Growing Cassava:
Training Manual for Extension & Farmers in Zambia

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Preface

Cassava is the second most important staple crop after maize for which an estimated 92 % of total production is utilized as human food. In the recent past, increased volumes of dried cassava chips and flour have been used as raw material in the feed, textile, wood and paper industries. Cassava is thus an important food security crop that can stimulate increased economic and rural development serving as a direct response to the crop diversification strategy and policy frameworks of Poverty Reduction Strategy Paper, Sixth National Development Plan, National Agricultural Policy, and Millennium Development Goals.

However, most of the cassava that is produced in Zambia is produced based on traditional knowledge that is passed on from generation to generation. This knowledge may not be based on science and has resulted in the productivity of cassava being very low. There are a number of factors that contribute to low yields. These include among others, poor soil, low moisture levels in the soil, use of low yielding and susceptible varieties to diseases, lack of mechanization and production technology information among others. Therefore, this manual has been developed based on scientific knowledge and experiences accumulated so far in Zambia. This knowledge when employed correctly will result in increased productivity and production of cassava in Zambia. This will in turn stimulate the operations of the cassava value chain which has been affected due to low productivity.

Although commercial, medium-scale cassava farmers are beginning to emerge in the country, 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 of maximizing yield.

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

1 Source of Planting Material

Cassava is propagated by stem cuttings and the main sources of the planting materials are the farmers' own fields, farmers' neighbours and sometimes rural markets. High-quality cassava cuttings for planting are often in short supply due to low multiplication ratio. However, it is necessary that farmers plant healthy stem cuttings as planting materials. The criteria used in determining quality of planting materials of cassava are generally based on the threshold levels of infestation of pests. For common diseases, such as cassava mosaic disease, cassava brown streak, anthracnose disease and cassava bacterial blight, threshold levels are determined during field inspections, to ensure good planting material production. At the same time, the incidence, levels of damage and reduction in quality to the plants caused by insect pests such as Green mites and Cassava Mealy bugs are also determined. Crop fields which fall within the acceptable score range of quality standards, qualify as good planting materials, while those outside the range are rejected. The use of disease free, mature, true to type planting materials is recommended to start the process of multiplication.

Breeder seed for seed multiplication and outline of seed production scheme

The seed supply system for cassava relies mainly on research institutions that are a source of breeder seed as a starting point. Special care needs to be taken during the multiplication process to ensure pest free planting material. The seed multiplication process thus follows a system where the certification process is guided by generations starting from breeder's seed to certified seed. The following generations are therefore important to observe:

1. **Breeder seed/pre-basic:** Breeder seed is the variety released and maintained by the breeder either at or close to the research station for easy supervision by research scientists. This is usually referred to as primary site.

2. **Basic seed:** This is the progeny of breeder seed. The seed is produced at secondary sites managed by mandated institutions such as seed producing institutions, departments of the Ministry of Agriculture, religious groups or NGOs. These institutions/

agencies are normally backstopped by the breeders/ researchers through training about the varietal characteristics and multiplication system of the varieties. Its production is normally under the control of mandated institutions under the direct supervision of the Seed Control and Certification Institute (SCCI).

3. **Certified seed:** This is produced through the multiplication of basic/foundation seed at tertiary sites. This can further be recycled three times provided it remains pest free. Under tertiary production, fields are managed by small-scale farmers, NGOs, but under the supervision of a certification scheme. Seed multipliers are registered for purposes of enforcing quality control. Seed multipliers should consider the following:

Improved varieties

Two types of crop varieties are generally bred and released by researchers: (a) industrial crop varieties; and (b) varieties for consumption. In the case of industrial crop varieties the objective is to breed for yield, starch content and quality. For food consumption the consideration is generally for yield, cooking ability, good in-ground storability and tolerance to pests and diseases. Whatever the case, the demand must be there. Below is a table showing released varieties and their potential yield.

Variety	Potential yield at 24 months (t/ha)	Root dry matter (%)	Taste
Mweru	41	42	Flat
Chila	35	41	Bitter
Kampolombo	38	40	Flat
Tanganyika	36	41	Flat
Bangweulu	31	39	Bitter
Kariba	40	40	Sweet

Seed multipliers

Persons or institutions duly registered with SCCI for purposes of producing seed must have undergone training in seed production and understand available classes of seed and their requirements.

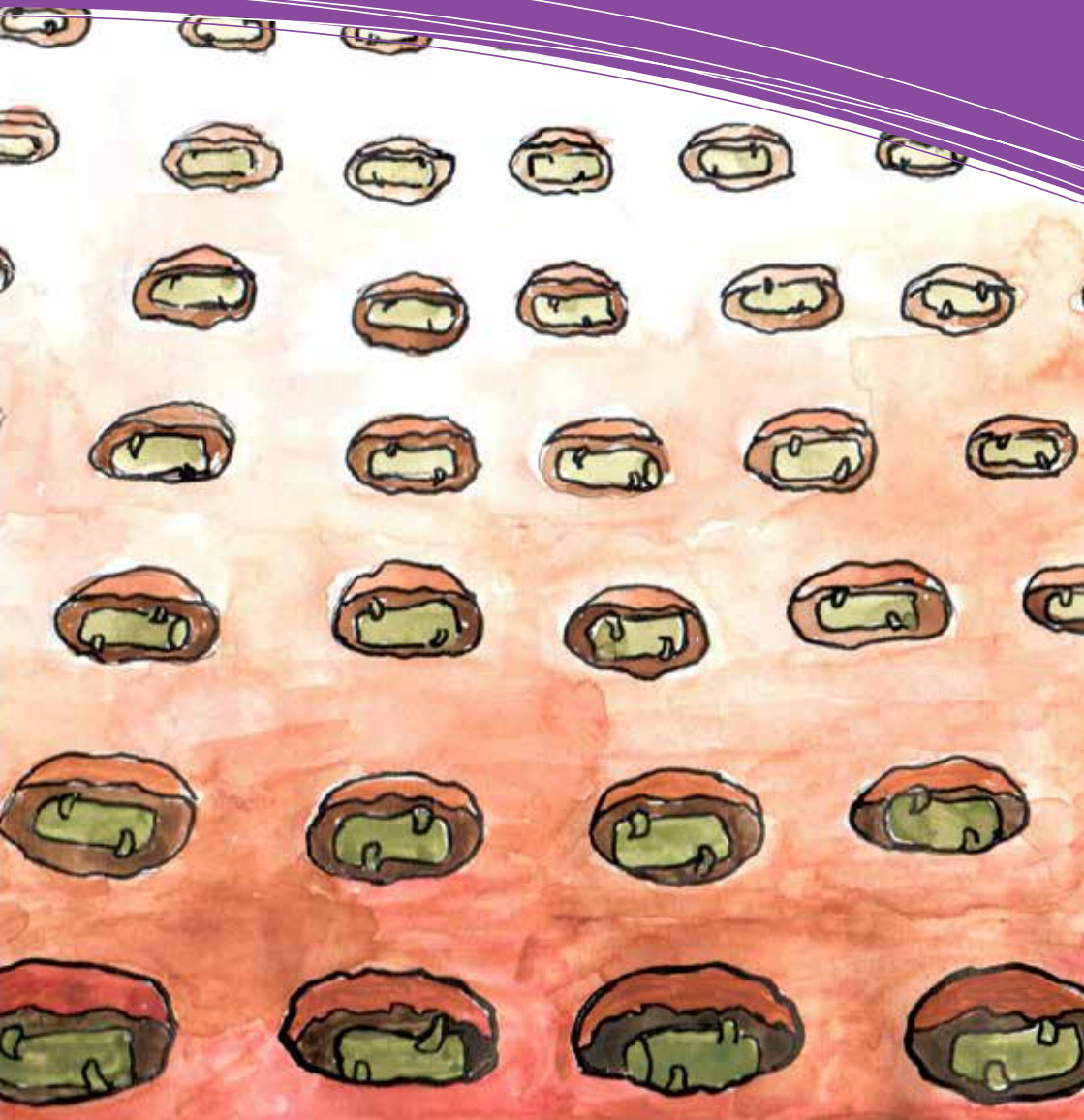
Certification

Seed certification ensures pest-free cassava seed planting material. The following certification standards are applied through field inspection to ensure clean planting material by seed multipliers:

Element	Seed Class*		
	A/B	C1/C2	QDS
Minimum rotation (years/seasons)	1	1	1
Minimum isolation (m)	200	100	50
Minimum distance between varieties (m)	3	3	3
Maximum permitted ratoons	3	3	3
Varietal purity (%) (5x30 counts/ha)	0.5	1	2
Cassava mosaic disease – Max incidence (%)	0.5	1	2
Cassava bacterial blight – Max mean severity	3.5	3.5	3.5
Cassava brown streak disease – Max incidence (%)	0	0	0
Cassava mealybug – Max incidence (%)	2	2	5
Cassava green mite – Max mean severity	3.5	3.5	3.5
Scale insects – Max incidence (%)	2	2	5
Harvesting age – new crop	8-24mths	8-24mths	8-24mths
Harvesting age – ratoon crop	6-24mths	6-24mths	6-24mths
Minimum length of stake	20cm	20cm	20cm
Minimum diameter of stake	2cm	2cm	2cm
Minimum number of nodes/stake	5	5	5
Maximum damaged nodes	10%	10%	10%
Validity of certification	2mths	2mths	2mths

**A=Breeder seed; B=Pre-basic seed; C1=Certified 1st generation; C2=Certified 2nd generation; C3=Certified 3rd generation; QDS=Quality declared seed*

2 Planting Material Multiplication Techniques



Cassava is grown using cuttings ranging from 20 cm to 1 m in length.The use of disease free, mature, true to type planting materials is recommended to start the process of multiplication. Apart from diseases and insect pests, the production of cassava planting materials also comes with other difficulties. Some of these are bulkiness, low multiplication ratio which requires transporting high volumes of planting materials which may result in damage to cuttings, to production fields. Hence the planting materials require special attention.

Conventional multiplication

The conventional cassava seed multiplication method is the easiest and most widely used. However, it has a disadvantage of having a low multiplication rate of 1:10 unlike the rapid multiplication technique of 1:60-100. Cassava for seed multiplication should be planted at 1m x 0.5m or 0.5m x 0.5m. The stem cutting should be 25-30cm long with 6-8 nodes per cutting. Care should be taken to avoid bruises and damage to the stem and buds when planting. The cuttings can be planted in an upright, horizontal or slanted position. In the horizontal position, the cutting is laid horizontally and covered with soil. To produce deeper lying storage roots for anchorage of the plant, plant the stem vertically in the soil with two-thirds of the length of cutting below the soil. To optimize on stem production, the whole stem should be buried in a horizontal position.

Rapid multiplication

Rapid multiplication of cassava stem cuttings as planting material involves producing cassava stems using 2 to 3 node cassava stakes. The technique requires selecting stems of improved or local varieties of choice and cutting the stems into 2 or 3 node stakes. To ensure pest free stakes, a mixture of insecticide and fungicide is sprayed before planting.

Planting of mini-stem cutting

For rapid multiplication the mini-stem cutting should be planted horizontally at a spacing of 10cm x 10cm and a depth of 4cm to 5cm.

It is important not to plant the cutting at shallow depth as they may become exposed and get dehydrated when weather conditions are unfavourable.

Positioning of stem cutting at planting

The mini stem cuttings should be positioned with the nodes on the sides in the hole in which it is planted. Avoid orienting one node on top and another one node at the bottom as the shoots developing from bottom may break when transplanted.

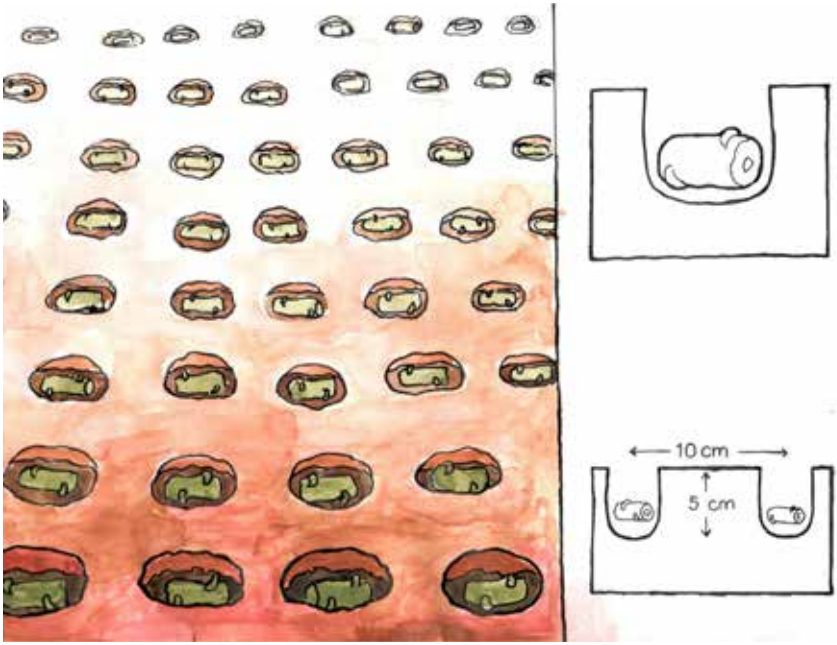


Figure 2.1 *positioning of stem cutting.*

Steps of producing 2 to 3 cuttings

1. Select physiologically mature, pest and disease free cassava stems. If the stems are infested with pests, an insecticide can be applied at manufacturer's recommended dosage by dipping the ministems in broad spectrum insecticides and fungicides.
2. Remove the green immature and the lower woody portion prior to cutting the selected middle part. Cut the stems into mini-stems containing 2 to 3 viable nodes.

3. Pre-sprout the mini-stems in nursery beds or in perforated polyethylene bags filled with good quality soil. Alternatively, a nursery bed can be prepared depending on the number of cutting required. Plant the two-node mini-stems horizontally in a small furrow in the bed at close spacing. It is necessary to ensure that the cuttings are not exposed to direct sunlight.

   After planting, the following measures should be taken:

   - Water the cuttings immediately after planting and once every day where necessary.
   - Where there is more than one variety the beds must be labeled.
   - Weed regularly to keep the nursery clean.
   - During watering care must be taken not to expose the buried stem.

4. Transplant mini-stem cuttings 4 weeks from the nursery bed to the field.
5. Transplant cuttings in a well-prepared field at a spacing of 1× 0–5 m.
6. Where mini-stems have been transplanted the field should be well managed by applying water where necessary. Weeds should also be removed using a hoe.
7. When the stems are physiologically mature or 8 months after transplanting, the stems can be cut and distributed to farmers as planting material.
8. Tie the stems together in bundles of a sizeable weight. Handle the stems with care when harvesting, loading, transporting, and unloading to avoid bruising.
9. Cassava cuttings cannot be stored for a long time because stems dehydrate. When storing, place the stalks in an upright position (bud facing upward) in a well-ventilated shed or under a tree providing good shade.

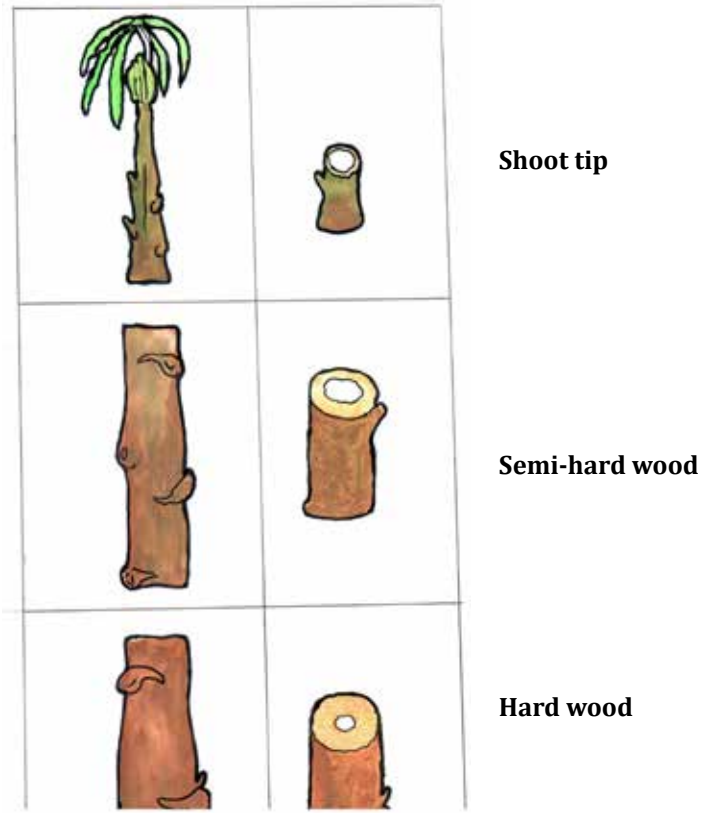


Figure 2.2 *Parts of the cassava stem.*

Planting shoot tip cuttings

Rapid multiplication using shoot tips requires extra care. Immediately the cuttings of about 10 cm long with 6-10 nodes are made, they must be put in a container of water to avoid dehydration. Leaves must be stripped off leaving the youngest leaves and not damaging the auxiliary buds. Bury two thirds of the cutting in the growth medium planting at a spacing of 10 cm x 10 cm in a nursery bed that enables one reach the middle by hand from either side to facilitate management. The cuttings must be watered regularly to avoid drying up of the growth medium that can lead to shoots dehydrating. Keep the nursery weed free and the plants can be transplanted into the field at 8 weeks after planting.

3 Handling Planting Material for Better Yields

Cassava is propagated by use of fresh stem cuttings which makes it prone to damage and loss of viability. Therefore to ensure good sprouting and establishment, cuttings must be handled with proper care. This section highlights on key agronomic determinants of quality cassava cuttings that need to be considered in stem handling for increased yield.

Preparing healthy cassava stems for planting

The quality of the cassava cuttings is determined by the following agronomic factors:

Age of the plant for source of planting material

To obtain good cuttings 12 – 18 months old plants should be used. Although cuttings from green, immature plants germinate, they are more susceptible to pathogen and insect attack. In addition, these cuttings cannot be stored for very long because they dry out rapidly due to their high water content. Their succulence makes it easy for many micro-organisms (bacteria and fungi) to infest them and cause severe rotting shortly after planting.

When plants are older than 18 months, about two-thirds of the stem is highly lignified and cuttings of this material would germinate slowly and produce non-vigorous shoots. In addition, stems from plants older than 18 months could have a greater number of lesions caused by localized pathogens or by insects. Finally, when older stems are used, cuttings are difficult to cut and transportation costs are increased.

In cases where stems stored for some time are utilized, the cut surfaces should be checked for exuding latex; if the latex appears slowly, the material should be discarded because it has dried out.

Appropriate part of the plant for preparing cuttings

It is the age of the stem that should be taken into account here and not that of the plant, since the age of the stem depends basically on the plant section where the stem piece is located. The middle third of a 12 months old plant can be used, while for an 18 month old plant, the upper third can be used and the lower basal third discarded.

Cutting diameter

Cutting diameter is determined by the age of the plant and the part from which the cutting has been obtained. To determine the diameter a relationship between the total cutting diameter and that of the pith has been established. A transverse cut is made on the cutting; if the diameter of the pith is equal to 50% of the cutting diameter, the material is adequate for planting (Figure 3.1). As a general rule, it is recommended that the total diameter of the cuttings selected not be less than one-half the diameter of the thickest part of the stem for the variety being used.

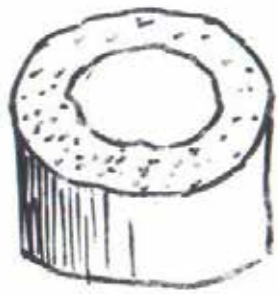


Figure 3.1 *Proportion of pith and wood for best cutting.*

Cutting length and number of nodes per cutting

The size of cutting is between 20 and 25 cm long and taken from mature parts of the plant. Each node on the stem has an auxiliary bud that theoretically can produce a plant. It is recommended to plant cuttings having 5 to 7 nodes; as these cuttings have more buds they give a better guarantee of producing a plant and if some of the buds are damaged, the others can germinate (Figure 3.2).

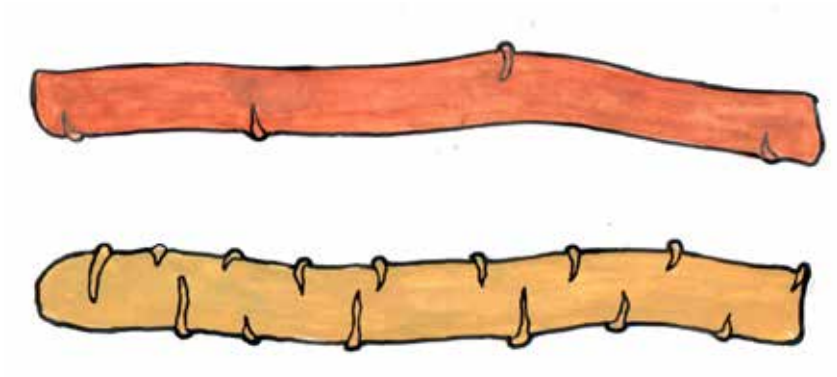


Figure 3.2 *Recommended cutting at the bottom.*

Stem cutting and the cutting angle

- Stem cuttings should be cut with sharp machetes, knives, secateurs, or cutlasses to ensure straight smooth cut ends and avoid jagged cuts (Figure 3.3).

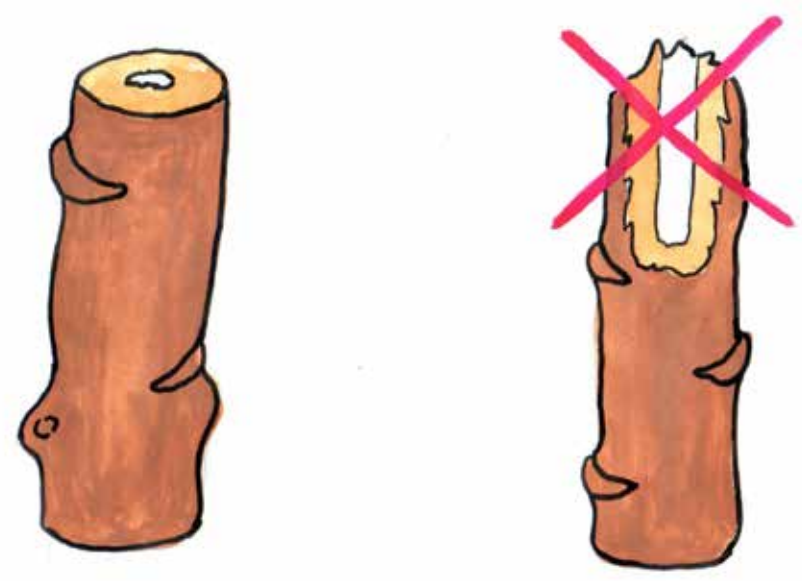


Figure 3.3 *Make a straight, smooth cut.*

- If a machete is used, cutting is done in the air as uniformly as possible taking care to avoid tearing the bark or splinting the woody piece. It is most convenient to hold the stem in one hand and make a small cut, then turn the stem 180° and make a second cut to separate the stem pieces.
- When cut transversely the cutting is able to root uniformly around the perimeter giving better root distribution.

Handling stems in transit and storage

Cassava stems are bulky and do not store well for a long time. Their transportation and distribution, therefore, deserve special effort by the people who are responsible for making the materials available to farmers.

1. In cases where materials have to be transported over long distances and stored before planting, it's advisable to prepare 1m long stakes instead of planting size.
2. Any strong blow against the stems or branches selected for planting material should be avoided during cutting and transporting. Any physical damage the cutting suffers can decrease its quality. Physical damages both to the epidermis and to buds can occur from striking or friction to the cuttings during preparation, transport, storage and planting (Figure 3.4).

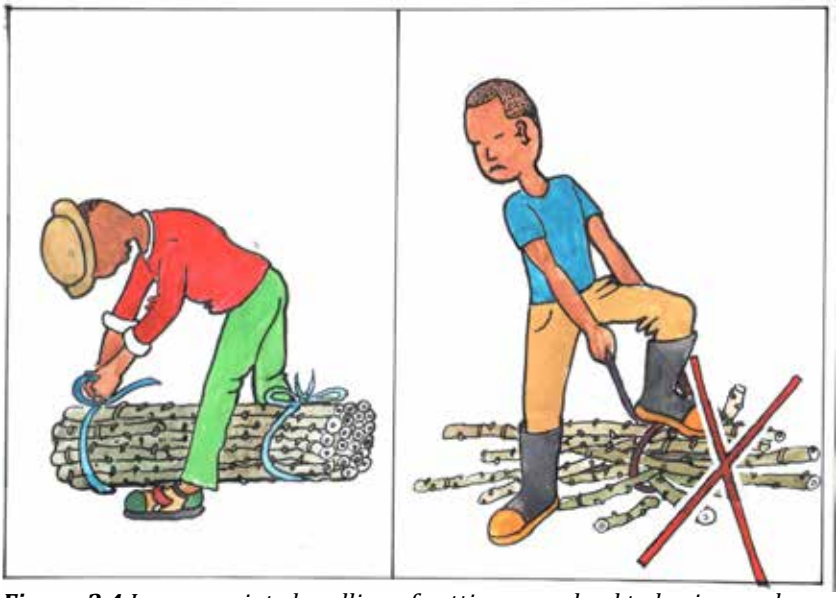


Figure 3.4 *Inappropriate handling of cuttings may lead to bruises and breakages to the planting material.*

3. To ensure safe transportation always handle the stems with care. Avoid throwing bundles of stakes about on trucks and to hard grounds or standing on and pressing them heavily for this would cause bruising and destroy nodes that may result in losses (Figure 3.5).

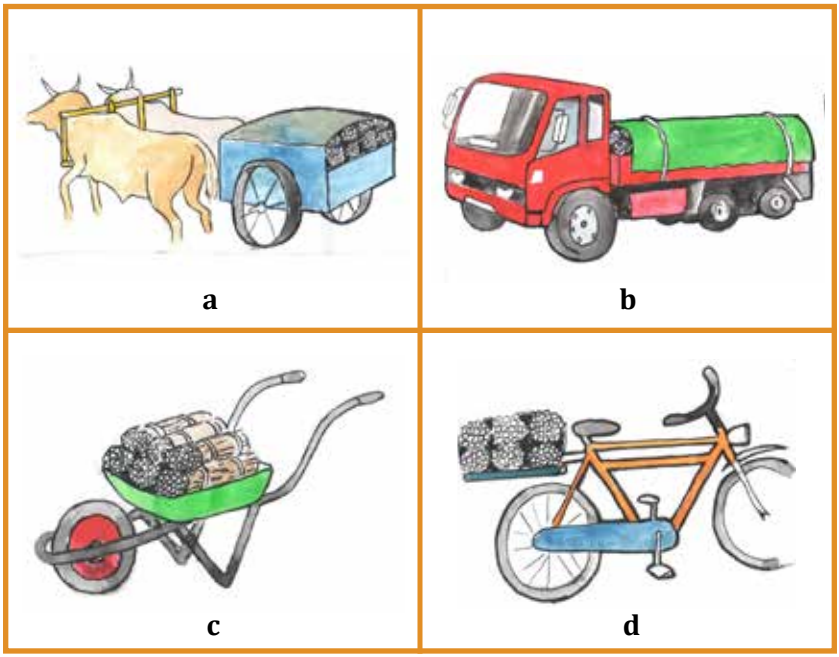


Figure 3.5 *Transporting of cassava cuttings by: (a) ox cart; (b) motorized vehicle; (c) wheelbarrow; and (d) bicycle.*

Storage methods

1. The stems are tied into bundles and stored upright under a roof, in a well-ventilated shed or under a well-developed tree providing good shade for up to about 8 weeks before cutting into planting size and planting.

2. The oldest ends of 1m long cassava stems are inserted upright into the soil which is moistened regularly, with the surrounding kept free from weeds (Figure 3.6). The basal portion of the

stems should touch each other. The stems are inserted so that they lean on a strong support (a tree stem or bamboo stick) which has been tied horizontally between two trees a few meters apart.

3. The stem bundles can also be hanged horizontally between tree branches or along the building walls under a grass thatched roof.

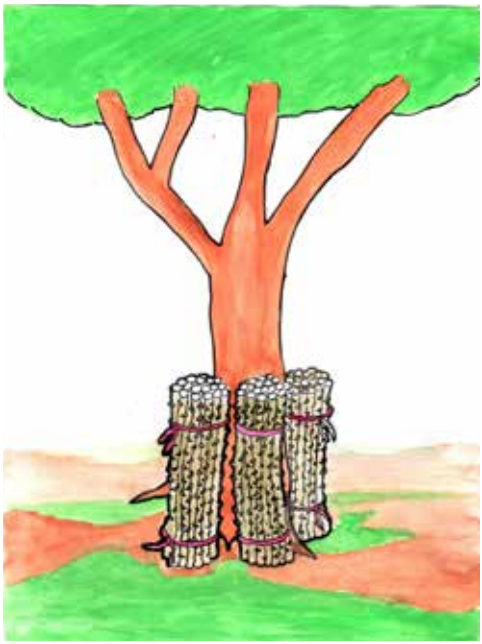


Figure 3.6 *Storing cassava stem cuttings under a tree.*

Precautions

When storing cassava stems, there are a number of important points to bear in mind:

- Avoid direct sunlight and hot or cold winds.
- Let the buds point upwards when stems are stored vertically.
- Long stems store better than short ones.
- Use mature stems from healthy cassava plants or plantations.
- The viability of the stems under storage depends on a number of factors including the variety, the storage and the quality of planting material.

How to plant cassava cuttings

Land preparation

Land preparation improves soil structure, eases planting, facilitates root penetration, increases microbial activities and helps in weed control. Cassava can be planted on flat or ridges.

Ridges

A good ridge should be at least 30 cm high and the distance between the ridges vary from 80 to 100 cm. Where the soil is not sandy, ridging is considered the best land preparation method for cassava. The advantages of ridges is that they are relatively easy to prepare either by hand or machine, less land is wasted compared to mounds, spacing is regular leading to better plant density, light interception and even plant nutrients distribution. The planting and harvesting is easier.

Flat

On sandy soils, like in Western province, cassava may be planted on flat land; otherwise this practice is not recommended for cassava production. Planting on the flat has disadvantages of poor drainage, soil compaction leading to poor plant growth and tuberous root development.

Time of planting

Although cassava is considered seasonally flexible crop, it is necessary to have the best planting time so that best plant establishment can be achieved.

Plant cassava as early as November provided the rains have started or soil moisture is sufficient for plant growth. Early planting will enable cassava plants to establish reasonably good to face cold and dry season and possibly dry season pests such as cassava green mite, cassava mealybug and termite attack.

Method of planting

There are three methods of planting cassava (Figure 3.7).

- **Horizontal method:** Cassava 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. Horizontal planting is better in dry areas.
- **Slanting method:** Cassava cuttings can be planted in a slanting or angular orientation (45°). Even in this case the cuttings should be buried in the ground with two-thirds in the soil. Always ensure that the buds point upwards.

- **Vertical method:** Cassava cuttings can be planted vertically upright with two-thirds of the cutting inserted deep in the ground.

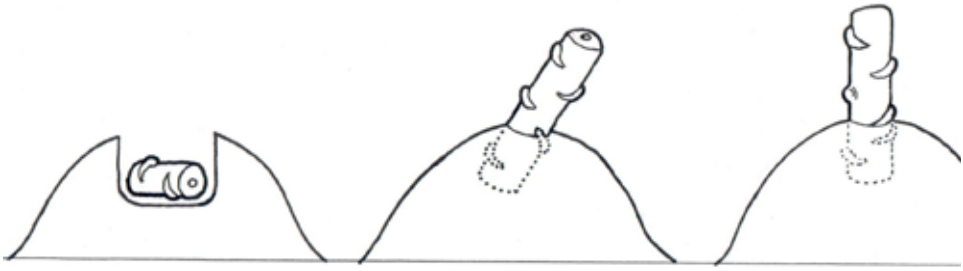


Figure 3.7 *Orientation of stem cuttings according to method of planting: (a) horizontal method; (b) slanting method; and (c) vertical method.*

Plant density

Optimum plant density varies from upland to low land or *dambo* areas and depends on whether cassava is an intercrop or a monocrop. Denser planting is practiced in *dambos* (with higher moisture) with distance between cassava plants ranging from 50 to 100 cm. In a monocrop, space cassava 80-100 cm within and between rows. A plant density of 10,000 to 15,000 plants/ha gives an optimum crop stand and yield.

Remember!

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.

4 Increasing Yields Without External Inputs

Cassava can be grown without using any input such as fertilizers and herbicides or organic compost. Cassava is highly productive under favourable environments where no major production constraints prevail. Under harsh environments-particularly where prolonged drought and poor soils are major constraints for the successful production of other staple food crops such as cereals cassava can produce reasonably well with virtually no purchased inputs. Potential productivity of cassava under favourable environments compares favourably with other major staple food and energy crops in the tropics. Based on the observed experimental yields, cassava produces more calories per hectare than maize, sorghum, and rice (assuming one crop per year) but less than sugar cane.

Zero external input

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 field.

How to use zero external input technologies to get good yields

- Choose a field that has good soil with medium fertility and good drainage.
- Avoid stony, clayey, or water-logged soils.
- Use a field that has been well maintained.
- Practice minimum tillage in sandy soils to conserve organic matter and moisture.
- In shallow or hard soils, make ridges or mounds to increase the topsoil volume per plant for a better establishment (Figures 4.1a and 4.1b).
- Choose improved varieties with the highest and most stable yield performance.
- Select planting materials from healthy cassava plants (8-24 months old) without stem or leaf damage from pests

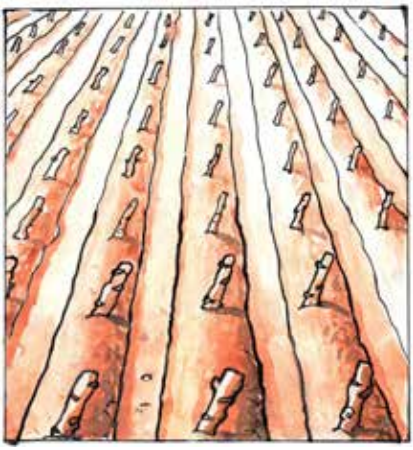


Figure 4.1a *Planting of cassava stems on ridges.*

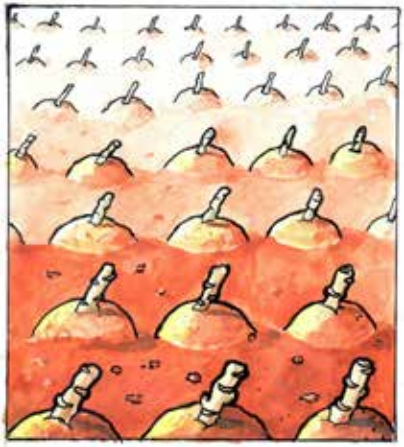


Figure 4.1b *Planting of cassava stems on mounds.*

- Handle the stems carefully to avoid bruising or damaging the nodes and to improve sprouting
- 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 4.2).

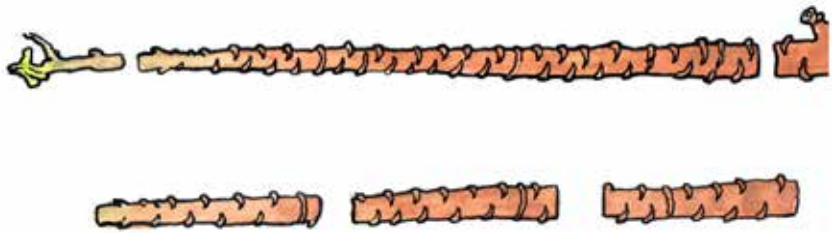


Figure 4.2 *Planting size and minimum nodes from the middle part of the stem.*

- 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 to optimize plant growth. The recommended planting space is 1m × 1m for branching types and 1m × 0.8m for non-branching types (Figures 4.3a and 4.3b).

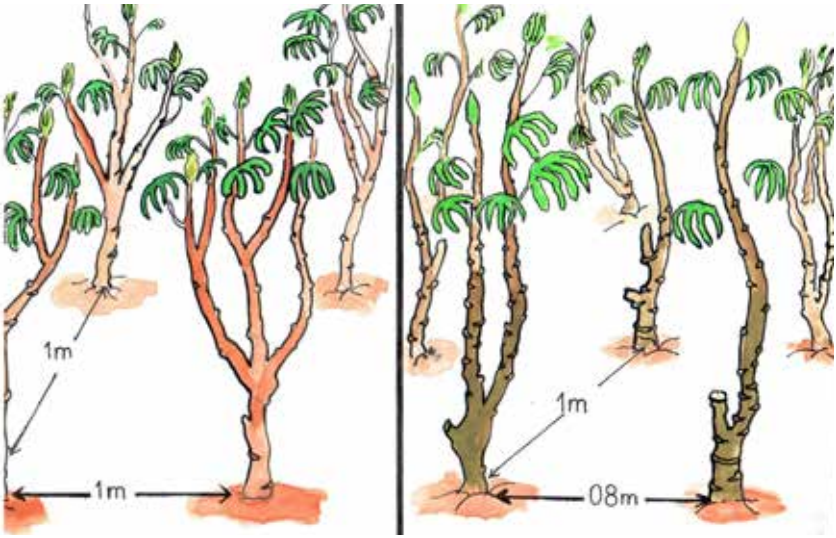


Figure 4.3a *Spacing forbranching varieties*

Figure 4.3b *Spacing for non-branching varieties*

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 external input

Intercropping cassava with short-duration crops is a common practice among smallholder farmers in Zambia (Figure 4.4). Cassava is regarded as a long-season crop and due to its slow growth at the early growth stages; it does not efficiently use the available space, light, water and nutrients. Hence short-duration crops may be inter-planted to make more efficient use of these growing environments. Among all, legumes can be considered for use in intercropping systems with cassava because of their fast growing and the ability to improve soil fertility through nitrogen fixation.

Figure 4.4 *Cassava intercropped with maize.*

The intercrops are used because they supply either food or additional income, especially when the cassava crop cannot be harvested immediately; they may fix N and supply other nutrients to the topsoil; they may protect the soil from the direct impact of rainfall, and may decrease the speed of runoff water when the cassava canopy is not yet closed, thus reducing soil erosion; and they may reduce weed growth during the early stages of cassava development. However, intercrops need to be carefully managed in order to reduce the competition with cassava, for light, water and nutrients. This is usually done through modifications of the plant spacing or planting pattern of both crops, by adjusting the relative time of planting and by fertilizing each crop adequately to maximize yields.

How to increase yield without external inputs

Plant leguminous crops such as soybean in rotations or intercrops, or Velvet bean and Sunhemp in fallows. This helps to sustain soil fertility and quality, and to manage water, weeds and pests.

Mulching 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 several advantages:

- Improves the fertility of the soil.
- Increases the ability of the soil to hold water 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.

Remember!

- A good yield of cassava can be achieved without external inputs 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. Although cassava responds well under low input environment; additional nutrient supplementation can increase the yields much more.
- 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 that multiply cassava for sale in your area.

5 Controlling Weeds in Cassava Production

Weeds can cause serious competition for cassava for space, light, water, and nutrients if left unattended to. Inadequate weed control can result in low yields. Keeping a field weed free is a requirement to avoid yield loss (Figure 5.1).

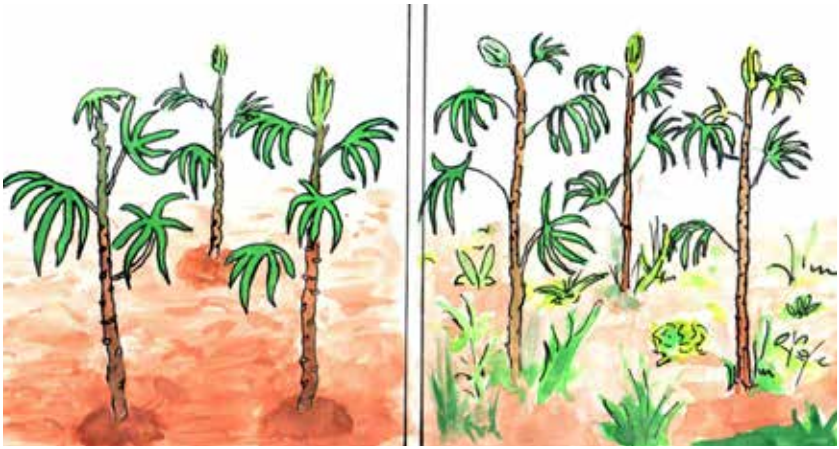


Figure 5.1 *A weed-free cassava field (left) and a weed-infested cassava field (right).*

Hand pulling, hand slashing, and hoeing are the most widespread weed control methods used by subsistence farmers in Zambia. However, these have proved to be inefficient due to drudgery, time consuming, labor-intensive, and expensive. To overcome this challenge herbicides can be used and are effective when applied to young and actively growing shoots.

Common weeds found in 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**: *Celosia trigyna* [[Local Names:sunku (Chitonga)], *Amaranthus* spp. [Local Name: bondwe (Icibemba), libowa (Silozi), bongongwe (Cinyanja), bonko (Chitonga)], *Spilanthes* spp., *Chromolaena odorata*, *Commelina benghalensis*, *Euphorbia heterophylla*, *Aspilia africana,* and *Mimosa* spp.

- **Grasses** – *Eleusine indica* [Local Names: rapoko/ kalolo (Icibemba), sikwaluku (Silozi), Dulu (Cinyanja), lukata(Chitonga)], *Imperata cylindrica*, *Cynodon dactylon* [Local Names: katazi (Icibemba), Lawanda (Silozi), kapinga (Cinyanja), nzinza (Chitonga)], *Panicum maximum*, and *Pennisetum polystachion.*
- **Sedges** – *Cyperus rotundus*, *Cyperus esculentus* [Local Names:ndawo (Icibemba), natwa/njeko (Silozi), sekwasekwa (Chitonga)], *Mariscus alternifolius*, and *Mariscus labelliformis*

When and how to control weeds

Time and frequency of weeding depends on plant population and the type of weeds. However, three weedings at 45-day intervals from planting date are recommended with a hand hoe. Care should be taken not to injure the roots during weeding as this could result in rotting of roots. Weeding together with earthing up results in better plant growth and root development. This helps the plant anchor into the soil preventing it from being blown by the wind.

- Hand weeding is effective on small farms; therefore hand weeding is common among small-scale cassava farmers.
- Use of *in situ* live mulch in the form of a cover crop is an effective method of weed suppression. For example, *Mucuna pruriens* var. *utilis* grown during the season prior to cassava cultivation helps to suppress weeds. Cassava cuttings can be planted directly into the mulch cover with little or no land clearing.
- Appropriate intercrops (such as legumes, melons and pumpkin) can significantly reduce weeding frequency and intensity. Intercropping with leguminous crops has the additional benefit of soil improvement.
- Improved cassava cultivars which are vigorous, able to branch rapidly and are competitive against weeds, effectively suppress weeds during the early and more vulnerable growth stages. Slow growing and late branching cultivars are less competitive against weeds.

- Use of inter-row weeders pulled by either tractor or animal draft power can also be employed where their cost can be justified.

Chemical control

Several pre-emergence herbicides have been identified for weed clearing in sole and multiple cropping:

- Chloramben (1-3 kg/ha)
- Diuron (1-3 kg/ha)
- Formulated mixtures of fluometuron and metolachlor (2+2 kg/ha)
- Metobromuron and metolachlor (4 kg/ha)
- Fluometuron and pendimethalin (2+2 kg/ha)
- Primextra (pre-mix of atrazine + metolachlor) (2-3 kg/ha)

Herbicides are most effective if applied before weeds infest a field. When planting or weed control is delayed until weeds become visible, mix pre-emergence herbicide with a contact herbicide such a glufosinate-ammonium (*Basta*). This is referred to as post–emergence application of herbicides (Figure 5.2)

Herbicides are cost-effective when applied in recommended appropriate quantities.

Figure 5.2 *Applying herbicide at post-emergence.*

Integrated control measures

Integrated control combines the four weed control methods mentioned above. Examples of integrated weed control are:

- Combining one weeding with the use of an improved variety, planted at optimum density; and
- Combining a pre-emergence herbicide with late weeding.

Remember!

Early weeding prevents weeds from competing with the crop for nutrients, water, light and space. Hand weeding is recommended if labor is available and economical.

6 Identifying and Managing Pests and Diseases

Important pests

Cassava pests occur in all cassava growing areas of Zambia. Insect pests reduce crop yield causing food and income losses by damaging planting materials, leaves, roots and acting as vectors of major cassava diseases. Insect pests of importance in Zambia include cassava mealybug, termites and cassava green mite while diseases of importance in Zambia include cassava mosaic disease and cassava bacterial blight.

Identification of some pests

Cassava Mealybug (CM)

CM causes yield loss through leaf loss and weakening of planting material and consequently root yield reduction which has been estimated up to 70%.

Initially the CM attacks the terminal ends of cassava shoots which become stunted and the leaves curl and fold. The internode length is reduced, causing twisted stems, and the emerging leaves are compressed together into 'bunchy tops' (Figure 6.1).

When the attack becomes very serious plants die starting with the top most growing point of the plant, where the highest pest population is found.

Figure 6.1 *Symptoms of Cassava Mite attack: curling and folding of leaves (left) and reduced internodes (right).*

The attack of CM on lower leaves and natural leaf fall in the dry season causes a so called "candle-stick" appearance. The affected plants may produce lateral leaves but even these become attacked by the insect pest.

CM damage reduces cassava yield by reducing the capacity of the plant to form tubers, and by reducing the quality of leaves as a vegetable. The twisting of stems also reduces the quantity and quality of planting material. Since the attacked plant loses leaves more weeds tend to grow underneath.

Cassava Green Mites (CGM)

Due to its non-conspicuous nature, CGM is only noticed through its damage symptoms. The CGM damages cassava by sucking sap from the leaves and shoot tip. The damage initially appears as yellowish (chlorotic) "pinpricks" (Figure 6.2) on the upper surface of developing and newly formed leaves, and later takes a blotched and bronzed like appearance.

Figure 6.2 *Typical symptoms of Cassava Green Mite attack.*

On heavily attacked plants, the youngest leaves die and drop, the shoot remains without leaves and looks like a "candle-stick", and the plant appears stunted. CGM reduces production of the tubers by inducing chlorosis, and causing loss of leaves.

Scale insects

Scale insects are tiny wingless white insects that cover the cassava plant stem (Figure 6.3). The scales feed by sucking sap from the cassava plants. Therefore, they may reduce the likelihood of cassava cuttings to sprout, or they may cause death of the entire plant through loss of water from the plant.

The scale insects are dispersed passively by wind, spreading from one plant to another. They are also spread through use of infested planting materials.

Figure 6.3 *Scale insects on a cassava stem.*

Termites

Termites are small white wingless social insects with brown heads that live in underground tunnels or above ground nests. In addition to cassava, termites also attack other food crops including maize, yam, and groundnuts. Termites normally feed on dead wood materials but some species also feed on living plants (Figure 6.4).

Figure 6.4 *Termite attack on a cassava plant.*

Termites eat below and above ground parts of cassava stem cuttings. The attacked stems grow poorly, die and rot causing poor plant stand. Termites attack weakens and causes the plant to fall down easily. This contributes greatly to loss and shortage of cassava planting material. Attacked stems and cuttings are usually filled with soil particles lessening the likelihood of cuttings to sprout into new plants.

Management of pests

- Use resistant or tolerant varieties which are released or recommended by the Root and Tuber Improvement Programme at research stations.
- Always select and get cuttings only from plants that are not showing presence of pests
- Plant cassava early in the rainy season to allow the crop to establish well before the dry season, as a strong plant is more likely to withstand pest attack.
- Avoid burning cassava plantations at harvest as the burning indiscriminately kills insects including the natural enemies.

Identification of diseases

Cassava Mosaic Disease (CMD)

CMD is a disease of cassava and is caused by a number of viruses which are transmitted by the whitefly. CMD attacks only cassava and causes reduction in yield ranging between 20 and 90% depending on the variety, location and virus strain. The yield reduction is basically in terms of reduced fresh weight of roots as well as reduced plant vigour.

The disease damage can either appears as patches of normal green leaf colour mixed with light green, or patches of yellow interspaced with white chlorotic areas. The leaves on infected plants become small, distorted and twisted along the edges. As the disease progresses the affected leaves may reduce and the plants become stunted (Figure 6.5).

Figure 6.5 *Typical symptoms of CMD on a cassava plant.*

Cassava Brown Streak Disease (CBSD)

CBSD is a disease of cassava caused by either one or more viruses. It is also transmitted by whitefly (*Bemisia tabaci*). CBSD displays a number of symptoms. On the leaves, the disease appears as a feathery chlorosis on the smaller veins. On the stems the disease displays small streaks hence the name CBSD. On the roots the symptoms occur as yellow/brown, corky necrosis in the starch-bearing tissues and radial root constrictions in very severe infections. The necrosis begins as discrete areas, but in fully susceptible cultivars, it may affect most of the root, rendering them unfit for consumption.

There variations of symptom expressions, depending on cultivar, crop age, virus strain/combination, and weather conditions. CBSD foliar symptoms normally occur only on mature leaves and the young expanding leaves are symptomless (Figure 6.6).

Figure 6.6 *CBSD symptoms on the leaves and its progression on a cassava plant.*

On stems, CBSD is noticeable by the appearance of necrotic lesions in the leaf scars remaining after the leaves have been shed. In case of highly prone varieties, the entire stem tissue may degenerate and such plants are liable to be killed by the disease. CBSD causes substantial root yield loss of up to 100% (Figure 6.7).

Figure 6.7 *Constriction of roots (left) and lesions on tuberous roots (right) due to CBSD.*

Cassava Bacterial Blight (CBB)

CBB attacks only cassava and no other food crops. CBB is spread through infected cuttings. CBB is recognised by the presence of water-soaked, angular spots on leaves and wilting of the stems, branches, and leaves (Figure 6.8). These spots occur between leaf veins and are best noticed on the underside of leaf surfaces.

Figure 6.8 *Water-soked angular leaf spots and wilting of stems due to Cassava Bacterial Blight.*

Brownish gum exudates are observed on the leaves, petioles and shoots infected with CBB (Figure 6.9). Severely infected leaves wilt but remain attached to the plant for some time before falling down causing plant defoliation, tip die-back and considerable yield losses of both roots and leaves.

Figure 6.9 *Gum exudation on cassava stems due to CBB.*

Other disease affecting cassava but less important in Zambia are Cassava Anthracnose, Cassava Root Rots, and Cercospora leaf spots.

Management of diseases

- Use recommended varieties which are disease resistant or tolerant from the Root and Tuber Improvement Programme at Research Stations.
- Plant only cuttings from healthy plants and regularly inspect fields to remove any plant showing disease symptoms.
- Bury the diseased plant residues just before the onset of the dry season.
- Plant cassava in rotation with other crops.
- Obtain planting materials from sources recommended by Root and Tuber Improvement Programme.

Remember!

Obtain clean planting materials from recommended sources, if the materials are infested with insect pests or diseased, pesticides can be applied in recommended quantities.

7 Mechanization in Cassava Production

In Zambia cassava is mostly produced by small-scale farmers who depend mostly on manual labour. Though improved varieties with high yielding potentials have been made available by research institutions in some African countries; including Zambia, the full benefit of such technologies cannot be realized without mechanization. This section provides a guide on cost effective mechanization in cassava production and focuses on small-scale mechanization for small to medium scale farmers.

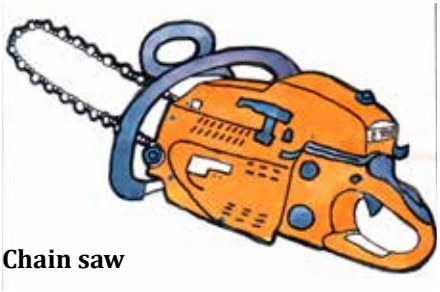
Mechanization practices and farm operations

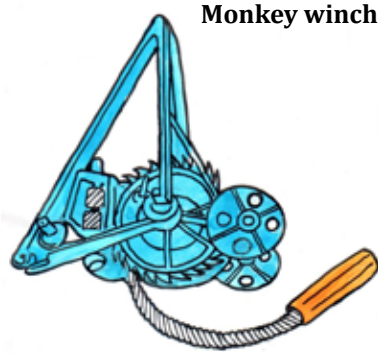
The level of mechanization can vary to suit small-, medium- or large-scale farmers and suitably designed for different activities in production such as land clearing, cultivation, fertilizer application, weed control, and harvesting. However, choice of a machine will depend on land size, financial capacity, terrain, soil type, and rainfall in the area. Some of the machines available for cassava production are indicated in the table below (Table 7.1 and Figure 7.1)

Table 7.1 Available machines for commercial small-to medium-scale cassava production

Activity	Machine	Use/Operation
Land Clearing	Bulldozers	Push down the trees and shrubs
	Monkey winches	Uprooting trees
	Monkey jacks	Rolling tree trunks after cutting
	Chain saw	Felling trees, cutting logs and shrubs
	Brush-cutter	Clearing grasses and small shrubs
Primary Tillage or cultivation	Tractor mounted plough, or power tiller	Loosens and aerates the soil, enhances root penetration, mixes organic matter, and raises soil

Activity	Machine	Use/Operation
Secondary Tillage	Tractor mounted harrow	Slices, loosens and levelling of the ploughed soil
Planting	Tractor mounted planters (Two-row planter)	Cuts and plants cassava stakes horizontally. Applies fertilizer, and covers the planted stakes,
	Hand held hacksaw, motorized chain saws	Cutting stem cuttings of same size, length, and with clear cut ends
Weeding	Boom sprayer mounted on a tractor	Applying herbicides
	Knapsack sprayer	Small-scale application of herbicides





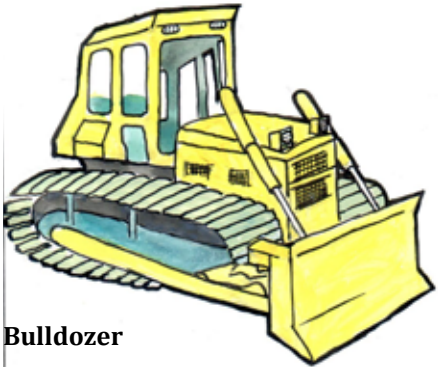


Figure 7.1 *Some examples of equipment and machinery usually used in land-clearing*

Planting

Hand planting

This is the most common method of planting cassava but the operation is tedious and labour-demanding (Figure 7.2).

Figure 7.2 *Planting cassava by hand*

Machine planting

The first step in cassava planting using a planter is the careful selection of cassava stems that will be used as planting material. In addition to good attributes of good planting material straightness of the stem is another. This characteristic allows it to pass through without blocking the cutting mechanism. The following considerations need attention:

- The stems have to be prepared in enough quantities so that the down time of the tractor during loading is minimised.
- Bundles of prepared stems are loaded on the trays of the planter before the planting operation begins.

- The operation of the cassava planter requires a tractor operator, two adult people to feed stems in the cutting mechanism and another person on the ground.
- The planter has a mechanism that will cut the cassava stems to stakes of constant preset length, plant at predetermined distances, apply fertiliser and cover the planted stake in a single operation. The cassava two-row planters that are available in Zambia plants cassava stakes horizontally and the field has to be thoroughly harrowed before the planting operation.

Weeding

Weed infestation in a cassava field reduces yield as outlined in section 6. With the increase in the size of cassava fields due to mechanisation of other operations it would be virtually impossible to weed the cassava field on time using manual labour. Therefore, any delay in carrying out the weeding operation will have an effect on the yield of the crop.

Weeds can be effectively controlled by applying an appropriate herbicide by using a tractor mounted boom sprayer or knapsack sprayer depending on the size of the field.

Remember!

A suitable mechanized production system developed with care can reduce the labor requirement and operational costs. Farmers should carefully select the machines required for each operation, depending on the scale of production, to avoid choosing a production method too expensive for the work. The Zambian government and the private sector are encouraged to make agricultural machine hiring services functional, organized, and accessible as well as affordable. Farmers are therefore encouraged to take advantage of these services available with Zambia National Service at all provincial headquarters.

8 Harvesting

Knowing when the roots are ready for harvest is a key first step in ensuring cassava roots with good eating and processing qualities are harvested. Therefore, cassava has to be harvested at an appropriate age, size and tenderness in order to meet the quality of its intended use. Generally, if cassava harvesting is delayed, the roots tend to become fibrous and lose good qualities for the fresh market.

It is also important to harvest cassava roots at the right time so that the land where it was planted is freed up for other agricultural production activities.

Generally, the time from planting, eating quality are important considerations in the determination of time of harvest. However in Zambia the time of planting gives an indication when cassava roots are ready for harvesting because most of the existing improved varieties bulk between 8-18 months after planting.

Harvesting and field handling

How to harvest cassava

Manual methods

Once the roots are ready for harvesting, they should be carefully removed from the soil. Manual method is involves the use of hand hoe for cassava harvesting. It is a common and predominant method of harvesting for cassava that is planted on ridges, mounds or flat land among the smallholder famers in Zambia.

Ridges and mounds facilitate the easiest harvesting of roots compared to the other systems of bed formation since the roots are generally confined to the ridges and mounds.

When cassava is planted on flat land, it is difficult to know exactly where the roots are, therefore it is always likely to have roots damaged during harvesting operations.

In manual harvesting, losses are usually higher during the dry season because of compacted soil leading to roots breaking and remaining in the soil. Therefore, care must be taken to loosen the soil first before the cassava roots are gently pulled to avoid bruises on the roots.

Figure 8.1 *Harvesting cassava using a hand hoe*

Mechanical methods

This involves the use of specially designed tools or machines to aid in harvesting operations. These come in different forms and capacities.

Cassava up-rooter or harvester

Prior to start harvesting, cut the cassava stems leaving about 40-50 cm above the ground. The up-rooter is coupled to at least a 90 horse power (Hp) tractor. The uprooter is pulled in cassava rows and harvests one (1) row at a time, spaced between 0.80 m to 1.0 m. It cuts and loosens the soil containing the cassava root cluster with minimum bruises/damage. Using the stem the roots are pulled and collected in one place for packing or loading.

The up-rooter can harvest an average of 3 - 5 ha/day. The harvester requires minimum human labour with minimum root wastage. It saves time and reduces drudgery and operational costs.

The cassava harvester is easily operated but requires the cassava field to be planted in well-defined and straight rows.

In either manual or mechanical harvesting methods, once the cassava has been uprooted, the root clusters are carefully separated into individual roots by cutting above the swollen storage roots leaving a piece of woody tissue attached to each root. Do not separate the root from the stump by hand breaking because it will cause injuries to the root.

Harvested roots should be placed under the shade of trees to avoid direct sun as this would accelerate deterioration. The practice of placing cassava roots in polypropylene bags or sacks as a mode for packing during transportation must be avoided because it increases the chances of damaging them resulting in a greater incidence of spoilage.

When harvesting cassava if possible crates must be used to avoid damage to the roots.

Selecting or sorting roots in the field

It is good practice to sort cassava roots in the field because some amount of damage is expected during harvesting operations. Therefore, damaged or roots showing visible symptoms of rotting should be removed from undamaged ones at this stage.

Remember!

Harvesting requires good planning in terms of timing and method to be used. Manual harvesting is labour intensive and expensive. For commercial farmers it is advisable to use the mechanised harvesting operations because it is cost effective. The amount to be harvested must always match the processing capacity so that losses of quality caused by delayed processing are minimised. In Zambia, all the existing cassava planters are imported from Brazil and are not found with local agricultural machinery suppliers. However, importation of this equipment could be facilitated for those who intend to go into commercial cassava production as individuals or as a cooperative.

9 Post-harvest Handling & Storing Fresh Roots

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

Cassava roots deteriorate and lose quality when not utilized within 48 hours of harvest. Hence, they must be transported to the homestead, market or processing plant immediately after harvesting. The following considerations should be taken when transporting the roots:

- Use wheel barrows, sacks 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, sack or container without causing bruises or damage to the roots
- Vehicles transporting cassava for long distances should be covered with tarpaulin to avoid rapid moisture loss from the roots.
- Use oxen-cart for transportation especially in the rural areas where there are no paved roads or impassable to vehicles.
- 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 hours of harvesting. Fungi and bacteria infection may cause rotting in untreated roots.

How cassava roots are stored

Traditional storage methods

Fresh cassava roots are traditionally stored in the following ways:

- Fresh cassava roots once mature are left in the ground and harvested when needed. This practice is called piecemeal harvesting and is common when cassava is used for food security. However, it is not suited for commercial production.
- Fresh cassava roots are heaped under shade and watered daily.
- Undamaged fresh roots are stored in pits or trenches dug in well drained soils, sloppy and shaded area. The trenches (usually 1 meter long and 30-40cm wide), 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 either river-sand or sea-sand. Water-logged areas and heavy clay soils used for covering must be avoided.
- Fresh cassava roots are coated with clay or mud.
- Freshly harvested or peeled cassava 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.
- The storage methods described here extends the shelf life of the roots by only 2–3 days. This cannot sustain commercial operations.

Postharvest losses can be reduced by harvesting when the soil is wet or by growing the crop in loose soil. Root damage and bruises must be avoided during harvest and transportation. Only uninjured roots must be selected for storage of more than one week. Storage could be enhanced by treating unpeeled roots with a fungicide before storage.

Improved storage methods

No.	Storage Method	Step-wise Procedure	Remarks/Precautions
1	Pit storage	1. Select a well-drained area, preferably shaded, and slightly sloping.	Do not keep cassava in a waterlogged area because roots will rot easily
		2. Dig trenches measuring 1 m wide and 30–40 cm deep, in such a way that the length is directed downhill.	The length varies according to the volume of roots. A trench 1 m long can contain 70–80 kg of roots.
		3. At the lower end of the trench, make a drainage ditch, at least 20 cm wide and 5 - 10 cm deeper than the storage trench.	
		4. Arrange mature, undamaged roots inside the trench.	
		5. Cover each layer with either river- sand or sea- sand.	Do not use clay-loam soil if it is too wet.
			Do not use heavy clay. Soil of this type could speed up root deterioration.
2	Storage in saw dust	1. Select healthy roots that were not damaged or bruised and were harvested no later than 24 hours.	To avoid microbial spoilage, the sawdust must be damp, not too wet
		2. Put a layer of damp sawdust in wooden crates or baskets lined with plastic foils that prevent the sawdust from drying up	
		3. Arrange the roots in alternate layers of damp sawdust in the wooden crate and store	

No.	Storage Method	Step-wise Procedure	Remarks/Precautions
3	Storage in clamps	1. Choose a dry spot in the farm or processing area and dig a shallow trench.	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.
			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
		2. Place a layer of straw, add a layer of selected undamaged roots to form a cone or mound shape	Ensure proper ventilation and that the floor remains dry
		3. Add 20cm 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.	

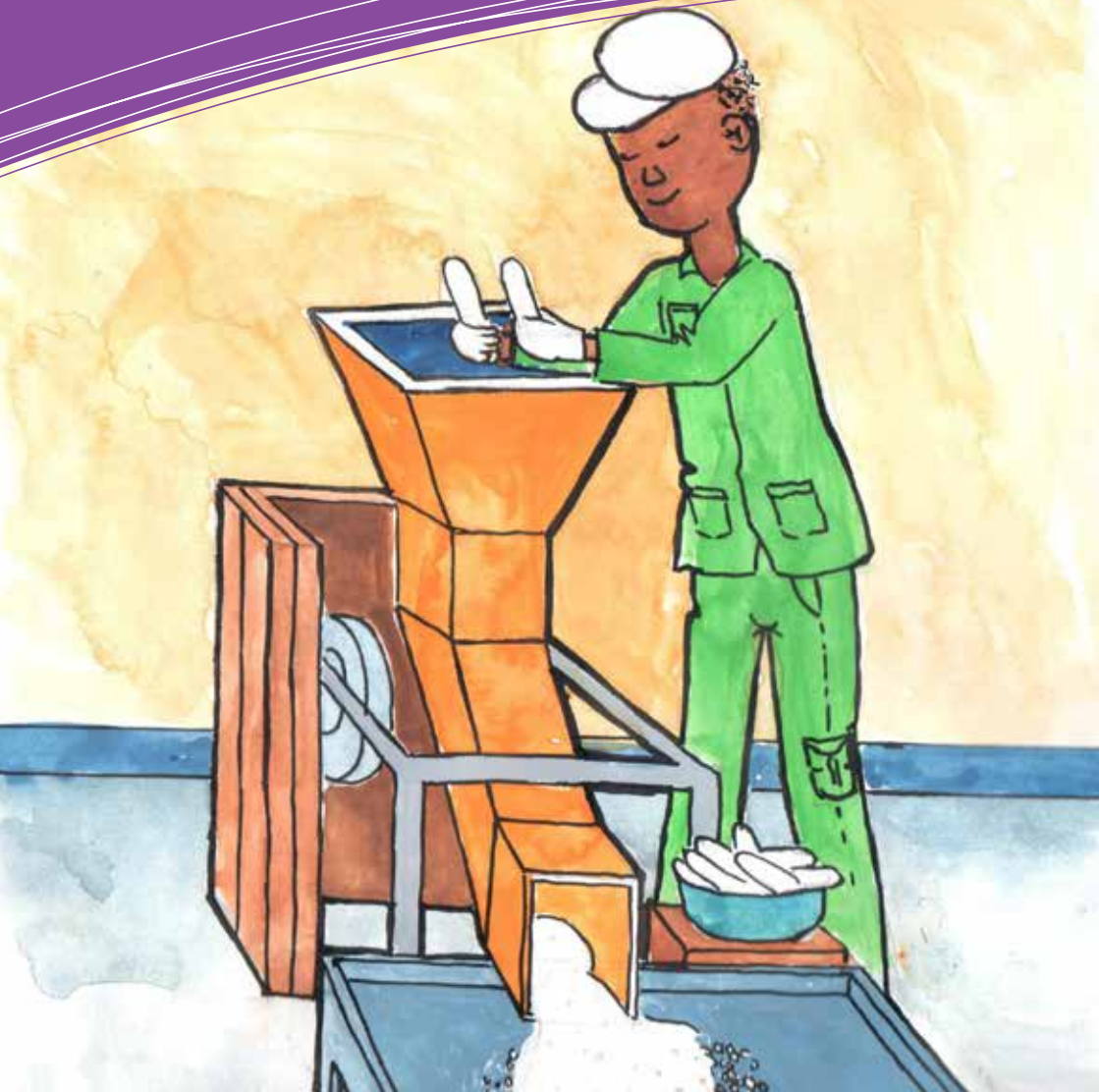
No.	Storage Method	Step-wise Procedure	Remarks/Precautions
4	Storage in polyethylene bags	1. Add 20cm of straw, then cover the clamp with soil, leaving openings at the bottom for ventilation, to maintain temperature below 40°C for curing wounds and for the storage.	
		2. Treat non-bruised or undamaged 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.	The storage period is 2 – 4 weeks.
		3. Vacuum pack in polythene bags	Vacuum packing make the polythene bag air tight and creates the atmosphere (reduced oxygen and appropriate humidity) for the storage.
		4. Keep the package at ambient temperatures	
5	Storage in refrigerators	1. Select healthy (non-bruised or undamaged) roots.	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.
		2. Wash with cool chlorinated water	
		3. Pack or vacuum pack in nylon bags	
		4. Store in the refrigerator at below 4°C.	

No.	Storage Method	Step-wise Procedure	Remarks/Precautions
6	Freezing	1. Select healthy roots	Peeling and/or cutting into small sizes are optional.
		2. Wash and freeze the roots.	To reduce texture damage, apply blast freezing to quickly freeze the roots.
		3. Store the roots whole or cut up in frozen condition	Freezing is suitable for long term storage and long distance marketing but the textural quality of the frozen roots may be affected.
7	Waxing	Wash non-bruised or undamaged roots in chlorinated cooled water.	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.
		Dip in melted paraffin wax at a temperature of 51.5–52.5°C.	Waxing slows down respiration rate and transpiration, and prevents physiological deterioration.
		Pack in well ventilated cartons	
		Waxing is done for commercial export of roots.	

Remember!

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.

10 Processing Operations & Machinery



Cassava processing

Cassava as a staple food is a good source of carbohydrates and energy in comparison to other root crops. However, it has one major nutritional drawback; the presence of toxic compounds (cyanogens) in some varieties. Health problems that result from the consumption of cassava with high toxic compounds are due to inadequate or poor processing. Cases of poor processing of cassava are rare and result from extreme conditions that cause severe food insecurity.

Cassava is processed for the following reasons:

- To eliminate losses and prevent spoilage of fresh cassava roots after harvest.
- To transform or change it into a more desirable and stable product with less volume, which makes transportation easier.
- To eliminate or reduce the level of cyanogenic compounds, which make some cassava varieties or types poisonous in their raw form.
- To improve the flavor, palatability and make cassava food products suitable for consumption.
- To produce raw materials for a variety of industrial products.
- To stabilize seasonal fluctuations in the supply of the crop.
- To improve the net economic value of cassava and its products.

Common steps in cassava processing

The main steps in processing cassava include peeling, washing, slicing/chipping, grating, dewatering and drying. Other steps include boiling, fermenting, roasting, frying etc.. The steps could be combined in order to have desired product.

Peeling and washing

Peeling is the removal of the inedible outer skin (peel and cortex) leaving the central part of the root. It is the first and important step in processing cassava roots because it contributes to the reduction

of the cyanogenic potential of cassava, because its cyanogen content is usually 5 to 10 times more than that of the root cells.

Although mechanical peelers exist in other countries, in Zambia cassava peeling is achieved by using hand knives and this is mostly done by the women and youth. It is a slow and labour demanding operation and the peeling loses are usually very high estimated at about 22-30%.

As much as possible, use potable water during cassava processing.

Slicing/Chipping

It is a process that involves cutting of cassava roots into smaller particles or sizes. This process is recommended for low-cyanide or sweet cassava varieties. However, in the traditional cassava chipping operations, it involves cutting cassava roots in smaller chunks either longitudinally or horizontally which usually results in improper drying and poor quality products.

Processing of high quality chips involves reducing cassava roots to thin slices of fresh, peeled cassava with an average diameter of 3mm to 5mm which facilitates rapid drying cassava especially under sunny conditions thus cutting out any risk of fermentation or soil and dust contamination.

Unfermented Cassava chips are bright white and could be milled into flour for other uses such as cassava flour for nshima preparation and confectionery products e.g., dough-nut and biscuits etc.

High quality cassava chips can be produced by manual or motorised chipping machines which are locally fabricated by trained local fabricators.

Grating

The process involves pressing fresh cassava roots against a swiftly moving surface provided with sharp protrusions which tear up the whole root turning it into a mash (Figure 10.1).

This operation is recommended for high cyanide or bitter cassava varieties. This process facilitates reduction of toxic compounds associated with bitter cassava by more than 95% and the greater part

of the remaining compounds is eliminated by pressing or dewatering the mash.

This method is also used for extracting starch, flour and gari. Manual grating is laborious and predisposes processors to hand injuries.

Grating machines are locally made and come with different processing capacities.

Figure 10.1 *Grating cassava using a mechanized grating machine*

Pressing or dewatering

the water. In bitter cassava varieties this step contributes to reduction of toxic compounds. The cake that is obtained after pressing requires to be broken down into granules. This can either be done manually or mechanically by passing the cake again in a grating machine. The loose granules obtained can then be further processed into the desired products such as gari, high quality cassava flour, starch etc.

In Zambia the most common method used for dewatering grated cassava is the use of hydraulic presses which are also locally fabricated.

Drying

Drying is the process of removing moisture from cassava roots, slices/chips or granules by placing the products in the sun or in a drier. This process significantly reduces the water and increases the shelf-life of cassava roots, chips or granules. Although sun drying is

the most cost effective method it has limitations in the rainy season due to extended cloud overcasts.

Other methods used in the traditional sector for drying cassava include, exposing the cassava to fire especially in the rainy season, spreading the cassava mash on specially identified rocks, road side especially tarred roads, cooking places, roof tops etc. These methods are very slow and susceptible to contamination and yield poor quality products.

Poor quality of cassava products (discoloured, changed tastes, offensive smell etc) often leads to poor market acceptability and low prices of cassava products.

Shading nets on raised drying racks have the best drying efficiency and cleanest product for drying chips. Black shading net absorbs (60%) heat, allows air circulation and therefore has got a high drying rate. Unfortunately shading net is quite expensive and only available in few places. Bamboo racks can also be used as alternatives to nets (Figure 10.2).

Figure 10.2 *Drying cassava roots on a bamboo rack*

Cassava chips or granules from a grater are spread on a drying surface exposed to sunrays. The more chips on a drying surface, the slower the drying rate will be. Thin chips dry faster than thicker ones. It should be noted that the quality of the chips is higher if the drying time is short. However, the cyanogenic potential of cassava decreases when the drying time is longer. Therefore, drying parameters that affect drying rate, especially the loading rate (weight of drying material per unit area of drying surface), are important in determining the residual cyanogen content of the dried cassava.

In general one can put 5-8 kg of fresh (wet) chips per sq m depending on the weather conditions and expected drying period. Drying on concrete floors is not recommended for processing of cassava chips for human consumption as it will increase soil and dust contamination and free-range livestock may access cassava dried on the floor and reduce the quality. Concrete drying floor can be used in case of large scale drying of cassava chips for feed production.

Many types of mechanical dryers are available and these include cabinet, solar and flash driers as well as tunnel and rotary driers. The main sources of heat energy for driers are wood shavings, saw dust, wood, charcoal, diesel, electricity, sun etc.

Factors to consider when choosing a drying technology

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

Cabinet driers using charcoal wood and saw dusts have been tested in Zambia and the results were promising.

Flash drying technology is recommended for large-volume rapid drying of grated cassava granules, starch etc. Therefore it is important to establish the quantity of available raw materials for drying through the year before selecting the drier with an appropriate capacity. This technology has being tested in Zambia and it is promising.

Milling

This is the process of breaking down of dried cassava roots, chips or granules into flour of desired fineness for domestic or industrial use. Milling machines (hammer mills or roller-mills) that are used for grains can also be used for milling cassava chips and granules. However, the fineness of the flour largely depends on the sieve used and the ultimate use of the flour. Sieves of different sizes can be purchased from stocks of hammer mill spares.

Cassava that is meant for production of livestock feed should not be very fine while that is which is meant for baking and starch must be very fine.

The traditional method of milling dried cassava for home use is pounding. This method has very low throughput and is labour demanding especially for the womenfolk and young girls.

Packaging and storing

Proper packaging and appropriate storage conditions will preserve quality characteristics and extend shelf life of cassava products.

The selected packaging material and storage conditions must prevent the stored product from reabsorbing moisture from the environment and allow entry of insect pests. If the stored cassava products absorb moisture, it may lead to fungi growth which may increase the risk of mycotoxin contamination.

Polythene bags, paper or polypropylene bags lined with polythene are suitable for storage of cassava of products.

Remember!

- Chipping is not recommended for processing cassava varieties high HCN if the cassava flour is meant for human consumption.
- Commercialisation of cassava cannot be achieved by employing traditional methods and tools. It is most important to mechanise all processing unit operations.
- Selection of the type and capacity of processing machines must match the quantity of available raw material (cassava roots) for processing.
- Always store cassava products at an appropriate moisture content and select packaging material that will prevent entry of moisture and other storage pests.

Postface

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 expertise is usually available at research and extension centers specializing on cassava. Therefore, these subject matter specialists are either very few or are located too far from majority of the farmers. In order to increase the quality of service provision to farmers, the Ministry of Agriculture 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. Farmer Training Centers could be utilized for these trainings.

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.

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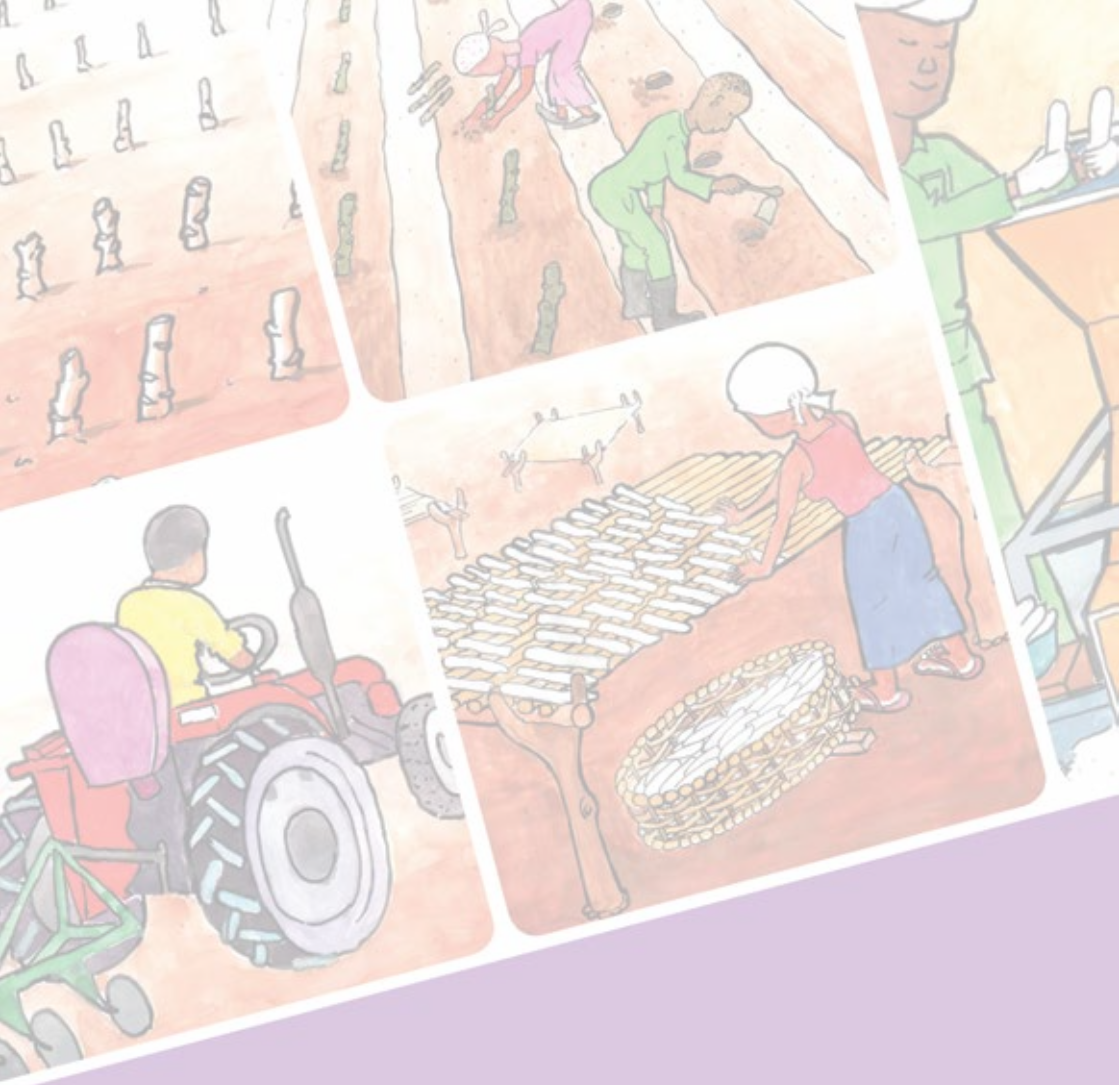

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