in order to obtain fragments of 15 to 30g. Each fragment must have part of the skin.
4. For 150 g of wood ash in a bucket and 8 l of water and mix properly. A fungicide that has been homologated for use in the country could also be added.
5. Soak the fragments in the liquid thus obtained, stir with a stick and leave the fragments to rest for about 10 minutes.
6. Remove the fragments and leave them to dry under shade.

7. Prepare a shaded nursery, put a fine cover of saw dust and water it.
8. Spread the fragments on the nursery beds and cover with another layer of saw dust.
9. Water regularly for 2 to 4 weeks. Avoid excess water that may provoke rotting.
10. Transplant the sprouted fragments unto the farm on ridges spaced 1m apart, that have been prepared on rich hand well-drained soil. Space plants on the ridges at 25cm.
11. Mulching the ridges ensures the maintenance of humidity and controls weeds better.
12. Harvest the minisetts 5 to 6 months after planting in the farm. They should weigh between 200g and 1 000g.
13. Keep minisetts in a well aerated and fresh place, away from rodents until planting.


Fig5. Planting on ridges

Planting can take place before or at the beginning of the rainy season. The earlier we plant, the better the yield. A planting distance of 1 x 1m (1m between lines and 1m between plants on the same line) is recommended. This gives a planting density of 10 000 plants per hectare. Proceed with mulching which consists in covering the mounds or ridges with straw or dried grass before or after planting. This shall favour sprouting because it lowers soil temperature, reduces evaporation, and slows down erosion and growth of weeds. Mulching is thus necessary for the survival of the development of the minisetts thereafter.

NB. After complete maturity, yam tubers start sprouting after 2-4 months of dormancy (vegetative rest). Given that transplanting pregerminated mini-fragments of tubers into the farm has to be done on humid soil, their planting in the nursery should be done 15 to 30 days before the rains. Transplantation thus takes place 3 to 4 weeks after planting in the nursery.

At harvest, some fragments give average tubers of 1 to 2 kg although minisetts of 200 to 600 g are recommended. The average tubers thus go directly to consumption or are reserved to serve as mother-setts for new production. We also find tubers of less than 100 g (small yam) at harvest. These shall be replanted to give mother-tubers. The higher the planting density (more than 40 000 plants/ha), the smaller the tubers at harvest.

II.3 Field maintenance

Field maintenance activities are: weeding (3 to 4 times), staking and manuring.

As concerns **staking**, experience shows that leaves of early-maturing varieties die earlier if they are not supported by stakes thus leading to low yields.

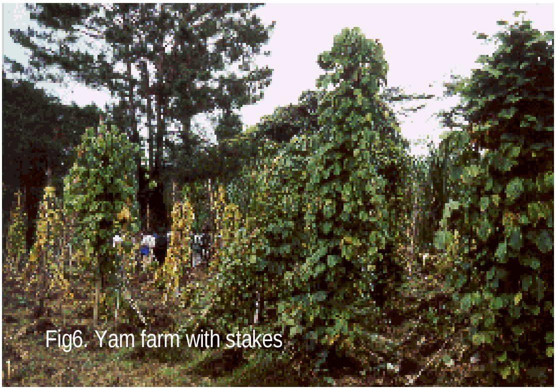


Fig6. Yam farm with stakes

Yields of yams for fufu production increase by 50 to 60% with stakes. However, this operation is labour-intensive and costly. In zones where stakes are rare, the surplus of yield gained because of staking does not compensate for the extra expenses committed to do this work.

With respect to **manuring**, yam prefers soils that are rich in macro-nutrients (N-P-K) and it is for this reason that it is planted at the head of rotation immediately after a long fallow period after a good biomass stock would have been constituted.

When the fertility of the soil has been depleted, mineral and organic supplements in the form of chemical or organic fertilizers are necessary (harvest residues, compost, dung, etc.).

Applying only mineral fertilizer on a soil that has low organic matter content will not increase yield. If there is too much nitrogen (urea, ammonium sulphate) in the fertilizer that is applied, yam tubers obtained shall contain too much water and consequently shall not store well and shall germinate early in store. If on the contrary, higher doses of phosphorus (Simple Super Phosphate, Triple Super Phosphate) or potassium (potassium chloride, potassium sulphate) than that of nitrogen are applied, the tubers harvested shall store well ant their germination in store will be reduced. Yam thus needs balanced fertilisation. However, it is important to know the nutrient content of the soil before applying any mineral fertilizer. Since this is not affordable by resource-poor farmer, organic fertilizers are recommended.

Good yields can be obtained with fertilizer placement using animal droppings or compost rich in organic matter content (0.5 to 1 kg per stand, thus 10 to 15 tons per hectare).

The recommended dose for inorganic fertilizer is such that the potassium content should double that of nitrogen. The formulation available on the market that is nearest to this norm is the 12 6 20. The usual application rate is 10 to 20 grams per stand, thus about 250 kg per hectare.

Table 1: Diseases/pests and control methods

Diseases	**Symptoms and damage caused**	**Control methods**
Nematodes	Tubers and roots rot in farm Drying of stem Pronounced scales on roots, tubers and nodules Stunting of stems Deformation of leaves	Use healthy tubers Eliminate and burn infested tubers Treat planting material with fungicide solution before planting
Heteroligus	They bore holes on the tubers thus reducing their market value	Treat planting material with insecticide such as thiodan, actellic, carbofuran
Coleoptera	Gnawed tubers	Avoid wounding tubers at harvest Rotate cultivation, fallows and plant healthy (clean) tubers

Mosaic	Deformation of leaves Stunting of stems	Use healthy (clean) tubers
Anthracnosis	Appearance of brown and sometimes black spots on leaves	Use healthy (clean) tubers


Fig 7 Symptoms indicating outset of anthracnosis


Fig 8 : Outset of foliar yellowing
Caused by cercosporiosis


Fig 9 : Incidence of mosaic

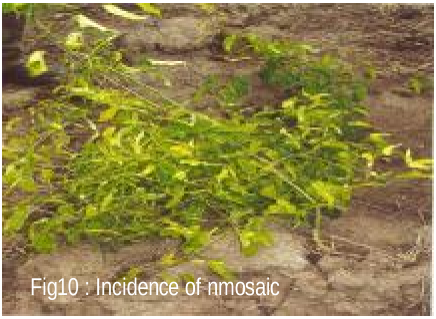


Fig10 : Incidence of nmosaic


Fig 11: Yam tubers destroyed by rodents

III. HARVESTING

Harvesting takes place 8 to 10 months after planting. this is done when the aerial part of the plant yellows and dries up. Small tubers are put back in the soil to constitute planting material for the next season.

The yield is 5 to 12 tons per hectare. However, yields can go up to 20 tons per hectare with the use of mineral fertilizers (organic and chemical manuring)


Fig12. Ageing announcing harvesting


Fig13. Returning from farm after harvesting

Yams are the root and tuber crops that produce the largest of tubers, hence their extremely fragile nature. It is for this reason that particular care should be taken to avoid wounding during harvesting.

Harvesting is generally done with sticks, dibbles, machetes or hoes with which the mounds or ridges are opened up while making sure that the tubers are not wounded. After harvesting, the tubers should be removed from the farm immediately to avoid the weakening of the skin by the sun, predisposing the tubers for rot during storage.

Harvesting is done once or twice a year according to the variety. When it takes place twice a year, we talk of weaning. Dioscorea rotundata is the species that is often harvested twice a year, but in practice, this technique is also applied to D. cayenensis and D.alata. D. esculenta is never harvested twice a year.

Weaning is practised as described in the following box:

Box 2: Yam weaning
Yam weaning is a harvesting technique that targets obtaining table (ware) yam at an early stage (off-season) which could be sold at high prices because its demand will be greater than its supply. Weaning is practised at mid-season, during the rainy season, at about 4 to 5 months after the appearance of stems. The soil should be carefully removed around the tuber so as to avoid wounding the roots of the crop. Then, carefully harvest the tuber at the root collar to avoid wounding either the stem or the roots. Once through, cover up the hole and the plant will produce a second harvest of adventitious tubers which shall be used as planting material. Weaned yams have very high water content because of their incomplete maturity, rendering them unsuitable for storage. Storage, however, is not necessary in practice because there is no problem selling early tubers. On the contrary, this is the period when demand is higher than supply in market.

Varieties that are harvested twice are generally early maturing and their tubers do not store well. A first harvest is done 5 to 6 months after planting to obtain ware yam. 4 to 5 months later, the plants produce regrowths which shall essentially be used as planting material.

Varieties that are harvested only once are late maturating and their tubers generally store better. Harvesting is done 8 to 9 months after planting when the stems start to wilt and die. Intermediary varieties can be harvested once or twice with respect to prevailing conditions (rainfall, etc.). The two harvesting techniques have both advantages and disadvantages compared in the table below.

Both harvest systems are economically viable but single harvesting is five times less profitable than harvesting by weaning. This difference is mainly due to the better price offered for weaned tubers that get to the market when the scarcity of yams is highest and consumers are ready to pay higher to obtain fresh yams.

Table 2: Advantages and disadvantages of the two yam harvesting techniques

	Double harvesting	**Harvesting without weaning**
Advantages	Planting material for the next season is ensured The market value for the tubers of the first harvest is high as these are off-season yams The second harvest can be used or sold as high quality planting material, which equally stores well Generally, income is maximized	Large tubers of high market value are produced Tubers harvested at maturity store well Harvesting is easier and faster than in the case of weaning
Disadvantages	Weaned tubers do not store well because of their incomplete maturity Very high labour requirement for harvesting as opposed to single harvesting (more than double) and the presence of thorns on the stems during the first harvest may render harvesting difficult. First harvesting is a delicate operation and cannot be mechanised The second harvest does not produce good quality ware yams	The prolonged stay of the tubers in the soil Increases their exposure to the attack of farm pests Low market prices because of abundance in supply

IV. STORAGE

Since African consumers have high preference for fresh tubers and as tubers cannot stay long in the farm after maturity, it is necessary to have adequate storage means in order to prolong the period of availability of tubers in the market and to make production more profitable

The respect of fundamental rules of preventing mechanical loss and rigorous hygiene are prerequisites for storage (see section IV.1). This is particular important because here we are dealing with large tubers that are more fragile than smaller ones.

In order to prepare for yam storage, we should remove the soil particles that were sticking to the tubers under dry conditions. In case there is no alternative use of wounded tubers, the wounded parts are cut with a sharp knife. As a supplementary protective measure, wood ash is recommended to improve conservation.

Another less expensive special preparation for yam conservation exists. This is called and is described in the following section.

IV.1 Curing

Curing is an operation to heal small wounds on tubers. It was developed with solanum potatoes, but has proven to be efficient on yams. Curing is an operation whereby favourable surrounding conditions (temperature and humidity) are created that favour drying of wounds to such an extent that scars are formed. Given that this is a metabolic process of the tubers which entails the consumption of small quantities of starch, a weight loss of about 1% results. Curing should be done immediately after harvesting.

There are several methods that vary in duration from 3 to 5 days with respect to temperature (between 25 and 40 °C) and relative humidity (between 70 and 95 %). The Following box gives an efficient method developed in Togo by the FAO which may be modified to suit individual requirements.

Box 3: **Curing under cover (tarpaulin)**

Curing under cover is practised in the following manner:

1. Properly excise all wounds and crushed parts of the tubers.
2. Pile the tubers in a fresh place (under shade).
3. Cover the pile with grass to a thickness of about 15 cm
4. Cover everything with a tarpaulin or jute bags.
5. Leave covered for 3 to 4 days.

During the period of curing, tubers generate a temperature of about 32 to 40°C and a relative humidity of about 70 to 95 % which favours the self-scarring of the wounds, the hardening of the skin and the aptitude for prolonged storage.

IV.2 Storage techniques and facilities

Some species and varieties do not store well (examples: Dioscorea cayenensis and D. dumetorum). Others like D. alata and D. rotundata, on the contrary, store well for several months if the storage conditions are fulfilled.

Several traditional yam storage facilities and methods exist. A lot of improved storage systems have been proposed. The most important and widespread of them are described in this section.

IV.2.1 Traditional yam storage systems

Amongst the traditional yam storage systems, we find underground stores, piles that are more or less covered and more elaborate structures such as clay barns or vertical tying. Some of the current systems are illustrated in figure 14. Table 3 gives an overview of various traditional storage systems.

However, it can be noted that there is no traditional yam storage system that provides enough protection against rot and pests and at the same time, facilitates regular inspection in order to detect damage in a timely manner and to take required measures to reduce them. Thus, it is necessary to improve the storage of yam so as to reduce losses and optimize yields that could be obtained with this crop.

Fig 14: Traditional yam storage systems.

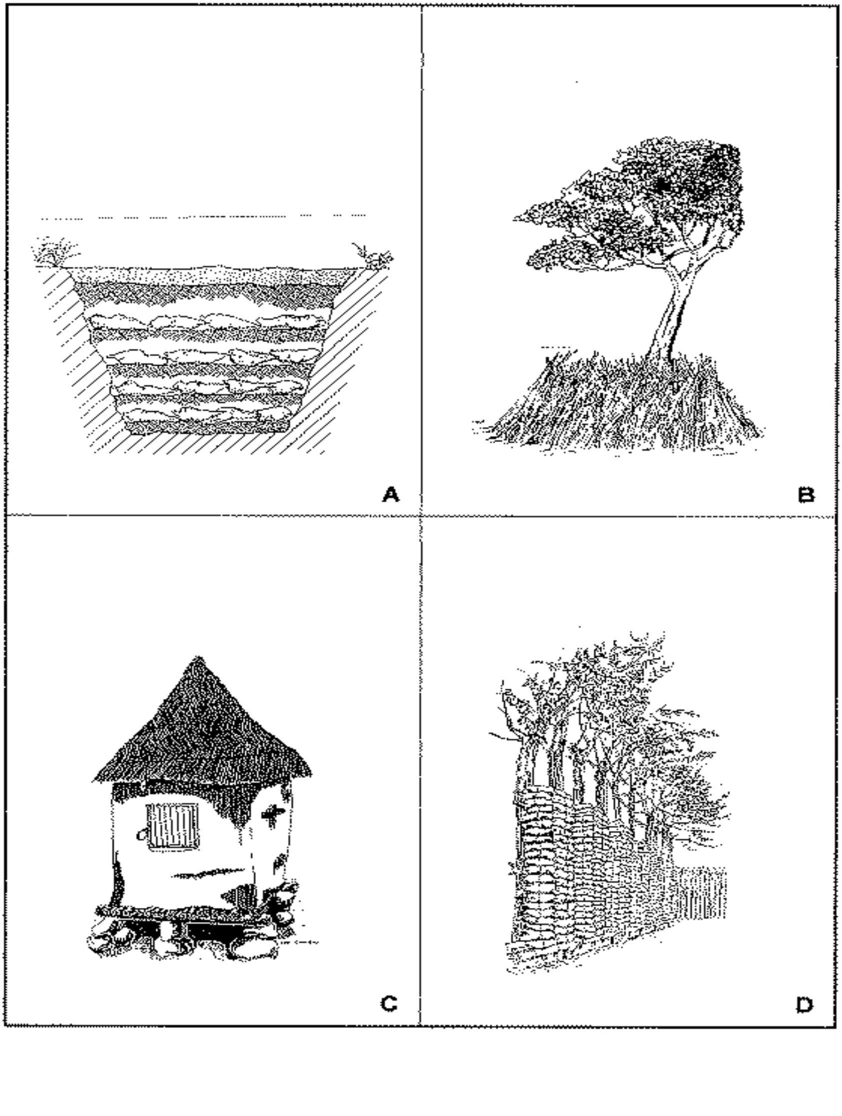


Table 3 : Advantages and disadvantages of different traditional yam storage systems found in Africa.

Storage system	Advantages	Disadvantages
A. Pit – Silo (pit situated in the farm and padded with straw, in which tubers are placed either horizontally or vertically; see figure 14A above	The pit-Silo ensures cutting down of labour meant for transportation. It offers protection against weight loss owing to respiration and transpiration.	Tuber rot is favoured by the absence of aeration and the direct contact established between tubers. Regular control is not possible
Heap on the soil (a pile of tubers on a layer of straw placed under the shade of a tree and covered with straw, etc.).	This facility does not require supplementary funds and provides protection against heat.	It is not well aerated and does not enable necessary control. Yams usually rot in series.
B. Straw shelter (a pile of yams inside a cone-shaped shelter, constructed with the help of maize or sorghum stalks and placed under the shade of a tree; see figure 14B above)	Minimal investment is required. Aeration is better as compared to heaps on the soil, thus reducing damage.	The shelter is open to insect and rodent attack. Domestic animals foraging for food at times destroy the shelter. The quality of yams cannot be controlled.
C. Clay barn (construction in the form of a hut, found especially in savannah regions, with clays walls covered with a roof of straw; see figure 14C above)	This barn has a life span of at least 20 years if well catered for. Tubers piled inside are protected from rain and sun. Clay and straw used as construction material create a favourable temperature.	The construction of this barn requires a lot of work and is more expensive than the previous storage facilities. Aeration of tubers is not sufficient and their inspection is difficult. Yams easily rot in series.

D. Vertical tying (well shaded construction with wooden stakes of about 3m high, spaced 50 cm apart; they are stabilized by horizontal poles; tubers are tied with ropes one above the other, on the vertical stakes; see figure 14D above)	This is the most popular storage system in West Africa. It enables perfect aeration. Control and removal operations are easy.	This construction equally requires a lot of work and is relatively expensive. Storage entails a lot of work since each tuber is tied separately. Yams are not protected from insects and rodents. Tubers receive a lot of humidity and rot easily during the rainy season.

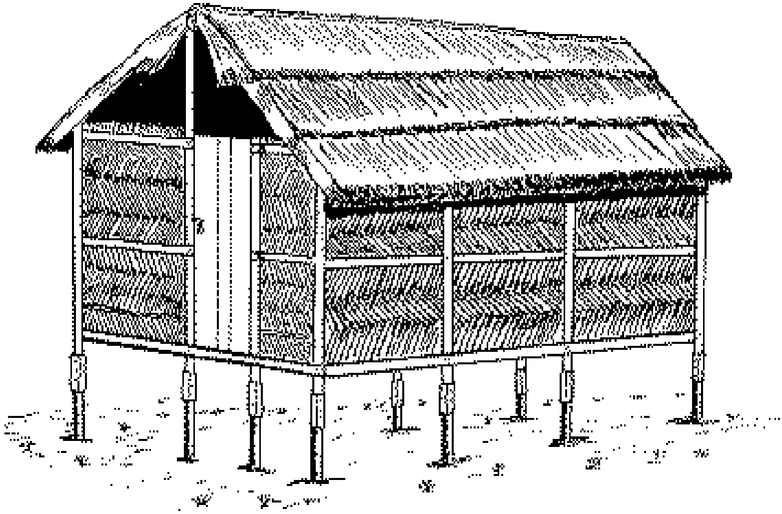
IV.2.2 The elevated hut as an example of an improved store

Diverse proposals had been made to improve yam storage. Even though all of them have advantages, some do not fulfil all necessary storage conditions for reducing post harvest losses to a minimum. Others may not be economically viable for all producers.

To evaluate an improved storage facility, the following criteria can be used:

. simple and cheap construction
. high solidity and long life span
. good aeration and reduced losses from rot
. protection against store insects and rodents
. protection against theft
. easy inspection of tubers

Fig15: Elevated hut for yam storage



On the basis of these criteria, the elevated hut seems to be the best store it combines almost all the advantages, with the exception of protection against insects which is only possible with underground storage. But underground storage has a lot of disadvantages, notably, the high risk of rot and lack of possibility to control the harvest during storage; (see table 3 above).

According to the means available, the hut can be constructed with local material such as bamboo, stakes and poles obtained from local trees, lianas, straw, etc., or with construction material that is bought such as prefabricated construction wood, corrugated iron sheets, nails and wire meshes. The hut is equipped with shelves on which tubers are placed in layers of up to 3 so as to facilitate control. To construct an elevated hut, one should proceed as follows:

Box 4: **Construction of an elevated hut**

The hut should be situated as close as possible to the market or the road to facilitate access to delivery trucks. The steps to follow in the construction are:

1. Determine storage requirements in terms of volume and conceive a sufficiently large hut.

2. Choose construction site and dig deep holes (at least 50 cm to take the main stakes)

3. Treat the parts of the stakes that will be buried with neem oil or mineral oil so as to protect them from termite attack

4. Implant the stakes and construct a platform at about 1m above the soil so as to dissuade rodents.

5. With the help of nails, fix zinc sheets of 30 to 40cm long, large enough to go round the stakes, at a height of about 60cm above the soil.

6. Construct the wall of the hut making sure that there is an access door provided with a lock.

7. Place the roof and cover up with adequate roofing material (straw, zinc, etc.).

8. Construct simple shelves inside the hut capable of carrying the tubers.

9. Fabricate a simple ladder to facilitate access to the hut. This ladder must be removed when the hut is not being used so as to avoid rodent invasion.

Complaints are sometimes made that the construction of an elevated hut requires a lot of expenses and labour. To evaluate the profitability of this type of yam store, one should lose sight of the increase in yield owing to reduction in storage loss (see following Box), the extended period of use and the flexibility of this store which can equally be used to store other foods, such as cereals and grain legumes in bags, onions, dried vegetables, other tuber crops (with the exception of solanum potato which needs to be protected from sunlight), etc.

Box 5: **Storage of yams destined for the market**
Yam is a crop that farmers can gain a lot from, if they take good advantage of the price fluctuation in the market. Except for weaning, adequate storage of yam for several months is the second way to enable the introduction of yams to the market when supply is low. It is necessary for the store to be well constructed in such a way as to prevent the entry of rodents and to ensure good aeration. The store should be located in a place that is easily accessible all year round to delivery trucks so as to facilitate marketing. If the owner of the store respects the rules for construction a good storage facility as indicated in this guide, all he is left to do is to monitor attentively the evolution of yam prices in the market in order to sell when profits are highest. The experience of GTZ in Ghana showed that this system of harvest management could increase the gross benefit of yam cultivation by about 50%.

IV.2.3 Processing

Yam processing is not a current practice in Africa. The reasons are:

- Yam is a tuber crop that is very much appreciated by consumers in its fresh state. Dishes much cherished by consumers (especially fufu) are prepared from fresh tubers.
- With the exception of the not so important *Dioscorea dumetorum*, yams do not contain toxic or bitter substances and as such, do not need to be processed in order to be edible.
- Fresh tubers store well enough to get to the market and to consumers before they get bad.
- Through the practice of weaning and improved storage, yam tubers are available almost all year long.

Attention has to be paid to some already existing processing techniques because they can play a more important role in the future development of instant foods for urban populations than they currently do.

Chips are the most common products of yam processing. Their production (peal tubers, parboil them, dry in the sun) differs from that of cassava in two aspects:

1. Small lateral tubers of Dioscorea rotundata are used (locally called kokoro), and do not need to be cut into pieces before sun drying as is the case with large cassava roots.
2. Parboiling of yam chips is imperatively done for 15 to 45 minutes at temperature of 70 to 80°C, whereas in the case of cassava, this is rarely practised.

Fig16: Improved drying facility for yam chips
FAS Abomey-Calavi University (Benin)

In traditional post-harvest systems, yam chips play the role of food reserves in times of hunger. With the galloping urbanisation, yam chips are increasingly becoming important as food adapted to populations of large towns. In West Africa, flour from chips is used in the preparation of an appetising paste called “amala”.

Box 6: **Amala – the new dish for city dwellers**
Given the food and economic value of yams and the necessity to develop sustainable buffer zones between the producing rural zones and the consuming urban centres, a stabilised yam-based product appears to be promising. In the South West of Nigeria and to a lesser extent in Benin and Togo, **amala**, which is prepared from yam chips, is gradually replacing fufu and even maize-derived foods (in Nigeria especially). A survey in these three countries showed that consumers appreciate its taste, its permanent availability and the ease of preparing amala. Introducing this foodstuff into other countries may seem interesting because it shall ensure the cutting down of constraints related to the marketing of mainly fresh yams and consequently offer new openings to the small-scale and semi-industrial processing of roots and tubers.

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APPENDIX: PROFIT/LOSS ANALYSIS FOR YAM PRODUCTION (1 hectare)

1) Cost of material and duration for use

Material	Cost FCFA	Number of years in use	Annual cost FCFA
Cutlass	2500	4	625
File	1750	3	583
Digger	5500	5	1100
Spade	2500	4	625
Hoe	1500	4	375
Truck	70000	5	14000
Wheel barrow	30000	5	6000
Total			**113750**

2) Profit /loss analysis

Year 1	**Expenditure**				**Income**
Description	**Unit**	**Quantity**	**Unit cost**	**Amount**	Yield = 15 tons per hectare
A) Material					
Cutlass	Depreciated value	10	625	6250	
File		3	583	1750	
Digger		4	1100	4400	
Spade		4	625	2500	Sales of yam= 250 FCFA /kg
Hoe		10	375	3750	
Truck		1	14000	14000	
Wheel barrow		2	6000	12000	
Planting material	number	10000	100	1000000	
Fertilizer (mineral)	bag	5	14000	70000	
Fertilizer (organic)	Bag	200	1000	200000	Income= 15000kg x 250 FCFA/kg
Pesticide	Lump sum	1	10000	10000	
B) Labour					
Land preparation	Man day	25	1000	25000	
Planting material preparation		5	1000	5000	
Digging of trenches		90	1000	90000	
Ridging over trenches		30	1000	30000	

pegging		20	1000	20000	
Weeding		30	1000	30000	
Staking		50	1000	50000	
Fertilizer application		5	1000	5000	
Harvesting		100	1000	100000	
Transport	Lump sum	1	150000	150000	
10% contingencies				182965	
Total				**2012615**	**3.750.000**
Balance sheet of year 1: 3.750.000 – 2.012.615 = 1.737.385 FCFA					