Draft FAO/CIP QDPM protocol for sweetpotato

Introduction

Origin
Sweetpotato, *Ipomoea batatas* (L.) Lam., belongs to family Convolvulacea (Morning glory). Sweetpotato originated in or near northwestern South America around 8000-6000 B.C. Guatemala, Colombia, Ecuador, and northern Peru have the greatest diversity in sweetpotato germplasm. Secondary centers of genetic variability are Papua New Guinea, the Philippines and parts of Africa.

Modes of propagation
The sweetpotato can reproduce asexually by: a) colonizing an area by production of storage roots which subsequently sprout to give new plants, b) reproducing vines which may form roots at the nodes, producing daughter plants. The sweetpotato can also reproduce sexually by production of seed, but seed is used only in research for breeding. Sweetpotato is a perennial dicot, but it is cultivated as an annual for vines and storage roots. Sweetpotato is sensitive with a photoperiod of 11.5 hr day length or less promoting flowering, while at 13.5 hr day light, flowering ceases but storage root yield is not affected. Short days with low light intensity promote root development.

Estimated reproductive rate using vine cuttings is 1:15 to 1:20. At optimum conditions, from one tissue culture plantlet it is possible to produce 64 000 cuttings from 800 m^2 field plot in one year.

Pests and diseases

A wide range of pathogenic organisms attack sweetpotato, and although most are widespread, damage levels vary. These organisms include viral, fungal and bacterial diseases, and those caused by nematodes. Globally, at least 20 viruses are known to infect sweetpotato. These viruses occur singly or as mixed infections. *Sweet potato feathery mottle virus* (SPFMV) is the most common virus infecting sweetpotato globally. In mixed infections with *Sweet potato chlorotic stunt virus* (SPCSV), SPFMV is associated with the severe sweetpotato virus disease (SPVD), the most important disease of sweetpotato in Africa. Other viruses include: *Sweet potato mild mottle virus* (SPMMV), *Sweet potato latent virus* (SPLV), *Sweet potato chlorotic flecks virus* (SPCFV), *Sweet potato virus G* (SPVG), *Sweet potato leaf curl viru*s (SPLCV). Whiteflies and aphids act as vector of some viruses.

Bacterial diseases can be economically damaging in some parts of the world. They include bacterial stem, and root rot (*Dickeya dadantii)* occurs worldwide; bacterial wilt (*Pseudomonas solanacearum*), important in southern China; and soil rot (*Streptomyces ipomoea*), is important in parts of USA and Japan. Use recommended control measures such as good crop hygiene, and resistant varieties.

Root-knot nematodes (*Meloidogyne species*) occur worldwide. The extensive root-knot nematode (RKN) host plant ranges, and their interactions with pathogenic fungi and bacteria in plant disease complexes, rank RKN among the major pathogens in crops. Nematode attack in sweetpotato causes stunting, yellow foliage, abnormal flower production, round to spindle-shaped swellings (galls), necrotic root system, and low

yields. More than 50 species of RKNs have been described, but *Meldogyne incognita*, *M. javanica*, *M. arenaria*, and *M. hapla* Chitwood account for more than 95% in agricultural soils globally.

Worldwide there are at least 270 species of insects and 17 species of mites that feed on sweetpotatoes. Insect pests are categorized into defoliators, virus transmitters, stem borers and root feeders. Sweetpotato weevil, *Cylas* spp. is the chief pest of sweetpotatoes. Worldwide there are three main economically important sweetpotato weevils: *Cylas formicarius* occurs globally, while *C. puncticollis* and *C. brunneus* are the main species in Africa. The West Indian sweetpotato weevil, *Euscsepes postfasciatus* occurs in Central and South America, the Caribbean, and the Pacific Islands.

The most damaging stage of weevils is the larval stage. The larvae mainly attack stems and underground parts, although they may also feed on leaves. Adult weevils oviposit in the bases of vines and in exposed roots, while the larvae tunnel through storage roots causing major economic losses. The damage caused by larvae and adults also stimulates the production of terpene phytoalexins, which make the storage roots unhealthy for human consumption. Weevil population and damage is most prevalent during dry seasons, probably because drought increases soil cracking, thus exposing roots to weevils.

Protocol for Production of planting material

Facilities/equipment

Established protocols specific for region or country or CIP are followed to clean up sweetpotato from different sources, field, screenhouse or tissue culture of all pathogens in tissue culture to produce virus-indexed plantlets for local, regional and international germplasm use (Figures 2.1 and 2.2). Important facilities include well-equipped greenhouses and/or screenhouses, tissue culture laboratories and virus detection equipment and indictor plants for virus indexing. Basic equipment for tissue culture includes: autoclave, lamina flow hood, pH meter, sensitive balances, refrigerators, and heaters. A growth room for in vitro plantlets can be constructed locally. The size of fields for multiplication and increase of stocks of clean plants depends on the demand for clean planting materials and the capacity of the country, organization or agent to meet the demand.

Agronomic practices (including rotations)

Sweetpotato is a perennial but is normally grown as an annual plant. In the tropics it is propagated from vine cuttings, but in temperate regions it may also be grown from rooted sprouts (slips) pulled from bedded storage roots. Apical cuttings, 30-45 cm long are planted by inserting into the soil at an angle. In some parts of East Africa, cuttings may be wilted or left in shade for a few days. In India, the central portion of a cutting is buried in the soil, leaving a node exposed at both ends.

Sprouts are obtained by planting small or medium sized roots close together in nursery beds. The resulting spouts, 22-30 cm long, are removed from the storage roots and planted in the field. Cuttings and sprouts are planted on mounds, or ridges, or on the flat if the soil is deep and well drained. Mounds are used extensively in the tropics especially where the water table is high to improve drainage. Mounds up to 60 cm high, about 90-

120 cm apart, are planted with three or more cuttings. Ridging is suitable for mechanical preparation of the ground. Ridges are about 45 cm high and 90-120 cm apart, with cuttings planted at 30 cm intervals.

Sweetpotato is often the lead crop in a rotation cycle, except in very fertile soils. In these soils, planting at the start of the rotation should be avoided, as excessive vegetative growth occurs at the expense of storage root formation.

Seed crop monitoring:

A sweetpotato crop for planting material (seed) production, when well established, with good vine growth, is carefully inspected by an experienced breeder or seed inspector or other trained personnel to detect off-type plants within a variety. In addition, all plantings undergo inspection for varietal purity by the appropriate authority some time during the growing season.

Inspection methods:
Field inspections before and during harvest are conducted to identify high yielding hills, desirable shape, detection of off-type plants, variety mixtures, serious diseases and pests, coupled with positive selection of roots or vines to serve as the breeder seed for planting the next season's crop. Field inspections are conducted at to coincide with the time when diseases are most conspicuous, such as at months after planting when SPVD is vivid. Inspection of one percent of field taken randomly in four different places of a large field is representative, but for smaller fields a higher percentage can be used.

Harvesting:

At harvest, roots are dug out of the soil, and each hill is separately handled and graded. Only those hills with a high yield of well-shaped roots and are free of any defects are selected, and only disease-free vines are cut to serve as breeder seed.

Storage: Proper handling after harvest includes curing of seed roots, proper sanitation, including removal of all old sweetpotato and fumigation of the house before storage of new roots. Dust and debris from the grading and packing area must not come in contact with seed roots or vines. Vines must be stored in well ventilated, shaded places before planting. All storage roots and vines for seed must be transported in net bags or well aerated containers to avoid excess heat damage due to respiration and close packing.

Labeling requirements:

Each container of seed roots or vines is appropriately tagged to identify them as foundation, registered, or certified. If the container or bundle of vines is not tagged, the seed is not certified. Label information includes, variety name/code, farm location, seed grower name, harvest date, batch number, weight/batch, number/bath, length, inspector name/code, and quality standards-logo. All labeled seed roots or vines should follow quality standards (Table 2.1).

Multiplication Program Protocol:

Breeder seed of all varieties officially released in a country is produced and maintained by the sweetpotato breeder. Breeder seed is the highest quality available of the variety.

The breeder seed is carefully maintained until the next multiplication cycle is repeated. Guidelines for production of foundation seed, registered, and certified seed are basically the same. The guidelines relate to land requirements, inspections, and standards for fields, seeds and plants. Sweetpotatoes grown for certification are handled much the same way as the commercial crop except for the following: plants showing any mutations and symptoms are discarded, a 4-year rotation is followed, only vine cuttings may be used for production of foundation seed, and during the growing season fields that are to be certified must have at least one field inspection by the relevant official.

Materials for rapid multiplication:

Fertilizer, NPK 17-17-17 at the rate of 42 gm^{-2} is applied after planting. Urea is applied at the rate of 13 gm^{-2} after each harvest of cuttings, followed by light watering. Manure at 2.5 kgm^{-1} is applied as farmyard manure before planting. The manure should be well decomposed.
Insecticides: all cuttings should be dipped in carbofuran (0.05% ai) solution for 20 min before planting. This will kill all stages of the weevil and provide some residual protection for the young plants. Before planting, apply carbofuran at the rate of about 5 gm^{-2}. Mix thoroughly with soil. To control aphids and white flies, and mites, apply weekly acricide or Ambush or available alternative pesticides on market following recommended dosage.
Fungicides: Apply Benlate (4 g in 10 l of water) or other available fungicide on market following recommended dosage when symptoms appear.
Varieties: Identify appropriate varieties for rapid multiplication.
Cuttings: three node cuttings are taken from vines whose leaves were previously removed. Apical or top cuttings are planted separately.

Preparation of nursery beds
The beds are raised, 10 m long, 1.2 m wide and 20 cm height. Fertilizer (17-17-17), manure (2.5 kgm^{-2} and insecticide (carboduran) are applied and mixed thoroughly with soil before planting.

Preparation of planting material: Cuttings are taken from vigorous mother plants of about 3 months. Leaves are removed from the vines. Prepare three node cuttings from all parts of the vine. Apical cuttings with three nodes are planted separately. Deep the cuttings in a solution of carbofuran and water for 20 minutes before planting.
Planting
Density: 50 cuttings m^{-2} (0.2 m between rows x 0.10 m intra-row). The cuttings are planted upright with two nodes below the soil surface.
Cultural practice
Irrigate 2-3 times a day, early morning and late afternoon with a horse pipe or watering can. **Weed** periodically to maintain the nursery beds clean. **Rouge** all diseased plants. Where there is excessive sunlight and hit, use mats or other locally available material to shade the nursery beds. Remove the mats when the first leaves start developing. Avoid keeping the mats for more than 2 weeks to prevent etiolation.
Cutting (Harvesting) vines: Cut apical cuttings (25 cm long) 5 cm above the soil level leaving some nodes on the stems to enable further production of cuttings from the axillary buds. The procedure of cutting above the soil surface ensures a 98% chance of selecting weevil-free plants.
Data to be collected in rapid multiplication beds includes, % sprouting or establishment (2 weeks after planting), harvesting (cutting) dates of apical cuttings,

number of apical cuttings harvested, % rooting success (survival in the open field), and reaction of cuttings in the open field related to the yield.

Selected references:

Ames T (editor). 2002. Proceedings of the First International Conference on Sweetpotato, Food and Health for the Future. *Facta Horticulturae*, Vol. 583.

Ames T, Smit NEJM, Braun AR, O'Sullivan JN and Skoglund LG. 1996. *Sweetpotato: major pests, diseases, and nutritional disorders.* International Potato Center (CIP). Lima, Peru. 152 p.

Aritua V, Bua B, Barg E, Vetten HJ, Adipala E and Gibson W. 2007. Incidence of five viruses infecting sweetpotatoes in Uganda; the first evidence of Sweet potato caulimo-like virus in Africa. *Plant Pathology*, 56:324-331.

Clark CA and Moyer JW. 1988. Compendium of sweetpotato diseases. *The American Phytopathological Society*, St Paul, MMN, USA. 74 P.

Dangler JM. 1994. *Compendium, sweetpotato foundation programs.* HORTTECH, 4(3)223-238.

Degras L. 2003. Sweet Potato. *The Tropical Agriculturalist.* CTA/CIP edited by Coste L. Macmillan, Oxford, UK.

Jansson RK and Raman KV. 1991. *Sweet potato pest management: A global perspective.* Westview Press Inc. Oxford, UK.

Kreuze J and Fuentes S. 2007. Sweetpotato viruses. In: *Encyclopedia of Virology, Third Edition*. Elsevier (UK) Ltd, Kidlington, Oxford

Mukasa SB, Rubahiyo PR and Valkonen JPT. 2006. Interactions between a crinivirus, an ipomovirus and a potyvirus coinfected sweetpotato plants. *Plant Pathology* 55: 458-467.

Onmueme IC. 1978. *The tropical tuber crops: Yams, Cassva, Sweetpotato and Cocoyams.* John Willey and Sons, New York.

Untiveros M, Fuentes S and Salazar LF. 2007. Synergistic interaction of *Sweet potato chlorotic stunt virus* (*Crinivirus*) with carla-, cucumo-, ipomo-, and potyviruses infecting sweetpotato. *Plant Dis*. 91: 669-676.

Woolfe JA. 1991. *Sweetpotato: An untapped food resource.* Cambridge University Press Cambridge.

http://www.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/media/html/FrontPage/FrontPage.htm

http://www.ncsweetpotatoes.com/index.php?option=com_content.

Table 2.1. Maximum tolerances for disease, insect damage, and internal quality standards for foundation, registered, and certified sweetpotato seed.

Standards	Foundation (1st generation)	Registered (2nd generation)	Certified (3rd generation)	QDPM (4th generation)
Black rot	None	None	0.1%	0.5%
Root-knot Nematodes	None	0.2%	0.5%	1.0%
Scurf	None	None	0.1%	0.5%
Wireworms	1.0%	2.0%	5.0%	10.0%
Wilt	None	None	0.1%	0.5%
SSR-Pox[1]	None	5.0%	5.0%	10.0%
Sweetpotato viruses				
Mosaic and stunting	None	None	None	1%
Leaf curl	None	None	None	5%
Other (e.g. purpling of old leaves, chlorotic spots, vein clearing)	None	None	None	5%
Other varieties	None	None	None	2%
Storage rot	None	None	None	None
Sweetpotato weevil	None	None	None	None

[1]Seed with pox will be labelled *Sterptomyces* soil rot (pox) below 5%. Other defects are none for foundation, registered and certified seed: other varieties, storage rot.

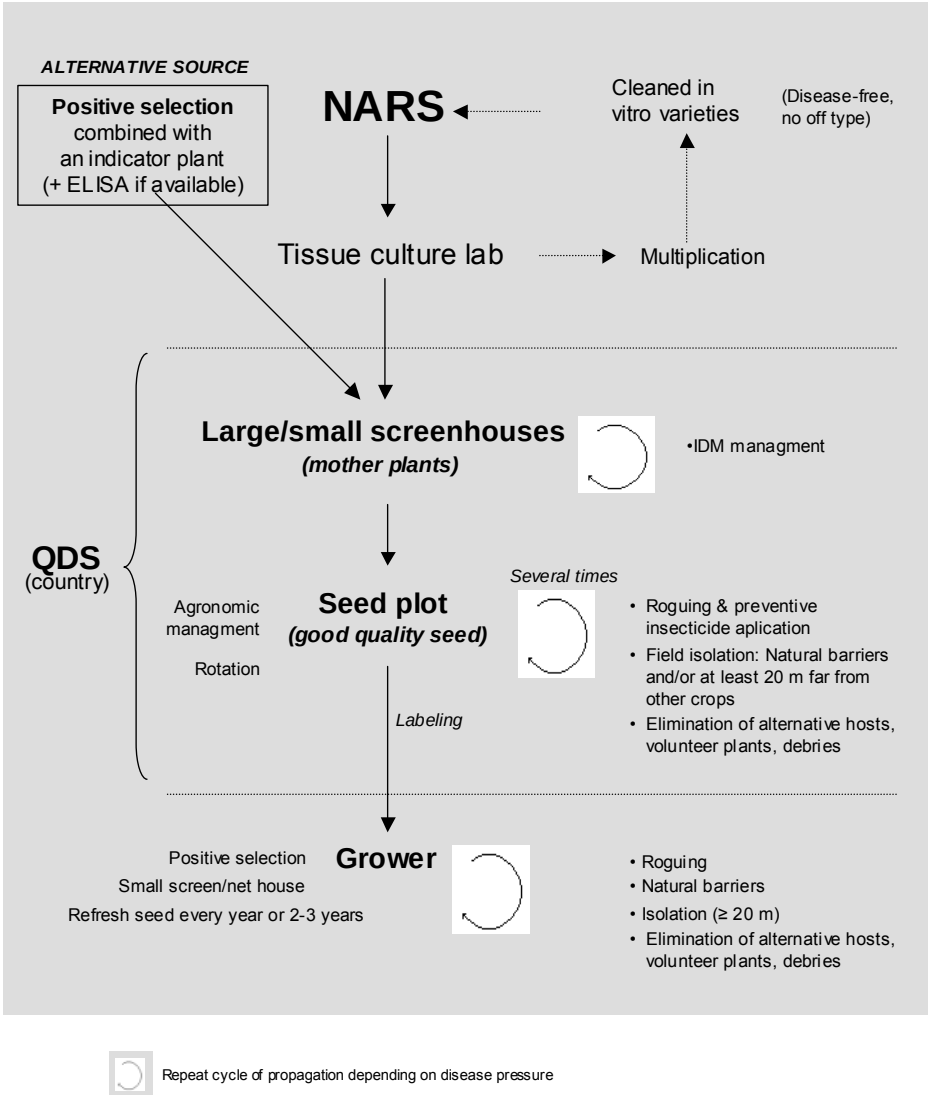

Figure 2.1. Outline of sweetpotato multiplication program

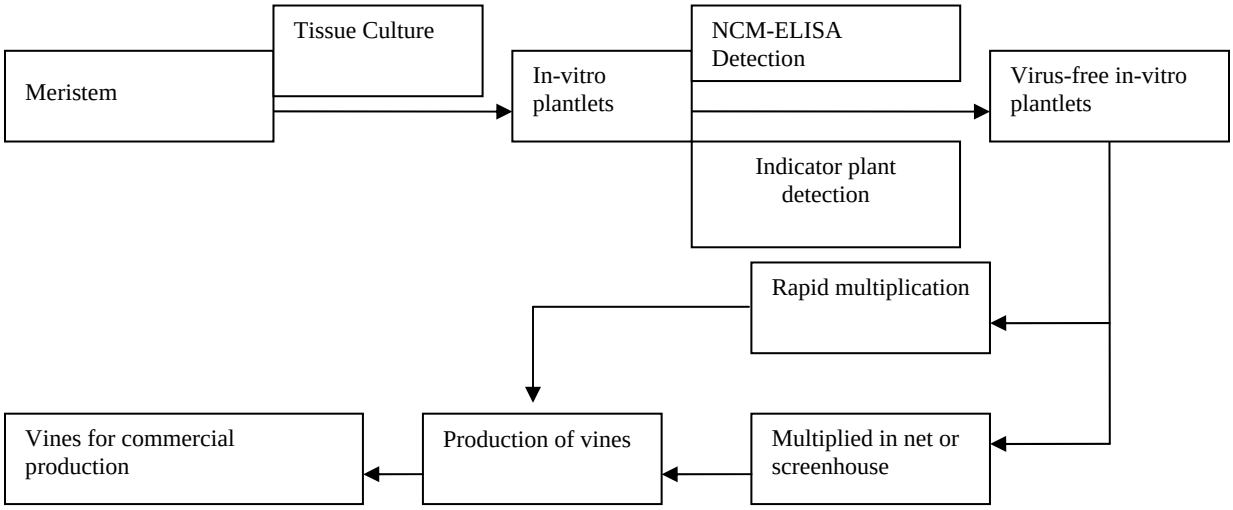

Figure 2.2. Protocol for virus-free sweetpotato planting material production