Proceedings of the 13th ISTRC Symposium, 2007
pp. 129 - 135

Assessment of genetic diversity, farmer participatory breeding, and sustainable conservation of Eastern African sweetpotato

Gichuki S.T.[1], Kapinga R.[2], Villordon A.[3], Kulembeka H.[4], Jeremiah S.C.[4] and Ndolo P.J.[5]
[1]KARI-Biotechnology Center, P.O. Box 57811, Nairobi, Kenya
[2]International Potato Centre, Kampala, Uganda
[3]Louisiana State University, Baton Rounge, USA
[4]Lake Zone Agricultural Research and Development Institute, Ukiriguru, Mwanza, Tanzania
[5]KARI- Regional Research Centre Kakamega, P. O. Box 169, Kakamega, Kenya

Abstract. Sweetpotato [*Ipomoea batatas* (L.) Lam] is one of the most important crops in densely populated East Africa. The crop is vital to small-scale farmers with limited land, labour and capital. A project funded by the Collaborative Crop Research Programme (CCRP) of the McKnight Foundation was initiated from July 2002 to run for four years. Project partners are the Kenya Agricultural Research Institute (KARI), Louisiana State University, The International Potato Center (CIP), Austrian Research Centers-Seibersdorf and the Root and Tuber crops programme of Tanzania. This project aims at improving East African sweetpotato productivity and sustainability through collaborative and participatory research on germplasm conservation, crop improvement, and development of technology for planting material production. So far a total of 679 sweetpotato germplasm accessions have been collected in eight regions of Kenya and Tanzania. Focussed Participatory Rural Appraisals to collect indigenous technical knowledge on sweetpotato germplasm have been conducted in 25 communities in six sweetpotato production regions. Twenty high dry matter and ß -carotene rich sweetpotato clones were transferred from CIP-Lima to four SSA countries. A publicly accessible website www.viazitamu.org has been established to support the project, enable online access of germplasm records, as well as share information with the general public. A publicly available, license-and royalty-free, web based GIS viewer for use on the web site has been adapted. Six local orange and yellow fleshed varieties were virus-tested and are being cleaned and multiplied for dissemination to farmers. A number of partner NGOs and CBOs have established field seed multiplication nurseries for distribution as co-funded activities. KARI and LZARDI have also established basic seed nurseries.

Introduction

Sweetpotato *Ipomoea batatas* (L.) Lam] is the world's seventh most important food crop after wheat, rice, maize, potato, barley, and cassava (CIP, 1996). It is one of the most important crops in densely populated East Africa (Low *et al*., 1997). The crop is vital to destitute small-scale farmers with limited land, labor and capital. The crop grows well on soils with limited fertility, is relatively drought tolerant, provides good ground cover, and is usually cultivated without fertilizer or pesticides (Ewell, 1990). Traditional cereal crops often fail in these same environments. Sweetpotato also thrives in fertile environments, producing remarkable amounts of energy quickly, often producing more edible energy than any other major food crop (CIP,

1996). Sweetpotato roots provide energy, little but high quality protein (e.g. lysine), Vitamin B1, B2, niacine, pyridoxine, folic acid and ascorbic acid (Woolfe, 1992). Orange-fleshed sweetpotato have reasonable quantities of â-carotene, a precursor for Vitamin A (Hagenimana *et al.*, 1999). Other important nutrients found in sweetpotato include calcium, phosphorus, iron, sodium and potassium. In short, it has great potential in combating the food shortage and rampant malnutrition in this region. Sweetpotato is utilized as a tropical salad, a staple or vegetable food, a sweet dessert, a fast food, an animal feed, or a basic industrial raw material (Woolfe, 1992). The value of sweetpotato is now being recognized and rewarded with increased funding by national and international agricultural research centres. The national programmes, together with the international agricultural research centres and other institutions, have made significant progress in germplasm conservation and crop improvement in East Africa. However, an institutional mechanism is needed to sustain and speed up the progress.

Sweetpotato originated in the Central and Southern America, although the precise location remains unknown (Woolfe, 1992). The crop was introduced to Europe through Spain in the 15th century, from where it was further dispersed to the rest of the world. The Portuguese are thought to have introduced the crop to Africa through Mozambique and Angola. The British colonialists may also have brought sweetpotato from India in the 17th and 18th centuries. East Africa is believed to be a secondary centre of diversity of the sweetpotato. This diversity needs to be assessed, conserved and utilised for the benefit of the farmers in the region.

The major constraints to sweetpotato production include continued use of low yielding and late maturing local cultivars, post harvest yield losses, diseases and pests and inadequate planting material. The major pests includes insects such as the sweetpotato weevils, vertebrate pests such as moles, rats, porcupines and monkeys (Bashaasha *et al.*, 1995; Kapinga *et al.*, 1995). The most important disease in Kenya is the sweetpotato virus disease (SPVD) (Wambugu, 1991). In addition there is poor institutional support and recognition and inadequate research capacity in most African countries.

A project funded by the Collaborative Crop Research Program of the McKnight foundation aims at improving regional sweetpotato productivity and sustainability through collaborative researches on germplasm conservation, crop improvement, and development of technology for planting material propagation. These research activities will be carried out in a multi-disciplinary framework including national programmes and advanced institutions. There will be extensive capacity building for the national scientists both through degree training and on-job, specific training programs. The outcomes of this project will greatly contribute to conservation of sweetpotato genetic diversity, increased sweetpotato productivity, enhanced sustainability of sweetpotato based production system, improved nutrition status, disaster preparedness, and strengthened sweetpotato research capacity in East Africa. The key partners in this initiative are, The Kenya Agricultural Research Institute (KARI), The Ministry of Agriculture and Food Security of Tanzania, National Root Crop Program, Louisiana State University, Austria Research Centers Seibersdorf and the International Potato Center. The project targets resource poor farmers in the three East African countries, Kenya, Uganda and Tanzania.

Documentation of indigenous technical knowledge. For technology transfer to be efficient, the needs of the clients must first and foremost be established. The client, in this case the farmer, must participate in the process of identifying technologies that might solve his problems. The project has used Participatory Rural Appraisal (PRA) methods

to collect indigenous knowledge on germplasm conservation and role of sweetpotato in the farming system.

The objective of the PRAs was to identify current sweetpotato production constraints, its productivity and sustainability within the farming systems, genetic diversity, production systems and other positive aspects that contribute to the enhancement of livelihoods of farmers. Sites were selected with the assistance of extension staff using criteria such as agro ecological representation, farming systems and the diversity of sweetpotato varieties grown in the area. Farmers listed and prioritized agricultural constraints they experienced and suggested solutions to alleviate them. Activities and tools used included historical profiles, matrix and pairwise ranking of enterprises, collection and reviewing of secondary data, access and control profiles by gender, problem-causal analyses and potential solutions, village mapping, seasonal calendars and cropping activity calendars

The PRAs took 1-3 days depending on ease of access, availability of secondary data and farmers availability. Initially, a meeting was called with community leaders and the local administration. Checklists were prepared for use by the multidisciplinary teams, which included breeders, agronomists, social scientists and extension staff and where possible an entomologists or pathologist.

In Kenya PRAs were conducted in a total of 15 communities in four regions (Table 1). In Tanzania 10 villages in two zones were covered (Table 2). Several production constraints were identified in each area including;

1. Rotting of sweetpotato tubers in dry period (associated with sweetpotato weevils)- Farmers do opt to process sweetpotato when rain season stops.
2. Pests and diseases - Farmers have no solution. They still depend on the susceptible varieties
3. Insufficient rainfall especially in Meatu and Magu districts- No solution to this problem.
4. Limited land for sweetpotato cultivation which is caused by different factors like overpopulation and overstocking- Farmers have no solution to that problem

Table 1: Location and number of villages where participatory rural appraisals were carried out in Kenya.

Region	Area	Number of villages
Western Kenya		3
South West Kenya	Rongo	2
	Ndhiwa	1
	Kabondo	2
	Kendubay	1
Eastern Kenya	Kangundo	1
	Kangundo	1
	Matungulu	1
Central Kenya	Mukurueni	3
	Kibirigwi	1

Table 2: Location and number of villages where participatory rural appraisals were carried out in Tanzania.

Region	District	Sample villages
Lake Zone	Sengerema	Nyamadoke, Igurumuki
	Magu	Kabita, Mwamabanza
	Meatu	Bulyashi, Mwanjolo
Lake zone	Ilala	Chanika
	Tanga	Mombo
	Morogoro	Sanje
		Msolwa

5. Lack of improved sweetpotato varieties
6. Inadequate planning material

Several important issues were also raised by farmers which included;

- Soil fertility - In all villages it was mentioned to be declining over time, hence need consideration for improvement. The problem is reflected in yield reduction. Soil fertility declined due to continuous cultivation without replenishment.
- Water resources - Water resources were mentioned to be declining over the past ten years, this affected the planting material preservation over seasons.
- Competition between livestock and crop production. This has implications in land allocation depending on the ranking and value of the enterprise
- Human population - Increasing population had led to food insecurity in many areas. Expansion of sweetpotato production areas and introduction of high yielding sweetpotato varieties is desirable in most areas.
- Institutions - Several institutions exist in most project areas with potential support for the distribution of improved varieties and planting material.
- Importance of sweetpotato in comparison with other crops. This varied between villages depending on rainfall, soils, markets, biotic constraints and use. In some dry areas the rank was very high while in areas with heavy rains it was ranked low because farmers grow other higher value crops. Hence there is room to improve production of sweetpotato in areas where the ranking of sweetpotato was high, but the room for expansion can also be considered in the other areas for purposes of food security and after addressing specific constraints identified. There are also socio-cultural values attached to the crop. In most areas it is regarded as the women's crop.
- Income - Generally, crop production is the main source of income for most communities. This contributes more than 50% of the total income available to the farm families. Improved sweetpotato varieties and marketing may therefore significantly improve farmers' income.
- Expenditure - Very low investments in agriculture was noted in most of the villages surveyed. Although agriculture was an important source of income, most of the income generated was used for purchase of food, clothes and domestic needs.
- Time use profile - Women contribution to labour is very high. Sweetpotato production in most villages is done by women, with small contribution of men. Introduction of high yielding, early maturing varieties will reduce the area to be cultivated per season while maintaining the total yield per season hence reduce work load on women. Technologies developed for labour saving can be important for example; processing equipment, ox-drawn implements and cultivation technologies.

Strengths, weaknesses, opportunities and threats (SWOT) analysis were done for each village. This was followed by development of intervention recommendations for each village.

Germplasm collection. The project aims at collecting germplasm in selected agro-ecologies and recording minimum morphological characteristics and farmer knowledge of the varieties during the collection exercises. Use of Geographical Information Systems (GIS) to select target agro-ecologies is encouraged. In addition existing diversity knowledge is used to determine areas of maximum diversity and plan collection strategies. So far a total of 679 accessions have been collected. A total of 260 accessions have been collected in four regions of Tanzania (Table 3) and 419 accessions in

Table 3: Sweetpotato germplasm collection locations and numbers in Tanzania.

Zone	District	Number of accessions collected
Lake zone	Meatu, Sengerena, Magu, Bukoba Tarime	97
Eastern zone	Ilala, Temeke, Bagamoyo, Kisarawe, Bagamoyo	73
Northern zone	Mwanga and Same	85
Southern	Mbeya, Songea	5

Table 4: Sweetpotato Germplasm collection locations and numbers in Kenya.

Region	Areas	Number of accessions collected
Western	Kakamega, Siaya, Vihiga, Teso, Busia, Bungoma, Kisumu	189
South Western	Migori, Rachuonyo, Homabay, Kisii	146
Eastern	Kangundo, Matungulu, Kathiani	42
Central	Mukurueni, Kibirigwi, Kieni	42

four regions of Kenya (Table 4). In Tanzania the highest number of collections were in the Lake and Eastern zones while in Kenya the highest numbers were in the western and south western regions. Several reasons were sited by farmers for selecting or abandoning varieties. These include, taste, marketability, tolerance to pests and disease, drought tolerance, yields, maturity period and utilization. Adoption of new varieties must satisfy these multiple criteria. Participatory breeding approaches are therefore recommended to increase adoption rates.

A publicly accessible web site www.viazitamu.org has been established to support the project, enable online access of accession records, as well share information to site visitors.

A publicly available, license- and royalty-free, web-based GIS viewer for use on the web site was adapted. A preview version can be accessed via the "Objectives" link on the main menu. Work is currently ongoing to test and evaluate the GIS viewer as well as incorporate preliminary sweetpotato accession information from the different research partners. The usage logs indicate that the GIS viewer preview page is one of the frequently visited pages on the web site.

Germplasm evaluation and introduction of high dry matter, high beta-carotene content varieties. Up to 20 high dry matter, ß -carotene rich sweetpotato clones have been received *in-vitro* from CIP – Lima. These clones have been multiplied in green houses and fields and are ready for field evaluations. Earlier CIP introduced orange-fleshed varieties still maintained at PQS Muguga were distributed to various countries in the region where they are being tested for adaptability and acceptability. Evaluation of local orange-fleshed varieties is being carried out in Kenya (Kabete, Kakamega). Those that have been found acceptable to communities are currently being multiplied by partner NGOs and CBOs for distribution to farmers.

Production of clean planting material. Availability of healthy planting materials of improved sweetpotato varieties is a prerequisite to realizing high root yield. Full access by farmers to new improved sweetpotato varieties is dependent on multiplication and distribution of clean planting materials. Supply of planting materials from research has not met the demand by farmers because sweetpotato like any other vegetative plant has low

multiplication ratio. In most seasons most farmers suffer shortage of planting materials, which has resulted into most fields being not planted with sweetpotato. Non-government organizations have been supportive in multiplication and distribution of planting materials. The objective of basic seed production was to establish sweetpotato seed nurseries to act as source of nucleus planting materials for secondary multiplication by farmers, NGOs and CBOs.

Six varieties were tested for viral infections, cleaned and multiplied at PQS Muguga. These were local orange and yellow-fleshed varieties. A number of partner NGOs have established field seed multiplication nurseries for distribution as co-funded activities. In Kenya REFSO and UCRC have established nurseries in swampy areas to ensure continuous supply of planting materials to farmers. This is in addition to the nurseries being maintained at KARI-Kakamega, KARI Kisii, KARI Katumani and Kabete field station in Nairobi.

During the 2002 season, in anticipation of food shortages due to drought, the Tanzanian government insisted on each household growing drought tolerant crops particularly cassava, sweetpotato and sorghum. This was to make sure that every household is self sufficient in food supply to mitigate food insecurity in extended periods of drought. Lake zone Agricultural Research and Development Institute (LZARDI) responded by multiplying and distributing sweetpotato planting materials to farmers for secondary multiplication. This activity was done in collaboration with CARE International, an NGO operating in Misungwi and Magu and the district covered was Misungwi.

Varieties that were multiplied and distributed from sweetpotato seed nurseries at LZARDI, Ukiriguru were Simama, Jitihada, Vumilia, Mavuno and Sinia, which are officially released varieties. Other varieties include NC 1560, Mafutha, Japon Tresimesino and Tainung No. 64. These are some of the orange-fleshed sweetpotato varieties that have been tested on farm for acceptability. Tests done in 2001 and 2002 seasons have shown most of them to be acceptable by farmers.

Acknowledgements

The authors wish to thank the Director, of Kenya Agricultural Research Institute the Zonal Director, Lake Zone Agricultural Research and Development Institute for their continued support for activities in Kenya and Tanzania. We also acknowledge the support of our partners in Louisiana State University, the Austrian Research Centres, Seiberdorf and the International Potato Center for valuable technical backstopping to the project. Last but not least we are greatly indebted to the Collaborative Crop Research Program of the McKnight Foundation for funding this project.

References

Bashaasha, B., Mwanga, R. O. M., Ocitti, P. O. C. and Ewell, P. T. 1995. Sweetpotato in the farming and food systems of Uganda: a farm survey report. International Potato Centre (CIP)/National Agricultural Research Organization. 63pp.

CIP, 1996. CIP sweetpotato facts. A campendium of key figures and analysis for 33 important sweetpotato – producing countries. April, 1996.

Ewell, P. T. 1990. Sweetpotatoes in Eastern and Southern Africa. Paper presented at the workshop on sweetpotatoes in the food systems of Eastern and Southern Africa, Nairobi, Kenya.

Hagenimana, V., Carey, E. E., Gichuki, S. T., Ayunga, M. A. and Imungi, J. K. 1999. Carotenoid contents in fresh, dried and processed sweetpotato products. Ecology of Food and Nutrition 37: 455-473.

Kapinga, R., P.T. Ewell, S.C. Jeremiah and R. Kileo. 1995. Sweetpotato in Tanzanian farming and food system: Implications for Research. A farming systems survey report by the Tanzania National Root and Tuber Crops and Farming Systems

Research Programme and the International Potato Centre. Nairobi, Kenya.

Low, J., Kinyua, P., Gichuki, S., Oyunga, M. A., Hagenimna, V. and Kabira, J. 1997. *Combating Vitamin A Deficiency Through the Use of Sweetpotato*. Results from phase I of an action research project in South Nyanza, Kenya. International Potato Centre, Lima, Peru.

Wambugu, F. m. 1991. In Vitro and epidemiological studies of sweetpotato (*Ipomoea batata*) (L.) Lam.) virus diseases in Kenya. Ph.D. Thesis, University of Bath. 271 pp.

Woolfe, J. A. 1992. *Sweetpotato: An untapped food resource*. Cambridge University Press, Cambridge.