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Development of Quality Planting Material of Roots and Tubers in the Caribbean Region

TECHNICAL REPORT

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- **An output of the CFC/EU-financed project: "Increased Production of Root and Tuber Crops in the Caribbean through the Introduction of Improved Marketing and Production Technologies"**

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Abstract

The inability of farmers to access high quality planting material has been identified by the FAO as one of the most important elements of successful agricultural production and development in the Caribbean. Through CFC grant funding (CFC Project Document, 2010-2013), facilities were established in Barbados, St.Vincent and the Grenadines, Dominica, Trinidad and Tobago and Jamaica for the production of high quality planting material for growers of yam, cassava and sweet potato in the region.

Introduction

The United Nations Food and Agriculture Organization (FAO) declared (FAO, 2009): "Ensuring that farmers have access to seed and planting material of good quality is one of the most important elements of successful agricultural production and development". This issue was presented as a major component of the high level Conference on World Food Security "The challenges of climate change and bio-energy" held in June 2008 at FAO Headquarters in Rome (FAO, 2009). The Conference recognised that increased access by farmers to appropriate locally-adapted seed is a key element in support of agricultural production in the context of high food prices.

Given this reality, the planting material available to small–scale farmers in many developing countries is often of insufficient quality, which undermines potential yields and overall harvest values and performance of crop production (Ogero, K. O. et al., 2012). Crops such as yam, cassava and sweet potato belonging to tropical or subtropical agricultural systems, are staple foods in many developing countries and, while being minor crops at the global level, contribute significantly to the food security of rural populations in specific countries and regions (FAO, 2009; DCED, 2008).

Recently in the Caribbean, the improvement and development of vegetatively-reproduced crops (yam, cassava and sweet potato) were being given impetus through the investment by the Common Fund for Commodities (CFC) via a project executed by the Caribbean Agricultural Research and Development Institute (CARDI) (CFC Project Document, 2010-2013). The main objective of the project is to contribute to the improvement of livelihoods along the root and tuber crop commodity chain in the Caribbean through appropriate marketing and production technologies. The principal activity includes the establishment of advanced propagation infrastructure for the purpose of increasing the availability of planting material of sweet potato,

cassava and yam in Haiti, Jamaica, Trinidad & Tobago, Barbados, Dominica and, St. Vincent & the Grenadines.

This investment was made in the context of rising food prices and the challenges of climate change. The infrastructure allows for rapid multiplication of varieties at volumes that were not possible in the past. Additionally, the material will be screened for pathogens, thus enabling propagated plants to maximise their yield potential and thereby provide better economic returns to farmers.

The infrastructural facilities will allow for the conservation of germplasm that could be used for future research and development activities. The development and distribution of quality planting material that is disease-free are also expected to improve productivity with lower inputs while production levels can be sustained and improved over the long term leading to improved food security and sustainable livelihoods for communities.

The CFC investment includes plant propagation facilities in pilot countries to enable production and distribution of quality planting material in volumes that will service markets for fresh and value-added products in the entire Caribbean region.

State of the sweet potato, yam and cassava industries in the Caribbean

(i) Sweet potato

Sweet potato is cultivated in over 100 developing countries and ranks among the five most important food crops produced in over 50 of these countries. World production (FAO, 2012) was estimated at 121.8 million tons in 2003, concentrating on Asia (87%) followed by Africa, South America, the Caribbean and, North America. At the global level, an overall declining trend can be observed for all producing countries except for the Caribbean, North America and Oceania regions. The Caribbean has an approximate 1% share of global production with the bulk concentrated in just a few countries. Total regional production figures show an increase from 530,000 t in 1999 to 731,000 t in 2004. Major Caribbean producers are Cuba, with an annual production of 390,000 t (60% of total regional production) and, the Dominican Republic with 33,900 t (5%). The largest producer within CARICOM in 2003 was Jamaica (28,000 tonnes). While the world yield averages 15,500 kg/ha, figures in Caribbean countries are heterogeneous and range from 500 to 22,000 kg/ha (FAO, 2012).

Sweet potato is grown throughout the Caribbean region, primarily by small farmers, on marginal lands with limited use of improved technologies and practices with regard to land preparation, irrigation, fertiliser use and pest management. Consequently, yields are usually well below their genetic potential. Traditionally, sweet potato is simply used in its primary form and cooked as an item in popular Caribbean main course meals or as a meal in itself. Up to the present time, there has been limited capitalisation on export and processing opportunities, even though sweet

potato can be processed into a number of products including chips, flour and many other non-traditional value-added products.

Sweet potato became increasingly important in the current agricultural development plans of CARICOM countries with respect to food security. However, constraints to its development include poor yields associated with poor agronomic practices, inconsistent quality, high incidence of pests and disease and inappropriate post-harvest handling. The main bottlenecks in the value chain are pest management, propagation protocols, changing varietal preferences for the export markets, post-harvest management, plant nutrition and product presentation.

(ii) Cassava

Cassava is the developing world's fourth most important crop, with production in 2006 estimated at 226 million t and grown in 101 countries (FAO, 2012). In 2003, about 54% of the world's cassava was produced in Africa, 29% in Asia and 14% in Latin America and the Caribbean. In 2004, the world's largest producers of cassava were Nigeria, Brazil and Thailand, whose shares of global production were 19%, 12% and 11%, respectively. Cassava yields can be as high as 40,000 kg/ha, although world average is about 10,000 kg/ha. With an average yield of 4,500 kg/ha in the six Caribbean project countries, they are currently well below world average. Between 2000 and 2006, total production in the Caribbean ranged averaged 350,000 t/year.

In the Caribbean, Cassava is known as a 'poor man's crop' and is predominately grown by subsistence farmers as a staple on marginal land, due to its tolerance to drought and poor soil conditions. The access to sufficient quantities of clean planting material (stem cuttings) for new high yielding varieties has been a major constraint for improving the supply of the commodity. Cassava does not have a distinct mature stage and harvesting can commence as soon as the farmer verifies that the roots have stored an economically acceptable amount of carbohydrates. However, due to the plant's physical attributes (e.g. high water content of 70%), it is highly perishable and deteriorates 1-3 days after harvesting. Post-harvest activities are, therefore, critical to ensure marketable yields.

In Caribbean countries, cassava is consumed by the traditional food sector (fresh and minimally processed as bread, farina and, bammy) while there is limited diffusion of the fresh product into other industries such as livestock and manufacturing (flour and starch). This is an untapped area which represents an opportunity for developing the industry. CARICOM countries agreed in 2008 to explore options for substituting up to 15% of imported wheat flour with flour processed from regionally-produced cassava by 2013. In order to ensure a sufficient regional supply of cassava, it is necessary to increase productivity (by adopting improved varieties resistant to pests and diseases), improve physical and marketing infrastructure and adopt appropriate processing technologies.

(iii) Yam

Yam is produced on five million ha in 47 countries in tropical and subtropical regions of the world. According to FAO statistics (FAO, 2012), 48.7 million tons of yam were produced worldwide in 2005, with 97% in sub-Saharan Africa. Nearly all African production takes place in the 'yam zone', comprising Cameroon, Nigeria, Benin, Togo, Ghana, and Côte d'Ivoire. Yields in this area are about 11 t/ha. In the Caribbean, the production data (consolidated) on yams for the period 2000-2006 ranged from 250,000 to 367,000 t/year; the biggest producer is Haiti with 197,000 t in 2005. Yields in the six CFC project countries vary between 5.5 t/ha (Haiti) and 15 t/ha (Jamaica). Within the region, yam has been traditionally utilised and exported as a fresh commodity, with Jamaica being CARICOM's largest exporter (about 11,000 t/year).

In the Caribbean region, yam is being considered as an important crop for achieving food security; this is attributed to its excellent storage properties and its revenue generating capability. Similar to sweet potato, yams are primarily cultivated on small to medium-sized farms and are considered a high revenue crop, as there is a significant demand for the tubers in local and export markets. Over the years, production has been constrained by the limited adoption by farmers of improved technologies, such as IPM strategies, high yielding varieties and mass propagation techniques (i.e. the utilisation of rapid multiplication and tissue culture); use of these technologies can potentially double currently-achieved yields.

The CFC Roots and Tubers Project activities in the region 2010-2012

(i) St Vincent and the Grenadines (SVG)

Propagation facilities constructed /refurbished included:

- One fully equipped micropropagation facility (tissue culture laboratory) at Orange Hill.
- One weaning and hardening facility at Perseverance.

Local elite cassava, sweet potato and yam varieties were being stored in the propagation facilities constructed by the project in 2011. The Government of SVG is operating the project-constructed tissue culture laboratory with assistance from CARDI and is sourcing new improved varieties of cassava, sweet potato and yam from international institutions. The project has facilitated the training of one technician at the Latin American and Caribbean Consortium to support Cassava Research and Development (CLAYUCA), Colombia, in cassava micropropagation and conservation techniques.

A conservation strategy has been developed in which CARDI is assisting the country to become a regional depository of elite germplasm of roots and tubers for research and development.

(ii) Dominica

Propagation facilities constructed /refurbished included:

- A hardening/propagation facility was constructed at Portsmouth.

The focus here was on the valued-added and labour-saving practices for sweet potato production. Combining improved management practices with higher quality planting material is improving the ability of farmers to enhance their economic returns.

The project has facilitated the training of one technician at CLAYUCA in cassava micropropagation and conservation techniques. Local elite cassava, sweet potato and yam varieties are being stored in the propagation facilities constructed by the project in 2011.

(iii) Barbados

Facilities constructed /refurbished included:

- One weaning and hardening facility constructed at Graeme Hall.
- One fully-equipped plant virus testing (ELISA equipment) laboratory established at Cave Hill.

This laboratory serves as the quality control hub for the region by screening materials for economically-important disease pathogens from the tissue culture laboratory constructed in St Vincent & the Grenadines. A total of 56,000 cassava 1-node and 2-node cuttings were planted in seedling trays and later multiplied and supplied to farmers for planting an area of 4 ha. Rapid propagation of seven cultivars of cassava was carried out in a screenhouse, nursery beds and field. The project has facilitated the training of one technician at CLAYUCA in cassava micropropagation and conservation techniques.

(iv) Jamaica

Facilities constructed /refurbished included:

- One fully equipped micropropagation facility (tissue culture laboratory) at Christiana at the property of the Christiana Potato Growers Cooperative Association (CPGCA).
- Two hardening sheds at Devon (property of CPGCA).
- One weaning facility at Devon (property of CPGCA).

To date, the project has maintained *in situ* collections of sweet potato, cassava and yam varieties at the CARDI Mona Demonstration and Training Centre. Twelve minisett yam plantlets produced under the project have been supplied to the Scientific Research Council (SRC) for multiplication while the SRC has supplied a cassava variety to the CARDI germplasm bank at Mona.

The Christiana laboratory began elimination of bacteria from commercial sweet potato cultivars Uplifter, Fire-on-land, Clarendon, Brandol, Dor, Ganja, Big Leaf and, Blue Bud. Four new sweet potato cultivars (Black Slip, Yellow Coby, Cock-up, LA44) were being multiplied.

Ten introduced varieties of cassava and two of yam were placed in the tissue culture laboratory (*in vitro*) at Christiana (CPGCA). The project has facilitated the training of three technicians at CLAYUCA in cassava micropropagation and conservation techniques.

(v) Haiti

Facilities to be constructed /refurbished include:

- Yam propagation facilities at Salagnac.

The tissue culture facility needs of the National University of Haiti were being assessed. The project has facilitated the training of five Haitian Technicians in micropropagation and conservation techniques at the Scientific Research Council in Jamaica. A total of 35,000 cuttings of sweet potato was distributed to farmers at Les Cayes for planting five demonstration plots. Eight improved varieties of *Colocasia esculenta* (taro) were supplied by the Secretariat of the Pacific Community (SPC) in Fiji and are maintained in the greenhouse managed by the National Seed Service in Haiti.

The strategy being used in Haiti is the use of alternative technology for the growth of yam and sweet potato; farmer beneficiaries have been trained in micropropagation techniques imparted to Haitian technicians at the SRC in Jamaica.

It is recognised that high quality planting material can have a huge impact on the wellbeing of Haitian farmers and the quality of life in several communities since one of the major constraints to the supply of roots and tubers products is the availability of planting material.

(vi) Trinidad & Tobago

Facilities constructed /refurbished include:

- Small sweet potato propagation shed established in Cunupia, Central Trinidad.
- Feasibility of refurbishing hardening facilities at the Field Station of the University of the West Indies (UWI) for sweet potato, cassava and yam was being studied in a collaborative effort with the Faculty of Agriculture of UWI.

A germplasm bank was established in Tobago with 12 sweet potato and 11 cassava varieties conserved; the collection of local varieties was on-going. Mass production of cassava variety HYV was continuing in collaboration with UWI, the Trinidad & Tobago Agri-business Association (TTABA) and, the Ministry of Food Production. Plantlets of 15 varieties of sweet potato were being imported from the project-constructed tissue culture laboratory in SVG. Four National Germplasm Bank technicians were trained in germplasm collection techniques. The project also facilitated the training of two technicians at CLAYUCA in cassava micropropagation and conservation techniques.

The level of financial investment by the CFC/EU in plant propagation infrastructure, equipment and, planting material already made and projected under the CFC Roots and Tubers project in the above six countries during the period 2010-2013 is shown in Table 1.

Table 1. Levels of investment (US$) in plant propagation infrastructure, equipment and, planting material already made and projected and the number of technicians trained in the six CFC roots and tubers project countries during the period 2010-2013. Funds were provided to CARDI under the CFC/EU project agreement.

Country	**Propagation facilities (hardening sheds, demo plots, lab equipment, etc.)**	**Tissue culture laboratory and equipment**	**Planting material**	**Number of technicians trained at CLAYUCA and (SRC)**
Barbados	79,200	-	-	1
Jamaica	133,800	109,885	5,550	3
Trinidad & Tobago	162,142	-	40,000	2
St Vincent & the Grenadines	126,900	229,300	-	1
Dominica	84,700	-	54,000	1
Haiti	207,500	-	-	5
TOTAL	**794,242**	**339,185**	**99,550**	**14**

Quality planting material development system

CARDI's developing high quality roots and tubers planting material system consists of (Figures 1 and 2):

a) *Availability of disease-free high yielding planting material* (basic seed) - CARDI's Roots and Tubers Program has introduced, tested and identified improved germplasm in St. Vincent and the Grenadines. Based on results obtained, a number of these cultivars have been multiplied in the Ministry of Agriculture's tissue culture laboratory and are

presently available for distribution regionally. Under the Common Fund for Commodities/ European Union (CFC-EU) project, some US $176,000 has been spent building a new tissue culture laboratory in St. Vincent. Similarly, in Jamaica, US $32,500 of CFC project funds was used to improve the tissue culture laboratory at the Christiana Potato Growers Cooperative Association's facilities. These expenditures have enhanced the micropropagation capacity of the two facilities making them more capable of producing tissue culture roots and tubers plantlets to meet demands for these planting materials in CARICOM Member States.

b) *Protocols for cleaning planting materials* (if necessary) – the cultivars currently being propagated in the tissue culture laboratories were introduced *in vitro* from international research institutes (for example, the member institutes of the Consultative Group for International Agriculture Research). Should local or regional cultivars be identified as promising, then standard protocols have been developed to clean-up the material before micropropagation is pursued.

c) *Protocols for micropropagation of disease-free planting materials*, - in general most CARICOM countries have tissue culture facilities (e.g. Barbados, Guyana, Trinidad, Jamaica, Grenada, St. Lucia, St. Vincent) engaged activities of conservation and multiplication. Trained experienced personnel at these facilities share protocols for the successful micropropagation of a number of crops such as anthurium, banana, plantain, tannia, sweet potato, white potato, etc. Thus, protocols for the successful micropropagation of sweet potato, yam and cassava are readily available.

d) *Certification of material as being disease-free by CARDI Barbados* - typically, tissue culture plantlets are introduced into a country *in vitro* via approximately 10 to 25 test tubes to ensure sterile conditions and disease-free status. In order to accelerate the availability of this new germplasm to the region, CARDI's plant material development system facilitates the introduction of several hundred tissue culture derived plantlets to CARICOM Member States. CARDI pioneered the use of a procedure whereby the culture media is washed from the *in vitro* produced plantlet roots under sterile conditions and the media-free plantlets are then packed in zip lock bags. Since the countries receiving the plantlets are sovereign states, and the plantlets are no longer in sealed sterile culture tubes, appropriate quarantine measures must be in place to ensure that exotic pests and diseases are not introduced into the importing country. This challenge is alleviated by indexing the material from the St.Vincent tissue culture laboratory by an 'independent' laboratory (CARDI Barbados) to certify that the plantlets are disease-free. Once so certified, the planting material can be safely imported by other roots and tubers producing countries in the region. Some US $55,172 was spent to refurbish the biotechnology laboratory at Cave Hill (CARDI Barbados) to provide this certification. With the elimination of the potential for transboundary movement of pathogens (especially viruses) the introduced plantlets are thus guaranteed to be disease-free.

e) *Tissue culture material introduced to importing countries* - a critical stage re plant tissue culture derived plantlets is the interim phase between the laboratory and field conditions. *In vitro* derived plants need to be gradually hardened to field conditions. Acclimatisation (plantlet weaning and hardening) is usually carried out under greenhouse conditions that ensure high survival of the tissue-cultured plants in the field. The CFC-financed project has financed the upgrading or building of such nurseries to complement already existing national facilities. The capacity to efficiently acclimatise tissue culture plantlets has, therefore, been increased regionally.

f) *Rapid propagation of high-yielding disease-free planting material by trained personnel* – once acclimatized, the new high-yielding material must be made available to farmers as quickly as possible. Rapid propagation techniques, utilising both nursery and field techniques, have been optimised for the ready increase of the planting material. Additionally, technicians have been trained in these techniques making the production process more efficient. An outline of the procedures adopted in Barbados for the rapid propagation of cassava is detailed in Figure 1 while the flow for the production of high yielding disease-free planting material to farmers by CARDI and other national stakeholders is shown in Figure 2.

Figure 1. Diagram of flow processes for movement of planting material

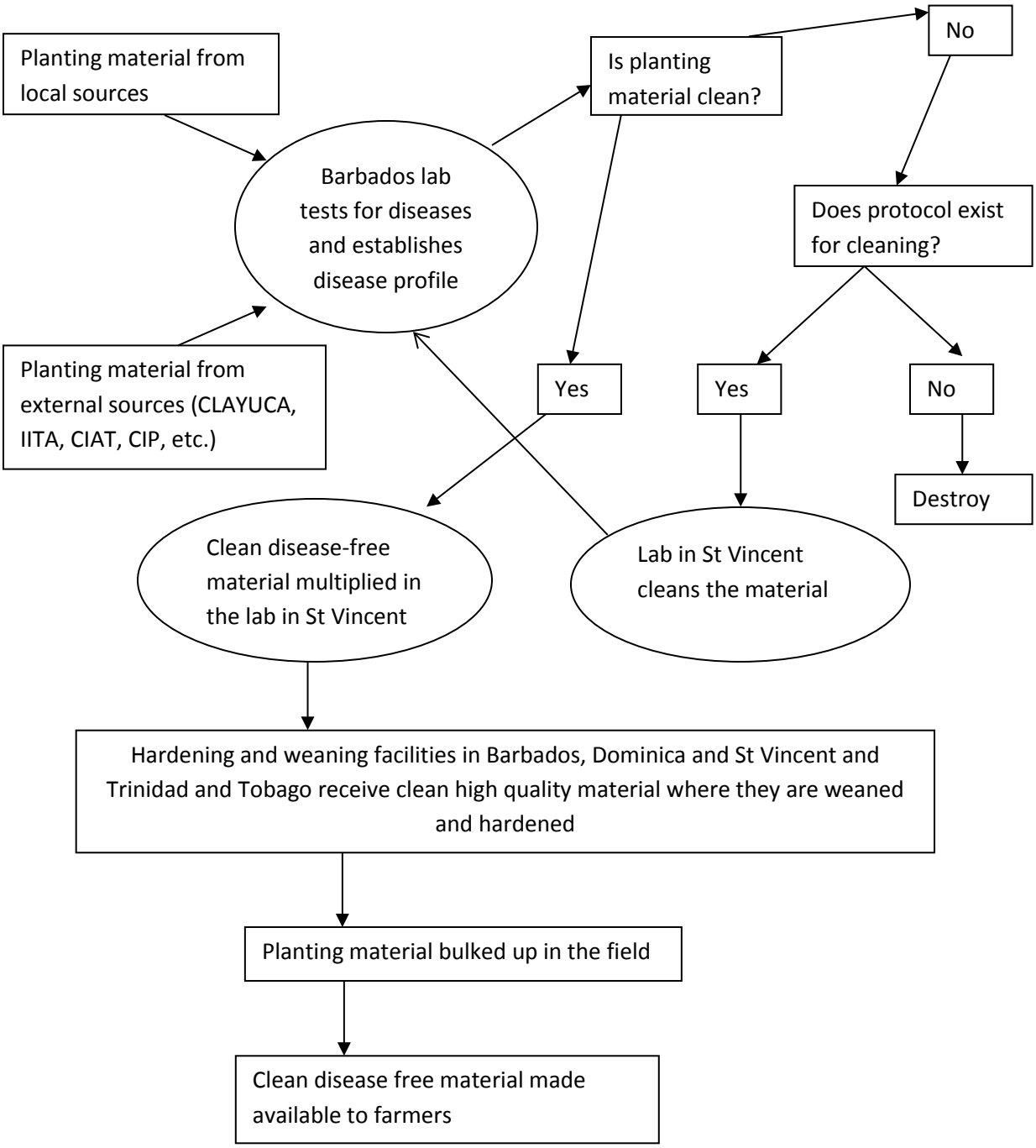
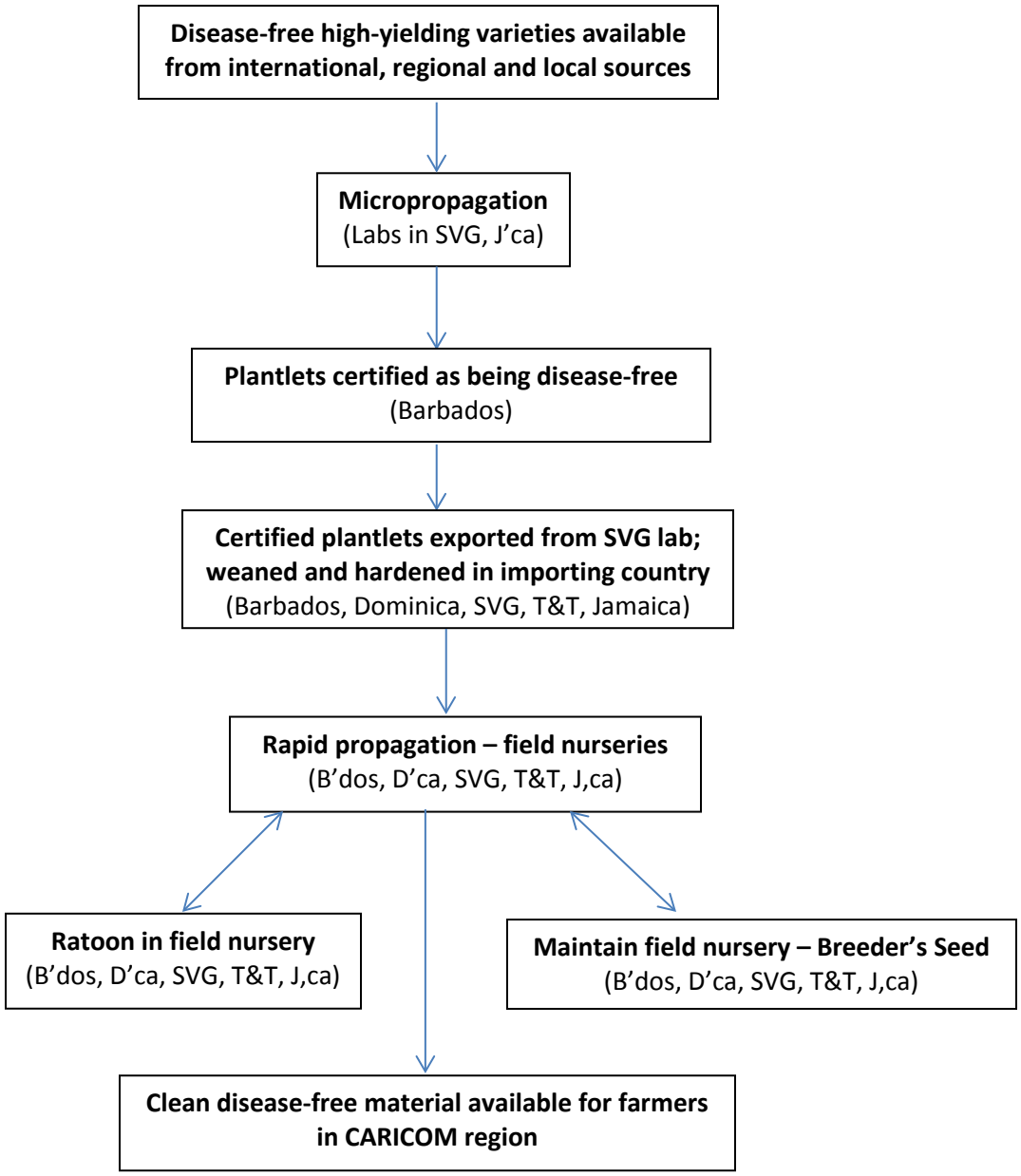


Figure 2. Diagram of flow for the production of high yielding disease-free planting material to farmers by CARDI and other national stakeholders



Summary

CARDI's developing system for the production of high-quality roots and tubers planting material will facilitate the increased productivity of sweet potato, yam and cassava in CARICOM Member States. Given these states thrust towards food security and sovereignty, the reliable provision of planting material of these crops is critical. CARDI seeks a well-defined and institutionalised partnership with stakeholders to create a self-sustaining system to maintain primary (public) and secondary (public and private) nurseries to conserve, multiply and deliver quality sweet potato, yam and cassava planting material to the region's farmers in a timely manner.

Lessons learnt

- Cassava plants produced in seedling trays in the CARDI nursery in Barbados via rapid propagation were distributed to farmers. However, the seedlings were not given the necessary in-field care to conserve their genetic potential resulting in thousands of plants being lost in farmers' fields. Therefore, it was decided that in future, farmers should be provided with hardier planting material (sticks) produced from material generated in CARDI's nurseries via rapid propagation.
- Field nurseries should be established at 3-month intervals to ensure that cuttings are always available to farmers.
- The infrastructure facilities should have been established much sooner in the life of the project (still not completed in Trinidad & Tobago and Haiti) so as to allow for their adequate use and sustainable development within the project. The slow pace of construction and establishment of the facilities negatively affected the attainment of the required outputs under Component D (production of quality planting material) of the project. Also, the duration of the project could not adequately lead to an achievement of the stated goal and to measure the impact from the use of the facilities constructed.
- There have been concerns about continuity and sustainability of actions that would ensure desired impact. This has forced CARDI to put in place sustainability plans including the utilisation of funds from other donor sources for continuation of key activities after the end of the project.

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