Sweet Potato Technical Manual

CARDI Root and Tuber Commodity Group

CARDI

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Caribbean Agricultural Research and Development Institute (CARDI)

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Acronyms

ac	acre
ACP	African, Caribbean and Pacific Group of States
ACP-EU	African, Caribbean Pacific – European Union
AVRDC	Asian Vegetable Research and Development Center
BADMC	Barbados Agricultural Development and Marketing Corporation
CARDI	Caribbean Agricultural Research and Development Institute
CARICOM	Caribbean Community
CIP	International Potato Center
cm	centimeters
CMV	Cucumber Mosaic Virus
CTA	Technical Centre for Agricultural and Rural Cooperation
DAP	Days After Planting
EC$	Eastern Caribbean Dollars
EU	European Union
EurepGAP	Eurep Good Agricultural Practices
fl. oz	fluid ounce
ft	foot or feet
ft^2	square feet
g	gram(s)
gal	gallon
ha	hectare
IITA	International Institute for Tropical Agriculture
in	inch(es)
IPM	Integrated Pest Management
kg	kilogram(s)
KONARC	National Research Council for Kyushu and Okinawa
lb	pound(s)
l	litre(s)
m	metre(s)
m^2	square metre(s), metre(s) squared
mm	millimeter
NPK	Nitrogen, Phosphorus and Potassium
^{o}C	degrees Celsius
^{o}F	degrees Fahrenheit
oz	ounce(s)
pH	Measure of acidity and alkalinity
PPM	Parts Per Million
SPCFV	Sweet Potato Chlorotic Fleck Virus
SPCSV	Sweet Potato Chlorotic Stunt Virus
SPFMV	Sweet Potato Feathery Mottle Virus
SPMSV	Sweet Potato Mild Speckling Virus

SPVG	Sweet Potato Virus G
SRC	Scientific Research Council
t	tonne(s)
UK	United Kingdom
US	United States
USA	United States of America
USDA	United States Depart ment of Agriculture
UWI	University of the West Indies
Vit	Vitamin
WI	West Indies
yd	yard(s)

Conversion table

Metric	**Imperial**
Length	
1 millimetre (mm)	0.03937 inches (in)
1 centimetre (cm)	0.3937 inches (in)
1 metre (m)	1.0936 yards (yd)
Area	
1 hectare (ha)	2.4711 acres (ac)
Volume	
1 litre (l)	35.195 fluid ounces (fl oz)
1 gallon (gal)	4.5461 liters (l)
Weight	
1 gram (g)	0.0353 ounces (oz)
1 kilogram (kg)	2.2046 pounds (lbs)
1 tonne (t)	0.9842 ton (t)

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Preface

This Technical Manual is intended to provide producers with guidelines for cultivating sweet potato, *Ipomoea batatas* (L.) Lam., a crop with growing importance within the Region. Recently, many countries have embraced this commodity as a substitute for imported cereals and grains and for attaining national food security goals. The crop is also an important income earner for many rural families and a foreign exchange earner for countries. As such, there is a growing demand for the commodity.

This manual provides a comprehensive overview of the production and marketing aspects of sweet potato. The information presented is from a combination of sources including results of research and development activities conducted by the Caribbean Agricultural Research and Development Institute (CARDI).

The various sections were written by scientists from the CARDI root and tuber commodity group, a multidisciplinary team which continues to generate, validate and transfer technologies to improve the competiveness of sweet potato and the livelihood of producers and other key stakeholders along the value chain.

It is hoped that this publication will provide current and potential producers with practical information that will assist in increasing production and productivity of the crop. It is also hoped that there will be an expanded view of sweet potato by industry stakeholders; from being a primary product to one with huge potential for value addition.

Thanks to Rohan McDonald (Agricultural Officer - Tissue Culture, Ministry of Agriculture, Forestry and Fisheries, St Vincent and the Grenadines) who provided invaluable technical information. CARDI also acknowledges the many staff members who assisted in developing this Sweet Potato Technical Manual. The authors, reviewers (Bruce Lauckner, Claudette de Freitas, Opal Morris, Raeann Beckles), designer (Elizabeth Hamilton) and other technical personnel too numerous to mention.

CARDI extends thanks to the Technical Centre for Agricultural and Rural Cooperation (CTA) which provided funding for this technical manual (2-6-21-102-9) as part of its support to improving the Institute's outreach and communication.

Introduction

Great potential exists for the development of the sweet potato industry in the Caribbean. Sweet potato is particularly attractive as a crop because of its adaptability to different growing conditions and low susceptibility to natural disasters like hurricanes which plague the Region. The growing market potential for the crop, as it is now recognised as a health food with significant antioxidant and antimicrobial properties, has also contributed to its attractiveness.

Sweet potato is grown throughout the Caribbean, in the main by small farmers, usually on marginal land. Productivity is below the agronomic potential of the crop and there is limited export and crop diversification. These observations are attributed in part to the generally poor agronomic practices conducted by producers and the high incidence of pests which result in inconsistent quality of the harvested crop. Poor market intelligence and the limited knowledge of market opportunities and the potential uses of the crop are also contributory factors.

Developing a sustainable and competitive industry therefore requires a significant increase in the production and productivity of the crop. The generation, validation and transfer of suitable technologies and the strengthening of services to support industry development are therefore critical.

Towards this goal, stakeholders within the industry have identified several research and development interventions which are necessary for industry development. These include: the conservation of local landraces, an improved knowledge of the agronomy of the crop, identification of suitable pest management strategies, improved post harvest handling and storage systems, value added product development and an assessment of the market opportunities of the crop.

This manual seeks to provide information that will assist producers and other key stakeholders along the value chain to improve the productivity and production of sweet potato. The manual is presented with respect to the value chain and provides information relating to the critical components of marketing, input supplies, production, harvesting, post harvest handling, fresh market and value addition.

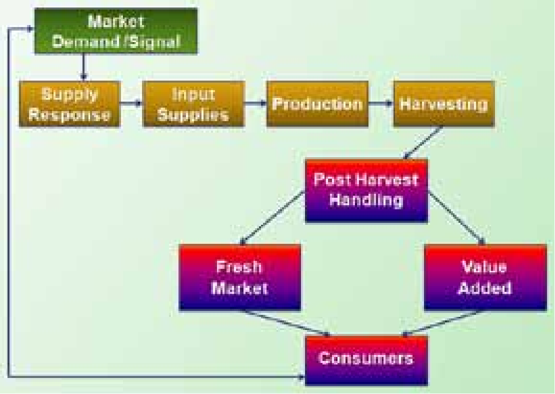


Figure 1: Value chain

The sweet potato crop

Botanical description

The sweet potato, *Ipomoea batatas* (L.) Lam. is a dicotyledonous herbaceous trailing vine which is the only economically important member of the family Convolvulaceae. The plant is generally characterised by starchy, succulent and tuberous storage roots; alternating palmately lobed leaves and medium-sized sympetalous flowers which grow individually and vary in colour from white to varying degrees of purple.

The plant is a perennial but is grown as an annual by vegetative propagation using either storage roots or stem cuttings. Its growth habit is predominantly prostrate with a vine system that rapidly expands horizontally on the ground. The types of growth habit of sweet potatoes are erect, semi-erect, spreading and very spreading. There are several hundred varieties with varying forms and growth habits. The most dominant forms have twining and trailing long stems of slender to moderate thickness and moderately to widely spaced leaves.

Origin and distribution

Available archaeological, linguistic and historical evidence indicates that the sweet potato originated in or near Central America and northwestern South America. The greatest diversity of sweet potato germplasm is in Columbia, Ecuador, Guatemala and Peru. The crop is grown in several countries globally, but production primarily occurs in tropical and sub-tropical areas where it is an important staple in the diets of many people.

Ecology

The crop is highly adaptable and is able to grow in a wide range of agro-ecological zones. It grows best in the tropics between 40° north and 32° south. Temperature, light, rainfall, soil and altitude are the main environmental factors that affect the growth and development of the plant. Optimum growth requires mean temperatures of 24 °C (75 °F) or above, 750 - 1250 mm (30 - 50 inches) of rainfall, abundant sunshine and moist nights. The plant is better adapted to seasonal variations characterised by wet and dry seasons rather than by warm and cold seasons.

Crop growth cycle

The sweet potato plant has three growth phases which are more or less distinct. The initial phase is characterised by slow vine growth and rapid growth of adventitious roots. The first 20 days of this initial phase are important as they determine the total number of storage roots formed. An intermediate phase follows where there is the rapid growth of vines and an increase in leaf area as well as storage root initiation. By 100 days after planting (DAP), the leaf area is at its maximum and any further increase in biomass is due to storage root formation. The deposition of starch within storage roots can occur as early as 8 DAP and storage root formation can be visible as early as 28 DAP. By 49 DAP, 80% of the storage roots can be identified. At the final stage there is bulking of the storage roots, which can reach a maximum after 90 days. Storage roots enlarge throughout the life of the plant but after 120 days enlargement peaks. It should be noted that most of the growth phases are controlled genetically (i.e. variety) and environmentally (i.e. agro-ecological conditions of the area where the crop is established).

Marketing and supply response 2

Introduction

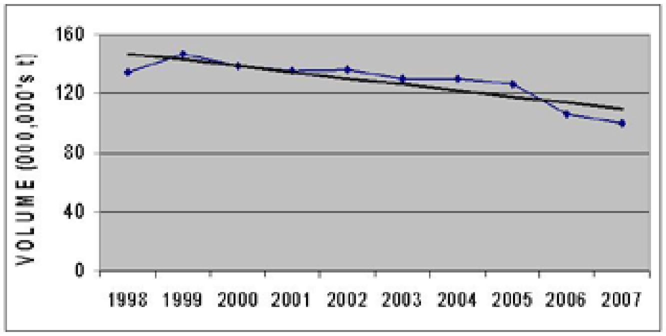
To successfully compete in contemporary agrifood markets necessitates effective marketing strategies. In the 21st century, a farmer cannot rely on planting a crop hoping to find a market at harvest time. There must be a paradigm shift from a production-oriented agricultural sector to a market-oriented sector so that Caribbean farmers are able to exploit the numerous opportunities offered in the global marketplace.

Aligning fresh produce chains to the needs of consumers/customers and developing a system that is responsive to changing customer needs is a must for success in today's competitive business environment. In the case of sweet potato given the multiplicity of varieties grown in the Caribbean and their numerous uses, clearly identified markets are a must before production commences. Sweet potato uses, include convenience food, snacks, puree as an additive to soups and baby foods, nutraceutical, animal feed, as well as a staple food in many diets. Varietal selection for specific use and targeted market is of critical importance.

2.1 Sweet potato production

World overview

Global sweet potato production decreased over the 1998 - 2007 period (Figure 2). The production level in 2007 is approximately 20% lower than in 1998. The top three sweet potato producers for the period were China, Nigeria and Uganda. In 2007, China produced 78% of the world's sweet potatoes.



Source: FAOSTAT

Figure 2: World production of sweet potato (1998 – 2007)

Caribbean overview

The statistics for the Caribbean as a whole for sweet potato production are not readily available from any one source; however, using multiple sources Table 1 provides an illustration of production in 2006. World production for 2006 was 105 million tonnes (104 million tons). Caribbean production was only 0.03% of world production.

2.2 Markets

The U.S.A. market is not open for sweet potato produced in the Caribbean, consequently the main developed countries' markets available are Canada and the European Union (EU). Figure 3 illustrates the importation of sweet potatoes to the EU for 2002 - 2008. Over the period, imports displayed an increasing trend with an increase of close to 200% over the seven year period.

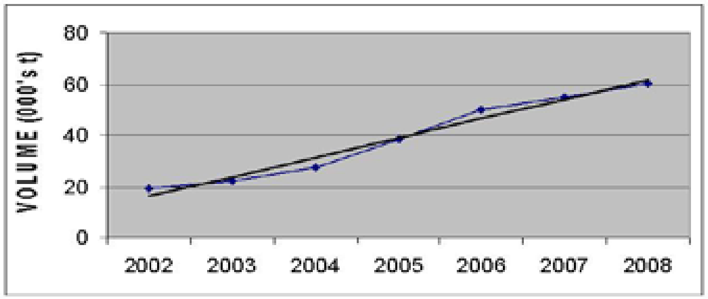
The top three exporters of sweet potatoes to the EU in 2008 were United States, Israel and Honduras. It is important to note that Honduras has only recently embarked on the production of sweet potatoes for export, as a diversification crop, and in less than 10 years they have become the third largest exporter to the EU. In 2008, the top three countries exported a total of 50,680 tonnes (49,879 tons) of sweet potato or approximately 89% of the imports to the EU.

During the period under review the UK, a country with which most CARICOM states have a long history, was the largest importer in the EU. Figure 4 provides an illustration of the UK imports for the period 2002 - 2008. As can be observed from the graph, UK imports increased for the period, with the 2008 volume being approximately 260% more than the 2002 volume.

Jamaica is the only CARICOM state that has consistently exported sweet potatoes to the UK. Figure 5 illustrates UK sweet potato imports from Jamaica for 2002 - 2008.

Table 1: Caribbean sweet potato production (tonnes) for 2006

COUNTRY	PRODUCTION Tonnes (t)
Jamaica	27.5
Barbados	2.2
St. Kitts/Nevis	0.3
Dominica	0.3
St. Vincent & the Grenadines	1.6
Trinidad & Tobago	0.5
Total	**32.4**

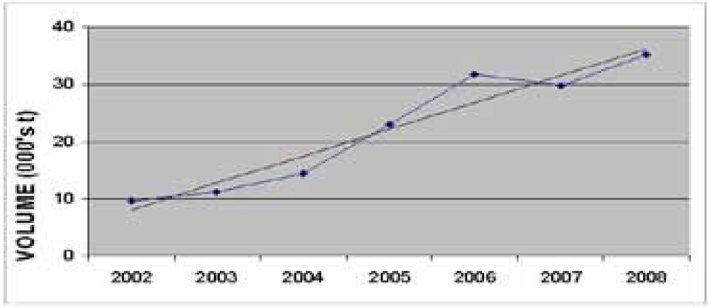


Source: Market Access Database

Figure 3: EU sweet potato imports (2002 - 2008)

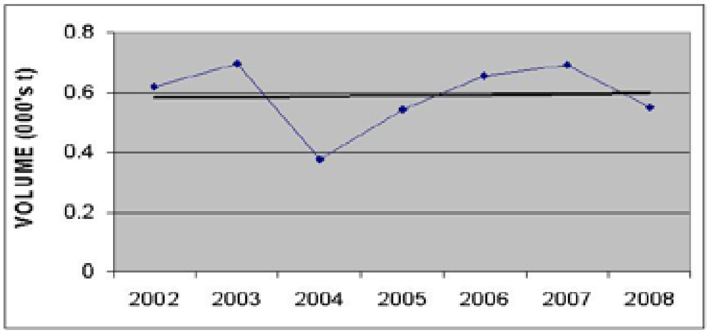
EU market

Caribbean sweet potato suppliers to British retail chains must comply with EurepGAP standards. Issues such as maximum residue levels and traceability are critical. In addition, many supermarkets in developed countries have implemented private standards of which small producers in the Caribbean must be aware. As consumers become more health conscious, greater emphasis is placed on consuming natural high nutritional foods. Orange flesh cultivars of sweet potato, containing a high concentration of carotenoids, a precursor of vitamin A, are a regular feature on contemporary supermarket shelves.



Source: Market Access Database

Figure 4: UK sweet potato imports (2002 – 2008)



Source: Market Access Database

Figure 5: UK sweet potato imports from Jamaica (2002 - 2008)

2.3 Marketing

2.3.1 Building the market plan

There are many different markets for sweet potato including fresh or processed; domestic, regional and extra-regional. The requirements of different markets vary widely.

Building a market plan for sweet potato requires a clear identification of the targeted market. The use of the product in the targeted markets can be fresh, value added or industrial (e.g. animal feed, starch). In the Region the major market is for fresh produce consumption.

2.3.2 Guidelines for marketing

An indepth assessment of the markets should be conducted to assist the producer to select production systems which are appropriate for market penetration and sustainability.

The following pointers are offered to Caribbean sweet potato growers attempting to penetrate regional and extra-regional markets:

- Identify the target market
- Determine the volumes required by the market including possible changes in production volumes over time
- Identify the buyer(s)
- Determine the volumes the buyer is willing to take and the frequency of purchase
- Determine and follow the guidelines of the buyers. They know the targeted market segment (i.e. varieties, production and post-harvest practices inclusive of packaging required)
- Build strong relationships along the value chain

- Produce consistently high quality sweet potatoes at competitive prices
- Ensure that quantities produced are sufficient for the market
- Keep abreast of the changes in the requirements of the market, as they are dynamic. As such, it is also important to link into a market system which provides updated market intelligence information

3 Germplasm selection

Globally, great strides have been made to breed sweet potato varieties to meet the wide range of requirements of products for which they are utilised. China, Japan and the USA are leaders in this area. There have been few breeding and selection efforts in the Caribbean.

Within the Region, most introductions of sweet potato varieties were obtained from the United States, the International Potato Center (CIP), the Asian Vegetable Research and Development Center (AVRDC) and the International Institute for Tropical Agriculture (IITA). In addition, landraces have been selected and conserved. Some of these landraces have also been collected by the international centres and characterised, conserved and included in their breeding programmes.

Selection and evaluation of local and introduced clones in the Region have been conducted by farmers, the Ministries of Agriculture, and other institutions, such as, The University of the West Indies (UWI) and the Caribbean Agricultural Research and Development Institute (CARDI).

Currently there are germplasm collections in a few countries within the Region, some of which have been evaluated and characterised. Activities within the Caribbean have focused on identifying the best clones to meet fresh market demands and more recently the processing market. However, the characterisation and nomenclature of landraces in the various Caribbean countries, is still in its infancy. There is much confusion since different names are given to the same clones and there are little data on morphological characters. Work is needed to describe and catalogue the sweet potato germplasm in the Region.

Selection of the sweet potato variety/ies for commercial production

- Determine the sweet potato variety or varieties required by the target market (i.e., fresh, processed, local, regional and extra-regional). The fresh market demands are different from those of the processing industry. In the former, some of the characters of importance are taste, size, shape, skin and flesh colour of the fresh tuberous roots. The processor, on the other hand, focuses on the chemical composition of the tuberous roots (Plates 1 - 5).
- Select the variety with a high degree of adaptability to the agro-ecological conditions of the production area. The chosen variety or varieties must produce high quality yields notwithstanding pests, droughts, floods and other environmental problems.
- Ensure that there are sufficient quantities of clean planting material of the selected varieties.

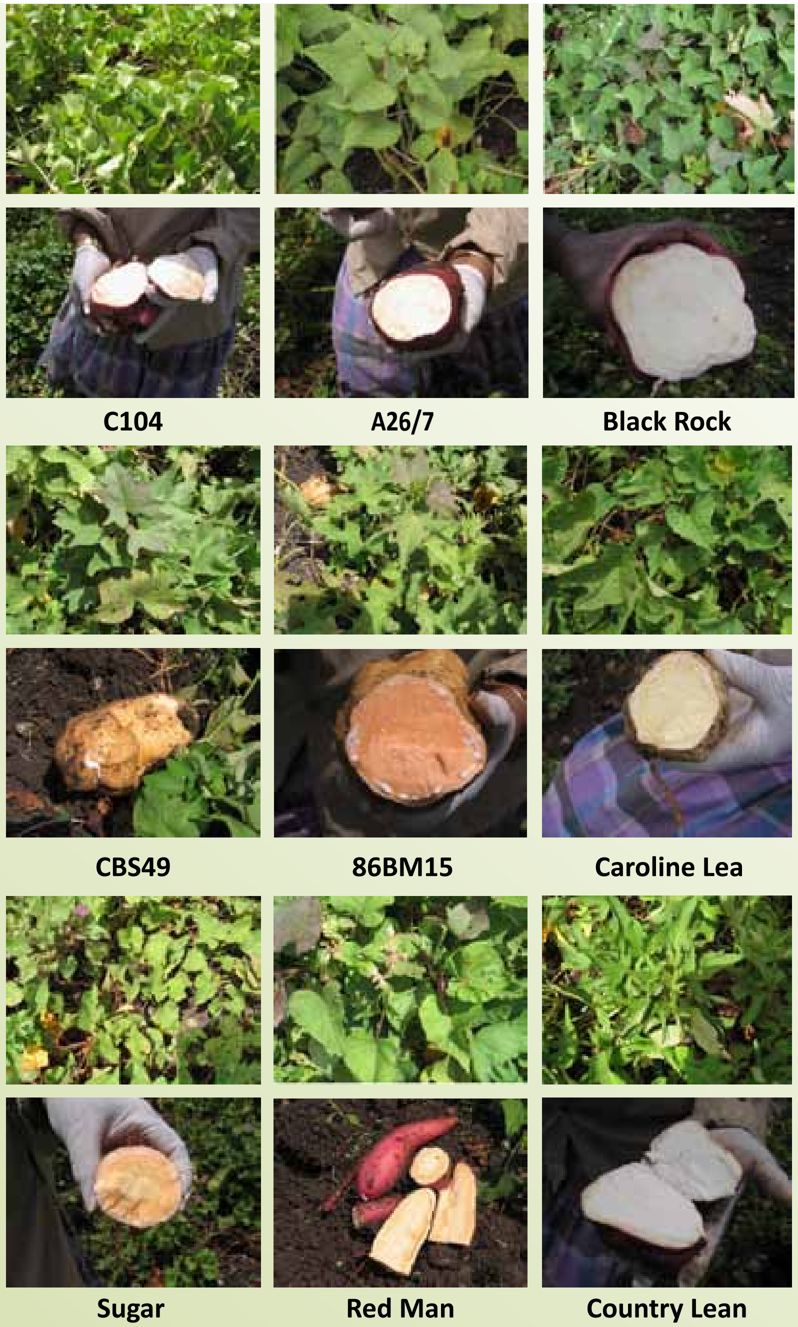


Plate 1: Popular varieties from Barbados

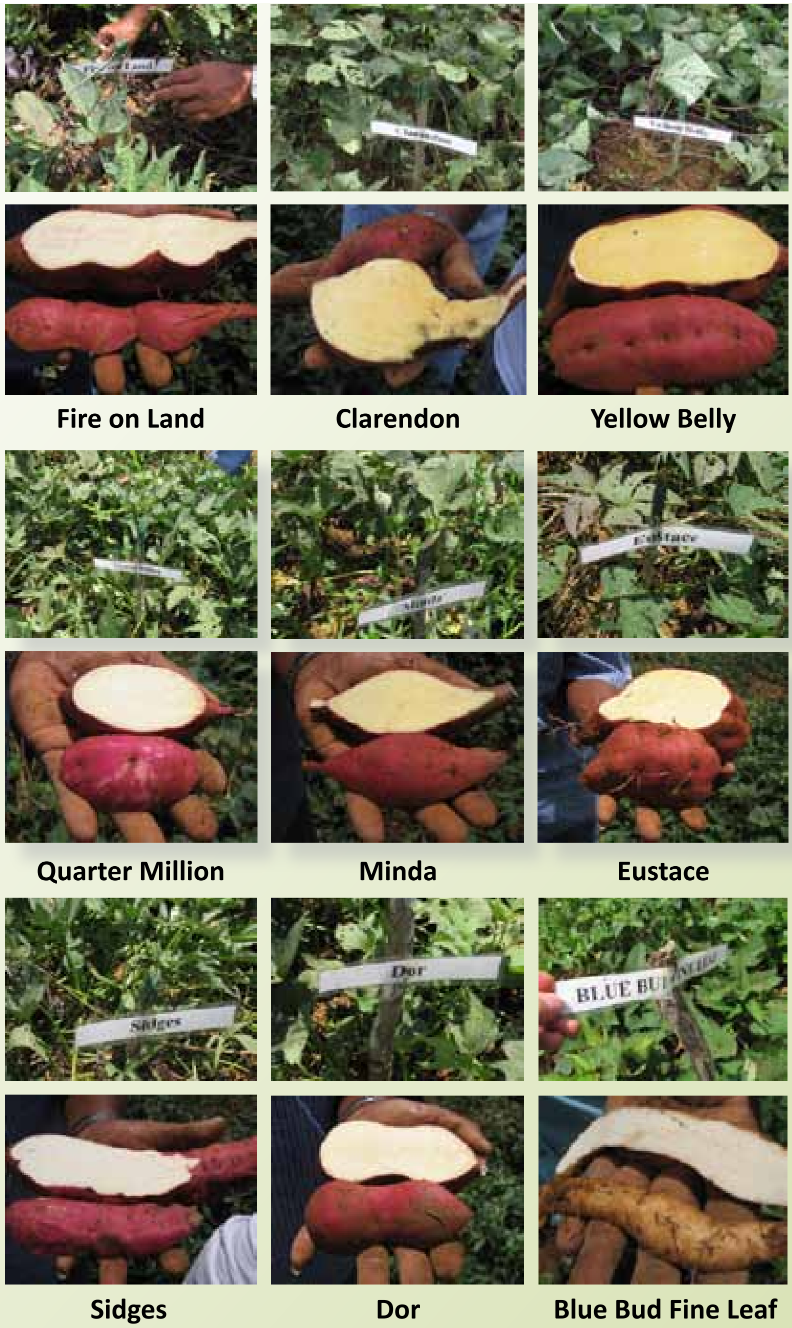


Plate 2: Popular varieties from Jamaica

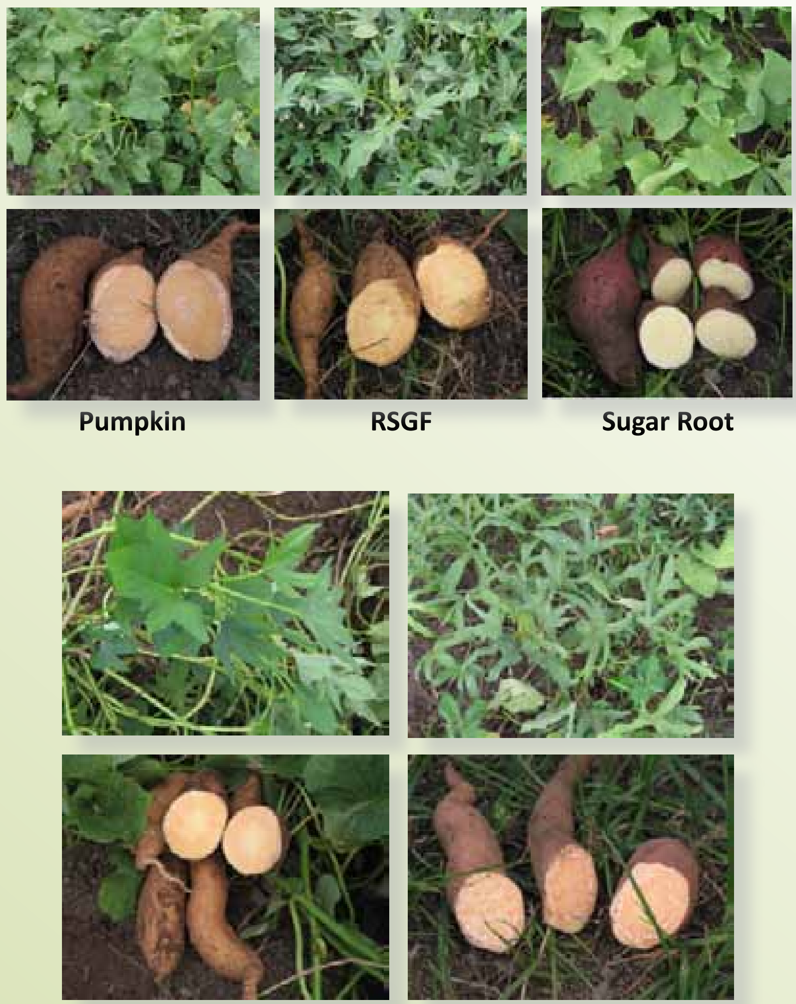


Plate 3: Popular varieties from St Kitts and Nevis

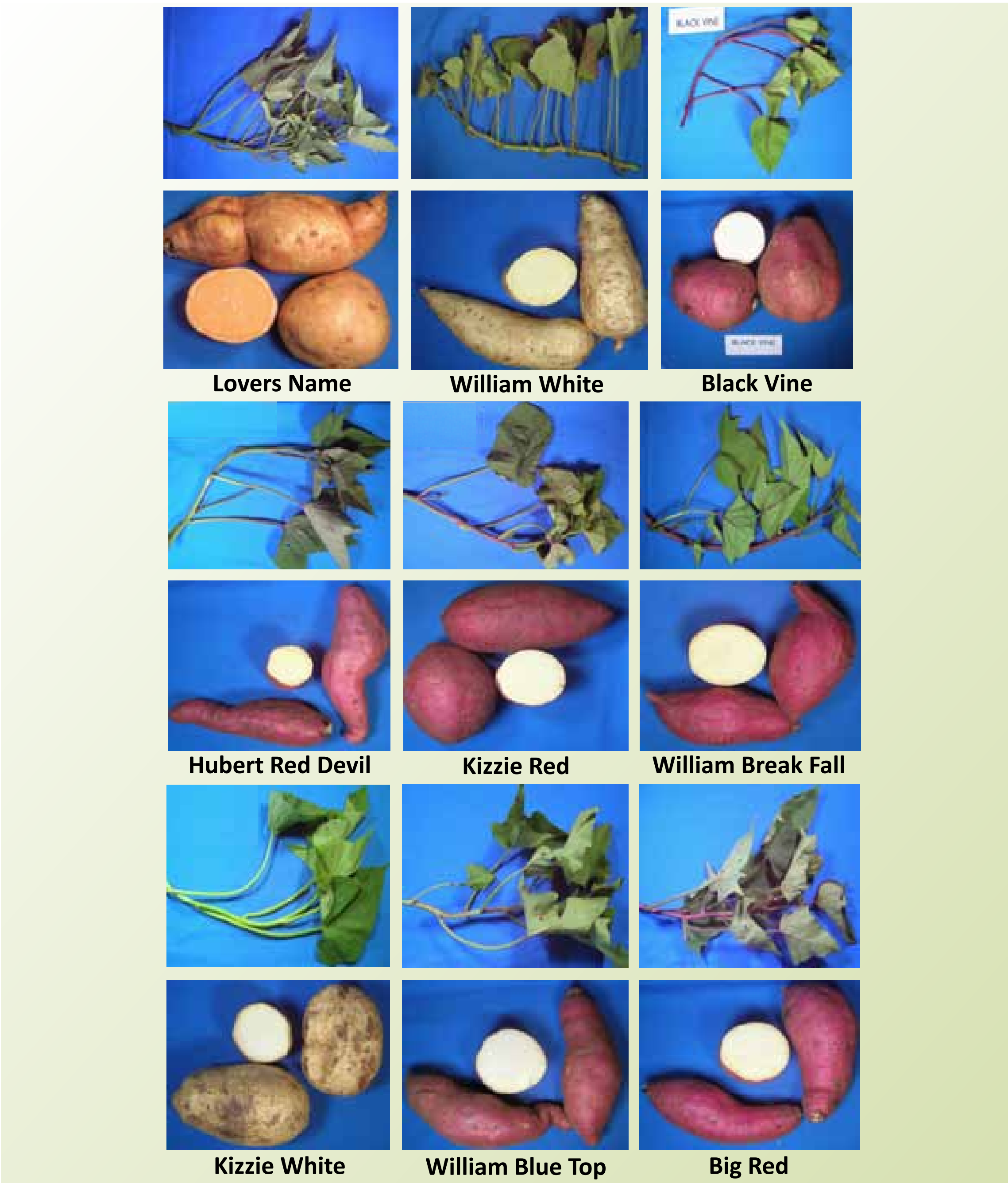


Plate 4: Popular varieties from St. Vincent and the Grenadines

Plate 5: Popular varieties from Trinidad and Tobago

Production

4.1 Pre-production

Pre-production involves the practices and procedures that precede the establishment of the crop and are critical for ensuring optimal growth and development. It includes primarily, site selection and land preparation.

Site selection

Soil. Well drained sandy or sandy loam soils are best for sweet potato production. Heavy clays and soils high in organic matter are not recommended. Heavy clay soils retard root development and result in poor root shape. High organic matter leads to abundant vine growth and poor storage root development. Fields with high nematode populations should also be avoided. In general, fields that have not been used for sweet potatoes in the last 2 - 3 years are preferred.

Sweet potatoes are sensitive to alkaline or saline soil; hence, these soils should be avoided. To achieve high yields, the soil within the planting area should have a pH between 5.8 and 6.4. If the pH of the soil is low, lime should be incorporated to increase the pH. The application of lime should be done to allow sufficient time for the soil pH to be increased.

Soil testing. Soil tests must be carried out to determine the natural fertility of the site. Interpretation of the results should guide the fertility management strategy that is implemented.

Rainfall. Regions/zones with an annual rainfall of 750 - 1250 mm (30 - 50 in) per annum, with about 500 mm (20 in) falling during the growing season, are best suited for sweet potato production. Although the crop can withstand drought conditions, yields are considerably reduced if a dry period occurs during the first 6 weeks after planting.

Temperature. Sweet potato is a warm weather crop. It grows best at mean temperatures above 24 °C (75 °F) and requires abundant sunshine. It is therefore not recommended to plant sweet potatoes in shaded conditions.

Land preparation

Sweet potato is usually planted on ridges or mounds. Ridges are usually 75 - 90 cm wide (30 - 36 in) and 30 - 45 cm (12 - 18 in) high and mounds 40 cm (15 in) at the base and 20 - 30 cm (8 - 12 in) high. On flat terrain, land is prepared mechanically and on sloping land, ridges are made manually along the contours (Plate 6).

Ploughed and harrowed (well worked) beds provide the developing roots with loose friable soil so that they can expand to their potential size and shape without restriction. These methods of land preparation allow adequate drainage and make harvesting easier.

The main consideration is that the developing roots remain under the soil within the hill. If using a mechanical digger at harvest time, it is important to match the width of the mound with the width of the digger's mouth.

The advantages of planting on ridges and mounds are:

- Higher and better quality yield
- Prevention of soil erosion
- Production of larger storage roots
- Less possibility of deformed storage roots
- Easier harvesting
- More efficient pest management

Ridges prepared manually on flat land

Ridges prepared manually on sloping land

Plate 6: Ridges prepared for planting

4.2 Crop establishment

The establishment of a sweet potato crop includes the propagation as well as measures necessary for ensuring a high yielding good quality crop. Such measures include irrigation, fertility and pest management.

4.2.1 Propagation

It is important to select high quality planting material to ensure the production of a good crop. Sweet potato can be propagated in a variety of ways; tissue culture, sprouting, vine cuttings and seeds. Vine cuttings and sprouts and, to a lesser extent, tissue culture are the most commonly used propagules within the Region.

4.2.1.1 Propagation material (propagules)

Vine cuttings

Traditionally, many growers utilise the cuttings from the previous crop to establish new cultivations of sweet potato. As with most vegetatively propagated crops the quality of the planting material impacts growth and resultant yield. It is therefore critical in the establishment of new cultivations that high quality planting material be used.

Generally, vine cuttings/slips ranging in length from 30 cm to 40 cm (12 - 15 in) should be planted. The apical region of the plant should be used as it is more likely to be free of pest infestations and it gives better yields than cuttings from the middle or base of the plant (Plates 10 and 11). The implement used to cut the vines should be sharp and clean. The lower leaves of the vines/slips should be cut as tearing may damage the nodes that could eventually produce roots.

Sprouting

Sprouting involves the use of small to medium sized storage roots to obtain slips for planting. Storage roots selected for sprouting should be free of pests and washed carefully with a disinfectant before planting (e.g. 20% bleach solution). Sweet potatoes selected should be cut crosswise into two or three sections to increase the number of sprouts produced. To avoid spreading viruses, cutting knives should be disinfected.

Cut roots should be planted in a nursery bed that is located in an area where there is good drainage. To prevent contamination, the nursery bed should be established far away from existing sweet potato fields. To prepare planting material for one hectare, a nursery bed of approximately 35 m^2 (400 ft^2) is needed.

Storage root sections should be established in the nursery bed, close together but not touching. Storage roots (sections) should be covered with about 5 cm (2 in) of soil and then a layer of mulch added to retain moisture. Sweet potato vines should not be used as mulch. Water is necessary to keep the soil moist, but not wet. When the sprouts have grown to 40 - 50 cm (15 - 20 in), they should be cut and used to establish the crop. This is approximately 4 - 8 weeks after bedding.

Plate 7: Sprouted sweet potato storage root

Plate 8: Sweet potato nursery

Tissue culture

Tissue culture is the rapid propagation of plants within a controlled environment. This process involves the growing of tiny pieces of the plant (explants) on solid or liquid nutrient media. Plantlets obtained are placed under sheltered conditions to undergo weaning and hardening and then transferred to the field (Plate 9). This propagation method ensures a consistent and clean source of planting material.

Plate 9: Micro-propagation of sweet potato through tissue culture

(A-C: culturing of plantlets,
D-F: hardening and weaning of plantlets under sheltered conditions)

Storage of planting material

When vine cuttings/slips cannot be planted immediately, they can be stored under damp/ shaded conditions for up to 7 days. Note, if the vine cuttings are being stored the majority of leaves should be removed with only a few leaves being left at the tip. The cuttings should be tied in a bundle and the cut ends covered at the base with a damp cloth. During this period, roots will begin to grow at the nodes and the cuttings will become more resistant to the "shock" of planting (Plate 12).

4.2.1.2 Planting

Time of planting

Under rain fed conditions, it is best to plant sweet potatoes early in the rainy season so that establishment can take place quickly. In areas where the rainy season is prolonged, planting may be timed so that the crop matures just as the rainfall begins to decline.

Transplanting

Vine cuttings should be planted at about a 45° angle, as this promotes even root development. Half of the cutting or three to four nodes should be buried at a spacing of 25 - 30 cm (10 - 12 in) between plants. On average, depending on the spacing 30,000 - 35,000 cuttings are required per hectare (12,000 - 14,000 per ac). Within the Region, planting is usually manual. This can be as simple as pushing the cuttings into mounds or ridges with a forked stick. Cuttings should be watered at or immediately after planting. The field should be routinely monitored during the first 2 - 3 weeks to replace any dying plants. If the market secured requires produce at intervals, the planting should be staggered.

Plate 10: Sweet potato cuttings with short internodes

Plate 11: Sweet potato cuttings with long internodes

Plate 12: Cuttings showing nodal roots

4.2.2. Irrigation

Although sweet potatoes are deep rooted and drought tolerant, they still require sufficient moisture to grow and produce quality storage roots. Water supply fluctuations can cause the development of small and misshapen roots. These fluctuations can also cause growth cracks. These defects will impact upon the marketability of harvested sweet potatoes.

In contrast, excessive moisture can cause vigorous vine growth and elongated roots. However, year round production of sweet potato (including production in the dry season) is required for sustained markets and food security. Year round production therefore requires irrigation for dry season production. Two types of irrigation systems are recommended, the drip tape (Plate 13) and the mini-sprinkler (Plate 14).

Drip irrigation

During dry periods, drip irrigation is important for sustaining yields and is an efficient method of providing the required amount of water at the appropriate time.

Mini-sprinklers

Another option for providing the required moisture to the plant is mini-sprinklers. Yields are improved under this system. This is attributed to more vigorous growth due to the rooting of vine nodes on the wet soil between the beds. However, it should be noted that there is more weed growth under this system.

The best way to maintain the desired moisture content is to monitor the soil moisture with tensiometers; these instruments provide an indication of when and how long to irrigate. The water requirement will vary with the soil type and the crop stage.

Moisture levels are especially important from 10 weeks onward as storage roots start to enlarge (bulk-up). Fluctuating soil moisture levels during this stage will reduce yield and cause cracking of roots.

4.2.3 Fertility management

Sweet potatoes require nitrogen, phosphorous, potassium and small quantities of boron, calcium and magnesium. Nitrogen is required for the initial growth of the plant but excess application leads to abundant vine growth and reduced storage root formation. Potassium is critical for storage root development whereas phosphorous is linked to yield.

The recommended fertiliser rate for sweet potato production is based on crop removal (Table 2). Potassium is the element that is mostly removed by the crop. Complete fertilizers (NPK) used on the crop should therefore supply adequate amounts of each of these critical elements. Fertiliser should be incorporated at land preparation and when the vines start to run.

Plate 13: Drip lines established before planting

Plate 14: Mini-sprinklers irrigating sweet potato

Table 2: Estimated nutrients removed by the sweet potato crop

ELEMENT	CROP REMOVAL (kg/ha)
Nitrogen	70 - 100
Phosphorous	40 - 90
Potassium	100 - 210

Source: Traynor 2005, Rao 1991, Ngeze 2000

4.2.4 Pest management

Sweet potato production is affected by pests which significantly reduce both the quantity and quality of yields. Some producers within the Caribbean have reported losses due to pests reaching as high as 60 - 100% of harvested yields. The term "pest" refers to any unwanted plants or animals that negatively affect the crop and includes insects, mites, fungi, viruses, bacteria and weeds.

Before pests can be managed, it is important that there is proper diagnosis so that the most appropriate and effective strategies can be implemented. Therefore it is necessary for farmers to inspect the crop to determine the presence of pests, their numbers, and the level of damage to the crop.

Once diagnosis has been completed an integrated management strategy should be identified to reduce pest numbers and damage to the crop. Integrated Pest Management (IPM) refers to the management of pests through the use of a combination of compatible tactics. IPM emphasises the use of non-chemical methods and only relies on chemicals when all other methods prove to be ineffective in protecting the crop. IPM aims at ensuring that the farmer gets the best possible returns and the environment is protected. There are many different options to manage pests impacting sweet potato, they include: cultural practices, biological control, physical and mechanical measures and chemical applications. Legislation is also an option to reduce the movement of infested material from one country to another. The integrated approach relies on informed decision making in that, a decision is only made after information is collected (i.e., crop stage, pest type and numbers, production practices, prices, inputs available, tools available). Integrated management is critical for the sustained management of pests and the achievement of optimal production.

Major pests

Although all classes of pests are associated with the sweet potato crop, significant losses in yield (quality and quantity) are attributed mainly to insects. With emphasis on this pest grouping, life cycles and possible management strategies for some of the reported pests within the Caribbean are discussed.

Insects

Several insect species attack the leaves, stems and storage roots of sweet potato. However, only a small number are viewed as economically important and warrant intensive management. Important insect pests in the Caribbean are the sweet potato weevils, (*Cylas formicarius, Euscepes postfasciatus*), white grubs (*Phyllophaga* spp.), sweet potato leaf beetle (*Typophorus nigritus viridicyaneus*) and the stem borer (*Megastes grandalis*).

Root feeders

- Sweet potato weevil, *Cylas forimicarius* (Coleoptera: Apionidae)

  The sweet potato weevil, *Cylas forimicarius*, is one of the most destructive pests of sweet potato worldwide. Adult females lay eggs in stems and/or the surface of the roots just under the skin. The eggs hatch and the larvae tunnel into vines and roots where they feed and develop. The larval feeding results in tunnels within the sweet potato; often the tunnels are filled

Adult

Larvae

Pupae

Plate 15: Life stages of the sweet potato weevil, *Cylas formicarius* (Coleoptera: Apionidae)

with excretement. Fully grown larvae pupate and adults emerge from the stems and/or roots. As a result of feeding, the plant produces terpenoids that render the sweet potato unpalatable.

Management

The management of *C. formicarius* consists of a combination of cultural practices and the trapping of weevils with a sex pheromone (physical measure).

Cultural practices: There are crop management practices that help prevent the entry and/or reduce the number of weevils in the crop. Such practices include:

- Using clean planting material
- Removing alternate hosts (such as morning glory, “wild slip”, *Ipomoea* spp.)
- Conducting field sanitation (destroying old sweet potato fields, removing crop residues)
- Ensuring adequate soil moisture
- Molding/hilling plants to reduce cracks in the soil area
- Harvesting promptly
- Rotating the crop
- Using tolerant varieties

Physical measures - trapping: The second component of the management strategy reduces the number of sweet potato weevils through trapping. Traps are baited with a chemical that attracts male sweet potato weevils. The chemical known as a sex pheromone, is produced by female weevils for mating purposes. In response to the chemical (sex pheromone) placed in the trap, males move towards the baited traps, enter and drown in a container in which there is a soap solution. In time, as the male weevils are removed, less mating occurs and therefore fewer weevils are produced.

Plate 16: Features of the pheromone trap used in the management of the sweet potato weevil, *Cylas formicarius* (Coleoptera: Apionidae)

The key features of the trap include:

A. the sex pheromone (attractant) which is impregnated on a dispenser (e.g. rubber septa). A high dose pheromone is used in order to mass trap the weevils

B. a container for catching the male weevils that enter the trap

C. a frame on which the trap is suspended

Traps designs range from simple and inexpensive to complex commercial designs.

Plate 17: Various trap designs used in the IPM of the sweet potato weevil, *Cylas forimicarius* (Coleoptera: Apionidae) in the Region

Regardless of the trap design, the critical factors for the pheromone trapping system to work efficiently are:

- sufficient air vents to allow the diffusion of the scent to spread across the field
- a catchment container that is deep enough to prevent the weevils from escaping
- a frame which allows the trap height to be adjusted in relation to the crop canopy

The trap should be placed in the field as soon as planting is completed. It is important to place the trap just above the canopy. The trap should be moved around the field every week and the pheromone bait changed every 6 - 8 weeks. One or two traps should be placed within a hectare of sweet potato.

Biological control: There have been promising studies that demonstrate a reduction in weevil populations and damage to the crop with the use of entomopathogens (fungi and nematodes) and arthropod predators, such as, ants.

- West Indian sweet potato weevil, *Euscepes postfasciatus* (Coleoptera: Curculionidae)

The West Indian sweet potato weevil, *Euscepes postfasciatus*, has a similar life history to the sweet potato weevil, *C. formicarius*. Females lay yellow-greyish eggs singly in a cavity excavated in the roots/stems; roots are the preferred site for oviposition. Larvae tunnel, feed and grow within roots/stems. Fully grown larvae enter a resting stage (pupa), thereafter, adults emerge. *E. postfasciatus* adults are not as distinctive as those of *C. formicarius;* they resemble soil particles and are hard to detect in the soil. The body of the adult has short erect bristles and scales are reddish brown to grayish black. The plant produces terpenoids as a result of the feeding and the damage results in discoloration. Adults feed on sweet potato tissue and emerge by chewing exit holes.

Adult

Sweet potato damaged by larval feeding

Plate 18: Adult stage and damage caused by the West Indian sweet potato weevil, *Euscepes postfasciatus* (Coleoptera: Curculionidae)

Management

The management of the West Indian sweet potato weevil is mainly through cultural practices and chemical applications.

Cultural practices: The recommended practices are similar to those outlined for the sweet potato weevil, *C. formicarius* (see above).

Chemical applications: Recommended chemical applications include the use of systemic insecticides; however, care should be taken to ensure that applications are made within the guidelines of the manufacturer so as to avoid any residues on the roots at harvest.

- White grubs (*Phyllophaga* spp.) (Coleoptera: Scarabaeidae)

  Several species of white grubs occur in the Caribbean. Eggs are laid in the soil and young larvae feed on organic matter and later on roots. Larvae gouge out broad shallow areas on the root thus reducing marketability. Larvae are "C" shaped, have well developed legs and range in colour from white to off-white/grayish-white, depending on the species. They have well developed legs and a brown head capsule. Fully grown larvae penetrate the soil and pupate. Emerging adults feed on a wide range of plants (including sweet potato), but do not usually cause economic damage. During the day the adults shelter in the soil around the bases of plants.

Adult

"C" Shaped larva

Surface damage by larval feeding

Plate 19: Life stages and damage caused by white grubs *Phyllophaga* spp. (Coleoptera: Scarabaeidae)

Management

Management of white grubs includes the use of cultural practices and chemical applications. It is important to observe the field after it has been prepared, as grubs are often exposed during land preparation. Early detection and monitoring with light traps can improve the timing of management interventions.

Cultural practices: The removal of weeds that may harbour the pest is important for avoiding infestations. Grub populations can build up on land that is fallow with weeds. Crop rotation and avoiding soils with excessive levels of organic matter are also recommended practices.

Chemical applications: The use of soil treatments with selective insecticides can also be used in combination with the cultural practices. Utilising insecticides such as imidacloprid (Admire®) and thiamethoxam (Actara®) during the early stages of the crop can reduce damage by white grubs. To reduce the probability of having residues on harvested sweet potatoes, care should be taken to apply at the recommended rates and ensure proper timing.

Biological control: There have been promising studies that demonstrate a reduction in the population and damage to the crop with the use of entomopahtogens (fungi and nematodes).

- Sweet potato leaf beetle, *Typophorus nigritus viridicyaneus* (Coleoptera: Chrysomelidae)

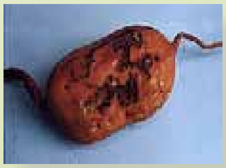
  The sweet potato leaf beetle Typophorus nigritus viridicyaneus (*Coleoptera: Chrysomelidae*) is an emerging pest of sweet potato. Adult beetles lay eggs at the base of the plant or on lower leaves near to the soil. The larvae feed on roots and the resulting damage resembles that of the white grub. Fully grown larvae pupate in an earthen cell and adults emerge later. Adults are shiny blue beetles observed on the underside of leaves as well as within the soil. Adult beetles chew the leaves but never the stems and can defoliate plants.

Management

The management of the sweet potato leaf beetle includes the use of cultural practices and chemical applications.

Adult

Larva and Pupa



Surface damage by larval feeding

Plate 20: Life stages and damage caused by sweet potato leaf beetle, *Typophorus nigritus viridicyaneus* (Coleoptera: Chrysomelidae)

Cultural practices: Prevent the entry of the beetle into the crop area by (i) removing weedy areas surrounding the plot which may harbour the beetle, and (ii) molding the soil to reduce cracks. Practising crop rotation can assist in protecting the crop from damage.

Chemical applications: Selective insecticides should be used in combination with the cultural practices. Using the insecticide imidacloprid (Admire®) during the early stages of the crop can reduce damage by the sweet potato leaf beetle. To reduce the probability of having residues on the roots, care should be taken to ensure that the recommended rates are applied at the proper crop stage.

Stem borer

- Stem borer, *Megastes grandalis* (Lepidoptera: Pyralidae)

  The stem/vine borer, *Megastes grandalis* (Lepidoptera: Pyralidae) is unique to Guyana and Trinidad and Tobago and is thought to be second in the order of economic importance to the sweet potato weevil in those countries. Eggs are laid singly or in clusters of less than five; they are bright green and turn purple at hatching. Newly hatched larvae feed on the surface of the vine or may burrow immediately into the stem where they tunnel and feed. Mature larvae are white with a pink colour and they have a dark head capsule. Fully grown larvae spin a co-

coon inside the stem. Adults exit the stems after approximately 14 days.

Damage is insidious as infested plants can appear symptomless. Damage results from the larva boring from the stem to the main roots. Swelling and splitting of the stems and the deposit of frass external to the split stem or on the ground may be observed. Silken threads may also be seen at split stems. Other symptoms include stunted plants, leaf shedding and the lack of storage root production.

Management

Tolerant varieties, cultural practices and to a lesser extent chemical applications are the tactics recommended to manage.

Tolerant varieties: Differential tolerance among sweet potato varieties has been reported. These observations have been linked to (i) the shape of the leaf in that, eggs survive poorly on narrow leaves when compared to wide leaves and (ii) the ability of the plant to correct the damage to the food transport channels by the larva boring into the stem.

Cultural practices: Molding the crop late in the growth stage, i.e. greater than 7 weeks, prevents adults from exiting the stems. In addition, the removal of alternate hosts (e.g., morning glory family) can reduce population build-up.

Sweet potato root damaged by the stem borer larva

Sweet potato crown damaged by the stem borer larva

Plate 21: Stem borer, *Megastes grandalis* (Lepidoptera: Pyralidae)

Chemical applications: The cryptic nature of this stem borer reduces the effectiveness of chemical applications. A systemic insecticide, such as fripronil (Regent®) applied at the recommended rate can reduce infestations.

Leaf feeders

There are several leaf feeding pests that occasionally damage the crop and may infrequently require attention. These include: tortoise beetles (*Metriona* sp., *Chelymorpha multipunctata*, *Deloyala* sp), cucumber beetle (*Diabrotica* sp.), armyworm (*Spodoptera* sp.), hornworm (*Agrius cingulatus*), leaf webber (*Trichotaphe* sp.), leaf hopper (*Empoasca* sp.), sweet potato whitefly (*Bemisia tabaci*) and thrips (*Frankliniella* sp).

Management

Field sanitation, hand picking and the use of "soft" pesticides can be used to reduce infestations. Pesticides include *Bacillus thuringiensis* (*Bt*) – entomopathogenic bacteria, neem, insecticidal soaps and oils.

Diseases

Sweet potato is subjected to a number of diseases caused by bacteria, fungi and viruses. These pathogens impact yield both in the field and in storage and can result in substantial losses. Management is primarily through the use of preventative measures. The most commonly reported pathogens associated with field production in the Caribbean are highlighted.

Bacteria

- *Soil rot (Streptomyces ipomoea)*

Soil rot (*Streptomyces ipomoea*) is a bacterial disease of sweet potato. Symptoms are quite distinct and include roots developing a black necrotic lesion which sometimes breaks off when the roots are harvested. Infected plants may be wilted and/or severely stunted with lower leaves bronzed or yellow.

Management

Cultural practices: Removal of old storage roots, crop rotation, the use of clean planting material, and the disinfecting of farm tools are all important practices for reducing the chance of infecting the crop with this pathogen.

Fungi

Fungal diseases that are commonly associated with sweet potato in the Caribbean include leaf spots and rusts.

- *Leaf spots*

Leaf spots are caused by the fungal pathogens Cercospora sp., *Alternaria* sp., and *Phyllosticta batatas*. Leaf spots initially show as tiny circular or oval spots on plant leaves that expand with time. These spots can vary in colour. In later stages of the disease, the leaves may become yellow and fall. Damage to leaves is most severe during wet weather conditions.

Management

Cultural practices: Due to the persistence of the fungus in plant residue, field sanitation is critical for managing leaf spots.

Chemical applications: Leaf spots are not usually sufficiently severe to warrant the application of a pesticide. However, if the infection is severe a recommended fungicide should be applied.

- *Rusts*

  Leaf rust or red rust (*Coleosporium ipomoeae*) and white rust or leaf mold (*Albugo* sp.) are of minor economic importance and have not been sufficiently severe to recommend management.

Viruses

Worldwide there are over 20 viruses that affect sweet potato. They are thought to reduce yields by up to 30% or more. Within the Caribbean, viruses have been detected in some major producing countries. These include in part, Sweet Potato Feathery Mottle Virus (SPFMV), Sweet Potato Mild Speckling Virus (SPMSV), Sweet Potato Chlorotic Fleck Virus (SPCFV), Sweet Potato Chlorotic Stunt Virus (SPCSV), Sweet Potato Caulimo-like Virus, Sweet Potato Virus G (SPVG) and Cucumber Mosaic Virus (CMV).

Frequently, the viruses occur in mixed infections. In some cases, these mixed infections cause a synergistic effect that result in a more severe reduction in yields than would be expected if the individual virus alone was present. Viral infestations reduce yields but have not been shown to impact the quality of sweet potatoes. Symptoms include vein clearing or mosaic, chlorosis stunting, leaf reduction and deformation. The vectors responsible for the transmission of viruses include aphids and whiteflies.

Management

Cultural practices. The main management approach for reducing viral infections is the use of cultural practices. Such practices include the use of clean planting material, rouging of infected plants and the removal of weedy borers that may serve as reservoirs for the viruses and their vectors.

Chemical applications: The management of the vectors of the viruses, that is, aphids and whiteflies assists in reducing the spread of the infection. Fields should be monitored and applications of “soft chemicals”, such as soaps and oils used to reduce populations.

Nematodes

Nematodes are microscopic worms that feed on the roots of sweet potato and can significantly impact yields. Of note, are root-knot nematodes (*Meloidogyne* spp.). Other species of nematodes have also been associated with the crop and include: *Tylenchulus* sp., *Radopholus* sp *Rotylenchulus reniformis*, and *Pratylenchus* sp.

Typically, symptoms can be observed both below and above ground.

Below ground, the symptoms include:

- galls on adventitious and storage roots
- abnormal formation and function of the root system

Non-specific above ground symptoms include:

- patchy stunted growth
- discolouration and leaf chlorosis
- excessive wilting during dry, hot conditions
- stunting of whole plants
- reduced yield and quality
- sometimes premature death

Management

Cultural control: This includes field sanitation and crop rotation for two or more years, where plots are heavily infested. The use of clean planting material is also important. Introducing plants that repel nematodes within the soil, in and around cultivated areas, is also useful in reducing infestations. Plants which repel nematodes include marigold and neem.

Physical measures: Soil solarisation is an effective method to reduce nematode populations. The soil has to be moist and covered with a thick plastic for approximately 2 weeks. The heat build-up under the plastic reduces the survival of the nematode.

Chemical application. In severe infestations, a nematicide can be applied after all other practices have failed. To be effective, the nematicide has to be a systemic so it is important that the chemical used is not very persistent as this may result in pesticide residues on the crop.

Rats

Damage due to rats can range from 5 - 30% of the harvested crop. Management practices include placing bait around the edges of the field to prevent rats from entering. Exposed roots are the most frequently attacked and as such ensuring that the roots are covered is important.

Weeds

Several weed species are associated with the sweet potato crop. If weeds are not managed, they can impact the productivity of the crop by competing for space, nutrients and moisture. The critical period for managing weeds in sweet potato is during the first 2 months of growth. After this period, vine growth should effectively cover the ground surface, thus suppressing weeds. Before planting occurs a pre-emergent herbicide can be used and thereafter hand weeding. If herbicides are being used after vines have trailed, care must be taken to ensure that the plants are not burnt.

Plate 22: Virus symptoms in sweet potato: stunting, bunching, chlorosis, vein clearing, yield reduction

Post production

5

Post production includes harvesting, handling, curing, packaging, storing, shipping, wholesaling, retailing, and any other activity to which the produce is subjected. It should be noted that the price received for produce is largely determined by the quality at the marketplace. Therefore the quality at harvest must be maintained by proper handling, packaging and storage conditions.

5.1 Harvest

Maturity indices

The crop is ready for harvest when the leaves turn yellow and begin to drop. Maturity can also be assessed by cutting sample roots in the field and examining the colour of the latex exudation. Latex from mature storage roots remains creamy white, while in immature storage roots when cut, the latex turns black.

In instances where there are no external visible signs of maturity to indicate that harvesting should take place, growers will have to monitor the development of the storage roots with regular checks of root size after 18 weeks.

Harvesting

Harvesting must be timely; if harvesting is done too early yields can be reduced. However, if the crop is left too long in the ground, the storage roots can become prone to rotting and weevil attack. Traditionally, on small farms, sweet potato is harvested as the need arises. However, this system of harvest exposes plants to weevil attack.

Plate 23: White exudate from a mature sweet potato storage root

Sweet potatoes are normally harvested 3 - 8 months after planting, depending on the cultivar and climatic conditions.

Field operations

Sweet potatoes are usually harvested manually with the use of a fork/cutlass or mechanically with a harvester. A high level of damage may result from mechanical harvesting.

- *Manual method*

  The vines are cut and a fork/cutlass or other appropriate lifting tool should be placed more than 30 cm (1 ft) away from where the vine is attached to the storage roots. The roots are exposed by turning the soil. The vines may not separate easily and individual roots have to be detached by hand.

- *Mechanical method*

  The sweet potato ridges are cleared of vines to allow the harvester to have easy access (Plate 24). The harvester moves slowly through the field and the sweet potatoes are brought to the surface along the ridge (Plate 25).

The skin of the sweet potato is thin and delicate and easily damaged at harvest. Storage roots should therefore be handled carefully and sparingly. The harvested crop, whether by hand or mechanically should be placed in field crates to be transported from the field. Do not use sacks as this can result in rubbing off the surface skin and the build-up of disease organisms. Sweet potatoes should be graded in the field.

Yields

The yields obtained from a sweet potato crop are dependent on the following:

- whether the crop was rain fed or irrigated
- variety selected
- the time of the year the crop was planted (impact of dry and wet season)
- the location in which the crop was planted (agro-ecological zone)

Currently yields in the Caribbean range between 9 - 22 t/ha (8,000 - 20,000 lbs/ac). However, in several major producing countries yields up to 40 t/ha (35,000 lbs/ac) have been reported.

5.2 Post harvest handling

The storage roots harvested should be washed in water using a sponge to remove all soil particles; care must be taken to minimise the removal of surface skin. This operation can be done by hand or by a specialised washing machine. To avoid spoilage, the washing water should contain 15 cc per 4.5 l (160 fl oz/gal) of commercial bleach. The water should

Plate 24: Sweet potato vines cleared from the ridges in preparation for the harvester (manual)

Plate 25: Harvester up-rooting the sweet potatoes (mechanical)

Plate 26: Storage roots exposed for selection

Plate 27: Exposed storage roots

Plate 28: Harvested crop (manual) being placed in field crates to be transported from the field

be changed when it looks dirty or after every 500 kgs (1,100 lbs) of sweet potatoes. Once clean, harvested roots should be dipped in a solution Mertec® 20S (500 ppm of TBZ active ingredient) before being left to dry overnight. The storage roots should be placed in field crates and held at ambient temperature for 3 - 5 days to allow root curing before final selection, packing and shipment (Plate 28).

Grading

Sweet potatoes are graded according to size with 200 g (8 oz) being the minimum weight for acceptance. Storage roots may also be graded according to shape.

Grades

Large: > 800 g (28 oz)

Medium: 450 - 800 g (16 - 28 oz)

Small: 200 - 450 g (8 - 16 oz)

Post harvest treatments

Curing

A period of wound healing or curing is recommended to prevent fungal infection of damaged roots. Optimal conditions for curing are between 26 - 29 °C (80 - 85 °F) and 85 - 90% relative humidity for 4 - 7 days. This forms a corky periderm layer below the damaged areas which limits microbial invasion and water loss.

Fungicidal dips

The use of fungicides in the post harvest treatment of sweet potatoes has been discontinued due to consumer health concerns related to chemical residues.

Storage

Rotting of sweet potatoes in storage is closely related to injury during harvest and subsequent handling. This can be prevented by prompt curing, careful handling and discarding infected roots before storage. The major pathogens causing rot are: *Ceratocystis fimbriata, Fusarium* spp., *Rhizopus* spp., *Botryodiplodia theobromae* and *Sclerotia rolfsii*.

Packaging

Sweet potatoes should be packed in two piece full telescopic fibreboard cartons (banana type) holding 18 kg (40 lbs). Allow for weight loss of about 4% when shipping by sea. Cartons should be properly labeled to include the crop name (sweet potato), net weight as well as the importer and supplier names.

Transportation

Sweet potatoes can be transported by air or by sea for up to 14 days in refrigerated containers. During sea shipment, the required storage temperatures are 12 - 13 °C (54 - 55 °F). Storage below these temperatures induces chilling injury. Higher storage temperatures will result in increased decay, water loss and sprouting.

Sweet potato nutrition, uses and value addition 6

In the Caribbean, there has and continues to be a growing awareness of the health benefits of sweet potato. Research across the globe has shown that sweet potato has attributes that can assist in managing many lifestyle diseases. Antidiabetic, antihypersensitive, anti-inflammatory (asthma, arthritis), antimicrobial and antioxidant properties have been associated with the crop. Diversifying the range of products available to consumers is an important aspect of promoting the consumption of this important food and developing and sustaining the industry.

6.1 Nutritional content

In addition to containing simple starches, sweet potatoes are rich in complex carbohydrates, dietary fibre, vitamins A, C and B6 as well as manganese, copper, potassium and iron. When compared to Irish potato, sweetato ranks higher in nutritional value and has similar calories (Table 3).

Sweet potato varieties range in flesh colour from white, cream, yellow, orange and purple. Orange flesh varieties have higher levels of beta carotene than those with lighter coloured flesh. Purple fleshed varieties have higher antioxidant properties. In the Caribbean the predominant varieties are white, cream and yellow with growing amounts of orange fleshed varieties.

Table 3: Nutrient profile: sweet vs Irish potato

Nutrient	Sweet potato	Irish potato
Energy	90.00	93.00
Protein (g)	2.01	1.96
Total Fat (g)	0.15	0.10
Carbohydrate (g)	20.71	21.55
Fibre (g)	3.30	1.50
Calcium (mg)	38.00	5.00
Iron (mg)	0.69	0.35
Potassium (mg)	475.00	391.00
Vitamin C (mg)	19.60	12.80
Niacin (mg)	1.49	1.40
Folate (mcg)	6.00	9.00
Vitamin A (IU)	192.18	0.00
Vitamin E (mg)	0.71	0.04

Source: Holdip J, 2006. Cajanus The Caribbean Food and Nutrition Institute, Quarterly

6.2 Value addition

Woldwide

A wide range of processed products can be produced from sweet potato, including snacks, starch, confectionaries, condiments and drinks. In Japan, the sweet potato processing industry is well developed with many commercial products available on the market. In some cases these are retailed in specialty sweet potato stores. Products made from the crop in Japan include noodles, jams and jellies, sauces, flour, juices, wines, ice cream, alcohol and industrial starch.

Caribbean

Traditionally within the Region, sweet potato is consumed primarily boiled or baked and eaten as a side dish. As consumers transition from imported grains and cereals and consume more traditional staples for health and

Plate 29: Sweet potato products manufactured in Japan (flour, juices, alcohol, candy)

wellness reasons, there is a growing market for more “easy to prepare” forms of sweet potato. Such foods range from minimally processed (peeled, cut and blanched) to completely processed forms (flour, cereals, snacks, pudding mixes).

The development of local value added products requires information on the chemical/nutritional properties of local popular lines so that the products for which they are best suited can be identified. Among the institutions that have been working in this area are the Barbados Agricultural Development and Marketing Corporation, Northern Caribbean University (Jamaica), Scientific Research Council (Jamaica), the Trinidad and Tobago Agri-business Association, The University of the West Indies and CARDI.

Under a CARICOM/JAPAN bilateral project, CARDI, collaborated with the National Research Council for Kyushu and Okinawa

Plate 30: Products made by the Food Technology Department of the Scientific Research Council (SRC), Jamaica

(KONARC) of Japan to evaluate several Caribbean varieties for their suitability for processing. Thirty-four varieties were evaluated, from Jamaica, St Vincent and the Grenadines, St Kitts and Nevis, St Lucia as well as Trinidad and Tobago. Parameters examined were brix, and dry matter content. The results identified the varieties that were suitable for either juice, flour, paste or fries (Table 4).

Efforts are being made to identify additional varieties within and outside of the Region that will assist in expanding the range of products available for Caribbean consumers.

Table 4: Varietal suitability for value-added products

Value added product	Sweet potato varieties	
	Orange flesh	Yellow flesh
Flour	Centennial (TT)	Caroline Lee (BDS)
	Sampson Lover's Name (SVG)	Chicken Foot (TT)
	Audian's Lover's Name (SVG)	SLU #1 (SLU)
	CARDI Lover's Name (SVG)	Mandela (SLU)
	Clarke (SKN)	Blue Bud (JAM)
	Thetford (JAM)	Eustace (JAM)
		Up Lifter (JAM)
Paste	86BM-15 (BDS)	Caroline Lee (BDS)
	CBS49 (BDS)	Up Lifter (JAM)
	Centennial (TT)	
Juice	Carrot (TT)	
	Centennial (TT)	
Fry	86BM-15 (BDS)	William White (SVG)
	CBS49 (BDS)	Red Man (BDS)
		C104 (BDS)
		St. Vincent Unknown (TT)
		SLU #1 (SLU)

BDS – Barbados, JAM – Jamaica, TT – Trinidad and Tobago, SKN - St. Kitts and Nevis, SLU – St Lucia, SVG- St. Vincent and the Grenadines

7 Disaster mitigation and adaptation

With the effects of global climate change and the increasing occurrence of natural disasters, farmers must be aware of and adopt preventative measures to minimise the impact of these disasters on their operations. In the Caribbean, the natural disasters impacting crop production systems are hurricanes, floods, droughts, volcanic ash and acid rain. If unprepared, these events can prove catastrophic to food supply.

Of all the cultivated root and tuber crops, sweet potato is probably the best at adapting quickly to new conditions. Nevertheless, its growth and development can be affected by adverse environmental conditions. Due to the unpredictability of natural disasters, sweet potato farmers should take preventative measures to reduce their impact. Such measures implemented must take into consideration the features of the planting site and the crop.

Planning is one of the most important aspects of mitigation as it can help to minimise the impact of disasters and also help the farmer to recover. In addition to measures directed to specific disasters, there are general practices that should be undertaken regardless of the nature of the disaster.

7.1 General practices

- Develop a farm plan indicating areas which have the potential for flooding, drying, slippage and wind damage. Essential information to record include: soil type, slope of the land and wind direction
- Plant hedgerows to shelter areas which are prone to extreme winds
- Clear farm refuse and other debris that surround fields; such materials may clog drains and increase the chance of flooding
- Establish physical (plant, non-plant) rows and barriers or a cover crop to hold the soil in areas which are prone to erosion caused by wind and/or rain
- Have an idea of weather patterns/seasons; determine dry periods, those of heavy rain and hurricane months
- With consideration of the market, where possible adjust planting times so that production is conducted during seasons less prone to extreme weather conditions
- If planting is occurring during disaster prone seasons, plant varieties of sweet potato that mature quickly. In drought times use varieties that are deep rooted and reduce the chances of pest infestation of storage roots

7.2 Practices for specific disasters

Hurricanes and flooding

- Establish the crop on raised beds so as to increase drainage and reduce erosion
- Cut drains in flood prone areas of the field to reduce the impact of water logging
- Secure and store planting material that could be used to re-establish a crop. This could be through harvesting vines and/or small potatoes which are sprouted when needed
- Once the field has been drained, apply a fungicide to prevent the impact of pathogens

Droughts

- Irrigate the field; a drip system will provide the most efficient water use
- Use plastic mulch to cover beds and conserve soil moisture. Grass mulch could also be used, but care has to ensure that the mulch does not harbour pests
- Mold plants to reduce soil cracks that provide entry of pests to the root zone

Volcanic ash and acid rain

Although not widespread, volcanic ash fall and acid rain which results from an interaction between rainfall and volcanic gas are of concern for some locations e.g. Montserrat. A possible measure to reduce the impact of ash and acid rain is to grow the crop under a partial or fully covered structure. Structures can be row covers, shade and/or hoop houses. Care has to be taken that the covering used provides the right amount of light. Therefore, the structure has to be cleaned regularly. In addition the structure must be able to withstand the weight of the volcanic ash. Sweet potato has been grown under protected systems with yields achieved comparable to open field.

Record keeping

8

Record keeping

Record keeping is the process of collecting data on all factors that may impact on crop production, post-harvest and marketing activities. Accurate records allow producers to have a clear understanding of the factors that influence productivity and other costs and as such, insights as to profitability of the operation.

Cost of production

Cost of production calculations are important as they allow farmers to assess their profit margins. Table 5 gives an example of the type of data which has to be collected for accurate cost of production calculations.

Table 5: An example of the information required to calculate the cost of production

Expenditure (variable costs)
Crop establishment
Land preparation
Land clearing (man days)
Ridging (man days)
Forking (man days)
Tractor services
Lime stone (kg) / Liming (man days)
Other (establishing irrigation system (man days), soil test)
Planting material
Slips/cuttings per hectare
Crop care
Agro-chemical inputs and other materials and suppliers
Fertiliser (50 kg bag)
Fungicides (packets/bottles)
Insecticide (packets/bottles)
Herbicide (packets/bottles)
Other (packets/bottles)

Table 5: Example of the information required to calculate the cost of production (continued)
Crop care (continued)
Agro-chemical inputs and other materials and suppliers
Pheromone and traps
Fuel for maintaining farm equipment (e.g., weed wacker)
Other
Maintenance labour
Planting (man days)
Fertilising (man days)
Pesticide applications
Weeding (manual - man days)
Harvesting
Harvesting (manual - man days)
Harvesting (mechanical - harvester)
Transport from field to market
Overhead expense (e.g., % of total cost)
Land lease
Spray cans
Tractor
Irrigation system
Other
Returns
Total harvested yield (kg/ha)
Marketable yield (kg/ha)
Sweet potato plants (slips/ha)
Yield per plant (kg/plant)
Average price (per kg)

Bibliography

CARDI. [2008]. Sweet potato industry. In: CARDI 2007 Annual report. St Augustine, Trinidad and Tobago: Caribbean Agricultural Research and Development Institute, pp.21-26 <http://www.cardi.org/images/public/resources/annualreports/AR2008.pdf>

Degras L. 2003. Sweet Potato. The Tropical Agriculturalist Series. Oxford: Macmillan Education. pp. 10-11

Edmunds B, Boyette M, Clark C, Ferrin D, Smith T and Holmes G. 2008. Postharvest handling of sweet potato. North Carolina: North Carolina Cooperative Extension Service. <http://www.agctr.lsu.edu/NR/rdonlyres/F3155C1B-F146-4BFB-A400-C35BCDDC59DB/50057/SweetPotatoPostHarvestBulletin.pdf>; <http://www.agctr.lsu.edu/en/crops_livestock/crops/sweet_potatoes/Postharvest+Handling+of+Sweet+Potatoes.htm>

Fletcher D and Prevost S. 2002. Regional market study for sweet potato, Ipomoea batatas L (Lam). St Augustine, Trinidad and Tobago: Caribbean Agricultural Research and Development Institute

Kader A A (ed.). 1992. Postharvest technology of horticultural crops, 2nd edn. University of California. Division of Agriculture and Natural Resources, Special Publication 3311. California: University of California. Division of Agriculture and Natural Resources

Kemble J M, Sikora E J, Fields D, Patterson M G and Vinson E, III. 2006. Guide to commercial sweet potato production in Alabama. Alabama Cooperative Extension System ANR-982. Alabama: Alabama Cooperative Extension System

<http://www.aces.edu/pubs/docs/A/ANR-0982/ANR-0982.pdf?PHPSESSID=dd1976228a5ad0cb03d9db4d355ff684>

Mariscal A M. 1987. Ecological and cultural requirements of sweet potato. Root Crops Digest 2(1). <http://www.pcarrd.dost.gov.ph/consortia/vicarp/cropTech/rootCrop.html>

Holdip J. 2006. Common Caribbean food and your health (1), Sweet Potato. Cajanus, The Caribbean Food and Nutrition Institute Quarterly. Vol. 39 No. 1, pp. 19

Martin F W and Jones A. 1986. Breeding sweet potatoes. Plant Breeding Reviews 4: 313-345

<http://www.pubhort.org/pbr.htm ISSN 0730-2207 >

Medlicott, A P. 1990. Product specifications and post harvest handling for fruits, vegetables and root crops exported from the Caribbean. St. Michaels, Barbados: CARICOM Export Development Project, pp. 27-29

Ngeze, P B. 2000. Learn how to grow sweet potatoes. Nairobi, Kenya: Acacia Stantex Publishers

Onwueme I C and Sinha T D. 1991. Field crop production in tropical Africa principles and practice. Wageningen, Netherlands: Technical Centre for Agricultural and Rural Cooperation

Rankine L and Singh R. 1995. Insurance and disaster related consideration for the agricultural sector in the Caribbean. St Augustine, Trinidad and Tobago: University of the West Indies, pp. 1-4

Rao M M. 1991. Guidelines for the production of sweet potatoes in the Caribbean. A paper presented at a workshop/training course on the Production and Pest Management of Sweet potato, Jamaica, 23- 25 January 1991

Seesahai A and Ramlal M. 2008. Know your sweet potato varieties. GreenVine Monthly Bulletin 4(5):7

<http://www.namistt.com/DocumentLibrary/GreenVine/2008/May/GreenVine%20May%202008%20Issue.pdf>

Shah A. 2009. Climate change and global warming: introduction. IN: Global Issues: social, political, economic and environmental issues that affect us all. Cited: 19th January 2010

<http://www.globalissues.org/article/233/climate-change-and-global-warming-introduction#WhatisGlobalWarmingandClimateChange>

Simonne E H, Maynard D N, Hochmuth G J, Lamberts M L, Vavrina C S, Stall W M, Kucharek T A and Webb E. 2004. Sweet potato production in Florida. HS738. Gainesville, Florida: Institute of Food and Agricultural Sciences, University of Florida

Singh R H Seepersad G and Rankine L B. 2006. The global market for sweet potato: sources of supply and competitiveness for the CARICOM industry. St Augustine, Trinidad and Tobago: University of the West Indies

Titus P. 2008. An overview of the Regional sweet potato industry. A paper presented at Trinidad and Tobago Agri-Business Association Sweet Potato Workshop, Trinidad and Tobago, July 2008

Titus P. 2008. Sweet potato (Ipomea batatas) post harvest practices, grades and standards and IPM methodology for managing the white grub affecting the crop in St. Vincent and the Grenadines

Traynor M. 2005. Sweet potato production guide for the top end. Information Booklet IB1. Darwin, Australia: Northern Territory Government. Cited April 2010 <http://www.nt.gov.au/d/Content/File/p/Vegetable/IB1.pdf>

Trotz U O'D. 2002. Climate change: a priority for the Caribbean. IN: Climate change and the Caribbean's response to its impacts. A presentation at the Adaptation to Climate Change in the Caribbean Tourism Sector Workshop, Grenada, 27-28 May, 2002. Cited 19th January 2010. <www.oas.org/macc/Present/CC_Resp.ppt>

Wickham L D. 2001. Small scale processing of starchy staples in CARICOM countries. Rome: Food and Agriculture Organization of the United Nations (FAO)

<http://www.fao.org/AG/ags/agsi/Starchfinal/hs~wickhamrev3proof.htm>

Yoshimoto M. 2001. New trends of processing and use of sweet potato in Japan. Farming Japan 35: 22-28

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