QUALITY DECLARED SEED FOR SWEETPOTATO: A SIMPLIFIED SEED INSPECTION SYSTEM FOR HAITI

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Quality Declared Seed for Sweetpotato: A Simplified Seed Inspection System for Haiti

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Specialized production of sweetpotato seeds in a lagoon at Boucan-Carré/1st Chambo section (Chibas, Benedique Paul, 2022)

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Contents

Acronyms

CIP	International Potato Center
FAO	Food and Agriculture Organization of the United Nations
NGO	Non-governmental organization
QDS	Quality declared seed
QDPM	Quality declared planting material
SPCSV	Sweetpotato chlorotic stunt virus
SPFMV	Sweetpotato feathery mottle virus
SPVD	Sweetpotato virus disease
VPC	Vegetatively propagated crop

Summary

Sweetpotato is a staple food in Haiti, but yield is considerably lower than in neighboring countries. Low yield can be explained by several reasons, including low quality seed. Sweetpotato is a vegetatively propagated crop (VPC) and is multiplied primarily by vine cuttings. These cuttings are bulky, perishable, and susceptible to seed degeneration which makes seed production a challenge. Production and distribution of sweetpotato seed in Haiti is entirely farmer-based, with no formal seed system in place and no improved varieties. New germplasm from the International Potato Center (CIP, by its Spanish acronym) is being tested and it is expected that improved varieties will be available in few years. However, the full potential of these new germplasm, and of existing local varieties, will only be realized if farmers can access healthy seed. This document describes a simplified seed inspection system using the quality declared seed (QDS) scheme, with information from several countries in Africa. The purpose is to help commercial seed producers, the national seed authority, and local organizations that give support to commercial seed producers, such as non-governmental organizations (NGOs), universities, or farmers' associations, to produce good quality seed at affordable prices in Haiti. It provides recommended practices for field selection, sourcing of planting materials, varieties, planting, agronomic practices, harvest and postharvest. It also provides standards for quality declaration, including composition of the inspection team, registration, seed classes (with a single seed class: QDS), visual inspection procedures, labels, costs, and tolerances for the two most important seed-borne pests and diseases in Haiti: the sweetpotato weevil (*Cylas formicarius*) and viruses: sweetpotato feathery mottle virus (SPFMV), sweetpotato leaf curl virus (SPLCV), sweetpotato chlorotic stunt virus (SPCSV), sweetpotato virus C (SPVC), and sweetpotato leaf curl virus (SPLCV) and related begomoviruses. Eventually, improved varieties will be released, and a more sophisticated seed inspection system could be designed, including more seed classes and more precise methods for estimating phytosanitary seed quality.

1. Introduction

Sweetpotato is a staple food in Haiti. It covers nearly one third of the area of roots and tubers and about 7% of the total cultivated area, ranking first before yam and cassava (Paul et al., 2024). In 2022, the harvested area was 48,755 ha, total production of 111,662 t, and average yield of 2.3 t/ha. This yield is lower compared to neighboring countries, such as Antigua 4.0 t/ha, Barbados 26.2 t/ha, Cuba 8.3 t/ha, Dominican Republic 8.6 t/ha and Jamaica 17.4 t/ha (FAOSTAT 2022).

Low yield can be explained by several reasons but one of the most important is low quality seed. Sweetpotato is a vegetatively propagated crop (VPC) and is multiplied by vine cuttings that form roots at the nodes, producing daughter plants; or storage roots that subsequently sprout to give new plants. These are called planting materials or seed[1]. Vegetative propagation gives farmers the advantage of obtaining seed from their previous field crop. However, this type of propagation also has limitations. First, vines and roots are bulky: around 30,000 vines per ha, or around 500 kg of roots per ha using the triple S method (CIP, 2021). Second, in the case of vines, they are perishable as they cannot be stored for more than seven days. Finally, pests and pathogens, especially viruses such as sweetpotato feathery mottle virus (SPFMV, and related potyviruses), sweetpotato chlorotic stunt virus (SPCSV), and sweetpotato leaf curl virus (SPLCV, and related begomoviruses) can build up in successive cycles of vegetative propagation leading to lower yields, a phenomenon called seed degeneration. This phenomenon is fostered in farming contexts like Haiti where vines are exchanged between farmers across the production areas and recycled from season to season. Bulkiness, perishability, and propensity to degeneration make seed production a challenge for VPCs, such as sweetpotato.

In 2023, the International Potato Center (CIP, by its Spanish acronym) introduced 3,000 botanical seeds belonging to three breeding families and 30 improved sweetpotato clones into Haiti. This germplasm has the following characteristics: high dry matter content, weevil (*Cylas formicarius*) resistance, white, yellow or orange flesh, good processing quality, early maturing, and double purpose for food and forage use. However, the full potential of these new germplasm, and of existing local varieties, will only be realized if farmers can access healthy seed.

This document describes a simplified seed inspection system using the quality declared seed scheme (QDS) proposed by the Food and Agriculture Organization of the United Nations (FAO) and CIP (Fajardo et al., 2010). The purpose is to help commercial seed producers, the national seed authority, and local organizations that give support to commercial seed producers, such as non-governmental organizations (NGOs), universities, or farmers' associations, to produce good quality seed at affordable prices in Haiti. It is structured following a similar document designed for potato in Ethiopia (Dereje at al., n.d.) with elements from a QDS regulation for sweetpotato in Tanzania (The United Republic of Tanzania, 2020), a report from Uganda and Tanzania (Gibson et al., 2016), technical guidelines from Uganda (Mukasa et al., 2016) and a training of trainers' manual (Stathers et al., 2018).

[1] Sweetpotato sexual seeds are used for breeding purpose, not for production. In this context, the term 'seed' refers to quality cuttings or storage roots that have been selected for use in generating new plants. It does not refer to just "any vine" or botanical seed which is used for breeding.

2. Sweetpotato seed system in Haiti

Production and distribution of sweetpotato seed in Haiti is entirely farmer-based, with no formal seed system in place. Paul et al. (2024) identified that all the varieties grown are landraces with few specialized seed producers, and poor coordination among the different stakeholders. Rainfall patterns in Haiti are predominantly bimodal and, therefore, farmers can usually access sweetpotato planting materials from the previous field crop, although drought was recently identified as the second production constraint after weevils and viruses (Paul et al., 2023). There are no enforced regulations nor standards in place to ensure seed quality and good management practices. Under these conditions, seed systems could be improved through strengthening farmers seed management practices, such as ensuring that cuttings are obtained from healthy plants, roguing out infected plants; taking cuttings from the apical section of the vines to avoid weevil eggs; and working with breeders, farmers, and consumers so that the new varieties meet farmers' and consumers' needs (Stathers et al., 2018).

3. Quality declared seed

Quality declared seed (QDS) was proposed by FAO to improve the production and distribution of seed in countries, areas, or crops in which the formal system for producing certified seed is not functional, mainly because seed quality control activities are difficult to conduct (FAO, 2006). The QDS scheme is not intended to replace or compete with the formal seed system but rather is an intermediate step between farmer-based seed systems and a fully developed certification system. The QDS scheme is implemented primarily by seed producers and the main element is that the label on the seed package represents quality of the contents (FAO, 2006). The quality declared system is based on four principles (FAO, 2006): (1) a list of varieties eligible to be produced as QDS is established; (2) seed producers are required to register with the national seed authority; (3) the national authority will check at least 10% of the seed crops; and (4) the national authority will check at least 10% of the seed offered for sale as QDS.

The QDS scheme was adapted for VPCs, such as sweetpotato, by FAO and CIP (Fajardo et al., 2010). In this case it is called quality declared planting material (QDPM) scheme and focuses mainly on improving physiological and phytosanitary quality of the planting material (or seed).

4. Main pests and diseases for production of sweetpotato seed in Haiti

There are many pests and diseases that affect sweetpotato. For production of quality seed in Haiti, we will focus on the two most important: the sweetpotato weevil and viral diseases.

The **sweetpotato weevil** (*Cylas formicarius*) is the most important pest in Haiti (Lexidort, 2019; Paul et al., 2023; Paul et al., 2024). The adults feed on leaves, vines, and the external surfaces of storage roots. Larvae tunnel the vines and roots causing severe damage in roots, malformation, thickening, and cracking of vines, pale green leaves, and reduction of plant vigor (CABI, 2020). Integrated management practices include crop rotation, intercropping, mulching, sanitation, destruction of crop residues, control of alternative hosts and the use of healthy cuttings (CABI, 2020). Since the weevil lays eggs in older vines (if storage roots are not present or if roots are inaccessible), using cuttings from terminal sections of the stems and dipping them in insecticide solutions can help to ensure healthy seed (CABI, 2020).

As for **viral diseases**, three viruses are important for sweetpotato production in Haiti: sweetpotato feathery mottle virus (SPFMV), sweetpotato leaf curl virus (SPLCV) with the highest incidence, and sweetpotato chlorotic

stunt virus (SPCSV) with low incidence (S. Fuentes, pers. comm.). Characteristics of these three viruses are listed in Table 1. Importantly, the interaction between SPFMV and SPCSV may indicate the presence of sweetpotato virus disease (SPVD). SPLCV can also interact with SPCSV inducing leaf curl symptoms. In both cases, the titer of SPFMV and SPLCV increase in the plant tissues (Untiveros et al., 2007; Cuellar et al., 2015), which facilitates the transmission of viruses by their insect vectors (aphids and whiteflies, respectively).

Table 1. Main characteristics of sweetpotato viruses present in Haiti: sweetpotato feathery mottle virus (SPFMV), sweetpotato leaf curl virus (SPLCV), and sweetpotato chlorotic stunt virus (SPCSV)

	Virus		
Characteristics	**SPFMV[1]**	**SPLCV[2]**	**SPCSV[3]**
Genus	Potyvirus	Begomovirus	Crinivirus
Symptoms	Often inconspicuous or absent in leaves. If present, irregular chlorotic spots occasionally bordered by purplish pigment. In tubers, one strain causes external necrotic lesions or internal cork on certain varieties	Upward curling of leaf margins, vein clearing, chlorosis, stunting	Purpling or yellowing in lower leaves, mild vein yellowing, sunken secondary veins on adaxial leaf surfaces, swollen veins on adaxial surfaces. Virus infections may also be asymptomatic
Transmission	Non-persistent	Persistent-circulative	Semi-persistent
Vector	Aphids	Whitefly *(Bemisia tabaci)*	Whitefly *(Bemisia tabaci), B. afer*[4]*, Trialeurodes abutilonea)*
Long distance dissemination	Infected storage roots and cuttings	Infected storage roots and cuttings	Infected storage roots and cuttings
Host range	Convolvulaceae and Chenopodiaceae	Convolvulaceae	Convolvulaceae and Solanaceae
Control	Healthy planting material, sanitation, resistant varieties	Healthy planting material, sanitation, resistant varieties, vector management	Healthy planting material, sanitation, resistant varieties, vector management

[1] CABI, 2021a; [2] CABI, 2021b; [3] CABI, 2021c; [4] Gamarra et al., 2010.

5. Recommended Practices

5.1 Field selection

Fields for production of sweetpotato vines or storage roots that will be used as seed should have a rotation period of at least two seasons, and the previous crop should not have been sweetpotato. Distance to other sweetpotato crops should be of at least 20 m (The United Republic of Tanzania, 2020).

5.2 Sourcing of planting materials

Vines or storage roots that will be used as starting seed for QDS production should come from *in vitro* virus-indexed plants provided by known sources, such as organizations from the local or central public sectors, or a university. If *in vitro* plants are not available, plants from positive selection (combined with biological test) are an alternative (Mwanga and Fuentes, 2010). Ideally, genetic and phytosanitary quality should be assured with a lab certificate with the results of tests for SPFMV, SPLCV, SPCSV, and other related viruses (potyviruses, begomoviruses). Other sources include farmer's organizations and specialized seed producers reported by Paul et al. (2024). In this case genetic and phytosanitary quality should be assured visually, discarding all off-type[2] plants and plants with viral and weevil symptoms.

5.3 Varieties

As of 2024, there are no improved sweetpotato varieties officially released in the country. All local varieties described by Paul at al. (2024) are accepted for QDS production and should be registered by the national seed authority. In the absence of it, local organizations that give support to commercial seed producers, such as NGOs, universities, or farmers' associations, should have an updated list of the varieties most demanded by farmers and consumers with a brief description of their main morphological characteristics.

5.4 Planting

The most common way of multiplying sweetpotato is the use of cuttings, especially in areas with bimodal rain patterns, such as Haiti. Three-node cuttings (0.3-0.4 m long), with the basal leaves removed, are taken from apical portions of vines from vigorous 3-month mother plants. If there is risk of weevil damage, the cuttings should be dipped in a solution of a systemic insecticide before planting. The latter should be made available at affordable price, since specialists have reported the high price of such products (Paul et al., 2023).

In areas with unimodal rain patterns, storage roots are used to produce sprouts. Roots are planted in nursery beds (1.2 m wide, 0.2 m high) at 0.25-0.30 m between them. Sprouts are harvested when they are 0.2-0.3 m long and with 5 – 7 nodes, and then planted in the field (Mwanga and Fuentes, 2010). Another procedure for obtaining sprouts from storage roots is the Triple S method (CIP, 2021).

Sprouts and cuttings are planted in the field in mounds, ridges, or flat terrain. For harvesting vines and roots ("dual purpose method", Gibson et al., 2016), vines or sprouts are planted 0.3 m apart in ridges or mounds 1-1.2 m apart. For harvesting vines ("on the flat method", Gibson et al., 2016) shorter cuttings (0.15 m with 3 – 4 nodes) are planted at higher densities (0.1 m between plants and 0.2 m between rows) in beds that are 1-2 m wide and 6 m long. The beds are sunken in areas that are dry and require watering and raised when prepared in swampy

[2] "A plant which does not display the recognized characters of growth, morphological formation either in leaf or flower, a shape or color or is in any way obviously different from accepted characters of the variety being grown." (Mukasa et al., 2016)

areas. Cuttings are planted upright with two nodes below the soil surface. Net tunnels can be used in areas with high pressure of viruses and their insect vectors to protect the seed vines from virus infection (CIP, 2018).

5.5 Agronomic practices

Well decomposed farmyard manure should be applied before planting at 2.5 kg/m^2. Commercial fertilizers should be applied at recommended doses at planting, e.g., 17-17-17 NPK at the rate of 42 g/m^2. Urea is applied at the rate of 13 g/m^2 after each harvest of cuttings, followed by light watering. Use commercial approved insecticides at recommended doses for controlling aphids, whiteflies, and mites (Mwanga and Fuentes, 2010). Weed and water plants as needed. Use personal protective equipment and follow local regulations for handling pesticides.

5.6 Roguing or negative selection

A critical practice for ensuring phytosanitary quality of vines and storage roots is the periodical removal of off-type plants and plants showing viral and weevil symptoms. This should be done at least twice during the cropping cycle. For better protection, roguing of viral-diseased plants must be done during the first month after planting (Gibson et al., 2004). Removed plants should be buried or composted properly.

5.7 Positive selection

Roguing can be complemented by pegging the best plants (those with the characteristic of the variety that is being grown, vigorous and with no virus symptoms or signs of weevil damage) and then obtaining cuttings and roots from those plants only. This is called positive selection as opposed to negative selection or roguing. Pegging can be done with sticks, and it should be done at least twice during the cropping season to ensure that the plants selected remain healthy and vigorous. If the purpose is obtaining roots, then at harvest select the roots from the pegged plants that had the highest yield (Stathers et al., 2018).

5.8 Harvest

In the “dual purpose method” (Gibson et al., 2016) cuttings are harvested once or twice and roots are harvested periodically during crop growth, while both roots and vines are taken in the final harvest. In the “on the flat method” (Gibson et al., 2016) several harvests of cuttings are taken depending on management (irrigation and, pest and disease control).

Harvest cuttings (0.25 m long) from the apical portions of the vines, 10 cm above the soil level, leaving some nodes on the stems to enable further production of cuttings from the auxiliary buds. Obtaining cuttings above the soil surface increases the chance of selecting weevil-free cuttings (Mwanga and Fuentes, 2010).

For roots, they are dug out of the soil when they are physiologically mature (with a well-developed skin, full sized, 90-120 days after planting, depending on the variety), with each hill or ridge handled and graded separately. Only those hills/ridges that have a high yield of well-shaped roots and are free of defects are selected (Mwanga and Fuentes, 2010).

5.9 Post-harvest

Roots must be selected visually discarding those off-type, with malformations and symptoms and signs of weevil infestation. They are cured, i.e., they are stored after harvest at 29–32°C and 95–100% relative humidity for 5–7 days with adequate ventilation. Subsequent storage is best at around 13°C and 95% relative humidity (Mukasa et al., 2016).

Roots and vines must be stored in well ventilated, shaded, clean places, and transported in net bags or well-aerated containers to avoid excess heat damage due to respiration. In the case of cuttings, it is recommended to strip off the lower leaves and then tie them in 50-100 cuttings bundles with their bases covered with a wet cloth or sack, and then packed together in large bundles of 1000 cuttings (Gibson et al., 2016; Mukasa et al., 2016).

6. Quality declaration and standards

6.1 Inspection team

The inspection team should have at least one representative of the national seed regulatory body, the research system, or delegated to an "authorized inspector" at a decentralized level for example a district crop protection officer, or a village extension officer (Stathers et al., 2018). In the absence of an official inspection team, commercial seed producers can be trained to inspect their fields to determine whether the material reaches the QDS standards. Seed inspection can also be conducted by local organizations that give support to commercial seed producers, such as NGOs, universities, or farmers' associations.

6.2 Registration

Commercial seed producers that want to produce and sell sweetpotato QDS should be registered with the national seed regulatory body (Stathers et al., 2018). In the absence of it, commercial seed producers should coordinate with local organizations that give support to commercial seed producers, such as NGOs, universities, or farmers' associations, to have an updated list of commercial seed producers. Improved varieties should be registered in the national variety catalogue.

6.3 Seed classes

It is proposed to start the QDS scheme in Haiti with a single seed class (using the terminology used by Stathers et al., 2018): QDS produced in field conditions. Once improved varieties are released two new classes can be added: breeder seed (or nucleus seed): *in vitro* plants produced in laboratory conditions; prebasic seed: cuttings or storage roots produced in greenhouse conditions; and certified seed: cuttings or storage roots produced in field conditions in areas and seasons with low vector incidence for delivery to growers.

6.4 Tolerances

It is proposed to start the QDS scheme in Haiti with tolerances for four parameters: off-type plants, virus symptoms, weevil damage, and weeds (Table 2).

Table 2. Tolerances (%) of parameters for production of quality declared seed (QDS) for Haiti.

Parameter	Quality declared seed
Maximum other varieties or off-types	2
Maximum virus symptoms (chlorotic spots, chlorosis, upward curling of leaf margins, vein clearing, stunting, purpling or yellowing, mild vein yellowing, sunken secondary veins on adaxial leaf surfaces, swollen veins on adaxial surfaces)	10
Maximum plants with signs of weevil	10
Weeds	Reasonably free from weeds

Source: Stathers et al., 2018

6.5 Inspection

Following the principles of the QDS scheme (FAO 2006), 1 in 10 fields should be inspected at random. The remaining fields are not inspected, and it is up to the commercial seed producer to ensure the quality of the seed that is being produced.

Two visual inspections are typically done, the first about 4-6 weeks after planting when disease symptoms would first start, and at which point the multiplier can be advised to rogue, weed, or spray the crop. The second inspection should be done about two weeks before harvest. If the pest or disease level is above the tolerance level (Table 2), the field is rejected, vines cannot be used as seed and storage root are used as ware. During this second visit, the estimated quantities of planting materials which can be harvested from the field are also calculated. A third inspection may be done at harvest if a particular problem is observed (Stathers et al., 2018; The United Republic of Tanzania, 2020).

Inspection procedure (The United Republic of Tanzania, 2020)**.**

1. Before entering the field, the inspector confirms with the commercial seed producer the following: name of the producer, location of the seed crop field, variety to be inspected, seed source, and previous cropping history of the field.
2. Then the inspector checks if the sweetpotato plants conform to the characteristics of the variety and examines the boundaries of the field to confirm the isolation requirement.
3. Then the inspector estimates the percent of off-types plants, plants with virus symptoms, and plants with signs of weevil damage:
    a) Estimate the number of plants in the field by dividing the area of the field (m^2) by the plant density (plant/m^2). For example, if the field is around 500 m^2 and cuttings were planted at 1.0 x 0.3 m then the plant density is 0.3 plants/m^2. Dividing 500 m^2 by 0.3 plants/m^2 the inspector estimates 1667 plants in the field.

    b) Estimate the number of plants to be inspected by multiplying (5%, The United Republic of Tanzania 2020) by the number of plants in the field. Following the example, 1667 plants x 0.05 = 83 plants, which is rounded to 80 plants.

    c) Select several rows at random and in each select the number of plants to be inspected. Following the example, the inspector selected 4 rows and in each 20 plants are inspected.

    d) Estimate the percentage of off-types, plants with virus symptoms, and plants with signs of weevil damage for each of the rows. Then average the values to obtain the value for the field. Following the example and using the off-type plants parameter to illustrate the example, the inspector found 1 off-type plant in row 1 (1/20*100 = 5%), 3 in row 2 (15%), 2 in row 3 (10%), and 0 in row 4 (0%). The average percentage for off-type plants for the field is (5+15+11+0) / 4 = 7.5%.
4. The final step in the inspection procedure is to complete the inspection report and decide either to accept or reject the field or to recommend further remedial action before a final decision is taken. Following the example, the inspector decides to recommend to the seed producer to rogue out off-type plants. The inspector will come back two weeks before harvesting to reassess the field and make a final decision.

6.6 Labels

Tags are a critical part of the QDS scheme because the tag on the seed package represents quality of the contents (FAO, 2006). The tag should have the following information: seed producer's name, location, phone number, and variety. In the case of cuttings, include the number of cuttings. In the case of roots, include harvest date and weight. Labels should have a standard format (color, size, paper, font) and should be provided by the national seed regulatory body to those seed commercial producers that are registered as QDS producers. In the absence of the national seed regulatory body, the labels can be provided by local organizations that give support to commercial seed producers, such as NGOs, universities, or farmers' associations.

6.7 Costs

The cost of producing sweetpotato QDS will be covered by the commercial seed producer. The inspection costs could be subsidized by the national seed regulatory body. In the absence of it, the cost could be covered by local organizations that give support to commercial producers, such as non-governmental organizations or universities.

7. Looking forward

This simplified seed inspection system aims at helping commercial seed producers, national and local organizations to produce good quality seed at affordable prices in Haiti. It focuses on local varieties and a single seed class (QDS), but eventually improved varieties will be released and a more sophisticated seed inspection system could be designed, including more seed classes and more precise methods for estimating phytosanitary seed quality. Its implementation requires some organizational and institutional innovations among local actors. Training is also necessary for the different types of actors. Such training can be provided by local regulatory body, or universities in collaboration with NGOs.

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