Is sweetpotato root production cost-effective when using planting material conserved in protected structures in high virus pressure areas?

- Two methods of protected vine conservation beds (insect protected net tunnel (Fig. 1) and mini-screenhouse (Fig. 2)) were compared with an open field control to assess cost effectiveness for quality seed production and subsequent root production.
- Mean percent Sweet Potato Virus Disease (SPVD) infection was not significantly different across methods of protected and open field conservation; however, there was increasing virus infection from generation 0 to generation 2 for each method.
- Although net tunnels produced more cuttings per unit area. Sweetpotato planting material sourced from the mini-screenhouse produced higher root yields (14.2 t/ha) than the net tunnel (11.5 t/ha) or open field (9.3 t/ha).
- Sweetpotato root production (per kilogram) is cost-effective and root producers can reduce their production costs by 21% if they buy planting material from commercial multipliers who use mini-screenhouses for conservation of planting material.
- In high sweetpotato virus disease pressure areas, support for the use of protected structures by medium to large scale multipliers is justified to increase availability of quality basic seed for farmers.

SASHA Sweetpotato Action for Security and Health in Africa

AUGUST 2019

Fig 1. Ready for harvesting from the net tunnel (Credit: S. Namanda)

What was the problem?

In many developing countries, farmers source their sweetpotato planting material from their own fields; however, disease incidence and severity build up with repeated cycles of planting leading to significantly reduced root yields. Scientists identified multiplication of pathogen tested planting material as essential for improving farm yields of sweetpotato. Previous studies in high virus pressure areas in Uganda showed that when pathogen tested tissue culture sourced material of Ejumula variety was planted on-farm and recycled for more than three seasons, the storage root yield declined by 80 percent. We wanted to test whether it was cost effective for farmers to buy their planting material from multipliers who conserve materials under protected structures, before open field multiplication for commercial seed sales.

What objectives did we set?

We wanted to use a participatory research approach to sensitise farmers to understand the yield advantage of using pathogen-tested planting material to enhance uptake and adoption of improved varieties. The study assessed the biological and economic consequences of the mini-screenhouse, net tunnel and control (open field) treatments to produce symptomless and/or pathogen-free planting material for successive generations. Three conservation methods were established each using three varieties (Ejumula, Kabode, and NASPOT 11) at five sites in Kyotera district, Uganda. There were two different types and sizes of insect protected net structures which were used for conservation of planting material:

- insect protected net tunnels of 1.8 x 3 m which maintained one variety per tunnel (Fig. 1);
- insect protected mini-screenhouses of 4 x 8 m with the three varieties in individual beds of 1.8 x 3 m separated by 0.5 m walkways (Fig. 2).

Fig 2. Data collection during harvesting from the mini-screenhouse (Credit: S. Namanda)

The third treatment acted as the control with unprotected open beds (1.8 x 3 m) for each variety. The initial planting material for each treatment was sourced from BioCrops (U) Ltd. in April 2017 from screenhouses maintaining pathogen tested cuttings sourced from KEPHIS in December 2015.

Successive harvests of cuttings from the protected and non-protected conservation beds were planted out in open fields for rapid mass multiplication. Cuttings harvested from the open fields were then used for root production. Data were collected to:

1. Assess different conservation methods (protected and non-protected) for planting material on vine yield, vine quality and root yield
2. Measure the cost of seed production under the three different conservation methods
3. Measure the cost-effectiveness of root production using planting materials conserved under each of the three methods, and then further multiplied under open field conditions

Where did we work?

The trial was implemented in Kyotera district in South Central Uganda. The region is predominantly agricultural, with sweetpotato among the key food crops in addition to bananas, maize, cassava, potatoes and beans. Sweetpotato cultivation is greatly constrained by sweet potato virus disease (SPVD), commonly described as *Okugegewala* which refers to severe symptoms of SPVD.

What did we achieve during SASHA Phase 2?

This study was part of a longer study with data presented for one season (2017-2018).

A. Results: Vine yield, Vine quality, and root yield

Table 1 presents average results from five consecutive harvests at the five sites. The main findings are:

- Mean vine length (cm) from either type of protected beds was significantly (P≤0.05) longer than the open field beds
- The longest mean vine length (cm) was from net tunnels and shortest from open field beds
- The net tunnel method produced the highest number of 20 cm vine cuttings
- Vine diameter was thicker in materials from the mini-screenhouses and open field beds compared to the net tunnels
- % plant mortality was significantly (P≤0.05) higher in open field beds than either type of protected beds
- The net tunnel recorded higher mortality of growing plants compared to the mini-screenhouse

Table 1: Mean values at five sites over five harvests for vine characteristics of planting material conserved under different methods, Kyotera district, Uganda (April 2017-March 2018)

Parameter	Method			$Lsd_{0.05}$
	Mini-screenhouse	Net tunnel	Open field	
Total beds for data collection (N)	45	45	45	
Average plant length (cm)	78.7	86.4	56.8	11.6
Internodal length (cm)	4.1	4.6	3.5	0.4
Vine diameter (cm)	0.5	0.4	0.4	0.3
Percent plant mortality (%)	10	15	25	5.8
Number of 20-cm long cuttings	684	735	445	102

Leaf samples were collected and tested for virus at NaCRRI using NCM ELISA for Sweet Potato Feathery Mottle Virus (SPFMV) and Sweet Potato Chlorotic Stunt Virus (SPCSV). When they occur together Sweet Potato Virus Disease (SPVD) results. Table 2 reports the percent of pooled samples which tested positive for both viruses. Comparing across the different conservation methods, the laboratory-based test results showed that the percent virus infection was not significant (P≤ 0.05); however, there is an increasing trend of virus infection from generation 0 to generation 2 for each method. Moreover, the percentages were initially very low (less than 1%) for material multiplied under protected beds, but there was a sharp increase i.e. 77.7% (mini-screenhouse), 71.2% (net tunnel), and 75.8 % (open field) observed when the planting material was planted in the open fields for the first time. The increase in positive virus tests could be attributed to widespread presence of vectors in the open fields.

Table 2: Mean percent pooled samples testing positive (using NCM ELISA) for both SPFMV and SPCSV for different generations under three conservation methods: planted in April 2017, harvested in March 2018, Kyotera district, Uganda

Generation	% virus infection under different conservation methods		
	Mini-screenhouse	Net tunnel	Open field
Total pooled samples (N)	43	38	49
0 (initial protected or open beds)	0.7	0.7	0.8
1 (open field for mass multiplication)	3.0	2.3	3.2
2 (on-farm root production)	4.0	3.3	4.1

B. Results: Cost effectiveness of seed production under different conservation methods and cost effectiveness of root production

Financial Cost and Benefit Analysis (FCBA) was used to estimate the cost of seed and root production at various stages along the value chain. The hypothesis was that isolation of disease transmitting vectors from the host plant would be a cost-effective approach for farmers to source quality planting material for improved root yields assuming that quality planting materials purchased at current market price (i.e., 17,500 UGX per bag of 800-1000 20 cm cuttings). Table 3 shows the stages followed for the FCBA. Seed production went through two stages before commercial sale to root producers (stage 3).

- **Stage 1:** Seed multipliers buy pre-basic seed from the private company to plant in the protected and non-protected beds for conservation;
- **Stage 2:** Seed multipliers harvest cuttings from the conservation beds and plant them in the open field under rapid multiplication;
- **Stage 3:** Root production. The cost of root production was estimated during the peak period.

Table 3: Profit ratio of sweetpotato roots produced from planting materials using different conservation methods in high virus pressure area

Stage	Stages in the seed value chain	Mini-screenhouse	Net Tunnel	Open Field
Stage 1	Production of backup materials	Season (April 2017-March 2018) Area planted: 16.2 sqm; Number of harvests: 5		
	Total Production (number of cuttings)	10,771	14,985	10,379
	Cost of production per cutting (20 cm)	0.029	0.023	0.008
Stage 2	Rapid commercial multiplication	Season (June 2017-July 2018) Area planted: 16.2 sqm; Number of harvests: 5		
	Total Production (number of cuttings)	10,379	10,400	10,059
	Cost of production per cutting (20 cm)	0.009	0.009	0.008
Sweetpotato profit ratio		Season (September 2017-February 2018)		
	Root yield per ha (Kg)	14,206	11,505	9,304
	Cost of root production per ha (US$)	1,341	1,233	1,113
	Cost of root production per kg (US$)	0.09	0.11	0.12
	Total Revenue (US$)	1,585	1,286	996
	Net Profit (US$)	244	53	-117
	Net Profit Margin (%)	15.4	4.1	-11.8
	PERCENTAGE (%) COST REDUCTION COMPARED TO OPEN FIELD	21.1	10.4	0.0

Source: Primary Survey, 2017-18 and authors' calculation. Exchange rate in 2018 (1 US$: UGX 3,775)[1]

Fig 3. Ejumula planted using net tunnel sourced C2 (Credit: S. Namanda)

Fig 4. Ejumula planted using mini-screenhouse sourced C2 (Credit: S. Namanda)

Fig 5. Ejumula planted using open field sourced C2 (Credit: S. Namanda)

Although the net tunnel model produced more cuttings per unit/area (Table 3, Stage 1), planting material sourced from the mini-screenhouse model produced higher root yields (14.2 mt/h) than the net tunnel (11.5 mt/ha) and open field with (9.3 mt/ha) (Table 3). Therefore,

- using net tunnel conserved material (Fig. 3) increases root yield by 23.6% over open field conservation
- using mini-screenhouse conserved material (Fig. 4) farmers can increase root yield by 52.6% over open field conservation (Fig 5);
- using mini-screenhouse rather than net tunnel conserved material increases root yield by 23.5%

[1] Note: Market price for 100 Kg in season 1: DEC-FEB=30,000 to 40,000 UGX; MAR-APRIL=50,000 per bag of 100 kilograms of roots; In Season 2: May-June=60,000; July=70,000; August-October=90,000 UGX per bag of 100 kgs of roots

Table 3 shows that if root producers buy quality planting material from commercial multipliers at market prices, root production (per kilogram) is cost-effective, and they can reduce their unit production cost by 21% due to increased yields.

Were there any key challenges or lessons learned?

- Net tunnels had higher mean number of cuttings because of longer vine length due to competition for light and moist and warm micro-climate.
- The vine characteristics of materials conserved in the mini-screenhouses i.e. shorter mean internode length (4.1 cm) and vine diameter (0.5 cm) compared to longer internode length (4.6 cm) and thinner vine diameter (0.4 cm) in the net tunnel materials contributed to higher root production using miniscreen sourced materials. Thicker vines and more nodes per 20 cm cutting contributed to better establishment and higher root yield.
- Table 3 shows that at Stage 2 (i.e. open field rapid multiplication), the unit cost of seed production is higher for material initially conserved using protected structures, compared to materials conserved in open fields during Stage 1. However, when a farmer uses planting materials that have been conserved under the protected beds, she/he will benefit from lower unit production costs as follows:
    - using planting material that was conserved under either type of protected structure and then further multiplication in open field results in a 16% lower per unit cost of root production compared to material that was always under open field conservation and multiplication.
    - using materials conserved in mini-screenhouses, is 21% lower per unit cost of root production compared to material that was always under open field conservation and multiplication.
    - using materials conserved in net tunnels, is 10% lower per unit cost of root production compared to material that was always under open field conservation and multiplication.
- Comparing across the different types of protected structures, the per unit cost of root production using materials conserved in mini-screenhouse structures, is 12% lower compared to per unit cost of root production using materials conserved in net tunnels.

What's next?

To strengthen the financially viability of the seed value chain the following activities need to be integrated into the scaling process:

1. Real time data collection is needed to understand the financial viability for a seed producer to invest in a protected structure. This requires alignment of the seed multiplication calendar to market conditions for seed and roots so that commercial seed producers can plan for the area and volume required for mass field multiplication. This will contribute to a reduction in the unit production cost of seed due to economies of scale and a more competitive market, so that investment in a protected structure is financially viable in the long-run for seed multipliers.
2. Increased awareness among farmers of the benefits of using quality planting material to gain higher root yields is needed to drive willingness to pay for such material.
3. Improved understanding of farmer demand characteristics and whether different types of farmers are willing to pay a premium price for quality planting material.

Publications

Namanda, Sam., Margaret McEwan, Srinivasulu Rajendran, Scovia Adikini, Gerald Kyalo, Robert Mwanga, Jan Low, David Talengera and Elke Vandamme. (2019 under preparation) "Enhancing on-farm production of sweetpotato virus disease pathogen-free planting material: vector proof nets prevent infection by avoidance". For submission to Environmental and Experimental Botany.

Protecting Sweetpotato Planting Material from Viruses using Insect Proof Net Tunnels. A Guide to Construct and Use Net tunnels for Quality Seed Production. July 2017. https://www.sweetpotatoknowledge.org/files/protecting-sweetpotato-planting-materials-from-viruses-using-insect-proof-net-tunnels/.

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CIP thanks all donors and organizations which globally support its work through their contributions to the CGIAR Trust Fund. https://www.cgiar.org/funders/