

# GROWING CASSAVA

## A training manual from production to postharvest

**Adebayo B. Abass, Elifatio Towo,  
Ivor Mukuka, Richardson  
Okechukwu, Roger Ranaivoson,  
Gbassey Tarawali and Edward Kanju**



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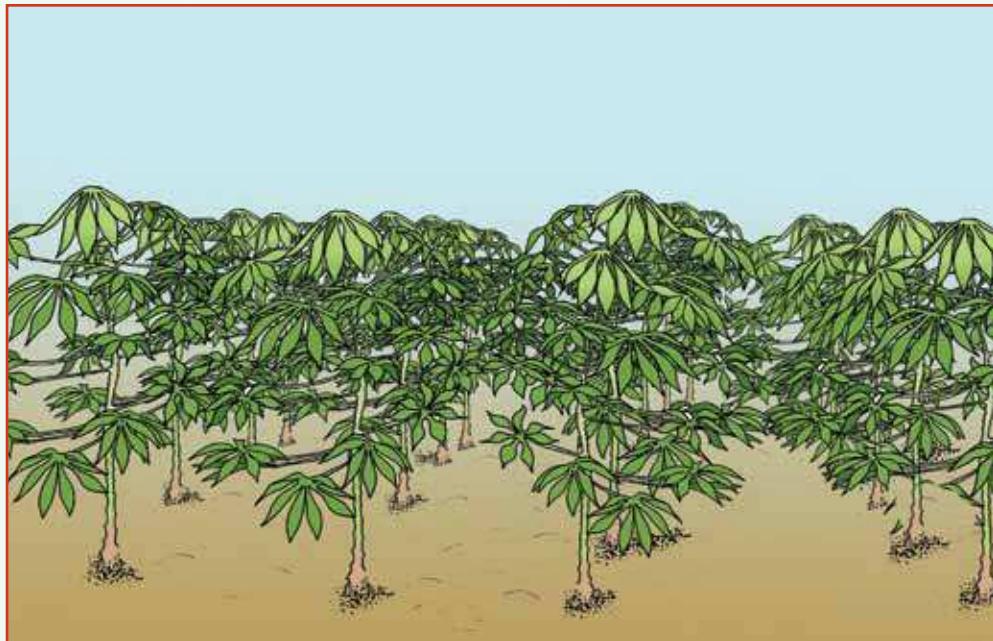


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## Introduction

Cassava is either the first or the second most important staple food in many sub-Saharan African countries. Cassava production and processing practices remain largely habitual in most of the producing countries despite the high potentials for its commercial production and processing, its export potential, and its use in local industries to reduce import expenditure on substitute imported products. Most cassava farmers are either not aware of available modern technologies for growing and processing cassava or lack the ability to use them.



Although new commercial, medium-scale cassava farmers are beginning to emerge in some cassava growing countries, such as in DRC, Ghana and Nigeria, most of them use only some and not all available or recently developed modern techniques that can increase efficiency of growing and processing cassava. Inability to apply modern technologies in a holistic or consolidated manner for cassava growing and processing operations reduces the prospect to maximize profit.

There is also paucity of cassava production specialists, agribusiness experts, processing and, agro-machinery experts to provide advice to farmers, processors, product assemblers, and other value chain actors. The lack of technical advice hinders the ability of small and medium scale farmers to improve value chain efficiency and profitability of their cassava enterprises. It contributes to the inability of most farmers to manage cassava production as a business and hinders processors from upgrading from the traditional rudimentary processing methods to mechanical, high capacity, efficient and profitable processing enterprises. Consequently, cassava value chain actors in Africa are not competitive enough to participate in the global market.

This training manual was developed based on research results and field experiences of cassava value chain development experts. It provides consolidated and relevant set of techno-commercial oriented information presented with simple annotated drawings to explain the step-by-step use of improved techniques and tools of cassava production, handling, processing, storage, quality assurance and marketing.

The manual will be useful to farmers, processors, marketers, extension agents and other experts who are supporting cassava commercialization in Africa. The use of the manual by value chain actors will enhance their knowledge and capacity to improve efficiency of their cassava related operations and can increase profitability.

### Background

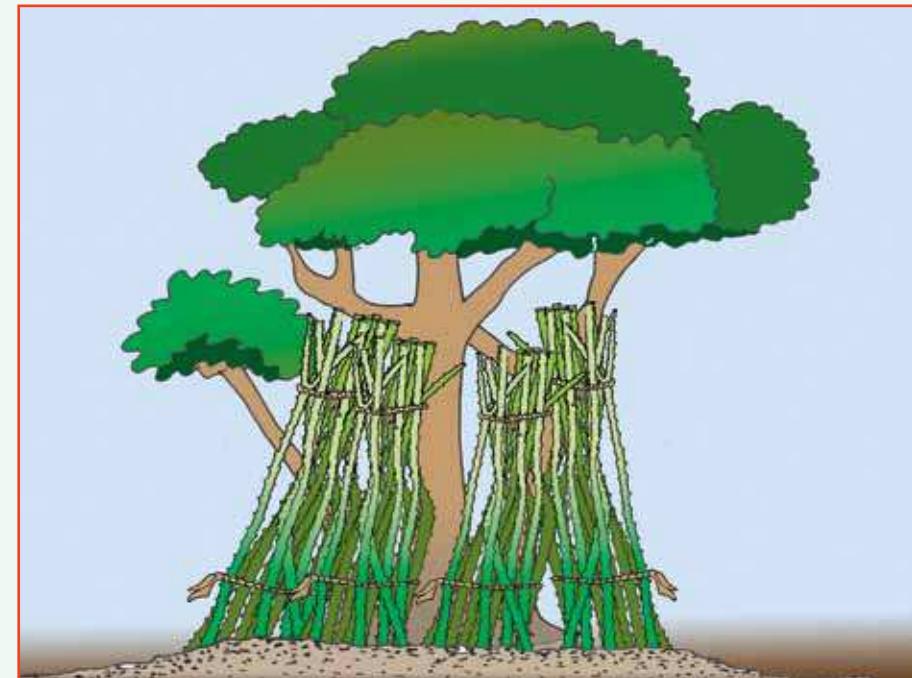
Cassava is propagated by stem cuttings. These cuttings must be handled properly for good sprouting and establishment. In this section we look at the best practices in stem handling for increased yield.

### Preparing healthy cassava stems for planting

- Obtain stems for planting from mature plants 10–12 months old.
- Store under the shade for 2–5 days (never more than 2 weeks) before cutting and planting. This makes the stems sprout faster than when they are planted freshly cut from the field.
- Stems should be stored vertically on the soil under a shade. The distal end of the stems should touch the soil, which is moistened regularly, with the surroundings kept free from weeds (Figure 1).
- Handle the stems with care not to destroy the nodes that may result in losses. Do not make jagged cut surfaces or keep stems in the open (leading to drying) (Figure 2).
- Cut stems, with sharp tools, preferably secateurs or cutlasses, into 25-cm cuttings with 5–7 nodes (Figure 3).

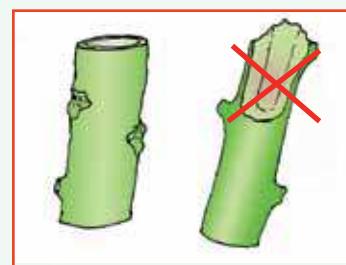
### How to plant cassava cuttings

- Cassava cuttings can be planted in a slanting or angular position ( $45^\circ$ ). In this case, the cuttings are buried in the soil with one-third above the soil surface. Ensure that the buds point upwards. This is where the cuttings sprout (Fig 4a).

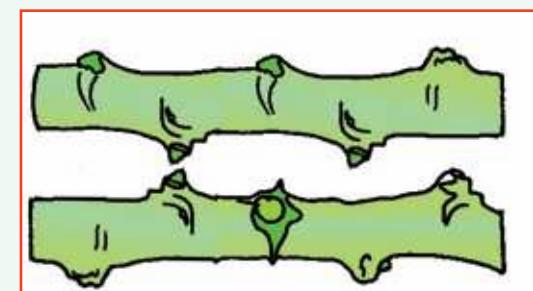


**Figure 1. Stored cassava stems under the shed**

- Cuttings can also be planted in a horizontal position in which the cuttings are completely buried in the soil to a depth of 5 cm (Fig 4b).

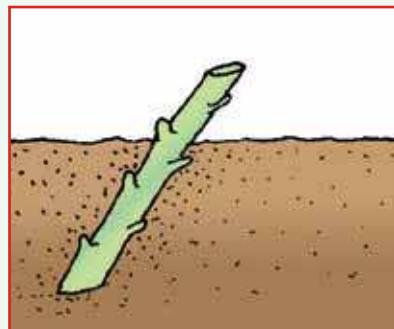


**Figure 2. Avoid destroying nodes and jagged cuts**

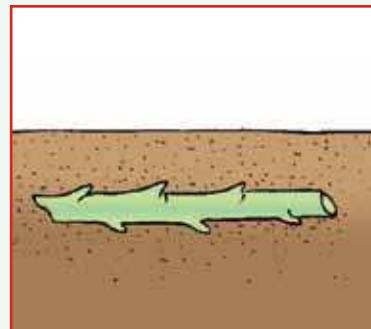


**Figure 3. Cassava cuttings**

- Plant the cuttings at a spacing of 1 m × 1 m on the crest of ridges or mounds as conventionally recommended. This will give a plant population of 10,000 stands/ha.
- Vertical or angular planting is recommended in areas of high rainfall
- Horizontal planting is better in dry areas.



*Figure 4a. Planting at 45°*



*Figure 4b. Planting horizontally*

## How to produce large quantities of cassava stems

Rapid multiplication technique can be used to produce large quantities of cassava stems as planting materials for subsequent seasons.

- Select and use improved, healthy, and pest/disease free cassava stems.
- Cut the stems into several 2-node or 3-node stakes using secateurs, a sharp knife/machete, or a stake cutting machine.

### *Rapid multiplication in a nursery using 2-node cassava stakes:*

**Step 1:** Treat the stakes with available insecticides or fungicides by measuring out the quantities into a container, add water and mix thoroughly. For example, 1kg of Neem leaf powder in 5L of water. Put the stakes into the solution for 10 minutes.



**Step 2:** Remove from the solution and place in perforated transparent polythene bags for pre-sprouting.

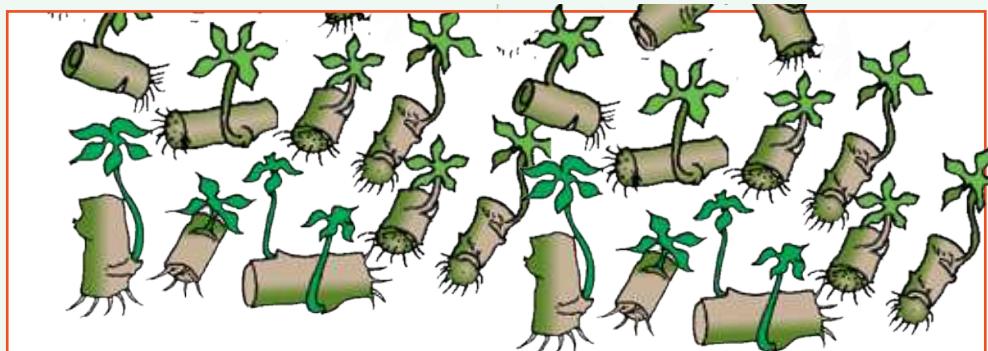


**Step 3:** Store in the polythene bags under the shade of a tree or under the cassava canopy or in a farm shed for 7–10 days to sprout.



#### **Step 4: Prepare the nursery for planting.**

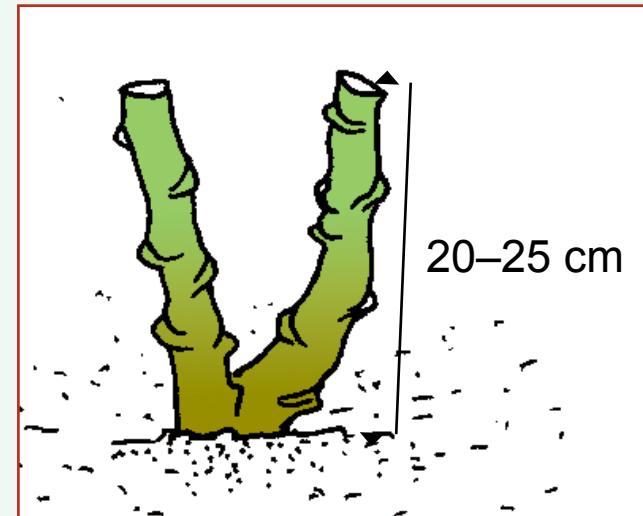
**Step 5:** Expose the polythene bags in the field by placing them on ridges and mounds, or on the flat ground for 20 minutes.



**Step 6:** Transplant the sprouted stakes into the nursery at 2–4 cm depth at a spacing of 100 cm × 50 cm or 50 cm × 50 cm in a well prepared rapid multiplication field. Handle the stakes carefully to avoid breakage.

**Transplant only when there is enough moisture in the soil.**

**Step 7:** Harvest cassava stems at 6–8 months after planting. To harvest, cut the stems at a height of 20–25 cm above the ground level with a sharp machete.



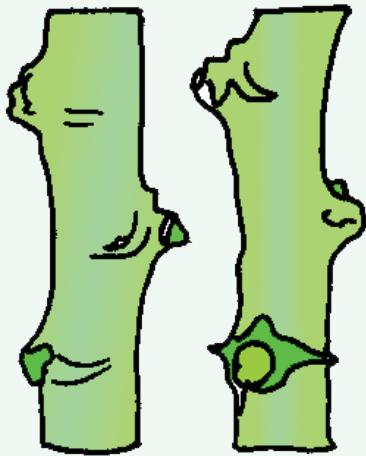
**Avoid bruising the harvested stems**

### **Step 8: Plant on the main farm.**

## Rapid multiplication from 3-node cassava cuttings for direct field planting:

**Step 1:** Treat the stakes with insecticides or fungicides as for the 2-node cuttings treatment.

**Step 2:** Plant the treated stakes directly on the multiplication field using the appropriate spacing as described in the 2-node cuttings method (Step 6).



**Figure 5. 3-node pieces**

## Highlights

Achieving increased yields of 20–45 t/ha from improved varieties starts with this critical stage of stem handling. To ensure increased cassava yields, start right by following the recommended steps.

# Zero input technologies to increase yield in cassava production

## Zero input

You can grow cassava using zero input technology. This does not need chemicals, such as fertilizers and herbicides, or organic compost. The zero input method encourages biological activity in the soil and provides natural protection from diseases. It can guarantee good yields, provided that you select a land with adequate organic matter, use the right varieties, plant at the right spacing and time, and ensure a weed-free farm. In this section we look at this environmentally-friendly farming practice.

## How to use zero input technologies to get good yields

- Choose a good soil with medium fertility and good drainage.
- Avoid stony, clayey or water-logged soils.
- Use a farm that has been well maintained.
- Practice minimum tillage in sandy soils to conserve organic matter, and moisture, and to reduce soil erosion.
- In shallow or hard soils, make ridges or mounds to increase the topsoil volume per plant for a better establishment (Figure 6a & 6b).
- Choose improved varieties with the highest and most stable yield performance in the particular farm locations.
- Select planting materials from healthy cassava plants (9-15 months old) without stem or leaf damage from pests or diseases.
- Handle the stems carefully to avoid bruising or damaging the nodes and to improve sprouting.

*Do not use force when tying the stems in bundles and when loading vehicles (Figure 7).*

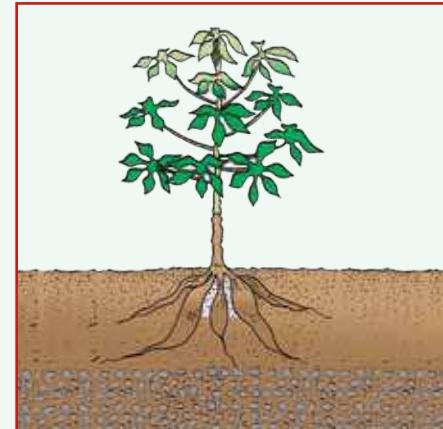


Figure 6a. In deep soils cassava is planted on flat land

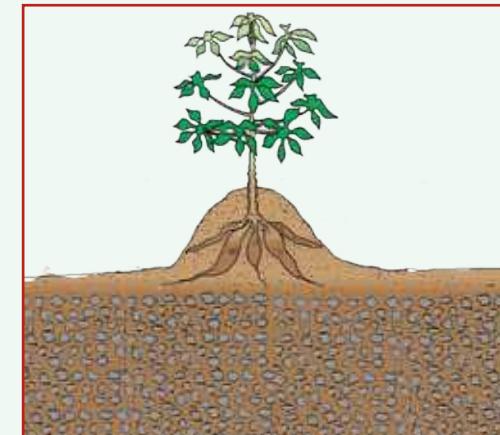
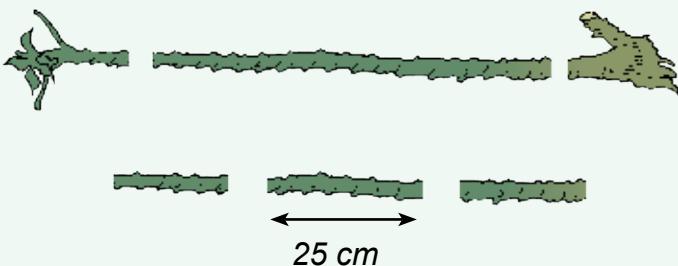


Figure 6b. In shallow soils cassava is planted on mounds to increase the topsoil volume per plant



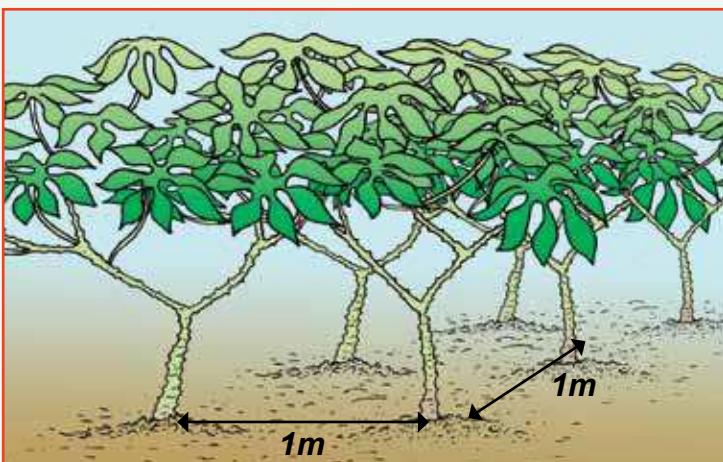
Figure 7. Using force when tying the stems in bundles may cause breakage

- Cut the middles of the stems into 25 cm lengths with 5–7 nodes. Middle portions establish better than the tips and basal parts (Figure 8).

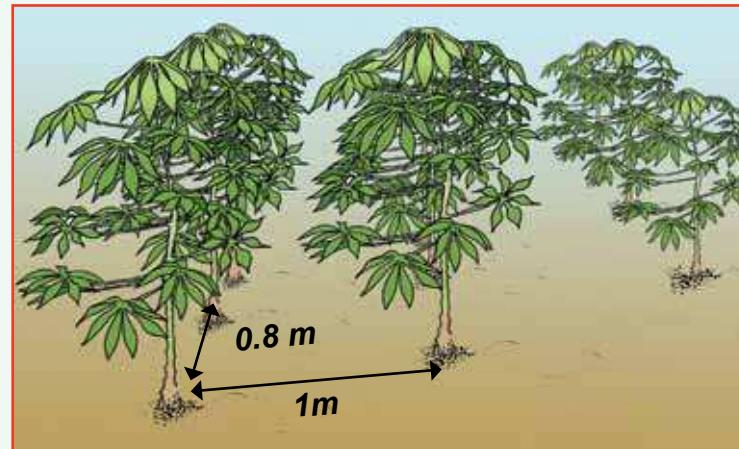


**Figure 8. Better cuttings are from the middle portion of the stem**

- Plant at the right time to ensure healthy sprouting and good crop establishment. Dry season planting is not recommended when the rains stop early or where the water table is low. There may not be enough moisture to allow sprouting and the stems to survive. In general, cassava should be planted when 2 months of adequate soil moisture is expected after planting.
- Plant at the correct spacing. The recommended planting space is  $1m \times 1m$  for branching types and  $1m \times 0.8m$  for non-branching types (Figure 9a & b).



**Figure 9a. Branching type**



**Figure 9b. Non-branching type**

- Weed the farm early. Early weeding is easier, and prevents weeds from competing with the crop for nutrients, water, light, and space at that important period. If planting early in the rainy season, weed at 4, 8 and 12 weeks after planting. If the rainy season ends before this schedule can be completed, continue weeding during the following rainy season at 6–10 weeks after the rains begin.

### Qualities of improved cassava varieties

- Grow fast and mature early
- Tolerate major diseases and pests.
- Give high root yields (fresh and dry).
- Meet end-users' quality needs.
- Store well in the ground for 12–15 months.

### Intercropping cassava under zero input

- Cassava/maize and cassava/legume intercrops have been found to make better use of the land, reduce soil erosion and the risk of crop loss.
- Cassava can also be intercropped with yam, sweet potato, okra, and leafy vegetables.

- For sole crop cassava, plant on the top of the ridge or heap. When intercropped with maize, plant cassava on the top and maize on the side of the ridge or mound.
- Where cassava is grown as an intercrop, adjust the spacing from  $0.8m \times 1m$  to  $1m \times 1m$  to suit the branching habits of cassava and the other crop(s).

## How to increase yield without purchasing soil nutrient-enhancing inputs

- Plant leguminous crops such as soybean in rotations or intercrops, or *Mucuna* in fallows. This helps to sustain soil fertility and quality, and to manage water, noxious weeds (spear grass), pests and diseases.
- Mulch cassava seedbeds: This means covering the soil surface with plant materials. It is especially valuable when growing cassava in dry areas and on slopes. It has these advantages:
  - Increases the ability of the soil to hold water
  - Improves the fertility of the soil. for plant growth.
  - Reduces erosion and weed problems.
- Sources of good mulching material include dead leaves from alley crops, rice husks, coffee hulls, crop/weed residues and leguminous plants (live mulch).
- Cover crops such as *Mucuna*, *Centrosema*, and *Aeschynomene*, when used as live mulch are usually incorporated into the soil before the crop is planted.

## Highlights

- A good yield of cassava can be achieved without chemicals since these are often unavailable or too expensive, and demand too

much technical knowledge from the small-scale farmer. But you must use the crop husbandry practices mentioned in this manual. This environmentally-friendly farming strategy is more suitable for cassava than crops such as maize, rice, and sorghum that have a high demand for fertilizer.

- High yielding and healthy planting materials can be received or purchased from your country's cassava Research Institutes, Cassava Program or Root and Tuber Programs.
- Good planting materials can be purchased from trained and individual farmers, farmers' associations or seed companies which multiply cassava for sale in your area.

# 4

## Weed control practices in cassava production

Controlling weeds in sub-Saharan Africa takes up to 60% of the labor in crop production and more than 40% of the total cost of growing cassava. In this section we look at efficient and cost-effective weed control practices in cassava production.

### Common weeds found on cassava farms

There are two broad categories: annual and perennial weeds. Weeds can further be grouped into broad leaved weeds, grasses, and sedges

**Broad leaved weeds** – *Chromolaena odorata*, *Commelina benghalensis*, *Euphorbia heterophylla*, *Aspilia africana* and *Mimosa* spp.

**Grasses** – *Imperata cylindrica*, *Cynodon dactylon*, *Panicum maximum*, and *Pennisetum polystachion*

**Sedges** – *Cyperus rotundus*, *Cyperus sculentus*, *Mariscus alternifolius*, and *Mariscus labelliformis*

### When and how to control weed

Weeds are controlled so that cassava grows and develops well. Control weeds in the first 3-4 months after planting (MAP).

**Biological method:** Biological weed control techniques suppress weed growth.

- Fallowing
- Plant density and canopy management

**Cultural method:** Good crop husbandry minimizes weed interference:

- Hand/hoe weeding (Fig 10)

- Tillage
- Mulching
- Burning
- Cropping system such as cover crops (Figure 11)



Figure 10. Hand/hoe weeding

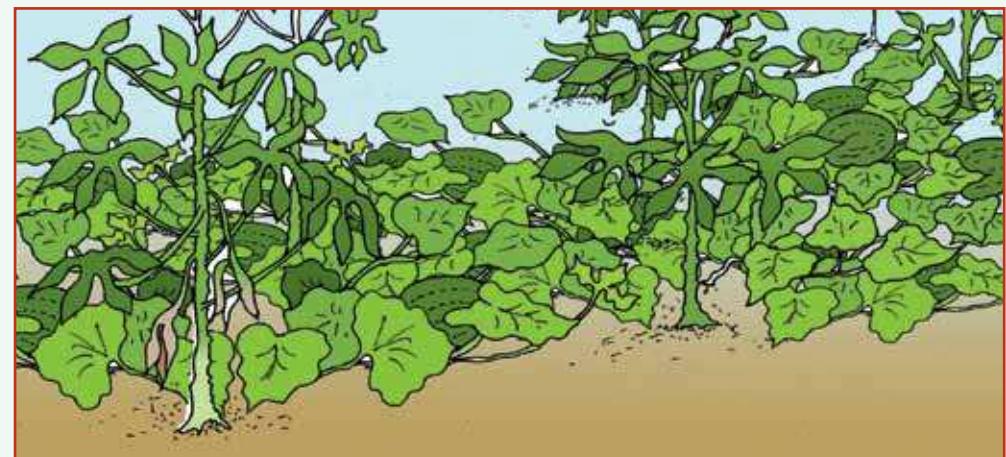


Figure 11. Cover crop

- Preventing the spread of weed seeds

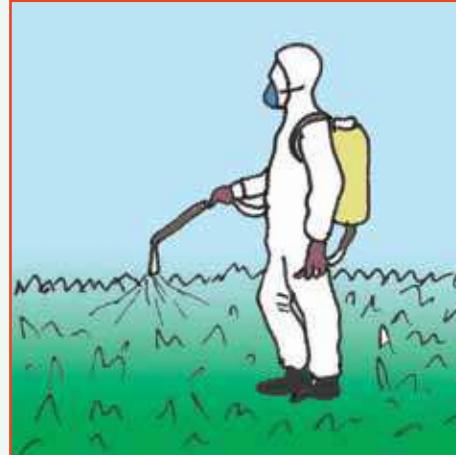
**Chemical method:** Herbicides kill or damage weeds .  
Herbicides can be applied before land preparation (pre-tillage), immediately after land preparation (pre-planting), and 4–8 months after planting (post-emergence).

## Chemical control

- To control hard-to-kill perennial weeds that hand-pulling cannot remove.
- To avoid damaging cassava roots.
- To control annual weeds that grow quickly and produce many seeds.
- To increase yield, reduce labor and weed interference
- To cost-effectively and quickly cultivate large farms.

## When and how to apply chemicals

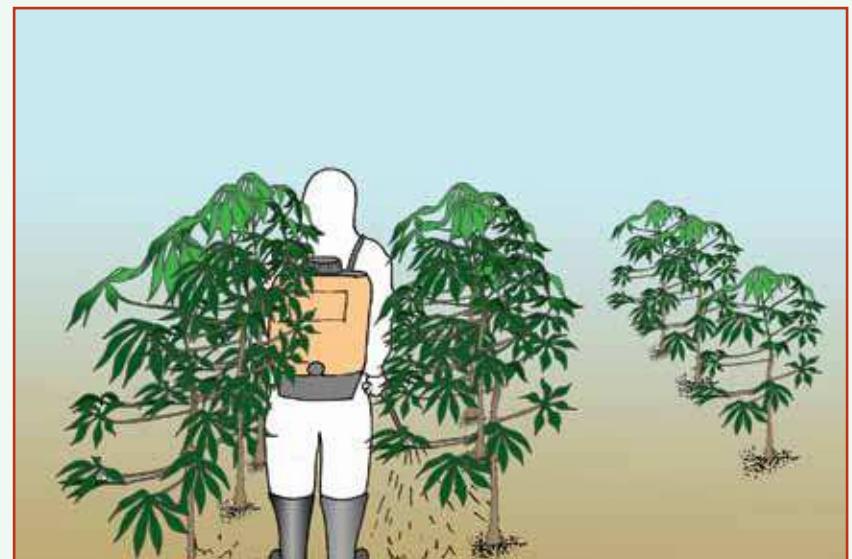
- **Pre-planting:** Use herbicides containing glyphosate at (3–4 L/ha), 10 days before land preparation (Figure 12).
- **Pre-emergence:** Depending on availability, use (Atropine + Metolachlor) at 4 L/ha, or Atrazine + Pendimethalin at 4-6 L/ha, or Fluometuron + Metolachlor at 5 L/ ha, or Fluometuron+ Pendimethalin at 4 L/ha (Figure 13).
- **Post-emergence:** Use Fusilade Forte 150EC recommended at 5–6 L/ha at 12 weeks after planting, for grasses. Apply Diuron + Paraquat at 7 L/ha (directed spray) 4–8 weeks after planting (early post emergence) for broad leaved weeds. Avoid direct or drift damage to the crop (Figure 14).



**Figure 12. Pre-planting application**



**Figure 13. Pre-emergence application**



**Figure 14. Post-emergence application**

## Tips for successful chemical weed control

- Choose the right herbicide for the job.
- Check and calibrate the sprayer.
- Know the spray volume needed. Standard spray volume is 200 L/ha, speed and walking is 1 m/sec or 3.6 km/h.
- Wear the right protective clothing.
- Follow the maker's instruction for every herbicide. READ THE LABEL AND HEED THE LABEL (Five times: 1 before purchase, 2 before mixing, 3 before application, 4 at storage and 5 before disposing of the excess herbicide) (Fig 15).
- Dilute the herbicide correctly. Too much is dangerous: too little does not work.
- Watch the weather. Do not spray on windy days or in very dry weather or when heavy rain is likely.
- Buy the amount needed for one spraying or for one growing season.
- Store herbicides correctly.
- Maintain the sprayer in good condition.

## Weed control groups

Agricultural extension departments of Ministry of Agriculture or Local Government Administration are encouraged to organize trainable youth to become weed control groups in various localities. These groups and herbicide companies should be linked. The companies can provide training to the youth to help farmers choose and apply herbicides correctly.

## Highlights

A combination of cost-effective cultural, biological, and chemical methods is needed for good, affordable weed management in cassava production. Chemical and biological control methods require technical knowledge.



**Figure 15. Read the label and heed the label five times:**



**a) Before purchase**



**b) Before mixing**



**c) Before application**



**d) At storage**



**e) Before disposing of the excess herbicide**

5

## **Cost-effective mechanization in cassava production**

## Introduction

Cassava production in Africa is mostly in the hands of small-holder farmers who depend on costly manual labor. Full benefits of using improved inputs, such as improved varieties, fertilizers, and herbicides in boosting cassava production, cannot be achieved without mechanization. This section, provides a guide on cost-efficient mechanization in cassava production and focuses on small-scale mechanization for farms between 1–20 ha.

## **Cost-efficient mechanization practices and farm operations**

- Cost-efficient mechanization means that all costs are covered and the farmer enjoys a good profit.
  - Land clearing, tillage, planting, fertilizer application, weed control, and harvesting can be mechanized.
  - The level of mechanization can be small, medium, or large, depending on the land area.
  - Careful planning is required because buying or hiring machinery is an expensive undertaking for a small holder.
  - The right machines and a suitable schedule for field operations are needed.
  - Terrain, soil type, and rainfall are all important when the farmer is choosing machines.

## Available machines for commercial small- to medium-scale cassava production

## 1. Land clearing

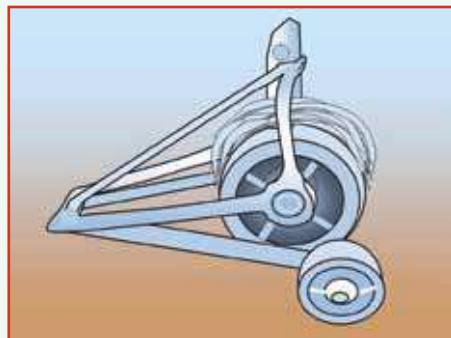
- Land clearing can be mechanized using light bulldozers, monkey winches, monkey jacks and chain saws.

- Figure 16 :**  
**D6 light bulldozer**

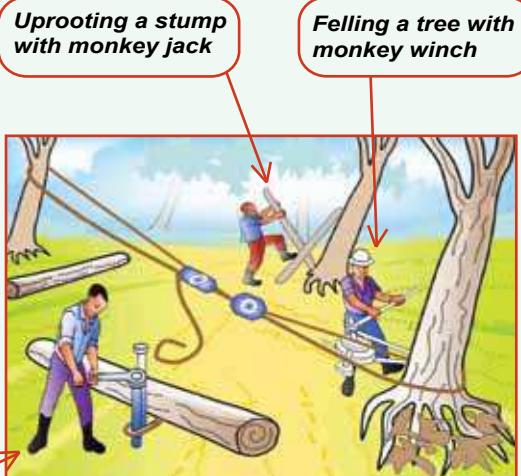

  - Light bulldozers such as **D6** or **D65**, can clear 2 or more ha in 1 day in fallow areas, depending on the vegetation. The bulldozers push down the trees and shrubs and the blade is not allowed to touch the topsoil.
  - Bulldozers are used only on dry soils, particularly during the dry season, to avoid compaction.
  - Whenever bulldozers are not necessary or not available, the monkey winch is the next most efficient machine for land clearing.
  - It can clear 1 ha in half the time that would be taken to do the work by hand.
  - Monkey winch is useful in felling trees, pulling out roots of the trees without damaging the soil and it is easy to take to the field because of its light weight.
  - The chain saw is portable and very useful for felling trees and cutting down shrubs but it cannot be used to uproot stumps.
  - For higher efficiency, it is usually combined with the monkey winch, or the stumps are removed by hand.
  - The brush-cutter is designed to clear grasses, small bushes, and shrubs.
  - With a medium powered brush-cutter, a farmer can clear 1 ha of land in less than 2 hours.

**Figure 16 :**  
**D6 light bulldozer**





**Figure 17. Monkey winch**



**Figure 18. Using monkey winch and monkey jack**



**Figure 19. Chain saw**



**Figure 20. Cutting tree by chain saw**



**Figure 21 a and b. Clearing grasses and bushes using a brush cutter**

## 2. Tillage

- Tillage loosens and aerates the soil, and mixes organic matter and nutrients fairly evenly; roots can penetrate more deeply and plants are established better.
- In fallow land, it takes 40 to 50 people one day to till one ha by hand and make mounds. In the savannas, it takes 25% less labor to do the same work.
- Soil tillage can be mechanized using tractor-mounted plows or power tillers (Figure 22).
- The most common plows in Tanzania, for example, are the disc type. They are designed to break, turn, mix, and raise soil.
- A trained operator can plow 4 ha in a day. A disc plow is cost saving and faster than tillage by hand.
- The use of a power tiller is the next most efficient machine for soil tillage whenever tractor-mounted plows are not necessary or not available (Fig 23).
- It can till 1.0–1.8 ha in 8 hours, depending on how wet and heavy the soil is.
- Many small farmers could contribute funds to buy 1 power tiller that can service at least 250 ha of land in a year.



**Figure 22. Tractor-mounted plough**



**Figure 23. Power tiller**

### 3. Planting

- Depending on the type of planter, cassava stems are usually cut into 20–25 cm long stakes or cuttings stakes or cuttings which are planted horizontally, inclined, or vertically on
- Generally farmers plant by hand and it takes 8–10 persons to plant 1 ha in 1 day (Figure 24).
- Cassava planting can be mechanized using tractor-powered planters (Figure 25). Mechanical planters are suitable for large-scale planting. For small- or medium-scale farmers, hiring a mechanical planter and paying a fee for planting could be more cost-effective.
- A 2-row planter can plant 7–10 ha in 1 day, depending on the terrain.
- It is faster and 50% less expensive than planting by hand.
- The planter requires a tractor 60–70 hp, especially in soils likely to become compacted. Four people are often required to operate a 2-row planter: a tractor driver, two people to feed the stakes into the planter and one person on the ground.
- The cuttings need to be the same length, size, and shape with cleanly cut ends. Stem cuttings could be prepared by hand using simple tools such as hacksaws or a small motorized chain saw. A cassava stem cutting machine has also been developed.
- Some mechanical planters can simultaneously cut cassava stems to stakes of constant length, plant at equidistance, apply fertilizer, and cover the planted stakes. Generally this type of mechanical planter can plant 3–6ha in 1 day.

#### How to plant cassava by machine

- The cuttings need to be the same length, size, and shape with cleanly cut ends.

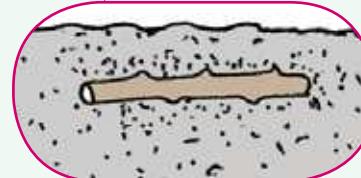
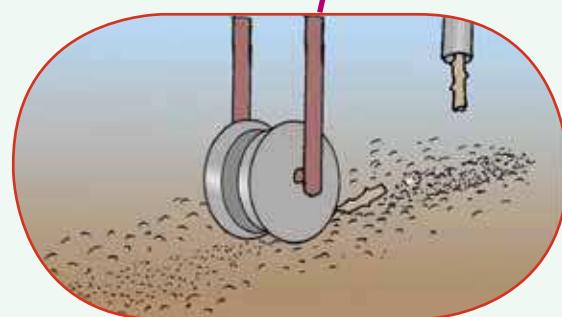
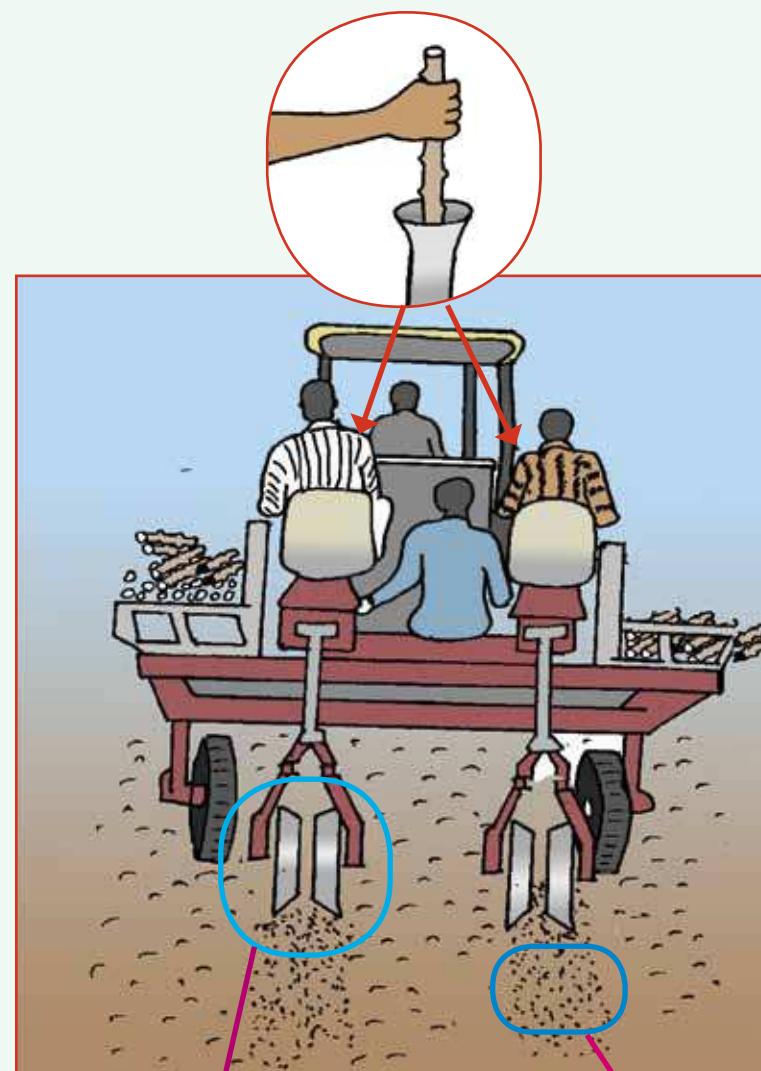


**Figure 24. Farmers planting cassava by hand**

- Stem cuttings could be prepared by hand using simple tools such as hacksaws or a small motorized chain saw. A cassava stem cutting machine has also been developed.

### 5. Weeding

- Weeds reduce crop yield. Weeding is the most expensive item in cassava production.
- Weeds can be controlled with use of herbicides and a boom sprayer mounted on a tractor.
- Boom sprayers have a tank which can carry 400–610 liters of



**Figure 25.**  
*Mechanical cassava  
planting*

- the chemical. They reduce the cost of labor, and save time and energy.
  - The knapsack sprayer is also used and is hand-operated. It takes a lot of time and is not cost-effective but it works well for small-scale farmers.

## Highlights

A suitable mechanized production system developed with care can reduce the labor requirement and operational costs. Farmers are advised to carefully select the machines required for the operations, depending on their scale of production, to avoid choosing a production method too expensive for the work. Many of the States/Local Government Areas and the private sector in many countries have institutions responsible for mechanical machine hiring services. African governments are encouraged to make agriculture machine hiring services to be functional, organized, and accessible. Farmers are therefore encouraged to take advantage of these services.

### When to harvest

Cassava roots should be harvested at peak of maturity or at the right age, size and tenderness required for fresh market (use of roots as a snack or home cooking). Fully matured cassava roots should be harvested for processing.

Cassava roots may lose the valuable starch, rot or become woody if not harvested at maturity. They are exposed to rodents and the land cannot be put into productive use in the next season if the roots are not harvested. This contributes to the general agriculture outputs in smallholder systems and can cause shortage of land and increase production costs, especially in places where land is scarce.

This section provides a guide on proper harvesting and postharvest handling of cassava.

- Harvest cassava roots when they are mature to have accumulated enough starch but have not yet become fibrous.
- The optimum age when the starch and dry matter yields are highest is 9 – 12 months after planting, depending on the variety and the climate. Some varieties mature in 15 – 18 months. Extended cold season may delay the maturity of cassava.
- Harvesting too early results in a low yield while delayed harvesting could reduce yield.
- Harvest cassava when the soil is slightly soft but has no excessive water so that you can easily remove soil from the roots. Harvesting in soft soil is easier than when the soil is harder. Roots harvested in soggy conditions get soil stuck between them and this can lead
- to inaccurate weight records. Also, the roots may be very dirty and highly contaminated when peeled, thereby requiring large volume of water and extended time to wash the peeled roots thoroughly.

### How to harvest cassava

- Cassava roots are harvested by pulling the stem which carries the roots out of the ground. Harvesting could be done manually or by mechanical methods.
- ***Manual method:***
  - Cut the plant at about 30–50 cm above the ground; use the stem to lift the roots.
  - Pull the plant gently and do not drag the roots. Dragging can cause bruises and cuts which may lead to early deterioration (Figure 26).



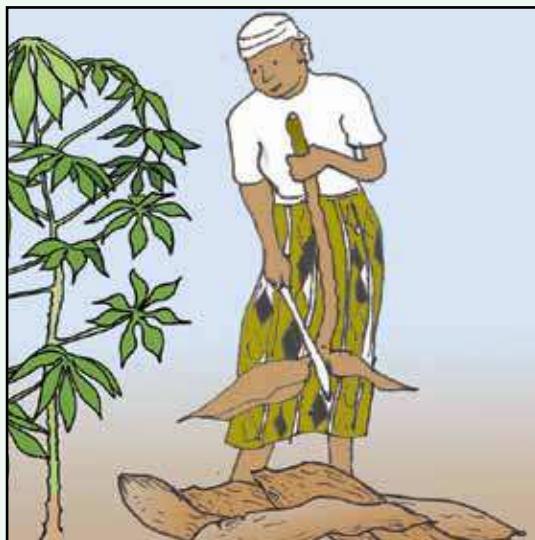
Figure 26. Harvesting

- If the soil is compact, loosen it first but take care not to damage the roots (Figure 27).



**Figure 27. Loosen hard soils**

- Separate the roots from the stem using a sharp knife or cutlass. Cut each root near to the stem. Do not break the roots from the stump by hand. This will cause injuries which lead to root rot (Figure 28).



**Figure 28. Cut each root near to the stem**

- After harvesting, do not leave the roots under the sun. Too much heat causes weight loss and early deterioration.
- Manual method of harvesting usually requires 40-60 persons, depending on the season, to harvest 1 ha of cassava in 1 day.

#### **Mechanical methods:**

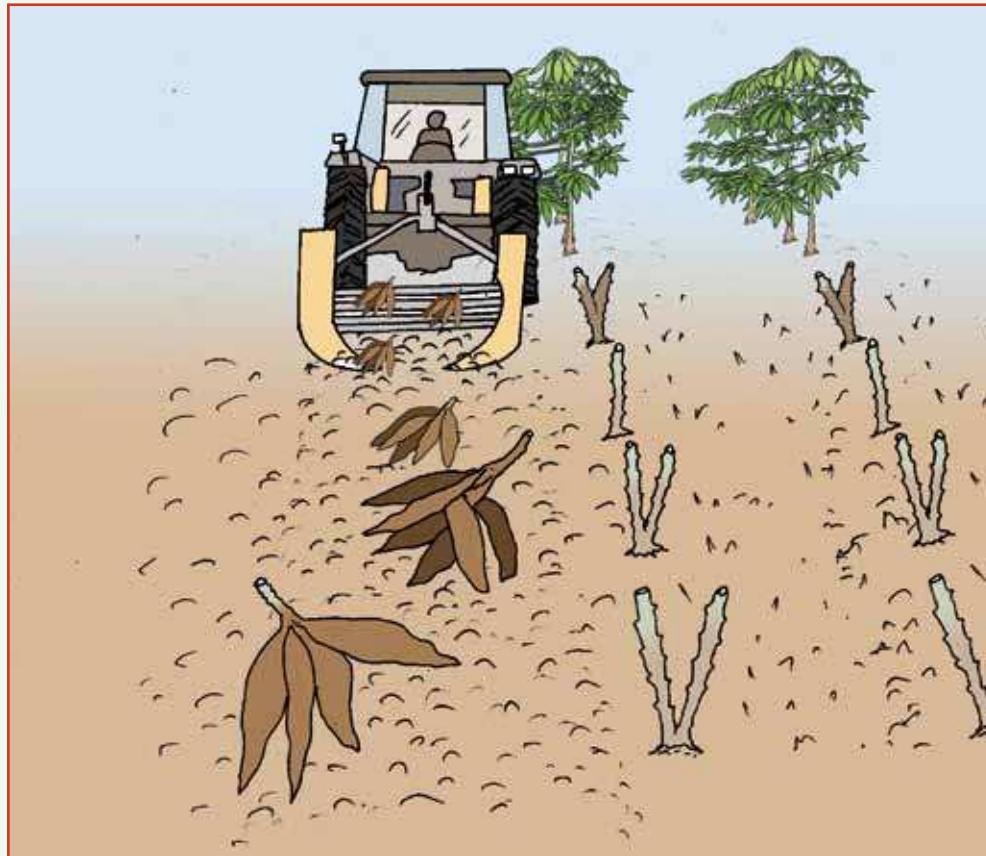
- **Cassava lifter**
- This equipment is manually operated and reduces the drudgery in lifting tubers (Figure 29).
- The jaws will grip the base of the stem tightly.
- The lever is then used to lift the roots.
- The lifter can harvest up to 200 plants/hour.



**Figure 29. Cassava lifter**

### *Motorized cassava harvester*

- The mechanical harvester cuts, digs, and raises up soil containing the cassava root cluster.
- The equipment is usually pulled by a tractor and used by large-scale farmers (Figure 30).
- A 2-row mechanical harvester can harvest 3-5 ha cassava farm in 1 day, depending on the terrain. It is faster and 50% cheaper than harvesting by hand. Mechanical harvesters can be imported or bought locally.



*Figure 30. Motorized cassava harvester*

### **Highlights**

- Harvesting requires proper planning in terms of timing and method to be used. Manual harvesting is labor intensive and expensive.
- To reduce cost in a commercial operation, farmers are advised to harvest the roots using mechanical methods. To avoid loss of quality and quantity of roots (postharvest losses), the amount of roots to be harvested should be gauged depending on immediate market demand or quantity needed for immediate processing.

Cassava tubers attached to the main stem can remain safely in the ground for several months. However, after harvest the roots start deteriorating within 2 – 3 days, and rapidly become of little value for consumption or industrial use.

This section, provides a guide on post-harvest handling and storage of cassava.

## Transporting cassava roots

To avoid root deterioration and loss of quality, transport to the homestead, market or processing plant immediately after harvesting.

## How to transport cassava roots

- Use wheel barrows or any other suitable container to transport roots in small quantities and short distances, such as from the farm to road side or bulking center where they will be loaded on a vehicle for long distance transportation.
- Gently off load the roots from the wheelbarrow or container without causing bruises or damage to the roots
- Vehicles transporting cassava a long distance should be covered with tarpaulin to avoid rapid moisture loss from the roots (Figure 31).
- Use oxen-cart for transportation especially in the rural areas where there are no paved roads or the roads are not passable to vehicles (Figure 32)
- Carefully sort and arrange roots neatly in the vehicle or cart to save space
- Do not seat or put heavy objects such as vehicle tyres on roots after loading.

## Storing cassava roots

Cassava roots start deteriorating soon after harvesting. Internal discoloration and loss of marketing value occur if they are not cooked or processed within 24 – 48 hour of harvesting. Secondary fungi and bacteria infection may cause rot in untreated roots.



*Figure 31. Transportation of cassava roots*



*Figure 32. Oxen-cart loaded with cassava roots*

## How to store cassava roots

### Traditional storage methods

- Cassava roots are left underground after maturity and harvested in piecemeal when needed. This practice is common when cassava is used for food security. However, it is not recommended for commercial practice.
- Cassava roots are heaped under shade and watered everyday.
- Undamaged roots are stored in pits or trenches(usually 1 meter long and 30-40cm wide) dug in well drained soils, sloppy and shaded area. The trenches, with the long side directed downhill are lined with straw and dried leaves before roots are arranged in them after which the roots are covered with soil, preferably river-sand or sea-sand. Water-logged areas and heavy clay for covering should be avoided.
- Cassava roots are coated with clay or mud.
- Freshly harvested or peeled roots are stored for 1 – 2 days by completely submerging in water. The roots are simultaneously detoxified but may ferment or spoil after 3 days,
- Storage by heaping or soaking, in pits, or by coating extends the shelf life of the roots by only 2–3 days.This is not suitable for commercial operations.

### How to reduce postharvest losses

- Harvest when the soil is wet or loose.
- When harvesting, cut the roots from the stem leaving 2-5cm of the stuck on the roots.
- Avoid bruises or damage to the roots during harvesting and transportation.
- Select uninjured roots if storage of more than 1 week is desired.
- Treat unpeeled roots with fungicides before storage.

### Improved storage methods

- Select a well-drained area, preferably shaded, and slightly sloping.

- ○ Dig trenches measuring 1 meter (m) wide and 30–40 cm deep. The length varies according to the volume of roots. A trench 1 m long can contain 70–80 kg of roots.
- ○ Dig the trenches in such a way that the length is directed downhill.
- ○ At the lower end of the trench, make a drainage ditch, at least 20 cm wide and 5 to 10 cm deeper than the storage trench.
- ○ Arrange mature, undamaged roots inside the trench. Cover each layer with soil, preferably river- sand or sea- sand. Clay-loam soil can also be used if it is not too wet.
- ○ Do not use heavy clay. Soil of this type could speed up root deterioration.
- ○ Do not keep cassava in a waterlogged area because roots will rot easily.

### Storage in sawdust

- ○ Select healthy roots that were not damaged or bruised and were harvested no longer than 24 hours.
- ○ Put a layer of damp sawdust in wooden crates or baskets lined with plastic foils that prevent the sawdust from drying up.
- ○ Arrange the roots in alternate layers of damp sawdust in the wooden crate and store (Figure 33).
- ○ To avoid microbial spoilage, the sawdust must be damp, not too wet.

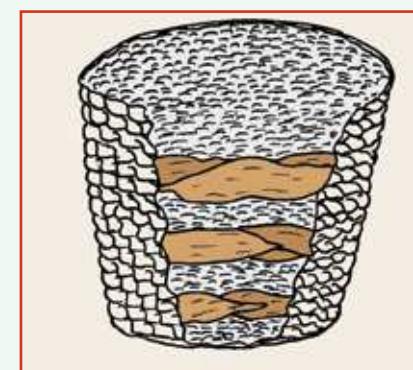
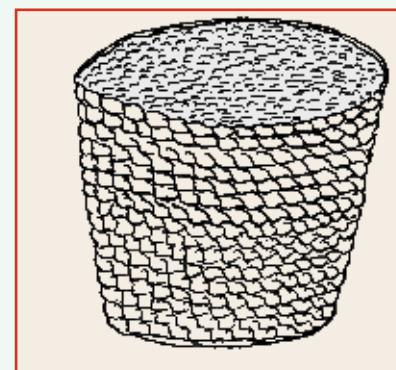
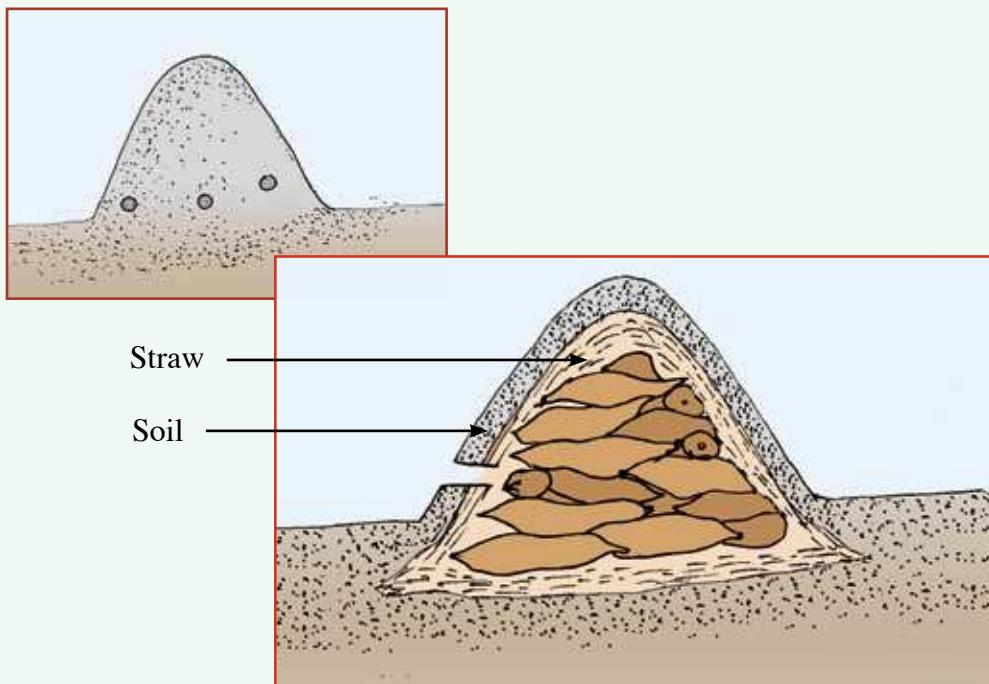


Figure 33. Storage in sawdust

### **Storage in clamps**

- The method is practical where fresh (sweet) roots are marketed over many days for fresh uses or transported over long distances. The storage period is about 1 month.
- Choose a dry spot in the farm or processing area and dig a shallow trench.
- Place a layer of straw, add a layer of selected undamaged roots to form a cone or mound shape (Figure 34).



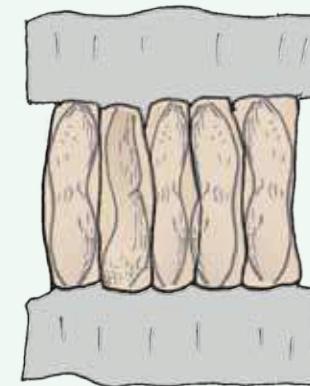
**Figure 34. Field clamp with cassava**

- Add 20cms of straw, then cover the clamp with soil, leaving openings at the bottom for ventilation, to maintain temperature below 40°C for curing wounds and for the storage.
- Ensure proper ventilation and that the floor remains dry.

- This method works best for farmers, marketers or processors to hold large stocks of non-bruised or undamaged roots for up to 4 weeks without quality loss.

### **Storage in polythene bags**

- Treat non-bruised or undamaged roots with fungicide such as thiabendazole solution (0.4% w/w) to avoid microbial spoilage. Alternatively, household bleach (0.95% active chlorine) could be used.
- Vacuum pack in polythene bags, which makes it air tight and creates the atmosphere (reduced oxygen and appropriate humidity) for the storage. (Figure 35).



**Figure 35. Fungicide treated roots stored in polythene bags**

- Keep the package at ambient temperatures
- The storage period is 2 – 4 weeks.

### **Storage in refrigerators**

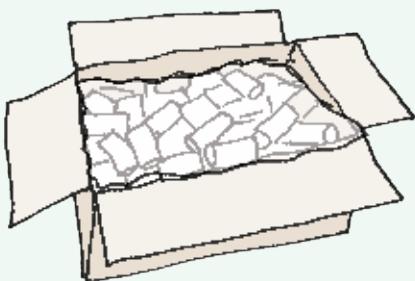
- Select healthy (non-bruised or undamaged) roots.
- Wash with cool chlorinated water
- Pack or vacuum pack in nylon bags
- Store in the refrigerator at below 4°C.

The cassava roots can be stored for about a month but they may lose same moisture. However, their texture and taste may not be significantly affected.

### Freezing

- Select healthy roots
- Wash and freeze the roots. Peeling and/or cutting into small sizes are optional. Store the roots whole or cut up in frozen condition (Figure 36).

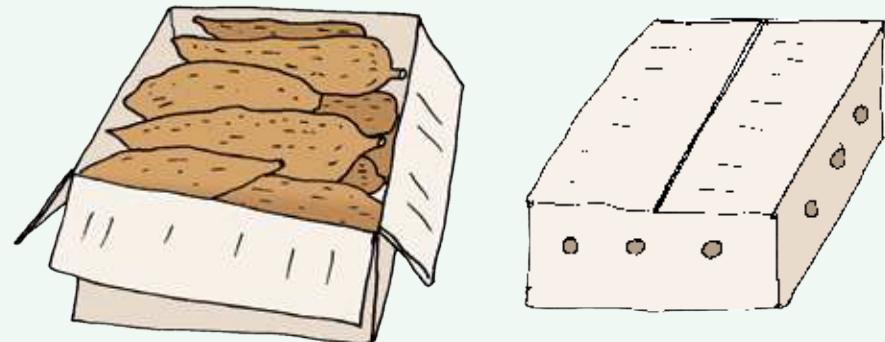
Freezing is suitable for long term storage and long distance marketing but the textural quality of the frozen roots may be affected. To reduce texture damage, apply blast freezing to quickly freeze the roots.



**Figure 36. Frozen cassava**

### Waxing

- Wash non-bruised or undamaged roots in chlorinated cooled water.
- Dip in melted paraffin wax at a temperature of 51.5°C–52.5°C.
- Edible coating/film formulated with cassava starch, glycerol, carnauba wax and stearic acid have been tested for waxing of cassava roots and were found suitable.
- Pack in well ventilated cartons (Figure 37)



**Figure 37. Waxed cassava in ventilated cartons**

- Waxing is done for commercial export of roots. Waxing slows down respiration rate and transpiration, and prevents physiological deterioration.

### Highlights

- The improved storage methods for roots help to extend shelf life of stocks of fresh roots by 2 – 6 weeks. The methods are suitable for storing small amounts of roots by consumers, restaurant operators and itinerant food vendors. Low temperature storage can be combined with fungicide treatment or waxing and is suitable for export of large amount of roots. In this case, the processors or exporters can afford the needed specialized equipment and have the necessary technical skills while the consumers can afford the higher cost.

This section provides a guide on processing of cassava into highly valuable products at both large and small scale.

## Why cassava is processed

Cassava is processed for many reasons. These include:

- To increase shelf life of roots and prevent spoilage or food loss
- To reduce bulkiness, ease transportation and reduce the cost
- To remove the toxic compounds in cassava
- To create varieties of foods with acceptable taste, aroma and texture
- To produce industrial raw materials.

## Operations in cassava processing

There are many operations used for processing cassava. These operations include peeling, washing, size reduction, drying, fermenting, cooking by steaming, roasting, frying, etc. These processing operations are combined in different sequence to make different products such as granules, dried chips/flour, pastes, fermented starch, etc.

### *Peeling*

Cassava is peeled to improve the quality and safety of cassava foods. Nearly all cassava products are made by first peeling the roots.

- Peeling is labor intensive, slow and is done manually mostly by women. A woman may peel 20 -25 kg roots in one hour and peeling loss could be between 22% and 30%.
- Mechanical peelers are now available in countries such as Brazil, DRC and Nigeria (Figure 38a & 38b). Peelers that peel and wash cassava are also available (Figure 39).
- Mechanical peelers in Nigeria, although they are still being improved, can peel between 600kg and 800k roots per hour, removing 60-90% of the peels.

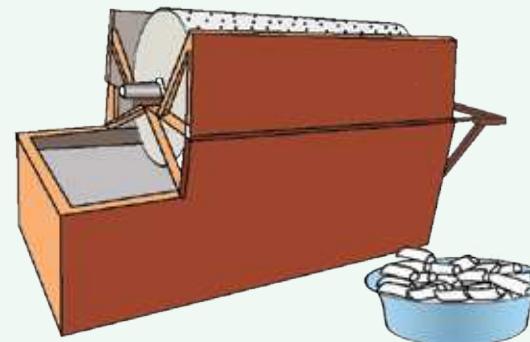


Figure 38a. Mechanical peeler

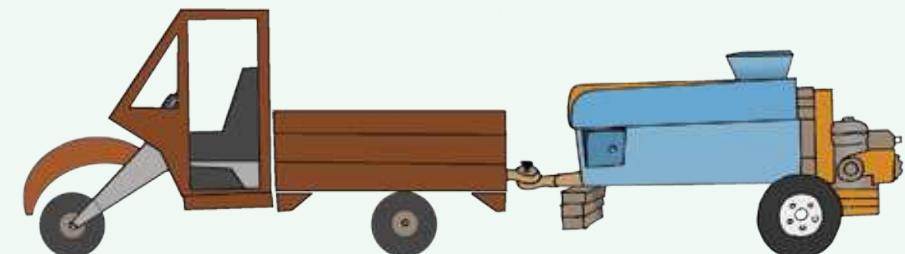


Figure 38b. Mechanical peeler



Figure 39. Mechanical peeler and washer

Efforts are ongoing to reduce the high (up to 30%) peeling loss for some of the designs.

Some mechanical peelers (and graters) in Nigeria are mobile. The machines are transported with power tillers or tricycles to the farm or remote villages to carry out the two or three processing operations - peeling, grating and pressing at farm gate. This approach can eliminate transportation of bulky fresh roots to long distances before processing and can reduce the cost of the processing operation by nearly 50%. It can significantly increase access of farmers in remote villages to mechanical processing machines and increase the amount of processed products produced by such farmers.

#### *Size reduction*

- Size reduction facilitates detoxification and drying of cassava. Size reduction is mostly by chipping, slicing, and grating.
- Grating is widely used for making gari or rale, starch, flour, and some other products. Manual grating is labor-intensive and exposes the women processors to injuries.
- Grating is very efficient in hydrolyzing more than 95% of the toxic compounds within 3 hrs, after which the compounds can be almost entirely removed by dewatering.
- Chipping, although is a new technique compared to grating, is used for making dried chips that could be milled to flour if lowcyanide cassava variety is processed or for making animal feed from any cassava variety.
- Commercial mechanical chippers (Figure 40) and graters (Figure 41) could process 2-3 tons of fresh roots per hour, significantly reducing labor inputs and saving time for women

#### *Dewatering*

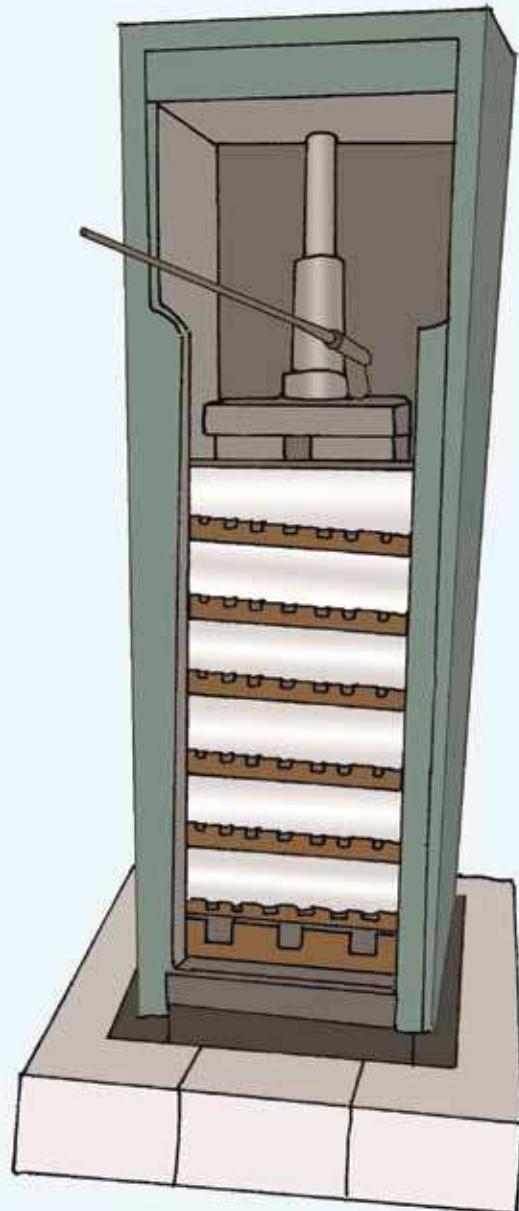
- Dewatering or removal of water facilitates of cassava, drying of fermented or fresh mash. Processed cassava is dewatered during making of gari, high quality flour starch, fufu, etc.



**Figure 40. Mechanical chipper**

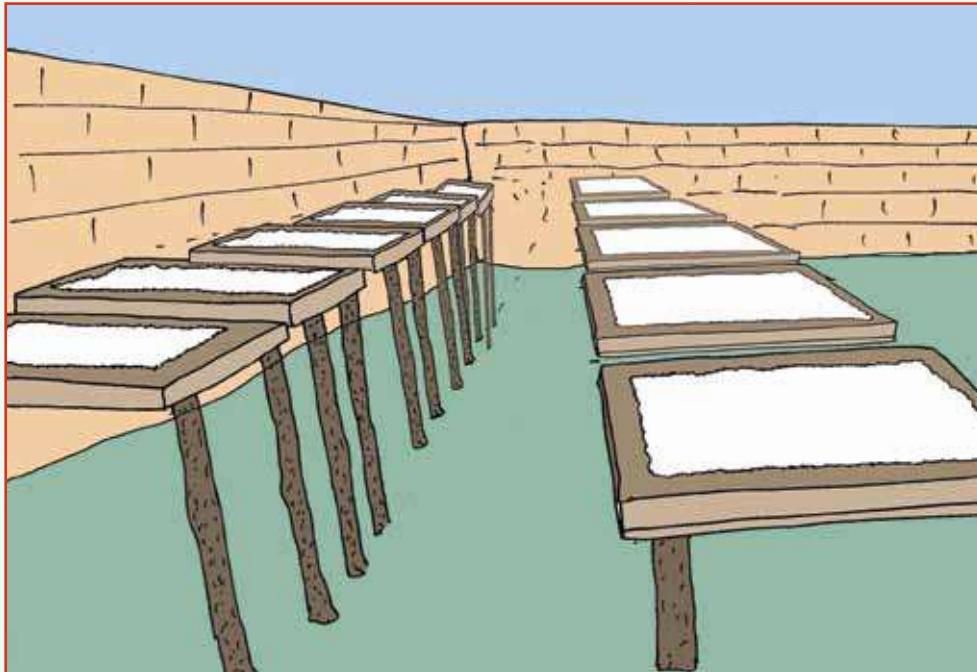


**Figure 41. Mechanical grater**



**Figure 42. Hydraulic dewatering machine**

- ○ Traditional methods of dewatering cassava with heavy stones and logs are dangerous, labor-intensive and slow.
- ○ Mechanized single-screw, double-screw, hydraulic, and double basket presses have replaced the traditional methods (Figure 42).
- ○ There are on-going research efforts at IITA and some Nigerian universities to develop machines that will grate and dewater cassava in a single operation.
- **Drying**
- ○ Cassava is traditionally dried to increase storability. Roots are dried to 12-14% moisture before storage. The most common traditional method of drying cassava is sun-drying (sun-heat and wind) on the ground in the farm, road-side, around the homestead, on roof tops, etc. Sometimes the roots are dried on-top of or cooking places in the homes.
- ○ These methods are prone to microbial contamination, infestation by insects and is slow, especially during the rainy season when drying could take 2-3 weeks. These promote poor quality and insect infestation.
- ○ The poor quality of the product (discolored, changed tastes, offensive smell, etc) lead to poor market acceptability and low prices.
- ○ An improvement to this is the drying of cassava on raised platforms on black polythene sheet (Figure 43).
- ○ For large scale processing, mechanical drying of cassava is the most suitable. It hastens the drying operation thereby saving time, preventing insect infestation, and preserving color, taste and smell.
- ○ Many types of mechanical cassava dryers are now available, these include cabinet, rotary, tunnel, solar, and flash dryers. Sources of heat energy for dryers are electricity, sun, wood, charcoal, gas, diesel, etc.

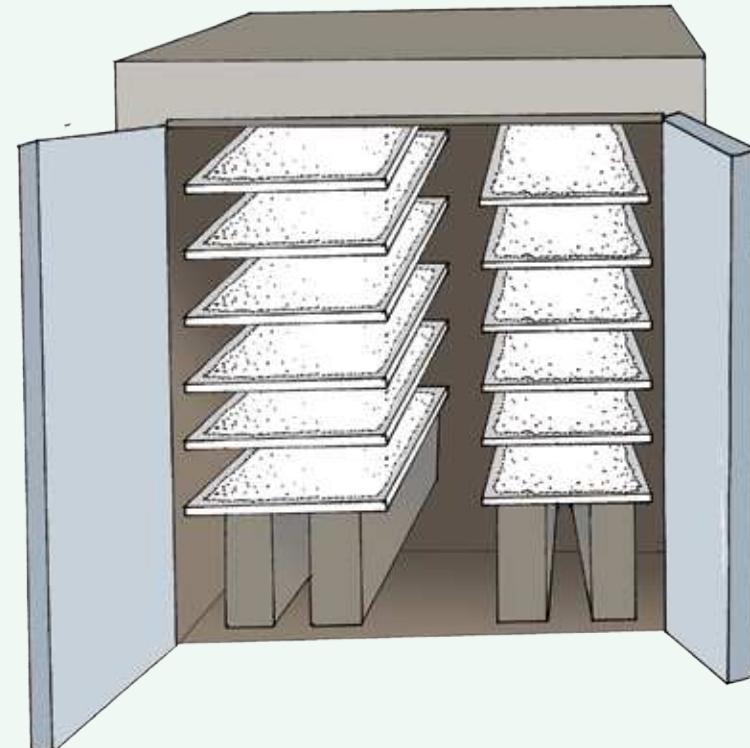


**Figure 43. Raised platform drying**

Some of the factors that increase the profitability of cassava drying operations are:

Use of dryers with the appropriate drying capacity  
high drying efficiency through low energy-use, low fuel-consumption, or low heat-loss.

- Cabinet (Figure 44) and rotary dryers using charcoal, wood or agricultural wastes are being tested in Nigeria, Ghana, Madagascar, Tanzania and Zambia.
- Flash dryers (Figure 45) are used for large-volume rapid drying of cassava starch, fermented pulp (fufu), grated and pressed cassava into flour, etc.
- The amount of roots that can be sourced should be considered when choosing a dryer. Drying capacity excessively higher than the available cassava roots will be wasteful and might make the drying operation too expensive, reducing profitability.



**Figure 44. Cabinet dryer**

### *Milling*

- Dried cassava is mostly made into flour before home or industrial use.
- The traditional method of milling dried cassava for home use is pounding. The method is labor-intensive and slow.
- Milling machines for grains and other crops are very common and are used for milling of cassava. The appropriate fineness of milled cassava depends on its final use (Figure 46).
- Cassava for animal feed should be milled gritty, flour for home use needs to be fine while the flour for bread baking and starch must be very fine.

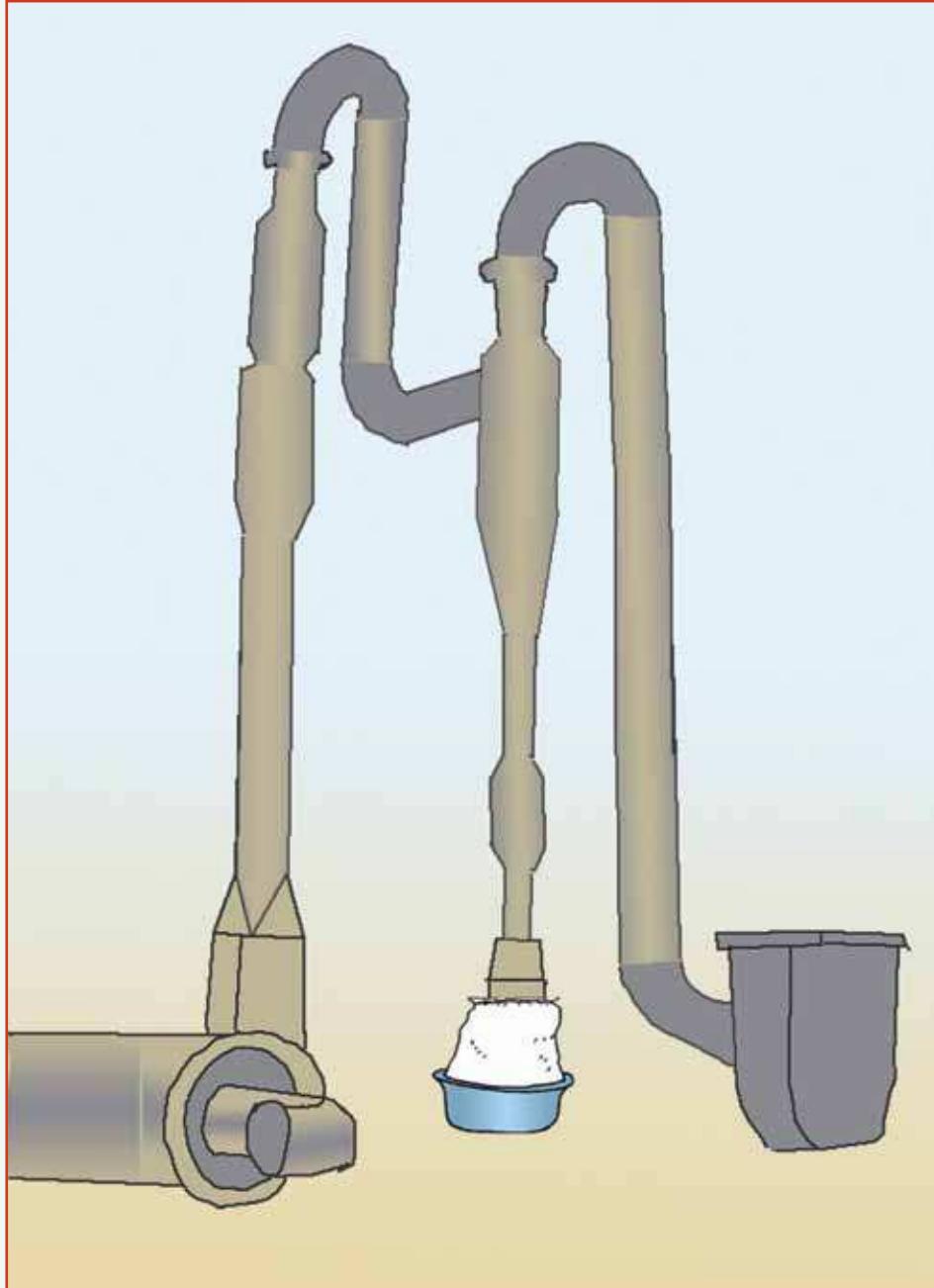


Figure 45. Flash dryer



Figure 46. Milling machine

**Gari frying:**

Gari is made by roasting or frying cassava granules until cooked and dried (Figure 47 & 48). The traditional frying method exposes women to heat, smoke and possible inhaling of free cyanide. Mechanical fryers reduce these risks and increase gari output.

**Packaging and storage:**

Cassava products, fermented or unfermented chips, flour, starch, etc. are hygroscopic. The moisture absorbed from the atmosphere promotes mould growth and spoilage. The growth of mycotoxicogenic fungi such as *Aspergillus flavus* may increase the risk of mycotoxin contamination of mouldy cassava products.

○ The traditional methods of storing dried cassava exposed to the moisture in the atmosphere in porous bags, on the floor, or in the arctic. The methods are not effective against moisture absorption, mould growth, and insect damage. *Prostephanustruncatus* (Horn), *Dinoderusminutus* and *Tribolium* sp. are the common insects that damage dried cassava.

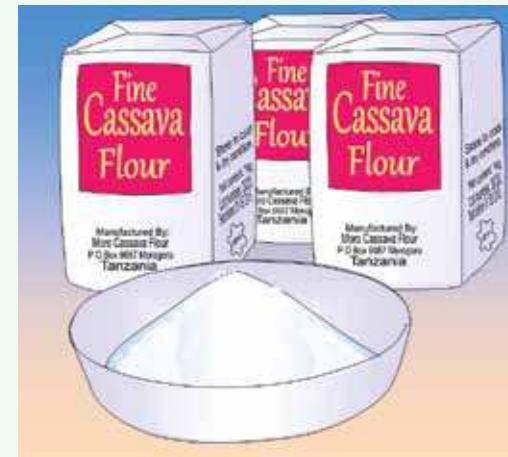


**Figure 47. Mechanical gari fryer**



**Figure 48. Firewood stove**

- Proper packaging and appropriate storage conditions will preserve quality characteristics and shelf life of cassava products.
  - Packaging materials and storage conditions to be used for cassava products must prevent the products from reabsorbing moisture, and should avoid infestation by pest insects.
  - Polythene bags, paper or polypropylene bags lined with polythene are suitable for packaging of cassava products. (Figure



**Figure 49. Improved packaging for supermarket sale**

## *Highlights:*

The traditional processing techniques are laborious, time wasting and may result in poor products. Mechanization of cassava processing can solve these constraints of cassava processing. The choice of machines for making a cassava product depends on the unit operations involved in its production process. Machine capacity should be selected based on quantity of roots available or that can be sourced while packaging and storage systems should aim at preventing processed cassava products from reabsorbing moisture, mould growth and infestation by spoilage insects.

9

# Conclusion

Achieving increased yields starts with the selection of high quality planting materials and adopting proper planting procedures. The use of good agronomic practices that eliminate the use of chemicals or fertilizers can guarantee good yields of cassava at low costs and at the same time be friendly to the environment. A good agronomic practice starts with selecting varieties that are high yielding and by sourcing healthy planting materials from specialized institutions, certified individual farmers, farmers associations, or seed companies. In addition, cassava farmers need to seek advice or service on weed control from trained personnel who have the relevant technical knowledge and experience. Such expertises are usually available at research and extension centers specializing on cassava. Therefore, these subject matter specialists are either very few or are located too from majority of the farmers. In order to increase the quality of service provision to farmers, the agriculture ministries of cassava producing countries may consider establishing training programs to transfer these skills to educated youth in the rural areas and equip them with the necessary tools to provide these services to farmers in their localities.

Cost-efficient mechanization of cassava production up to harvesting and bulk transportation of harvested roots to point of processing or sale is necessary to enable farmers have the full benefits of using improved inputs, such as improved varieties, fertilizers, and herbicides. To reduce the labor requirement, a farmer may choose to hire his/her implements or processing machinery from implement hiring institutions or buy them. A careful selection of such implement will enable farmers and processors reduce operational costs.

- In the case of storage and packaging of fresh cassava, for a short or long time, the choice of storage technique depends on the form in which the cassava will be used or consumed at the end of storage, the intended storage period, and the level of freshness required. In any case, it is beneficial to use improved storage methods that are cost effective. If processing is desired, improved mechanized processing methods are preferred to the traditional processing techniques, which are labor and time wasting, and may not guarantee quality and safety. The use of efficient and low-cost machinery and packaging system can guarantee the demand for the products high profitability for the processor.

## References

ICS-Nigeria (2003) Growing cassava in Nigeria, IITA Ibadan, Nigeria.

## **NOTES**



This training manual was developed based on research results and field experiences of cassava value chain development experts. It provides consolidated and relevant set of techno-commercial oriented information presented with simple annotated drawings to explain the step-by-step use of improved techniques and tools of cassava production, handling, processing, storage, quality assurance and marketing. The manual will be useful to farmers, processors, marketers, extension agents and other experts who are supporting cassava commercialization in Africa. The use of the manual by value chain actors will enhance their knowledge and capacity to improve efficiency of their cassava related operations and can increase profitability.

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