# Integration of Farmers in Technology Developments as a Basis for Enhancing Sweet potato Productivity in Kenya

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## Abstract

Sweet potato is a food security crop for smallholder farmers in Eastern Africa. Pest and disease constraints are the most important biotic stresses, with viral diseases being the most devastating. Through a focus-group discussion, it was established that lack of clean sweet potato planting vines is a major constraint in production. Consequently, most farmers establish a new crop from virus-infected volunteer plants or an old sweet potato crop. The objectives of the study were to identify farmer-friendly technologies for conservation and maintenance of healthy planting vines; disseminate the best appropriate technology for farmers and varieties tolerant to sweet potato virus diseases (SPVD); and expose farmers to sound sweet potato production and value-addition practices for increased income generation. The experiments evaluated spraying with dimethoate, physical barriers to virus vectors (insect-proof net and polythene), maize plants as a physical barrier surrounding plots, and roguing. Parameters monitored were SPVD incidence, whitefly and aphid populations. High numbers of whiteflies were recorded on the control and none on the plots protected by net or polythene barriers. Disease control through roguing was effective, and netting and polythene covers can be of value for rapid multiplication and maintenance of sweet potato planting materials. Through a participatory approach, the roguing, net and polythene-cover technologies were demonstrated to farmers in coastal Kenya alongside farm trials to evaluate 17 sweet potato genotypes for resistance and/or tolerance to the SPVD. By end of the project, more than 100 farmers had adopted roguing on their farms. Disease-tolerant varieties were also disseminated to the farmers after the end of the evaluation period. The on-farm evaluation trials formed a basis for training farmers. Some farmers from the two key groups had an opportunity to attend a farmer-exchange visit in Uganda by courtesy of the Regional Universities Forum for Capacity Building in Agriculture. Integration of farmers in research, coupled with capacity-

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building, can enhance the adoption of new technologies, thereby enhancing sustainability.

## INTRODUCTION

Sweet potato is an important food, feed and cash crop, especially for smallholder farmers in Eastern Africa, yet its productivity is greatly reduced by sweet potato virus diseases (Mukasa *et al.*, 2003; Njeru *et al.*, 2004). The main sweet potato-producing regions of Kenya are western, eastern, central and coastal areas (MoA, 2005). The most devastating virus disease affecting sweet potato encountered in Africa and elsewhere is sweet potato virus disease (SPVD) (Geddes, 1990). The disease is a complex caused by dual infection by and synergistic interaction of the aphid-borne *Sweet potato feathery mottle virus* (SPFMV) and the whitefly-borne *Sweet potato chlorotic stunt virus* (SPCSV) (Gibson *et al.*, 1998). Virus diseases alone can cause yield reductions ranging from 56 to 98% (Mukasa *et al.,* 2003). The disease is perpetuated through planting diseased sweet potato vines and this has led to its persistence in the farmers' fields (Ateka, 2004).

From a survey conducted in Kenya, it was observed that farmers seldom remove infected material from mature crops, destroy the infected haulms of harvested crops, or purposely isolate new plantings from affected crops – due to lack of information on the cause and spread of viruses. However, improved phytosanitation offers unknown but potentially considerable benefits for SPVD control (Ateka, 2004). Variety-based tolerance to SPVD has been identified (Byamukama *et al.*, 2002) and provides a cheap and sustainable way of increasing productivity. Farmers' awareness and knowledge of how to manage the disease, identification of tolerant varieties with traits desired by farmers and markets, and methods of maintaining clean planting materials in farmers' fields are vital for maintaining high productivity. Therefore this study aimed at identifying a farmer-friendly agro-technological package for conservation and maintenance of healthy sweet potato planting vines prior to planting, and evaluation and dissemination to farmers of disease-tolerant varieties.

## MATERIALS AND METHODS

### Participatory Rural Appraisal

Focus-group discussions were conducted in Lukore of Kwale district in 2006. Farmers (from Lukore and Mwaluvanga), scientists from the University of Nairobi and Kenya Agricultural Research Institute (KARI) Mtwapa and extension staff from the Ministry of Agriculture (MoA) jointly conducted the activity. The approach provided an interactive forum for farmers, extension and research staff to share views and jointly plan ways of addressing the issues identified. Information was collected on resource availability, crop production patterns, role of sweet potato in agricultural systems and marketing. There was a general group discussion, and later gender-based discussions were held (men and women separately). A structured questionnaire was used to guide the discussion. Fifty farmers (30 women and 20 men) participated and flip charts were used to capture pertinent issues.

### Evaluation of Technologies for Multiplication of Clean Planting Materials

Clean sweet potato vines of a moderately susceptible variety (SPK004) were obtained from the International Potato Centre (CIP) in 2006. Planting beds measuring $2 \times 3$ m were prepared. The experimental design was a randomised complete block design (RCBD) and treatments were replicated three times. Sweet potato cuttings with three or four nodes were planted on the beds at a spacing of $20 \times 10$ cm, with two-thirds of the cutting being buried in the soil. The treatments were: spraying with dimethoate once every 2 weeks after planting; physical barriers to virus vectors (insect-proof net and polythene); maize plants as a physical barrier surrounding plots; and the control. The polythene and net barriers were supported by wooden frames, which were about 1 m above the ground. During irrigation, the net and polythene covers were removed then replaced immediately after water application. The crop was irrigated weekly and weeded whenever weeds grew. Calcium ammonium nitrate fertiliser (30 kg $ha^{-1}$) was applied at 3 and 8 weeks after planting. The gross margin per unit area of spray, net, polythene, maize and roguing was analysed with labour costs excluded.

Sampling was done fortnightly, starting 1 month after planting, to monitor disease incidence and severity, and whitefly and aphid populations. To obtain disease incidence, the number of plants per plot showing SPVD symptoms (stunting, distorted leaves with a chlorotic mottle or vein clearing) was determined and expressed as a percentage of the total number of plants assessed. Severity was rated on a scale of 1 to 5, with 1 = no disease symptoms, 2 = mild disease symptoms, 3 = moderate disease symptoms, 4 = severe symptoms, and 5 = very severe symptoms (Hahn *et al.*, 1981).

Assessment of vector populations (whiteflies and aphids) was done early in the morning when the insects were less active. The number of adult whiteflies underneath the leaves was counted to obtain the whitefly population, whereas the number of aphids on the same plants gave the aphid population. Data were subjected to analysis of variance (ANOVA) using Genstat software, and least significant difference (LSD) was used to separate means.

**Sweet potato Variety Evaluation for Tolerance/Resistance to Virus Disease**

Seventeen sweet potato genotypes were tested at three sites for two seasons – short (May to September 2006) and long (October 2006 to February 2007) rainy seasons. The 17 genotypes were either improved or local landraces. The three sites were KARI-Mtwapa farm in Kilifi District, which is located at an altitude of 30 m above sea level, and Lukore and Mwaluvanga in Shimba hills, Kwale District, both located at an altitude of 46 m above sea level. The soils are sandy and sandy loams in Kilifi and Kwale, respectively (Michieka *et al.*, 1978). The mean annual rainfall is 1,200 mm in Mtwapa and 1,400 mm in Kwale, with a mean monthly maximum temperature of 33°C in Mtwapa and 27°C in Kwale, and minima of 22 and 16°C, respectively (Jaetzold and Schmidt, 1983).

Apparently clean planting materials were obtained from CIP and KARI-Embu, and multiplied at KARI-Mtwapa under a stringent spraying regime to control vectors. The vines were distributed to farmers, who planted in May 2006. At the beginning of the short rainy season (October 2006), vines were obtained from the previous season’s crop and planted in new fields approximately 200 m away at all sites. The experimental design was RCBD replicated three times. The land was ploughed, harrowed and ridged at the three sites before planting. The sweet potato clones were planted at a spacing of $0.8 \times 0.3$ m on plots measuring $4 \times 3$ m. Weeding was done twice a month in the first 2 months and the plots were rogued once thereafter. The parameters monitored were disease incidence, whitefly and aphid populations, assessed as in the previous experiment (above). Yield of varieties was also determined.

## RESULTS AND DISCUSSION

Lack of market, lack of quality planting materials, insect pests, drought and scarcity of land were the key factors that constrained sweet potato production. High transport costs, price fluctuations and lack of quality standards in markets were also mentioned. None of the farmers was aware that SPVD limits sweet potato production and is spread by insect vectors. Rather, they attributed low productivity and SPVD symptoms to soil infertility. There was therefore a need to make farmers in the area aware of SPVD, train them in methods to produce disease-free/clean vines, and evaluate and disseminate disease-tolerant varieties with consumer-acceptable traits. Field sanitation, selection of clean planting vines and isolation of new crops from the old ones were not practised.

There was no disease incidence observed in any of the treatments throughout the growing season at the two sites. The absence of SPVD incidence in all the treatments can be attributed to low disease inoculum level at the sites of experimentation, rather than the treatments. High incidence of SPVD is attributed to year-round cultivation of sweet potato, which provides ready sources of disease inoculum (Alicai *et al.*, 1999); the current study concurs with this as sweet potato is not widely grown at Kabete field station and Juja farm. Aphids were absent from all the treatments and whiteflies were in low numbers, thus the absence of SPVD can also be attributed to the low numbers of the insect vectors responsible for the transmission of the component viruses (Aritua *et al.*, 1998).

There were significant differences in the number of whiteflies among the treatments (Fig. 1). Whitefly population increased with time, then decreased. The whitefly population decreased greatly in the 19th week after planting, probably due to the onset of heavy rains. Whitefly population was highest in the control and lowest in the net and polythene cover treatments. The populations were high in sweet potato surrounded by a maize barrier at the end of the season. Whiteflies were absent in the net- and polythene-covered plots, as the structures formed a physical barrier to insect vector entry. Whitefly populations in the other treatments differed significantly only at 16 weeks after planting (Fig. 1). The maize barrier seemed to harbour a high population of whiteflies, possibly because maize has wide leaves, which provide a sheltered micro-climate. The wide maize leaf offers conducive conditions for whitefly multiplication and oviposition (Legg, 1994). The low population in the maize-protected plots in weeks 12–14 could be attributed to oviposition and multiplication within the maize barrier itself. Where a maize barrier is used, it would be prudent to spray the maize, and the maize would act as a trap and reduce the spray area since it would not be necessary to spray the sweet potato crop.

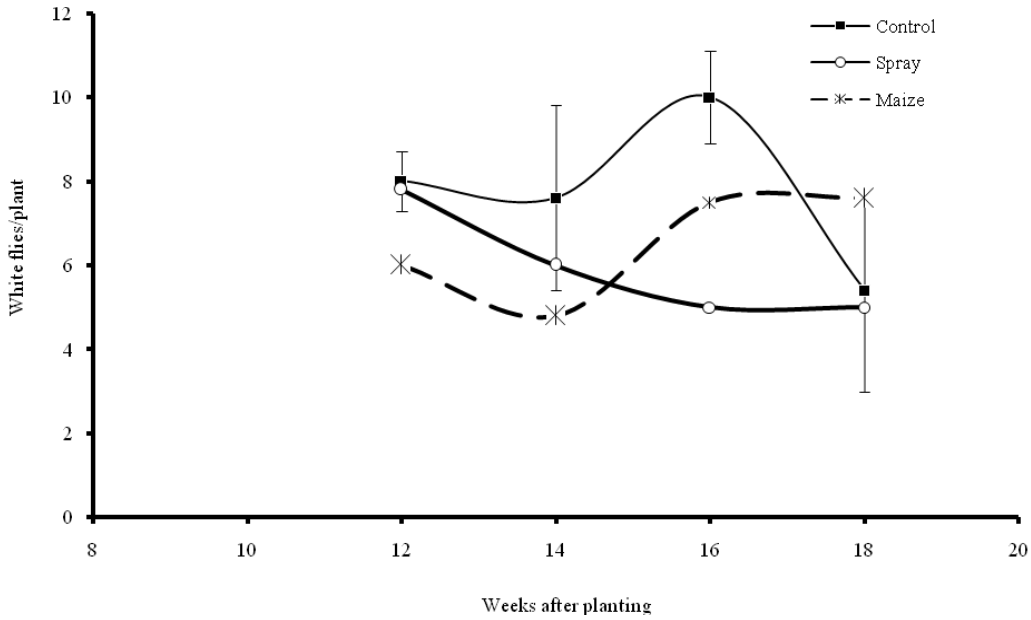


***Figure 1*** *Whitefly population among treatments over time*

*Note: The polythene and net covers had no whitefly infestation, so are not presented in the graph. Error bars (standard difference) are given only for the control as it acted as the check against the other treatments.*

Chemical spray would lead to a reduction in the number of whiteflies only for a short period, then the population would build up steadily, concurring with reports by Aritua *et al.* (1998) that spraying does not always keep away disease vectors. It was also observed that, immediately after irrigation, the whitefly population was greatly reduced, possibly due to physical damage caused by the impact of water drops (Legg and Ogwal, 1998) or reduced oviposition (Fishpool and Burban, 1994). These results are consistent with earlier reports by Aritua *et al.* (1998), Alicai *et al.* (1999) and Otim *et al.* (2001) that climatic conditions have a strong influence on the population dynamics of insect vectors.

The unit cost of polythene, spraying and netting was 0.5, 0.5 and 1.2 Kenyan shillings[7] (Ksh), respectively. Thus the use of polythene covers is cheaper for farmers and farmer groups for fast multiplication of sweet potato without a delay in transferring the vines to the field.

**Disseminating the Technology to Farmers**

Dissemination of the technology was enhanced through a participatory research approach whereby farmers were involved in the on-farm sweet potato evaluation for tolerance to SPVD. The farmers were from two major sweet potato-growing groups in Shimba Hills, Kwale District. Variety-based tolerance was found in Jonathan, Japonese and Zapallo. Evaluation of sweet potato quality was done at the end of the long rainy season. More than 50 farmers took vines of the different varieties. The farmers preferred Jonathan, SPK004, Zapallo, Japonese, Ejumula, Kemb10 and Ex-shimba, because they had consumer- and farmer-preferred traits and had reasonable

[7] Exchange rate: €1 ≈ Ksh 120.

tolerance to SPVD. This indicated that these varieties possess the best farmer-preferred traits, and they can be used in breeding as a source of those traits. Although variety Jonathan was ranked among the best field performers coupled with high yields, farmers ranked it as intermediate on general acceptability. Thus its adoption could be slow compared with other farmer-preferred varieties. Consequently, it would be of great value if the desirable traits were incorporated in this variety through breeding. Ranking of varieties by children might well influence selection of the best varieties, so this should be included in the future – children are also key consumers of sweet potato as food.

Maintenance of disease-free planting vines over the dry season was identified as a pivotal requirement for sustainable supply of planting materials. Consequently, an on-farm demonstration of maintenance and multiplication of healthy planting materials was conducted. The farmers established a communally owned nursery near a river. They practised roguing to keep the vines of different varieties free from disease. The varieties multiplied were Jonathan, SPK004, Ejumula, Kemb10 and Jubilee. This was expected to supply clean planting vines and save farmers the cost of accessing them from research stations (Kapinga *et al.*, 2005). Extension staff from MoA and scientists from KARI were also trained so that they can continue promoting the appropriate technologies and practices among farmers.

The farmers who were involved in the participatory research had a chance to visit fellow farmers in Uganda as a capacity-building strategy. This was facilitated by the Regional Universities Forum for Capacity building in Agriculture (RUFORUM). The farmers visited national agricultural research stations, food processing industries and farmers' groups in Uganda, where they learned good methods of crop production (particularly sweet potato, among others) and on-farm value addition to generate more income. For instance, they were trained in how to make juice from orange-fleshed sweet potato and how to process fruits into juice by a fellow farmers' group. This again contributed to technology transfer, and the Forum enlightened the farmers on how they can use locally available farm produce to empower themselves economically.

## CONCLUSION

The key outcomes were that farmers and extension staff jointly identified production problems and solutions; awareness was created; 20 farmers were trained in maintaining clean germplasm; and disease-tolerant varieties were disseminated to the farmers. The netting and polythene covers can be recommended for maintenance and multiplication of quality sweet potato planting materials due to their ability to exclude disease vectors. Commercial farmers and farmers' groups can adopt net structures if they grow vines for seed as a business. Farmers can also adopt roguing of infected plants as a way of managing the disease in both nursery and field. The identification of tolerant varieties with consumer-preferred traits together with the farmers was a major boost to sweet potato production in the region.

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