



Ministry of Blue and Green
Economy, Agriculture and
National Food Security

TECHNICAL MANUAL

SMALL SCALE CASSAVA PRODUCTION in DOMINICA





**Ministry of Blue and Green Economy,
Agriculture and National Food Security**

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Foreword

The production and processing of cassava are increasing in Dominica. A growing migrant population that consumes the fresh tubers, development of value added products and improvements to agro processing plants by the Government of Dominica are fueling this increase. However, in Dominica like across the Caribbean, the commercial expansion of cassava is impeded by the high cost of production.

This manual - Small Scale Cassava Production in Dominica - is an output of the Caribbean Development Bank (CDB) and the Food and Agriculture Organization of the United Nations (FAO) funded project “Cassava Industry Development-Market Assessment and Technology Validation and Dissemination” (GCP/SLC/010/CDB). It is a guide for the sustainable and profitable production of cassava. Detailed in the manual are the best practices farmers should adopt across the cassava production value chain to achieve improved yields and increase their competitiveness.

The information presented draws on research findings nationally, regionally and internationally as well as the experiences of the Farmer Field Schools conducted under the project.

This manual is a valuable resource for farmers and all stakeholders involved in the development and expansion of Dominica’s cassava industry. Expanding production and processing of cassava have the potential to become significant income earners and raise the standard of living of people involved in the industry.



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Abbreviations and Acronyms

CARDI	Caribbean Agricultural Research and Development Institute
CARICOM	Caribbean Community
CDB	Caribbean Development Bank
CIAT	International Centre for Tropical Agriculture
FAO	Food and Agriculture Organization of the United Nations
HACCP	Hazard Analysis and Critical Control Point
IPM	Integrated Pest Management
MoBGEANFS	Ministry of Blue and Green Economy, Agriculture and National Food Security
PPE	Personal Protective Equipment



1.0 Cassava - a 21st century crop with unlimited potential

Cassava (*Manihot esculenta*), also known as yucca, manioc and tapioca, is one of the most popularly cultivated root crop in the Caribbean. Production is done mainly by small farmers, a few of whom have shifted to mechanization. In Dominica, however, the crop is cultivated on a small scale using traditional methods.

Globally, cassava is the third most important source of carbohydrates or food energy after maize and rice.

Governments of the Caribbean Community (CARICOM) have identified the development of the cassava industry as an opportunity to effectively respond to the region's food security and nutrition challenges. While the crop is not widely traded within the region or with international trading partners, the development of the cassava industry presents tremendous opportunities to Dominican and Caribbean stakeholders.

About the plant

Cassava belongs to the Euphorbiaceae family. It is a perennial, woody shrub which grows from 1 m to 5 m in height. Depending on the variety, the tubers (roots) are ready for harvesting in 8 to 14 months but can remain in the soil for up to two years. In the Caribbean, the plant is grown mainly for human consumption of its starchy roots.

Unlike most tropical crops, cassava can thrive and still produce reasonable yields on nutrient poor soils with little or no inputs. However, research has shown that by adopting good agricultural practices, optimal yields are attainable.

Cassava can tolerate drought conditions, making it an ideal crop to grow in the Caribbean's changing climate. Cassava production has a lower carbon footprint when compared to other crops. Among the major staples, cultivated cassava is found to be the least sensitive to climate change and can withstand natural disasters such as hurricanes as its storage roots are underground. The plant however, cannot tolerate waterlogged conditions for more than a few days.

Nutritional value

Cassava roots have a high starch content making them a rich source of dietary energy.

Nutritionally, the roots contain significant amounts of vitamin C, thiamine, riboflavin and niacin. They are also a good source of calcium, iron, potassium, magnesium, copper, zinc and manganese. The nutritional content of the roots is comparable to that of many legumes.

Compared to other tropical crops, cassava produces carbohydrates most efficiently. Cassava is also gluten free, making it an ideal food for persons with celiac disease and gluten intolerance. These qualities, coupled with the fact that cassava produces reasonable yields with little or no inputs, makes it a model crop for achieving food security.

Cassava industry development

Cassava has the potential to substitute for a significant proportion of CARICOM's imports of intermediate inputs used in food



manufacturing such as corn (for animal feed), wheat (consumer food applications) and malt (for brewing). Governments have identified the development of the cassava industry as an opportunity to improve food and nutrition security, improve livelihoods and reduce poverty in the Region. It is estimated that developing the cassava industry will contribute to reducing the region's food import bill by as much as 10 percent (Ford, 2015).

Across the Caribbean, fresh cassava continues to be used in traditional cooking. Its application in value added product development is however, growing and today this multipurpose crop is being processed into flour, breads, pancake mixes, drinks, cereals, and a range of sweet and savoury snacks.

The leaves, roots and stems can also be processed into pellets, chips and meal and used as animal feed.

The growing global US\$12.9 billion plant-based food market provides a massive opportunity for cassava-based food products (Ewing-Chow, 2019). With the rise in gastronomy tourism, and more tourists seeking out immersive experiences, the development of a 'farm to fork' enterprise, based on cassava as a key ingredient, is a worthwhile venture.

Industrially, starch and bioethanol can be derived from the cassava plant, and for Dominica with its thrust to become the first climate resilient country, these can present significant opportunities. Starch is used in the agri-foods industry as a binding agent in food and beverage applications, to treat water, and to produce paper, textiles and bioplastics.

Value-added product development can give rise to several agro-based enterprises that have the potential to become important income earners and raise the standard of living of people involved in the industry.



Cassava Field.



Cassava tubers. Photo credit: CARDI



2.0 Cassava production in Dominica

Cassava has always been an important crop among the indigenous Kalinago people of Dominica. Traditionally, the crop has been grown along the southeast coast of the island in the communities of Kalinago Territory, Petite Soufriere, San Sauvier, Morpo, Tranto, Di Pax and Castle Bruce. Production has now extended to areas such as Grandbay, Delice, Boetica, Woodford Hill and Calibishie. Cassava contributes significantly to livelihoods in rural areas, although the quantities produced and exported are small compared to other root crops. A Caribbean Agricultural Research and Development Institute (CARDI) survey in 2019 showed that the crop provided between 75 to 100 per cent of income for 39 per cent of its producers. Another 38 per cent of producers made between 25 to 74 per cent of their income from the crop.

The crop is usually grown in pure stands on sloping land in plots of one quarter of an acre or less.

Cassava is grown in a traditional manner and linked to phases of the moon. Cultivation is done year-round and the crop is rain fed.

Initially, the bitter varieties of cassava were more widely cultivated in Dominica. However, recently, sweet cassava varieties have become more popular in response to consumer concerns about hydrogen cyanide content in cassava products. The CARDI survey also showed that Dominicans were cultivating equal acreages of sweet and bitter cassava.

Cassava is grown primarily for producing farine and cassava bread. The bread is a flattened, round, toasted product made of one hundred per cent grated cassava. Sweet / fresh cassava is seldom cooked and eaten as a staple food by locals. However, the growing numbers of Hispanics and Haitians in Dominica have created an increased demand for fresh cassava for cooking purposes.

Cassava varieties

Cassava varieties are classified as 'bitter' or 'sweet' depending on the levels of hydrogen cyanide (HCN) they produce. The 'bitter' varieties have a glucoside content > 100 mg/kg fresh weight whereas the 'sweet' varieties have a glucoside content < 100 mg/kg fresh weight (Alves, 2002).

Both sweet and bitter varieties are cultivated in Dominica. Over six local varieties are available for cultivation and can be obtained from other farmers and the Ministry of Blue and Green Economy, Agriculture and National Food Security (MoBGEANFS). Four improved, high yielding varieties (CM 3306-4; CM 3064-4; CM 6119-5; and COL 1522) obtained from the International Centre for Tropical Agriculture (CIAT)¹ are being evaluated by CARDI and the MoBGEANFS. Once completed, the better adapted varieties will be added to the existing gene pool.

¹ The importation of the varieties into Dominica as ready-to-plant tissue culture materials was facilitated through CLAYUCA Corporation (Colombia) and funded by the project Cassava Industry – Market Assessment and Technology Validation and Dissemination (GCP/SLC/010/CDB).



3.0 Growing conditions and land preparation for cassava production

Growing conditions

Dominica is ideal for growing cassava because of its tropical climate, volcanic soils, sloping land and abundant rainfall.

Soils

Cassava grows best in sandy or clay loam soils. The crop will grow within a pH range of 4.6 to 8, but a pH of 5.5 to 7.5 is best. Farmers should avoid soils that become waterlogged during wet periods.

Soils in Dominica are reasonably fertile and productive. They are closely related to the geology and topography of the island, and are broadly classified as proto soils, allophanoid soils, kandoid soils, smectoid clays and alluvial soils.

For large-scale cassava production, farmers need to do regular and continuous testing of the soil. The results of these tests will provide the data needed to develop and put in place a programme for maintaining the soil's fertility. Given that the soil type in areas where cassava is grown is primarily kandoid, it is best if farmers add plant nutrients to the soil in split applications during the crop cycle to maintain fertility. Kandoid soils are deep, freely drained, friable and readily erodible.

Contact the MoBGEANFS to perform a soil test before preparing the soil and planting.

Rainfall

Rainfall in Dominica is high and varies according to location. The mid-western coast has the least annual rainfall of below 1,250 mm while the east coast has 2,500 mm or more. Rainfall of 980–1524 mm (39-58.5 inches) annually is needed for adequate growth and development of cassava. In Dominica, annual average rainfall is adequate for cassava growth and development, and so irrigation is not required.

High rainfall can be a problem. The combination of high temperature and humidity tends to increase pests and diseases, leading to declining productivity. Cassava cannot tolerate waterlogged conditions. It encourages rot - a major obstacle to good yields. High rainfall also accelerates leaching of nutrients from the soil and a decrease in soil fertility.

While cassava can tolerate drought conditions, long periods without water at important stages of growth will result in lower yields.

In Dominica the rainy season is from June to October and the dry season starts in February and ends in May. The crop can be grown throughout the year. The best time to plant cassava is at the start of the rainy season to obtain robust plants and optimum tuber yields.



Temperature

Night temperatures between 20°C (68°F) and 30°C (85°F) encourage root (tuber) formation. However, the temperature should not fall below 15°C (58°F) during the first six months of the plant's growth.

Land preparation

Good land preparation is essential for the best development and easier harvesting of undamaged tubers. Land preparation involves site clearing, ploughing and preparing ridges or mounds for planting.

Site clearing

The site selected for planting should be cleared of unwanted vegetation. The type of vegetation present will determine the method used to clear the land. If there are large trees and woody shrubs, they will have to be cut down and removed from the land. The roots of these plants should also be removed. For small plots (1/4 acre or less), manual land preparation can be done using brush cutters, lawn mowers or a cutlass.

An approved contact or systemic herbicide can be used to kill weeds and grasses. Later on, an approved pre-emergent herbicide can be applied just prior to planting to kill germinating weed seeds. Always use Personal Protective Equipment (PPE) when handling chemicals.

In an environment-friendly, sustainable production system, unwanted vegetation should be managed without the use of herbicides or burning.

Ploughing

Ploughing breaks up the soil clods and exposes insect larvae and pupae, nematodes and weed seeds to the sun. The sanitising effect of the sun's rays will reduce pest, weed and disease pressures on the soon to-be-established crop. Ploughing also brings nutrients isolated in lower soil horizons higher up to the plant root zone.

Always plough deep enough to break up the subsoil. It is important to always plough along the contour, as this conserves topsoil and increases infiltration. This also improves drainage, which is important, as the crop cannot tolerate waterlogging.

A motorized tiller or tractor drawn implements can be used to plough the soil. For small scale operations, a hand fork can be used to break up the soil.

Forming ridges and furrows

Cassava grown on ridges and furrows are less prone to damage than those grown on flat land. Ridges are recommended as they facilitate easier harvesting of the crop. Ridges can be formed mechanically (motorized tiller or tractor drawn implements) or manually (hand fork). They should be 45 to 60 cm (18-24 inches) high and spaced 1 to 1.5 m (3-4.5 feet) apart.

Planting on unraised flat land is only recommended when the soil is deep and well-drained as with sandy loam soils.



Did you know?

The MoBGEANFS as well as private service providers can be contacted to do mechanical land preparation. Farmers will need to budget for this, when using private service providers as it is a paid service. Ideally, you should schedule this service 2 to 3 months in advance to avoid undue delays.



Manual land clearing.



Ploughing breaks up the soil clods.



Ridges and furrows facilitate easier harvesting of cassava tubers.

Photo credits: U.N.I.T.E



4.0 Varieties, planting material and planting

Cassava varieties

Both the 'bitter' and 'sweet' types of cassava are grown in Dominica. The varieties present on the island have not been characterized. As indicated earlier, four new varieties introduced from the Gene Bank at the International Centre for Tropical Agriculture (CIAT) are currently being evaluated by CARDI in close collaboration with the MoBGEANFS. These varieties are high yielding and possess desirable processing characteristics. Upon completion of the evaluation, the most adaptable, high yielding varieties will be added to the cassava gene pool of Dominica, further improving the ability of the cropping systems to survive and thrive.

Selection of planting material

In Dominica, like across most of the Caribbean, cassava is grown from cuttings. Using high quality planting material is one of the keys to a successful crop. The parent plant from which you take the planting material should be healthy, free of pests and diseases and high yielding. The use of infected planting material for commercial production can lead to widespread outbreaks of diseases from one cropping cycle to the next.

Stakes (cuttings) should be taken from healthy plants that are growing well and are between 8 to 18 months old. Always obtain planting material from reliable sources such as other farmers, the MoBGEANFS or research organisations.

The stakes from the parent plant must be cut using a sharp, clean cutlass, a handsaw or secateurs. Always handle stakes with care, as their quality can rapidly deteriorate due to bruising and

peeling. Wounds are pathways for the entry of pathogens and loss of moisture.

If the harvested stakes are not going to be prepared immediately for planting, they should be stored in a cool place away from direct sunlight. Dehydrated stakes will result in poor germination. It is good practice to store these stakes in an upright position with the base of the stems resting in the soil. The soil around the base of the stems should be moistened regularly. Ideally, stakes should not be stored for more than 5 days.

Preparing the planting material

When you are ready to plant, cut the stakes into smaller pieces (cuttings), approximately 20-30 cm (8-12 inches) long, with an average of 9-12 nodes (eyes). A minimum of 4 nodes is recommended. The diameter of the cutting should be at least 2 cm thick. Always use a clean, sharp pair of secateurs (or handsaw / cutlass) to prepare the cuttings. Take care to avoid damaging the eyes (nodes) or bruising the peels of the stakes.

Cuttings can be taken from the head, middle or lower part of the stem. However, cuttings from the middle part of the stem are best. Do not use green stems as they are soft and can become easily dehydrated. Also do not use older, woodier parts of the stems because they lack the food reserves necessary to support good growth. It is a good practice to group cuttings according to the parts of the stem they were taken.

The cuttings should then be dipped in an insecticide / miticide solution for 5-10 minutes and air dried before planting.



Choose stakes from healthy parent plants. Photo credit: U.N.I.T.E



Cuttings should have well developed eyes (nodes). Photo credit: C. Kesharie



The diameter of the cuttings should be at least 2cm thick. Photo credit: C. Kesharie



Before planting cuttings should be treated in an insecticide/miticide solution. Photo credit: U.N.I.T.E



Plant stakes at a 45° angle along the contour. Photo credit: U.N.I.T.E

Always use approved chemicals and prepare them according to the manufacturers' instructions. When handling chemicals always use personal protective equipment (PPE).

Planting

Always plant the cuttings within two days of treatment. Planting is done manually by placing the stakes into the soil vertically, horizontally or at an angle on flat or ridged beds.

In Dominica, cassava is planted 3 feet by 3 feet (90 cm x 90 cm) at an angle on the ridge, along the contours. At least two nodes should be above ground when planted. The buds must always face upwards.

In some other Caribbean territories, farmers use mechanization to plant and harvest. The planter is attached to the tractor to plant mechanically. This is ideal for large acreages and where the land is flat or the slope of the land is gentle to undulating.

If you are going to plant both the bitter and sweet varieties, you should plant them in separate plots. Cassava can be grown throughout the year in Dominica, but the best time to plant is at the start of the rainy season.

Other propagation methods

Cassava can also be propagated by the mini-stem technique and by tissue culture. In Dominica, while these methods are seldomly used, they are recommended for obtaining large amounts of clean planting materials for supply to farmers.



Mini-stem technique

The mini-stem technique uses small stem pieces. This means that a single cassava stem will provide more planting material than the conventional method. This method makes good use of planting material and is common in areas where planting material is in short supply.

A 3-foot (90 cm) single stem with 80 to 100 intact nodes will normally produce 3 plants, each 30 cm long with the conventional method. However, the same stem will produce 40-50 two-node cuttings or 20-25 four-node cuttings using the mini-stem technique.

Cut as many 2-4 node stem pieces, or mini-stems, from healthy cassava plants between 8 and 18 months old. Put the selected stem pieces to sprout in seedling trays, propagation bins, nursery beds or polythene bags. This will take 2 to 4 weeks. A foliar spray can be used to provide major and minor nutrients to enhance plant growth. From time to time, examine the young leaves for pests and diseases, identify any infestation or damage, and use appropriate control measures.

Mini-stem cuttings sprouted in bags without soil can be planted directly into the field after 7 - 10 days.

Tissue culture

Plantlets generated by the tissue culture method will provide a large quantity of clean (free of insects, mites and pathogens) planting material of consistent quality.

Tissue culture refers to the production of cassava plantlets resulting from the growth of cells from the apical meristem or shoot tip of the cassava plant. This is done under controlled and hygienic conditions in test tubes (*in vitro*) in a laboratory. Eventually, the plantlets are weaned and hardened under a Saran netting shed to ensure that they are properly rooted, growing well and properly acclimatized before distribution to the farmer for planting in the field.

Dominica does not have tissue culture laboratories but has excellent nursery facilities for weaning and hardening of plants produced from tissue culture materials. The tissue culture facilities at Orange Hill Station in St. Vincent and the Grenadines store a selected germplasm collection (*in vitro*) and accept orders for young plants.



2-node cuttings in nursery.
Photo credit: CARDI



Tissue culture cassava plantlets.
Photo credit: Ministry of Agriculture, Land and Fisheries, Trinidad and Tobago.



5.0 Soil and water management

Cassava grows best on loose, friable (easily crumbled between your fingers) soils with an abundance of available nutrients. These soils give the roots enough room and nutrients to grow and expand.

Soil testing

After the planting site has been selected, the first step is to get your soil tested. The MoBGEANFS offers a soil testing service. This test will provide details on the pH and the nutrients available for growth.

Soil pH is the measure of acidity or alkalinity of the soil. The pH scale goes from 0 to 14 with pH 7 as the neutral point. Soil pH is an important consideration, as it influences the availability of nutrients.



A soil test is recommended before land preparation. Photo credit: U.N.I.T.E

Cassava can grow over a wide pH range, however the most ideal is between 5.5 and 7.5.

A simple soil test will determine the soil pH, and this will guide the soil and fertilizer treatments. Soils with a pH of less than 5.5 are

acidic and the recommended practice is to incorporate limestone into the soil during land preparation to increase the pH to an acceptable level.

Liming the soil

Limestone is applied to soils, usually during land preparation (between 3 months and up to two weeks prior to planting) to raise the pH. The soil test will guide the type and rate of application of limestone to the soil.

Liming the soil reduces the uptake of aluminum and iron, which can be toxic to cassava. It also provides calcium for proper cell wall formation that enables good bacteria to decompose the soil's organic matter, thereby making nutrients more available for plant growth.

Organic matter

It is not a common practice to add organic matter to soils for cassava cultivation in Dominica. However, once they are available you can mix them into the soil to improve its texture and fertility. Other advantages of adding organic matter to the soil include:

- improved water retention;
- improved soil health as it decomposes;
- an increase in the water holding capacity of the soil; and
- a reduction in the rate at which the soil loses water and regulates its temperature.

If you are using animal manure, you need to allow it to cure or break down properly before application or it can burn the plant.



Soil erosion

Most of the lands where cassava is grown in Dominica are gently sloping. To conserve soil and prevent erosion, you must always plough and ridge on slopes along the contour, rather than up and down the slope. This will slow the rate of water flow down the slopes, conserve topsoil and increase water infiltration.

Water management

Due to an adequate amount of rainfall on the island, irrigation is not necessary. Cassava cultivation in Dominica can be entirely rain fed.

While cassava can tolerate drought or water scarcity, it is important that the crop has adequate moisture at crop establishment and for the first 3 months to facilitate proper root and shoot growth and tuber formation.

Given that climate change is already exacerbating drought conditions across the region, investing in some simple cost-effective technologies will ensure water is available when it is needed most by the crop. These include:

- Using tanks or other non-porous containers to collect rainwater, usually from roofs or structures which cause the water to cascade due to gravity.
- Building ponds close to the production area, ideally with pond liners to prevent water from leaking out of the catchment area.

If you decide to irrigate the crop, then do a cost/benefit analysis, as cassava is a low resource crop and the cost for setting up such

a system can be prohibitive. The most cost-efficient systems for cassava are drip irrigation or fountain tubing. Overhead irrigation systems are a poor choice because the thick canopy of the plant can lead to high evaporation of the water before it gets to the soil.

Two other strategies you can use to conserve soil moisture are mulching and intercropping.

Mulching

Organic mulch such as hay or live mulch such as peanuts can improve the water availability to the cassava plant. Mulching can also regulate the solar radiation penetrating the soil, thereby lowering soil temperature, reducing wind velocity, reducing evaporation from the soil and increasing relative humidity.

Intercropping

Intercropping is the growing of two or more crops in the same field at the same time. Intercropping adds to agro biodiversity in the fields, contributes to sharing of nutrients between crops and helps in weed suppression.

Intercropping is not practiced in Dominica, but elsewhere it has been used quite effectively to conserve soil moisture, enhance soil fertility and also provide an income stream to farmers while they await maturity of the cassava crop. Research is needed to identify the best complementary crops for cassava in Dominica. In other parts of the world, maize, beans and selective herbs were suitable intercrops at the start of the cropping cycle.



6.0 Nutrition Management

Cassava can grow on nutrient-poor soils where other crops fail. Because of this, many farmers often opt out of fertilizing the crop. However, to achieve the best yields, it is recommended that you use fertilizer treatments. Healthy plants produce higher yields and are more resistant to pests and diseases.

Cassava uses large quantities of nitrogen (N), and potassium (K) and smaller quantities of phosphorous (P), calcium (Ca) and magnesium (Mg) from the soil. It is important you replace these, especially when cassava is being grown repeatedly on the land.

The results of the soil test will guide the type of fertilizer to be used and the rate of application. A pH test is also very important, since the pH affects the nutrient availability to the plants. The MoBGEANFS will conduct the soil test. The extension officers will provide the technical assistance required to interpret the results and guide the development of the fertilizer regime.

Acidic soils

If the soil test reveals the soil has a pH of less than 5.5, then it is too acidic and limestone can be applied to raise the pH. By reducing acidity, soil nutrients become more available to the plants. Extension officers will determine the rate of application of limestone based on the test results. Limestone must be applied during land preparation - from 3 months to at least two weeks before planting

Inorganic fertilizers

Generally, fertilizers are applied in split applications at planting or shortly thereafter and then at approximately 90 days after planting when the cassava reaches maximum growth.

At planting, or up to 5 days after planting, is the best time to apply the first fertilizer treatment. The fertilizer should be placed 4 cm from the plant and 6 cm deep. It must be covered with soil to prevent volatilization of nitrogen and loss through run off and erosion.

The second fertilizer application should take place approximately 90 days after planting. Here, a fertilizer high in potassium should be used to promote root bulking. Potassium helps to mobilize the sucrose produced in the leaves and transfer it to the tubers where it is converted to starch. This treatment should be applied approximately 15 cm from the base of the plant.

Some points to note:

- A soil test will help you decide on the type of fertilizer required and its rate of application.
- Do not fertilize the crop with extra nitrogen, as this can cause excessive leaf growth at the expense of tuber formation.

Organic fertilizers

Manure and compost can also be added to the soil to improve its structure, water holding capacity, fertility and biological activity.



The rate of application will be guided by the soil test. If using animal manure, ensure that it is properly cured or broken down so that the plants are not burnt.

Intercropping

Intercropping of cassava is not practiced in Dominica. However, because cassava establishes and grows slowly, farmers in other parts of the world have used the space between plants to cultivate a variety of short-term crops. Crops that have been shown to be complementary to cassava are legumes, maize and some vegetables. The critical success factor here is that the intercrops don't shade the growing cassava as tuber growth can be negatively impacted.

Suitable intercrops will provide nutrients, control weeds and provide farmers with an additional income stream as they await the cassava crop.

Research is needed to identify the suitable crops that can be profitably intercropped with cassava in Dominica.



Intercropping of cassava, St Lucia. Photo credit: CARDI



*First fertilizer application takes place at planting or within 5 days of planting.
Photo credit: U.N.I.T.E*



*Second fertilizer treatment takes place, 90 days after planting.
Photo credit: U.N.I.T.E*



*Organic matter must be well cured before use.
Photo credit: U.N.I.T.E*



7.0 Weed management

Weeds are plants that grow where they are not needed. They compete for nutrients, space, water and light, which often lead to poor growth and yield of the crop. They also serve as alternate hosts for pests and diseases.

The initial growth rate of cassava is very slow. This, together with the wide spacing between stakes, provides ideal conditions for weed growth. In cassava production, weed management is critical during the first 3 to 4 months of the crop.

Adopting an Integrated Weed Management Strategy

To effectively and sustainably control weeds, it is best to adopt an integrated weed management strategy. This involves the combination of manual, mechanical, chemical or cultural methods to manage weeds.

Some basic strategies to effectively control weeds are:

- Always practice good sanitation. Ensure all clothing, machines, tools and equipment are cleaned and free of soil and debris. Weed seeds attach to these surfaces and as a result they can be easily transferred from field to field.
- Always remove weeds before they start to flower and produce tiny seeds in very large numbers, which facilitates rapid spread. This prevents the weed population from becoming uncontrollable.
- Understand the life cycle and reproductive habits of the weeds in your field. Some weeds such as water grass (*Commelina spp*) and pig weed (Purslane) grow vegetatively (from pieces). If a weed whacker is used to control their

growth, the farmer can inadvertently be giving rise to many new plants.

- Nut grass has thickened underground storage roots, which provide food reserves that allow regrowth if the plant is not uprooted and removed from the field.
- Vines or twining plants should also be removed by uprooting as they can wrap around the cassava plant and smother it.

Weed management strategies - Pre-planting

Early weed management is important, as it is a determining factor in the success of your crop. It is good practice to leave the soil exposed after tilling and allow weed seeds to germinate. These can then be removed by physical or chemical means. A broad-spectrum herbicide can be effective.

Sometimes a pre-emergent herbicide can be applied prior to planting. This prevents weed seeds present in the soil from emerging, or at least reduce their growth.

Weed management strategies - Post-planting

After planting, closely monitor your fields and actively remove weeds. Weeds grow vigorously and if left uncontrolled they will out compete the crop. It is recommended that weed management be continued up until the crop is able to outcompete the weeds.

It takes between 3 and 4 months for the cassava canopy to close up. At this stage, the plants can block out the sunlight and more effectively compete with the weeds for water and nutrients.



If there is a weed problem at harvest time, but the crop is thriving, weed management can be a waste of time and money.

In small scale production systems, weeds can be removed by hand pulling, hoeing and through the use of a weed whacker. The selected method would be influenced by the growth habit of the weed. Hand pulling and hoeing are the most common methods when the weed population is low and labour is cheap.

In large scale production systems, and when labour is expensive, chemical control may be the most cost-effective option. Always exercise caution, as incorrect use can be harmful to you, the crop and the environment. Always use chemicals under the guidance of your plant protection officer or extension officer.

Cassava is a broad leaf crop and during crop growth, depending on the type of weeds in the field, a selective or broad-spectrum

herbicide may have to be used. Always place a shield over the nozzle of the spray-can when using a broad leaf herbicide or broad-spectrum herbicide. This will prevent the chemical from drifting onto the crop.

Tips for successful chemical control

- Always wear personal protective equipment (PPE).
- Spray early in the morning or late evening.
- Never spray under windy conditions or when heavy rainfall is expected.
- Always consult your plant protection officer or extension agent to select an approved herbicide.
- Check and calibrate your spray can.
- Always read your labels and follow the manufacturer's instructions for mixing, application, storage and disposal.



*Some weeds are best controlled by uprooting and destroying.
Photo credit: U.N.I.T.E*



Place a shield over the nozzle of the spray-can to prevent chemical from drifting onto the crop. Photo credit: CARDI



8.0 Pest and disease management in cassava

A pest is anything that negatively affects the growth, development and productivity of a crop. Pests that affect cassava range from insects, mites, bacteria, fungi, and viruses to rodents, nematodes and weeds.

In Dominica, cassava is affected by few pests and diseases, but this is expected to change as a result of production intensification and climate change.

Major pests of cassava

It is best that you adopt an Integrated Pest Management (IPM) approach to control pests thus avoiding overreliance on chemicals. IPM refers to the management of pests by using a suitable combination of compatible methods and practices. These include

cultural practices, biological, physical, mechanical and chemical control methods. The IPM approach emphasizes the use of non-chemical control methods and only relies on chemicals when other methods have been ineffective. Over time, pests develop resistance to specific chemicals such that they provide little to no control. IPM aims to ensure that you get the best possible returns from an effective pesticide while protecting the environment.

Before you can effectively manage pests, it is important that you accurately identify them and decide on the best control strategy. Plant protection officers will assist you with accurate pest identification and guide the development and execution of an integrated pest management strategy. A list of major pests of cassava is given in Table 1.

Table 1. A list of the major pests of cassava.

Overview of Pests	Signs/Symptoms	Control
<p>SHOOT FLIES (<i>Silba chalybea</i>, <i>Silba spp.</i>)</p> <p>Shoot flies damage the tips of the young plant.</p> <p>Attacks occur year-round, but heavy infestations are common at the start of the rainy season.</p> <p>Yields can be decreased by 30% when infestation is high.</p>	<p>Growth of the plant is stunted.</p> <p>Apical dominance is destroyed resulting in the growth of lateral shoots.</p> <p>Damage caused by the feeding larvae is detected by the presence of white to brown exudates.</p>	<p>Shoot flies are managed by natural enemies such as parasitic wasps in the field.</p> <p>Practice good field sanitation.</p> <p>Crop rotation can break the cycle of shoot flies.</p> <p>At low populations, infested plants can be rogued from the field.</p> <p>In heavy infestation use an approved, systemic insecticide.</p> <p>Having flowering plants near the field can increase the population of beneficial natural predators.</p>



Overview of Pests	Signs/Symptoms	Control
<p>CASSAVA MITES</p> <p>Mites are tiny arthropods that suck the juices from the leaves and growing tips of the shoots.</p> <p>Mites are commonly found on the lower surface of the first 5-10 upper leaves, green stems and buds.</p> <p>Mite infestation is most severe in the dry season. When infestation is heavy, farmers can experience 20% to 80% loss in yields.</p>	<p>Leaves develop yellow spots described as 'pinpricks', and have a mottled, bronze, mosaic appearance.</p> <p>Leaves get smaller, internodes are shortened, and plants are stunted.</p> <p>Severe infestation may cause leaves to fall, shoots lose colour and stems develop scars.</p> <p>Fine webs may be visible on the deformed leaves.</p>	<p>Crop rotation can break the life cycle of the pest.</p> <p>Use of clean planting material, removal of infested plants and spraying of plants with water during the dry season are effective cultural practices.</p> <p>Insecticidal soaps and oils and environmentally friendly chemicals can also be applied to manage mites.</p>
<p>GALL MIDGES</p> <p><i>(Latrophobia brasiliensis)</i></p> <p>Tiny flies called midge flies usually cause galls.</p> <p>Commonly found on the upper surface of the leaf where they lay their eggs.</p> <p>The larvae cause abnormal cell growth, leading to galls being formed.</p>	<p>Galls are generally found on the upper surface of the leaf where the flies lay their eggs.</p> <p>Galls are yellowish green to red in colour and are conical in shape.</p> <p>Severe outbreaks retard the growth of the plant; leaves yellow and roots may thin and become fibrous.</p>	<p>Gall midges are of little economic importance and generally do not require control.</p> <p>The use of resistant varieties as well as collection and destruction of affected leaves at regular intervals may help to reduce pest presence.</p>
<p>CASSAVA THRIPS</p> <p><i>(Corynothrips stenopterus)</i></p> <p>Thrips are tiny, yellow insects found mainly on the growing points of the plant.</p> <p>Most of the damage is done in the dry season and yield reduction can range between 5% to 30%.</p>	<p>Nymphs feed on the leaf veins and stems resulting in chlorotic (yellow) spots.</p> <p>The space between the leaves may become shorter with the plant becoming bushy in that area (like the appearance of Witches Broom).</p>	<p>Crop rotation can be used to break the life cycle of the pest.</p> <p>Use clean planting material.</p> <p>Remove infected plants from the field once detected.</p> <p>Insecticidal soaps and oils as well as environmentally friendly chemicals can be used to control thrips.</p> <p>Natural enemies such as ladybirds and spiders feed on thrips. However, they can be impacted by toxic pesticides.</p>



Shoot fly damage. Photo credit: C. Kesharie



Gall Midges. Photo credit: C. Kesharie



Thrips damage. Photo credit: Ministry of Agriculture, Land and Fisheries, Trinidad and Tobago.



Leaf wilt caused by Cassava Bacterial Blight. Photo credit: Rob Williams (CABI)



Major diseases of cassava

Currently, diseases don't cause severe losses to the cassava crop in Dominica. However, as intensification of crop production increases so to will disease pressures. Climate change is also expected to have an impact on the occurrence and spread of diseases.

As with pests, you should adopt an integrated approach for management of diseases. The key is to avoid overreliance on chemicals. Farmers must always strive to maintain a healthy agro-ecosystem. Critical components of an effective integrated disease control strategy are the use of clean planting material, choosing tolerant varieties, crop rotation to suppress pathogens and removal of infected plants and weeds. Healthy plants are always more resistant to pests and disease; so you should always focus on effectively managing the nutrition of the crop as well. A list of major diseases of cassava is given in Table 2.

Table 2. A list of the major diseases of cassava.

Overview of Disease	Signs/Symptoms	Control
<p>CASSAVA BACTERIAL BLIGHT (CBB) <i>(Xanthomonas campestris, pv. manihotis)</i></p> <p>This disease is spread by infected cuttings, mechanically by raindrops, use of contaminated farm tools, chewing insects, movement of man and animals through plantations.</p> <p>Yield loss ranges from 20-100%.</p>	<p>Characterized by spots on the underside of the leaves that appear as angular wet areas.</p> <p>A heavy attack causes defoliation and stems and roots show brownish discolouration in susceptible varieties.</p> <p>During periods of high humidity, bacterial oozing can be observed.</p>	<p>The management of CBB is mainly through cultural practices such as crop rotation. This is especially important since bacterial spores can remain in the ground for 2 years.</p> <p>Use clean planting material.</p> <p>Removal of infected plants from the field and using resistant varieties are also effective.</p>
<p>ANTHRACNOSE <i>(Glomerella cingulata)</i> (teleomorph); <i>(Colletotrichum gloeosporioides)</i></p> <p>This disease is caused by a fungus and usually appears after long periods of rainfall.</p>	<p>Characterized by the presence of leaf spots.</p> <p>There is partial or total drying of the affected tissues.</p> <p>The pathogen attacks the green stem producing cankers and die-back.</p>	<p>Cultural practices such as pruning to increase and improve airflow between the trees as well as removal and destruction of diseased portions of plants (through burning or deep burial), and crop rotation can help reduce inoculum levels.</p> <p>Fungicidal treatments.</p> <p>Use resistant varieties.</p>



9.0 Harvesting and post-harvest handling of cassava

In Dominica, cassava is grown on a small scale and harvesting is done manually.

Depending on the variety and its intended use, cassava is harvested between 6 to 18 months after planting. However, the harvesting period can range from 6 to 24 months. If not harvested at maturity, cassava roots may lose valuable starch, rot or become woody. Leaving the roots in the ground also exposes them to rodent attack.

Some physical signs that the crop is ready to be harvested:

- Yellowing and dropping of the lower leaves.
- An increase in the size of the tubers which crack the top of the soil.

Manual harvesting

Prior to harvesting, the stems of the plants are cut back, leaving 30 to 50 cm above ground. The stem is used to pull the tubers from the ground. If the soil is too hard or compact at harvesting, it is best to loosen the soil around the plant using a garden fork.

Next, hold the stem and gently pull the roots out of the ground. In some countries a manual hand lifter is used to lift the tubers from the soil.

Do not jerk or drag the tubers as this can cause bruising, cuts and breakage. Wounds such as these will lead to loss of moisture and provide pathways for entry of oxygen and pathogens, which lead to spoilage.



Cutting back trees for easy harvesting.

Photo credit: Ministry of Agriculture, Land and Fisheries, Trinidad and Tobago.

After uprooting, the cassava roots should be separated from the stem using a clean, sharp knife or cutlass.

Store roots in a cool spot and take them away from the field as soon as possible. It is important to minimize the exposure of tubers to field heat, as high temperatures can lead to deterioration of the crop as a result of high respiration and moisture loss. Therefore, the harvested tubers should be taken to the market or packing house as soon as possible.

Mechanical harvesting

In some Caribbean countries where large scale production occurs, farmers have modified mould board ploughs and even chisel ploughs to harvest cassava. These can penetrate and lift the soils so that tubers can be easily extracted.

Private enterprises have also invested in commercial harvesters. The mechanical harvester cuts, digs and raises up the soil



containing the roots. The main advantage of this method is it is cheaper and faster than manual harvesting.

Packing and transporting tubers

It is best to use harvesting crates to pack and transport the tubers from the field. Crates are durable, well-ventilated, easy-to-sanitize and many are stackable. If they are being stacked, ensure there is sufficient room between the crates for ventilation. The main drawback of the crates is that they are expensive.

When packing, it is good practice to sort the tubers. Tubers that are damaged, rotting or showing signs of pest and disease attack should be placed in separate crates from the undamaged ones. The damaged tubers can contaminate the wholesome tubers.



*Transporting cassava in harvesting crates minimizes compression damage.
Photo credit: U.N.I.T.E*

While sacks and baskets are much cheaper and widely available in Dominica, improper use leads to compression damage.

The harvested roots should be taken to the market or packing house as soon as possible.

Post-harvest handling

Harvested cassava deteriorates rapidly. Post-harvest handling must maintain the quality of the tubers while extending their

shelf-life. Physiological deterioration is the main cause of losses after harvesting cassava. This usually manifests as a bluish/blackish discolouration in the roots known as vascular streaking. It is caused by loss of moisture and the entry of oxygen through wounds on the tubers. Vascular streaking results in the roots becoming unpalatable and unmarketable.



*Vascular streaking reduces the quality of cassava tubers.
Photo credit: Ministry of Agriculture, Land and Fisheries, Trinidad and Tobago.*

Washing

Washing is an important operation as it removes the soil from the roots. Wash gently to prevent damage to the peels, as wounds are a pathway for entry of microorganisms and oxygen, as well as loss of moisture.

Tubers should be placed in a chlorinated dip after washing for 60 to 90 seconds. The chlorinated dip is made of 150 parts per million (ppm) – chlorine and water. After, the tubers should be rinsed in clean potable water to remove any chlorine residues from the surface of the crop.

Storage

In Dominica, cassava is either sold at the market fresh or to processors. If there is no ready market, the tubers can be stored at temperatures ranging between 41°F and 45°F (5°C to 7°C) with a relative humidity of 85% to 90%.



10.0 Value-added product development

Cassava roots contain approximately 65 per cent water, making it very easy for them to spoil. If not consumed, properly stored or processed within 2 to 4 days after harvesting, rotting occurs.

Value-added technologies are processes for transforming the crop from its raw state to various products, which increase its shelf life. Value-added processing also makes this bulky crop easier to transport, reduces the cyanide content and improves its taste.

In Dominica, the Kalinagos pioneered the processing of the crop. While they still do so, processing is also now done by many small-scale processors operating cottage industries scattered throughout the island. Farine and bread are the most popular value-added cassava-based products on the island. However, as the popularity and production of the crop increases, so to will the opportunities for developing other value-added products.

Presently, tubers are peeled, washed and cut into logs and chunks, vacuum packed and sold at supermarkets. Flour is also produced on a small scale. Cassava flour is gluten-free and can replace imported wheat flour in cooking and baking. Across the region, cassava flour is widely combined with other flours to make bread. Here, cassava and other traditional flours replace the wheat flour in recipes.

The fresh tuber is also grated and transformed into several savoury and sweet snacks such as khaki. Cassava is also fermented as a beverage.

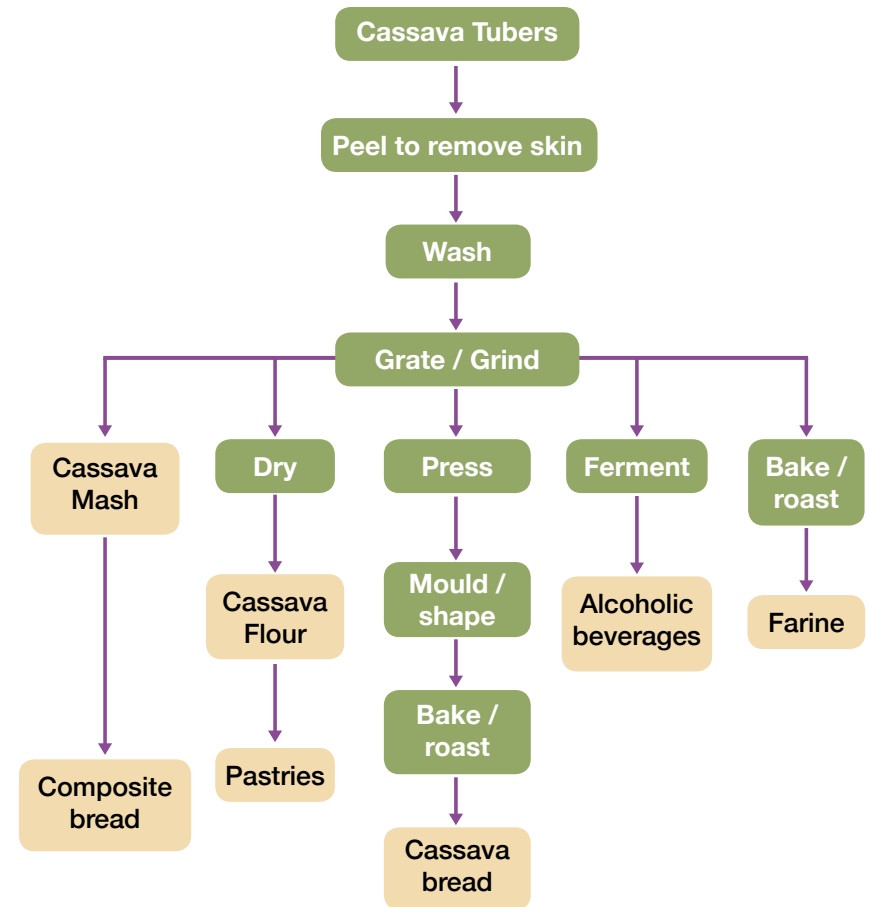


Figure 1. A diagram representing a typical small-scale processing line for popular cassava products



New opportunities

Cassava has the potential to substitute for a significant proportion of CARICOM's imports of intermediate inputs used in food manufacturing such as corn (for animal feed), wheat (consumer food applications) and malt (for brewing), among other uses.

Across the Caribbean, cassava continues to be used in traditional cooking. In terms of value-added product development, this multipurpose crop can be processed into flour, breads, pancake mixes, drinks, cereals, and a range of sweet and savoury snacks. The leaves, roots and stems can also be processed into pellets, chips and meal and used as animal feed.

Industrially, starch and bioethanol can be derived from the cassava plant and with Dominica's thrust to become the first climate resilient country, these can present significant opportunities.



Farine production. To propel the industry, local agroprocessors must be trained in food safety. Photo credit: U.N.I.T.E.

Starch is used in the agri-foods industry as a binding agent in food and beverage applications, to treat water, and to produce paper, textiles and bioplastics. With bans being imposed on single-use plastics and styrotex containers across the Caribbean, bioplastic products present another unique opportunity that is yet to be explored.

Value-added product development can give rise to several agro-based enterprises that have the potential to become significant income earners and raise the standard of living of people involved in the industry.

However, to ensure the manufacture of quality products, small scale processors will require access to capital and the requisite training in areas such as Hazard Analysis and Critical Control Point (HACCP) practices, Good Manufacturing Processes, Food Safety and Handling, and Financial Management.



Cassava Man a local entrepreneur has added a variety of fillings to cassava bread in Dominica. Photo credit: Cassava Man (Facebook).



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SMALL SCALE CASSAVA PRODUCTION in DOMINICA



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