Pre-basic sweetpotato vine multiplication using a sandponics system

- A nutrient media for multiplying pre-basic sweetpotato vines under a sandponics system was optimized
- The vine multiplication rate for pre-basic seed multiplication increased by 22% using sandponics
- The cost of producing a 3-node cutting has been reduced by $0.027
- Root yields were 7.1 t/ha higher using sandponics sourced planting material compared to material sourced from the conventional screen house production system

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Fig 1. Experimental set up at KEPHIS Muguga. Conventional screen house medium (on left) and sandponics medium (on the right) (Credit P. Makokha)

What was the problem?

The production of sweetpotato is highly constrained by shortage of quality planting materials in most of sub-Saharan African (SSA) countries. Sweetpotato seed systems are typically informal, where farmers source planting material from either their own fields or from the fields of neighbours. Strengthening sweetpotato seed systems to ensure that farmers have timely access to adequate quantities of quality planting material starts with the availability of adequate pre-basic seed that will drive multiplication of quality planting material of new and improved varieties by trained farmer multipliers. However, the production of quality pre-basic cuttings, that is the micropropagation of pathogen-tested tissue culture plantlets, which are then hardened into plants for *in-vivo* production in screen houses, is expensive. Conventional screen house production methods require sterilizing the soil to keep planting materials pest and disease free. However, sterilizing the soil with either diesel or firewood is expensive and environmentally unsustainable, and requires a lot of labour. This translates into high running costs. Earlier work by CIP had developed an aeroponics system with nutrient media optimised for seed potato mini-tuber production. We wanted to adapt this for sweetpotato vine production. Given the challenges of aeroponics (requirement for stable electricity, and clean water supply), we proposed to test the use of sand in place of sterilised soil. Sand is chemically inert and can be sterilized at a reasonable cost with sodium hypochlorite (i.e. a locally available household bleach such as Jik). We wanted to develop an appropriate nutrient solution for sweetpotato vine production; and then compare the cost of production with the conventional screen house production method.

What objectives did we set?

We wanted to test and adapt the sandponics system and evaluate its potential as a cost-effective alternative method of pre-basic seed production (Fig. 1).

Where did we work?

A series of experiments to optimize nutrient media for a cost-effective sandponics system were conducted by the International Potato Center (CIP) in collaboration with Kenya Plant Health Inspectorate Service – Plant Quarantine and Biosecurity Station (KEPHIS-PQBS) at Muguga, Kenya; the National Crops Resources Research Institute at Namulonge in Uganda; the Bvumbwe Agricultural Research Station in Malawi and the Mansa Research Station in Zambia.

What did we achieve during SASHA Phase 2?

We have demonstrated that sweetpotato vines for pre-basic seed can be multiplied cost-effectively in a sandponics system with an optimal nutrient media (Fig. 2). Table 1 shows the optimized nutrient media and the symptoms associated with deficiencies of specific nutrient components.

Fig 2. Trellised sweetpotato vines growing in sandponics (L) and conventional (R) multiplication systems in experiment to optimize the amount of nitrogen used (Credit B. Wanjala)

Table 1. Optimized nutrient media for multiplying sweetpotato vines in the sandponics system

Element	Optimal Application rate (ppm)	Probable source	Nutrient deficiency symptoms
Nitrogen	200	Calcium nitrate, Magnesium nitrate	Stunted plants with minimal expansion of leaf area. Reddening of basal leaf edges advancing to younger leaves.
Phosphorus	60	Calcium triple phosphate	Yellowing of older leaves spreading from discrete interveinal patches affecting half of the blades.
Calcium	200	Calcium nitrate	Chlorosis, curling, cupping and distortion of younger growing apical leaves. Plants exhibit detrimental effects of root rot.
Sulfur	120	Magnesium sulfate	Yellowing of middle growing leaves succeeded with entire yellowing of the whole plant.
Boron	0.3	Microsol B	Chlorosis In the apical leaves spreading to the basal foliage in the later stages of growth. Necrosis in the symptomatic leaves at advanced stage of vine growth, death of severely affected leaves, apical buds eventually leading to premature death.

Source: Makokha *et al* 2018.

The vine multiplication rate in the sandponics system is 21.8% higher when compared to the conventional vine propagation system of using soil (Table 2). The sandponics system has a high production efficiency per area with 1,021 cuttings (3-nodes each) per square meter (Fig. 3). Consequently, the cost of producing a 3-node sweetpotato cutting in the sandponics system (10.5 KSH (US$ 0.105) is significantly lower by 0.27 KSH (US$ 0.027) than the conventional system of propagating with soil (at 13.2 KSH (US$ 0.132). (Table 3). However, the cost-effectiveness of producing vines in a sandponics varied among the genotypes.

Fig 3. Data collection during harvesting to determine the number of cuttings produced under each system (Credit P. Makokha)

Table 2: Comparison of sweetpotato vine production in sandponics and conventional across 6 harvests

Vine yield trait	Ratoon (Harvesting interval in days after planting)	Sandponics	Conventional	t	p
Vine multiplication rate	42	27.6±1.2	28.3±1.3	-0.8	0.4
	84	28.2±1.6	20.7±1.2	7.5	<.0001
	126	35.9±2.4	25.7±1.7	6.9	<.0001
	168	34.8±2.6	22.4±1.8	7.8	<.0001
	210	36.3±3.1	31.6±2.3	2.4	0.02
	252	41.4±3.3	35.1±2.4	3.1	0.002
	Average	**34.0±1.1**	**27.3±0.9**	**9.6**	**<.0001**

Table 3: Average value for the cost (KSH) of producing one sweetpotato node in sandponics compared to conventional after 6 harvests (ratoons) for the four sweetpotato genotypes and test of equality using one-way test

Sweetpotato variety	Sandponics	Conventional	Difference	p value	Bartlett's test	Kruskal-Wallis equality-of-populations rank test
Ejumula	3.284	4.465	-1.181	<.0001**	0.020**	0.0001**
Kabode	3.949	4.997	-1.048	<.0001**	0.299	-
Irene	2.449	3.141	-0.692	<.0001**	0.845	-
Gweri	4.37	5.049	-0.679	0.0002**	0.175	-
Overall (all varieties)	3.513	4.413	-0.9	<.0001**	0.331	<.0001

Exchange rate 1 US$ = 100 KSH in year 2019; *, ** indicates 5% & 1% level significant respectively

Moreover, the storage root yield potential of planting materials multiplied by the sandponics system is higher by 7.1 tons per hectare 1 than vines multiplied conventionally in soil when grown in the open field (Table 4).

Table 4. Means for vine survival, storage root yield, number of storage roots, foliage weight and root dry matter content for the two types of vine source multiplication systems

Vine multiplication system	Vine survival (%)	Storage root yield (tons/ha)	No. of storage roots/ plant	Fresh foliage yield (tons/ha)	Storage root dry matter content (%)
Sandponics	98.4^a	33.4^a	3.4^a	16.8^a	26.8^b
Conventional (soil)	94.3^b	26.3^b	2.6^b	13.2^b	27.3^a
p value	0.003	0.004	<.0001	0.01	0.03
LSD (5%)	2.7	4.6	0.3	2.7	0.5

In each category and trait, means with different letters in the same column are significantly different at 0.05 probability level.

Were there any key challenges or lessons learned?

- The first experiment used the same nutrient media that had been used for seed potato mini-tuber production. This media was found not to be cost-effective for sweetpotato vine production.
- Work in Zambia has shown that in areas where soluble inorganic fertilizers are not readily available, filtrates of pig manure can also be used as nutrient manure for pre-basic seed multiplication (Fig. 4). However, due to variations in the mineralization of the pig manure, nutrient deficiencies are sometimes observed on the vines.

What's next?

Sandponics is a feasible alternative technology for pre-basic sweetpotato seed business enterprises that can be scaled in conditions where there are diminishing reserves of forest soils; where sterilisation using diesel or firewood is expensive and environmentally unsustainable; and where sand is locally available. Guidelines are in preparation explaining the set-up, nutrient mix, irrigation, and harvesting regimes for sweetpotato business enterprises.

Fig 4. Soaking bags of pig manure to be used as as a source nutrients for vine multiplication in sandponic system in Zambia

Further studies are required on: (i) evaluating the vine multiplication rate for the next generation of basic seed with planting materials sourced from the sandponics system (ii) compare vine multiplication rate in sandponics using trellising and ratooning technique within a particular crop calendar (iii) using sandponics for growing different varieties in experiments modeling climate change (iv) explore more options other than planting in pots; these could include planting in benches and troughs to optimize on plant density and (v) investigate the effect of ratooning on vine quality under sandponics multiplication.

Publications

Makokha, P., et al. 2018. Optimization of nutrient media for sweetpotato (*Ipomoea batatas* L.) vine multiplication in sandponics: Unlocking the adoption and utilization of improved varieties. *Gates Open Research*, 2, 59.

Wanjala, B.W., et al. 2019. Improving rapid multiplication of sweetpotato (*Ipomoea batatas* L. (Lam) pre-basic seed using sandponics technology in East Africa. *In press.* Experimental Agriculture Journal.

Makokha, P., et al. 2019. Comparative analysis for production of quality sweetpotato vines using sandponics and conventional systems. *Under review.*

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