Efficiency of Insect-proof Net Tunnels in Reducing Virus-related Seed Degeneration in Sweetpotato

- Affordable insect-proof net tunnels proved effective in reducing virus-related degeneration in sweetpotato in Tanzania.
- Re-infection in high virus pressure area was prevented for up to 20 months and 18 months for Polista and Kabode varieties, respectively.
- Seed degeneration modeling showed that virus buildup could lead to significant yield loss after 4 generations in the open field but would not be reached within 10 generations if seed was sourced from the protected structure and multiplied once before use (Fig. 1).

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Fig 1. Harvesting vines from a net tunnel (small protected structure) at one of the trial sites. Mwanza, Tanzania. (Credit: K. Ogero)

What was the problem?

Sweetpotato production in the Lake Zone, Tanzania, is hampered by high virus pressure. Sweet Potato Virus Disease (SPVD), caused by the synergistic interaction between Sweet Potato Feathery Mottle Virus (SPFMV) and Sweet Potato Chlorotic Stunt Virus (SPCSV), can result in up to 98% yield loss. Vegetative propagation in sweetpotato through vine cuttings leads to a buildup of virus infection over generations. Multiplication of virus-free planting material sourced from virus-indexed tissue culture (TC) plantlets may contribute to improving farm-level seed health. However, farmer-multipliers face a challenge in maintaining healthy material once planted in open nurseries. Affordable, insect-proof net tunnels can be used to protect the vines from attack by white flies and aphids, which are the main vectors of sweetpotato viruses. However, the effectiveness of net tunnels under farmer-multiplier management is not known.

What objectives did we set?

We sought to determine virus infection and related degeneration in sweetpotato planting material maintained in net tunnels and open fields under farmer-multiplier management. Virus incidence was assessed for two varieties, Kabode (an improved orange-fleshed variety) and Polista (a local cream-fleshed variety), grown in net tunnels and open fields at two sites with varying virus pressures.

Where did we work?

This research was conducted at two sites, Mwasonge (2º 40´ 13´´ S 32º 54´ 45´´E) and Nyasenga (2º 39´ 40.1´´ S 32º 44´ 30.6´´E) villages, in Mwanza Region, Lake Zone, Tanzania. Mwasonge is a high virus pressure area owing to high intensity of sweetpotato production and high insect-vector presence, whereas Nyasenga is a low virus pressure area due to limited sweetpotato cultivation in the area.

What we did?

A 21-month experiment assessing virus infection on vines grown in net tunnels and open fields was conducted between June 2014 and March 2016 (Fig. 2).

Two net tunnels and two open beds were established at each site and virus-free planting material of two sweetpotato varieties, Kabode and Polista, planted. Leaf samples were collected after every 60-80 days and screened for Sweet Potato Leaf Curl Virus (SPLCV), potyviruses and SPCSV using polymerase chain reaction (PCR), reverse transcriptase PCR (RT-PCR) and quantitative real-time PCR (qPCR), respectively. Weather conditions and presence of virus vectors were also monitored. Virus incidence was assessed over time and data from the high virus pressure site used in seed degeneration modelling.

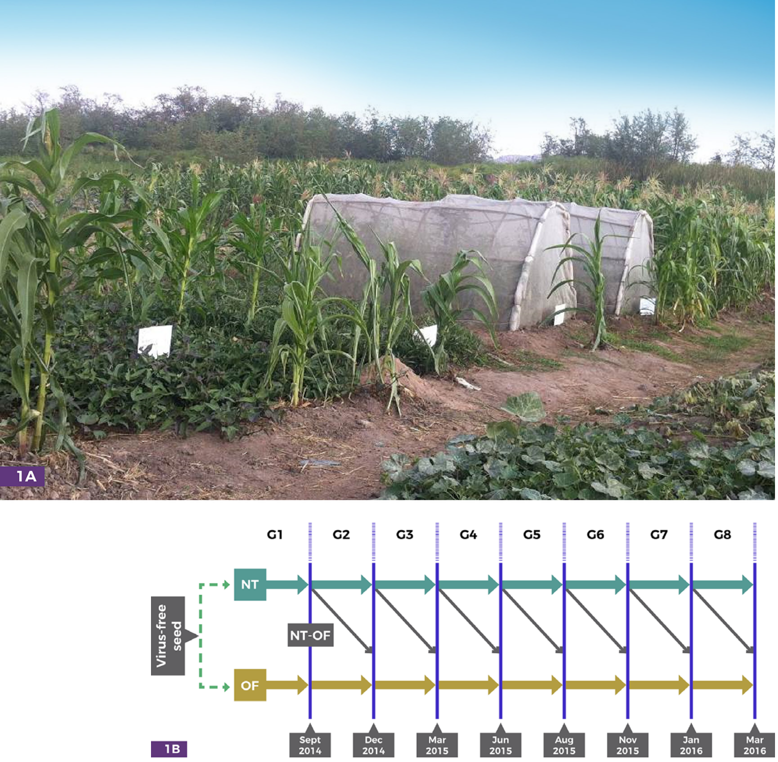

Fig 2. (1A) Net tunnels (Right) and open fields (Left) at the high virus pressure site (Mwasonge). (1B) The growing cycles of the experiments: The green line is the intervention (net tunnels (NT)) and the red line is the control (open fields (OF)). Black arrows indicate vines harvested from the net tunnels and multiplied once in the open field (Net tunnel-OF); blue vertical lines indicate points of leaf sampling.

What did we achieve?

Our findings indicate that:

- Virus infection started occurring in generation six and increased with successive generations at both sites (Fig. 3). As expected, there was higher virus incidence at Mwasonge as compared to Nyasenga in generations 7 and 8.
- Only SPFMV and SPCSV were detected, occurring singly or in combination to form SPVD.
- Kabode had higher virus loads (infections) compared to Polista (Fig. 4). No infections were detected at the low virus pressure area, Nyasenga, for Polista, regardless of being source from the net tunnels and open fields.

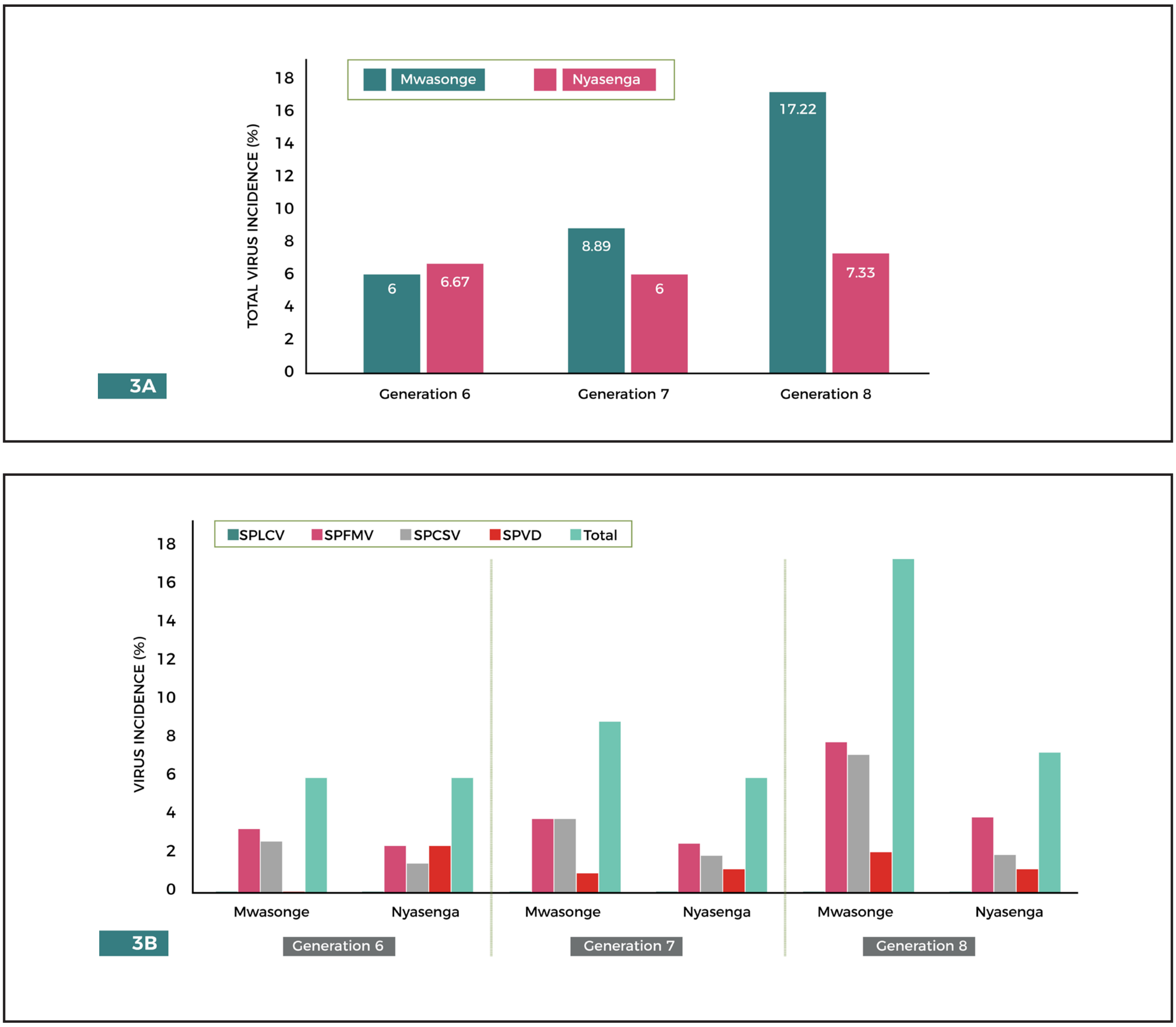

Fig 3. Virus incidence as detected by PCR assays at Mwasonge (high virus pressure) and Nyasenga (lower virus pressure).

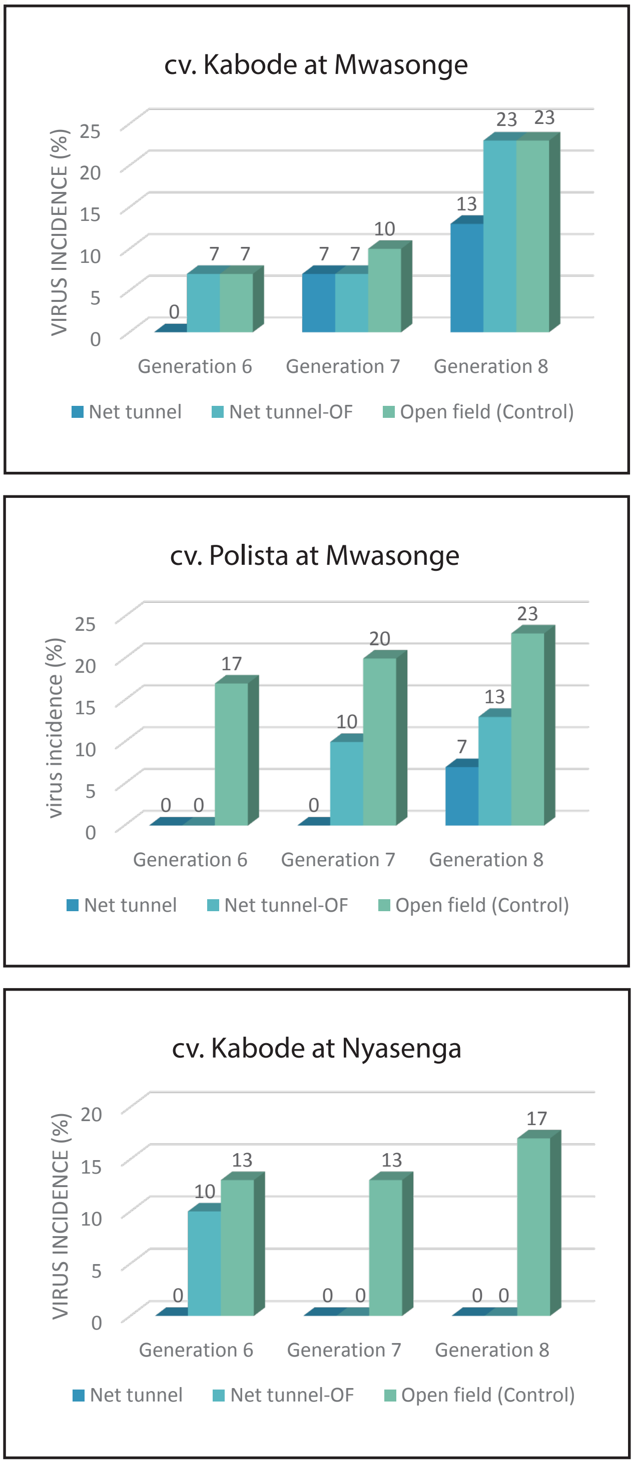

Fig. 4. Incidence of viruses detected by PCR assays in Kabode and Polista during the last three generations.

- Seed degeneration modelling illustrated that for both Kabode and Polista, root yield loss due to virus degeneration was reduced by the maintenance of vines under net tunnel conditions (Fig. 5).

End users and benefits of the net tunnel technology

The primary end users of the quality planting material from the net tunnel technology are farmer-multipliers who are benefiting by vine sales and realizing high root yields. Experience shows that female farmers benefit from closer access to quality planting material, hence improved

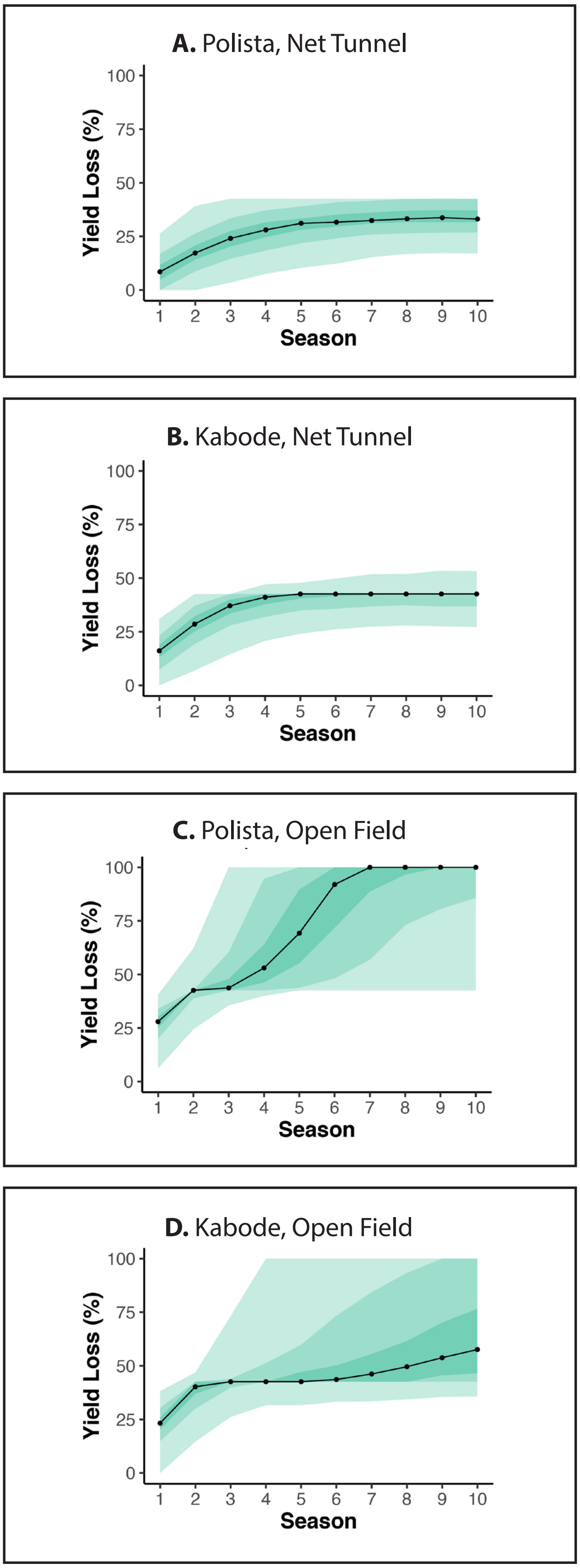

Fig 5. Modeled percentages of yield loss over ten seasons in scenario analyses for the high virus pressure site (Mwasonge), in extrapolations based on estimates of infection rates from the experiment combined with a generic model of yield loss. The yield loss percentages are the results of 1000 simulations, where each simulation started with seed with no infection so that the initial infections came from the surrounding area. Black lines indicate the median (0.50 quantile) yield loss across the 1000 simulations, and the shading indicates quantiles starting at 0.05, with 0.25, 0.40, 0.60, 0.75 and 0.95 indicated.

household food security. Increased root yields are also beneficial to male farmers since the extra can be sold to generate income for the family. Multipliers who produce basic and quality declared seed for sweetpotato are the intermediary beneficiaries. Through protected structures they can maintain a stock of healthy virus-indexed starter material therefore reducing the cost of production by reducing the number of times they have to purchase clean material from tissue culture. They are also benefiting from increased income generation through sale of quality vines.

Key drivers and bottlenecks in technology uptake

- **Drivers:**
  - Farmers are becoming increasingly aware of the yield losses associated with virus-infected planting material, leading to increased demand for quality seed;
  - Net tunnels provide local sources of clean planting material derived from virus-indexed material;
  - Development and implementation of seed standards and inspection schemes are on-going in various countries (Tanzania approved her standards in January 2017); Protected environments are now recognized as a key component of the seed system;
  - Strengthening and diversifying root markets. Strong root markets will create a pull effect on the use of quality planting material;
  - Multipliers can combine quality vine production and root production;
- **Bottlenecks:**
  - Supply chain for insect-proof nets is not in place in some countries;
  - Likelihood of re-infection in the open fields if not well-managed.

Scaling strategy

Moving forward, the use of protected structures will focus on high virus pressure areas, where farmers already buy planting material. A multi-stakeholder approach should be adopted since different actors play unique roles:

- Extension partners: Identify enterprising farmers and traditional multipliers with potential for irrigation and enough land; train multipliers on business and technical skills;
- Agro-dealers: Supply irrigation kits and insect-proof nets; could act as root aggregators and brokers to link with traders, creating a pull effect on the seed system
- NARIs: Production of pre-basic seed and coordination of DVMs and buyers to match demand and supply
- District level platforms: Strengthen communication and coordination among local stakeholders and provide the link to national level seed traders, and farmers apex associations
- Local authorities: Be engaged and champions identified to aid with promotion and awareness creation
- CIP: Strengthen links between existing national platforms for RTB crops and district-level stakeholder initiatives

Efficient communication and awareness creation on the benefits of quality seed will play a key role in uptake. Strategies such as demonstration plots, field days, signboards, radio spots, and ICT apps can be useful in reaching diverse audiences to demonstrate gain in root yield that comes from using quality seed.

Conclusion

This research provides evidence supporting the use of protected structures such as insect-proof net tunnels among farmer-multipliers to reduce seed degeneration in sweetpotato. By avoiding physical contact between vectors and sweetpotato plants the crop is protected from virus infection. Up to 100% protection can be achieved for 5 generations of multiplication in all areas under trained farmer-multiplier management. Protected structures can contribute greatly in the improvement of local seed systems in high virus pressure areas when combined with other on-farm management options such as positive selection and rouging. Subsidized support for establishing protected structures among medium- to large-scale multipliers can enhance availability and access of quality seed among root producers. The findings of this research contributed towards updating the net tunnel construction manual available on the Sweetpotato Knowledge Portal.

Partners • Tanzania Agricultural Research Institute (TARI) • University of Florida (UF) • Wageningen University & Research (WUR) • Louisiana State University Agricultural Center (LSU AgCenter)

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