



GUIDELINES FOR CONSTRUCTION AND MANAGEMENT OF MINI SCREENHOUSE FOR SWEETPOTATO SEED PRODUCTION

Prepared by: Namanda S., Oloka B., Rajendran S., McEwan M., Namazzi S., Tenywa M., Ogero K., Mwangi R.O.M, Low J.W., Adikini S., Kyalo G., Talengera D., Mukasa S., Omongo C., Campos H., Yada B., Bazalaki S.

2023



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Guidelines for construction and management of mini screenhouse for sweetpotato seed production

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Preface

These construction and management principles for a mini screenhouse are adapted from the screenhouses used at research stations and other institutes to protect healthy sweetpotato planting materials (vines) from infestation by insects such as whiteflies and aphids that spread sweetpotato virus disease (SPVD). The initial mini screenhouses were designed and used under the HarvestPlus implemented Reaching End User (REU) project.

Earlier projects (SASHA 1 and Kinga Marando) had also promoted small insect proof net tunnels but evaluations with commercial seed producers highlighted the need for larger structures to manage several varieties, with easier access and longer durability of the structure.

During the SASHA II project, on-farm trials were conducted to evaluate the relative potential of mini screenhouses (4 m wide by 10 m long) to produce basic seed of three varieties¹ with varying growth and vine spreading habits, and susceptibility to SPVD. The initial findings informed the draft protocol which was subsequently validated under the SweetGAINS project in eastern Uganda. Notably, the size of the structure was rationally increased to 4.8 m wide by 10.4 m long, to allow more space for seed production, and the layout of the internal seed beds ensures at least 70 percent effective production area, easy access to all beds, and enough space to plant up to 2 – 3 varieties in a single mini screenhouse. We recommend that screenhouses be constructed using adequate quantities of metal (reinforcing bars) instead of wood to avoid frequent replacement due to rotting or termite damage.

The functions of mini screenhouses in the sweetpotato seed system are to:

1. Strengthen seed distribution/delivery systems by linking the upstream early generation seed (EGS) supply with downstream commercial seed producers (CSPs) for production of certified planting material.
2. Maintain disease-free planting material in areas with high sweetpotato virus pressure. Commercial seed producers can purchase pathogen tested starter stock from an early generation seed producer and multiply for sale to other seed producers or root producers. If allowed by national seed standard requirements, they can maintain their material over more than one year, thus reducing the need for replacement, which has a significant cost.
3. Provide decentralized access to quality sweetpotato seed at an affordable price for root producers.
4. Sensitize root producers about the importance of using disease-free/clean planting material.

The mini screenhouses size can be tailored to specific environments, considering limitations such as land availability and topography, level of management, and expected volumes of planting material to be produced.

This guide includes information on quantities and specifications of construction materials required, site layout, recommendations on seed production skills and practices.

¹ Kabode, Ejumula and Naspot 11

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Much appreciation is directed to the commercial seed producers (CSP) of Miti FFS Cooperative Society and BUSECO, Joseph Kasekende and Emma Kasulubedhe for coordinating implementation of the demonstrations that informed the development of these guidelines. BioCrops, Senai and NaCRRRI laboratories supplied the basic cuttings each 15-cm long from on-station screenhouses for planting under the on-farm screenhouses. Grateful to Sully Bazalaki (MAAIF) for orientating and training CSPs in sweetpotato seed inspection and certification procedures. Finally, we would like to extend our thanks to local government extensionists and other partners who ensured that the demonstrations were successful.

Introduction

More than 80 percent of sweetpotato farmers still depend on local sources of planting materials often from fields that have degenerated due to several seasons of recycling planting material and the accumulation of viruses it causes (Mukasa et al., 2006, Namanda et al., 2018, Adikini et al., 2015). Most farmers have trouble accessing certified seed of preferred varieties at planting time, and in adequate quantities (Namanda et al., 2012), due to distance to sources of early generation seed, such as screenhouses managed by research stations or private sector laboratories. The limited spread of information on the benefits of using clean planting material and high cost of basic seed also limit farmers' interest in purchasing certified seed. Conceptually, commercial seed producers (CSPs) with mini screenhouses can bridge the gap between upstream EGS production and the downstream farmers who could benefit from using certified planting material.

Module 1: Pre-construction

1.1 Site selection and orientation of the mini screenhouse

Objective: Build understanding on necessary conditions for suitable sites and factors to consider for mini screenhouse construction.

Key message: Location and orientation should ensure optimum production by enabling reliable access to water, security of the structure and minimizing pest and disease outbreaks.

1.1.2 Factors to consider.

It's important to ensure that enough sunlight enters the screenhouse with minimal shade from the terrain, trees, and structures.

- Mini screenhouse should be in an open space, away from trees and overhanging branches.
- Foundation or sub-soil: Screenhouse should be constructed on a firm foundation/flat ground.
- Size of site needed: Enough space to accommodate a screenhouse measuring at least 10.4m by 4.8m
- Slope: Screenhouse should be located on a leveled ground to avoid water runoff, which could contaminate the water used for the crop or cause erosion.
- Access: It should be on a site that is easily accessible by the seed producer or workers.
- Proximity to resources: should be located near a source of clean water, labourers and the homestead for security purposes. Note that it should not be near a pond with stagnant water which could act as a source of algae infestation in the mini-screenhouse.
- Avoid very open spaces as strong winds may blow in insects such as mites or tear off the net.
- Avoid proximity to fields that are or have been used to grow sweetpotato; at least 70 meters between the screenhouse and fields used to grow sweetpotato crop or other crops that can host sweetpotato virus vectors.
- It should be safe from vandalism or damage by livestock or falling tree branches.



Poor site

Suitable site

1.2. Materials, tools, and supplies required.

Objective: To build knowledge of the different tools and materials used to build a mini screenhouse.

Key message: Ensure that the different tools and materials needed are of high quality. assembled, and delivered to the construction site.

The items needed to construct a standard 10.4 m by 4.8 m, mini screenhouse are outlined in the table below. The prices included are estimates and may vary according to location and time.

Table 1: Materials and supplies for establishment of mini screenhouse.

Item	Description	Unit	Total Units	Unit cost (USD)	Total (USD)
High grade insect-proof net	OPTINET 50 (4 m in width)	Length in meters	31.5	27.8	875.7
Metal reinforcing rods (Rebar)	10 posts each measuring 2.4 m long for the two long sides	Bars	10	3.9	38.9
Centre metallic posts	5 posts each measuring 3.0 m long	Bars	5	3.9	19.4
Isolation frame	1' metal bars	Pieces	2	3.9	7.8
Wall plate	Metal bars	Pieces	4	3.9	15.6
Bricks or cement blocks	22 cm x 10cm x 5 cm dimensions	Bricks	600	0.1	33.3
Cement	50-kg bag	Bags	5	11.1	55.6
River sand	3-ton truck	Truckload	1	41.7	41.7
Metal cross bars	4. 6-metre-long bars	Pieces	4	5.6	22.2
Roof Rafters (1 inch size)	10.5-metre-long bars	Pieces	10	1.4	13.9
Struts and perlins	1-inch pipes	Pieces	3	3.9	11.7
Bolts and nuts	Bolts and nuts	Pairs	36	0.3	10.0
Double -sided zip	Zip	Metres	6	2.2	13.3
Sewing Zip	Sewing and fixing	Work days	3	66.7	200.0
Welding work	Labour	Work days	6	13.9	83.3
Door	Metallic	Door	1	55.6	55.6
Lock	Padlock	Piece	1	6.9	6.9
Bed setting	Bricks	Bricks	200	0.1	11.1
Coordination	Organize materials	Work days	4	16.7	66.7
Construction	Labour	Work days	6	13.9	83.3
Water resistant paint	White paint	Tins	2	16.7	33.3
Painting	Labour	Work days	1.5	13.9	20.8
Forest soil	3 ton-truck load of compost soil	Truckload	1	22.2	22.2
Polythene sheets	Waterproof	10 metres	10	2.8	27.8
Sticky trap cards	Blue and yellow to attract insects	Pieces	5	0.3	1.5
Others	Water, meals, etc.	Mixed	1	138.9	138.9



Angle pieces and joint



Joints



Bolts and Nuts

1.2.1 Personal protection equipment (PPE)

It's important that all persons working on with in the screenhouse are well protected from spray chemicals or any sharp objects that could cause injury to any part of their body. These PPE can include:

- protective clothing, such as lab coats.
- surgical gloves.
- eye and face protection, such as goggles or masks.
- safety equipment such as overalls during pesticide application.
- gumboots or another water-resistant footwear.
- rubber gloves.

Module 2: Construction

Objective: To erect a long-lasting standard (10.4 m x 4.8 m) mini screenhouse.

Key message: The structure should be strong, fitted with a foot bath at the entrance and completely covered by netting with no openings or holes that would easily let insects or pests in.

2.1 Foundation and metallic Frame erection

- Hire an experienced local builder to lead the construction of the foundation.
- Gather all construction equipment needed: wheelbarrow, hoes, spades, water containers, welding machine.
- Clear the site by removing rubble, grass, shrubs, and trunks and ensure that it is leveled.
- Each mini-screenhouse should measure 10.4 m long x 4.8 m wide.
- Measure and mark the points where the foundation will be laid.
- After setting out, commence with the digging of 0.45 m (wide) by 0.6 m (deep) foundation trenches.
- Prepare concrete mix at the ratio of 4 wheelbarrows of sand: 1 bag of cement each 50-kg: 2 wheelbarrows of pebbles each about 0.05 m diameter size. This mixture is poured into the excavated trenches up to 0.2 m deep and 0.45 m width or as guided by an experienced builder depending on existing soil structure.
- A wall should be built from the concrete strip footing to about 0.3 m above the ground to avoid direct splashes of rainwater.
- The inside of the foundation walls must be filled to 0.15 m above the ground by using the excavated soil.
- Measure and mark the points where the vertical posts are going to be placed (Plate 2b).
- Dig the holes each 0.45 m deep and place the posts.
- Align the posts and fix the rafter to hold them firmly in position.
- Fix the posts firm with concrete.
- After erecting the frame, cover the sharp edges with net cutoffs to ensure that the joints or edge points are not sharp. Otherwise, they will tear the net.
- After raising the screenhouse frame, paint all the posts and bars white to ensure that light is reflected and directed to the plants.

NB: Angle of the roof should be as slanting as possible to minimize on shading and light interception.

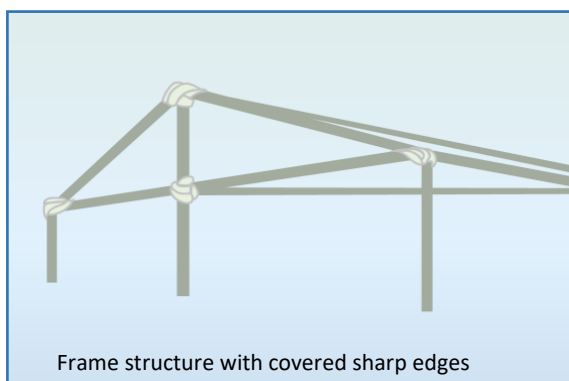
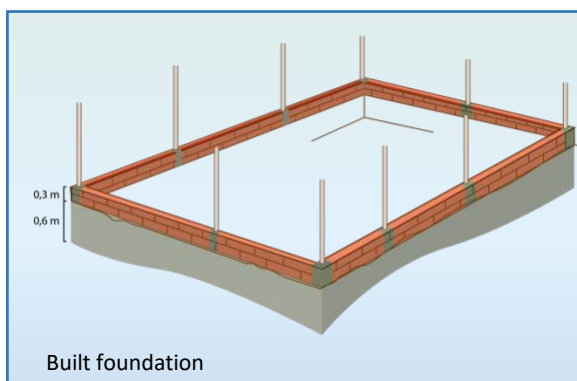
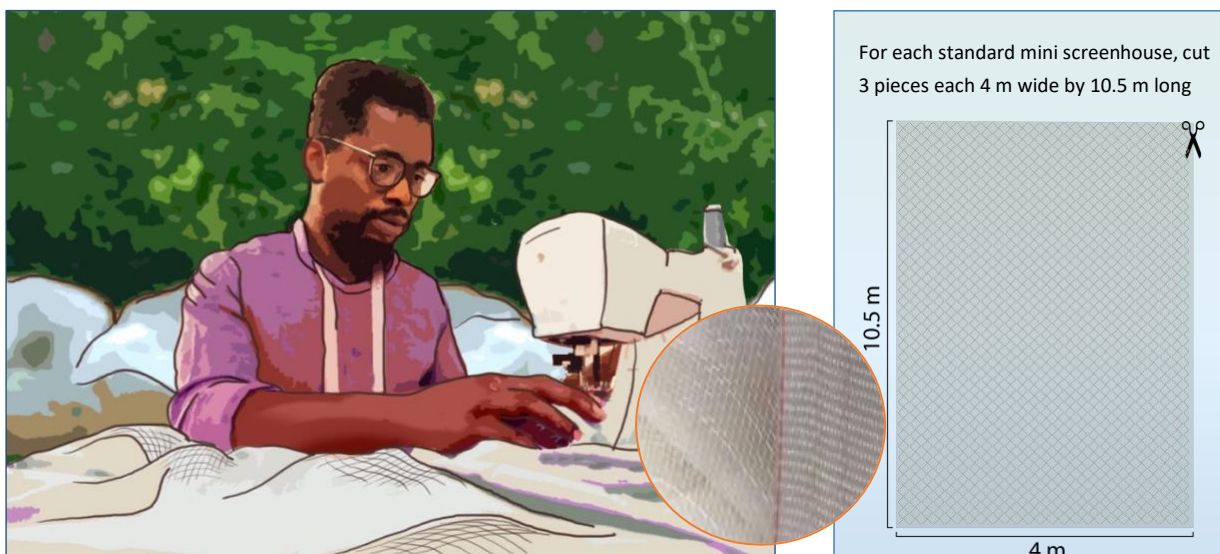




Plate 2a-c: Construction of foundation and house frame (Credit. Sam Namanda)

2.2 Net quality, sizing and sewing.



Tools required: sewing machine, threads, pair of scissors, double-sided zip.

NB: Standard roll of net is normally 4 m wide by 100 m long, enough to construct 3 standard mini screenhouses each 4.8 m wide by 10.4 m long. The size aims at maximizing utilization of net and available bed space for planting material production.

- For each standard mini screenhouse, cut 3 pieces each 4 m wide by 10.5 m long.
- The 3 pieces are used to sew together the entire net roof cover and a double entry area.
- Each standard mini screenhouse requires a total net size of 4 m by 31.5 m dimensions.
- Provide zipped piece for the inner door.
- Cut off the piece overlapping the door entrance and seal the edges to ensure no insect entry.

2.3 Fitting net cover onto the screenhouse frame

- After sewing the net, mount it onto the frame making sure that it is well stretched.
- Fix the lower end of the net by folding its end portion flat on top of the built foundation and build a single brick layer to hold the flattened end firmly.



Plate 5: Fitting the sewn net on the wooden frame
(Credit: Sam Namanda)



Plate 6: Mini screenhouse with access door fitted. There is a water bath and another zipped access inside (Credit: Sam Namanda)

A thin layer of river sand is poured outside to ensure the snails and slugs do not find their way inside.
Ground bricks laid, door fixed, and structure frame completed

2.4 Fixing of the entrance and foot bath.

- Special care should be taken in providing an appropriate entry to the mini screenhouse, ensuring that there are no openings that may act as entry points for insects and other pests.
- A net fitted with a double-sided zip should be fixed covering an area measuring 1 m² between the door and the remaining area of the screenhouse.
- This area should be fitted with a foot bath measuring 0.5 m by 0.5 m and 0.2 m deep that will be filled with a disinfectant to disinfect the footwear of each person entering the screenhouse.
- The foot bath should have an outlet to easily remove old or dirty disinfectant before refilling with new disinfectant, which should be done regularly.



NOTES

- Dimensional layout scale: Length side: 0.1 m represents 0.5 m, and width side: 0.3 m represents 1 m. Bed sizes and layouts should aim at optimal use of the available space including.
- Maximizing the plant population, ensuring easy movement and access to all the beds.
- In this case the total screenhouse available plant space is 10.4 x 4.8 metres = 49.92 m².
- Actual total bed space:
 - 7 beds each measuring 1.2 by 3 m = 25.2 m²
 - 2 beds each measuring 1.2 by 4.2 m = 10.08 m²
- Available total bed plant space = i + ii or 25.2 + 10.08 = 35.28 m², representing about 71 percent of the total screenhouse area.
- Since the spacing is 0.2 m between rows by 0.15 m within the rows, then each plant occupies 0.03 m²
- Total plant population = available total bed plant space divided by 0.03 = 1176 plants.
- This helps to project the expected cuttings to be harvested from the screenhouse and planning for open field production.
- Each plant in mini screenhouse is expected to produce an average of 12 cuttings each 15 cm long per harvest lot at the interval of 45 – 60 days between successive harvests.
- Expected total number of cuttings for 5 successive harvest lots = 70 cuttings each 15 cm long
- Open bed space = 35,280 cuttings multiplied by 0.04 (planted at 0.2 by 0.2 m) = 1,411 m²

Module 4: Pre-planting

Objective: To prepare appropriate growing media and planting material for seed production

Key message: The growing media, as the mix of soil and organic material used in seedbeds is known, should provide the nutrients sweetpotato plants require in adequate quantities to ensure production of sufficient planting material.

4.1 Soil media preparation

Media preparation should ensure minimum nutrient needs to support high productivity.

- Collect organic material, preferably from under tree shade, and stack it in a heap.
- Add urea at a rate of approximately 2 kg per 100 kg of organic material and mix well.
- Cover the heap completely with a polythene plastic sheet to ensure favorable conditions for complete decomposition.
- The end product is well decayed organic matter with humus and nutrients called compost.



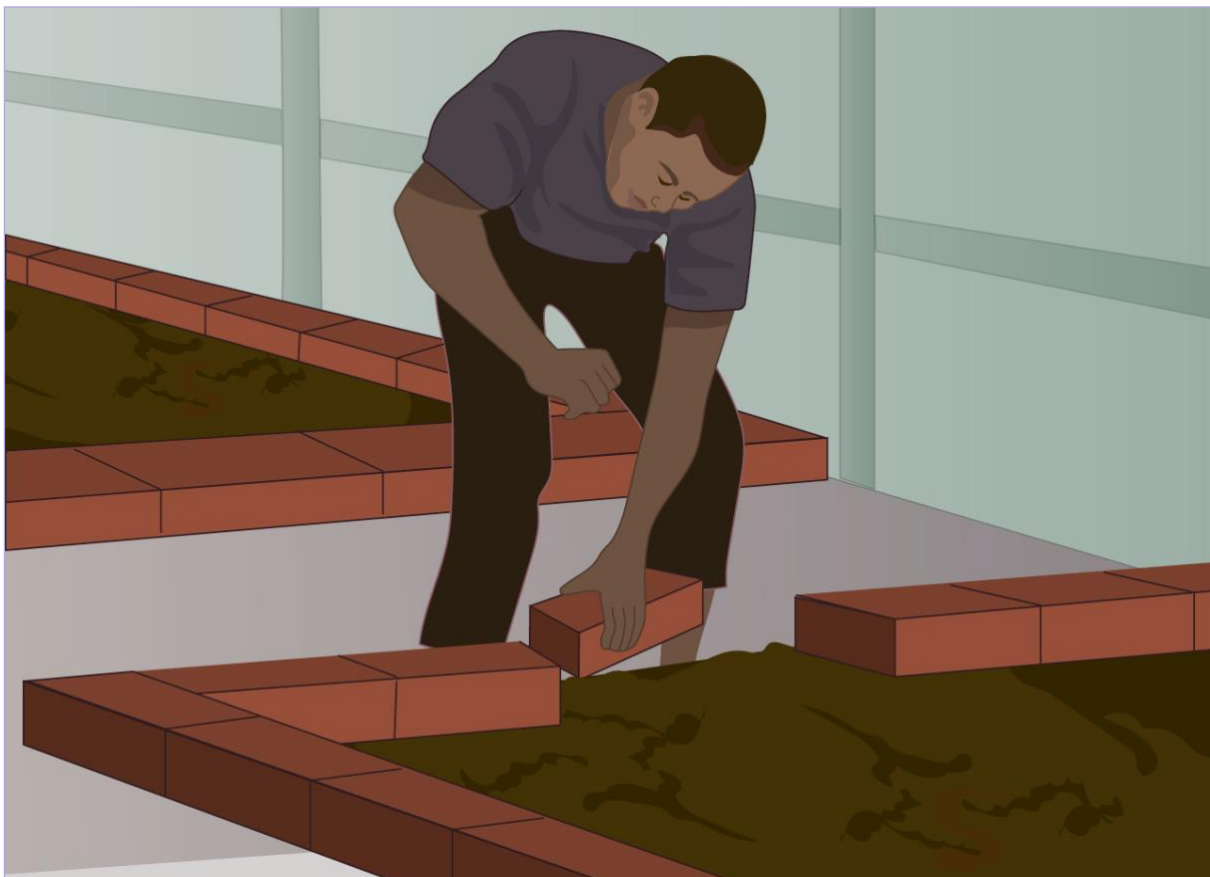
Sprinkling the fertilizer and mixing with hoe.



Collection and preparation of forest soil for use in the screenhouse: a) gathering compost, b) covered for decomposition, c) and d) compost ready for amending seedbed soil.

4.2 Preparation of seedbeds

- Measure and mark off the desired beds' borders.
- Lay a single line of bricks along each seedbed's sides to shape it and contain the soil.
- Mix composted forest soil with well decomposed animal manure and river sand at a ratio of 3:2:1 Soil in seedbeds should reach a height of 0.2 m above the ground.
- Add NPK (e.g., 25:5:5) fertilizer and mix well with the soil medium prior to planting, at a rate of 40 – 50 grammes per m² or 150 - 200 grammes per 1.2 m x 3 m bed (3.6 m²).



Demarcated and well-laid beds.



(Credit. Sam Namanda)

- a) Pre-planting NPK application of 40 grammes per metre of bed in cases where the compost was only partially decomposed
- b-c) Collecting well decomposed media
- d) Final preparation of beds.
- e) Planting cuttings

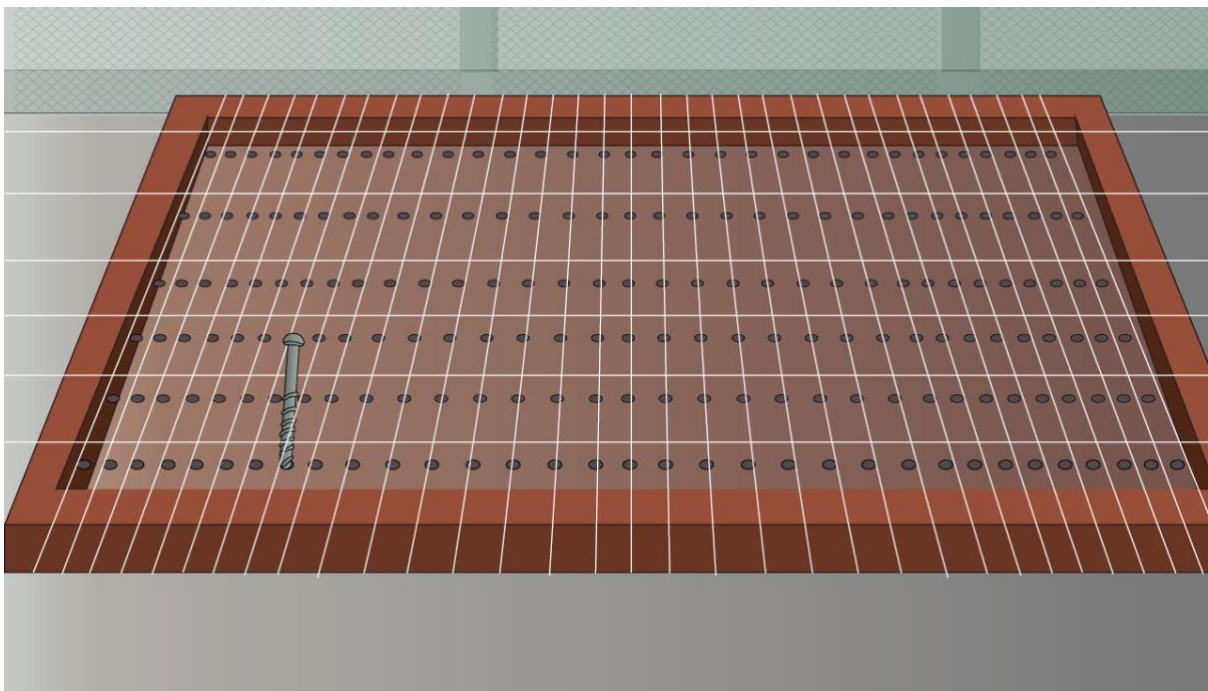
Module 5: Planting

Objective: To ensure optimum plant population for maximum productivity of the mini screenhouse.

Key message: When planting, follow the recommended spacing and ensure the right vine length is used.

5.1 Procedure

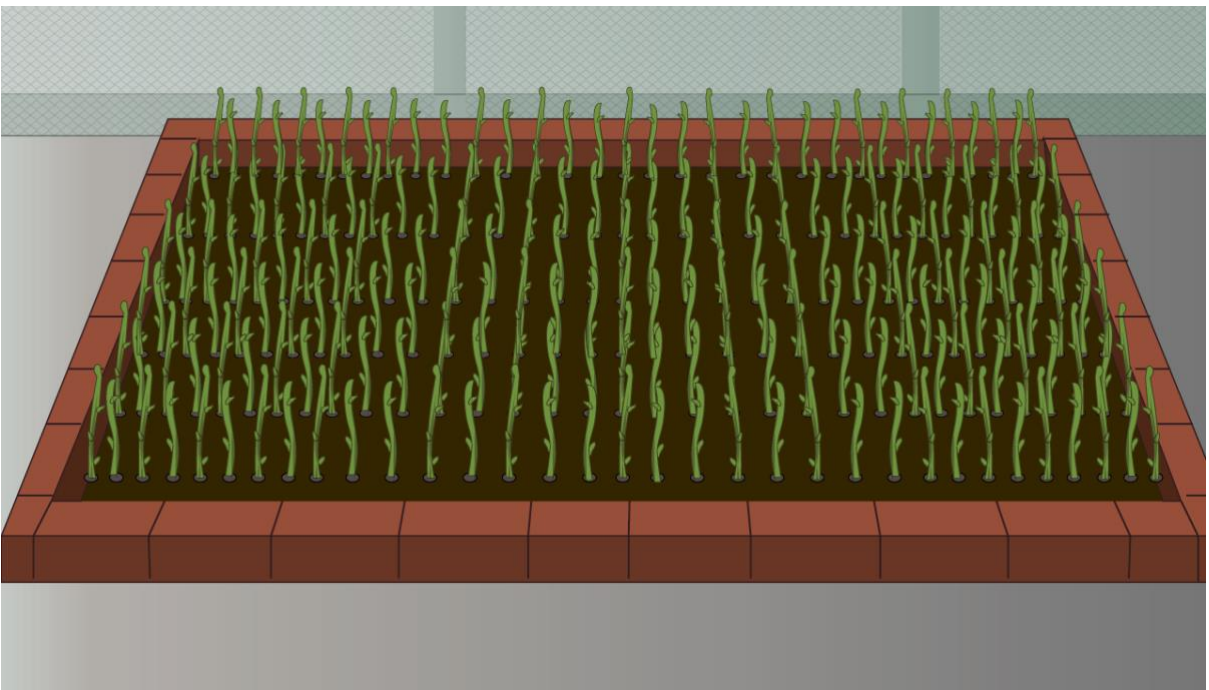
- Use a pre-marked line string and dibble to plant holes at a distance of 0.2 m between rows and 0.15 m within the row in the seedbeds.
- Planting material only from healthy new growth should be used to minimize contamination during transfers.
- Sort the planting material and discard unhealthy cuttings (e.g., with dead buds).
- Trim the cuttings to desired length (e.g., 0.2 m) with at least 3 nodes for planting.
- Gently insert the trimmed cuttings singly in each hole and fill them with soil so cuttings aren't washed out during watering.
- Each 0.2 m long cutting is planted with two thirds buried in the soil and one third above the soil surface.
- Each bed measuring 1.2 m wide by 3 m long is planted with 6 rows of cuttings each containing 30. This gives a total of 180 plants per bed.
- Water the planted beds well immediately after planting using an appropriate watering system.
- After planting all the beds, spray the mini screenhouse with insecticide to ensure that there is no pest trapped inside.
- Insert sticky trap cards (could be locally made by cutting pieces of plastic, preferably bright colours such yellow, and smearing Vaseline on them to trap insects) in the screenhouse to monitor the presence of insects.



Marking of holes with a string



Sorting the material and the actual planting



Bed fully planted

Module 6: Post planting

Objective: To maximize the productivity of both the plants and the screenhouse space available.

Key message: Activities required to maintain a healthy plant population and ensure availability of planting material for continued production all year round.

6.1 Watering

- Water is crucial to the health of the sweetpotato plants, but there is no hard-and-fast rule on how much water to give them, or how often.
- Watering can be done using a handheld watering can or any other watering system available.
- Water thrice every week for the first 2 weeks after planting, and once or twice during the subsequent weeks during the dry season, until 6 weeks before harvesting.
- During the rainy season, always check the soil to avoid overwatering. This is done by putting a finger into the soil mixture to a depth of about 2-3 cm and checking if the soil feels wet, moist or dry. If it feels dry, especially if a sample of bed soil cannot form a ball if squeezed in the hand palm, then watering should be done.
- Stop watering for about 2 weeks before harvesting to enable the vines to harden.
- **Timing of watering:** Avoid watering just before sunset (evening) because water will stay overnight on the plants. Water should have little time on the foliage as overstay causes reflection of light and can facilitate fungal growth.

6.2 Measures to minimize insect entry and fungal contamination.

- Insect-proof all places of potential entry, including windows, doors, and walls.
- Regularly check for insects and mites.
- Spray fortnightly with insecticides; choose products that are active against mites and insects. Treat plants with a fungicide 1 week before harvesting.
- Ensure that the net is not rubbing on any parts of the metal or timber frame, especially on the corner joints, as rubbing can create holes that may allow entry of insects and mites.
- Use sticky traps to remove insects and as an indicator of possible entry of pests.
- Keep walkways within the mini screenhouse clean and dry, free from weeds and algae. If possible, cover the walkways with pebbles.
- Remove old plants and vines as soon as possible.
- Neither allow rubbish of any kind to accumulate nor store things in the screenhouse
- Either off-strips of net or cloth-pieces should be used to wrap around the joints or cover sharp edges to reduce rubbing that could tear the screen.
- Regularly check for any holes in the netting on the roof or walls and make immediate repairs where possible.

6.3 Weed management.

- Use prevention and sanitation to manage weeds in the screenhouse.
- Keep weed seeds and rhizomes out of the screenhouse by using clean growing media and clean planting material.
- The outside of the screenhouse should also be kept clean and free of weeds.
- If weeds get into the screenhouse, they should be removed by hand as soon as possible and never be allowed to flower and produce seed.

NB: Herbicides should not be used inside the screenhouse.

6.4 Trellising

- Place stakes in the ground along the beds to support the spirals of the sweetpotato vines, save space and avoid mixing of varieties. This will also increase the multiplication rates of seed under screenhouse.



Trellised plants under the mini screenhouse.

Trellised plants, especially varieties that are wide spreading, save space, avoid variety mixing and increase the multiplication rate of sweetpotato seed.

6.5 Managing the after effect of relative humidity on vine growth.

- Relative humidity (RH) is the percent (%) of water in the air compared to the amount it could hold. Warm air has more water vapour (water holding capacity) than cool air, so temperature has a big impact on relative humidity.
- High relative humidity during warmer periods interferes with plant transpiration.
- Droplets on the net roof reflect light and water splash on the ceiling can spread diseases.
- Too little relative humidity stresses plants by accelerating transpiration.
- Immediately after planting the cuttings, create high relative (RH) chambers by placing a temporary roof over each planted bed with sheets of transparent polythene. This ensures reduced transpiration and facilitates plant establishment. The temporary roof should be withdrawn after 24 hours, and watering continues as scheduled.



Plate 10: High relative humidity chambers for freshly planted cuttings (Credit: Sam Namanda).

6.6 Managing algae colonization on the screenhouse.

Algae growth starts as a slight greening of the growing medium surface, and as the algae grows and becomes thicker, it turns black. Algae can be particularly problematic in screenhouse with high moisture levels and excess nutrients around the screenhouse. Note that:

- The cells and spores of algae are found everywhere. Irrigation water is the most common source, especially if it comes from a pond or shallow well.
- Dust that gets blown into the greenhouse may contain algae spores.
- Some algae can be found in the growing medium too.

Algae growth on the net attracts fungus gnat and shore flies, which slow gas exchange into and out of the screenhouse. Aside from feeding on the algae and fungal growth, fungus gnats and shore flies also feed on plant roots and can potentially transfer plant pathogens through their mouth parts.

Allowing the growing medium surface to dry out between watering will reduce algae growth.

Precautions

- Water as needed and prevent excess puddling on the floor.
- Surface water from ponds may be high in nutrients that contribute to algae growth.

- If you use surface ponds or reservoirs as a water source, use disinfectants or algaecides on a routine basis.

6.7 Controlling algae on the growing medium surface.

- To control algae growth on the growing medium surface or in other areas in the screenhouse, start by looking for potential sources of algae.
- If algae are in the water lines, they will need to be cleared out and then kept clean using chlorine dioxide and copper ionization, which are commonly used compounds.
- Water coming from ponds or shallow wells may have high algae loads, in which case the water may need to be treated with the same chemicals.

6.8 Pest monitoring and control

6.8.1 Monitoring pest infestation using cards.



- Hang plastic sticky cards (yellow) in the screenhouse to monitor and kill insect pests such as whiteflies.
- Blanket spray with pesticides in cases of outbreaks.
(Credit: Sam Namanda).

6.8.2 Managing other pests in the screenhouse.

Measures include:

- i) Hand pick and crush visible pests such as bollworms or larval stages of butterflies
- ii) Spray with pesticides such as fenitrothion or malathion

6.9 Harvesting

- During the first harvest, leave at least 0.15-m stump height above the soil surface to support growth of lateral vine branches, which will be harvested in subsequent successive lots.
- Similarly, during ratoon harvesting, 0.15-m of plants starting from the main stem should be maintained to support subsequent vine foliage growth, until successive harvesting rounds are completed.
- Record the number of vines harvested.



(Credit: Joseph Kasekende)

Table: Record of virus scores (scale: 1- 9) and number of vine cuttings harvested

Date	Bed number	Variety	Virus score	Number of cuttings	Comments
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	Etc				

Appendix

7.1 Advantages and recommendations for mini screenhouses

Note that the level of skills, precision and resources at farm level are lower than those at research stations. In this regard, slightly longer cuttings (0.15-m long) may be preferred to avoid mortality, rates as shorter ones are less likely to survive if watering or planting are delayed. The spacing can also be adjusted from 0.1 between rows and 0.1 x 0.1 m within the rows to 0.2 m and 0.15 m, respectively, for easier management.

7.2 Advantages

- A single mini screenhouse can accommodate more than one variety.
- Appropriate size for farmer-managed screenhouse is recommended at 4.8 m wide by 10.4 m long.
- Planting material initially sourced from mini screenhouses has produced higher root yields compared to planting material grown in net tunnels.
- Enables direct watering and weeding, compared to net tunnels, which are opened once either at planting or harvesting.
- Cost effective for on-farm production of pathogen-tested material.

7.3 Important considerations

- Plants should be replaced with pathogen-tested material every year, or according to national standards and regulations.
- Link up with a research station or extension officer annually to test the existing planting material for virus infection using NCM ELISA or LAMP diagnostic tests or by grafting on *Ipomoea Setosa* as an indicator plant.
- The mini screenhouse roof should not be very steep to improve light penetration and to avoid the folds or wrinkled places becoming water collection or condensation points (Photo 6).
- Ensure that the growth media composition facilitates easy surface drying and remove any excess water to avoid fungal build up. In areas of seasons of cloudy and cold weather, it may be very difficult to dry out the growing medium, in which case chemical controls, such as hydrogen dioxide or Physan 20 may be needed.
- There should be good air flow in the screenhouse.

Further resource materials and references

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