Cassava Cultivation and Post Harvests Handling

CASSAVA

INTRODUCTION

Cassava *(Manihot esculenta* Crantz) reportedly has two geographical centres of specialization. One area is in western and southern Mexico and parts of Guatemala and the other is in north eastern Brazil. Presently, cassava is grown through out the tropics. Guyana is one of these tropical countries in which cassava is cultivated.

This crop is produced in all ten Regions of Guyana. The Regions of highest production are Regions 1, 8 and 9. In Guyana, cassava is used mainly for food. Nutritionally, cassava is primarily an energy source since it is an excellent supplier of calories. The roots also contain quantities of vitamin C, thiamine, riboflavin and niavcin. It should be noted, however, that boiling reduces vitamin C content by 50 to 70 percent. Processing into such products as farine reduces it by 75 percent or more. In terms or food preparation in Guyana, the simplest is boiling of the tubers. Cassava is also processed into farine, cassava bread and casareep.

An industrial use of cassava, in Guyana, is as the raw material in starch production. There are several other uses of cassava. One of these is as animal feed. Its starch has uses in the food industry, for paper making, as a lubricant in oil wells and in the textile industry.

VARIETIES

There are several cassava varieties under cultivation in Guyana. Some of these are Four Month, Brancha Butterstick, Uncle Mack, M Mex 59, Mex 52 and Bad Woman.

ENVIRONMENTAL REQUIREMENTS

Cassava is well adapted to rainfall ranging between 1000 and 3000 millimeters per year but it requires good drainage. One day of flooding on heavy soils can destroy the crop. Cassava is, however, highly tolerant of drought. The plant becomes dormant in the dry weather. When rains resume, it draws on its carbohydrate reserve to produce new leaves and the plant again becomes productive. This crop is grown on a range of soils but it needs light, deep soils that will enhance tuber development. In Guyana, cassava is grown mainly on soils rich in organic matter, on loamy soils and on sandy soils.

CULTIVATION

LAND PREPARATION

Land preparation should be deep enough to accommodate the tubers of cassava. Since the crop cannot withstand water logged conditions, there should be adequate drainage. Soils should be ploughed and harrowed and adequate drains should be made. For lighter soils flat planting can be done. In heavier soils, however, ridging may be necessary to facilitate drainage.

PLANTING

The planting material for cassava is the stems of mature plants. The material may be planted immediately after harvest or can be stored for up to six months. If the material is to be stored it should be placed in bundles and stored in the shade.

Before planting, the material should be cut into pieces about 20-30 cm long. In order to control pests during the initial period of growth, planting material should be soaked in insectical solution for approximately ten minutes. The insectides recommended are Tria zophos (Hostathion) at a rate of 6 ml/gal water or Diazinon at a rate of 10mI/gal water. The cuttings should be planted vertically in the soil.
Cassava should be planted 0.9 m between rows and 0.9 m within rows

MAINTENANCE OF CULTIVATION

General Maintence

Drains must be properly maintained during rainy periods since cassava cannot withstand flodding or even very moist soil over prolonged periods.

Fertilizer Application

Most soils in Guyana are acid but cassava seems tolerant to these soils. As a general rule before applying fertilizers, the soil should be analysed to determine the types and amounts to be used. If a soil analysis is not done the following rates of fertilizer elements may be applied.

ELEMENT	RATE OF APPLICATION
Nitrogen	- 68 kg/ha
Phosphorus	- 100 kg/ha
Potassium	- 150 kg/ha

Weed Control

Weed control is important during the early stages because newly planted cassava grows slowly. For a good crop, weeds must be controlled during the first three to four months after planting.
During the course of production, cassava may need two to six hand weedings depending on the severity of the weed infestation.

Insect Pests of Cassava in Guyana

Cassava crops are grown mainly from stem cuttings in Guyana. Planted cuttings start to root from the soil-covered nodes, at the base of the axillary's buds and the stipule scars, some five days after planting. Two to four months after planting, storage roots start to develop by secondary thickening of a number of the adventitious roots.

Economical damage by diseases, pests and weeds of cassava is relatively moderate, although white flies can be a menace in some regions, if the problem is not identified early, and remedial action not implemented in a timely manner. Correct identification of the pest and an understanding of its behaviour, including its most vulnerable stages would provide insights into its management.

Care must be then taken if pesticide application is contemplated, since there is the likelihood of high residual levels remaining in the product after harvest if an inappropriate formulation is used.

The following provide a detailed description of the pests and the nature of the damage caused by the pests. Appropriate management strategies that may be employed are also provided.

1. Cassava Mealybug

(Phenococcus manihoti)
(Homoptera:Pseudococcidae)

In cassava and on Manihot spp, the pest causes leaf loss and weakens the stem planting material (Figure 1).

Symptoms:
Whole plant: dieback; dwarfing; seedling blight.

Leaves: abnormal colours; abnormal forms; abnormal leaf fall; wilting; yellowed or dead; honeydew or sooty mould; leaves rolled or folded.

Stems: witches broom; stunting or rosetting; dieback; distortion.

Roots: reduced root system.

Growing points: dieback; distortion.

Cultural Control:

- Integrated Pest Management
- Field sanitation
- Crop rotation

Fig 1. Symptom of cassava mealybug

Biological Control:
Use natural enemies such as predators, parasitoids and parasites e.g. ladybirds

2. White Flies

Bemisia tabaci
(Homoptera: Aleyrodidae)

Fig 2. Nymph and adult white flies

Sumptoms

These insects are in fact bugs. The adults are white, moth-like insects that fly upwards from the plant when disturbed. They are about 2 mm in length and their wings are covered with a white waxy powder (Figure 2).

The pinhead size nymphs are oval and flattened, and are attached to the leaf surface until maturity. All stages of this pest can be found on the underside of leaves. Nymphs and adults feed by sucking plant sap, resulting in leaves becoming mottled, yellow and brown before dying. Feeding whiteflies excrete honey dew on leaf surfaces which encourages the growth of sooty mould, thus hampering photosynthesis. Ants are also attracted to the honey due. This pest is also a vector of viral diseases. The life cycle may be completed in about 28-35 days.

Cultural Control:

- Do not plant a new crop next to one which is mature: The common practice of having mature crops adjacent to newly planted ones makes management of the pest very difficult since the cycle of the pest is never broken.
- An integrated control strategy is necessary for the effective management of this pest.
- Good farm sanitation, Including removal of weeds around the cultivation area is recommended since many weed species are hosts for white flies.

Chemical Control:

Several new generation insecticides are now available for the effective control of white flies. Targeting both nymphs and adults with *soap based products*, should be applied very early in the morning or late in the evening. Other chemicals which may be used include Admire, Pegasus and or Basudin/ Vydate L at 10 mls to 4500 mls water.

3. Aphids

Aphis gossypii
(Homoptera: Aphididae)

Symptoms

This pest attacks all roots and tubers. They are commonly known as “plant lice” or “nit” and are small, yellow, green or black pinhead-size insects (Fig 3). They are soft bodied, slow moving and multiply rapidly within a short time span.

These insects attack plants at all stages of growth and are usually found in dense clusters on the under surface of the young leaves and also on young tender stems and growing point. They suck plant sap and make the plant weak; some also act as vectors of plant diseases. Seedlings are weakened and killed when the infestation is high, and growth of older infested plants is retarded. Infested leaves curl, shrivel and may turn brown and die.

Aphids secrete a sweet substance known as “honey dew” while they feed. This substance attracts ants and serves as a substrate for sooty mould (black fungus) thus impairing photosynthesis.

The lifecycle ranges between 21-28 days.

Cultural Control:

- **Good field sanitation-** rid the field of weeds and plant residues from previous crops.
- Integrated Pest Management

Fig 3. Nymph and adult aphid

Biological Control:

- The natural predator, lady bird beetle frequently feeds on aphids. When aphid population is low and lady bird beetles are present, there is no need for chemical control.

Chemical Control:

- This may be applied when the population is high. A contact or stomach insecticide may be used such as: Fastac, Decis or Karate at 6mls to 4500mls water, Sevin 85% W.P. (Carbaryl) at 6grms to 4500 mls water or Malathion 57% E.C. at 15 mls to 4500 mls water.

N.B. Sprays should be directed to underside/surfaces of leaves. When Sevin or Malathion is used, crops should not be harvested until 7 -10 days after application of the chemicals. In the case of Fastac, Decis or Karate, crops can be harvested within 3-5 days after chemical application.

4. Thrips

(*Frankliniella williamsi*)
(Thysanoptera: Thripidae)

Symptoms

Thrips are yellow, tiny, elongated insects about 1mm in length and can be found on the upper and lower surfaces of leaves (Fig 4). Infestations are more severe in the dry season.
Both young and adult suck the sap from leaves and cause them to loose their colour (Figure 5). If attack occurs early, the young leaves become distorted. Older tissues become blotched and appear silvery or leathery in affected areas, thus hindering photo-synthesis. Flowers and fruits are also affected. Infected fruits are discoloured, distorted and hardened. Thrips are also vectors of major viral diseas. The lifecycle maybe completed in about 14-21 days.

Fig 4. Adult thrips

Fig 5. Damage caused by thrips

Cultural Control:

- **Good field sanitation-** rid the field of weeds and residues of all previous crops.
- **Crop rotation**- cultivation of crops (vegetables) which are not host to the pest.
- Overhead irrigation will help in reducing population of infestation during the dry season.
- An integrated approach is recommended for the management of thrips

Chemical Control:

- Among the insecticides which may be used are Regent (Fipronil), Admire, Abamectin and Vydate L at 5 mls to 4500 mls water, to both surfaces of leaves for effective control.

N.B. Spray should be directed to both surfaces of leaves for effective control.

5. Mites

(*Mononychellus tanajoa*)
(Acarina: Tetranychidae)

Symptoms

Mites are arachnids and are not insects (adults have four pairs of legs and two pairs of eyes). They are extremely tiny and appear as dust- like particles on the underside of leaves (Figure 6). Their colour ranges from red, translucent fawn to green. Eggs are laid on the underside of leaves and hatch beneath a web, which is spun by the adults.

Both immature and mature stages suck plant sap, resulting in leaves becoming yellow and eventually turning reddish.

Fig 6. Egg and adult mite

Cultural Control:

- **Good field sanitation-** rid the field of weeds and plants residues from previous crops.
- Integrated Pest Management

Chemical Control:

- During severe infestations chemical control may become necessary. Any miticide may be used for their control such as Abamectin, Newmectin or Vertimec at 5mls to 4500mls water.

6. Lace wing bugs

Croythaica cyathicollis
(Hemiptera: Tingidae

Symptoms

Lace wing bugs are usually found in clusters on the under surface of leaves. Adults are about 1.5 -3 mm in length and have characteristic lacy patterned wings (Figure 7). Their sucking action results in leaf mottling. The mottled areas eventually become necrotic and this leads to premature abscission of leaves. The life cycle lasts for approximately 28-35 days.

Fig 7.Lace wing bug

Cultural Control

- **Good field sanitation-** rid the field of weeds and plant residues from previous crops.
- Integrated Pest Management

Chemical Control:

- Decis, Karate or Fastac at 6 mls to 4500 mls water Sevin or Padan at 5gms to 4500 water are recommended for chemical control of Lace wing bugs.

7. Gall Midge

(Latrophobia brasiliensis)

Diptera:Cecidopmyiidae

Symptoms

The gall midges are tiny flying insects (Figure 8). The name is derived from their inciting gall formation by plants, attacked by larvae of some species. Most are plant feeders but some are carnivores. They feed on flowers/flower buds, fruit, developing seed and decaying material. Galls are mostly found on leaves, buds and stems. A large number also feed on fungi (and is sometimes beneficial to agriculture).

Fig 8. Larva & adult gall midge

Cultural Control:

- Where possible, plant in dry areas.
- Establish fields in open locations and space plants to allow adequate ventilation.
- Control weeds beneath and around plants.
- Remove all fallen leaves from fields, bury or burn.
- Colour traps present a potential tactic for monitoring or mating disruption. Along with bio-control and other tactics, they form the basis of an IPM programme.

Chemical Control:

- **Insecticides:** Sevin, Trigard, Diazinon, Admire, Malathion
- **Fungicides:** Manzeb, Maneb, Ridomil
- **Herbicides:** Fusillade, Roundup, Gramoxone, Nabu-S

8. Horn Worm

(Erinnyis ello)

Symptoms

Larvae grow quickly to a relatively large size of 3 to 5" long, and can devour cassava leaves in one to two days (the speed at which major damage can occur often takes farmers by surprise) (Figure 9).

Adult

Larval stage (caterpillar)

Feeding on leaves

Fig 9. Various stages in the life cycle of the Hornworm and damage caused

Hornworms can be found in all regions of Guyana year-round, because these caterpillars are heavily parasitized and a favourite of birds and toads.

Hornworm eggs are deposited on the upper or lower leaves of the plant and hatch in about seven days. The larvae feed on the plant leaves for about three to four weeks and develop into fat, green caterpillars about 5" long. The fully grown larvae eventually make their way down the plants and burrow into the soil where they transform into the pupal stage. Depending on weather conditions the moths emerge from the pupae within two to four weeks. The emerging moth makes its way to the soil surface and mates. The females begin to deposit eggs on the cassava plants for the next brood of hornworms.

Cultural Control:

- Hand picking tomato hornworms then squashing them is very effective.

Biological Control:

- Controlling breakout of these and other caterpillars can be achieved by spraying ***Bacillus thuringiensis*** **(BT)** on susceptible plants before caterpillars become a major problem. **Do not take any action if you find hornworms with something that looks like little fuzzy pieces of rice standing upright on the caterpillar's back**. These are the cocoons of the **braconid** wasp pupae. When these parasitic wasps emerge from their cocoons they will not only parasitize this caterpillar, but other insects as well.

9. Acoushi Ant *(Atta sp.)*

Acoushi ants are social insects, living in colonies (Figure 10), whose size may range, depending on the species, between a dozen individuals and several millions of individuals. There are at least three morphologically different forms: queens (fertile females), males and workers.

Acoushi ants display various major feeding strategies. Leaves are cut and transferred to the nest (Fig 11). Fungus growers consume fungi that are cultured in special nest chambers on leaf parts collected by workers.

Cultural Control:

- Integrated pest Management

Chemical Control:

- Baiting is the recommended method for Acoushi ant control (Bait is formulated and packaged by **NARI**).

Fig 10. Active acoushi ant nest

Fig 11. Leaf cutting in progress

Managment of Common Cassava Diseases in Guyana

1. Cassava Mosaic Disease (African Mosaic Virus)

Cassava mosaic disease is caused by a virus which occurs inside cassava leaves and stems.

Damage symptoms:

The leaves of cassava plants with the disease are discolored with patches of normal green color mixed with light green, yellow, and white areas (Figure 12). This discoloration is known as chlorosis. When cassava mosaic attack is severe, the leaves are very small and distorted and the plants are stunted. The disease symptoms are more pronounced on younger plants.

Method of spread:
The main sources of the virus which causes cassava mosaic disease are cassava plants with the disease and the whitefly *Bemisia tabaci*. The virus multiplies and occurs in large numbers in the leaves and stems. Cassava mosaic disease is also spread by planting stem cuttings from plants infected with the disease.

Cultural Control:

- Integrated Crop Management
- Field sanitation
- Crop rotation
- Use of disease free planting material

Do not introduce cuttings from the continent of Africa to Guyana

- If you suspect the disease is present, contact your extension officer immediately

Fig 12. Symptom of cassava mosaic disease

Chemical Control:

- Spray for whiteflies using Admire, Vydate L, Abamectin, Vertimec at the recommended rates.

2. Cassava Bacterial Blight (*Xanthomonas manihotis*)

Cassava bacterial blight is caused by a bacterium which occurs inside cassava leaves and stems.

Damage symptoms:
Initially, damage by cassava bacterial blight appears as water-soaked lesions. The lesions occur between leaf veins and are most evident on the lower surfaces of the leaves. The lesions are small, not completely round in shape, and have a few angles at their edges. These angular lesions later join together into larger patches killing the leaf blade as they enlarge.
The leaf blade turns brown with the water soaked area at the leading edge of the brown patch (Fig 13). This damage symptom is known as leaf blighting. Severely blighted leaves wilt, die, and fall causing defoliation and shoot tip die-back or complete death of the shoot. Leaf blight starts from the leaf blade and moves towards the petiole. Drops of brownish gum may occur on the leaves, petioles and stems of plants infected with cassava bacterial blight. The damage symptoms of cassava bacterial blight are more evident in the wet season. The disease is more severe in young plants.

Method of spread:
The main sources of the bacteria which causes cassava bacterial blight are cassava plants with the disease. The bacterium enters cassava plants through wounds and scratches on the stems and leaves. Insects can also transfer the pathogen to healthy plants. It multiplies and occurs in large numbers in the leaves and stems. Cassava bacterial blight is therefore spread by planting stem cuttings from plants with the disease symptoms. Dead cassava stems and leaves with the bacterium also serve as sources of the disease if they are not destroyed after root harvest.

Fig 13. Symptom of cassava Bacterial Blight

Cultural Control:

- Integrated Crop Management
- Field sanitation
- Crop rotation
- Use of disease free planting material

Chemical Control:

- Farm tools that are used to cut infected cassava plants should be cleaned with a bleach solution after use to prevent the bacterium on them from spreading to other plants.
- Use for vector control Fastac, Decis or Karate

3. Cassava Bud Necrosis

Cassava bud necrosis is caused by a fungus which occurs on the surface of stems and leaves.

Damage symptoms:
The disease appears as patches of a brown or grey fungal covering of the stem. The fungal matter covers buds which reduces their sprouting ability (Figure 14).

Fig 14. Cassava bud necrosis

Cultural Control:

- Integrated Crop Management
- Field sanitation
- Crop rotation
- Use of disease free planting material

Chemical Control:

- Spray a fungal solution for fungus control
- Farm tools that are used to cut infected cassava plants should be cleaned with a bleach solution after use to prevent the fungus from spreading to other plants.

4. Leaf Spot Diseases

Cassava leaf spot diseases are caused by fungi. There are three different types, namely **white leaf spot**, **brown leaf spot**, and **leaf blight**.

Damage symptoms:
Cassava white leaf spot *(Cercospora caribaea)* disease appears as circular white or brownish-yellow spots on the upper leaf surfaces (Figure 15).
Cassava brown leaf spot (*Cercospora henningsii*) disease appears as small brown spots with dark borders on the upper leaf surfaces. Under severe attack the infected leaves become yellow, dry, and die prematurely (Figure 15).

Cassava leaf blight *(Xanthomonas cassavae)* disease appears as light brown lesions on the upper surfaces of the leaves. The lesions enlarge to cover most of the leaf surface and cause leaf blighting. The blighted leaves lack water soaked areas, which are typical of leaf damage by cassava bacterial blight. Leaf blight lesions also lack the dark borders of brown leaf spots and they do not develop into shot holes" on the leaf surface (Figure 15).

Method of spread:

The main sources of the fungi that cause leaf spot diseases are infected cassava leaves. The fungi spread to new plants from this source by wind or rain. Leaf spot fungi can occur on weeds which then serve as hosts for the spread of the diseases.

Cultural Control:

- Integrated Crop Management
- Field sanitation
- Crop rotation
- Use of disease free planting material

Chemical Control:

- Spray a fungal solution
- Apply herbicide solution e.g. Gramaxone, Roundup or Karmex for annual and perennial weed control

Cassava white leaf spot
(Cercospora caribaea)

Cassava brown leaf spot
(*Cercospora henningsii*)

Cassava leaf blight
(Xanthomonas cassavae)

Fig 15. Leaf spot diseases of cassava

5. Cassava Root Rot Disease

Cassava root rot diseases are caused by various kinds of fungi living on or in the soil. The fungi occur mainly in soils that do not drain properly.

Damage symptoms:

The leaves on cassava plants affected by root rot disease turn brown, wilt, and the plant appears scorched. Root rot diseases kill both feeder and storage roots of cassava. The storage roots may swell unusually and develop light brown discoloration (Figure 16). The roots may give out a bad smell as they rot.

Fig 16. Symptoms of cassava root rot disease

Method of spread:
The important sources of cassava root rot fungi are soils, cassava root and stem debris contaminated with the fungi. The fungi enter cassava plant through wounds caused by pests or farming tools.

Cultural Control:

- Cassava plant debris in farms with the disease should be destroyed by burning.
- Integrated Crop Management
- Field sanitation
- Crop rotation
- Use of disease free planting material

Chemical Control:

- Farm tillage tools used in cassava farms with the disease should be cleaned after use with a bleach solution.
- Spray a fungal solution.

Harvest Maturity Indices

Time after planting is a commonly used index for determining when to harvest cassava. Roots are typically sufficiently well-developed beginning 6 to 7 months after planting. Harvest maturity is based on the root size desired by the market. Harvest may be delayed until market, processing, or weather conditions are favourable. However, as the roots age beyond a year, they become woody and fibrous. Several randomly selected plants,
representative of the entire field, should be harvested beginning 6 months after planting to determine the average root size.
Foliage senescence and lower leaf yellowing can also be used as an indication of harvest maturity. When the lower foliage is distinctly yellow and some leaves have dried up, it is likely the plants are mature enough for the roots to be harvested.

Harvest Methods
Harvesting cassava roots is usually done by hand and is easier when the soil is moist. Harvesting is also easier if planting is on ridges or in beds and in loose or sandy soils, rather than on flat ground and in clay or heavy soils. To facilitate lifting of the roots out of the ground, the main stem of the plant is usually cut back to a height of 30 cm to 50 cm (12 in to 20 in). The stem is used as a handle to lift the roots out of the ground (Figure 17). In light soils, the roots are slowly drawn from the soil by pulling the stems or with the help of a kind of crowbar. In heavier soils or during the dry season, harvesting usually requires digging around the roots to free them prior to lifting the plant. While lifting, care should be taken not to break the roots or split the skin. Wounded tissue is an entry point for decay causing micro-organisms.

Fig 17. A short section of the stem is used to lift cassava roots out of the ground.

During the dry season, the upper parts of the cassava plant should be removed several weeks prior to harvest. Removing the vegetative growth will lengthen the shelf life by several weeks. This may be attributed to partial root curing and skin thickening while still in the soil.

After the roots have been pulled out of the ground, they are removed from the base of the plant by hand. Care must be taken during the harvesting process to minimize damage to the roots. Mechanical damage incurred by the roots during harvest will result in higher amounts of postharvest moisture loss and secondary decay. Cassava roots usually start rotting from the neck, which is the point of attachment of the root to the mother plant.

Harvesting the roots with a short section of the stem still attached may prevent spread of decay into the root. Cassava should be graded in the field and any unmarketable, damaged, or diseased tubers should be discarded. Damaged roots are highly susceptible to decay, particularly if the postharvest curing is inadequate. Loosely adhering soil should be removed from the root surface at the time of harvest. Cotton or soft fabric gloves work well to facilitate field cleaning of the roots. The cassava should be gently placed in strong wellventilated field containers for transport out of the field. Wooden crates or strong plastic containers are much better field containers than sacks or reed baskets, which can cause significant root skinning during transport (Figure 18). The roots should be taken to a shaded area prior to loading on a vehicle for transport out of the field. When locally made containers have sharp edges or rough inner surfaces, an inner liner made from fiberboard or foam can be used to protect the roots from abrasions during handling.

Fig 18. Cassava roots put in reed field containers often suffer considerable skinning.

Curing

Roots intended for storage should be properly cured immediately after harvest. Curing improves potential market life by reducing water loss and lowering the incidence of decay during storage. Curing is a process in which the skin thickens and new tissue forms beneath the surface in injured areas of the root. Non-cured cassava will deteriorate faster and lose more weight than properly cured roots. The injured tissue must heal quickly to avoid disease-producing organisms entering the root. The curing process should begin as soon as possible after digging. However, curing will not be effective on roots with extensive damage.

Cassava can be cured outdoors if piled in a partially shaded area (Figure 19). Cut grasses or straw can be used as insulating materials and the pile should be covered with canvas, burlap or woven grass mats. Curing requires high temperature and high relative humidity (RH), and this covering will trap self-generated heat and moisture. The stack should be left undisturbed for about four days.

Cassava can also be cured inside a protected structure at ambient temperature, provided the (RH) is high. Wetting the floor or using a small electric humidifier can obtain a high RH.

Fig 19. Preparation of an outdoor pile of cassava for curing.

The optimal conditions for cassava curing are 26.5°C to 29.3°C (80°F to 85°F) and 90% to 95% RH for 4 days immediately following harvest. The temperature should not exceed 35°C (95°F) nor should the RH be so high (i.e. 100%) that moisture condensation occurs on surface of the cassava roots. Cassava should never be washed prior to curing and/or storage, as this will likely result in severe decay. The roots should be stored in bins or crates, and washed only prior to packing for market.

Storage

The simplest means of preserving cassava is to delay harvesting and allow the roots to remain in the ground. However, cassava roots will become fibrous and woody with prolonged in-ground storage time and flavour may be impaired. Also, the longer the roots remain in the ground the more risk there is of insect, disease, or rodent attack.

Harvested roots can also be stored in the ground buried in trenches or holes filled with a sand/soil mix at 15% moisture. It is necessary to keep these in-ground storage areas protected from heavy rain. Roots will typically lose about 20% of their original starch content after 2 months stored underground.

Above-ground clamp silos are low-cost structures that generally work well for cassava storage. Roots are piled up on a layer of straw in conical heaps weighing between 300 kg to 500 kg (600 lb to .5 tons). The pile is covered with straw and soil and openings should be left for ventilation. It is possible to store cassava for up to 4 weeks without significant weight loss or decay (Figure 20).

Another method of storing cassava is to place them in wooden crates containing damp sawdust. However, if the sawdust is too moist it promotes fungal growth and if it is too dry the roots deteriorate quickly. Lining the crates with perforated plastic prevents dehydration of the sawdust, resulting in a storage life of about 1 month.

Fig 20. Cleaning and weed removal around cassava storage structure.

Cassava roots treated with the fungicide thiabendazole can be stored for 3 weeks inside perforated plastic bags at ambient temperatures. Keeping the roots inside plastic bags also reduces the incidence of vascular streaking.

Various types of above-ground storage structures can be built for extending cassava postharvest life. The structures should be located in shaded areas free from standing water during heavy rains. A simple storage facility can be constructed from unfinished wooden planks painted white to reduce heat accumulation and covered with a thatched roof for protection against the sun and rain.

The structure has a large door on one side for loading and unloading. It is designed for holding between 1 to 2 tons (1000 kg to 2000 kg) of cassava. A brick or concrete floor is recommended for permanent storage buildings and the structure should have a large door for loading and unloading. A tin or shingled roof is ideal, and the structure should have good ventilation. The doors should be secured against rodent entry and theft.

Postharvest Temperature

Refrigerated storage may not be an economical, viable method for extending the postharvest life of domestically marketed cassava, but is typically necessary for roots intended for high-value export markets. Fresh cassava roots are highly perishable at normal air temperatures, often becoming unmarketable after several days to a week.

However, with proper handling, cured roots can be stored for at least several months, permitting export by sea container. The recommended temperature for maximizing cassava storage life is 2°C (36°F). Sound roots can be stored for up to 4 to 5 months at this temperature. Cassava is susceptible to chilling injury, but can be stored between 0º C to 5º C (32° F to 41° F) with minimal symptom development.

Relative Humidity

Cassava should be stored at a high RH in order to minimize weight loss and root shrivel. Ideally, the storage atmosphere should be maintained between 90% to 95% RH.

Preparation for Market

Cleaning/Washing

The surface of the cassava should be sufficiently cleaned to meet market expectations. For the domestic Guyanese market, excess soil should be removed from the cassava surface with a soft brush or cotton gloves. Cassava destined for export should be cleaned by carefully submerging the roots in a tank of clean water sanitized with 150 ppm hypochlorous acid (household bleach) and maintained at a pH of 6.5. The water in the
tank should be replaced frequently as dirt and debris will quickly accumulate.

Grading/Sorting

Following cleaning, the roots should be graded according to size, shape, and amount of defects. Remove all cut, cracked, diseased and unattractive roots to make the package as attractive as possible. Good quality cassava should be smooth, firm, fairly straight, and uniform in shape and size. In addition, the roots should be free from mechanical damage, decay, and vascular streaking. The pulp should be a uniform white or light yellow, depending on the cultivar. Grades are based on freedom from defects, size, shape and uniformity. Export markets typically prefer large sized roots, between 15 cm to 25 cm in length (6 in to 10 in). Root lengths in excess of 30 cm (12 in) are undesirable to many importers.

Waxing

Dipping the roots in melted paraffin wax at 51.5°C to 52.5°C (125°F to127°F) for one second adds a smooth thick surface coating to the root. This coating helps reduce root moisture loss and extends market life for up to 2 months. It also improves the external appearance of the root and reduces discolouration of the vascular tissue. A wax treatment is highly recommended for export market destined cassava roots. It is essential that the
root surface be completely dry prior to the paraffin wax application. After waxing, the roots are typically packed immediately for export. Waxing and holding at 0°C to 5°C (32°F to 41°F) can extend shipping time to over several months with minimal occurrence of vascular streaking.

Packaging

After waxing, the cassava roots should be placed in a clean, strong, well-ventilated carton. If the cassava is not waxed, the surface of the root should be thoroughly dry prior to packing. Wet or damp roots will develop surface mould. Cassava is typically packed loose inside the carton. Wrapping alternate roots with soft paper may provide additional protection. Some importers in the U.K. prefer cassava packed in dry coconut fiber or
sawdust, but due to phytosanitary reasons, this practice is not allowed for exports to the U.S. Net carton weights are typically 18.2 kg or 20.5 kg (40 lbs or 45 lbs) depending on the market and importer requirements. For marine shipments, an additional 5% packing.