

Agricultural Innovations for Sustainable Development

**Contributions from the Finalists of the African Women in
Science Competition**

Volume 2 Issue 1



Agricultural Innovations for Sustainable Development

Contributions from the Finalists of the
African Women Professionals in Science Competition

Volume 2 Issue 1

Edited by

Dr Kevin Urama
Judith Francis
Mr Marsden Momanyi
Dr Sheila Ochugboju
Mr Arnold Ominde
Dr Nicholas Ozor
Mr Guy Manners



Alliance
for a Green Revolution
in Africa



Acknowledgements

We sincerely thank the consortium partners – ATPS, CTA, AGRA, FARA, NEPAD and RUFORUM - for making the Women Professionals in Science Competition 2008 a successful one. The event will go down in history as one of the stakeholder partnerships that has empowered the African women towards the attainment of sustainability in science and technology innovations in Africa. We appreciate the women who submitted articles that eventually led to this unique publication. We note that several efforts and inputs have been made to ensure that this publication becomes a reality. To this end, we owe many thanks to the following people:

Dr. Kevin Urama, ATPS; Judith Francis, CTA; Dr. Catherine Adeya-Weya, ATPS; Myra Wopereis-Pura, FARA; Dr. Rufaro Madakadze, AGRA; and Lily Aduke, ATPS. Others include Wellington Ekaya, RUFORUM; and Dr. Ruvimbo Mabeza-Chimedza, Gender Specialist.

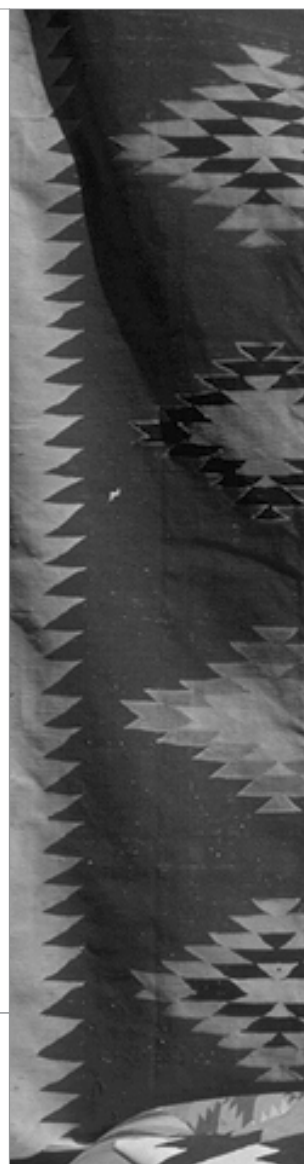
Finally, we wish to immensely thank the editorial team for their steadfastness in ensuring that this publication stands the test of time and is of high standard. They include Dr Kevin Urama, Executive Director, ATPS; Judith Francis, CTA; Mr Marsden Momanyi, Communication and Outreach Officer, ATPS; Dr Sheila Ochugboju, Senior Communication and Outreach Officer, ATPS; Mr Arnold Ominde, Intern and Dr Nicholas Ozor, Post Doctoral Research Officer, ATPS; Mr Guy Manners, Science Editor.



Published by the African Technology Policy Studies Network
P O Box 10081, 00100 GPO Nairobi Kenya

© 2009 Published by the African Technology Policy Studies Network

ISBN: 978 9966-7434-3-X



Agricultural Innovations for Sustainable Development

Contributions from the Finalists of the
African Women Professionals in Science Competition

Volume 2 Issue 1

Foreword

As part of its contributions towards building stronger institutions through science, technology and innovation policy research for sustainable development across African Continent, the African Technology Policy Studies Network (ATPS) and her partners, the Technical Centre for Agricultural and Rural Cooperation (CTA), the Alliance for a Green Revolution in Africa (AGRA), the Forum for Agricultural Research in Africa (FARA), The New Partnership for Africa's Development (NEPAD), and the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), organized the maiden Competition for Young Professionals and Women in Agricultural Science & Technology in 2008. The final competition and award ceremony was hosted during the African Union Fourth conference of Ministers of Agriculture, Lands and Livestock, Addis Ababa, Ethiopia from 20-21 April 2009.

This initiative led to the production of the maiden issue of the book series, *Agricultural Innovations for Sustainable Development 1(2)*, based on the contributions made by African women who have carried out diverse researches in agricultural science, technology and innovations on the continent. Contributions mainly ranged from issues in agricultural production, marketing, value addition, to biotechnology, information communication technology, and climate change. Participation was open to all African women but only about 17 women from 8 African countries emerged as finalists in the competition after a rigorous expert review and assessment processes. Special awards were given to the best two researchers whose research was judged to have contributed most to the improvement in agricultural innovations and sustainable development.

African Young Professionals in Science competition was organized in furtherance of the partners' belief that the future of African development largely lie with building Africa capacity to generate own knowledge, adequate technologies and innovations to address her own problems in key sectors, especially agriculture. The contributions of women in agricultural development in most African countries are above 70%, yet their voices are not always heard. African women are still often marginalized in Africa's development dialogue including in political, socioeconomic, religious, and even in cultural processes. It is for this reason that the partners place a huge emphasis on women as key actors in Africa's agricultural systems of innovation both at national and regional levels. We believe that African women can chart their own destinies and foster development in Africa, through engagement in science, technology and innovation capacity building and policy initiatives.

Agricultural Innovations for Sustainable Development is therefore a must read. It provides a succinct collection of the best agricultural practices and innovations by African women today for sustainable development tomorrow. More so, this volume uniquely contains the contributions and voices of African women only.

**Dr. Kevin Chika Urama,
Executive Director, ATPS**

Table of Contents

Foreword	4
Information Seeking and Use among Urban Farmers in Kampala District, Uganda . <i>Helen M. Byamugisha</i>	8
Participatory Development Communication as a Tool in Agricultural Technology Transfer: The Experience of Apac District Pigeon Pea Farmers' Groups <i>Harriet Muyinza and Ambrose Agona</i>	15
A Regional Network of Dialogue and Exchange Platforms to Improve the Identification of Farmers' Needs and the Dissemination of New Varieties of Banana and Plantain: The Case of Cameroon <i>D.I. Nkapnang, K. Tomekpe, B. Demba, A. Bikoï and J. Okollé</i>	21
Gender and Social Issues of RiceBased Farmers in Rokupr, Kambia District, during the 2005/06 Cropping Season <i>Finda B. Jenkins</i>	28
Empowering Smallholder Farmers in Kilifi and Malindi Districts of Kenya through Improved Mango Production Techniques, Marketing and Information Dissemination to Ensure Poverty Reduction, Food Security and Creation of Employment <i>Christine K. Masha, F. Pole and L.A. Wasilwa</i>	41
Enhancing Food Safety and Market Access for Smallholder Export Vegetable Producers in East Africa <i>Brigitte Nyambo</i>	48
Using the Participatory Market Chain Approach (PMCA) to Generate ProPoor Innovations in the Sweet Potato Sector in Uganda <i>B. Akello, I. Mugisa, W. Nakyagaba, M. Nampeera, P. Lusembo and D. Magala</i>	54

An Agrobiotechnology System for Improving Traditional Landuse System in SubSaharan Africa <i>Abiodun Olusola Salami</i>	60
Climate Change in Africa, Based on Tree Rings and Stable Isotope Results, and its Potential for Climatic Teleconnections <i>Aster Gebrekirstos</i>	66
Pesticide Risk Reduction Strategies for Vulnerable African Populations through Regulatory Capacity Building and Gender Appropriate Risk Communication Strategies <i>Hanna-Andrea Rother</i>	73
Participatory Testing of Forage Legume Innovations with Women Farmers in Masaka District, Uganda: Impact on Fodder Availability, Animal Performance and Household Income <i>J.M.L. Kabirizi</i>	79
The Use of Remotelysensed Data as Methodology to Determine Grazing Capacity in Namibia <i>Celesté Espach</i>	85
Farmer–Breeder Partnership in Barley Varietal Selection: A Case for Decentralized Plant Breeding in Drought Prone Areas of Northern Ethiopia <i>Fetien Abay and Åsmund Bjørnstad</i>	92
Development and Promotion of Technologies for Sustainable Production and Utilization of Indigenous Vegetables for Nutrition Security and Wealth Creation in Kenya <i>Mary O. Abukutsa-Onyango</i>	100
Performance of Maize Varieties of Different Maturity Groups under the Marginal Rainfall Conditions of a Rainforest Location <i>A. Oluwaranti, M.A.B. Fakorede and B. BaduApraku</i>	109
Traditional Medicine and its Impact on Livelihoods <i>Ameenah Gurib-Fakim</i>	115
Policy Issues for Smallholder Farmers' Productivity <i>Joy M. Kiiru</i>	123

Information Seeking and Use among Urban Farmers in Kampala District, Uganda

Helen M. Byamugisha

Keywords: information, information access, information use, urban agriculture, urban farming, information needs, information sources

Abstract

Information seeking and use by urban farmers are important for enhancement of urban food security in Kampala district in Uganda. The fast growth in urban population coupled with rural–urban migration has given rise to food insecurity in Kampala city.

Urban farming is characterized by low agricultural production and food insecurity, particularly among the urban poor. With increasing lack of food and more complex life for urban dwellers, urban agriculture is viewed as one possible survival strategy. Although useful agricultural information is constantly generated and is available in agricultural research institutions, public, research and university libraries, and non-governmental organizations, urban farmers in Kampala district do not readily access these information resources. This is partly because much of this information is packaged in elitist formats that urban farmers cannot use. This paper examines information seeking and use practices among urban farmers in Kampala district.

It hypothesizes that if urban farmers in Kampala district were accessing, using and sharing agricultural information effectively, they would make the best use of the resources at their disposal and improve food production, while reducing food and nutrition insecurity as well as urban poverty. The preliminary findings indicate that 70% of the urban farmers are women.

In addition, the farmers use different strategies when seeking information. They mainly rely on informal sources, with a preference for oral channels. Nevertheless, urban farmers face various impediments when seeking and utilizing agricultural information.

¹ PO Box 37802, Kampala, Uganda; or PO Box 204, Lira, Uganda.

INTRODUCTION

Statement of the Problem

Information is regarded as a new factor in agricultural production, playing as critical a role as the traditional factors of production such as land, labour and capital (Mchombu, 2003). However, lack of access to adequate information on innovative agricultural technologies and inputs by urban farmers has led to continued low agricultural production and food insecurity in Kampala city in Uganda (Semwanga, 2005). Urban farmers in Kampala cannot use the available information resources for better agricultural production, because most of it is packaged in elitist formats that they cannot readily use.

Literature Review

Recent surveys suggest that the locus of poverty is shifting to urban areas, making food and malnutrition insecurity urban problems (Drescher, 2008). As food insecurity and unemployment become increasingly familiar characteristics of urban populations of the world's cities, urban agriculture (production of food and non-food products through cultivation of plants, tree crops, aquaculture, and animal husbandry within urban areas) is being revitalized (UNDP, 1996). Globally, about 200 million urban dwellers are now urban farmers, providing food and income to about 700 million people (UNDP, 1996).

In Kampala, although urban agriculture has been practised since the 1890s, it only became legal in 2006 (KCC, 2007). Many of the residents practise agricultural activities ranging from horticultural crops (fruits, vegetables, flowers); to root tubers (cassava, yams, sweet potatoes), legumes and cereals; livestock farming (cattle, poultry, pigs, goats); and some paddy rice fields in the swampy areas (Semwanga, 2000). Studies have shown that urban agriculture improves local food supplies, puts marginal land to good use and enables urban farmers to enjoy the benefits of better diets and higher incomes (Flynn, 1999). Urban agriculture contributes to the farmers' well-being in several ways, including food security, nutrition, health, income generation and, more especially, provides employment for women (Kaweesa, 2000; Mireri et al., 2006). Although gender analysis is not the main focus of this paper, previous studies have shown that a customary gender division of labour is common in that women dominate urban farming because traditionally they are responsible for food in the household (Musiimenta, 1997); women especially cherish cultivation of food crops in towns because the practice supplements food reserves in the homes and provides the option of not buying vegetables valuable as vitamin source (Musiimenta, 1997). Increasingly, urban agriculture is now seen as an important component of urban development and urban environmental management in Kampala City (Sawio, 1994; Armar-Klimesu, 2000), with the potential of being an important strategy for addressing the Millennium Development Goals (MDGs) that include eradicating extreme poverty and hunger by the year 2015 (KCC, 2007). However, urban agriculture has emerged as an unplanned activity in most cities in developing countries (Kaneez, 1998). Furthermore, the socio-cultural biases against urban agriculture are strong and arise from the outdated, European 'city beautiful' views about aesthetics, efficiency, hygiene and modernity in general (IDRC, 1994). In addition, urban farming is one of the most misconstrued urban activities, often regarded as a basis of life for the poor, either as a 'hangover' of rural habits, a marginal activity of little economic importance, or as a health risk and a source of pollution that has to be curtailed—the result is insufficient official support, private financing, policies and legislation, including those related to access to and use of agricultural information (IDRC, 1994).

Aim

This paper is about accessing, using and sharing agricultural information. Access to information is expected to enable farmers to innovate and make the best use of resources at their disposal, thereby improving the quality and quantity of their agricultural production. Increased agricultural production would lead to reduced prices of food, as many urban dwellers would get access to food that is not only affordable, but also fresh and nutritious. The paper provides some insights on how innovative information-access strategies can address information needs of urban farmers in Kampala district. As a starting point, I examine how the farmers access and use agricultural information; the sources that they use to access agricultural information; and the constraints or barriers that they encounter when accessing and utilizing the information obtained.

MATERIALS AND METHODS

A study was conducted in Kawempe II parish, which was randomly selected from 22 parishes of Kawempe Division in Kampala district, between August 2007 and March 2008. Respondents comprised 30 randomly selected urban farmers, 12 focus-group respondents and 13 purposefully selected key informants (including agricultural extension staff, extension-link farmers, technocrats, local council officials and politicians that deal with urban farming-related issues). In-depth household interviews, focus-group discussions and key-informant interviews were used to collect both qualitative and quantitative data. Quantitative data analysis was done using the Statistical Package for the Social Sciences (SPSS) software, while the qualitative data were analysed on the basis of the themes/objectives of the study, namely, information needs, information access and use, sources of information, and barriers to seeking and using information by urban farmers in Kampala district.

RESULTS

Profile of Respondents: Sex, Age Group, Marital Status and Educational Level The study showed that both men and women were engaged in urban farming, although the demographic data showed that a higher proportion (70%) of the respondents were women. All of the respondents were adults (over 18 years old), indicating that urban children attend school rather than working the land, and a majority of the respondents were married (63.3%). Over 93% of the urban farmers had some degree of formal educational, while only 6.7% of the group had no formal education. Sixty-three per cent of the respondents had lived in Kawempe II for over 10 years.

Type(s) of Farming Practised

Urban farmers in Kawempe II are a heterogeneous group. Almost half (47%) of the farmers practised both crop and livestock farming, while 30% practised livestock farming only and 23.3% practised crop farming only. Crops grown included bananas, cassava, sweet potatoes, beans, vegetables, maize and vanilla, while livestock included zero-grazing cattle, poultry (both exotic and local breeds), pigs, goats, sheep, turkeys and ducks. Sixty per cent of the respondents carried out their farming activities around their house or compound. Urban farming is largely practised to provide food for families (43.3%), while over a quarter (26.7%) use it as a source of income.

Information

The information needs of urban farmers seem to vary, ranging from improving soil for improved production to how to treat and look after animals. The pilot study revealed that different strategies and sources were used by farmers when seeking for information. Attending seminars organized by extension staff (36.7%), talking to friends, neighbours, relatives or opinion leaders (20%) and listening to radio (16.7%) seemed to be the most prominent information-seeking strategies. Information Use among Urban Farmers Information use was as varied as the farmers' information needs, and ranged from learning how to manage a farm effectively to starting a poultry project. Benefits that accrued from using information included improved food production, improved quality of output, and improved health of animals. Some of the respondents indicated either expanded business or employment-creation, while others indicated either increased income or improved dietary consumption.

Problems Faced in Seeking For and Using Agricultural Information

In the household survey, the problems encountered when seeking for information were related to the lack of co-operation from fellow farmers (10%), high transport costs, and lack of understanding of the language in which information was disseminated (10%). Other problems included high cost of animal (veterinary) drugs, concealing of information by some veterinary staff, and lack of knowledge about existing information. The farmers also reported problems encountered when using information, including dubious 'veterinary doctors' (10%) who provided inaccurate information, inadequate human resources to offer information (10%), inadequate facilities in applying information obtained (6.7%), and insufficient information (6.7%).

Focus-group discussions raised problems related to lack of information on access to credit and loans, as well as lack of information on urban agricultural ordinances. Most farmers had not been sensitized about urban farming and were therefore unable to access agricultural information because of inadequate human, financial and other resources. Lack of materials, including urban agricultural ordinances printed in local languages, hampered information use by many farmers. Extension staff and other technocrats' views concurred that there was a lack of adequate funding in Kawempe division to facilitate various personnel reaching the urban farming communities, to supervise and monitor urban farming activities, and to conduct seminars and workshops to sensitize the farmers. To overcome problems related to accessing and using of agricultural information, some of the farmers used indigenous farming practices, such as using cow urine and soap to kill pests, or used past experience that had yielded good results despite the fact that these are not approved farming practices.

Strategies to Improve Access to and Use of Agricultural Information

Suggestions made by household-survey respondents to improve access to and use of agricultural information included sensitization on better agricultural practices by extension workers, and the knowledge of where to buy animal drugs and inputs. Forming farmers' groups, and monitoring and evaluation of farmers' agricultural activities by extension staff seemed to be the most frequently voiced suggestions. The focus-group discussion respondents overwhelmingly suggested that if the farmers formed groups and elected a representative, it would improve their access to agricultural information. Most technocrats and extension staff emphasized the need for financial facilitation and for farmers to form special-interest farmers' groups and to join functional literacy classes. Sensitizing farmers through media like the radio, television and printed documents written in local languages were also suggested by the key informants. The government, through the Ministry of Agriculture, Animal Industry and Fisheries, National Agricultural

■ **Information Seeking and Use among Urban Farmers in Kampala District, Uganda**
Helen M. Byamugisha

Advisory Services (NAADS) and NGOs dominated as organizations suggested to introduce urban-agriculture information services. Agricultural demonstrations, regular seminars, workshops and written materials in that order were the services preferred.

DISCUSSION

The findings revealed that both men and women were engaged in urban farming, although the demographic data showed that a higher proportion (70%) of the respondents in the pilot study were women. This appeared to support the views of Atukunda et al. (2003) that most women, especially of the low- and middle-income classes, remain at home and engage in urban farming to ensure availability of food in the household and to supplement household income while their husbands go to the city to work in formal or informal jobs. Over 93% of the urban farmers had some degree of formal educational, an indication of the respondents' potential for seeking and utilizing information to improve agricultural production as well as food and nutrition security.

The findings revealed that different strategies and sources were used by farmers when seeking for agricultural information. Seminars, field demonstrations, and oral messages were the most preferred forms in which farmers obtained information, because they regarded these as the simplest and credible forms of communication. Oral methods (field demonstrations and radio messages) seemed to be the most pronounced channels through which the farmers received information. This was in line with what Aguolu (1997) observed, i.e. that the majority of the people (including farmers) who live in developing countries cannot exploit information stored in print and other media, because they are unaware of the need for information and live their lives routinely using whatever information they may stumble on, or is passed to them orally by relatives, friends, colleagues, community and religious workers. Information use was as varied as the farmers' information needs, ranging from learning how to manage a farm effectively to starting a poultry project. Moore (2002) found that availability of information is not a guarantee that it will be used. Data from the pilot study indicates that 53.4% of the respondents encountered problems when searching for agricultural information. The responses tally with Blake (1983), who identified some of the factors that prevent farmers from accessing and using information to be lack of information, lack of knowledge, physical isolation, information overload, inadequate information systems, cultural differences or stereotypes, lack of information skills, work pressures, cultural environment, and professional roles.

CONCLUSION

Recent surveys suggest that the locus of poverty is shifting to urban areas, bringing food and nutrition insecurity as urban problems (Drescher, 2008). In Kampala city in Uganda, urban agriculture was previously outlawed and ignored on the basis of the claim that urban farms are not only unsightly, but also promote pollution and illness (Maxwell, 1995; Kiguli et al., 2003). However, the practice is now increasingly seen as an important component of urban development and urban environmental management (Sawio, 1994; Armar-Klemesu, 2000).

The findings indicated that women appear to dominate urban farming in Kampala district. Urban farming activities are heterogeneous in nature and information needs vary according to farming activities. Farmers

use different strategies for seeking information. Oral information sources, such as extension workers and fellow farmers, were the preferred methods for accessing information as they were regarded as the most reliable forms for the farmers. However, information seeking and use are fraught with various problems, including inadequate human resources to offer the information, inaccurate information, inadequate facilities to apply information obtained, as well as insufficient information. Urban farmers therefore face various impediments in their information seeking and use practices. In some cases, urban farmers are even considered to be worse off in comparison to their rural counterparts, as the latter have access to National Agricultural Advisory Services and field extension officers; NGOs also tend to favour the rural setting, because of an earlier belief that poverty is confined to rural areas. Therefore, this paper advocates for the recognition of urban farming beyond policy, to service delivery (including agricultural information services) to the sector, particularly if food and nutrition security and the MDGs, especially eradicating extreme poverty and hunger, are to be achieved by the year 2015.

Acknowledgements

The author acknowledges the Government of Sweden, which provided financial support for this research through the Swedish International Development Agency (Sida). I also wish to thank the study respondents and local leaders in the study area for their cooperation. Logistical support by Makerere University, particularly the Gender Mainstreaming Division, is acknowledged. CTA, ATPS, FARA, NEPAD and RUFORUM are also acknowledged for organizing the Women and Young Professionals in Science Competitions and conference.

This paper was originally published in *Agricultural Information Worldwide* 1(3): 94–101 (2008), and is reproduced here (in edited form) with permission from IAALD.

Literature Cited

- Aguolu, E.* 1997. Accessibility of information: A myth for developing countries. *New Library World* 98(1): 25–29.
- Armar-Klemesu, M.* 2000. Urban agriculture and food security, nutrition and health. In: *Growing Cities, Growing Food: Urban agriculture on the policy agenda*. Deutsche Stiftung für Internationale Entwicklung, Zentralstelle für Ernährung und Landwirtschaft, Feldafing, Germany.
- Atukunda, G., Baseke, F., David, S., Jagwe, J., Kalyebara, M., Kaweesa, M., Miiro, R., Musoke, P., Nabulo, G., Namagembe, A., Niringiye, C., Nyapendi, R., Odongo, B., Owor, C., Azuba-Ssemwanga, M. and Tumwegamire, S.* 2003. *Farming in the City: Participatory Appraisal of Urban and Peri-urban Agriculture in Kampala, Uganda*. CIAT Africa Occasional Publication Series No. 42. CIAT, Kampala, Uganda.
- Blake, B. 1983. Information services models: Some options, some choices. *ASLIB Proceedings* 35(3): 138–151
- Drescher, A. W.* 2008. Food for the cities: Urban agriculture in developing countries. *ISHS Acta Horticulturae* 643: International Conference on Urban Horticulture. International Society for Horticultural Science. http://www.actahort.org/members/showpdf?booknr=643_29.
- Flynn, K.* 1999. *Urban Agriculture and Public Health: Risk Assessment and Prevention for Contamination and Zoonoses* (draft). Cities Feeding People Program Initiative. International Development Research Centre, Ottawa, Canada.

■ **Information Seeking and Use among Urban Farmers in Kampala District, Uganda**
Helen M. Byamugisha

IDRC 1994. Cities Feeding People: An Examination of Urban Agriculture in East Africa. International Development Research Centre, Ottawa.

Kaneez, H.M. 1998. Gender Capacity in Urban Agriculture: Case studies from Harare (Zimbabwe), Kampala (Uganda) and Accra (Ghana). Gender and Sustainable Development Unit, International Development Research Centre, Ottawa, Canada.

Kaweesa, M. 2000. Responses to urban food insecurity: Kampala City's case, Uganda. Paper presented at a regional workshop on food security and nutrition in urban areas, 4–16 December 2000, University of Zimbabwe, Harare.

KCC 2007. Is Urban Agriculture Significant in Kampala? Unpublished report, Department of Production and Marketing, Urban Agriculture Section, Kampala City Council.

Maxwell, G.D. 1995. Alternative food security strategy: A household analysis of urban agriculture in Kampala. *World Development* 23(10): 1669–1681.

Mchombu, K. 2003. Information dissemination for development: An impact study. *Information Development* 19(2): 111–125.

Mireri, C., Kyessi, A., Mushi, N. and Atekyereza, P. 2006. Urban agriculture in East Africa: Practice, challenges and opportunities. *Urban Agriculture Notes*. City Farmer, Vancouver. <http://www.cityfarmer.org/EastAfrica.html#east> (accessed 12 November 2006).

Moore, N. 2002. A model of social information need. *Journal of Information Science* 28(4): 297–303.

Musiimenta, P. 1997. Urban agriculture and women's socio-economic empowerment: A case study of Kiswa and Luwafu areas in Kampala City. MA Thesis, Makerere BUiversity.

Kiguli, L.N., Nuwagaba, A., Mwesigwa, D. and Kiguli, J. 2003. Access to land for urban agriculture in Kampala. *UA Magazine* (December): 11–12. <http://www.ruaf.org/node/350>.

Sawio, C.J. 1994. Who are the farmers of Dar es Salaam? In: A.G. Egziabher, D. Lee-Smith, D.G. Maxwell, P.A. Memon, L.J.A. Mougeit and C.J. Sawio (eds.), *Cities Feeding People: An Examination of Urban Agriculture in East Africa*. International Development Research Centre, Ottawa. <http://www.idrc.ca/openebooks/706-x/> (accessed 12 December 2006).

Semwanga, A.M. 2000. Challenges, constraints and local solutions to urban food security: A situation analysis of Kampala – Uganda. Paper presented at the Regional Workshop on Food Security and Nutrition in Urban Areas, 4–16 December, University of Zimbabwe, Harare.

Semwanga, A.M. 2005. Urban agriculture in Uganda: A rapid appraisal of the characterization, opportunities and challenges that would influence policy formulation. Unpublished report, Kampala, Uganda. UNDP 1996. *Urban Agriculture: Food, Jobs and Sustainable Cities*. United Nations Development Programme, New York.

Participatory Development Communication as a Tool in Agricultural

Technology Transfer: The Experience of Apac District Pigeon Pea Farmers' Groups

Harriet Muyinza¹ and Ambrose Agona²

Key words: value addition, dhal, market access, subsistence farmers

Abstract

Pigeon pea (*Cajanus cajan* (L.) Millsp.) is an important food crop in the semi-arid parts of northern Uganda in East Africa. The crop is largely cultivated at subsistence level, although efforts to boost production have been increased in recent years. However, due to the prevalence of poor and inefficient traditional methods of value addition, farmers sold their produce as grain in small volumes at local markets, which led to poor incomes. Moreover, traditionally processed pigeon pea is of poor quality, which leads to lack of market access. A project aimed at the promotion and improved handling, processing, utilization and marketing of pigeon pea to enhance farmers' incomes in Apac district, was thus implemented in the subcounties of Aduku, Akalo and Nambieso. Three farmers' groups—Imaki Ocun Kwan farmer group in Nambieso, Aduku Agro-forestry farmer group, and Akalo United farmer group—were selected. With these groups of farmers, technologies from the shelves of the national post-harvest programme in Uganda were subjected to participatory selection, demonstration and transfer to enhance farmers' processing skills and knowledge in developing better pigeon pea products with better market access. A 10-step participatory development method ensured maximum participation of the farmers in the identification of intervention areas right up to the dissemination of project outputs. Lessons learnt during the project implementation were documented. Participatory development communication approach enhanced farmers' participation and ownership of project outputs, and ensured sustainable uptake of the transferred technologies in the target areas. Highlights and lessons learnt during this project are presented and recommendations given.

INTRODUCTION

Pigeon pea (*Cajanus cajan* (L.) Millsp.) is the seventh most important legume in the world (Salunkhe et al., 1986). In East Africa, the crop is an important staple in the drier areas, especially in the semi-arid areas of

1 National Post-Harvest Programme, National Research Laboratories Research Institute, PO Box 7065, Kampala, Uganda.

2 National Research Laboratories Research Institute, PO Box 7065, Kampala, Uganda.

■ **Participatory Development Communication as a Tool in Agricultural**
Harriet Muyinza and Ambrose Agona

north and north-eastern Uganda. It is rich in proteins and micronutrients, including B vitamins (including folic acid) and iron. It is usually used as green pods, dehulled split grain known as 'dhal', and as dry grain. The crop is usually grown and processed by women and is characterized by poor quality as a result of lack of pest management techniques during the pre- and post-harvest stages, use of poor and laborious traditional methods of processing, limited use (beyond grain) and low product output. As a result of these constraints, farmers were receiving very low returns from pigeon pea. This was particularly due to selling of grain on the local markets at prices that ranged between 800 and 1200 Ugandan Shillings (less than US \$1), while good-quality split grains (dhal) fetched as much as 2000 shillings (about \$1.20) (Agona and Muyinza, 2005). However, in spite of this, dhal processing technologies were not accessible to farmers and thus pigeon pea was still sold in small quantities on local markets. Although the farmers had received high-yielding improved seed, they had been reluctant to produce large quantities of the crop, due to the drudgery during processing and low prices offered for the grain. In spite of these constraints, farmers were interested in increased pigeon pea production if better processing technologies were available, and if they could market the produce. Improved seed was available from the National Agricultural Research Organisation (NARO). In addition, technologies for the improved handling, processing and utilization of pigeon pea existed within the Post-Harvest Research Programme under NARO. There was thus a need to transfer these technologies to end-users, and this called for the development of a participatory communication strategy to address the constraints.

A project entitled 'Promotion of improved handling, processing, utilisation and marketing of pigeon pea in Apac district' was a farmers' group-oriented project funded by the UK Department for International Development (DFID) Client-Oriented Research Project. The project aimed at transferring agricultural technologies that improved the quality of pigeon pea through better handling and utilization of the crop, thus raising farmers' incomes by improving the market access of the crop. Apac district is one of the main production areas in Uganda. The project sites were three sub-counties in Apac district: Nambieso sub-county, where we worked with Imaki Ocun Kwan farmers' group; Aduku sub-county, with Aduku Agro-forestry farmers' group; and Akalo sub-county, with Akalo United farmers' group. The selected farmer groups were involved in pigeon pea farming and had a minimum membership of 20, at least half of whom were female. The overall goal of the project at each site was to improve the livelihoods of rural resource-poor farmers, specifically to improve the nutrition and incomes of the farming families involved with pigeon pea. In doing this, the need for participatory communication was taken to be crucial from the very beginning of the project. Participatory development communication (PDC) is a method of reaching local communities for developmental purposes, through a series of communication stages aimed at an active participation of the community from the stage of diagnosing a natural resource and development problem, through planning, intervention or experimentation, to the final assessment of the project activities (Kamlongera, 2005). It is aimed at reaching a consensus among the communities and all stakeholders, on a development problem aimed at poverty reduction within the target areas of the projects' implementation.

As suggested by Bessette (2003), PDC involves a strategy of operation in a given project in which the communication process is undertaken in 10 key stages. The first stage involves establishing a relationship with a local community and understanding their setting. This is followed by involving the community in identifying the problem and potential solutions, and a decision to carry out a concrete initiative. Then, the different community groups and other stakeholders concerned with the problem are identified. The

■ **Participatory Development Communication as a Tool in Agricultural**
Harriet Muyinza and Ambrose Agona

communication needs, objectives and activities are identified by the group and the appropriate communication tools are then selected. Information materials are prepared and pre-tested, partnerships in the community are facilitated and an implementation plan made for the project activities. Monitoring and evaluation of the communication process, documenting the research process and finally, planning, sharing and utilization of the results is done. All these stages are undertaken by arriving at a consensus among the participating community following discussions at each stage of the project, thus reinforcing the potential of the project in helping the community to overcome poverty. The process aims at ensuring active participation of the community at all stages of the project.

Thus, the aim of this project was to transfer appropriate post-harvest technologies, including dryers, dehullers, pest-management packages, and recipes, to produce pigeon pea products for increased market access. It also aimed at improving food and nutrition security, and incomes at household and national levels, and building farmers' groups' capacities in entrepreneurship, group dynamics and leadership. PDC approach was to be used in the implementation process. This paper presents the activities and lessons learnt during the implementation of this project using PDC.

MATERIALS AND METHODS

In the first stage of the implementation process, we conducted a background study of the farmers' way of life and the way their social structure operated, in order to gain a means of establishing a relationship with the communities. This was done by gathering information from the reports of other projects that had previously operated in the target areas. The information collected was used in planning project activities. Additionally, the farmers' group leaders and sub-county offices were contacted for additional information on the farmers' groups, including group profiles, and how activities were carried out in each of the groups.

The community was involved in identifying the post-harvest constraints of pigeon pea. This was done with all the farmers' groups using focus-group discussions (FGDs). The FGDs were held with at least 20 group members and at least two observers captured the reactions of the farmers. The FGDs also prioritized the key issues to be addressed by the project to increase pigeon pea market access. A matrix rank method was used to prioritize the constraints in pigeon pea production at the start of the project for all the project sites. Results of this process revealed that poor and inadequate processing technologies, lack of markets and poor drying facilities were the most important constraints in all three farmers' groups. This information then enabled the researchers to identify the technologies to transfer in these areas. Thus, a training workshop was organized in which the farmers were exposed to the available technologies and they prioritized the most relevant ones they were to adopt for enhanced value-addition and utilization of pigeon pea. The technologies demonstrated included the dhal machine, pestmanagement technologies, recipes for pigeon pea value addition, and improved drying and sorting methods for good-quality grain.

The next stage involved identification of the groups and organizations involved in utilization and marketing of pigeon pea in the communities. These included Appropriate Sustainable Development Initiative (ASDI), a non-governmental organization working among farmers' groups on the marketing of agricultural produce, and the Northern Uganda Private Sector Development programme, which deals with obtaining market information for farmers and carrying out farmers' group training in management and providing farmers with

■ **Participatory Development Communication as a Tool in Agricultural**
Harriet Muyinza and Ambrose Agona

micro-finance services. These partners were linked to the farmers' groups; and the core implementation team³ facilitated their activities, especially as far as promotion of use and marketing of pigeon pea technologies in the communities was concerned

The research team, farmers' groups and the new partners then selected the technologies for farmer uptake, using information from the FGDs on the most important constraints. Among the technologies selected were those for improved drying, threshing and pest management of pigeon pea grain for better grain quality, and recipes for pigeon pea products like bagia (a snack food) and agira (a pigeon pea sauce). Among the main value-addition products, dhal (decorticated split pigeon pea grain) had the biggest potential to raise farmers' household incomes. Dhal was found on the urban markets of Uganda and was being sold at about 2000 shillings/kg (equivalent to \$1.10), while grain sold for 900 shillings/kg (about \$0.50) in the urban markets. The project thus needed to help the farmers exploit the opportunity of adding value to their grain by turning it into dhal to obtain better income from the crop. This was, however, a decision the farmers had to make in a participatory manner and they had to agree on how they were to achieve this objective

The project then offered the farmers a dhal-making machine, among other technologies. All the selected technologies were then demonstrated to the farmers with active participation of all members of the farmers' groups. Groups were also facilitated in the development of messages on the different technologies. This was a key stage in the participatory communication process. These messages were designed with farmers in the local languages (Labi-luo) and English, for dissemination among their own and other communities. Print was selected because it was the most appropriate medium for the type of information we needed to transfer and it was the cheapest for the farmers at this stage of the project. During the message development, the scientists made the first draft, pretested it with a few participating and non-participating farmers, and then messages were edited to suit their needs.

Each of the project groups then drew up an implementation plan. In doing this, the farmers' groups were facilitated in preparing participatory budgets, where they quantified and analysed resource inputs and outputs for their pigeon pea enterprise for a given season. Additionally, there was a need to cost the production process to ensure that production of pigeon pea products was profitable and would positively impact on farmers' incomes. Thus, participatory evaluation of pigeon pea production was done with the three farmers' groups using participatory budgeting (Fig. 1). Participatory budgeting is a method used to examine the profitability of the use and production of resources over time for a particular enterprise. It also aims at exploring resource implications of a change in enterprise, comparing of different enterprises and planning new ones (Dorwar et al., 2000). This process revealed that the production of pigeon pea variety SEP2 cost 165,900 shillings (\$83) per kilogram, including costs of labour and bags. The unit cost of production of 1 kg of grain was 346/= (about \$0.20) per kg for grain and 500/= (\$0.30) per kg for dhal. The yield of a typical farmer's second-season plot (2 acres/0.8 ha) would sell of 576,000/= (\$288) as undehulled grain (600 kg), yet the equivalent dhal (480 kg) would sell for 960,000/= (\$480). Participatory budgeting enabled farmers to plan for the next seasons' crop by incorporating the learnt technologies. In the process of drawing up the participatory budget, women were specifically encouraged to participate since they were to a large extent the ones playing major roles during field production activities and could give the best estimates of the cost of production.

■ **Participatory Development Communication as a Tool in Agricultural**
Harriet Muyinza and Ambrose Agona

PDC skills were also used for dissemination of the project outputs to other groups and to other communities around the research sites. This was done through dissemination workshops, where farmers invited other non-participating community members and demonstrated the learnt technologies. Monitoring and evaluation was done with all the farmers' groups half way through and at the end of the project, and included an evaluation of the quality of farmers' pigeon pea products. Farmers' group leaders were the key people involved in this process, in which the researchers served as moderators.

Fig. 1: Farmers in Nambieso Imak Ocun Kwan group doing participatory budgeting



RESULTS

As a result of the participatory technology transfer process, farmers adopted the improved pest-management, drying, processing and utilization technologies for pigeon pea. As a result of this, the quality of the farmers' grain improved such that damage levels in grain were less than 2%. In addition, female farmers learnt to produce snacks (including bagia) from pigeon peas and had started earning some income from selling these products in the local and regional urban markets. Furthermore, they adopted group production of dhal as a more valuable product and set in place a system for collective marketing of pigeon pea to obtain the volumes needed for large-scale markets. The project team also linked the groups to urban dhal buyers and obtained an order to supply up to 2 tonnes of dhal in the following season.

During this project, PDC enabled the participating farmers to feel that they owned the project from the very start. Through the numerous communication activities, they gained the confidence to train other farmers in the acquired skills and knowledge. We further learnt that integration of PDC in the project enabled women farmers to obtain more opportunities to contribute in the project activities due to the extensive time given to

■ **Participatory Development Communication as a Tool in Agricultural**
Harriet Muyinza and Ambrose Agona

the hands-on experience and demonstrations. This enhanced project ownership and increased technology uptake and consumption of pigeon pea in the community. The production of dhal and other products opened a window for farmers to obtain more income from the crop, and adoption of the utilization techniques increased the farmers' nutrition status. Additionally, researchers obtained a lot of insight into the way the uptake of the technologies was affected by the social structure and attitudes of the farmers in the target communities.

Acknowledgements

Financial support from the DFID/NARO Client Oriented Research Project is acknowledged.

Literature Cited

Agona, A. and Muyinza, H. 2005. Promotion of improved handling, processing, utilisation and marketing of pigeonpea in Apac district. DFID-NARO 3006 Final project report.

Bassette, G. 2003. Isang Bagsak: A capacity building and networking programme in participatory development communication. IIDRC CRDI Canada.

Dower, P., Galpin, M. and Sheperd, D. 2000. Participatory Farm Management (PFM) Methods: A Field Manual. <http://www.livelihood.org/info/tools/ppyfarm.html> (19 Nov. 2008).

Kamlongera, C. 2005. Communication for development. Isang Bagsak Newsletter 1 (1): 3–5.

Salunkhe, D.K., Chavan, J.K and Kadam, S.S. 1986. Pigeonpea as an important food source. CRC Critical Reviews in Food Science and Nutrition 23 (2): 103–145.

A Regional Network of Dialogue and Exchange Platforms to Improve the Identification of Farmers' Needs and the Dissemination of New Varieties of Banana and Plantain: The Case of Cameroon

D.I. Nkapnang¹, K. Tomekpe², B. Demba³, A. Bikoï⁴ and J. Okollé⁵

Keywords: evaluation, participative, platforms, banana, plantain, varieties

Abstract

In Western and Central Africa, banana and plantain farmers need improved varieties (resistant to disease and productive) to increase their production. However, it is difficult for researchers to know if these varieties are appropriate, as farmers' needs are very diverse. Therefore, the African Research Center on Banana and Plantain (CARBAP) and its partners used participatory varietal evaluation through platforms for dialogue and exchange between all the stakeholders of the value chain to identify their needs and disseminate varieties. The experimental design was made of two platforms established in Cameroon. Each platform includes (i) a common reference plot with 10 varieties; (ii) a network of 20 farmers, each testing three varieties, chosen among the previous 10 varieties, on his or her individual plot; (iii) a steering committee to manage the platform; and (iv) local users and experts club. Plantain cultivars and hybrids, cooking and desert banana were chosen according to the production constraints and consumer's demand. At key steps during the cycle and at harvest (vegetative growth, flowering to harvest and postharvest stages), stakeholders were brought together by the steering committee for joint evaluation. Selection criteria varied according to platform, gender and the stage of evaluation. Among the evaluated varieties, five and four varieties were chosen for dissemination at Ambam and Kombé, respectively. Therefore, there is need to scale up the INNOBAP project for more impact.

¹⁻⁵ Centre Africain de Recherche sur Bananiers et Plantains (CARBAP) – Njombé, Cameroon, PO Box 832, Douala, Cameroon.

INTRODUCTION

Banana and plantain are two major food crops in Central and West Africa. Whether they are intended for subsistence, local, national, regional and urban markets, or even for export, there are high economic and social stakes related to their improvement. Indeed, their consumption makes it possible to limit the imports of substitute products such as rice cracks and wheat flour of low quality, while generating rural employment related to production, processing and marketing. They therefore contribute to food security of the concerned countries.

Since the mid-1980s, the African Research Centre on Bananas and Plantains (CARBAP) has been carrying out research which has yielded many options for application by stakeholders of the banana and plantain value chain. Among these is a reference collection of cooking varieties (about 300) that it wanted to propose to farmers. However, it was difficult to know if these varieties were appropriate to users, because their needs were diverse. Therefore, the CARBAP was interested in organizing a full-fledged participatory testing programme through a project called INNOBAP (Varietal Innovation on Banana and Plantain). It developed a system that combined the perceptions and preferences of end-users with a scientific approach. The project set up eight such systems in the four participant countries (Benin, Cameroon, Gabon and Guinea) with a comparable methodology.

Objective

The objective of INNOBAP was to increase the access of Central and West African stakeholders of the value chain to a wide range of variety of bananas and plantains, by improving the identification of their needs and the dissemination of new varieties using a network of platforms of exchange and discussion. From March 2007 to June 2008, I served both as national co-ordinator for Cameroon and as co-ordinator of the Kombé platform; sometimes representing the regional co-ordinator in meetings and workshops. The objectives of this paper are:

- to describe the Local Users Experts Association's (LUEA) varieties characteristics';
- to rank the disseminated varieties based on their agronomic and culinary characteristics.

EXPERIMENTAL DESIGN

Platforms (the basic system) were designed and managed in a spirit of partnership using a decentralized and participatory selection process. Two platforms were established in Cameroon, at Kombé and Ambam. These served as forums for evaluating varieties chosen by researchers for their potential for local adaptation. The platform combines the use of field experiments (Common Reference Plot and Individual Evaluation Plot) to test

genetic materials and an approach based on regular discussion, exchange and joint evaluation whose aim is to formalize the partnership among all actors (INNOBAP, 2005a, b; Nkapnang et al., 2008). Each platform has four principal components (Fig. 1):

- A Steering Committee (SC) composed of representatives of the principal partners of the value chain. The SC was in charge of making strategic decisions for the platform.
- A Local Users and Experts Association (LUEA), representing the expertise of operators of the value chain—farmers, nursery gardeners, processors, conveyors, bakers or processors, traders

■ **A Regional Network of Dialogue and Exchange Platforms to Improve the Identification of Farmers' Needs and the Dissemination of New Varieties of Banana and Plantain: The Case of Cameroon, D.I. Nkapnang, K. Tomekpe, B. Demba, A. Bikoï and J. Okollé**

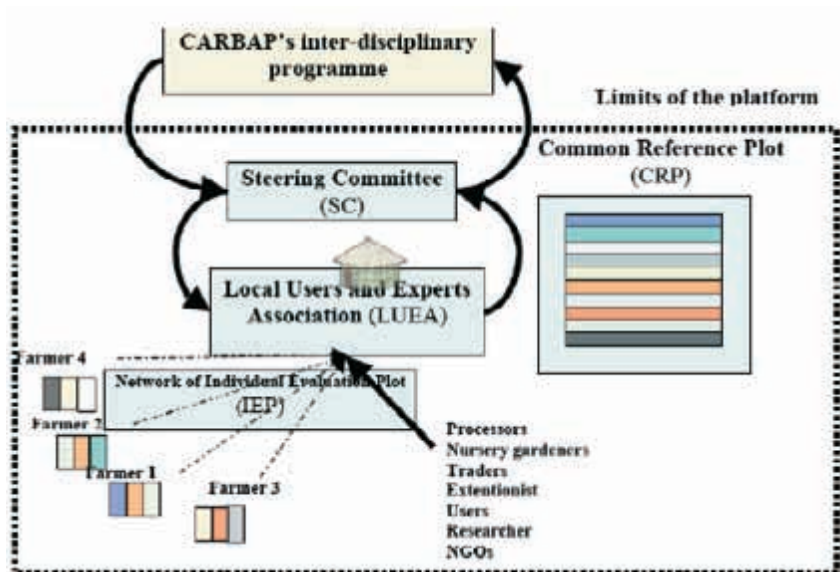
and agricultural professional organizations (researchers, extensionists, NGOs, etc.), who participate at different levels of the variety evaluation.

- Common Reference Plots (CRP)—each CRP contains 10 banana and plantain varieties planted by the LUEA and replicated 10 times.
- Individual Evaluation Plots (IEP), for individual evaluation of three varieties from the 10 planted in the CRP. The experimental research using these participatory methods (CRP and IEP) was also called the mother-and-baby plots experiment (Snapp, 1999).

Partners with different skills and outlooks were brought together in the platforms in order to achieve the objective. At key steps of the cycle and at harvest (vegetative growth, flowering, harvesting), stakeholders were brought together by the steering committee for joint evaluation (Nkapnang et al., 2008). The Cameroon platforms evaluated a total of 16 varieties:

- 8 cultivars of plantain from the Congo Basin (Corne Type, Ekona No. 1, Elat Noir, Mbouroukou No. 2, Bâtard, French Clair, Red Yade, Ekon Zok)
- 2 exotic varieties from Asia and the Pacific (Pelipita, Popoulou)
- 4 hybrids resistant to black sigatoka (FHIA 21, CRBP 832, CRBP 755, C244)
- 2 local cultivars (Douala, Big Ebanga) (to serve as control) (Tomekpe et al., 2004).

Fig. 1: INNOBAP Platform (INNOBAP, 2005a, b)



However, each platform evaluated only 10 varieties. Data collected were analysed using frequency, Preference Index and preference marks.

■ **A Regional Network of Dialogue and Exchange Platforms to Improve the Identification of Farmers' Needs and the Dissemination of New Varieties of Banana and Plantain: The Case of Cameroon, D.I. Nkapnang, K. Tomekpe, B. Demba, A. Bikoï and J. Okollé**

Each respondent chose and ranked (weighted) his or her criteria for each variety. For example, five criteria were ranked from 1 to 5 (weighted 5–1). The Performance Index (PI) was calculated by summing the number of times a criterion was mentioned multiply by respective weights, i.e.

$$PI = \Sigma(PF \times W)$$

Where, *PF* = Preference Frequency (number of respondents who allocated the criterion weight *W*), *W* = weight. In other words, the *PI* of a criterion is the sum of the weights allocated to that criterion by the respondents. To rank the disseminated varieties on the basis of their agronomic (vegetative and flowering stage) and culinary characteristics, each respondent allocated a mark out of 10 to each variety in the platform. The preference mark was calculated from the agronomic and culinary mark, which helped to rank varieties.

RESULTS

INNOBAP Members

Sixty-five stakeholders were members of the project in Cameroon (Table 1), Of whom about three-quarters were male. During the project life cycle (2006–2008), eight categories of actors —NGOs, researchers, extension agents, farmers, traders, funding agencies, processors, transporters and producers—took part in INNOBAP. This shows the low specialization level of the banana and plantain value chain in Kombé and Ambam.

Table 1: Respondent by platforms, category and gender (Survey, 2008)

Category	Male		Female		Total (%)
	Kombé	Ambam	Kombé	Ambam	
Project participant					
Producers	16	23	3	10	52
Others ¹	5	4	3	1	13
Non-participant					
Family members	1		3	4	8
Others	3		4		7
Total (%)	25	27	13	15	80
	52 (65%)		28 (35%)		

¹ 'Others' comprise NGOs, researchers, extension agents, farmers, traders, funding agencies, processors, transporters.

Evaluation Criteria

The stakeholders' criteria are ranked in Table 2 based on Preference Index. This result is out of a survey of 52 farmers for the vegetative growth stage and 80 respondents for the flowering and harvesting stages. These latter respondents comprised 52 farmers, 8 members of their families (wives, husbands, children, brothers), 13 persons of other categories of actors and 7 participants external to the project). Only producers were involved in the first stage of evaluation; for only they received varieties for an individual evaluation and were, therefore, able to give information about the agronomic behaviour of varieties.

■ **A Regional Network of Dialogue and Exchange Platforms to Improve the Identification of Farmers' Needs and the Dissemination of New Varieties of Banana and Plantain: The Case of Cameroon, D.I. Nkpnang, K. Tomekpe, B. Demba, A. Bikoï and J. Okollé**

Twenty-one criteria were mentioned during evaluation stages: 16 at Kombé and 14 at Ambam. Women had the greatest number of criteria in both platforms. At Kombé, multiple uses of leaves (175), attractive bunch for commercialization (126), fitted for many uses (510) were the most important criteria at the three stages. At Ambam, easy to harvest (48), attractive bunch for commercialization (237) and good for ntuba2 (112) were the most relevant criteria.

The level of acceptance and the perception of criteria varied according to gender and platform. This can be explained by the production's objective or the cultural practices in the project area. At Kombé, the most important criterion was the same for men and women—fitted to many uses (230 and 280, respectively). However, at Ambam women preferred varieties that are good for ntuba (76), while men long for those that produce attractive bunches for commercialization (187).

Table 2: Stakeholders' criteria by gender and platform (Survey, 2007 - 2008)

Selection criterion	Kombé (PI)		Ambam (PI)		Comments and research views on criteria
	Male	Female	Male	Female	
1. Vegetative growth stage					
1 Attractive trunk	14	22	36	12	13 > Good shape (big and tall), not dwarf (believed transferable to human gene); colour (greenish, brown base and green)
2 Good bedding	20	48	63	6	6 > Precocity/number of suckers
3 Resistance to wind	—	24	56	4	28 > Dwarfism
4 Resistance to drought/disease	59	—	59	—	4 > Cercosporiosis/drought
5 Precocity of maturation	45	—	45	6	14 > Maturation time, minimum
6 Multiple uses of leaves	—	175	175	—	— > Attractive leaf, green, thick
7 Medicinal value	5	16	21	—	— > Use for skin/tea
8 Easy to harvest	—	5	6	—	48 > Dwarfism
2. From flowering to harvesting stage					
9 Attractive bunch for commercialization	65	176	191	187	70 > Appearance of local varieties, big bunch
10 Easy to be carried	—	—	—	—	5 > Long stalk
11 Attractive finger (big and long)	—	—	—	20	35 > 55
12 Well-filled and firm finger	85	—	85	—	— > Maturation and niche in stock
13 Fruit remained on stalk when ripe	—	—	—	—	10 > 10
3. Post-harvesting stage					
14 Finger (homogeneous, greenish, ripening yellow or orange, spotted)	—	30	39	—	12 > Protection and a careful handling of bunches
15 Easy to be piled/arranged	—	20	20	—	10 > 10
16 Fitted to many uses	280	280	510	—	9 > 9
17 Good for chips	10	4	14	—	— > Colour of pulp
18 Ripe fruit good for frying	—	—	—	20	3 > 28
19 Green fruit good for cooking	—	—	—	—	7 > 7
20 Green fruit good for cooking 'Donata style'	10	10	20	—	— > Firm, taste, colour
21 Good for ntuba	5	5	10	36	76 > 112
Total number of criteria	12	14	8	13	

PI = Preference Index

The perception of criteria by LUEA members compared to researchers shows, for example, that farmers' perception of 'vigour' includes some specific colour attributes (e.g. at the base, the trunk, bunch), which may vary with variety. While dwarf plants were popular in Kombé, they were not favoured by some respondents at Ambam due to the fear that dwarfism could be transferred to human gene. Differences among LUEA criteria in between platform and also compared to researchers' criteria were more marked with women.

Varietal Ranking

Varieties were classified based on marks given to criteria (Table 3).

Table 3: Varietals ranking at Ambam and Kombé platforms (Survey, 2008)

Variety	Vegetative growth to flowering stage		Postharvest stage		Mean		Rank ¹	
	Ambam	Kombé	Ambam	Kombé	Ambam	Kombé	Ambam	Kombé
Big Ebanga	8.1		8.35		8.2		1	
Bâtard	7.7		8.05		7.9		2	
French Claire	7.7		7.65		7.6		3	
CRBP 755	4.9	9.2	3.72	7.1	4.9	7.5	8	5
Pelipita	6.2	8.5	4.16	8.14	5.3	8.2	6	3
Popoulou	5.9	8.3	4.22	8.35	5	8.5	7	1
Ekon Zok	7.6	7.3	6.95		7.3	7.3	4	6
Red yade	6.9		5.46		6.5		5	
CRBP 832	5.7		2.4		4.8		9	
Corne Type		6.5				6.5		7
Mbouroukon N°2		7.5		8.5		8.5		2
Douala		8				8		4
FHIA 21		6.5				6.5		8
Flat Noir		6.8				6.8		7
Ekona N°1		6.3				6.3		9

¹ The varieties at Ambam and Kombé platforms were ranked using mean marks.
Key: 0–2= nil, 3–4 = medium, 5–6 = passable, 7–8 = good, 9–10 = excellent.

At Ambam, nine varieties were ranked at all stages (Table 3). For vegetative and flowering stage, Big Ebanga was first, followed by Bâtard, French Clair and Ekon Zok. At post-harvest, the same ranking was obtained. In this platform, CRBP 755 and CRBP 832 were least appreciated at both stages.

At Kombé, only four varieties were evaluated at all stages. At vegetative growth and flowering stage, CRBP 755 was best, followed by Pelipita, Popoulou and Douala. However, the postharvest ranking classified Popoulou first, followed by Mbouroukou No. 2, Pelipita and CRBP 755.

CONCLUSION AND RECOMMENDATIONS

After two production cycles, certain varieties were appreciated (5 at Ambam and 4 at Kombé) and the evaluation process (including participatory approach) adopted by partners. Sustainable actions included: the grouping of actors of the value chain, which did not exist before the project; the platforms were formally recognized and institutionalized in some countries, and some institutions and community-based organizations (CBOs) changed their objectives in order to specialize in the sector.

For the local milieu, the experience had enriched its banana diversity through the introduction of new varieties, new production know-how and the emergence of a new category of intermediaries, such as nursery gardeners. A CBO in Ambam took over co-ordination to sustain the experience as the first financial support was coming to an end. A scaling-up of varietal innovation platform is necessary for a greater impact, and hence farmers' food security and poverty alleviation. This could be possible through the setting up of a second phase of the project to ensure wide dissemination of adopted varieties. This could involve activities such as dissemination of adopted varieties by extension agencies and NGOs. Women should receive due attention, because of their importance in banana and plantain value chain.

Acknowledgements

The authors would like to acknowledge DURAS coordinating body, the French Ministry of Foreign Affairs, GFAR (Global Forum on Agriculture and Research), and other institutions that participated in this experience.

Literature Cited

INNOBAP, 2005a. Un réseau regional de plateformes d'échanges pour améliorer l'identification des besoins des agriculteurs et la diffusion de nouvelles variétés de bananier et plantain.

<http://documentation.leisa.info/DURAS/benin/innobap/introduction.htm>.

INNOBAP, 2005b. Proposition complete de projet DURAS. <http://selectionparticipative.cirad.fr/content/download/691/3455/file/INNOBAP.pdf>.

Nkapnang, D.I., Tomekpe, K. and Van Schoubroeck, F. 2008. A regional network of dialogue and exchange platforms to improve the identification of farmer's needs and the dissemination of new varieties of banana and plantain. p. 2–7. In: *Banana and Plantain in Africa: Harnessing international partnership to increase research impact*, Mombassa, Kenya, 5–9 October 2008. Programme and Book of Abstracts. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Snapp S. 1999. Mother and baby trials: a novel trial design being tried out in Malawi. TARGET (The Newsletter of the Soil Fertility Research Network for Maize-Based Cropping Systems in Malawi and Zimbabwe) (January). CIMMYT.

Tomekpe, K., Jenny, C. and Escalant, J.V. 2004. Conventional breeding strategies for Musa improvement and their world status. p. 3 In: C. Picq and A. Vézina (eds.), *First International Congress on Musa: Harnessing research for improved livelihoods*, Penang, Malaysia, 6–9 July 2004. Abstract Guide. INIBAP, Montpellier.

Gender and Social Issues of Rice-Based Farmers in Rokupr, Kambia District, during the 2005/06 Cropping Season

Finda B. Jenkins¹

Keywords: gender roles, social issues, agriculture, rice-based farmers, food security, poverty reduction, development

Abstract

Both women and men play critical roles in agriculture throughout the world, producing, processing and providing the food we eat. Rural women in particular are responsible for half of the world's food production and produce between 60 and 80% of the food in most developing countries. Yet, despite their contribution to global food security, women farmers are frequently underestimated and overlooked in development strategies. This has led to global concern, which in turn has led to a special focus on women in developmental issues. This study was conducted in selected areas in Rokupr: Robat, Mawir, Royanka, and Magbolontor in the Kambia District, Northern Province of Sierra Leone. A simple random sampling was made from all registered rice-based farmers in gender-segregated groups and coding their names by assigning figures to them. Those selected were used as the sample. A total of 55 males and 25 females was proportionately selected. Semi-structured questionnaires, focus-group discussions and inter-personal discussions were used to investigate gender and socio-economic issues and constraints in the rice-based farming system. The response rate was 100%. Data analysis included percentages, tables and graphical presentations. Major findings included an ageing and illiterate farming population, very low use of fertilizer and farm machinery, increased use of improved rice seeds; heavy reliance on hired labour; and some form of joint decision-making processes. Some recommendations made were the provision of certain facilities like the need for agro-processing industries and storage to reduce postharvest loss, which will increase the income of farmers, thus reduce the rate of rural-urban migration, provision of micro-credit in the form of rice seeds, fertilizers, and machinery or tools which should be repaid during harvest. Also, the educational status of farmers needs to be improved. Farmers should be functionally literate to be able to analyse the costs and benefits of their farm activities and appreciate the use of improved technologies.

¹ Social Scientist/Research Officer, Rokupr Agricultural Research Center (RARC), Sierra Leone Agricultural Research Institute (SLARI), Tower Hill, Freetown, Sierra Leone..

INTRODUCTION AND BACKGROUND

Agriculture in Sierra Leone is in a transition from a predominantly subsistence shifting cultivation to a settled agriculture. The former system has been in place for centuries, and has served people well in the economic environment of the past. As the domestic economy has deteriorated, and it is apparent that the attainment of rice self-sufficiency is difficult, the emphasis has now shifted to food security and poverty reduction. (Government of Sierra Leone, 1999a) Rice is the single most important crop in terms of production, consumption and imports in Sierra Leone. Availability of rice is crucial to the well-being of Sierra Leoneans as it forms the highest volume in their diets and it is the country's most produced food crop. Low national production of this all-important staple has a negative effect on the economy of the country, as scarce foreign exchange is spent to meet the shortfall in demand. Poverty reduction and increased prosperity in Sierra Leone cannot therefore be addressed without sufficient attention being paid to improving rice productivity and production to achieve the national goal of food self-sufficiency and food security. (Government of Sierra Leone, 2005a). The current focus on women in development ties them into a nexus with poverty and the environment. Women are seen as the main victims of land degradation because of their role in food production and in meeting household requirements for fuel and water. However, such perspectives simplify the division of labour within the household and the complex and dynamic relationship that men and women have with nature (International Development Magazine, 2001).

Research conducted by the International Food Policy Research Institute (IFPRI, 2000) confirms the central role women play as producers of food, managers of natural resources, income earners and caretakers of household food and nutrition security (IFPRI, 2000). This work looked at a similar situation, to ascertain the importance of gender differences generally and especially the roles of male and female farmers within the ricebased farming system, with a view to making relevant recommendations for changes in gender and social approaches. Many men are now leaving the land, on either a long-term or seasonal basis, to find non-farm employment in cities, and their wives and children are being left behind to carry on the farm work (IFPRI, 2000).

There is a universal perception that men are the heads of household, and that women are just the helpers. The researchers interviewed 120 families in north-eastern Thailand, 189 in southern Vietnam, and 162 in the northern Philippines. The question is, if the management of rice farms is left in the hands of women, are they equipped with the proper skills, training and knowledge required to sustain rice production (IRRI, 2000). The need then arose for research to ascertain the roles of women and men farmers—after a decade of war in Sierra Leone that left many female-headed households and teenage mothers—in order to inform policy interventions on gender roles and social issues in the agricultural sector.

Agriculture has not always remained high on the agenda of international development assistance. However, there are signs that international development agencies are returning to recognize the important role played by agriculture in rural and national development efforts. In many developing countries, around one-quarter of total output comes from their agricultural sectors. The World Bank is urging rich countries to stop spending \$1 billion a day on agricultural subsidies, but rather accelerate the transfer of new technologies, and to provide more aid, particularly to Sub-Saharan Africa (Hafkin and Hambly, 2002).

■ **Gender and Social Issues of Rice-Based Farmers in Rokupr, Kambia District, during the 2005/06 Cropping Season**
Finda B. Jenkins

There are strong relationships between gender and agriculture in African, Caribbean and Pacific (ACP) nations: women are twice as likely to be involved in agriculture-related activity as men (Hafkin and Hambly, 2002). National averages of women in the agricultural labour force vary, but globally they have a principal role in agribusiness, food processing and consumer-related activity. For example, in Sub-Saharan Africa household studies have identified that 90% of women are farmers; they perform the bulk of the subsistence production (70%) and reproductive work as producers— women’s work in the field helps them feed their families, but goes beyond farming alone.

Women’s rural activities in many parts of Africa range from agricultural production and food processing to food provision, marketing and crafts. Women, however, lack influence over the agricultural research and development agenda, and seek accountability for their concerns. Debate concerning food security and poverty alleviation in many ACP nations has recently increased, as some 815 million people worldwide suffer from chronic malnutrition (Hafkin and Hambly, 2002). Whereas in the Pacific, one in six people are estimated to be malnourished, the figure is as high as one in four in Sub-Saharan Africa (Hafkin, and Hambly, 2002). Lack

of adequate nutrition saps the economic productivity of individuals and undermines the economic health of nations. It is now widely recognized that women and children’s endemic anaemia and vitamin deficiencies are indicators not only of persistent food insecurity, but also of women’s declining status, lack of education and overall rural poverty

In Sub-Saharan Africa, women have less access to education and farm inputs than men. When women obtain the same levels of education, experience and farm inputs that currently benefit the average male farmer, they will increase their yields. In Kenya, where the amount of education women receive is extremely low, a year of primary education provided to all women farmers would boost yield of males’ farms by 24% (Quisumbing, 1996).

In Burkina Faso, men and children provide more labour to field crops controlled by men than to women’s plots, while women primarily contribute the labour on plots they control. Men have greater access to non-household labour and inputs than women. Not surprising then, farm plots controlled by women have 20–40% lower yields than plots controlled by men. Total household agricultural output could increase by 10–20% if currently used inputs were reallocated from men’s to women’s plots (Alderman and Haddad, 1995). Women constitute an estimated 51.3% of the population, but their low status is deep-rooted in discrimination by traditional customs and law (Government of Sierra Leone, 2005a). Various measures have been taken to address some of the challenges facing women. The key challenges are: gender-based violence; barriers to economic empowerment; exploitation of poor, unskilled women and girls; need for sensitization and education on gender and development issues.

The Sierra Leone Government has created a separate Gender Ministry and programmes specifically focused on women, including credit initiatives in education and agriculture. The Government has also signed major international and regional human rights instruments, including ratification of the Convention on the Elimination of all forms of Discrimination Against Women (CEDAW) and its optional protocol. It is expected that more radical progress will be made to support women in Sierra Leone to enhance their effective contribution to the reduction of poverty and the attainment of critical Poverty Reduction Strategy

Paper (PRSP) objectives and Millennium Development Goals (MDGs) (Government of Sierra Leone, 2005b) For instance, in the agricultural sector, it is recognized that women do the bulk of the farm work, yet they remain marginalized with limited access to productive resources such as finance and training. In the current circumstances, significant improvement in agricultural output could be effectively realized if more emphasis was placed on endemic, women will be deprived of the opportunities in education and other socioeconomic activities necessary to achieve parity with men (Government of Sierra Leone, 1999a).

Women play a key role in food security throughout Africa, yet local customs and legal institutions often discriminate against women, denying them access to land, resources, education, healthcare and public services. Increasing the rights of women increases food productivity, but the gap between men and women still exists in many countries, particularly in Sub-Saharan Africa (Quisumbing et al., 2005). Rural women in particular are responsible for half of the world's food production and produce between 60 and 80% of the food in most developing countries (Warham, 2001). But this must be done concurrently with the men, as the social structures which promote male superiority and female subordination are created and maintained by men; therefore any meaningful and sustainable change in the socio-economic status of women must (among other issues) help change the mentality of men to see women as partners in development.

Also, in the area of land ownership, the tenure system in the provinces (where 70% of the inhabitants are engaged in agriculture) is one that does not allow individual ownership. This responsibility is in the hands of the family heads, who are predominantly men. There are very few successful woman farmers because of other socio-cultural constraints like the patterns of inheritance including wife inheritance, early marriage of young girls, women being left out of decision-making processes and participation in both local and national politics, to name but a few. It was against this backdrop that this research tried to examine gender and social issues of rice-based farmers during the 2005/06 cropping season, in Rokupr.

MATERIALS AND METHODS

The thrust of this research was to examine gender and social issues of rice-based farmers during the 2005/06 cropping season, in Rokupr, Kambia District, northern Sierra Leone. Rokupr is in Magbema chiefdom, and is 112 miles from Freetown by road, but it is also accessible by sea. Rokupr has very rich and vast agricultural land, which is made up of upland and lowland ecologies, and has been the host to the Rice Research Station.

since 1938. Major problems are related to water control, heavy weed infestation and iron toxicity caused by low pH (Fomba and Taylor, 1994). About 49% of the inhabitants of Kambia District are involved in farming. The remaining 51% are involved in petty trading, fishing, and technical repairs. In 2004, the district had a population of 276,989 (130,699 male, 146,290 female). The population of Magbema chiefdom was 32,059 males and 35,152 females, making a total of 67,211 (Government of Sierra Leone, 2004).

Research Design

A case-study design was used, which basically entailed detailed and intensive analysis of a case. In this research, the case was rice-based farmers around the Rice Research Station crop sites in Rokupr, during the 2005 cropping season. This group of farmers was studied in detail by collecting information from them

on the following: general demographic and socio-economic issues, type of agro-ecology, land acquisition, source and selection criteria of rice variety, labour utilization during cropping season, and farm management decision making.

Sampling Procedure, Frame and Size

One hundred and fifty-nine rice-based farmers (110 males and 49 females) were registered around the four crop sites of the Rice Research Station (Mawir, Robat, Royanka and Magbolontor sections) in Rokupr (the sample frame). In Robat, 54 males and 20 females; in Mawir, 10 males and 14 females; in Royanka, 22 males and 3 females; in Magbolontor, 24 males and 12 females. Fifty per cent of the registered farmers per section in sex-segregated groups was randomly selected as the sample, making a total of 55 males (27 in Robat, 5 in Mawir, 11 in Royanka and 12 in Magbolontor) and 25 females (10 in Robat, 7 in Mawir, 2 in Royanka and 6 in Magbolontor).

Data Collection

An earlier visit was made to consult with and brief traditional leaders about my research and the essence of the information needed. Their consent was given, but they requested prior notice for data collection so they could make themselves available. Ricebased farmers were then registered and the sample selected. Semi-structured questionnaires were pre-tested in some sections of Bombali Shebora chiefdom. This site was selected for pre-testing because the population is similar to that of the study area in terms of ecology and farming systems. The pre-testing helped greatly in rearranging the sequence of questions, and identification of what was missing

or not relevant. Both pre-testing and data collection proper were done with the help of data collectors (Rice Research Station Technicians) as there was a language barrier. The time allocated for each questionnaire was 3 minutes per person, but it took longer, as the farmers had to be given time to express themselves, and gradually information needed was obtained.

Information for this piece of work was collected from both primary and secondary sources. Primary data were collected from the sample of 80 farmers. Secondary information was collected from the review of relevant literature on gender and social issues in agriculture and on the study area.

Research Instrument

Semi-structure questionnaires were administered to the selected farmers and focus groups. Additional information was collected from interpersonal discussion with respondents to compare responses in the questionnaire and those from focus-group discussion.

Data Analysis

Data collected were presented using simple percentages, tabular presentations or descriptive statistics such as bar graphs and pie charts. Some grouped data were statistically analysed using the measure of central location or tendency.

RESULTS AND DISCUSSIONS

Twenty-four per cent (which is the highest) of male rice-based farmers were in age category 50–59 years

and 30% of female rice-based farmers (which is also the highest) were in age category 30–39 years (Table 1). The female rice-based farmers were generally younger than the male rice-based farmers.

Table 1: Age distribution of rice-based farmers

Age group	Male farmers (%)	Female farmers (%)
20–29	9	15
30–39	14	30
40–49	22	28
50–59	24	19
60–69	13	8
70–79	11	0
80–89	7	0

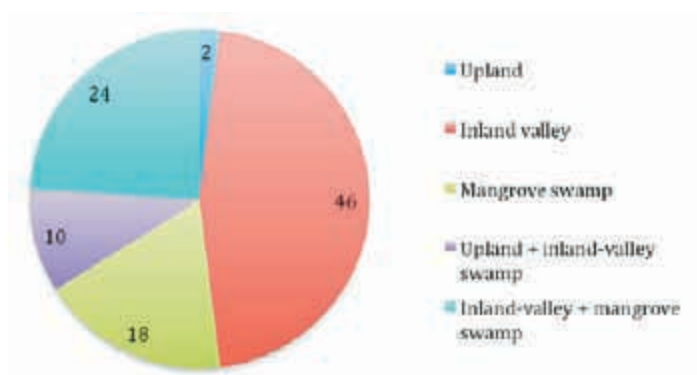
Forty-nine per cent of male and 80% of female farmers were illiterate (Table2). The illiteracy level was thus higher for the female farmers than that of the male farmers

Table 2: Gender based educational status of rice-based farmers

Educational status	Male (%)	Female (%)
None	47	80
Primary	18	4
Secondary	6	4
Tertiary	3	0
Arabic	26	12

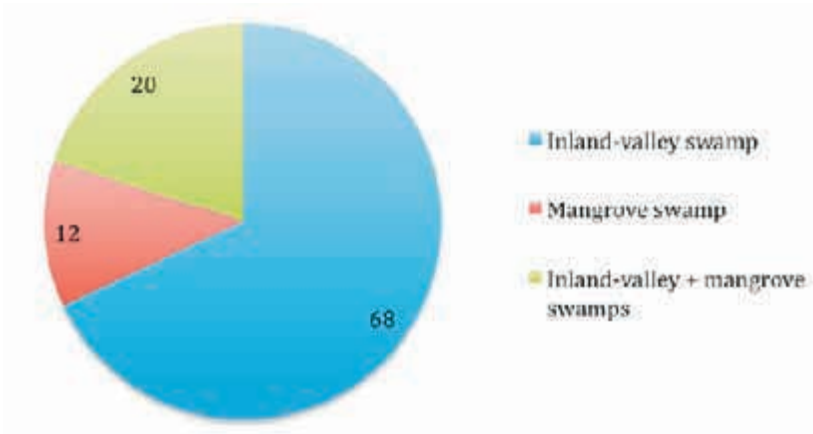
Figure 1 presents the various types of ecologies cultivated by targeted male ricebased farmers. From this figure, the most cultivated ecology was the inland-valley swamp (46%), and the least was the upland ecology (2%).

Figure 1: Type of ecology cultivated by male farmers



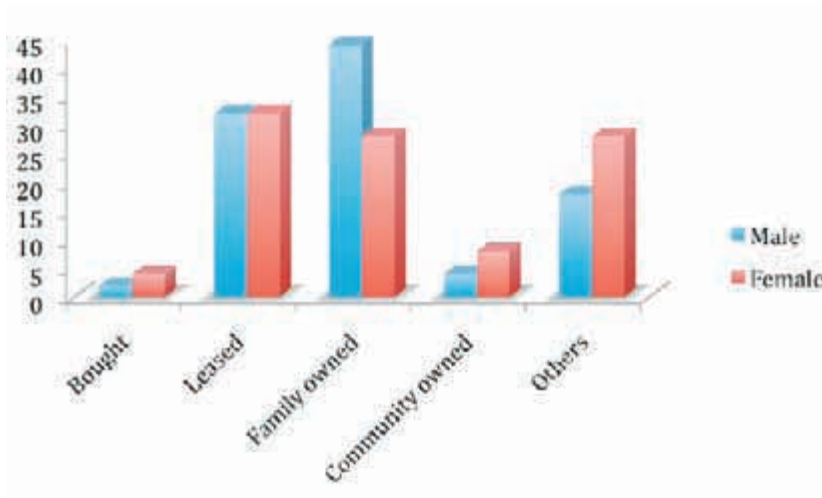
The majority of the targeted female rice-based farmers cultivated in the inlandvalley swamp (68%), with the lowest proportion cultivating solely in the mangrove swamp (12%) (Fig. 2). There was no cultivation of upland ecology. The inland valley swamp was the largest cultivated because it was less labour intensive, than the other two ecologies, it has more yields than upland and there is no pest or rodent infestation.

Fig.2: Type of ecology cultivated by female farmers



Information collected on methods of land acquisition (Fig. 3), showed that the predominant means of land acquisition by male respondents was family ownership, followed by leased and permission to farm on land. For female farmers, the predominant type of land acquisition was leased, followed by family ownership and other means (concession). Forty per cent of males and 28% of females indicated that land acquisition for farming activity was from family ownership. Twenty-eight per cent of females and 18% of males acquired land by other means. Thirty-two per cent each claimed to lease farmland.

Fig. 3: Gender-based land acquisition



Responses varied between male and female farmers in the length of years involved in farming. The male farmers had been longer in agriculture: 21% of them had been in agriculture for 21 to 25 years. Whereas, 31% of female farmers had been involved in farming for 11 to 15 years (Table 3).

Table 3: Gender-based length of years involved in farming activity

Years involved in farming activity	Male respondents (%)	Female respondents (%)
1-5	15	16
6-10	16	27
11-15	13	31
16-20	18	11
21-25	21	10
26-30	9	5
31-35	4	0
36-40	4	0

With regards to whether farming was the main economic activity, 95% of male respondents said yes. The remaining 5% said they are involved in other activities apart from farming, such as fishing, carpentry, tailoring, civil service and teaching. Of the female respondents, 92% said they are involved in farming as main economic activity and 8% that they are also involved in petty trading. It could be inferred therefore, that farming is the mainstay of the people. They only get involved in other activities to augment their income.

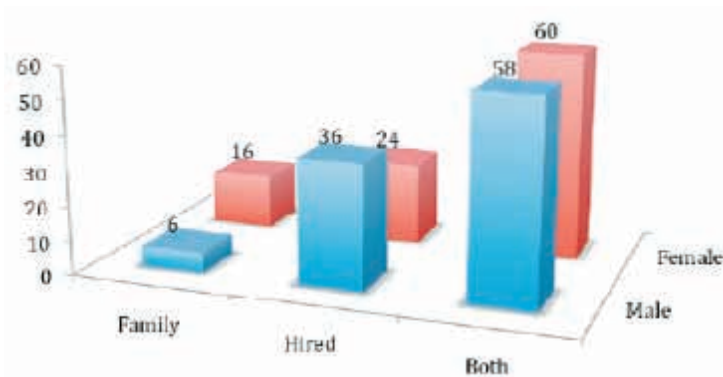
With regards principal variety cultivated, there was an increase in the use of improved rice seeds: 68% of female and 54% of male farmers used improved rice as the principal variety on their farms during the 2005 cropping season. The main source of these seeds was through 'others' (actually the contact farming system of the Rice

Research Station), followed by exchange of seeds with friends for both male and female farmers, and then by purchase from other farmers for female farmers, and loan from government for male farmers (Table 4). Investigation was also done to examine gender-based attributes used in rice seed selection. There was slight variation in the responses of the sexes. Both sexes said that for family consumption they preferred palatability, keeping quality and the tendency for it to stay longer in the stomach, but the female added another attribute of being easy to cook. For commercial purposes, they preferred grain yield; and for the hungry season, they preferred shorter duration so that they can plant more than once, during one cropping season.

Table 4: Gender-based source(s) of improved seed rice

Source of attaining improved seed rice	Female respondents (%)	Male respondents (%)
Purchase from another farmer	18	7
Purchased from local business man	3	0
Loan from NGO	2	4
Gift from NGO	0	5
Gift from relatives	0	7
Gift from Government	0	0
Loan from Government	7	10
Gift from friends	0	7
Exchange of seeds with relatives	5	7
Exchange of seeds with friends	30	23
Self stock	0	3
Others	35	27

Fig. 4: Gender-based Sources of Labour



Family and hired were the most commonly used types of labour for both sexes, accounting for 60% of female respondents and 58% of male respondents (Fig. 4). However, 86% of male farmers and 96% of female farmers used hired labour to some extent. Female farmers relied heavily on hired labour during land preparation, fencing, processing, sowing and planting. For male farmers, a larger percentage of hired labour was used in land preparation, weeding and processing (Table 5). This was because family labour was not enough as some said their farm sizes were large and that there was a problem of general labour shortage.

Table 5: Gender-based use of hired labour by farm operation(s)

Farm operation(s)	Percentage hired labour allocation	
	Male respondents	Female respondents
Land preparation	10.9	12.5
Land preparation + sowing/planting	9.1	16.8
Harvesting	9.2	4.2
Land preparation + fencing	14.5	18.5
Land preparation + harvesting	16.3	14.5
Land preparation + weeding	20.0	15.3
Land preparation + processing	20.0	18.2

Figure 5 presents the views of female farmers, with regard to decision making on certain farm activities. From the data collected, the control of sales of produce ranked highest as being the responsibility of women only. On the other hand, ecology, farm size, crop to plant, seeds to plant, when to start doing certain farm operations and who funds labour were said to be decided by men only. Whether to hire extra labour, amount and type of credit to take, and amount of farm produce to sell, consume and save were said to be joint decisions; therefore, there was some form of participatory decision-making in some farm management activities.

Fig. 5: Gender-based farm management decision making as stated by female farmers

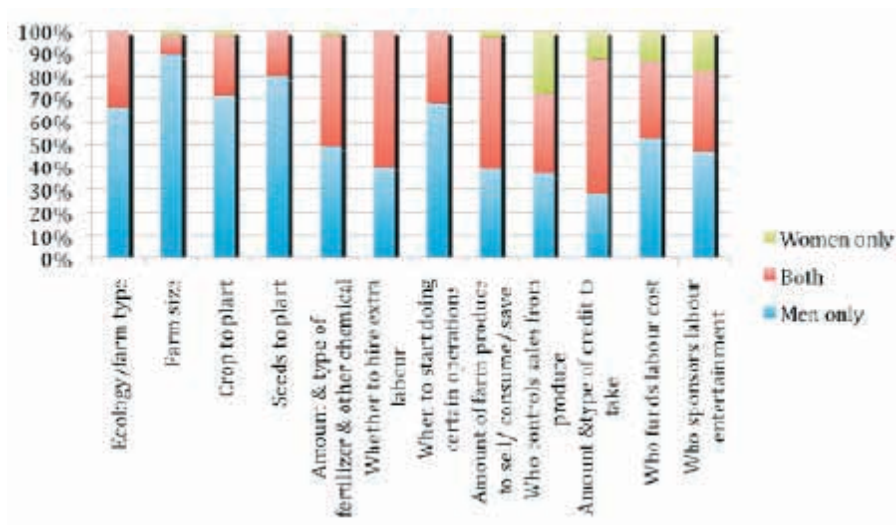
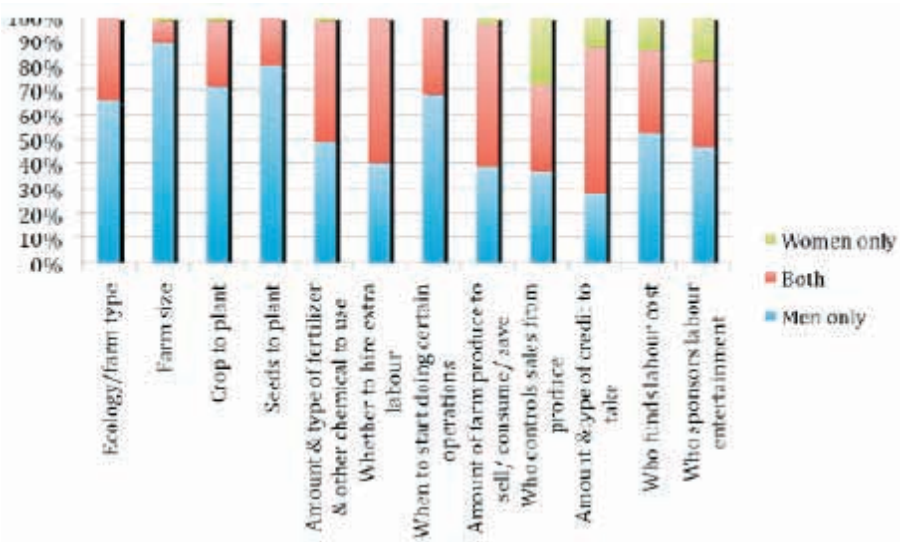


Fig. 6: Gender-based farm management decision making as stated by male farmers



The cost of fertilizer per 50 kg bag, according to the 48% of female farmers' and 29% of male farmers who applied fertilizer during the 2005 cropping season, was Le. 120,000. With regards reasons for non-usage of fertilizer, the main reason was it was expensive. A few said it was not needed, as their crops did well without it, as their land was fertile.

Forty-nine per cent of male and 44% of female farmers said they knew about the existence of micro-credit for farmers, and mentioned the following: America Refugee Committee (ARC), Association for Rural Development (ARD) and Cooperatives. However, only 7% of males had access to it, and the predominant source was ARC followed by ARD. Twenty per cent of female farmers took credit, spread across all three sources.

Reasons given for not using micro-credit was that it was not available. When asked further, through focus-group and interpersonal discussions, they said that though they were aware of the existence of certain institutions providing micro-credit, they could not access it due to lack of influence.

Reasons for utilizing micro-credit as stated by the 7% of male respondents who took it included: to acquire seeds, fertilizer and tools, and to hire machines and labour. Reasons for taking micro-credit as stated by the 20% of female respondents who took it included: to acquire seeds and to hire machines.

Information collected on what respondents disliked about the micro-credit revealed that 47% of male farmers referred to the embarrassment in the event of not paying on time, which at times leads to police warrant. Seventy-three per cent of females said the terms of payment—while farming activity is seasonal, the credit scheme expected them to pay on a monthly or fortnightly basis, which they said they couldn't afford.

All female farmers and 98% of male farmers said there were ready markets. The type that ranked highest was periodic market 'Lomor' in Bamio. The cost of transportation from farm site to markets ranged from Le. 500 to Le. 3,000 for a 50 kg bag.

CONCLUSION

This study reveals that the farming population of the study area is ageing. Although this has some negative consequences, it also has some advantages like bringing many opportunities, as older people have considerable knowledge and experience particularly of traditional agricultural practices and medicine. They are also important in caring for young people whose parents have moved to cities or have died.

In the absence of young labour force, older people have to look after crops and livestock. In many cases, they are unable to work the land effectively. This can reduce the agricultural productivity of an area, leading to food insecurity and poor nutrition. The educational level was low, especially among women farmers. This is a concern as literacy is needed to spread information on improved technological packages and basic arithmetic to be able to calculate costs and benefits. Thus, there is a need for adult literacy classes to make them functionally literate.

There has been slight improvement in the availability of land for agricultural activity, which is encouraging for agricultural development. Land could be bought, leased and even given on concession to both sexes for farming purposes. Also, there was an increased use of improved rice seeds, but these have to go with fertilizer for an improved yield, but the use of fertilizer was very low. Traditional farming involves the development of knowledge and skills, and the various processes that take place within the farm are generally well understood. Local farmers prefer risk-minimization strategies to profit-maximization strategies, but they are not unaware of the value of experimental procedures. For example, rice-based farmers try out new seeds introduced to them over and over again, to test them for various attributes like germination and yield. They do this on smaller plots before they plant them on a large scale. Local farmers' knowledge is derived from, and is constrained by, indigenous agricultural practices.

Availability of credit schemes to farmers is very small and the conditions are not favourable, and do not fit in with the farming calendar. The farmers expressed the need for it as certain farm operations need extra cost or funding. Also, it came out that male farmers have been longer in agriculture than female farmers. With mean length of time in farming being 16 and 15 years, respectively. Moreover, there was some form of joint decision-making processes. of milled rice, but was distance and market-type dependent. With regards storage facility, 72% of male and 64% of female farmers said they had no storage facility.

Hired labour is heavily invested in, thus reducing the income of farmers; however, there was very minimal use of machines and this was restricted to the lowlands. From this study, it came out vividly that there were ready markets in the form of market days commonly referred to by them as 'Lomor', which at least can now reduce the extent of postharvest losses and enhance the earning capability of the farmers.

Literature Cited

Alderman, H., Hoddinott, J., Haddad, L. and Udry, C. 1995. Gender Differentials in Farm Productivity:

■ **Gender and Social Issues of Rice-Based Farmers in Rokupr, Kambia District, during the 2005/06 Cropping Season**
Finda B. Jenkins

Implications for Household Efficiency and Agricultural Policy. FCND Discussion Paper No. 6. Food Consumption and Nutrition Division, International Food Policy Research Institute, Washington, DC.

Fomba, S. and Taylor, D. (1994). Rice blast in West Africa: Its nature and control. p. 343–355. In: R.S. Zeigler, S.A. Leong and P.S. Teng (eds.), *Rice Blast Disease*. CAB International, Wallingford, UK and International Rice Research Institute, Manila, The Philippines.

Hafkin, N.J. and Hambly, H. Draft 23 (August 2002). A Situation Analysis for the Fifth Consultative Meeting of expert. CTA ICT Observatory Meeting on Gender and Agriculture in the Information Society.

Government of Sierra Leone 1999a. Agricultural Sector Master Plan. Prepared by the Ministry of Agriculture and Natural Resources and Ministry of Fisheries and Marine Resources. ABCO Limited.

Government of Sierra Leone 1999b. Situation Analysis of Women and Children in Sierra Leone. Government of Sierra Leone, Freetown.

Government of Sierra Leone 2004. Housing and Population Census. Government of Sierra Leone, Freetown.

Government of Sierra Leone 2005a. Millennium Development Goals for Sierra Leone. Government of Sierra Leone, Freetown.

Government of Sierra Leone 2005b. Poverty Reduction Strategy Paper (PRSP). Government of Sierra Leone, Freetown.

IFPRI [2000]. Women: The Key to Food Security – Looking into the household. International Food Policy Research Institute, Washington, DC. www.ifpri.org/pubs/ib/tb3.pdf.

International Development Magazine 2001. Issue 13. The Gender Agenda.

IRRI 2000. Empowering women. p. 38. In: *IRRI Annual Report 1999–2000: The Rewards of Rice Research*. International Rice Research Institute, Los Baños, Philippines. www.irri.org/publications/annual/pdfs/ar2000/empoweringwomen.pdf.

Quisumbing, A.R. 1996. Male-female differences in agricultural productivity: Methodological issues and empirical evidence. *World Development* 24(10): 1579–1595.

Quisumbing, A.R., Meizen-Dick, R.S. and Smith, L.C. 2005. Increasing women's role in food security in Africa. *id21 natural resources highlights: rural livelihoods*. p. 3.

Warham, E. 2001. Feeding the world. *Developments [magazine]* 13. www.developments.org.uk/articles/feeding-the-world/?searchterm=Issue%2013,%202001.

Empowering Small-holder Farmers in Kilifi and Malindi Districts of Kenya through Improved Mango Production Techniques, Marketing and Information Dissemination to Ensure Poverty Reduction, Food Security and Creation of Employment

Christine K. Masha¹ F. Pole¹ and L.A. Wasilwa²

Key words: postharvest, processing, marketing, constraints, intervention, technologies, dissemination, impact

Abstract

Mango production has the potential to contribute to rural incomes through sales and employment creation from value-added products, especially in coastal Kenya. The region represents some of the arid and semi-arid zones of this country, where women constitute 75% of the household labour force; and where about 35% of the women and children suffer from malnutrition. The coastal lowlands have one of the country's highest poverty levels, although it has an environment that is suitable for production of tree crops, including mango. The main problem for mango is that each year there is a market glut and prices are extremely low, often not worth the cost of transportation to the markets. Other constraints include poor crop management and postharvest technologies; pests and diseases; and limited processing technologies and marketing, exacerbated by poor infrastructure. The objective of this project was to commercialize mango in Malindi and Kilifi districts using a consortium of stakeholders. Professional intervention through a multidisciplinary approach was launched by Kenya Agricultural Research Institute (KARI) and related stakeholder organizations to empower farmers towards solving production and processing constraints so as to exploit the potential of mango. This was achieved through intensive farmer training on the relevant technologies, establishment of field demonstrations, improvement of existing mango nurseries and linking farmer groups to markets. An umbrella body (Kilifi, Malindi Product) was established to co-ordinate mango activities in the two districts. This body was registered under the Registration of Companies Act and is networking and coordinating activities that address the obstacles. Through the farmers' efforts to adopt production, processing and marketing skills they have learned, mango losses have been reduced by 50%. The interventions have also created employment for 80 men and 50 women in fruit-tree nurseries and mango processing. Communities have realized that mango farming could be a profitable business.

¹ KARI Mtwapa, Box 16, Mtwapa, Kenya.

² KARI Headquarters, Box 57811 Nairobi Kenya..

INTRODUCTION

In Kenya, mango (*Mangifera indica* L.) is one of the most important fruits in terms of area under cultivation, volume of production and value. The crop is adapted to a wide range of climatic and soil conditions. The low cost of its culture and maintenance and the nutritional value of its fruit make it popular. In 1997, mango production was 66,707 tonnes valued at KES 855,556,660 (€8,148,159). This increased to 163,726 tonnes valued at KES 1,057,046,600 (€10,067,111) in 2006 (MoA, 2006; HCDA, 2006). Coast Province is Kenya's leading mango-producing region (9,020 ha); there are 3,264 ha of mango in Kilifi and Malindi districts.

A report on poverty levels in Kenya by the Ministry of Planning and National Development indicates that 11.5 million or 47% of Kenyans cannot afford basic requirements and general poverty levels have been declining since 1997 (National Bureau of Statistics 2007). The challenge of poverty alleviation requires both government and private-sector interventions. Communities themselves must be empowered to take greater control of their well-being through, for example, taking greater responsibility for development programmes and community-held resources. This project attempted to empower the farmers/peasants who were organized in production units in Kilifi and Malindi districts, 40% of whose mango production goes to waste (Kilonzo et al., 2003) or is sold at very low prices in the midst of hunger and poverty. The potential for mango in Kilifi and Malindi districts has not been realized because of limited knowledge of recommended agronomic practices; ageing mango trees; cultivation of low-yielding old varieties (Ngoe and Kitovu); low adoption of new high-yielding varieties; poor pre- and postharvest handling, including poor packaging of fruits, and lack of refrigeration and processing facilities; instability of mango marketing groups; farmer exploitation by agents and intermediaries; inadequate market information and poor market prices; poor infrastructure; lack of a reliable international market; and lack of capital, including credit facilities (Retief, 1984; Griesbach, 2003; DAO, 2004; MoA, 2006).

Studies indicate that farmers are anxious to learn techniques for enhanced production and processing of surplus produce into fruit pulp, juices, jams, preserves, dry and pickled fruit for domestic and commercial use (Kilonzo et al., 2003; Ndungu et al., 2008). In addition, the small-holders want to establish commercial villages (cottage industries) in their areas, managed by the farmers themselves in order to add value to their horticultural produce and thus enhance household incomes and generate rural employment, while at the same time conserving environmental resources and conforming to national food-safety standards. Mango production has potential to contribute to the economy through foreign-exchange earnings and employment creation, but the region is characterized by high poverty levels. Farmers' groups, in collaboration with exporters, food technologists, entrepreneurs and other experts on horticultural production, have the capability to organize and manage the training courses in production, food processing and marketing. KARI—along with Kenya Industrial Research Development Institute, Kenya Plant Health.

Inspectorate Service, DHODEA (horticulture marketing non-governmental organization), the Ministry of Agriculture and local community-based organizations—facilitated mango production and processing technology acquisition, verification and transfer. The Kenya Bureau of Standards (KEBS) conducted training on food safety, quality control and evaluation. The goal was to improve mango production, processing and marketing. The objectives were to maximize production of high-quality fruit in Kilifi and Malindi districts; to

■ **Empowering Small-holder Farmers in Kilifi and Malindi Districts of Kenya through Improved Mango Production Techniques, Marketing and Information Dissemination to Ensure Poverty Reduction, Food Security and Creation of Employment**
Christine K. Masha¹ F. Pole¹ and L.A. Wasilwa

disseminate environmentally safe production technologies; to reduce losses of mango both pre- and post-harvest; to introduce varieties suitable for various end uses in the districts; to train farmers on mango processing; to disseminate technologies on handling and storage; and to build the capacity of small-holder mango farmers and economically empower them in technological, entrepreneurial and business skills.

MATERIALS AND METHODS

Study Area

The study was carried out in Kilifi and Malindi districts that have a total population of about 800,000. The minimum and maximum temperatures are between 26° and 30°C. Average rainfall is 400–1400 mm/year, and average relative humidity is 60%. The farm sizes in Kilifi District are between 6 ha (small-scale) and 20 ha (large-scale); and in Malindi District are between 3.2 ha (small-scale) to 72 ha (large-scale) (MoA, 2004).

Sampling Methods

Both probability and non-probability sampling methods were used, through cluster and purposive sampling. Probability and purposive sampling was carried out on locations where mango covers large acreages (clusters) while non probability and non purposive sampling involved any other existing farmer groups outside the targeted clusters.

Target

Two hundred and fifty mango farmers in Malindi and Kilifi districts were targeted, with a cross section of genders—male/female and youth. Interviews for selection of farmers or groups were done to members of groups that had shown cohesiveness in the running of group activities. Cohesiveness or groups' welfare was judged through their activity records, information given by members and recommendations from the area Field extension officer

Crop Production and Processing Technologies

The interventions focused on the dissemination of technologies of good agricultural practices; production; proper and safe application of agrochemicals; postharvest handling and processing techniques for longer shelf-life; scaling up of recommended varieties; training of model small-holder farmers as part of capacitybuilding; record-keeping; development of partnerships with input suppliers to improve access to inputs through an efficient and consumer-driven supply chain; and training of farmers in quality requirements for various products, including the fresh fruit, for both local and export markets. Superior cultivars/ rootstocks and proven agronomic practices, collective storage and, where appropriate, adding value through processing, were used to improve on general groups performance towards forming business entities and hasten transition out of poverty. The basic aim was, however, to enhance production to meet the demands of the market and to ensure sustained availability of raw materials. Commercial village-farmer groups were encouraged to form linkages with private sector, research, and government service-delivery systems. Farmers in the target units were regularly updated of market conditions using their acquired entrepreneurial skills, this was through linkage with exporters to be able to bargain for farm gate prices.

Postharvest, Processing and Utilization Technologies

Available technologies were disseminated after research on better postharvest management and processing technologies was conducted. The aim was to reduce postharvest losses, which were initially as high as 40%, to empower the groups to start commercial villages and build the capacity these groups to a level where they could supply larger industries with semi-processed products (e.g. fruit pulp, dried mango chips and concentrates), and consequently to improve incomes and profit margins. Processing and utilization technologies were disseminated to small-holder farmers who were empowered to conduct mango farming as a business and linked to the market.

Farming as a Business

The main problem small-holder farmers have is that during the peak harvest period, they cannot sell their mango quickly enough or for a profitable price. Consequently, at times they discard the produce at the markets or farms. Although there is a realization that their current production and marketing approaches are unsatisfactory, no one has come forward to offer a better system and this has led to a feeling of helplessness.

Limited research in the area has indicated that the agricultural potential is substantial, while actual experience is that both physical and economic returns to farming and farm labour input are discouraging. Alternative employment opportunities in this area are

Data

Data were collected through interviews and visits to record numbers of mangotrees and production. Data analysis was done through descriptive and inferential statistics, through MS Excel and simple statistical packages.

RESULTS

Farmer Capacity-building

Intensive training (through a series of workshops) was conducted for 20 farmer groups of 292 females and 223 males on good agricultural practices for the management of both new and old mango orchards; propagation techniques for the newly introduced mango varieties; processing; and postharvest handling and quality control. Farmers were trained on how to process mango into various products, including dried mango chips, mango juice, jam, pickles and chutney. They were also taught packaging and product certification to ensure that they conform to the standards set out by KEBS. Groups under the umbrella network processed some products (jam, juice and dried mango) that were certified by the Bureau.

Technical packages and bulletins were prepared to facilitate dissemination of the technologies, and information communicated during the implementation of the study. A workshop was organized to develop extension training materials in the form of brochures, booklets and posters on various topics related to mango production, value addition and marketing. The following titles were prepared Propagation of High Quality Mango Seedlings, Mango Production, Mango Orchard Management, Generate Income from Dried Mango Chips, Jam and Juice, How to Market your Mango for Better Prices, Mango Post-harvest Handling, How to Identify and Manage Mango Pests and Diseases, and How to Fabricate your own Solar Drier.

■ **Empowering Small-holder Farmers in Kilifi and Malindi Districts of Kenya through Improved Mango Production Techniques, Marketing and Information Dissemination to Ensure Poverty Reduction, Food Security and Creation of Employment**
Christine K. Masha¹ F. Pole¹ and L.A. Wasilwa

Farmers participated in identification of production constraints through interviews during a baseline survey and project planning; joint meetings were held between all stakeholders to plan for the activities to be carried out. The farmers also made decisions on demonstration and training sites. At the end of each quarter, at least six farmers' groups (three from each district) were visited to determine the progress on adoption of technologies.

Farmers could not access credit due to lack of title deeds for their land parcels. They were sensitized on available sources of funding, including banks and microfinance institutions, by officials from Agricultural Finance Co-operation, and Malindi Saving and Credit Cooperative. As a stop-gap measure, the project set aside a revolving fund worth KES 200,000 (€1,905). Most roads in rural areas are impassable, especially during the rainy season. Delay in transporting fresh goods results to high levels of mango spoilage. The local authority was made aware of this and attention drawn from the committee managing the Constituency Development Funds kit to alleviate this situation. Some of the roads are now being rehabilitated.

Beneficiaries' Involvement

Farmers' views captured during monitoring and evaluation and training activities were incorporated in the final reports. Farmer-trainers were mandated to train fellow farmers. This resulted in three more groups being incorporated into the project after an application for participation.

Impact Assessment

Impact assessment was done through exchange visits among participating groups to evaluate their pace of adoption against one another.

Cost-sharing in Technology Development

Farmers provided material resources like land portions for tree nurseries, training sites and old trees as training materials for agronomic exercises.

Gender Issues

Farmers of different gender categories were equally involved in all the activities and were made to understand that equal participation results in faster technology adoption.

Study Tour

Farmers were taken on a study tour to expose them to the production practices. Three small-scale and two large-scale farmers were visited in Muranga and Maragwa districts. The farmers also visited Nairobi and Mombasa mango markets, where they interacted with business people who shared with them experiences and issues on handling business transactions. Some of the important issues included the safety and dangers of contract signing.

Sustainability of Project

An umbrella body—Kilifi, Malindi Product—was formed to network-link the districts. The committee members are currently networking for collection of member business. Kilifi, Malindi Product got an export

■ **Empowering Small-holder Farmers in Kilifi and Malindi Districts of Kenya through Improved Mango Production Techniques, Marketing and Information Dissemination to Ensure Poverty Reduction, Food Security and Creation of Employment**
Christine K. Masha¹ F. Pole¹ and L.A. Wasilwa

order for 20 tonnes of dried mango chips from the United Arab Emirates. It runs a revolving fund of KES 200,000 (€1,905) to sustain quality fruit production. Eighteen extension-service providers from the two districts were trained as trainers on mango management and postharvest handling.

DISCUSSION

Coastal Kenya produces 66% of Kenya's mango in 11 months of the year. The climatic conditions in this region favour adequate maturation and hasten fruit ripening. However, the same conditions also promote rapid multiplication, infection and infestation by plant pathogens, such as anthracnose and powdery mildew, and insect pests, such as fruit fly and mango seed weevil, which cause pre- and postharvest losses. The key pest is mango seed weevil, which has constrained farmers' access to export markets in Europe and Asia (DAO, 2004; MoA, 2006). Losses of up to 40% are attributed to poor postharvest handling practices.

Constraints listed as the major factors for limiting mango production in coastal Kenya could be addressed by appropriate technologies. Consequently, technologies were disseminated through intensive farmer training and workshops, which rekindled enthusiasm for adoption of mango. Other constraints such as poor road infrastructure and lack of credit are policy issues that need to be addressed by the government.

CONCLUSION

The multidisciplinary approach that was used throughout the project period was a key factor in the success of the activities carried out. Five hundred and fifteen farmers were trained on processing technologies for mature, ripe and over-ripe mango development stages—dried mango for the mature, jam for the ripe and juice for the over-ripened mangoes. It is now possible to harvest and process fruits of inferior qualities (colour and size) for market at household level, as some of the products have longer shelf-life than fresh mango. These technologies have reduced the mango spoilage by over 50%—farmers are able to harvest poorer-quality fruits early for drying, saving the good ones for the fresh-fruit market. Mango utilization has also been enhanced through improved taste, shelf-life and the variety of products. Formation of the umbrella body has united two districts into one production-to-marketing unit and empowered the farmers with bargaining power for price-setting, and a shorter market chain. The chain of activities coordinated by the body (spraying, harvesting, and management of mango nurseries) has created employment for 80 men and 50 women in the districts. Mango is now a reliable cash earner in the two districts. Training of trainers refreshed the knowledge of nine frontline workers and nine home-economics extension officers, thus improving the agricultural extension services. Eight publications have facilitated the extension work too.

The project therefore enhanced farmers' knowledge on mango management activities ranging from mango orchard management, pre- and postharvest handling, marketing and processing technologies, and united the two districts for farmer empowerment and income-generation. contributions (for purchase of inputs), buying of agrochemicals, monitoring of production and processing activities, and collection of produce and products. The body was registered under the Registration of Companies Act in order to power to undertake price setting and markets identification for member producers. This attracted a donor who, through cost-sharing, erected a mango-processing shed worth KES 300,000 (€2,857). The 500 farmers

■ **Empowering Small-holder Farmers in Kilifi and Malindi Districts of Kenya through Improved Mango Production Techniques, Marketing and Information Dissemination to Ensure Poverty Reduction, Food Security and Creation of Employment**
Christine K. Masha¹ F. Pole¹ and L.A. Wasilwa

who participated in the project were trained on crop protection, pre- and postharvest handling, processing and packaging, and record-keeping. Three farmers' empowerment and income-generation.

Lessons Learned from the Project

- i. A multi-disciplinary approach to technology transfer with good coordination enables projects to achieve the set objectives.
- ii. Farmers are keen on learning new technologies
- iii. Markets (local and international) for mangoes and their products are available as long as the farmers meet the required conditions.
- iv. The project was an eye-opener for the farmers, as it made them acquire knowledge on a wide range of technologies.

Way Forward

Extension staff trained by the project will continue working with the groups to sensitize them on cohesiveness and back-stop them where necessary.

Recommendation

The socio-economists should be facilitated to monitor and collect post-project data and document progress for 2 more years perhaps, "to record the sustainability of the new setup.

Acknowledgement

I acknowledge Farm Africa for the financial support. I acknowledge the Director, KARI headquarters and the Centre Director, KARI Mtwapa for their full support of the scientific activities. I acknowledge all the professional stakeholders for their participation in the project implementation. I acknowledge the farmers for their cooperation during the project period. I acknowledge the organizers of the Women in Science Competition for creating an avenue for women scientists' evaluation.

Literature Cited

- DAO 2004. Production Trends in Malindi District. District Report. District Agricultural Office – Malindi District, Malindi, Kenya.
- Griesbach, J. 2003. Mango Growing in Kenya. World Agroforestry Centre (ICRAF), Nairobi.
- HCD (Horticultural Crop Development Authority) 2006. Annual Report 2006. Ministry of Agriculture, Nairobi.
- Kilonzo, E., Danda K. and Kawira, C. 2003. Mango production, processing marketing and utilization. A baseline survey in Malindi and Tana River districts. Kenya Agricultural Research Institute, Mtwapa.
- MoA 2004. Annual Report 2004. Ministry of Agriculture, Nairobi.
- MoA 2006. Annual Report 2006. Ministry of Agriculture, Nairobi.
- National Bureau of Statistics 2007. Economic Survey. Ministry of Planning, Nairobi.
- Ndungu, J.M., Pole, F.N. and Katama C.K. 2008. Identification of market and marketing channels on mango in Tana Delta Coastal Kenya. Paper presented at the 11th Scientific Biennial Conference, Kenya Agricultural Research Institute, Nairobi.
- Retief 1984. Survey report on mango production in Malindi district. In: District Report. District Agricultural Office, Malindi.

Enhancing Food Safety and Market Access for Small-holder Export Vegetable Producers in East Africa

Brigitte Nyambo¹

Keywords: export sub-sector, quality, horticultural extension services, Kenya

Abstract

Introduction of EU regulations on maximum pesticide residue levels and food hygiene, and private food-safety standards particularly the EurepGAP (GlobalGAP) threatened the livelihoods of over a million Kenyans involved in the fresh fruit and vegetable supply chain export sub-sector. Compliance by small-holder vegetable producers was constrained by a combination of lack of technical know-how on the new international and private food-safety requirements and standards, and inefficient extension system. In collaboration with international and national public and private institutions, the International Centre of Insect Physiology and Ecology conducted a pilot programme (2003–2007) to facilitate proper interpretation and application of the requirements and standards by small-holder vegetable producers, targeting the fresh produce export sub-sector. The objectives were to improve extension service provision, promote good agricultural practices, develop a generic quality-management system manual, and lobby for policy issues on food quality and safety. It was demonstrated that with efficient extension services, it is possible for small-holder vegetable growers to adopt good agricultural practices that will foster production of quality vegetables with acceptable global safety standards without jeopardizing quantities.

¹ *Technology Transfer Unit, International Centre of Insect Physiology and Ecology, PO Box 30772-00100, Nairobi, Kenya.*

INTRODUCTION

The Kenyan fresh fruit and vegetable sub-sector is a source of livelihoods for over one million people, mostly women and youths. The fresh produce export sector is a vital source of foreign exchange earnings contributing about US \$1 billion in 2007 (MaCulloch and Ota, 2002; S. Mbithi, pers. comm., 2008). Up until the early 1990s, small-holders contributed about 80% of the total export produce. This dwindled to about 20% in the late 1990s (Dolan and Humphrey, 2000) due to the introduction of EU regulations on maximum pesticide residue levels (MRLs) and food hygiene, and private food standards, particularly the EurepGAP (GlobalGAP). The regulations and private standards threatened small-holders' continued access to EU fresh export markets due to a lack of efficient extension services (Man-Kwun and King, 2000; Nyambo et al., 2009).

In Kenya, horticultural crop extension services are provided partly by the national extension system under the Ministry of Agriculture (MoA) and also by fresh-produce export companies. However, the current extension system is inefficient due to low extension worker–farmer ratio (1:600) and lack technical know-how in EU MRLs and food-hygiene regulations and the EurepGAP Standard (Nyambo et al., 2009). Smallholder farmers had poor understanding and interpretation of the EurepGAP Standard.

The new regulations and private standards forced fresh-produce exporters targeting EU markets to source produce from large estates and their own farms at the expense of the small-holder producers, thus threatening the livelihoods of over 250,000 farm families involved in the supply chain. To mitigate this and to facilitate continued participation of small-holder producers and upcoming indigenous fresh-produce export entrepreneurs in the sub-sector, a project to ensure compliance was undertaken by the International Centre of Insect Physiology and Ecology (ICIPE) between 2003 and 2007 in collaboration with public and private national and international institutions. The objectives were to improve extension services, promote good agricultural practices (GAP), develop a generic quality-management system (QMS) manual and lobby for effective policy on food quality and safety.

MATERIALS AND METHODS

Improving Provision of Efficient Extension Services to Small-holder Vegetable Producers

Well-trained private extension-service providers conversant with current international and private food-safety requirements and standards were seen as the key through which extension services could be improved. Export companies contributed ideas and guidelines on the training programme (content, candidate qualifications and training model to be adopted) and a list of their outgrower-farmers' groups to participate in the programme. Candidate private extension-service providers (PESPs) were identified through an advertisement in one of the popular local daily newspapers. Nineteen applicants (including six women) were short-listed for the course.

Baseline studies on knowledge, practice and attitude of 27 outgrower-farmers' groups totalling 840 farmers (42% women) in Central and Eastern Provinces of Kenya were conducted using farmer participatory approaches in October 2003 and July 2004. Information gathered was used to fine-tune the training

curriculum of the trainees and to formulate radio and television programmes. The training curriculum included extension communication skills and working with farmers' groups, agricultural business management, GAP, EU food-safety regulations, internal auditing, setting up quality-management systems, and EurepGAP certification requirements. A comprehensive integrated training programme that included lectures, practical attachment to outgrower-farmers' groups and fresh-produce export companies, refresher courses and farmers' group workshops was developed and implemented from 2003 to 2004.

The course was planned and implemented by a multidisciplinary team of public and private institutions, including social scientists, crop-protection experts, business managers, pesticide-application experts (ICIPE, Natural Resources Institute, TechnoServe-Kenya, EurepGAP FoodPlus-Germany, The House of Quality-South Africa) and role-modelling through industrial attachment to outgrower-farmers' groups and fresh-produce exporters. Four large fresh-produce exporters participated in the training through industrial attachment arrangements. Nineteen outgrower-farmers' groups (of the 27 profiled) participated in the training programme. To improve understanding and implementation of the EurepGAP requirements in Kenya, a national awareness media (radio and TV) programme, including interactive sessions, was organized and transmitted over a 3-month period in collaboration with the Kenya Agricultural Information Research Centre (AIRC) and the Kenya Broadcasting Corporation (KBC) in September–November 2004. During April–December 2005, capacity-building for ADHEK Ltd, a small upcoming local fresh-produce export company, was organized and implemented through training seminars in collaboration with the Business Services Marketing Development Project (BSMDP-DFID)-Kenya and Pact-Kenya as a strategy to enhance participation of local entrepreneurs in the sub-sector. In addition, lessons learned during the training of PESPs in 2003/04 were used to fine-tune the training module for wider use. The resulting module was used to train second batch of PESPs. This phase involved 14 trainees (1 woman), 14 outgrowerfarmers' groups with a membership of 359 (38% women) in Central Province, one product-marketing organization (PMO), one large export company, two medium-sized exporters and ADHEK, all operating in the same areas.

Testing and Development of Kenyan Generic Quality Management Systems Manual

Large exporters have resources and in-house expertise to develop their own QMS manuals solely for company use, a luxury beyond many upcoming local entrepreneurs. To fast track setting up of QMS for certification of small-holder farmers' groups and participation of local fresh-produce export entrepreneurs under Option 2 of EurepGAP, development and formulation of a generic Kenyan manual for the public domain became imperative. This initiative was conducted from September 2005 to October 2006 with a wrap-up stakeholders' workshop in February 2007. The key objectives were (a) to field test a draft Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) QMS generic manual for EurepGAP Option 2 under Kenyan production systems, as part of an international study covering Brazil, Ghana, Macedonia and Vietnam; (b) to adapt the manual to Kenyan small-holder production systems; and (c) to facilitate Eurep GAP certification under Option 2 of participating farmers' groups. Nine groups (695 farmers, 37% women) of the 18 profiled were selected to participate in the initiative. The groups were in three clusters of three groups each. Four fresh-produce exporters and one PMO linked to the selected farmers' groups also participated in this activity.

The groups were selected on the basis of legal entity, existing contractual linkage to exporter(s) or PMO(s), having basic common facilities (grading shed, stores, health amenities) and access to water for irrigation.

ICIPE provided managerial services, technical backstopping to the whole process, pre- and post-harvest hygiene practices training. Agribusiness & Allied Kenya were responsible for:

- (a) hands-on training of the farmers' groups on basic concepts of integrated pest management, good agricultural practices and on EurepGAP Regulations;
- (b) establishment of QMS for participating farmers' groups; and (c) the internalization of the generic QMS manual developed by the project. The MOA–GTZ Promotion of Private Sector Development in Agriculture (PSDA) ran a 5-day residential course for participating farmers' groups on 'farming as a business'. Standards & Solutions Consulting Ltd conducted monitoring and evaluation of the project implementation platform for information exchange, project review and feedback. A restricted project web-page was established as a platform for information-sharing among project partners.

RESULTS

Improving Provision of Efficient Extension Services to Small-holder Vegetable Producer

PESPs and participating farmers' groups were trained in integrated pest management and pre- and post-harvest hygiene practices.

Of the 33 PESP trainees, 25 (6 women) completed the course successfully. These went into self-employment or got employment with export companies to prepare farmers' groups for EurepGAP certification.

Only one farmers' group (of the 19 trained) qualified for EurepGAP certification by the end of 2004. Despite the experience gained in 2003/04, none of the 14 groups supported in 2005 qualified for certification. As a result of project activities, some policy changes took place. The MOA commissioned a review of its EurepGAP training programme and facilitated refresher courses for the horticulture extension staff. Kenya-based large fresh-produce export companies reverted to supporting and sourcing vegetables from small-holder outgrowerfarmers' groups for export to the EU.

The EurepGAP Secretariat assisted Kenya to benchmark 'KenyaGAP' on the EurepGAP Standard to make the standard end-user friendly, and invited Kenya to nominate a representative to the Secretariat. The UK Department for International Development (DFID) committed additional funds to co-finance the field-testing and development of the QMS, in collaboration with GTZ.

Lessons learned during the implementation of the national awareness media campaign (radio and TV programmes) were used to formulate and develop the DFID/DANIDA-funded FITS Resources-led MALI SHAMBANI (Wealth in Farms) radio programme transmitted by KBC in 2007/08.

A model for training private extension-service providers of information, advice and input in the horticultural sub-sector was developed (Nyambo et al., 2009).

Testing and Development of Kenya Generic QMS

A functional project webpage (<http://icipe.sunfish.de>) was established in December 2005. Despite intensive training and close technical backstopping, only six of the groups (66.6%) achieved EurepGAP certification under Option 2 by the end of 2006.

Also a Kenya generic QMS manual was produced and posted on the ICIPE webpage (www.icipe.org/research_areas/plant_health/horticultural_crop_pests/index.html).

DISCUSSION

Proper interpretation and application of the private food-safety standard in the context of Kenyan small-holder vegetable production systems was a lengthy learning process that required a multidisciplinary team approach, experimentation and role-modelling, lobbying of policy-makers, information harmonization and dissemination, education of a wide range of stakeholders, and adequate financial support. It took 15 months of intensive technical support to get one of the 19 participating farmers' groups to qualify for EurepGAP certification. Others could not be certified due to lack of transparency and trust between farmers' groups and produce buyers, which impacted negatively on contractual arrangements between farmers' groups and exporters, and thereby led to failure to comply with the required regulations. The project worked with self-help farmers' groups registered with the Ministry of Social Affairs. Such associations are not legally recognized cooperatives, and therefore cannot sue or be sued in case of a breach of contract—a situation being exploited by exporters. Development of private extension service provision for improvement of services to farmers was a pilot in the direction of privatization of government services in Africa and was therefore a learning platform. In Kenya, the pilot was in line with the National Agricultural and Livestock Extension Programme (NALEP) Implementation Framework (MOARD, 2001), which supports the National Agricultural Extension Policy (NAEP). However, the policy on privatization of agricultural extension services is not operational, and farmers are unaware that they have to pay for extension services.

By December 2004, the general awareness about the EU MRLs and food-hygiene requirements and the EurepGAP Standard at national level had improved. Small-scale vegetable growers in the major horticultural production areas of Kenya targeting the export markets were well informed of the EurepGAP Standard and were prepared to implement it. The graduate PESP's reached out to small-holder vegetable farmers' groups by selling their services either directly or through exporters at a fee. This enabled farm families to sustain vegetable production for export markets, thus ensuring continued employment and income-generation for over a million people, including women and youth. Availability of the Kenya generic QMS opened a window for local new entrepreneurs to enter the fresh-produce export market, thus creating more job opportunities for school leavers. However, lack of price incentives for EurepGAP practitioners and the recent introduction of more stringent requirements under GlobalGAP are major constraints to wider adaptation.

CONCLUSIONS

It was demonstrated that with efficient extension services, it is possible for small-holder vegetable growers to adopt good agricultural practices that foster production of quality vegetables with acceptable global safety standards without jeopardizing quantities.

International private food standards are not necessarily technical trade barriers. Well interpreted and applied, they could be a benefit to Sub-Saharan Africa's domestic and regional markets in terms of introduction and promotion of food safety. However, a lot of resources (supportive government policies, financial, goodwill and expertise) are required before food safety becomes a reality for domestic and regional markets in Sub-Saharan Africa.

It is possible for developing countries to contribute to and influence the interpretation of international private food standards without compromising or lowering the standards.

Acknowledgements

This publication is an output from a research project (R8438 and R8297) funded by the Crop Protection Research Programme of the UK Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. I also wish to acknowledge the contributions of my team and colleagues from NR International, ICIPE horticulture sub-programme, PACT-Kenya, AfriCert Ltd Kenya, FPEAK, KHE, East African Growers, Myner Exporters, Indu Farm Ltd, Greenland Exporters, ADHEK, MeruGreens, FrigoKen, Vegpro, the MOA horticulture extension division, the MOA/GTZ-PSDA programme, GTZ HQ Agricultural Food Policy programme Germany, KBC, AIRC, BSMDP-Kenya, and vegetable farmers in Central and Eastern provinces.

Literature Cited

Dolan, C. and Humphrey, J. 2000. Governance and trade in fresh vegetables: the impact of UK supermarkets on the African horticulture industry. J. Developmental Studies 37(2): 147–176.

¹ *ANCAR de Saint-Louis, BP 272 Saint-Louis, Senegal.*

Using the Participatory Market Chain Approach (PMCA) to Generate Pro-Poor Innovations in the Sweet Potato Sector in Uganda

**B. Akello¹, I. Mugisa², W. Nakyagaba³, M. Nampeera⁴
P. Lusembo⁵ and D. Magala⁶**

Keywords: farmers, traders, consumers, competitiveness, research, development

Abstract

Rural farmers are constrained by their inability to access sustainable markets for their products. This challenge is experienced more by women, who in the African context are more involved in production, but less involved than men in marketing agricultural produce. Rural farmers are becoming more marginalized as urban markets demand better quality, quantity and sustainable production of agricultural commodities. Limited access to market information jeopardizes small-scale producers in the marketplace. Promoting collaboration between farmers and other market-chain actors enhances their competitiveness. In 2005–2007, Mukono Zonal Agricultural Research and Development Institute (ZARDI) co-ordinated a multiinstitutional, multidisciplinary and multi-stakeholder project piloting the Participatory Market Chain Approach (PMCA) on the sweet-potato sector in Uganda. The PMCA is a participatory action-research approach for identifying business opportunities in market chains that are important to small-scale farmers, and then carrying out research and development activities to exploit the opportunities. The project covered five districts representing two production agroecologies and one commercial centre. Challenges were identified by each group of market-chain actors. Farmers reported such things as limited access to good-quality planting material, low seasonal prices, and limited demand for orange-fleshed varieties. Traders noted difficulties associated with inconsistent and scattered production, while consumers noted inconsistent supplies, frequently poor quality of roots, and mixed varieties. At the end of the project, new joint commercial, technological and institutional innovations generated were launched at an event in September 2007. Innovations included new sweet-potato commercial products, marketing of new varieties and formation of new market-chain actors' associations and platforms. The success generated by using the PMCA in Uganda indicates that it is a methodology with great potential for generating pro-poor innovations along commodity market chains.

¹⁻⁶ Mukono Zonal Agricultural Research and Development Institute (ZARDI), PO Box 164, Mukono, Uganda.

INTRODUCTION

Rural farmers are constrained by lack of access to sustainable markets for their products. This challenge is experienced more by women, who in the African context are more involved in production, but less involved than men in marketing agricultural produce. One of the major challenges for rural farmers is low linkage to markets in urban cities due to poor infrastructure and poor links with related product and service markets (KIT and IIRR, 2008).

Addressing these problems requires new ways of carrying out agricultural research and development (R&D), that is, not only generating and transferring technologies to increase production, but also making sure farmers can access markets for their commodities. Furthermore, an ongoing process of innovation is needed along the market chain, to enable those involved to continually identify and take advantage of new market opportunities, thus positively affecting rural producers. Shepherd (2007) reports that the Food and Agricultural Organization of the UN (FAO) has for many years advocated that extension officers should work with farmers to link them more effectively to local traders.

The Participatory Market Chain Approach (PMCA) offers promise to fill a methodological gap to address the challenges of understanding market forces and enhancing productive participation by all market-chain actors in the production–marketing–consumption continuum. It is an instrument that intervenes in market chains that lack co-ordination, it creates an environment that fosters interaction among marketchain actors and generates shared innovations based on learning and mutual trust. The methodology was developed and used in Latin America (Bernet et al., 2006). The pilot applications of PMCA in Uganda were on sweet potato, *Solanum tuberosum* and vegetables (hot pepper and tomato). Sweet potato is one of the major food crops in Uganda that is also rapidly growing as a source of income for the rural poor in the major production districts. Recent emphasis has been on production of orange-fleshed sweet potato (OFSP) varieties as a cheap source of Vitamin A. There has been a noticeable increase in production of sweet potato in eastern and northern Uganda since 2004, but producers expressed limited market access as one of their biggest challenges. This paper reports the application of the PMCA process on sweet potato in Uganda to help producers to access markets, and highlights the potential of the method to facilitate the generation of pro-poor innovations.

commodities. Furthermore, an ongoing process of innovation is needed along the market chain, to enable those involved to continually identify and take advantage of new market opportunities, thus positively affecting rural producers. Shepherd (2007) reports that the Food and Agricultural Organization of the UN (FAO) has for many years advocated that extension officers should work with farmers to link them more effectively to local traders. The Participatory Market Chain Approach (PMCA) offers promise to fill a methodological gap to address the challenges of understanding market forces and enhancing productive participation by all market-chain actors in the production–marketing–consumption continuum. It is an instrument that intervenes in market chains that lack co-ordination, it creates an environment that fosters interaction among marketchain

■ **Using the Participatory Market Chain Approach (PMCA) to Generate Pro-Poor Innovations in the Sweet Potato Sector in Uganda**
B. Akello, I. Mugisa, W. Nakyagaba, M. Nampeera, P. Lusembo and D. Magala

actors and generates shared innovations based on learning and mutual trust. The methodology was developed and used in Latin America (Bernet et al., 2006).

The pilot applications of PMCA in Uganda were on sweet potato, *Solanum* potato and vegetables (hot pepper and tomato). Sweet potato is one of the major food crops in Uganda that is also rapidly growing as a source of income for the rural poor in the major production districts. Recent emphasis has been on production of orange-fleshed sweet potato (OFSP) varieties as a cheap source of Vitamin A. There has been a noticeable increase in production of sweet potato in eastern and northern Uganda since 2004, but producers expressed limited market access as one of their biggest challenges. This paper reports the application of the PMCA process on sweet potato in Uganda to help producers to access markets, and highlights the potential of the method to facilitate the generation of pro-poor innovations.

Project Objectives

The overall objective of the project was to improve market access for the farmers, while engaging all market-chain actors. The specific objectives were: (i) to identify and understand the different sweet-potato market-chain actors, their interests, activities, challenges and opportunities; (ii) to provide platforms for generating interest, trust and collaboration among market sweet-potato market-chain actors; (iii) to facilitate market-chain actors to generate joint market innovations, i.e. new products, technologies and institutions; and (iv) to enable market-chain actors to lobby and advocate for favourable market policies.

METHODOLOGY

The Implementation (Core) Team

Mukono ZARDI co-ordinated the PMCA process, which was implemented by a team of 10 R&D actors referred to as the 'core team'. These actors were drawn from the National Agricultural Research Organisation's (NARO) Namulonge, Kawanda and Mukono research institutes, International Potato Center (CIP-Uganda) and Makerere University after the first PMCA training workshop in Uganda. The team members were selected on the basis of their interest in sweet-potato production and marketing. Six of the team members also participated in a second PMCA workshop in the Andes (Peru and Bolivia), after which the team submitted a proposal for implementation of PMCA Phase I.

Implementation Process

1. Phase I. The objective of Phase I was to enable the R&D implementation team to become familiar with market-chain actors, their activities, challenges and market opportunities. A market-chain survey was conducted in September–October 2005 to obtain (mainly qualitative) information concerning the sweet-potato market chain. Interviews were conducted using a checklist administered to market-chain actors. Fifty-five sweet-potato market-chain actors were interviewed. Phase I was concluded with a workshop in November 2005, in which 83 actors participated. Participants were those interviewed in the survey and R&D actors in the sweet-potato sector. During the workshop, two thematic groups—Orange-Fleshed Sweet Potato (OFSP) Processing Group and Fresh Roots Sweet Potato Group were formed.

2. PMCA Phase II. The objective of PMCA Phase II was to discuss and analyse, in each thematic group, business opportunities that could be jointly implemented in Phase III. Each thematic group held five

■ **Using the Participatory Market Chain Approach (PMCA) to Generate Pro-Poor Innovations in the Sweet Potato Sector in Uganda**
B. Akello, I. Mugisa, W. Nakyagaba, M. Nampeera, P. Lusembo and D. Magala

meetings between April and August 2006. In addition to the meetings, market-chain actors were facilitated to visit sweet-potato production areas as well as processing and marketing centres. The tools used in Phase II included SWOT (strengths, weaknesses, opportunities and threats) analysis of potential innovations and rapid market appraisals to evaluate potential business opportunities. During this phase, a work-plan for implementation in Phase III was generated by the thematic groups. Phase II was concluded in a workshop in August 2007, in which 54 actors (24 women and 32 men) participated.

3. PMCA Phase III. The objective of Phase III was to implement the activities in the work-plan (generated in Phase II) to make the proposed market opportunities a commercial reality. As in Phase II, a total of five meetings was held for each thematic group. During this phase, small working groups worked around each market innovation. The main tool used was focus-group discussions with consumers, which provided information for development of the marketing concepts for various market innovations. Phase III was concluded with a gathering of PMCA project market-chain actors, the supporting R&D actors, government leaders and the press. In the Final Event, sweetpotato innovations, alongside Solanum-potato, tomato and hot-pepper innovations, were launched to the public. More than 250 people participated in this event.

4. Backstopping support after PMCA Phase III. Following the launch of the PMCA sweet-potato innovations, Mukono ZARDI maintained its support to participating marketchain actors. The major activities included: (i) monitoring of commercial innovations to ensure that the new products are adequately refined and moved into commercial production; (ii) facilitating multi-stakeholder platforms for R&D actors and existing farmers' groups, processors and traders that can support continued future innovations; and (iii) undertaking farmer-participatory and market-oriented research.

RESULTS

Technological, Commercial and Institutional Innovations

Innovations launched during the PMCA Final Event included a new snack food product made from OFSP. After the event, the processor (TomCris) received many requests for the product. Efforts are now geared towards supporting sustainable and consistent supply of fresh sweet potatoes for processing. A 'new' variety of sweet potato, 'Naspot 1', that had been in production for some time was introduced and marketed in Kampala's largest supermarket, Uchumi, for the first time during the PMCA project. Since then, the supplying firm (SULMA Foods) has contracted more farmers and introduced the variety to several groceries. Composite flours containing OFSP have been developed and pilot-marketed by two Ugandan processing firms, USPPA and Kasawo Millers. A kiosk for marketing clean, sorted and graded sweet potatoes and processed sweet-potato products was constructed and used for the first time at the Final Event of the PMCA (2007). It was later relocated to a local market, where farmers are now marketing OFSP.

One of the most successful outcomes is Bagyabasaaga women-farmers' group in Luwero district in central Uganda, specializing in OFSP. The group's initial objective was to promote the production and consumption of OFSP rich in beta-carotene (a precursor of Vitamin A) in order to improve the health of the communities, especially children and women. Before involvement in the PMCA, the group found it difficult to sell the extra OFSP they produced. Through the PMCA process, the group linked up with two processors, which purchased the extra OFSP they produced. The first outlet was a flour processor that uses dry OFSP

■ **Using the Participatory Market Chain Approach (PMCA) to Generate Pro-Poor Innovations in the Sweet Potato Sector in Uganda**
B. Akello, I. Mugisa, W. Nakyagaba, M. Nampeera, P. Lusembo and D. Magala

chips, and the second was a major snack processor, which started to produce a fried snack from OFSP. They have subsequently built business relationships that have increased sales and competitiveness of sweet potato, in turn improving their incomes.

Contributions to Knowledge, Skills and Attitudes

As a result of participating in the PMCA project, R&D actors reported many changes in knowledge, attitudes and skills. At Mukono ZARDI, the staff appreciated PMCA as a more effective approach for linking farmers to markets and for fostering market-driven innovation than other approaches they were familiar with. They also appreciated the concepts and tools associated with the PMCA, for example, facilitation skills, rapid market appraisals, key-informant interviewing, and focus-group research.

Beyond the core team, participating extension workers, farmers, traders and exporting firms in general reported that they had gained useful information and personal knowledge on a range of topics, for example, about Ugandan R&D organizations, the commodities they were working on, production and post-harvest technologies, market concepts, and innovation processes.

Farmers in particular obtained useful information from other producers or R&D workers for dealing with production or marketing problems—not only on sweet potato, but also for other crops and livestock activities. It was frequently noted that farmers and small-scale traders and processors had gained self-confidence and became more assertive during the process. At the outset, they couldn't imagine sitting at a table with researchers or important market agents, discussing their ideas or concerns, and having their views respected. By the end of the process, many of these individuals had developed a voice and expected to be heard.

DISCUSSION AND CONCLUSIONS

The use of PMCA in Uganda demonstrated that the process can generate innovations quickly. Capacity has also been built for future innovation processes. All the innovations created more market opportunities for rural farmers, especially women, to supply the sweet potato demanded by the processing and fresh-roots markets.

The process demonstrated a departure from the way R&D is usually carried out, that is, a change not only in knowledge and skills, but also in assumptions and attitudes. Learning in detail how commodities were produced, traded, processed and sold to final consumers, and being challenged to devise means of improving the livelihoods of market-chain actors was a new experience. Such personal changes in R&D actors could not have

been achieved from reading a book or participating in a workshop. This usually requires some sort of 'eye-opening' experience (Mezirow, 1991, 2000). This was achieved through partners visiting the Andes to meet with those who had developed the PMCA and to see the results firsthand. Also, arranging for farmers and other market-chain actors to visit other segments of the market chain, like processing facilities, wholesale markets and supermarkets, enabled them to receive new insights and perspectives on their own roles in the market chain.

■ **Using the Participatory Market Chain Approach (PMCA) to Generate Pro-Poor Innovations in the Sweet Potato Sector in Uganda**
B. Akello, I. Mugisa, W. Nakyagaba, M. Nampeera, P. Lusembo and D. Magala

The PMCA in Uganda has great prospects for use with other commodities both within and outside Uganda in facilitating pro-poor market innovation. Horton (2008) assessed the PMCA applications in Uganda and concluded that other countries in Sub-Saharan Africa could benefit from the PMCA in the same way that Uganda is benefiting. However, the most critical factor is the presence of an R&D organization that is committed to leading the PMCA process and having the resources needed to do so.

Acknowledgements

Funding for this work was provided by the Department for International Development (DFID, UK), International Potato Center (CIP), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and the National Agricultural Research Organisation (NARO).

Literature Cited

- Bernet, T., Thiele, G. and Zschocke, T. 2006.* Participatory Market Chain Approach (PMCA) User Guide. International Potato Center (CIP), Lima, Peru.
- Horton, D. 2008.* Facilitating Pro-poor Market Innovation: An Assessment of the Participatory Market Chain Approach in Uganda. International Potato Center (CIP), Lima, Peru.
- KIT and IIRR 2008.* Trading Up: Building Cooperation Between Farmers and Traders in Africa. Royal Tropical Institute, Amsterdam, and International Institute of Rural Reconstruction, Nairobi.
- Mezirow, J. 1991.* Transformative Dimensions of Adult Learning. Jossey-Bass Publications, San Francisco.
- Mezirow, J. 2000.* Learning as Transformation: Critical Perspectives on a Theory in Progress. Jossey Bass, San Francisco.
- Shepherd, A. 2007.* Approaches to linking producers to markets. Agricultural Management, Marketing and Finance Occasional Paper 13. Food and Agricultural Organization of the United Nations, Rome, Italy.

An Agro-biotechnology System for Improving Traditional Land-use System in Sub-Saharan Africa

Abiodun Olusola Salami¹

Keywords: resource-poor farmers, alley-cropping, VAM, PRA, hedgerows

Abstract

Participatory rural appraisal (PRA) was used to identify the constraints to agricultural production, likes and dislikes of the farmers, and trends in crop cultivation. The experiment for cassava was carried out in three farmers' farm sites, in alley-cropping systems. The trees served as the main blocks, while vesicular arbuscular micorhizzal (VAM) fungi served as the subplots. The experiment was a split-plot and plot size 20 m × 20 m with three replicates, while for soya bean the size of each farm was 15 m × 17 m where each farmer divided his or her farm into two plots which were designated inoculated and uninoculated. Inoculation with VAM fungi increased fresh root tuber yield of alley-cropped cassava over uninoculated alley-cropped cassava. Despite the fact that neither pruning nor inorganic fertilizers was applied, soya bean inoculated with VAM recorded a higher yield than the uninoculated plants in all villages. This result enhanced farmers' confidence in the use of VAM fungi, as they are now aware of the tremendous benefits to be derived from the use of effective VAM fungi in growing their crops because the experiments are researcher-farmer co-managed to emphasize the importance of participatory research.

¹ Department of Crop Production and Protection, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria.

INTRODUCTION

In the 21st century, the goals of reducing hunger, starvation and poverty, while at the same time building social and political security, remain central to any form of development in Africa (Emerton and Maganya, 2000). Improving agricultural productivity of the soils in Sub-Saharan Africa has been a major concern for some time now (Oyetunji, 2001). Continuous cultivation of these soils without adequate soil-nutrient replenishment has resulted in steady declines in crop productivity (Salami, 2007). Continuous cultivation relies solely on rotation of crops in fields rather than long periods of fallows. Also, the land area per capita is continually declining, because of rapid population increase and other economic changes. National Agricultural Extension and Research Liason Services (NAERLS) and the Agricultural Development Project (ADP), which are close to the farmers, have canvassed the adoption of chemical fertilizer in order to improve the traditional land-use system. The negative consequences of the application of inorganic fertilizers have, however, been shown in many studies. Since intensive smallholdings by peasant farmers dominate farming enterprise in most of the tropics, the option of using chemical fertilizer to raise productivity is no longer feasible due to the problems of affordability and accessibility for these poor peasants (Dixon, 2002). In developing agro-biotechnology in developing countries in general, and in Sub-Saharan Africa in particular, it is imperative to consider the needs of small-scale farmers, and their level of awareness and know-how (Osonubi, 1999). Other major constraints in

Sub-Saharan Africa are soil productivity maintenance and its capacity to grow food crops, which have been in decline because of the declines in soil fertility and traditional land-use systems (Salami and Osonubi, 2003). In recent times, rapid demographic and economic changes have caused expansion of the cultivated area into marginal soil types and reduction of fallow periods, resulting in systematic degradation of major land areas and declining yields. This is heightened by unavailability of agricultural inputs to support the infertile soils. In addition, most soils in Sub-Saharan Africa are sandy, low in organic matter content and susceptible to soil erosion and compaction (Salami and Osonubi, 2006).

Vesicular arbuscular micorhizae (VAM) help maintain and improve soil structure, the uptake of relatively immobile elements, both macronutrients (phosphorus) and micronutrients (zinc), the alleviation of aluminium and manganese toxicity, the interactions with other beneficial soil organisms (nitrogen-fixing rhizobia), and improved protection against pathogens (Osonubi, 1999). Mycorrhizal management through agroforestry is often a better option than other farming systems. Hence, this study demonstrates a mycorrhizal agro-biotechnology system for generating higher or sustainable yields per unit of land, while preserving the resource base of resource-poor farmers in Sub-Saharan African.

MATERIALS AND METHODS

Several field experiments were carried out based on participatory rural appraisal (PRA). This involved carrying out a survey in selected villages, especially in areas where the farmers were already participating in ADP on-farm trials in Oyo, Osun, Ondo and Ekiti states of south-western Nigeria. All farmers were invited to a meeting where semistructured interviews were conducted. Questions covered major constraints to agricultural production, major crops and cultivars grown, soil-conservation and soil-fertility practices, land use, land tenure system, gender distribution of farm activities, agroforestry types and other farming systems

in practice. Farmers' plots with gravelly soil were visited and selected from different villages on the basis of an assessment of their lands and the preparedness of each farmer not only to make available a small portion (20 m × 20 m plot) for the establishment of on-farm agroforestry and other farming trials, but also their willingness to manage the farms as necessary. The villages covered in this study were: Agboye, Ajibode, Apata-Olukole, Ilumokin and Lahan. Farmers were trained on the production of VAM fungi in the villages used for this study.

The experiment for cassava was carried out on three farmers' farm sites (in Ajibode, Agboye and Lahan), in alley-cropping systems where *Gliricidia sepium*, *Leuceana luecocephala* and *Senna siamea* were used as hedgerow trees. The experiment was a split-plot with a plot size 20 m × 20 m, where the trees served as the main blocks and VAM fungi served as the subplots; there were three replicates. All the inoculated or uninoculated plots were mulched (0.5 tonnes dry matter/ha) with mulch from their respective hedgerow trees depending on the treatments. At 12 months after planting, fresh roots of cassava tubers were harvested, the yields from each village were quantified by averaging the yields, and the data analysed.

For soya bean, the experiment was carried out in five villages where there had been mycorrhizal demonstration and farmers had previously used the mycorrhizal biotechnology to plant cassava or maize—*Agboye, Ajibode, Apata-Olukole, Ilumokin and Lahan*. The experimental design was such that each farmer divided his or her farm into two plots, which were designated inoculated and uninoculated, with each plot being 15 m × 17 m. Each soya bean seed was inoculated with 25 g crude mycorrhizal inoculum of *Glomus etunicatum* at planting. The VAM used for inoculation was propagated by the farmers themselves. During the growing period, neither pruning nor fertilizer was applied to the soya bean crops. Hence, the soya bean crop depended entirely on its fixed nitrogen in the nodules. After 3 months of growth, the seeds were harvested and the yields from each village were quantified by averaging the yields.

RESULTS

The interviews revealed that the most important constraints to crop production in the villages were low soil fertility, scarcity and high cost of inorganic chemical fertilizers, as well as pests and diseases, and transport problems. The Baale or head of each village is the one who allocates land for farming to new settlers. There were no indications of any restrictions regarding planting of trees once the land has been allocated. It was discovered that when VAM agro-biotechnology was introduced (Fig. 1 and 2), no farm was left fallow (at least for the period of this study, which lasted for 3 years) and the crop yield was either maintained or increased with every year of cultivation.

Farmers found that VAM inoculations with application of legume-tree clippings can substitute for NPK fertilizer, as VAM inoculation produced significantly higher tuberous root yield than uninoculated cassava in alley cropping (Fig. 3 and 4). Similarly, VAM inoculation significantly increased yields of alley-cropped cassava in all three farms (Graph 1–3). Soya bean inoculated with VAM gave a higher yield than uninoculated soya bean in all villages (Graph 4). The highest-yielding uninoculated soya bean was in Ajibode.

Fig. 1: Training farmers on Mycorrhiza propagation



Fig. 2: Farmers propagating Mycorrhiza Inoculum themselves



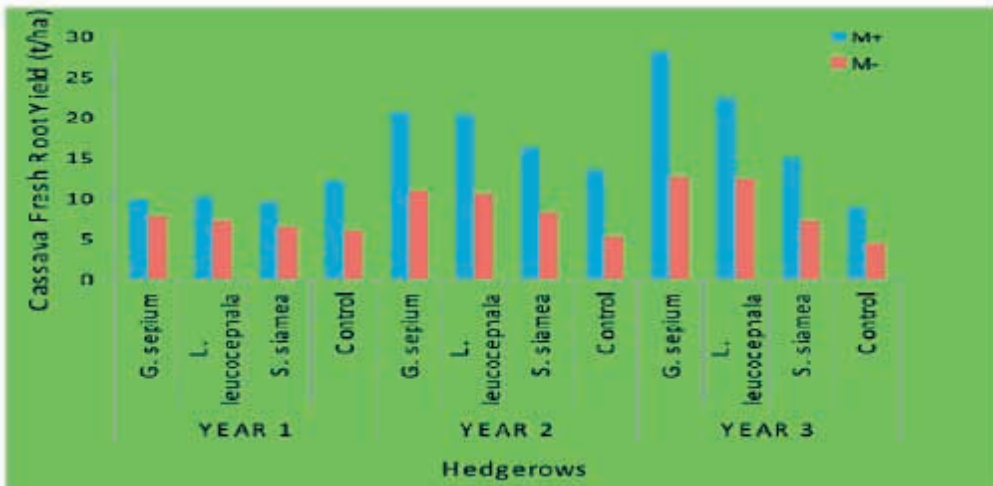
Fig. 3: Non-mycorrhizal cassava tubers



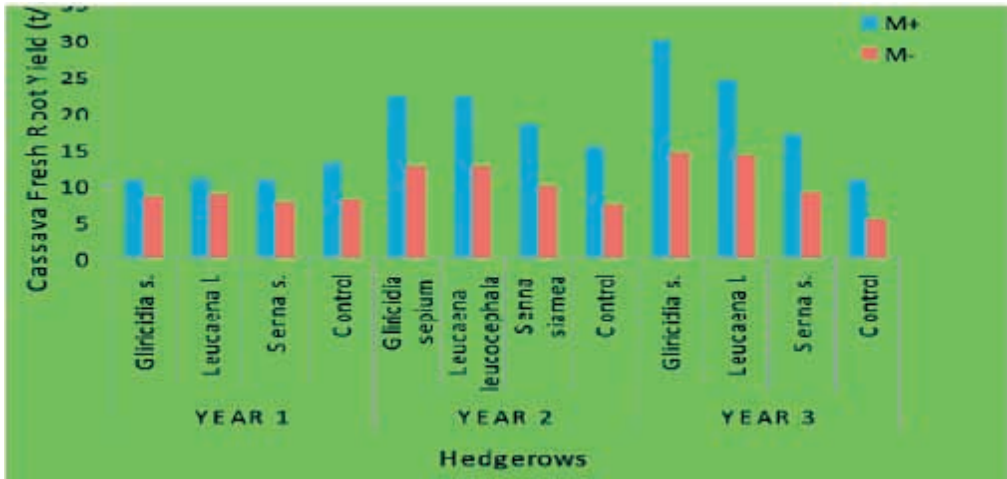
Fig. 4: Mycorrhizal cassava tubers



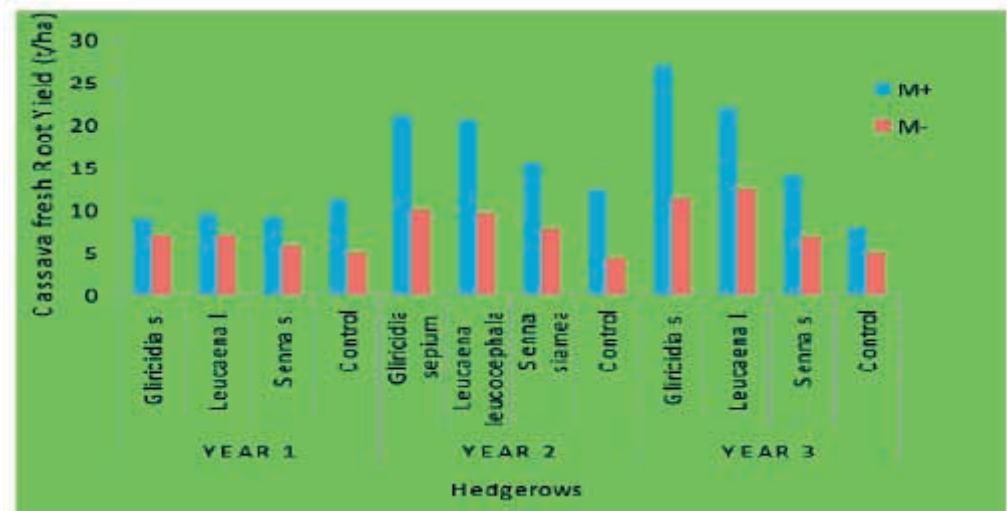
Graph 1: Fresh root-tuber yield of cassava in Agboye village



Graph 2: Fresh root-tuber yield of cassava in Ajibode village



Graph 3: Fresh root-tuber yield of cassava in Lahan village



DISCUSSION AND CONCLUSION

The yield increase of inoculated cassava in alley cropping could be attributed to more translocation of the nutrient released from decomposing leaves of the hedgerow trees to the mycorrhizal-inoculated cassava. The contribution of VAM alone without hedgerow trees or even their clippings was also found to be considerable in these experiments. This lends credence to the findings of previous workers (Bryla and Duniway, 1997). The results obtained on cassava tuberous yield in on-farm experiments in Ajibode, Agboye and Lahan for 3 years confirmed that cassava benefits from mycorrhizal inoculation (Oyetunji, 2001).

The inoculated soya bean yielded significantly higher than the uninoculated plants. The results of this

investigation confirmed the fact that soya depends mainly on efficient mycorrhizal association for nutrient uptake, particularly of P, and for improved growth in low available-P soil (Habte and Osorio, 2003). The implication of these results is that crops may be VAM inoculated for better performance and that indigenous mycorrhizae are not always very effective due to their low concentrations in the soil (Salami and Osonubi, 2006). The effectiveness of VAM in alley cropping in improving cassava economic yield demonstrated the value of agroforestry in that VAM fungus acts as the link between the soil and the crops, and they also mediate nutrient fluxes between legume and non-legume in associations (Salami and Osonubi, 2003). This makes the practice of VAM inoculation an efficient technology for crop production in both short- and long-term cultivations. This can be seen in the fact that soya bean inoculated with VAM recorded a higher yield than the uninoculated plants in all villages (Fig. 4), despite the fact that neither pruning nor inorganic fertilizer were applied to the soya bean crop.

The uninoculated soya bean in Ajibode apparently gave a higher yield than those of other villages. This can be attributed to the fact that the plots had been under agroforestry cultivation for some years and this had improved the plant's and the soil's health, as well as their productivity and soil conservation. In this study, we established that VAM can extract nutrients beyond the terminal zone of the roots and that the combination of VAM inoculation and alley cropping is a technology that, if properly developed, will alleviate the problems of food insecurity and improve the traditional land use system in Sub-Saharan Africa. The major obstacle in using mycorrhizae is the inability to produce large quantities of the inoculum and the cost of transporting it. This could be alleviated by organizations like the ADPs and NAERLS, who should educate the resource-poor farmers on how they can obtain and produce mycorrhizal inoculum in large quantities on their farms. Awareness should further be created that when the inoculum is well propagated on their farms, the productivity of the land will positively and encouragingly improve.

References

- Bryla, D.R. and Duniway, J.M. 1997.* Growth, phosphorus uptake and water relations of safflower and wheat infected with an arbuscular mycorrhizal fungus. *New Phytol.* 136: 581–590.
- Dixon, G.R. 2002.* Suppressing soil borne pathogens through biostimulation. Paper presented at the XXVIth International Horticultural Congress Symposium on Citrus and other Sub-tropical and Tropical Fruit Crops, 12–16 August, Toronto, Canada.
- Emerton, L. and Maganya, J. 2000.* Report of the First Eastern and Southern Africa Regional Biodiversity Forum: Using Biodiversity to Strengthen Livelihoods, Mombasa, Kenya. IUCN, Eastern Africa Regional Office, Nairobi.
- Habte, M. and Osorio, N.W. 2003.* Producing and applying arbuscular mycorrhiza inoculum. *Ecoliving Centre* 102: 1–4.
- Oyetunji, O.J. 2001.* The role of vesicular arbuscular mycorrhizae and woody legumes on sustainable cassava (*Manihot esculenta* Crantz) and maize (*Zea mays* L.) production in a derived savanna eco-system. PhD Thesis, University of Ibadan, Ibadan.

Climate Change in Africa, Based on Tree Rings and Stable Isotope Results, and its Potential for Climatic Teleconnections

Aster Gebrekirstos¹

Keywords: Acacia species, climate change, drought, dendrochronology, Ethiopia

Abstract

There is a growing need to develop long-term regional and sub-regional climate data, for proactive adaptation management of climate-change risk. However, in Africa, long-term climate information is still sorely lacking. Tree rings and stable carbon isotopes ($\delta^{13}\text{C}$) have the potential to provide empirical data regarding past climatic events. In this paper, the potential of tree rings and $\delta^{13}\text{C}$ as proxies for climate reconstructions in Africa is described. High correlations were found between the tree-ring chronologies and precipitation data, which demonstrates their potential to reconstruct precipitation in semi-arid tropics. When strong declines in tree-ring width were compared with past El Niño–Southern Oscillation (ENSO) events and drought/famine periods in Ethiopia, they showed a remarkable relation. Spectral analysis of the master tree ring indicated occurrences of periodic drought events, which fall within the spectral peak equivalent to 2–8 years. A declining trend with time was observed in $\delta^{13}\text{C}$ series, notably for *Balanites aegyptiaca* and could be attributed to anthropogenic increases in the concentration of CO_2 in the atmosphere. The results demonstrate the potential of tree-ring width and $\delta^{13}\text{C}$ to understand past and future climate changes.

¹ Georg-August University of Göttingen, Institute of Silviculture, Sect. II: Tropical Silviculture, Büsgenweg 1, D-37077 Göttingen, Germany.

INTRODUCTION

Climate change is now recognized to be a global threat. Scenarios derived from global change models for emission scenarios indicate temperature rise and water scarcity in most parts of Africa. Moreover, climate change is expected to place considerable additional stress on the biophysical, economic, political and social systems that determine livelihood security in Africa. Climate change will affect all sectors of society, especially the rural poor, and especially from the human health and agricultural perspectives. To become sustainable, societies will have to avoid extreme climatic changes, and to adapt to the climate change that does occur. Moreover, Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capacity. Accordingly, there is a growing need for proactive adaptation management of climate-change risk. Successful adaptation requires the best available information concerning the nature of future climate risks. Although a number of proxy data series have been developed from temperate and subtropical regions to trace the course of environmental and climatological fluctuations, precise palaeo-climate records from the tropics, notably from Africa, are still sorely lacking. Therefore, it is vital to identify potential climate proxies that could provide empirical data regarding past climatic events and that climate science is used more effectively in adaptation decision-making—this is one of the major goals of my research. I sought interactions between atmosphere and vegetation because the ongoing changes in climate would affect plant–atmosphere interactions. At the same time, plants will continue to respond to all the changes and their responses can be uncovered from tree rings and stable carbon isotopes in tree rings ($\delta^{13}\text{C}$).

Tree rings have long been acknowledged as indicators of annual climatic information. Radial growth responses can indicate the reactions of trees to past periodic droughts (Orwig and Abrams, 1997), and provide an eco-physiological record of past climate and ecological conditions and El Niño–Southern Oscillation (ENSO) events (Cook, 1992). For instance, Bradley and Jones (1993) reconstructed Northern Hemisphere summer temperatures back to AD 1400 by using a combination of historical, tree-ring and ice-core data, and found recent conditions to be very warm relative to the past. Briffa et al. (1995) reviewed high-resolution temperature histories from tree-ring and coral proxies to infer that the twentieth-century summer warmth was unusual relative to the previous millennium. $\delta^{13}\text{C}$ has also been demonstrated as a potential proxy indicator of past climatic conditions (e.g. Francey and Farquhar, 1982; Leavitt and Lara, 1994; Monserud and Marshall, 2001). In this paper, the potential of tree rings and $\delta^{13}\text{C}$ as a tool for climate reconstructions in Africa are summarized in the context of a case study in Ethiopia.

MATERIALS AND METHODS

Study Area and Species

The study was undertaken in Ethiopia, where symptoms of the adverse effects of recurrent droughts are visible on the livelihood of the local population. The specific study site was in the Acacia woodland in Abernosa ranch, which is located within the upper Rift Valley lakes sub-region about 170 km south of Addis Ababa, at an elevation of about 1600 m. The major and minor rainfall periods are June–September and April–June, respectively. Annual precipitation ranges between 550 and 900 mm. The mean annual temperature is 20.7°C. Acacia species are the major components of the vegetation in arid and semi-arid parts of Africa. Hence, the study was focused on the dominant trees in arid and semi-arid Ethiopia, namely, *Acacia tortilis* (Forssk.) Hayne, *A. seyal* Del., *A. senegal* (L.) Wild. and *Balanites aegyptiaca* (L.) Del. The

acacias are drought deciduous and are members of the family Fabaceae, while the evergreen *Balanites aegyptiaca* belongs to the family Balanitaceae.

Tree-ring Width Measurements and Building Master-site Chronology

For each species, up to seven stem disks were collected from fallen trees of known felling age. The surfaces of the stem disks were sanded gradually using sand paper of grit size 80 to 600 to prepare the samples for measurement. After identifying the growth boundaries, tree-ring structure was measured to the nearest 0.01 mm with a semi-automatic device. The cross-dating of the tree-ring series was further checked with the computer program Time Series Analysis and Presentation (TSAP) (Rinn and Jäkel, 1997). Hence, successfully crossdated mean ring width series of different samples (trees) were averaged to build species-specific mean chronologies. Finally, a master-site chronology of 68 years was constructed by calculating the mean of the four species. In order to eliminate tree age-related growth trends and inconsistent disturbances among trees, the tree-ring width series was standardized by division of a one-sided running mean of 5 years (Schweingruber, 1988).

Stable Carbon Isotope Measurements

For stable-isotope measurements, three stem disks were used for each species and 1 mg of powdered wood prepared for each year. The $\delta^{13}\text{C}$ was measured on line using an NA 2500 elemental analyzer (CE Instruments, Rodano, Italy), linked with an isotope-ratio mass spectrometer, at University of Göttingen, Germany. Variations of isotope ratios $\delta^{13}\text{C}$ are expressed in δ -notation, i.e. the relative deviation from the PDB (Pee Dee Belemnite) standard and given as: $\delta^{13}\text{C} = [(13\text{C}/12\text{C})_{\text{sample}} / (13\text{C}/12\text{C})_{\text{PDB}} - 1] \times 1000\%$

Data Analysis

The indexed mean ring width and $\delta^{13}\text{C}$ chronologies were compared with indexed values of precipitation data. Precipitation and temperature data recorded since 1980 were obtained from a weather station at Adamitulu, and for the period of 1930–1980 from the National Center for Atmospheric Research (<http://ncardata.ucar.edu/datasets>). Spectral analysis of the master tree-ring width chronology was also carried out to examine periodic events in time series (Jenkins and Watts, 1968). STATISTICA for Windows (Version 6.0) was used for the data analysis. Unless otherwise stated, results are statistically significant at $P < 0.05$.

RESULTS

Site Master Chronology, Drought Periods and ENSO Events

All studied tree species form distinct tree-ring boundaries. The growth ring boundaries of the acacias are characterized by thin parenchyma bands that run around the entire stem disc. A thin parenchyma band and the accumulation of vessels characterize tree rings of *B. aegyptiaca*. The master chronology showed similar annual patterns to seasonal precipitation (Fig. 1) and also strong positive significant correlation with rainy season ($r=0.61$) and total annual precipitation ($r=0.59$). A close look at the master ring-width curve indicated that tree-ring width declined between 1942 and 1945. In contrast, the ring width increased in wet years, notably from 1946 to 1950.

There were distinct pointer years with narrow rings in 1951/52, 1955–1957, 1962 and 1965/66. Despite some recovery in 1971, 1975 and 1980/81, there was a slow down in growth from 1970 to 1985, with sharp declines in 1970, 1972/73, 1977–1979 and 1984/85; then frequent narrow rings appeared every 2–3 years in the 1990s, with sharp decline in 1991. When strong declines in tree-ring width were compared with past ENSO events and drought/famine years in Ethiopia, they showed a remarkable correlation. Table 1, Fig. 1 and 2). Single-spectrum analysis of the master chronology, for the period 1937–2002, also revealed periodically recurring events. Peaks of high spectral power were in the frequency areas of 0.14, 0.22, 0.35 and 0.45 equivalent to periods of 7.1, 4.6, 2.7 and 2.2 years, respectively.

δ13C and Climate

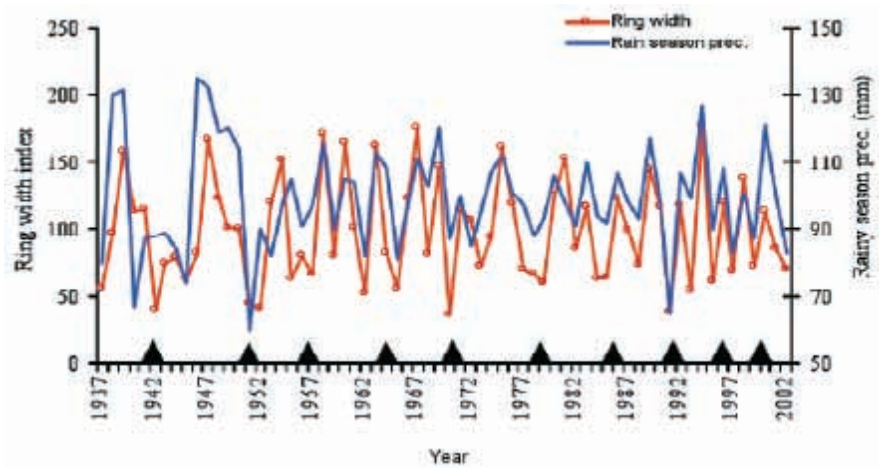
The master δ13C series showed excellent agreement and correlation ($r=-0.82$) with the rainy season series. The enriched δ13C values were obtained during extreme drought and ENSO years (e.g. 1978–79, 1984–85, 1991 and 1997) compared to other years (Fig. 2). The series of *B. aegyptiaca* showed a strong declining trend ($R^2 = 0.47-0.63$, with a mean value of 0.58) and, particularly, an abrupt decline starting in 1992. Temperature and relative-humidity data of 17 years and δ13C values were also considered. For all the species, neither temperature nor relative-humidity data were significantly correlated to δ13C or tree-ring width series (values not shown).

DISCUSSION AND CONCLUSION

The tree-ring and δ13C series correlates very strongly with precipitation (up to $r=-0.82$)—that is hardly found in temperate regions. This was possible since many tropical areas have at least 2 months of arid conditions, which can trigger formation of growth boundaries (Gebrekirstos et al., 2008). In addition, moisture stress may have a direct impact on the stomatal conductance and explains the strong negative relationship between δ13C and precipitation. This indicates that tree-ring width and δ13C ratios are good proxies for reconstructing precipitation in semi-arid tropics. A declining trend with time was observed in δ13C, notably for *B. aegyptiaca*. Similar time-dependent long-term decline in 13C were observed in the Northern (Monserud and Marshall, 2001; Li et al., 2005) and Southern (Leavitt and Lara, 1994) hemispheres, and are attributed to anthropogenic increases in the concentration of CO₂ in the atmosphere, which have resulted in a lowering of the 13C value of air by about 1.5‰ since industrialization. As anthropogenic increase in the concentration of CO₂ appears to be a global effect, it could also contribute to the declining trend of δ13C series in Africa.

Drought has affected millions of people in Ethiopia and its impact, in the form of famine, has been felt for a long time. This is evident by the high frequency of narrow rings and the incidence of large growth depressions in the 1970s and 1980s in the tree-ring chronologies. Similarly, the more enriched carbon-isotope values correspond with the extreme drought years, for instance 1984–85 (the worst famine tragedy in Ethiopia) and 1991. The drought frequency has increased since the 1990s. The ENSO effect and drought or famine years in Ethiopia are associated with the occurrence of narrow rings, i.e. pointer years and enriched δ13C ratios (Fig. 1 and 2). However, consistent with the occurrence of drought years in relation to the El Niño years (Wolde-Giorgis, 1997), some pointer years coincided with and some followed ENSO years. The spectral analysis of the master tree-ring analysis also revealed occurrences of periodic drought events. These peaks fall within a spectral peak equivalent to 2–8 years, which characterize the variability of ENSO-related time series (e.g. Schöngart et al., 2004). This suggests agricultural productivity would be affected every 2–8 years.

Fig. 1: Master ring width indices and rainy season precipitation (June to September)

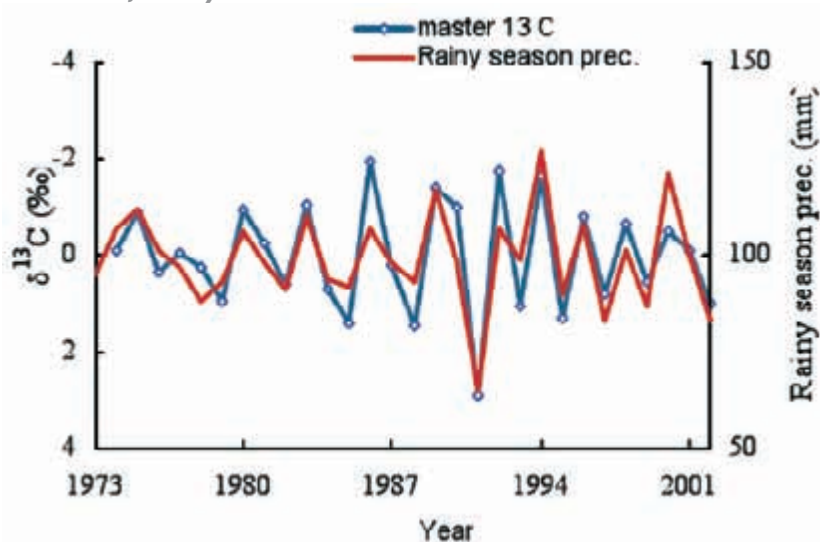


Arrow indicate pointer years (Gebrekirstos et al., 2008)

Table 1: Tree-ring pointer years compared with chronology of ENSO events and drought in Ethiopia (Gebrekirstos et al., 2008)

Pointer years	El Niño years	Drought/famine	Region(s)
1933–1934	1930–1932	1932–1934	Ethiopia
1942–1945	1939–1942	not reported	
1951–1953	1951–52 / 53–54	1953	Tigray and Wollo
1955–57	1957–1958	1957–1958	Tigray and Wollo
1962	1963	not reported	
1965	1965/66	1964–66	Tigray and Wollo
1970	1969–1970	1969	
1972–1973	1972–1973	1973–1974	Tigray and Wollo
1977–1979	1976–1977	1978–79	
1984–1985	1982–1983	1984–1985	Ethiopia
1988	1986–87	1987–1988	Ethiopia
1991	1991–1992	1991–1992	Ethiopia
1993	1993	1993–1994	Tigray, Wollo, Addis
1995	1994–1995	not reported	
1997	1997–1998	1997–1998	Ethiopia
1999		not reported	
2002		2002	Ethiopia

Fig. 2: $\delta^{13}\text{C}$ indices and rainy season precipitation (June to September) (Gebrekirstos et al., 2008)



The results demonstrate the potential of ring width and $\delta^{13}\text{C}$ in tree rings to reflect physiological responses to environmental changes as a vehicle for palaeo-climatic reconstruction, which is important to understand past and future climate changes. As climate change will affect all sectors of society, interdisciplinary and international collaborations are needed to extend research frontiers and to develop regional and sub-regional climate models at a scale for climatic teleconnections that would be meaningful to decision-makers. To this funded by the German Research Foundation (DFG), entitled Climate Response of Tree Growth in Ethiopia Along an Altitudinal Transect and Implications on Local Climate and Regional Atmospheric Circulation Dynamics. The final goal is the reconstruction of climate variability during historic times along an elevation gradient and of the large-scale interactions with the Asian Summer Monsoon (ASM) circulation during El Niños and La Niñas.

Similarly, a project Adaptation of Land Use to Climate Change in Sub-Saharan Africa (ALUCCSA) coordinated by Center for Tropical and Subtropical Agriculture and Forestry (CeTSAF), Georg-August Universität, Göttingen, Germany is running in Burkina Faso. ALUCCSA is funded by BMZ (Ministry of Technical Cooperation of the Federal Government of Germany) and aims to develop climate-change scenarios for the next 100 years on a regional/local scale for Sub-Saharan Africa. The goal is to achieve ready-to-use scenarios and recommendations for agroforestry and silvopastoral ecosystems on a highly resolved spatial scale.

The tree-ring series developed in the applied projects will be combined with tree-ring series formerly established by project partners in the Middle East (Iran) and southern Asia (Nepal, Tibetan Plateau). Additional tree-ring series from tropical South America (Ecuador) are being established within a ongoing project. Altogether this tree-ring network surrounds the Indian Ocean and the tropical eastern Pacific and can therefore be used to establish largescale correlation patterns between tree growth and sea-surface temperatures in order to explore global processes. These findings could help in the identification and

interpretation of extreme environmental and climatological events and the way societies and ecosystems respond to them in longer-term records, for which no historical meteorological records are available. The current study has thus indicated the potential of tree rings and stable isotopes for climate reconstruction in Africa.

Acknowledgements

The study was financed by the German Academic Exchange Service (DAAD), which is gratefully acknowledged. I thank Wondo Genet College of Forestry, Göttingen University and Abernosa Ranch for all their support. The support of Prof. Dr Ralph Mitlöhner and Dr Demel Teketay during the study is greatly acknowledged.

Literature Cited

- Bradley, R.S. and Jones, P.D. 1993.* 'Little Ice Age' summer temperature variations: their nature and relevance to recent global warming trends. *The Holocene* 3: 367–376.
- Cook, E.R. 1992.* Using tree rings to study past El Niño Southern Oscillation influences on climate. p. 203–214. In: F.H. Diaz and V. Markgraf (eds.), *El Niño: Historical and paleoclimatic aspects of the southern oscillations*. Cambridge University Press, New York.
- Briffa, K.R., Jones, P.D., Schweingruber, F.H., Shiyatov, S.G. and Cook, E.R. 1995.* Unusual twentieth-century summer warmth in a 1,000-year temperature record from Siberia. *Nature* 375: 156–159.
- Gebrekirstos, A., Teketay, D., Fetene, M., Worbes M., Mitlöhner R. 2009.* Stable carbon isotope ratios in tree rings of co-occurring species from semi arid tropics in Africa: patterns and climatic signals. *Global Planetary Change* 66: 253-260.
- Gebrekirstos, A., Mitlöhner, R., Teketay, D. and Worbes, M. 2008.* Climate-growth relationships of the dominant tree species from semi-arid savanna woodland in Ethiopia. *Trees* 22: 631–641.
- Francey, R.J. and Farquhar, G.D., 1982.* An explanation of $^{13}\text{C}/^{12}\text{C}$ variations in tree rings. *Nature* 297: 28–31.
- Orwig, D.A. and Abrams, M.D. 1997.* Variation in radial growth responses to drought among species, site and canopy strata. *Trees* 11: 474–484.
- Schweingruber, F.H. 1988.* *Tree Rings: Basics and Applications of Dendrochronology*. Kluwer Academic, Dordrecht.
- Schöngart, J., Junk, W.J., Piedade, M.T.F., Avres, J.M., Huttermann, A. and Worbes, M. 2004.* Teleconnection between tree growth in the Amazonian flood plains and the El Niño-southern oscillation effect. *Global Change Biology* 10: 1–10.
- Jenkins, G.M. and Watts, D.G. 1968.* *Spectral Analysis and its Applications*. Holden-Day, San Francisco.
- Monserud, R.A. and Marshall, J.D. 2001.* Time-series analysis of $\delta^{13}\text{C}$ from tree rings. I. Time trends and autocorrelation. *Tree Physiology* 21: 1087–1102.
- Rinn, F. and Jäkel, S. 1997.* *TSAP, Reference Manual*. TSAP, Heidelberg, Germany.
- Li, Z.H., Leavitt, S.W., Mora, C.I. and Liu, R.M. 2005.* Influence of earlywood-latewood size and isotope differences on long-term ring $\delta^{13}\text{C}$ trends. *Chem. Geology* 216: 191–201.
- Leavitt, S.W. and Lara, A. 1994.* South American tree rings show declining $\delta^{13}\text{C}$ trend. *Tellus* 46B: 152–157.
- Wolde-Georgis, T. 1997.* El Niño and drought early warning in Ethiopia. <http://ccb.colorado.edu/ijas/ijasno2/georgis.html>.

Pesticide Risk Reduction Strategies for Vulnerable African Populations through Regulatory Capacity Building and Gender Appropriate Risk Communication Strategies

Hanna-Andrea Rother¹

Keywords: pesticide label, Africa, pesticide regulators, risk communication

Abstract

Pesticides are perceived as effective in increasing agricultural productivity and promoting the economic livelihoods of poor farmers in Africa. However, there is less understanding on how the negative health impacts of pesticides on farmers, particularly women farmers and farm workers, impede agricultural productivity. In order to protect vulnerable populations, especially women, from short- and longterm health effects associated with pesticides, regulations on pesticides and riskcommunication tools must be effective and appropriate. Two initiatives in Africa are addressing these concerns by promoting capacity-building of African regulators through electronic networking (supported by occasional workshops) and evaluating the pesticide label as a risk-communication tool. Regulators of pesticides in Africa currently do not have the capacity or resources to effectively mitigate risks associated with pesticide use. Pesticide labels in Africa use pictograms to communicate risks associated with pesticides and precautionary behaviour recommended to reduce these risks. However, only 50% of farm workers interviewed were able to provide a technically correct definition for these pictograms. Furthermore, there is a gendered differentiation in interpreting riskcommunication elements on pesticide labels. These projects highlight the need for pesticide regulation capacity-building and gendered pesticide-risk communication strategies appropriate for the African pesticide use context.

¹ Occupational and Environmental Health Research Unit, School of Public Health and Family Medicine, University of Cape Town, Anzio Rd, Observatory 7925, South Africa.

INTRODUCTION

Pesticides are often perceived as an effective means for increasing agricultural productivity and promoting the economic livelihoods of poor farmers in Africa. What is less focused on is how the negative health impacts of pesticides on farmers, particularly women farmers and farm workers, impede agricultural productivity (London and Rother, 2003; Rother et al., 2008). That is, the negative externalities, especially those around short- and long-term health effects from pesticide exposures, are not included in the productivity equation. However, research has shown that women exposed to pesticides both directly and indirectly are put at risk of health effects, such as reproductive dysfunctions, cancer, birth defects in their unborn children, allergies, and immunological effects (Murphy et al., 1999; London et al., 2002; Colosio et al., 2003; Alavanja et al., 2004; Kamel and Hoppin, 2004; Strong et al., 2004; Kishi, 2005). These health effects result in loss of work time, health costs both to women and family members that must be cared for, and lowered productivity from long-term ill health (among other things).

Pesticide regulations are intended to protect all people from the potentially harmful effects of pesticides. However, many African countries lack the resources to develop, evaluate, maintain and upgrade pesticide policies and legislation in order to adequately protect vulnerable populations from pesticide exposure (Rother, 2006; Rother et al., 2008). As a result of inadequate regulations, risk-communication strategies (e.g., pesticide labels) are not evaluated for their effectiveness and appropriateness in developing countries, particularly for illiterate and vulnerable populations (Atreya, 2007). The pesticide label is based on scientific review of a pesticide and regulatory oversight by a government body registering the pesticide, with the aim of conveying technical information plainly and accurately to all end-users (e.g., rural farmers; Rother and London, 2008). The label serves a dual function of providing use and risk-assessment information for risk reduction and product efficacy, while also serving as a legally binding document (that is, penalties can be incurred if the product is used other than as stated on the label; Smith, 2004; Rother, 2008). The label uses written language, pictograms and colour codes as media for communicating risks; they are designed and developed by pesticide companies based in developed countries. Risk-communication tools are designed to transmit technical hazard information universally and cross-culturally (Rother, 2005b). However, one needs to ask whether riskcommunication tools are gender neutral and applicable in all gendered contexts? That is, are there circumstances in which women and men need to be given different (i.e., genderdifferentiated) hazard information? Or does the present hazard information on labels suffice to cover various gendered needs? An analysis of the pesticide label is one means of addressing some of these questions. In this paper, two interlinked projects are presented that aimed at promoting pesticide risk-reduction strategies, particularly for reducing women's health risks. One project focuses on capacity-building of African regulators to promote regulation of pesticides that is informed by current research, incorporates international pesticidereregulation trends and international conventions, as well as promoting risk-communication strategies. The second project assessed the pesticide label as a viable risk-communication tool for illiterate/semi-illiterate vulnerable populations and its relevance for women.

METHODS

Methodology for Project One – Building Pesticide Regulators’ Capacity

Since 2004, an ongoing collaborative project between Tanzanian and South African researchers—the Action on Health Impact of Pesticides Project as part of the Work and Health in Southern Africa (WAHSA) initiative—has been enhancing networking and capacity-building of African pesticide regulators through a dedicated electronic listserver and participatory workshops with regulators. In 2006, WAHSA held a health and policy workshop for African pesticide regulators in Arusha, Tanzania (Rother, 2006). Eleven registrars from eight countries attended the workshop. The use of ‘registrar’ in the title refers to either the actual pesticide registrar or assistant registrars, technical officers, programme managers, inspectors, and similar people, who work closely with the pesticide registrar of the particular country.

This participatory workshop included the unique approach of taking regulators into the WAHSA Tanzanian research site to observe effects and implications of smallscale farmers using pesticides, as well as for fostering discussions between regulators and farmers—regulators actually had the opportunity to interview farmers and observe pesticide-spraying activities at first hand. An outcome of the workshop was the creation of the African Pesticide Registrars electronic listserver, housed at the University of Cape Town. Regulators regularly receive current research on pesticides, updates on relevant meetings, and how particular pesticides are registered in other countries, and they are able to ask regulatory questions of each other and resource persons representing academia, industry and various United Nations bodies. There is no other such resource available to pesticide regulators in Africa providing this capacity and networking support. Messages are sent in English and French. Further capacity-building initiatives are currently taking place, such as workshops and postgraduate distance learning courses for regulators.

Methodology for Project Two – Evaluation of Pesticide Label as a Risk-communication Tool











A survey was carried out in March–May 2003 with farm workers working on commercial grape farms in the Western Cape Province of South Africa in order to evaluate the effectiveness of pesticide labels as a risk-communication tool. The sample consisted of 115 farm workers (46 females and 69 males). Ten pictograms based on riskassessment data and four colour codes based on the World Health Organization’s classification of hazards were evaluated especially in terms of ability of vulnerable populations to comprehend the scientifically intended meanings and their gender relevance (Rother, 2005a). Details of the study population and questionnaire are presented in Rother (2008).

RESULTS

Capacity-building of African Pesticide Regulators

Surprisingly, most of the pesticide regulators had not previously witnessed farmers’ hazardous pesticide use practices and exposures through field observations of farmers applying pesticides. Although many of the African countries represented by workshop participants have pesticide regulations, regulators generally were underresourced to implement these regulations. There are 105 members on the pesticideregulators electronic listserver (at the time of writing, April 2009), which consists of regulators from most African countries and resource persons.

Table 1. Gender variation in comprehension of pesticide label pictograms (percentage correct¹ responses; Rother, 2005a) Effectiveness of the Pesticide

Label pictogram	Total sample (%)	Male (%)	Female (%)
1.  Wear gloves	96.3 (n=105)	94.0 P=0.141† (n=63)	100 P=0.006† (n=42)
2.  Wash after use	91.4 (n=96)	90.8 P=0.355† (n=59)	92.5 P=0.120† (n=37)
3.  Wear boots	71.1 (n=69)	77.4 P=0.070† (n=48)	60.0 $\chi^2=3.59$ P=0.058 (n=21)
4.  Hazardous & extremely hazardous (class Ia & Ib)	90.0 (n=99)	94.1 P=1.00† (n=64)	83.3 P=0.546† (n=35)
5.  Keep locked away & out of reach of children	80.0 (n=72)	84.5 P=0.000† (n=49)	71.9 $\chi^2=5.35$ P=0.047 (n=23)
6.  Dangerous/harmful to livestock & poultry	55.3 (n=42)	63.2 $\chi^2=8.66$ P=0.003 (n=36)	31.6 P=0.484† (n=6)
7. 30/12/2005  Expiry date	23.8 (n=15)	36.4 $\chi^2=1.05$ P=0.305 (n=12)	10.0 P=0.542† (n=3)
8.  Dangerous/harmful to fish & water bodies	44.4 (n=36)	52.5 P=0.259† (n=32)	20.0 P=0.380† (n=4)
9.  Wear respirator	89.8 (n=97)	95.5 P=1.00† (n=64)	80.5 P=0.295† (n=33)
10.  Harmful	39.7 (n=27)	45.0 $\chi^2=3.17$ P=0.084 (n=18)	32.1 P=0.315† (n=9)

¹ Correct category = correct and partially correct responses; Incorrect category = incorrect, critical confusion and "don't know" responses.

† A Fisher's Exact Test was used to calculate this P-value as one or more cells contained less than five respondents.

Label as a Risk-communication Tool

Over half of the respondents had misleading, incorrect and critically confused interpretations of the label pictograms (Rother, 2008). Women were less likely to provide the technically intended definition for all pictograms except two (i.e., the 'wear gloves' and 'wash after use' pictograms; Table 1); in neither case was the women's performance significantly different from the men's, at even the $P \leq 0.1$ level. The definitions women gave for pictograms had less to do with pesticides and more with their broader social and cultural frame of reference (Rother, 2005a, 2008). Under the precautions section of many pesticide labels is often the following statement: "Do not eat, drink or smoke whilst mixing, applying or before washing hands and face." One female respondent, after being asked when one should wash one's hands in order to reduce the harmful effects of pesticides replied "before breast-feeding"; while another woman replied with, "before picking up a child".

CONCLUSION

There is a gendered differentiation in the interpretation of the pesticide label components. Although the pictogram illustrating 'wash after use' is blanket coverage for washing before anything is touched, the text part written on the pesticide label is more specific and limiting. Breast-feeding before washing hands after the person came into contact with a pesticide (e.g., harvesting, cleaning equipment, cleaning a pesticide store room, carrying containers to be burnt) is a potential source of contact exposure for a breast-feeding infant. Although a study respondent called attention to this issue, this is not an issue that has been highlighted or even recognized by industry or pesticide trainers. Perhaps the question to be asked is whether female farm workers need to understand pesticide risks and, ultimately, pesticide labels. The answer to this would be the affirmative, because of women's unrecognized work that exposes them to pesticides. That is, they need to understand exposure, avoiding exposure, re-entry intervals, waiting periods before harvesting, handling pesticide-contaminated clothing, cleaning spray equipment, mixing pesticides, and at times, spraying. Thus, women do need to be able to read and understand pesticide labels, because any female farm worker at any time may be instructed to do pesticide-related tasks.

In order to protect vulnerable agricultural populations, especially women, from pesticide exposure, adequate and effective legislation and policies are required, as well as gender-sensitive pesticide-risk communication strategies. Through an African-driven initiative of building regulators' capacity and regular networking, the groundwork for improved regulation is being laid. Although policies provide the framework for protecting vulnerable populations from pesticide risks, end-users (especially in remote rural areas) need to have access to pesticide-risk information in order to make informed risk decisions. This needs to be done through appropriate risk-communication strategies endorsed and regulated by legislation and policies. However, these strategies need to be context and gender specific, and developed in Africa for African populations. The African pesticide-regulators electronic network provides an example of a structure to emerge from joint regional research and training, affording regulators better access to research findings (national and international), as well as providing researchers with a better opportunity to share policy-relevant research findings with policy-makers. A researcher-driven electronic listserv for pesticide regulators is providing an innovative approach to promoting effective and more appropriate legislation for protecting vulnerable populations such as women and improving pesticide-risk communication tools.

Literature Cited

- Alvanja, M.C.R., Hoppin, J.A. and Kamel, F. 2004.* Health effects of chronic pesticide exposure: cancer and neurotoxicity. *Annual Review of Public Health* 25: 155–197.
- Atreya, K. 2007.* Pesticide use knowledge and practices: a gender difference in Nepal. *Environ. Res.* 104: 305–311.
- Colosio, C., Tiramani, M. and Maroni, M. 2003.* Neurobehavioral effects of pesticides: state of the art. *Neurotoxicology* 24: 577–591.
- Kamel, F. and Hoppin, J.A. 2004.* Association of pesticide exposure with neurologic dysfunction and disease. *Environ. Health Perspectives* 112: 950–958.
- Kishi, M. 2005.* The health impacts of pesticides: what do we now know? In: J. Pretty (ed.), *The Pesticide Detox: Towards a More Sustainable Agriculture*. Earthscan, London.
- London, L. and Rother, H-A. 2003.* Failing laws: assumptions and realities for women in South Africa. In: M. Jacobs and B. Dinham (eds.), *Silent Invaders: Pesticides, Livelihoods, and Women*. Zed Books, London.
- London, L., de Grosbois, S., Wesseling, C., Kisting, S., Rother, H-A. and Mergler, D. 2002.* Pesticide usage and health consequences for women in developing countries: out of sight, out of mind? *Int. J. Env. Occ. Health* 8: 46–59.
- Murphy, H.H., Sanusi, A., Dilts, R., Djajadisastra, M., Hirschhorn, N. and Yuliantiningsih, S. 1999.* Health effects of pesticide use among Indonesian women farmers: Part I: Exposure and acute health effects. *J. Agromedicine* 6: 61–85.
- Rother, H-A. 2005a.* Risk perception, risk communication and the effectiveness of pesticide labels in communicating hazards to South African farm workers. PhD dissertation. Michigan State University, Michigan, USA.
- Rother, H-A. 2005b.* Researching pesticide risk communication efficacy for South African farm workers. *Occupational Health Southern Africa* 1: 20–26.
- Rother, H-A. 2006.* Report of Registrar of Pesticides Workshop, October 13th – 14th, 2006, Tropical Pesticides Research Institute, Arusha, Tanzania. University of Cape Town, South Africa.
<http://www.wahsa.net/Uploads/c9ec5fab-596f-43f3-a906-4344b79e336d/Report%20of%20WHASA%20Registrars%20Workshop%20Oct2006.pdf>.
- Rother, H-A. 2008.* South African farm workers' interpretation of risk assessment data expressed as pictograms on pesticide labels. *Environ. Res.* 108: 419–427.
- Rother, H-A. and London, L. 2008.* Classification and labeling of chemicals: New Globally Harmonized System (GHS). In: D. Pimentel (ed.), *Encyclopedia of Pest Management*. Taylor & Francis, London.
- Rother, H-A., Hall, R. and London, L. 2008.* Pesticide use among emerging farmers in South Africa: contributing factors and stakeholder perceptions. *Development Southern Africa* 25: 399–424.
- Smith, W. 2004.* Pesticide labels. In: D. Pimentel (ed.), *Encyclopedia of Pest Management*. CRC Press, Florida.
- Strong, L.L., Thompson, B., Coronado, G.D., Griffith, W.C., Vigoren, E.M. and Islas, I. 2004.* Health symptoms and exposures to organophosphate pesticides in farmworkers. *Am. J. Ind. Med.* 46: 599–606.

Participatory Testing of Forage Legume Innovations with Women Farmers in Masaka District, Uganda: Impact on Fodder Availability, Animal Performance and Household Income

J.M.L. Kabirizi¹

Keywords: dry season, intensive dairy cattle system, maize crop–lablab residues

Abstract

Intensive small-holder dairy cattle production is a major source of milk and income for resource-poor households in Uganda. Napier grass (*Pennisetum purpureum*) contributes over 80% of the forage fed to cattle. However, the low dry matter (DM) yield and crude protein (CP) content of Napier grass during the dry season result in poor animal performance and reduced income. A study was therefore conducted on 48 (women=40) small-holder dairy farms in Masaka district to investigate the effect of Napier grass–*Desmodium intortum* (NGD) and maize crop–*Lablab purpureus* (ML) intercropping on fodder production. The study also evaluated response and profitability of crossbred dairy cows fed maize stover–lablab residues (MSL) or NGD forages with *Calliandra* leaf hay (CLH) and/or lablab hay (LH) and a homemade concentrate (HMC). The results showed that total fodder DM yield and CP increased ($P \leq 0.05$) by about 22% and 14%, respectively, in NGD intercrop when compared to the monocrop. ML intercrop increased ($P \leq 0.05$) stover NDM (25%) and grain (7%) yield and stover CP (93%) compared to maize monocrop. Cows fed MSL and Napier grass fodder with 1 kg CLH/day and 4 kg HMC/day produced higher ($P \leq 0.05$) milk yield (14.0 L/day) and gross margin (1,641,180 shillings) than cows fed NGD forages. More women (>80%) than men ($P \leq 75\%$) mentioned improved fodder and food production, milk yield and income as positive impacts from forage legume innovations. Land shortage and high cost of forage seed were negative impacts reported. In conclusion, forage-legume innovations improve fodder availability, animal performance and income. The major lesson learned was that participatory testing of forage-legume innovations with farmers is a key to adoption of forage innovations.

¹ National Livestock Resources Research Institute (NaLIRRI), PO Box 96, Tororo, Uganda.

INTRODUCTION

In Uganda, dairy farming contributes about 45% of the livestock Gross Domestic Product (GDP) and about 18% of the Agricultural GDP (Kabirizi, 2006). In order to improve household nutrition, income and food security among resource-poor households in Uganda, a number of livestock development projects have introduced intensive or stallfeeding dairy cattle production based on improved breeds. The first beneficiary of the project passes on their first in-calf heifer to another woman. Small-holder women farmers own over 60% of about 1.7 million improved dairy cattle in Uganda (Kabirizi, 2006). Therefore, cattle are of strategic importance to Uganda in addressing Millennium Development Goals 1 (eradicating extreme poverty and hunger) and 3 (promoting gender equality and empowering women). Pennisetum purpureum (Napier grass) provides over 80% of the fodder required in intensive small-holder dairy cattle systems in Uganda (Kabirizi, 2006). However, its low dry matter (DM) yield and crude protein (CP) (<10%) during the dry season result in poor animal performance and reduced income. Maize is a staple food and cash crop in small-holder dairy cattle systems. Maize stover is therefore a potential but untapped feed resource during the dry season, although it has low (<4%) protein content. Previous onstation studies showed that intercropping maize crop or Napier grass with forage legumes improves quality and quantity of fodder and overall animal performance (Mpairwe, 1998). The overall impact of this innovation on the performance and success of dairy enterprise had not been evaluated on small-holder farms. Thus, the objectives of this study were to: (i) determine the effect of intercropping maize with Lablab purpureus (lablab) cv Rongai (ML) or Napier grass with Desmodium intortum (desmodium) (NGD) on fodder and grain production; (ii) evaluate the response and profitability of dairy cows fed forages from ML or NGD intercropping systems supplemented with Calliandra calothyrsus (calliandra) leaf hay (CLH) and/or lablab hay (LH) and a homemade concentrate (HMC); (iii) highlight the impacts accruing from improved forage-legume innovations; and (iv) document lessons learned from testing forage-legume innovations with small-holder dairy farmers.

MATERIALS AND METHODS

The study was conducted in Masaka district, located between 0°15' and 0°43' south of the equator and between 31° and 32°E. The area's average annual rainfall is 1,000 mm with about 8 months of dry season. Participatory on-farm evaluation of forage-legume innovations began in 2002 with a baseline survey to identify feed resources and major constraints to intensive dairy cattle production systems (Kabirizi, 2006). During individual interviews and group meetings, farmers reported inadequate nutrition due to low quality and quantity of forages, and use of unimproved practices as major constraints.

A feedback workshop to present survey results to farmers was conducted at a research institute where eight improved forage-legume innovations were being evaluated. The farmers were guided around the experimental plots by a researcher. They scored each innovation on a scale of 1–3 (1=poor and 3=very good) based on: labour and land requirements; fodder yield; and contribution to income and food security. From total scores for each innovation and on-station recommendations, three innovations were selected for on-farm trials: (1) Napier grass–desmodium forages (NGD) and LH; (2) NGD, LH and CLH; (3) Napier grass fodder, maize stover–lablab residues (NGMSL) and CLH.

Forty-eight farmers (40 women) were selected and provided with seed to plant the forages. Selection of

farmers was based on: willingness of the farm owner to participate in the study; availability of 0.5 ha of well-managed Napier grass fodder field; land and labour to plant and manage the fodder banks; and one in-calf cow (parity = 1), 8–12 weeks in-calf at the start of the trials. The farmer had to allow other farmers to visit the trials to monitor and evaluate them and to learn from participating farmers. However, special consideration was given to female-headed and HIV/AIDS infected or affected households. Farmers were trained on various aspects of forage and dairy cattle management.

Study 1: Effect of Intercropping Napier Grass with Desmodium and Maize Crop with Lablab on Fodder Production

Maize monocrop (MC), ML, NG and NGD forages were established and evaluated for DM and/or grain yield and CP content using methods described by Kabirizi (2006). Plot size was 0.2 ha for MC and ML. In NGD intercrop, desmodium seed was introduced where the grass had been harvested and the field weeded. Compost manure (0.5–1 t/ha per year) was applied to improve fodder yields. Mean yield of maize stover–lablab residues (MSL), NG and NGD forages and maize grain were recorded. Dry maize grain was milled, the flour used for food and the bran used to formulate a HMC. Data were collected for four seasons. Maize stover–lablab residues were harvested and stored as animal feed on well-ventilated racks constructed by a farmer. All forages were used in Study 2.

Study 2: Response of Dairy Cows Fed Forages from ML or NGD Intercropping Systems Supplemented with CLH and/or LH and HMC

The feeding trial comprised four dietary treatments. In three diets, an HMC (16% CP) was supplemented to three diets of: (1) NGD and LH; (2) NGD, LH and CLH; and (3) NG, MSL and CLH. A fourth diet, Napier grass fodder (NG), served as a control. CLH and LH were established and conserved using methods described by Kabirizi (2006). Lablab hay and CLH were supplemented at rates of 3 and 1 kg/cow per day, respectively (Mpairwe, 1998). CLH and/or LH and HMC mixture were offered at milking time. Fresh chopped NG and NGD forages were offered to cows *ad libitum*. Diet 3 consisted of a mixture of fresh NG and about 10 kg DM of MSL per day. All forages were chopped before offering them to the cows. Experimental cows were crossbreeds (indigenous × Friesians) with a mean initial liveweight of 450±4.5 kg. Farmers recorded daily feed intake and milk yield. Two trained enumerators assisted farmers in collecting and recording data. The records helped farmers to decide which innovation they would adopt. Participatory techniques (meetings, workshops and field visits) were used to assess the performance of the innovations and to encourage interaction between participating and non-participating farmers. Study 2 lasted 12 months (2 months pre-partum plus 10 months post-partum).

Studies 1 and 2 were laid out in a Randomized Complete Block Design with 12 replications. The trials were replicated in 12 villages. Feed and forage samples were collected once a month and analysed for protein and energy content (Kabirizi, 2006). Data were analysed using Statistical Analysis Systems (SAS, 1999). Means were tested for significance using the Least Significant Difference. The gross margin for each diet was calculated based on extra costs incurred when they were incorporated into the production systems in relation to the income realized.

Study 3: Impacts Identified by Farmers as a Result of Integrating Forage Legumes into Farming Systems

A participatory technology evaluation survey and a feedback workshop were conducted as part of the exit strategy to identify indicators of positive and negative impacts that could affect wider adoption of the tested forage-legume innovations. Survey data were analysed using SAS (1999). Percentages were used to define the quantitative status of the data collected. Participating farmers were facilitated to present their findings to 600 (women=450) non-participating farmers.

RESULTS

Effect of Intercropping Napier Grass or Maize Crop with Forage Legumes on Fodder and/or Maize Grain Yield and Protein Content of Fodder Napier grass–desmodium intercrop increased ($P \leq 0.05$) plant growth, total fodder DM yield and CP content by about 12%, 22% and 14%, respectively (Table 1). Total stover DM and maize grain yield and CP content increased ($P \leq 0.05$) by about 25%, 7% and 93%, respectively, in ML intercrops (Table 1). However, CP of forages from NGD and ML intercrops was still below the minimum level (16%) required for maintenance and production of dairy cows similar to those used in the study (Mpairwe, 1998).

Table 1: Effect of intercropping Napier grass or maize crop with forage legumes on fodder, stover and maize grain production

Parameter	Cropping system		SEM
	Monocrop ¹	Intercrop ¹	
<i>Napier grass–desmodium</i>			
Napier grass plant height (cm)	79.1 ^b	88.2 ^a	0.93
Total fodder DM yield (kg/ha per year)	10,024.2 ^b	12,211.4 ^a	224.5
Crude protein content (%)	7.4 ^b	8.4 ^a	0.06
<i>Maize–lablab</i>			
Total stover DM yield (kg/ha per year)	4,373.2 ^b	5,485.2 ^a	174.7
Maize grain yield (kg/ha per year)	2,912.1 ^b	3,115.4 ^a	138.1
Crude protein content of stover (%)	4.0 ^b	7.7 ^a	0.22

¹ Means of individual households; SEM= Standard Error of Mean

Least square means within a row with different superscripts differ significantly ($P < 0.05$).

Dry Matter, CP and Metabolizable Energy (ME) Intake and Milk Yield

Total DM, CP and ME intake and milk yield were higher ($P \leq 0.05$) in cows fed on Diets 1, 2 and 3 than those fed on Diet 4 (control) (Table 2).

Impacts of Integrating Forage Innovations into Farming Systems

Women were consistently more positive and negative than men on various impact attributes (Table 3). More women (>80%) than men ($\leq 75\%$) mentioned improved fodder and food security, milk yield and income as major positive impacts from testing forage innovations (Table 3).

Table 2: Dry matter, CP and ME intake and animal performance

Parameter	Diets				SEM
	1	2	3	4	
Total dry matter intake (DMI)	10.3 ^c	11.0 ^b	13.5 ^a	7.0 ^d	0.03
Total CP intake (g/cow per day)	1,343 ^c	1,443 ^b	1,569 ^a	503.0 ^d	29.60
Total ME intake (MJ/cow per day)	112.6 ^c	114.3 ^b	116.3 ^a	60.7 ^d	0.30
Milk yield (L/cow per day)	9.0 ^e	9.7 ^b	14.0 ^a	6.6 ^d	0.04
Gross margin (thousand shillings/year)	880 ^e	956 ^b	1,641 ^a	346 ^d	31.42

Diet 1-NGD+LH+HMC; Diet 2- NGD+LH+CLH+HMC; Diet 3- NG+MSL+CLH+HMC; Diet 4-NG;
SEM: Standard Error of the mean

Least square means within a row with different superscripts differ significantly ($P<0.05$); Milk yield from cows on Diet 3 was consistently higher ($P<0.05$) by over 40% than in cows on NGD-based diets (Diets 1 and 2). Forage-legume innovations significantly increased ($P<0.05$) gross margin in Diets 1, 2 and 3 when compared to Diet 4.

Improved fodder availability improved animal body condition during the dry season and decreased cases of animal diseases. Moreover, lablab suppressed weeds and conserved soil moisture and farmers were able to use available land and labour efficiently. However, land shortage and high cost and/or unavailability of forage-legume seed were major negative impacts identified by farmers (Table 3).

Table 3: Major positive and negative impacts

Impact	Reported by (%)	
	Men (n=150)	Women (n=450)
<i>Positive</i>		
Improved animal body condition during the dry season	73	95
Improved fodder and food security	70	96
Lower cases of animal diseases	72	87
Improved milk yield	75	80
Lablab suppressed weeds	63	81
Maximum utilization of resources (land and labour)	74	90
Improved skills and knowledge on dairy farming	90	97
Improved household income	71	89
<i>Negative</i>		
Land shortage	67	93
High cost/unavailability of forage legume seed	80	90

DISCUSSION AND CONCLUSION

Higher fodder DM and/or grain yield and CP content in intercrops than monocrops could be attributed to forage legumes that increased soil nitrogen (N), the most limiting element in small-holder production systems in Uganda. Nitrogen deficiency reduces the productivity of crops, pastures and animals (Mpairwe, 1998). The legumes provided a soil cover, thereby reducing water loss from soil by evaporation and controlling weeds.

■ **Participatory Testing of Forage Legume Innovations with Women Farmers in Masaka District, Uganda: Impact on Fodder Availability, Animal Performance and Household Income, J.M.L. Kabirizi**

Improved milk yield in cows fed Diets 1, 2 and 3 could be due to higher CP and ME intake as a result of better feeds. The feeding value of NG (Diet 4) was inadequate to meet the nutritional requirements of the lactating dairy cows and this resulted in low milk yield. The supplements in Diets 1, 2 and 3 had higher CP levels (15.8–22.5%) than NGD and MSL, so improved N supply in the rumen, enhanced digestion, and increased DM intake and milk yield. The superior milk yield recorded in cows on Diet 3 compared to Diets 1 and 2 could be due to extra nutrient intake and adequate supply of MSL forages.

Intercropping enabled women to use land and labour more efficiently where land shortage and high cost of labour are major constraints in small-holder systems (Kabirizi, 2006). Forage-legume innovations had not been popular because women could not accommodate any flexibility in the cropping system. Farmers ranked MSL as the most important forage innovation because of its ability to fill the feed gap during the dry season, while improving maize grain yield from the same piece of land. However, the high labour required to harvest, transport and conserve MSL calls for more research into simple labour-saving technologies that are affordable to small-scale farmers. The higher gross margin on Diet 3 was due to extra income from sale of milk, surplus maize grain, flour, maize bran and stover. The participatory approach enabled farmers to form groups, exchange information, acquire new skills and knowledge, and start income-generating projects such as small-scale forage-seed production to improve supply of forage seed. The women used the groups as a social protection measure against societal and cultural exploitation.

In conclusion, forage-legume innovations improved fodder availability, animal performance and income. The major lesson learned was that participatory testing of forage innovations is a big challenge. It requires commitment from all stakeholders and institutional support, but it is a key to adoption of forage innovations. The innovations have been scaled out in 10 districts through workshops, on-farm demonstrations, agricultural shows, photos, posters, handbooks, mass media and nine new projects.

Acknowledgements

DANIDA and The World Bank are acknowledged for funding this study. I am grateful to: the district extension staff, local and farmers' group leaders who monitored project activities; TONNET, a private company that supplied forage choppers to farmers' groups; unemployed youths who provided labour to HIV/AIDS-affected households to harvest, chop and conserve fodder; MADDO that provided a market for milk and forage seed; NaLIRRI that provided technical support; and all the dairy farmers in the district. The research was part of a PhD study. Special thanks to my supervisors, Dr D. Mpairwe and Dr D. Mutetikka.

Literature Cited

- Kabirizi, J. 2006.* Effect of integrating forage legumes in smallholder dairy farming systems on feed availability and animal performance. PhD Thesis, Makerere University, Uganda. p. 38–160.
- Mpairwe, D. 1998.* Integration of forage legumes with cereal crops for improved grain yield, forage production and utilization for smallholder dairy production systems. PhD Thesis, Makerere University. p. 120–180.
- SAS. 1999. Statistical Analysis Systems Institute (SAS/STAT) User's Guide, Version 8. Statistical Analysis Systems Institute, Carry, NC.

The Use of Remotely-sensed Data as Methodology to Determine Grazing Capacity in Namibia

Celesté Espach¹

Keywords: agriculture, livestock, rangelands, productivity, biomass, land cover

Abstract

The Namibian rangelands consist of a mixture of herbaceous and woody components. The main income-generating farming system is livestock farming, and grass production is considered the main forage for livestock. For rangeland managers to utilize this source sustainably, the accurate determination of grazing capacity is vital since it allows for adaptation of the animal load, and therefore the grazing pressure, to the actual capacity of the land. The pre-independence political system deprived much of the population of relevant agricultural information, leaving subsistence farmers and communal pastoralists without basic rangemanagement tools in extensive animal production. Various practical approaches and methodologies are investigated to update the existing Namibian grazing-capacity map that was compiled more than three decades ago from expert, but nonetheless subjective opinion of farmers, extension officers and pasture scientists. These methodologies included the estimation of seasonal herbaceous biomass production using satellite imagery, land-cover mapping and the quantitative yield method of determining available forage. It is expected that combining all these methods (information from remote-sensing, adjusted with scientifically established coefficients for woody cover, accessibility and palatability, as well as the incorporation of the quantitative yield method as ground-truthing mechanism) will provide a tool to objectively establish rangeland productivity and thus grazing capacity in Namibia.

¹ Ministry of Agriculture, Water & Forestry, Directorate Research & Training, P/Bag 13184, Windhoek, Namibia.

INTRODUCTION

Agriculture, as the predominant land use in Namibia, is severely limited by variable and low rainfall. About 70% of the population is directly or indirectly involved in livestock farming. Considering that the Namibian livestock industry depends primarily on natural vegetation, the accurate determination of grazing capacity, and its application, is important for sustainable land utilization. Seasonal herbaceous-biomass production is seldom measured in practice, as it requires huge investments in labour, time and skill. Therefore, ranchers and pastoralists often fall back on fixed grazing capacities set years ago. This information is of limited use, because grazing capacity changes continuously over years (rainfall variation), and rangeland condition has deteriorated considerably due to widespread bush-encroachment. It is estimated that about 12–14% of Namibia's surface area suffers from bush-encroachment (Bester, 1996).

There is an urgent need for timely, accurate data on land, water, natural resources and grazing capacities to aid in successfully implementing the Land Reform Program in Namibia. The Directorate of Research and Training, within the Ministry of Agriculture, Water & Forestry, has been working towards an updated National Grazing Capacity Map. In addition to subjective 'expert opinion' from pasture scientists, extension staff and farmers, the directorate has adopted related remote-sensing and GIS methods for this task. SPOT VEGETATION imagery is used to assess rangeland condition through estimating seasonal biomass production, which is the amount of forage produced during a growing season. More recently, the Land Cover mapping project (Landsat 7 ETM+) provided an additional dimension to improve the methodology for estimating seasonal biomass production, as it differentiates between grazable and non-grazable vegetation.

The Normalized Difference Vegetation Index (NDVI) provides a simple and practical approach to estimate biomass production. An integration of the vegetation index over the entire season gives a direct indicator of the production, taking into account both the greenness and the duration of the vegetation activity (Ganzin et al., 2005). Based on this principle, the Satellite Monitoring of Arid Rangelands (SMAR) image-processing software was developed by GDTA (Groupement pour le Développement de la Télédétection Aérospatiale) between 1992 and 2002. It processes and computes, from a series of multi-temporal NDVI imagery, the seasonal biomass-production estimation. The core module of SMAR implements the vegetation-production model proposed by Monteith (1972) to calculate total seasonal biomass production (Monteith, 1972; Kumar and Monteith, 1981). The Monteith model, which is often referred to as an 'efficiency' model can be summarized as follows:

$$BP_{season} = \Sigma_{season} (ei.ec.eb.GR.\delta t)$$

Where **BP_{season}** = seasonal biomass production (kg/ha); **ei** = efficiency of interception of solar radiation by leaves (%); **ec** = fraction of solar energy suitable for photosynthesis (constant 48%); **eb** = efficiency of conversion of solar to chemical energy (g/MJ), (which varies with vegetation type, but is fixed here to the value 0.8 g/MJ, a value found in the literature for tropical herbaceous covers); **GR** = global radiation from the sun (Watts/m²); **δt** = time step (10 days) Namibia has a variety of range types with very diverse structures and species compositions. There is a clear need for further processing in order to correct the values of total seasonal biomass production to get to a reasonably accurate estimation of the forage that is available to

animals. Both the total seasonal Biomass Production Estimation (BPE) corrected for woodiness, accessibility and palatability (WAP), and the Land Cover mapping require ground-truthing. It is hoped that the application of the applied methodologies explained here will be able to give the ministry realistic values of the utilizable vegetative cover available to animals.

MATERIALS AND METHODS

Total Seasonal Biomass Production Estimation corrected with WAP

Total Seasonal Biomass Production (TSBP) Estimations are made yearly at the end of the growing season (May), and averaged for the accumulative years. The averaged image for 1985/86–2005/06 was further processed using three parameters, namely Woody cover, Accessibility and Palatability (WAP). The BPE module of SMAR is a GIS-related method that makes use of the vegetation type and structure (land-cover map) as described by these WAP parameters (fieldwork) in an operation that is applied to every pixel of the averaged biomass-production image, through WAP parameter 'masks'. The three 'masks' are image information format layers obtained by vector–raster conversions at the same resolution as the averaged BPE image in order to have exact pixel by pixel correspondence.

Land Cover Map Generation

A land-cover map was developed during January 2005 for a pilot area of approximately 11,000 km² east of Windhoek (Lat. 22–23° S, Long. 17–19° E) in which 18 different land-cover units were delineated. Based on vegetation structure and percentage canopy cover, 10 of the 18 land-cover units were classified as vegetation-cover units. The surface area of each of the 10 vegetation-cover units was considered. All those vegetation-cover units contributing <1% to the total pilot area (Forest, Low shrub–open) were discarded as insignificant. All encroached areas (Low shrub–closed, Tall shrub–closed) were also discarded, as grazing capacity in these areas is known to be very low and difficult to ground-truth. Six vegetation-cover units remained (Low shrub–sparse, Tall shrub–sparse, Tall shrub–open, Woodland–sparse, Woodland–open and Grassland), which comprised 72% of the total surface area of the pilot area.

Methodology for Generating WAP Parameters

1. Point Sampling. Point sampling provides a rapid, accurate and objective method to determine botanical composition and basal cover of herbaceous vegetation. A botanical survey, incorporating the nearest plant approach (Foran et al., 1978) in conjunction with 'strike' data, was conducted through a 500 m point line transect at randomly selected sites within the six vegetation-cover units, to acquire values for the respective WAP parameters. These values were extrapolated to the specific vegetation-cover units. Points were spaced 1 m apart on the transect, which made it possible to express the occurrence of species on a percentage basis.

2. Woody Cover and Accessibility. Counting bushes (density) and classifying them into height classes was useful in the allocation of a woody cover and accessibility value (expressed as percentage). A bush count was carried out concurrently with the botanical survey along the same 500 m transect line. All bushes within 1 m on either side of the transect line were tallied and classified according to height (≤ 50 cm, 0.5–1 m, 1–2 m, 2–4 m and ≥ 4 m). For determining accessibility, it was necessary that cut-off points be established in terms of density, as well as height. The following density classes were used, and a factor was assigned to each:

Accessible (penetrable) $\leq 8,000$, bushes/ha = 1
Inaccessible (impenetrable) $> 8,000$ bushes/ha = 0

Bushes exceeding 2 m in height were considered to be inaccessible, while those below 2 m were considered to be accessible in terms of forage. As the woody species were classified into height classes during the survey, it was possible to calculate the percentage of bushes lower than 2 m. This percentage was then multiplied by the density class factor (0 or 1) to arrive at a final accessibility figure. After completion of the botanical composition and bush-density surveys, data for each site were summarized and then transferred to a specially designed WAP Parameter Field Measurement form (Annex 1), which enabled workers to objectively calculate woody cover and accessibility parameters.

3. Palatability. Since palatability varies over time, it was decided to divide palatability into three periods: P1 = 1 month of the year (Jan), expressed as a percentage = 8% = 10%, P2 = 4 months of the year (Feb–May) = 33% = 30% and P3 = 7 months of the year (Jun–Dec) = 58% = 60%. Each percentage was multiplied by the subjectively estimated (expert opinion) palatability of species encountered during the survey. The palatability factors for all grass species at the respective sites resulted in a total palatability factor for the herbaceous component. Palatability for bushes followed a similar approach to that described for grasses; with the exception that all bushes are considered to be equally palatable, but retain this palatability for various lengths of time during the year. The palatability factors for all woody species at the respective sites resulted in a total palatability factor for the woody component. The contribution of each component (herbaceous and woody) to palatability was then assessed by multiplying its percentage contribution to total species composition by the total palatability factor for each component. The two assessed percentages were added to arrive at an overall palatability figure.

Methodology to Determine Grazing Capacity from WAP-corrected TSBP Image

The 800–1,000 kg biomass/ha on the WAP-corrected TSBP image is converted to grazing capacity as follows: a kilogram of animal biomass (kg AB) needs 3% per day in dry material to sustain itself. Per year, this is: $1 \times 3\% \times 365 = 10.95$ kg DM/year. The 800–1,000 kg is divided by 2 (only 50% is utilized to maintain vigour) = 400–500 kg plant biomass. This is divided by the dry material required per kilogram AB per year (i.e. 10.95) to give a maintenance range of 36.5–45.7 kg AB/ha. If a Large Stock Unit is 450 kg AB, then a unit would require between 12.32 ha (450/36.5) and 9.84 ha (450/45.7) to maintain itself.

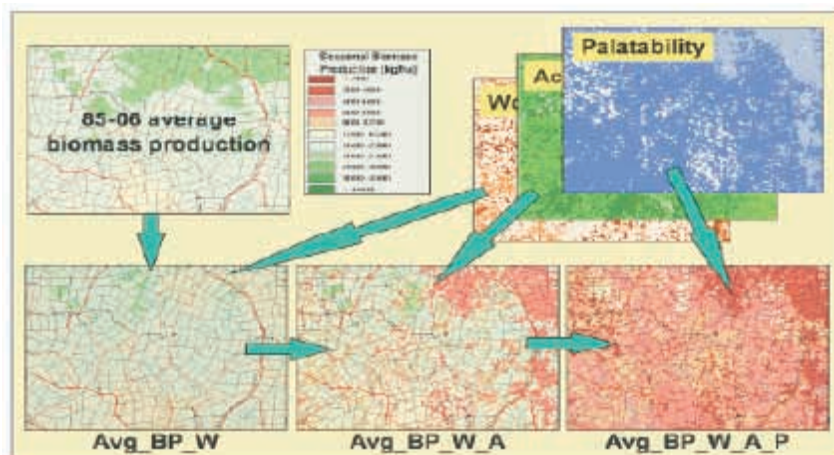
Methodology to Determine Grazing Capacity in Each of the Six Vegetation-cover Units

A joint effort between Pasture science and Analytical services ensures yearly grazing-capacity data for the pilot area. Thirty points were randomly selected within the six vegetation-cover units (land-cover map) for fieldwork. The quantitative yield method was used for this purpose, which consists of clipping forty 1 m² (Stein's two-stage sample size equation) quadrats per site, along a transect (line) one kilometre long. All grasses within these quadrats are clipped as close as possible to ground level, dried and weighed. By setting the daily dry-material (DM) intake of an animal at 3% of live weight and matching the amount of DM needed to the amount of available grass material, it is possible to determine the yearly grazing capacity of an area (Bester, 1998).

RESULTS

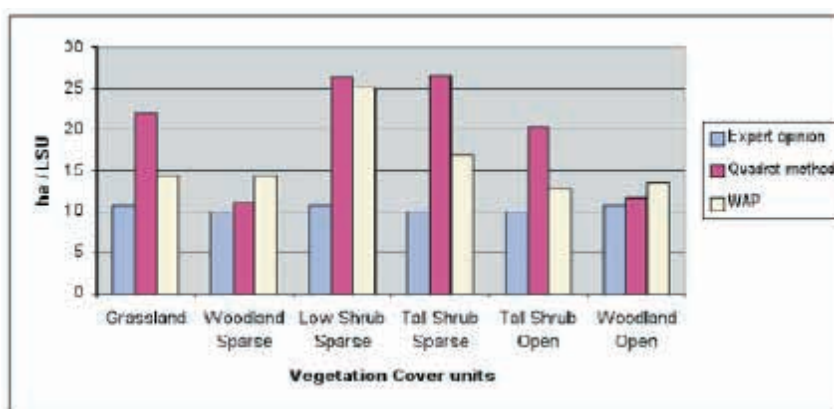
By following the approach described above, it was possible to generate woody accessibility and palatability masks. These masks were then applied to the TSBP image (21-year average) of the pilot area, which generated the final seasonal biomass image (Fig. 1, Avg_BP_W_A_P).

Fig. 1: Application of the WAP parameters to the estimated biomass production



The average TSBP image corrected with WAP for each of the 30 sites was then compared with the figures generated through the quantitative yield method, as well as with the currently accepted grazing capacities based on expert opinion (Fig. 2).

Fig. 2: A preliminary comparison of the grazing capacity for the six vegetation-cover units after application of the three methods



DISCUSSION

The land-cover image was essential to identify very woody areas (W) on the averaged TSBP image in order

■ **The Use of Remotely-sensed Data as Methodology to Determine Grazing Capacity in Namibia**
Celesté Espach

to mask them out, and as a result have areas that are accessible (A) to animals in terms of height and density. The point-survey methodology made it possible to objectively determine height and density. Attempting to generate a palatability (P) mask was somewhat arrogant, simply because it is subject to a huge number of variables.

These variables include chemical composition, proportion of plant parts, growth stage, and species availability in vegetation; hence the difficulty in allocating a value. Protein and carbohydrates, which usually correlate positively with palatability, vary tremendously over time and locality. Variation over time also applies to the plants' growth stage. Typically, the acceptability and palatability of grasses are highest in the early growth stages, but rapidly decrease as the plant matures, due to the increase in fibre, which is negatively correlated with acceptability and palatability. An attempt was made to make provision for this variable by integrating three time periods. However, it remains extremely difficult to allocate a realistic mark for this parameter.

CONCLUSION

Although it was possible to objectively calculate a value for woodiness and accessibility, calculating palatability to the same level of objectivity was not possible. The accuracy of allocating such a value is extremely difficult. Preliminary comparisons of the grazing capacity figures (2005/06, 2006/07 and 2007/08), with the old accepted norms (expert opinion) can be made at this point in time (Fig. 2). In all sites, grazing capacity determined by total seasonal biomass production corrected with WAP indicated lower grazing capacities than those generated through expert opinion. This may be due to the deterioration of rangelands in the pilot area.

Grazing capacity is calculated on dry-material production of a grazing area. The TSBP image corrected with WAP does not take moisture content, and subsequently the dry material yield, into consideration. Using the biomass figures on the WAP-corrected image may therefore lead to an optimistic grazing-capacity calculation, unless corrected for moisture. To avoid further over-estimations of grazing capacity from the corrected TSBP image, a proper use factor must be introduced. A 50% utilization level is considered appropriate in range science, as this is the accepted level of defoliation of a grass plant before physiological damage is incurred by the plant.

However, final comparisons or conclusions can only be made after the termination of the project, which is scheduled for April 2010. It is hoped that by that time rainfall variability will have been adequately captured. Although it is possible to start with the allocation of grazing capacities to a specific vegetation-cover unit, ground-truthing should also be carried out for a sufficiently long period of time before a specific grazing capacity can be attached to a specific vegetation-cover unit.

Acknowledgments

This project is taking place under the auspices of and with the approval of the Ministry of Agriculture, Water and Forestry, Government of the Republic of Namibia. The author would like to acknowledge the inputs of Messrs Lubbe, Van Rooyen, Mouton and Ngavetene, and Ms Campbell, all colleagues within the ministry, for their assistance.

WAP parameters field Measurement form

Date: _____ **Plot Number:** _____ **Nuwe Orde:** _____

GPS: Long (X): **Lat (Y):**

Vegetation type:

Herbaceous layer: 3-4 Dominant species Count/500 % of H Palatability

	Count/500	% of H	Period 1	Period 2	Period 3	Palatability	P _{weighted}
1 Schmidia pappophoroides	341	52.23	100	70	50	61	37.96
2 Stipagrostis uniplumis	54	9.85	70	30	20	28	2.76
3 Forb – unpalatable	54	9.85	10	10	0	4	0.39
4 Aristida congesta	34	6.20	40	10	0	7	0.43
5 Eragrostis lehmanniana	30	5.47	100	60	30	46	2.52
6 Other	35	6.39	60	40	10	24	1.53
Total →	548						Overall herbaceous layer palatability → 45.59

Woody layer: 3-4 Dominant species Count/500 % of W Palatability Accessibility

	Count/500	% of W	Pal. green	Period %	Palatability	P _{weighted}	%<2m dens	1st yr	access	
1 Grewia spp.	14	41.18	100	80	80	32.94				
2 Tarchonanthus camphoratus	10	29.41	100	50	50	14.71				
3 Acacia erioloba	7	20.59	100	20	20	4.12	83 %	570 / ha	1	83 %
4 Other	3	8.82	100	30	30	2.65				
Total →	34	100				Overall woody pal → 54.42	Woody acc	83		

Woody cover: (total woody counts/500) * 100 →

Accessibility: (100 * H_{proportion}) + (Acc_{woody} * W_{proportion}) →

Palatability: Herbaceous Woody

Overall Palatability (W) ((P_{herb} * H_{proportion}) + (P_{woody} * W_{proportion})) →

Farmer–Breeder Partnership in Barley Varietal Selection: A Case for Decentralized Plant Breeding in Drought-Prone Areas of Northern Ethiopia

Fetien Abay¹ and Åsmund Bjørnstad²

Keywords: genotype–environment interaction, specific adaptation, participatory varietal selection, local innovation, low input conditions

Abstract

Barley is a key cereal crop in Tigray region in northern Ethiopia. Despite decades of public breeding, no new cultivars have been adopted by farmers. The reasons for this were investigated. Ten barley varieties, including local checks, were tested over 21 environments in 2005 and 2006 in main seasons in decentralized participatory trials. The overall analysis of variance for the grain yield indicated significant effects of environment, genotype and genotype–environment interaction. The farmer-developed variety ‘Himblil’ was superior to the recommended varieties, ‘HB-42’ and ‘Shege’. There were two major groups of environments, the central and the northern highlands. The breeding history of ‘Himblil’ and these experiments have shown that participatory varietal selection is a fast and viable method for identifying preferences, constraints and the potential of varieties, and that the level of accuracy was acceptable and complements conventional breeding. The research results have been disseminated through the farming communities, as well as in journals, book chapters and proceedings of national and international workshops and symposia.

¹ Mekelle University, Department of Dryland Crop and Horticultural Sciences, PO Box 231, Mekelle, Ethiopia.

² Department of Plant and Environmental Sciences, Norwegian University of Life Sciences, PO Box 5003, N-1432 Ås, Norway.

INTRODUCTION

Barley (*Hordeum vulgare*) is a staple cereal crop for poor farmers in Tigray, northern Ethiopia. This area is known for its high diversity of cereals, but also for being plagued by recurrent drought and irregular rainfall. Officially recommended 'improved' varieties have not been accepted by farmers living in marginal, low-input conditions. The farmers rely on their own knowledge and selection strategies. Avoiding crop failure during drought is more important than achieving maximum yield in good seasons. Moreover, households value not only the yield of grain, but also its quality and the feed value of the straw.

Formal breeding often fails to address such complexity. Participatory varietal selection (PVS) was therefore developed as a complementary approach involving farmers in final selection under their conditions (Witcombe et al., 1996). The success of such programmes in raising crop productivity has been well documented (e.g. Joshi and Witcombe, 1996; Sperling et al., 2001). This case study from Tigray addresses the issue

of how to identify varieties adapted to low-input environments. Our hypothesis was that a decentralized breeding programme is required to produce varieties acceptable by farmers.

A partnership between breeders and resource-poor farm households may be a way to overcome the failures of conventional breeding programmes. Key questions investigated in such a partnership were:

1. The reasons for and outcomes of local innovation in varietal selection
2. The role of women in varietal selection
3. The performance of farmer-developed varieties over locations and years
4. The reasons for non-acceptance by farmers of the recommended varieties 'HB-42' and 'Shege'.

MATERIALS AND METHODS

Test Materials and Locations

Initially, farmers' innovations in varietal selection, including women's role, were identified. These findings were incorporated into the approach. Varieties that matched farmers' criteria were sought. These comprised farmer-developed varieties (FDVs) 'Himblil' (hulled) and 'Demhay' (hullless); three local varieties 'Rie', 'Sihumay' and 'Atona'. Two new modern varieties (MVs) 'Dimtu' and 'Misrach' (released by Holleta and Debrebrhan Agricultural Research Centres) were included for both high- and lowinput conditions, and 'HB-42' and 'Shege' (released by Holleta for high-input areas) were deliberately included because of their official recommendation for cultivation in Tigray.

On-farm and on-station experiments were conducted in 2005 and 2006 main seasons using the 'mother and baby' design (Snapp, 1999). Figure 1 shows the location of the trial sites. Hosts, including local seed selectors, were identified by the community of the experimenting farmers, 20% of the hosts were women. Data Collection and Statistical Analysis Focus-group discussions (FGDs) and diversity fair workshops were conducted. In the PVS experiment, quantitative and qualitative data were recorded. Participatory evaluation was conducted at vegetative, flowering and grain-filling stages. Household preferences were assessed (Christinck et al., 2005) and their acceptance level was determined for each variety.

■ **Farmer–Breeder Partnership in Barley Varietal Selection: A Case for Decentralized Plant Breeding in Drought-Prone Areas of Northern Ethiopia, Fetien Abay¹ and Åsmund Bjørnstad**

Analysis of variance (ANOVA) was done across locations and years using GLM in SAS (2001). Coefficients of variation and the mean standard error differences were calculated to compare the varieties. The relative stability of varieties across environments (regression coefficients, β) was examined (Hussein et al., 2000). GGE biplot analysis (Yan et al., 2000) was performed to graphically visualize the results. The qualitative household-level questionnaires were subjected to chi-square tests (Virk et al., 2003).

RESULTS

The FDVs identified in Tigray (Abay et al., 2008)—Demhay (naked) and Himblil (hulled)—were developed by a farmer (now aged 87) named Kahsay (Fig. 2a–d) in Bolenta village, using mass and single-plant selection. Women play a key role in seed management and varietal selection (Fig. 2e), as revealed by statements such as: “A wife who does not keep seed is like living with no wife at all”. For example, Kahsay’s wife experimented with different barley varieties to find the best one for making good injera (Ethiopian pancake). She is heavily involved in seed exchange and villagers regard the household as a local seed bank. Husband and wife jointly decide on the number of varieties to be grown, seed selection and plot allocation for barley; storage is a women’s domain (Abay et al., 2008).

Fig. 1: Location of trial sites in Ethiopia and Tigray region



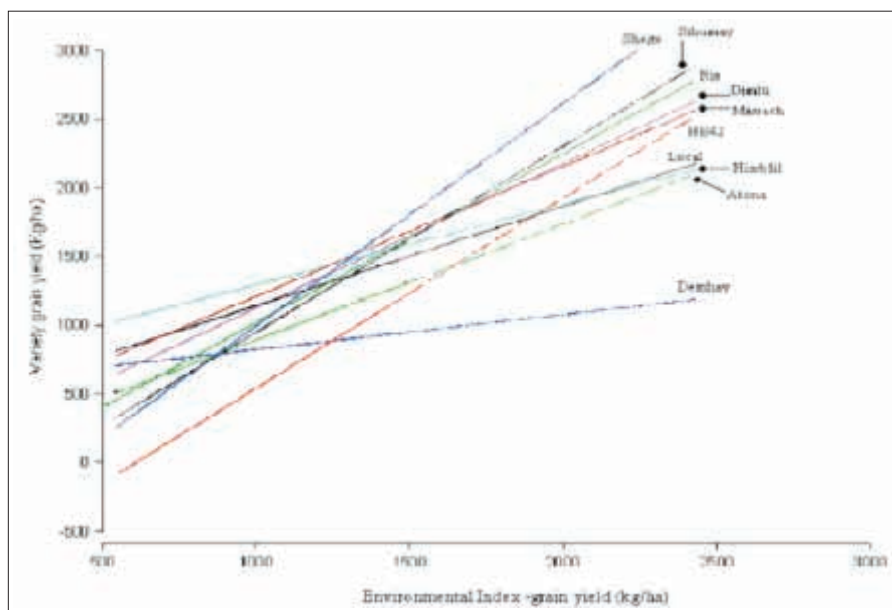
The ANOVA for grain yield indicated significant effects of environment, genotype and genotype–environment interaction (GEI), and acceptable precision (Abay, 2007). The chi-square test analysis revealed Himblil as most preferred variety (Abay and Bjørnstad, 2008). There was clear evidence of cross-over interactions (Fig. 3). Himblil yielded more than the other varieties in low-potential situations (<1200 kg/ha). Shege, Sihumay, Rie and HB-42 were adapted to high-input conditions. The biplot divided the locations into two sectors (Fig. 4). In the high-input on-station trials at Holleta and Debrebrhan, Shege, Dimtu and Misrach did best. Conversely, in the low-input locations in Tigray, Himblil did best. Farmers’ overall preferences of the varieties is shown in Figure 5. HB-42 was rejected by 98% of experimenter farmers (Fig. 5).

■ **Farmer–Breeder Partnership in Barley Varietal Selection: A Case for Decentralized Plant Breeding in Drought-Prone Areas of Northern Ethiopia, *Fetien Abay1 and Åsmund Bjørnstad***

Fig. 2: Farmer developed varieties Demhay and Himblil: a) Kashay’s first variety, Demhay; b) comparing Kalshay’s Demhay with others; c) Kalshay’s second variety, Himblil; d) Kalsay and his variety Himblil; women selecting seed



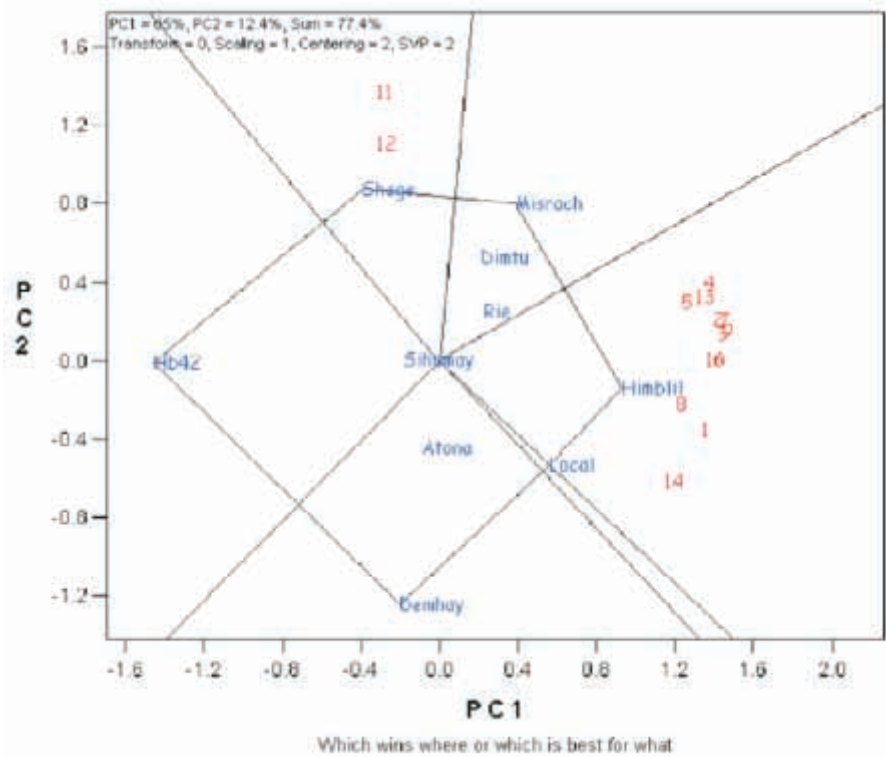
Fig. 3: Regression of mean grain yield (kg/ha) of ten varieties on the mean grain yield of on-station and on-farm trials 2005-2006



DISCUSSION AND CONCLUSION

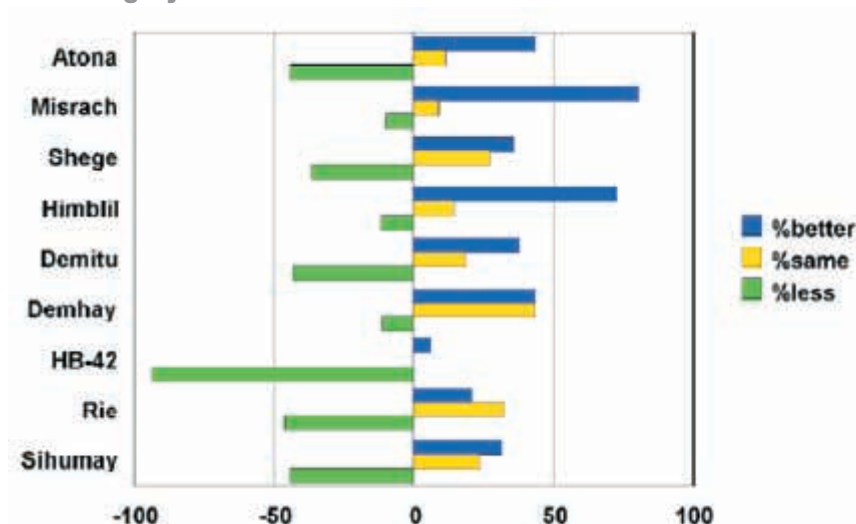
Choice of Breeding Strategies and Testing Sites for Recommendation of Varieties These experiments showed the importance of selecting in an environment close to farmers’ reality. Correlations between performance on farms in Tigray and under the more favourable growing conditions in central Ethiopia were poor. Hence under lowinput conditions, the FDV ‘Himblil’ was superior to the recommended ‘HB-42’ and ‘Shege’ varieties. This indicates a specific adaptation to the prevailing conditions and conforms to the theory that the largest gains for stress are expected from selection in stress conditions (Ceccarelli et al., 1992). The results suggested that Tigray and the central highlands of Ethiopia (where the recommended modern varieties were selected) are different breeding zones (Abay and Bjørnstad, 2009). The nature of GEI that cause the cross-overs among genotypes can be positively exploited by selecting different cultivars for the two mega-environments (Ceccarelli et al., 1998; Annicchiarico et al., 2005; Yan et al., 2007).

Fig. 4: Polygon view of yield data from 2005 in all locations



Test sites: 1=Bolenta; 2=Buket; 3=hables; 4=Mugulat; 5=fala; 6=Habes FTC; 7=Mekham; 8=Melfa; 9=Menkere; 10=Neksege; 11=Mugulat; 12=Holleta; 13=Debrebrhan; 14=Adinefas

Fig. 5: Overall preferences of barley varieties (compared to local variety) in the tests sites of Tigray



The Merit of PVS for Barley Improvement and Dissemination in Tigray

The experiments showed that PVS is a viable method for identifying preferences, constraints and potentials of varieties, with an acceptable level of accuracy. The breeding history of Himblil and the willingness of farmers to share their knowledge complemented the contribution of scientists to mutual advantage in selecting locally adapted varieties. Strong collaborative networks have been established between the farming communities and regional extension systems.

Experimenter farmers spontaneously formed a 'Barley Association' sharing information, ideas and seeds beyond the trial sites. The farmer experimenters have exhibited their results at a major agricultural fair attended by regional and national policymakers, the Norwegian ambassador to Ethiopia and other farmers. Coverage through the electronic networks of the Norwegian Embassy, the Development Fund and ProInnova (Promoting Local Innovation in ecologically-oriented agriculture and natural resource management) has also made the benefits of FDVs and PVS widely known beyond Ethiopia.

exhibited their results at a major agricultural fair attended by regional and national policymakers, the Norwegian ambassador to Ethiopia and other farmers. Coverage through the electronic networks of the Norwegian Embassy, the Development Fund and ProInnova (Promoting Local Innovation in ecologically-oriented agriculture and natural resource management) has also made the benefits of FDVs and PVS widely known beyond Ethiopia.

The research partners are now applying for official release of 'Himblil' through the Ethiopian Variety Release Committee, for multiplication and wider availability to farmers in similar environments. Women in particular will benefit from greater access to preferred barley seed for preparing injera, as an alternative to tef (*Eragrostis tef*). The study revealed that it is possible to improve grain yield of crops in low-input target environments. The research findings can be summarized as follows: (a) modern varieties released for high-

■ **Farmer–Breeder Partnership in Barley Varietal Selection: A Case for Decentralized Plant Breeding in Drought-Prone Areas of Northern Ethiopia, Fetien Abay¹ and Åsmund Bjørnstad**

input conditions were either inferior to or not better than the local varieties; (b) joint evaluation of varieties with farmers helped in identification and rapid dissemination of new varieties; (c) these can be a source of breeding for specific adaptation; and (d) the need for a decentralized breeding strategy was confirmed. The approach may give farmers confidence in and access to modern science, and identify true improvements through combined efforts.

The research results have been disseminated through the farming communities, as well as by the scientists in journals, book chapters and proceedings of national and international workshops and symposia. A follow-up project is funded by NUFU (Norwegian programme for Development, Research and Higher Education) from 2007 to 2011, which aims to improve productivity and food security through better access to quality seed in Tigray, using decentralized participatory breeding methods as a model for locally relevant research. The research includes investigation of the potential of barley as a high-quality alternative to teff for injera and developing fair-trade export of kollo (a nutritious traditional snack made from roasted barley) by women's groups.

Also of great significance is the dissemination of the decentralized approach to cereal breeding to similar areas. In collaboration with scientists from Wageningen University (The Netherlands), the trial sites were used in 2008 in practical training of senior breeders from Ethiopia and 12 other countries in Africa and Asia. The participants learned directly from the experimenting farmers about the PVS/PPB (participatory plant breeding) trials, which stimulated the scientists to consider these approaches in breeding and variety release. This may make formal plant breeding better attuned to the needs of poor farming communities in marginal areas.

References

- Abay, F. 2007. Diversity, Adaptation and G×E Interaction of Barley (*Hordeum vulgare* L.) genotypes in Northern Ethiopia. PhD thesis, UMB (Norwegian University Life Sciences).
- Abay, F. and Bjørnstad, Å. 2008. Participatory varietal selection of barley in the highlands of Tigray in northern Ethiopia. p. 56–85. In: M.H. Thijssen, Z. Bishaw, A. Beshir and W.S. de Boef (eds.), *Farmers, Seeds and Varieties: Supporting Informal Seed Supply in Ethiopia*. Wageningen International, Wageningen.
- Abay, F. and Bjørnstad, Å. 2009. Specific adaptation of barley varieties in different locations in Ethiopia. *Euphytica* 167(2): 181–195.
- Abay, F., Waters-Bayer, A. and Bjørnstad, Å. 2008. Farmers' seed management and innovation in varietal selection: Implications for barley breeding in Tigray, northern Ethiopia. *Ambio* 37(4): 312–320.
- Annicchiarico, P., Bellah, A. and Chiari, T. 2005. Defining subregions and estimating benefits for a specific-adaptation strategy by breeding programs: A case study. *Crop Sci.* 45: 1741–1749.
- Ceccarelli, S., Grando, S. and Hamblin, J. 1992. Relationships between barley grain yield measured in low and high yielding environments. *Euphytica* 64: 49–58.
- Ceccarelli, S., Grando, S. and Impiglia, A. 1998. Choice of selection strategy in breeding barley for stress environments. *Euphytica* 103: 307–318.
- Christinck, A., Weltzien, E. and Hoffmann, V. (eds). 2005. *Setting Breeding Objectives and Developing Seed Systems with Farmers: A handbook for practical use in participatory plant breeding projects*. Margraf Publishers, Weikersheim.

■ **Farmer–Breeder Partnership in Barley Varietal Selection: A Case for Decentralized Plant Breeding in Drought-Prone Areas of Northern Ethiopia, Fetien Abay1 and Åsmund Bjørnstad**

Hussein, M.A., Bjørnstad, Å. and Aastveit, A.H. 2000. SASG × ESTAB: A SAS program for computing genotype × environment stability statistics. *Agron. J.* 92: 454–459.

Joshi, A. and Witcombe, J.R. 1996. Farmer participatory crop improvement. II. Participatory varietal selection, a case study in India. *Exp. Agric.* 32: 461–477.

SAS 2001. SAS User's Guide (9th edn). SAS Institute, Cary, NC.

Snapp, S. 1999. Mother and baby trials: A novel trial design being tried out in Malawi. *Target Newsletter of the Southern Africa Soil Fertility Network* 17: 8–10.

Sperling, L., Ashby, J.A., Smith, M.E., Weltzien, E. and McGuire, S. 2001. A framework for analyzing participatory plant breeding approaches and results. *Euphytica* 122: 425–438.

Virk, D.S., Singh, D.N., Prasad, S.C., Gangwar, J.S. and Witcombe, J.R. 2003. Collaborative and consultative participatory plant breeding of rice for the rainfed uplands of eastern India. *Euphytica* 132: 95–108.

Witcombe, J.R., Joshi, A., Joshi, K.D. and Sthapit, B.R. 1996. Farmer participatory crop improvement. I. Varietal selection and breeding methods and their impact on biodiversity. *Exp. Agric.* 32: 445–460.

Yan, W., Hunt, L.A., Sheng, Q. and Szlavnic, Z. 2000. Cultivar evaluation and megaenvironment investigation based on the GGE biplot. *Crop Sci.* 40: 597–605.

Yan, W., Kang, M.S., Ma, B., Woods, S. and Cornelius, P.L. 2007. GGE biplot vs. AMMI analysis of genotype-by-environment data. *Crop Sci.* 47: 641–653.

Development and Promotion of Technologies for Sustainable Production and Utilization of Indigenous Vegetables for Nutrition Security and Wealth Creation in Kenya

Mary O. Abukutsa-Onyango¹

Keywords: research, technologies, outreach, indigenous vegetables, hunger, cash

Abstract

Over 60% of the rural population of Kenya lives below the poverty line, resulting in malnutrition, poor health and inadequate basic necessities. Malnutrition is manifested in various forms in children, such as their being underweight or stunted, or suffering from iron-deficiency anaemia. The most serious malnutrition problems are a result of inadequate consumption of micronutrients. These malnutrition problems are prevalent despite the fact that Kenya is endowed with agro-biodiversity like African indigenous vegetables (AIVs), which are highly nutritious, have health benefits and income-generation potential, and agronomic advantages that can be exploited. Major constraints that hinder optimal production and utilization of AIVs include neglect by stakeholders, lack of quality seed, lack of technical production and utilization packages, poor marketing channels and high perishability. Consequently, their potential has not been fully exploited. To address this situation, a multi-disciplinary research programme was initiated at Jomo Kenyatta University of Agriculture and Technology (JKUAT) in 1991 and at Maseno University in 1996, with the aim of promoting sustainable production and utilization of AIVs for poverty reduction. The programme continues to date. The following have been achieved: baseline and market surveys conducted; AIVs with nutrition and economic potential identified; germplasm collected, characterized, evaluated and multiplied; quality seed packaged and made available; seed production and processing protocols, and crop production and value-addition protocols developed and disseminated; seed support systems for AIVs established; AIVs promoted and disseminated through leaflets, DVDs, oral-media (folklore, poetry, song and dance), workshops, demonstration plots, field days and training; capacity built; conservation; high-iron products developed; and increased production and availability of AIVs in markets and supermarkets in major cities in Kenya. Universities should therefore be supported to provide a conducive environment for scientific research and technology development for sustainable development.

¹ Department of Horticulture, Jomo Kenyatta University of Agriculture and Technology (JKUAT), PO Box 62000, 00200 – Nairobi, Kenya.

INTRODUCTION

Background

Food insecurity is an issue of concern in Kenya (GoK, 1999): 60% of the rural population lives below the poverty line, resulting in malnutrition, poor health and inadequate access to basic necessities. Malnutrition in children is manifested in various forms and it has been reported that over 20% of the Kenyan children under 5 are malnutrition problems are a result of inadequate consumption of micronutrients normally referred to as 'hidden hunger'. The paradox is that while these malnutrition problems are prevalent in Kenya, the Lake Victoria, Western islands and Coastal regions are endowed with agricultural diversity including African indigenous vegetables (AIVs) (Schippers, 2000). AIVs are those vegetables whose primary or secondary centre of origin is known to be in Africa (Schippers, 2000). Vegetables whose secondary centre of origin is Africa may also be referred to as 'African traditional vegetables' (Schippers, 2000). Vegetables are a vital component of human diet as they provide essential micronutrients that ensure proper development of the human body (Abukutsa-Onyango, 2007a). AIVs have been grown and utilized traditionally by many African communities and possess several advantages and potentials that have not been fully exploited (Schippers, 2000). AIVs have been reported to have high nutritional value, where consumption of 100 g of the vegetables provides over 100% of the daily requirement of vitamins and minerals and 40% of proteins (Onyango, 2003).

African indigenous vegetables also possess medicinal properties and have agronomic advantages over exotic species, enabling the poorest people in the rural communities to earn a living (Schippers, 2000). Despite the many advantages, farmers achieve very low yields of 1–3 tonnes per hectare—far below the optimal levels that range from 20 to 40 tonnes per hectare (Onyango, 2003). AIVs that have medicinal properties are usually bitter and have been known to heal stomach-related ailments (Olembo et al., 1995). The vegetables have been neglected, and there has been a lack of quality seed and appropriate production technologies, which have led to low production and poor distribution. Increased and sustainable production and utilization of AIVs can be attained by ensuring supply of quality seed and development of environment-friendly production and utilization technologies. Improved production technologies like spacing, fertilizer rates and use of organic sources of manure will lead to increased yields and improved nutrition and economic empowerment of the rural communities in Kenya and other parts of Africa, and in urban and peri-urban regions. Given the advantages and potential value of AIVs and the constraints that curtail their optimal production and utilization, an AIVs research programme was initiated at Jomo Kenyatta University of Agriculture and Technology (JKUAT) in 1991 and Maseno University in 1996, with the aim of promoting sustainable production and utilization of AIVs for poverty alleviation in Kenya.

Objectives

The general objective of the Programme was to promote sustainable production and utilization of AIVs for poverty reduction in Kenya. Specific objectives were to:

- Develop multidisciplinary projects on AIVs and solicit for funding
- Identify priority AIVs with nutritional and economic potential
- Collect, characterize, evaluate and multiply germplasm of priority AIVs
- Conduct agronomic and physiological studies on priority AIVs
- Establish quality seed support systems on station and at the community level

■ **Development and Promotion of Technologies for Sustainable Production and Utilization of Indigenous Vegetables for Nutrition Security and Wealth Creation in Kenya, *Mary O. Abukutsa-Onyango***

- In-situ and ex-situ conservation of AIVs
- Capacity-building and training of stakeholders on AIVs
- Outreach, promotion and dissemination of AIV technologies to all stakeholders
- Develop micronutrient-rich AIV recipes and products for commercialization.

MATERIALS AND METHODS

JKUAT and Maseno University are among seven public universities in Kenya that were established by an act of parliament. Their respective visions are “to be a world class institution of higher learning for development” and “to be a leading institution and centre of excellence in University teaching, outreach, research and development”. The multidisciplinary African Indigenous Vegetable Programme was hosted and coordinated by the Departments of Horticulture, at JKUAT, 1991–92, at Maseno University, 1996–2007, and again at JKUAT from 2007 to date. JKUAT is located in central Kenya, 20 km east of Nairobi, and Maseno University is in western Kenya about 20 km west of Kisumu. Between 1992 and 1995, the principal researcher and co-ordinator went for studies abroad.

AIVs research projects (2001–2008)

Twelve national, regional and international research projects were undertaken between 1997 and 2008 on various aspects of AIVs. This was done by writing over 20 research proposals and sending them to funding agencies, with 12 of these ultimately receiving funding. Of the 12 that were funded, seven were implemented between 2001 and 2008.

1. Priority African Indigenous Vegetables with Nutritional and Economic Potential. To identify priority AIVs in Kenya and the East African region, household, baseline and market surveys were carried out in various parts western and central Kenya. Sampling methods included systematic, random, stratified and purposive sampling schemes. The main tools used in the surveys were checklists and structured questionnaires. Key informants were also used to corroborate the information from the respondents. Through these surveys, preferred and priority AIVs with nutritional and economic potential were identified and selected.

2. Germplasm Collection, Evaluation and Multiplication of Priority AIVs. Germplasm of the selected priority AIVs was collected from eight districts in western Kenya—Kisumu, Siaya, Vihiga, Butere-Mumias, Kisii, Nyamira, Homa Bay and Bondo. Collected seeds were subjected to laboratory analysis and field evaluation using completely randomized design (CRD) and completely randomized block design (CRBD) experimental designs, respectively. Agronomic studies were conducted on organic and inorganic fertilizers, intercropping and spacing, from which agronomic and seed production protocols were developed and repackaged.

3. Agronomic Studies and Water Use Efficiency Studies. Agronomic studies were conducted on organic and inorganic fertilizers, intercropping and spacing, from which agronomic and seed-production protocols were developed and repackaged. Studies have also been initiated at JKUAT in 2008 on water use efficiency in bambara nuts (*Vigna subterranea*) and slenderleaf (*Crotalaria ochroleuca*).

4. Conservation and Seed Support Systems for AIVs at JKUAT and Maseno University. Seed support systems for AIVs were established at Maseno University Botanic Garden in 2000 and at JKUAT in 2008 for the priority vegetables. Community seed-supply systems were established in eight districts in western Kenya and are currently being established in four districts in central Kenya. Seed bulking, processing and packaging are currently being undertaken at both Maseno University Botanic Garden and JKUAT, using organic sources of fertilizer with no chemical application. In-situ and exsitu conservation of AIVs was initiated at Maseno University Botanic Garden in 2001, at JKUAT farm in 2007, on contact farmers' farms in eight districts in western Kenya in 2001, and in five districts in central Kenya in 2008.

5. Capacity-building. Capacity-building in AIVs was achieved by restructuring undergraduate and postgraduate programmes, by including AIVs as a topic in the Bachelor of Science in Horticulture Programme in 2001, and as a unit in the Master of Science programme at Maseno University in 2002 and at JKUAT in 2008. Undergraduate research projects and MSc thesis projects on AIVs were also encouraged and supported.

6. Outreach, Promotion and Dissemination of AIV Technologies. AIV technologies were promoted among and disseminated to all stakeholders from 2003 through demonstration plots, field days, workshops, research projects, students' projects and thesis research, newspapers, documentaries and exhibitions.

7. Development of AIV Recipes and Products for Commercialization. Traditional AIV recipes were collected from western Kenya and standardized in 2002. New AIV recipes and nutritious products from AIVs were developed in 2007 by MSc students at Maseno University.

RESULTS

Projects Undertaken on African Indigenous Vegetables (2001–2008) Table 1 shows seven projects funded between 2001 to 2008 on AIVs. Two of the projects were funded by the Government of Kenya, four from international funding agencies, and one was self-funded. Three of these projects also covered other African countries. Table 2 shows the ten priority African leafy vegetables identified in Vihiga, Kisumu and Kisii districts. The priority AIVs represented seven botanical families. The main AIVs grown in urban and peri-urban Nairobi and Kisumu were African nightshade, vegetable amaranths, vegetable cowpeas, spiderplant, pumpkin leaves, slenderleaf and jute mallow. A market survey revealed that the most important AIVs in three markets (Kiboswa, Chavakali and Kakamega municipal markets) in western Kenya included cowpeas, leaf amaranth, African nightshade, jute mallow, spiderplant, slenderleaf, African kale and pumpkin.

2. Germplasm Collection, Evaluation and Multiplication of Priority AIVs. A total of 128 accessions were obtained by collecting two seed lots of each of eight vegetable species in eight districts. Selection was based on the weight, percentage germination and moisture content (Table 3). Except for spiderplant and African nightshade, laboratory germination was high (>70%) and correlated very well with field germination (>80%). Weight of collected sample (>15 g) was a criterion for selection (as priority accession) so that there was enough seed for multiplication. Moisture content for all the accessions ranged between 9.5 and 11.4%.

3. Agronomic studies. Organic and inorganic sources of fertilizers had a significant ($P \leq 0.05$) effect on growth and yield of cowpea and spiderplant. In the intercropping study, African kale was found to be a suitable intercrop for slenderleaf, cowpeas, spiderplant and African nightshade, since the land-equivalent ratio was found to be greater than one in all the intercrops.

Table 1: Projects on AIVs at maseno University between 1997 and 2007

	Title of project	Funding agency	Year and location
1	Market survey on African indigenous vegetables in western Kenya	Self-funded	2001 Kenya
2	Germplasm management of African leafy vegetables for the nutritional and food security needs of the vulnerable groups in Sub-Saharan Africa	IPGRI/Biodiversity International	2001–2005 Kenya and 4 other countries
3	Intercropping African kale with other selected African indigenous vegetables for sustainable production in the Lake Victoria region	International Foundation for Science	2004–2008 Kenya
4	Development of appropriate farming technologies for sustainable production and utilization of AIVs for improved land use in the Lake Victoria basin	SIDA-SAREC (VICRES)	2005–2009 Kenya, Uganda and Tanzania
5	Networking to promote the sustainable production and marketing of indigenous vegetables through urban and peri-urban agriculture in Sub-Saharan Africa	European Commission	2006–2008 7 African and 5 EU countries
6	Assessment of water use efficiency of bambara groundnut (<i>Vigna subterranea</i>) for food and nutrition security in Kenya	CHE	2008–2009 Kenya
7	Assessment of water use efficiency of slenderleaf (<i>Crotalaria ochroleuca</i>) for food, nutrition and health security	JKUAT	2008–2011 Kenya

¹All projects conducted by the author as principal investigator.

Sources: Director, School of Graduate Studies, Research Inventory, Maseno University, 2007; Deputy Vice Chancellor, Research Planning and Extension Division, JKUAT, 2008.

4. Seed Support Systems. Seed yields per hectare varied slightly with the vegetable species, but ranged from 1036 kg/ha (jute mallow) to 1320 kg/ha (vegetable amaranths). The 1000-seed weight of the seven species was also determined and this also varied with species. A total of 77 farmers in eight districts in western Kenya and 23 farmers in five districts in central Kenya were provided with seed and technical information on the production and seed processing of seven AIVs (Abukutsa-Onyango, 2007b). The processed seeds were packed in 50 g and 100 g plastic bags, sealed and distributed to the farmers.

5. Capacity-building. The proportion of BSc Horticulture students who undertook projects in AIVs in Maseno University increased from 20% in 2001 to 70% in 2006 and then dropped to 50% in 2008; in JKUAT there was an decrease from 31% in 2004 to 20% in 2007, but this doubled to 40% in 2008 (Table 4).

6. Conservation of AIVs at Maseno Botanic Garden. In-situ and ex-situ conservation of AIVs was implemented from 2001. Maseno University Botanic Garden was established in 2001 and is a home to 200 plant species, of which 10% are AIVs. This project was funded by the Federal Government of Germany, BIOTA Project and the purpose of the garden was combined research, teaching, conservation and recreational use.

Table 2: Priority African indigenous vegetables in three districts in Kenya (Abukutsa-Onyango, 2007a)

Rank	African indigenous vegetable	Botanical family	Vihiga ¹	Kisumu ¹	Kisii ¹	Total ²
1	Spiderplant (<i>Cleome gynandra</i>)	Capparaceae	100	100	100	300
2	African nightshade (<i>Solanum villosum</i>)	Solanaceae	100	100	90	290
3	Pumpkin leaves (<i>Cucurbita moschata</i>)	Cucurbitaceae	100	100	45	245
4	Cowpeas (<i>Vigna unguiculata</i>)	Fabaceae	100	100	40	240
5	Vegetable Amaranth (<i>Amaranthus blitum</i>)	Amaranthaceae	90	100	40	230
6	Jute mallow (<i>Corchorus olitorius</i>)	Tiliaceae	100	100	25	225
7	African nightshade (<i>Solanum scabrum</i>)	Solanaceae	90	100	30	220
8	Slenderleaf (<i>Crotalaria ochroleuca</i>)	Fabaceae	100	100	6	206
9	Slenderleaf (<i>Crotalaria breviflora</i>)	Fabaceae	90	100	0	190
10	African kale (<i>Brassica carinata</i>)	Brassicaceae	50	60	0	110

¹ The figures are the percentages of respondents who identified the vegetable(s) as priority.

² The total is the addition of the percentages to give the ranking.

Table 3: Selected accessions from a total of 128 of African leafy vegetables from eight districts in Kenya (Abukutsa-Onyango, 2007a)

AIV	Weight (g)	Germination (lab, %)	Seedling emergence (%)	Moisture content (%)
Spiderplant	40.6	30	90	11.2
Nightshades	15.6	50	85	11.0
Jute mallow	22.1	75	80	10.2
Slenderleaf (bitter taste)	20.8	100	95	9.5
Slenderleaf (mild taste)	22.3	100	99	9.5
Vegetable amaranth	34.0	85	86	9.6
Vegetable cowpeas	30.7	100	90	10.9
African kale	19.7	90	100	11.4

Table 4: Prportion of Bsc. Horticulture students who took AIV projects in their final year of study at Maseno University and JKUAT (Departments of Horticulture records, Maseno University and JKUAT)

Year	No. students taking projects in their final year of study			
	Maseno University		JKUAT	
	No. in class	AIV projects (%)	No. in class	AIV projects (%)
2001	10	20	–	–
2002	29	34	–	–
2003	14	28	–	–
2004	14	71	39	31
2005	–	–	41	29
2006	25	70	36	20
2007	14	42	32	20
2008	6	50	32	40

Note: – not available.

7. Outreach, Promotion and Dissemination of AIV Technologies. Promotion and dissemination was made as a component of the IPGRI, VICRES (SIDA) and IFS Research Projects. Several methods were used and some methods were common across projects. Different methods were used with different target groups. Some methods could be used for more than one target group. The main target groups were students, staff (both local and from other institutions), farmers and farmers’ organizations, policy-makers, funding organizations, consumers, and the general public. The focus was on the identified priority AIVs in Kenya. Venues of promotion included lecture rooms, Maseno University Botanic Garden, agricultural shows, Kenyan universities’ annual exhibitions, farmers’ fields, markets, and other institutions. Methods used in promotion and dissemination were lectures, workshops and seminars, demonstration plots, leaflets and brochures, posters, videos/DVDs, and oral-media (poems, song and dance).

8. Development of AIV recipes and products for commercialization. It has been demonstrated that high-quality products can be developed from AIVs. The high-iron recipes developed from AIVs can alleviate anaemia, which is a serious problem in Kenya. These recipes include vegetable recipes and vegetable-product recipes with high iron content (Habwe, 2008).

DISCUSSION AND CONCLUSION

Of the seven projects, five were funded by international organizations, one by the University and one was self-funded. University funding has been wanting in most African universities and inadequate funding is allocated for research (Akinkugbe and Kunene, 2001). Obtaining funds for this work took the passion for AIVs and personal initiatives of the individual researchers, and painstaking lobbying with funding agencies, with minimal involvement of university management and authorities. Seven research projects on AIVs were carried out at Maseno University between 2001 and 2008.

The list of identified priority AIVs (Table 2) agrees with Schippers (2000) and Onyango (2003), where the identified vegetables have been reported to be among the most important ones in Kenya and are widely distributed throughout Africa, although the importance of each vegetable varies by region. Cowpeas seem to be the most popular, as shown by large quantities traded, especially in the municipal market. This is probably due to cowpeas' good keeping quality and long shelf-life compared to the other vegetables (Schippers, 2000) and also the fact that the leaves do not have a bitter taste. Slenderleaf has smaller leaves and its preparation is tedious and may not be popular with busy working consumers. African kale and pumpkin leaves were not sold in the rural markets; the possible explanation is that farmers would prefer to sell them on their farms or use them for home consumption because of their perishability.

The leaf yields of cowpeas were consistently higher than those of spiderplant in the organic and inorganic study, and this could be attributed to the small leaves of spiderplant. In cowpeas, the best treatments were manure and Tithonia, an indication that cowpeas responded better to organic fertilizer than to inorganic. On the other hand, spiderplant's best response was to the organic–inorganic combination of half Tithonia (2.5 tonnes dry leaves per hectare) and half diammonium phosphate (100 kg DAP per hectare). This observation indicates differential response of species to fertilization, and agrees with Marschner (1995).

Agronomic studies on AIVs indicated that these vegetables have a short growth period, thrive as intercrops and respond well to both organic and inorganic fertilizers. Promotion of AIVs at Maseno University through their inclusion in the BSc and MSc Horticulture Programmes influenced the choice of topics by students undertaking research projects on AIVs between 2001 and 2006. This could be attributed to the promotion of AIVs and restructuring of the programmes; however, the proportion of AIV projects declined to 50% in 2008 due to a promotion of indigenous fruits in Maseno University. The great jump at JKUAT from 20% in 2007 to 40% in 2008 could be attributed to the seed support system at the university farm and the inclusion of AIVs in the programme. Inclusion of AIVs in horticulture programmes substantially contributed to the increased number of AIV projects undertaken by students.

Universities can play a vital role in promoting underutilized species through research, capacity-building, conservation and outreach programmes. Financial and infrastructural support should be provided to universities in Africa by their governments for science, research and technology development and innovation.

African indigenous vegetables have several advantages and values that need to be exploited. Our research has shown that these vegetables have nutrition-security and wealth-creation potential within and outside Kenya. In Africa, it is time to embrace African underutilized but useful plants to solve African malnutrition.

Acknowledgements

The author gratefully acknowledges Jomo Kenyatta University of Agriculture and Technology and Maseno University. Financial assistance from the International Plant Genetic Resources Institute (IPGRI), VicRes-SIDA, International Foundation for Science (IFS), European Commission, Commission for Higher Education, Kenya and JKUAT is acknowledged.

Literature Cited

- Abukutsa-Onyango, M.O. 2007a.* The diversity of cultivated African leafy vegetables in three communities in western Kenya. African Journal of Food Agriculture, Nutrition and Development (AJFAND) 7 (3) online www.ajfand.net.
- Abukutsa-Onyango, M.O. 2007b.* Seed production and support systems for African leafy vegetables in three communities in western Kenya. African Journal of Food Agriculture, Nutrition and Development (AJFAND) 7 (3) online www.ajfand.net.
- Akinkugbe, O. and Kunene, V. 2001.* Education Financing and Budgetary Reforms in Africa. Association for the Development of Education in Africa (ADEA), Tunisia, and Council for the Development of Social Science Research in Africa (CODESRIA), Senegal.
- GoK (Government of Kenya) 1999.* Sessional Paper No. 3 of 1999 on National Poverty Eradication Plan 1999–2015. Republic of Kenya Office of the President, [Nairobi].
- Habwe, F.O. 2008.* Development of high iron recipes of African indigenous vegetables from East Africa. Unpublished MSc Thesis, Maseno University.
- Marschner H. 1995.* Mineral Nutrition of Higher Plants (2nd Edn). Academic Press.
- Olembo, N.K., Fedha, S.S. and Ngaira, E.S. 1995.* Medicinal and Agricultural Plants of Ikolomani Division, Kakamega District. Development Partners.
- Onyango, M.O.A. 2003.* Unexploited potential of indigenous African vegetables in western Kenya. Maseno Journal of Education Arts and Science 4(1): 103–122.
- Schippers, R.R. 2000.* African Indigenous Vegetables: An Overview of the Cultivated Species. Natural Resources Institute, University of Greenwich, Chatham, UK.

Performance of Maize Varieties of Different Maturity Groups under the Marginal Rainfall Conditions of a Rainforest Location

A. Oluwaranti¹, M.A.B. Fakorede¹ and B. Badu-Apraku²

Keywords: planting dates, flowering traits, grain yield, drought, season

Abstract

This study was conducted to evaluate the performance of different maturity groups of maize varieties at different planting dates under the marginal rainfall conditions of the rainforest ecology of Nigeria. The study was carried out in two late seasons (2001 and 2005) and two early seasons (2002 and 2006). A total of 18 maize varieties was evaluated. All plantings were done at weekly intervals. Data were obtained on flowering traits, grain yield and yield components. Number of days to flowering in the late seasons showed a decreasing trend for the first three planting dates and increased thereafter; while in the early seasons, there was a contrasting trend for the two seasons evaluated. Grain yield and yield components decreased as planting was delayed in the late seasons, while in the early season of 2002, an initial decreasing trend was followed by an increasing trend from the fifth planting date. In contrast to 2002 early season, grain yield increased from the first to the fourth planting date and decreased thereafter in 2006 early season. AK95DMR-ESRW (2.19 t/ha), Sin 9432 (1.79 t/ha), ACR90POOL16DT (1.75 t/ha) and TZECOMP3DT (1.74 t/ha) gave the highest mean grain yields in the two late seasons of this study, while ACR95TZECOMP4C3 (4.19 t/ha), ACR90POOL16DT (4.12 t/ha) and HEI97TZE.COMP4C3 (3.84 t/ha) were the top yielders in the two early seasons. Overall, grain yield of ACR90POOL16DT (2.94 t/ha), BAG97TZECOMP3×4 (2.94 t/ha) and ACR95TZECOMP4C3 (2.86 t/ha) were the highest grain-yielders across the two seasons and years.

INTRODUCTION

¹ Department of Crop Production and Protection, Obafemi Awolowo University, Ile-Ife, Nigeria.

² Coordinator, WECAMAN, IITA, PMB 5320, Ibadan, Nigeria.

■ **Performance of Maize Varieties of Different Maturity Groups under the Marginal Rainfall Conditions of a Rainforest Location**
A. Oluwaranti, M.A.B. Fakorede and B. Badu-Apraku

The universally accepted most probable centre of origin of maize (*Zea mays* L.) is in an area of alternating wet and dry seasons in Mexico. The broad adaptation of maize to all agroecological zones in Nigeria is, therefore, not surprising. All of the ecological zones in Nigeria are characterized by alternating wet and dry seasons, although the duration of the seasons varies among the ecological zones. Observations by Fakorede and Akinyemiju (2003) at Ile-Ife (7°28'N 4°33'E, 244 m) in the marginal areas of the rainforest ecology of south-western Nigeria suggest that global climatic change is already impacting maize production practices. The combination of reduced rainfall and false starts of the rainy season provides an explanation for a shorter cropping season and increased drought probability in March, April and May observed at this location in the late 1990s. Nielsen et al. (2002) report that delayed planting shortens the effective growing season for maize, which can lead to moisture stress at flowering. Kucharik (2008) also reports that early planting of maize allows late-maturing varieties to perform optimally.

Badu-Apraku and Fakorede (2003) report that through collaborative research involving maize programmes in West and Central Africa, the West and Central Africa Collaborative Maize Research Network (WECAMAN), International Institute of Tropical Agriculture (IITA) and the Maize and Wheat Improvement Center (CIMMYT, Mexico) developed early maturing maize varieties that produce dry grains in about 90–95 days and extra-early varieties that produce dry grains in 80–85 days and could be eaten as fresh maize about 65 days after planting. The early and extra-early varieties were specifically developed for cultivation in the northern fringes of the northern Guinea savanna (NGS) and the Sudan savanna (SS) (Badu-Apraku and Fakorede, 1999; Onyibe et al., 1999). Although the early and extra-early maize varieties could also increase maize production under the marginal rainfall conditions of the rainforest zones, their performance in this ecology has not been evaluated. This study was therefore conducted to evaluate the performance of all the maize maturity groups under the marginal rainfall conditions of the rainforest ecology of southwestern Nigeria, and identify the maize varieties in all the maturity groups that are high yielding under such conditions.

MATERIALS AND METHODS

Field experiments were conducted at the Obafemi Awolowo University Teaching and Research Farm (7°28'N, 4°33'E, altitude 224 m above sea level) during the late cropping seasons of 2001, 2005 and early cropping seasons of 2002, 2006. The treatments were a combination of planting dates and 18 varieties of maize. Five planting dates at weekly intervals were used in 2001 (20 August to 17 September), three in 2005 (7–21 September) and seven in each of 2002 (13 March to 24 April) and 2006 (3 April to 24 May). The experiments were laid out as randomized complete block design with factorial arrangement, replicated four times. The varieties were randomized within each replicate.

Each plot was a single row, 5 m long, spaced 0.75 m apart and within row spacing of 0.5 m. NPK fertilizer was applied at a total rate of 180 kg N, 90 kg P₂O₅ and 90 kg K₂O per hectare in two splits: the first at 3 weeks after planting and the second at 5 weeks after planting. Weeds were controlled by spraying primextra (atrazine and alachlor) one day after planting, at a rate of 5 L/ha. Weeds were also controlled by hand-weeding as necessary after the crop had established. Data were collected on days to 50% tasseling, anthesis and silking as well as grain yield adjusted to 15% moisture content. The data were statistically analysed as factorials according to PROC GLM in SAS (SAS, 2003). Furthermore, regression analyses were performed to determine the trends in response of varieties to planting dates. Significant differences among

■ Performance of Maize Varieties of Different Maturity Groups under the Marginal Rainfall Conditions of a Rainforest Location
 A. Oluwaranti, M.A.B. Fakorede and B. Badu-Apraku

mean grain yields of all varieties were compared using the Least Significant Difference (LSD) at 0.05 level of probability.

RESULTS

Flowering traits (tasseling, anthesis and silking) showed similar trends in response to planting dates during the late seasons (i.e. 2001 and 2005), although the magnitudes of the values were different (Fig. 1). On the other hand, response in the early season, especially 2002, contrasted with that of the late season. Within the early season, response in 2002 also contrasted with that of 2006. The R² values, which is the coefficient of determination associated with the regression lines in 2001 were lower than those obtained in 2002, 2005 and 2006 (Fig. 1).

Fig. 1: Effects of planting dates on mean number of days to 50% tasseling (TS) anthesis (ANTH) and silking (SK) of maize varieties evaluated in the late seasons of 2001, 2005 and early seasons of 2002, 2006

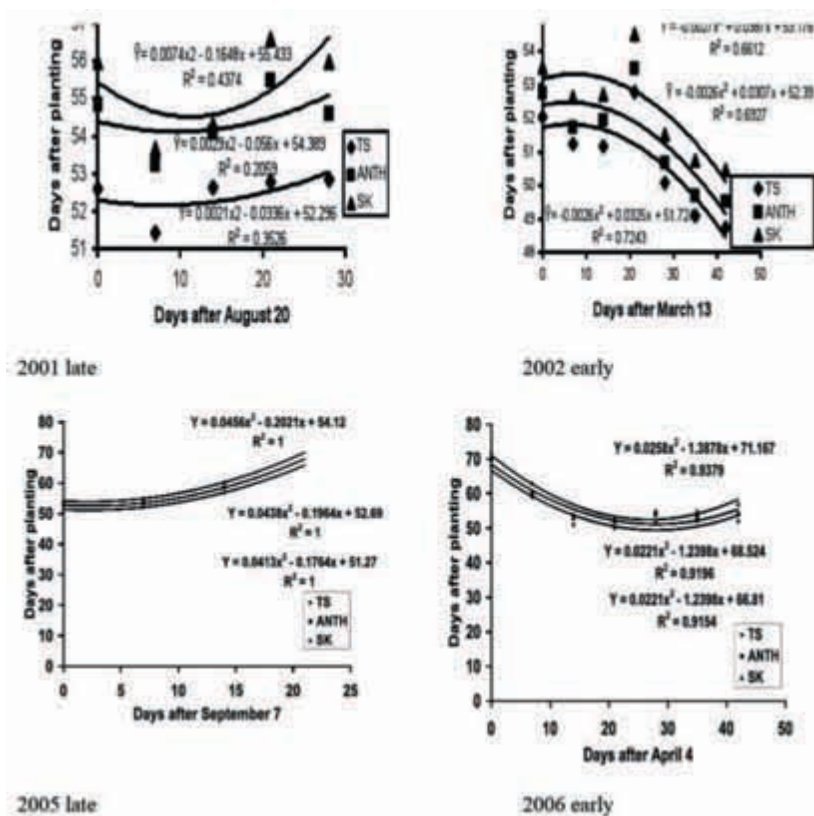
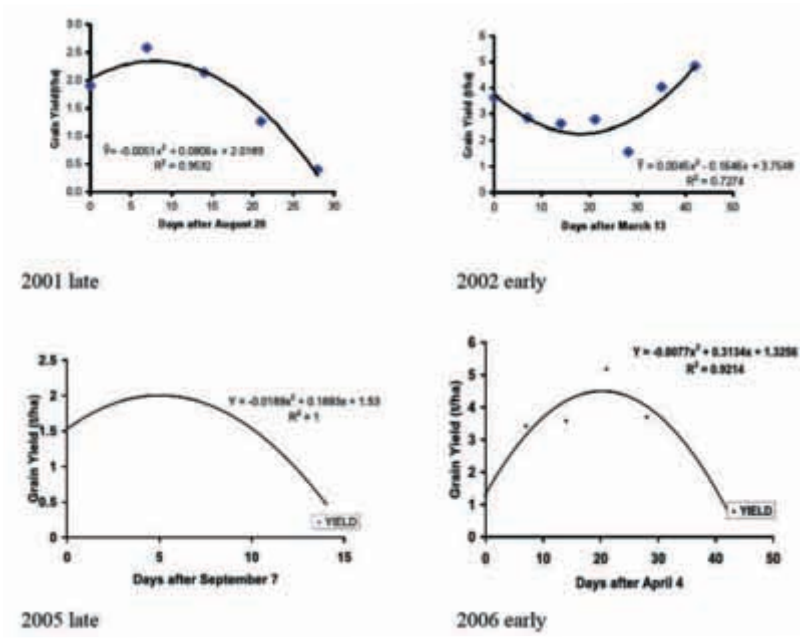


Fig. 2: Response of grain yield to planting dates of maize varieties evaluated in the late seasons of 2001, 2005 and early seasons of 2002, 2006



This value (R²) explains the variation observed in the traits as measured by ACR90POOL16DT) out-yielded the other varieties with grain yields of 1.70 t/ha and 1.60 t/ha, respectively (Table 1). The mean grain yield across 2001 and 2005 late seasons obtained shows that the highest-yielding varieties were AK95DMR-ESRW (2.19 t/ha), Sin 9432 (1.79 t/ha), ACR90POOL16DT (1.75 t/ha) and TZCOMP3DT (1.74 t/ha), while the mean of 2002 and 2006 early seasons indicated that ACR95TZCOMP4C3 (4.19 t/ha), ACR90POOL16DT (4.12 t/ha) and HEI97TZE.COMP4C3 (3.84 t/ha) were the top yielders (Table 1). The mean grain yield across the seasons and years of evaluation of these varieties showed that ACR90POOL16DT (2.94 t/ha), AK95DMR-ESRW (2.94 t/ha) and ACR95TZCOMP4C3 (2.86 t/ha) were the highest-yielding varieties (Table 1). Generally, the yields of the maize varieties in the early seasons of this study were higher than those obtained in the late seasons (Table 1).

DISCUSSION AND CONCLUSION

The observed significant differences among the planting dates could be ascribed to differences in amounts of rainfall received, which is the most important climatic factor determining the performance of maize in the rainforest zone of Nigeria (Fakorede and Akinyemiju, 2003). The early season normally receives larger amounts of rainfall with longer duration than the late season. Results of this study showed that the late-season crop should be planted in the last week of August or the first week of September for maximum grain yield.

Delayed planting not only reduced grain yield, but also tended to delay flowering in the varieties, thus

■ **Performance of Maize Varieties of Different Maturity Groups under the Marginal Rainfall Conditions of a Rainforest Location**
A. Oluwaranti, M.A.B. Fakorede and B. Badu-Apraku

making them tend towards late maturity. In the early seasons of the two years in this study, yield tended to decrease for plantings made in March, but increased from early April to a maximum at about 18–25 April. This corroborates Fakorede and Akinyemiju's (2003) finding, that the optimum planting date for maize in the forest zone is about mid- to late April. The inconsistency in the response of flowering dates to planting date in this study confirmed the fact that flowering traits, especially days to silking, are strongly influenced by the environment, as was also observed in the study of Fakorede (1985). This makes the use of flowering dates as indicators of maturity seriously questionable and quite unreliable. Data obtained from this study afforded an opportunity to test the hypothesis of Fakorede and Akinyemiju (2003) that availability of early/extra-early or drought-tolerant maize for planting during the early part of the early cropping season would increase maize production in the rainforest zone. TZECOMP3DT, ACR90POOL16DT, TZEE-WSRC5 and TZEWPOP×1368STRC1 were among the highest-yielding varieties in the first three planting dates of the 2002 and 2006 early cropping seasons, which were characterized by drought.

In conclusion, performance of the maize varieties during the early seasons of 2002 and 2006 was better than that in the late seasons of 2001 and 2005. AK95DMR-ESRW (2.19 t/ha), Sin 9432 (1.79 t/ha), ACR90POOL16DT (1.75 t/ha) and TZECOMP3DT (1.74 t/ha) were the highest yielders in the late seasons, while ACR95TZECOMP4C3 (4.19 t/ha), ACR90POOL16DT (4.12 t/ha) and HEI97TZE.COMP4C3 (3.84 t/ha) were the top yielders in the early seasons. Maturity classification of maize is highly influenced by the environment.

The information provided from this study has resulted in the improvement and promotion of these early, extra-early and drought-tolerant maize varieties by maize breeders and extension agents. This has led to the availability of maize almost throughout the year in the rainforest ecology of Nigeria.

Literature Cited

- Badu-Apraku, B. and Fakorede, M.A.B. 1999.* Progress in breeding for *Striga hermonthica* resistant early and extra-early maize varieties. p. 147–162. In: Proceedings of Workshop on Impact, Challenges and Prospects of Maize Research and Development in West and Central Africa, IITA, Cotonou, Benin, 4–7 May.
- Badu-Apraku, B. and Fakorede, M.A.B. 2003.* Promoting maize technology transfer in West and Central Africa: A networking approach. p. 45–65. In: Proceedings of Workshop on Maize Revolution in West and Central Africa, IITA, Cotonou, Benin, 14–18 May.
- Fakorede, M.A.B. 1985.* Response of maize to planting dates in a tropical rainforest location. *Experimental Agriculture* 21: 19–30.
- Fakorede, M.A.B. and Akinyemiju, O.A. 2003.* Climatic change: Effects on maize production in a tropical rainforest location. p. 272–282. In: Proceedings of Workshop on Maize Revolution in West and Central Africa, IITA, Cotonou, Benin, 14–18 May.
- Kucharik, C.J. 2008.* Contribution of planting date trends to increased maize yields in the central United States. *Agronomy Journal* 100(2): 328–336.
- Nielsen, R.L., Thomison, P.R., Brown, G.A., Halter, A.L., Wells, J. and Wuethrich, K.L. 2002.* Delayed planting effects on flowering and grain maturation of Dent corn. *Agronomy Journal* 94: 549–558.

■ **Performance of Maize Varieties of Different Maturity Groups under the Marginal Rainfall Conditions of a Rainforest Location**
A. Oluwaranti, M.A.B. Fakorede and B. Badu-Apraku

Onyibe, J.E., Daudu, C.K., Akpoko, J.G. and Iwuafor, E.N.O. 1999. Challenges to maize technology transfer in marginal zones of Nigeria. p. 383–393. In: Proceedings of Workshop on Impact, Challenges and Prospects of Maize Research and Development in West and Central Africa, IITA, Cotonou, Benin, 4–7 May.

SAS 2003. SAS/STAT User's Guide. Version 9. SAS Institute, Cary, NC.

Traditional Medicine and its Impact on Livelihoods

Ameenah Gurib-Fakim¹

Keywords: traditional medicine, livelihoods, documentation, validation, standardization

Abstract

Plants have formed the basis of sophisticated traditional medicines that have existed for thousands of years and continue to provide humans with remedies. According to the World Health Organization, over 80% of the world's population still depends on traditional medicine for primary healthcare. The interest in nature continues not only as a potential source of herbal medicines, which is finding increasing acceptance in the developed world, but also as chemotherapeutic agents.

Natural products and their derivatives represent more than 50% of all drugs in clinical use in the world. The African continent is blessed with a unique biodiversity accounting for almost 25% of the global pool of genetic resources. Paradoxically, the continent is experiencing the highest rate of biodiversity destruction. Conservation of plant genetic resources, documentation and validation of the traditional knowledge are key issues that will need to be addressed if the industrial potential of these plants is to be demonstrated. This paper gives an overview of the work that has been done on the extension of botanical information, documentation of traditional knowledge, and validation of the ethnobotanical information with a view to sustaining conservation efforts and to developing an African Herbal Pharmacopeia (AfrHP). AfrHP will not only ensure the availability of safe and effective herbal medicine, but will also ensure that standards for the eventual commercialization of medicinal plants are adhered to. By adhering to the standards of the AfrHP, the grower will be able to penetrate the international market and, by so doing, impact the livelihoods of the people on the continent.

INTRODUCTION

Throughout the ages, humans have relied on nature for their basic needs for the production of food, shelter, clothing, means of transportation, fertilizers, flavours, fragrances and, not least, medicines. Plants have formed the basis of sophisticated traditional medicine systems that have been in existence for thousands of years and continue to provide humankind with new remedies. Although some of the therapeutic properties attributed to plants have proven to be erroneous, medicinal plant therapy is based on the empirical findings of hundreds and thousands of years.

Interest in nature as a source of potential chemotherapeutic agents continues. Natural products and their derivatives represent more than 50% of all the drugs in clinical use in the world. Higher plants contribute no less than 25% of the total. Since the late 1960s, at least a dozen potent drugs have been derived from flowering plants.

With approximately half (125,000) of the world's plant species living in the tropical rainforests, it is understandable that the tropical rainforests support a vast reservoir of potential drug species. They will continue to provide natural-product chemists with invaluable compounds as starting materials for the development of new drugs. The potential for finding more compounds is enormous, as only about 1% of tropical species have been studied for their pharmaceutical potential. This proportion is even lower for species confined to the tropical rainforests. About 50 drugs have come from tropical plants. The existence of undiscovered pharmaceuticals for modern medicine has often been cited as one of the most important reasons for protecting rainforests, whose extinction rate is a matter of concern (McNeely et al., 1990).

According to the World Health Organization (WHO), the vast majority of people (80% of the world's population) still rely on their traditional materia medica (medicinal plants and other materials) for their everyday healthcare needs (Akerle et al., 1991). Often people who use traditional remedies, especially those from the developing world, may not understand the scientific rationale behind their medicines, but they know from personal experience that some medicinal plants can be highly effective if used at therapeutic doses. Since we have a better understanding today of how the body functions, we are thus in a better position to understand the healing powers of plants and their potential as multifunctional chemical entities for treating complicated health conditions.

While it is understood that the validation of traditional knowledge is important for the treatment of diseases, the documentation of this traditional knowledge and the conservation of the plant genetic material are equally important. Dissemination of information on the importance of plant resources and conservation issues (among other things) can no longer be emphasized enough.

MATERIALS AND METHODS

Documentation of the Traditional Knowledge on Medicinal Plants of Mauritius and Africa

The documentation of traditional knowledge has been carried out by interviews and questionnaires. Old literature was also searched in order to confirm past utilization with current use. The popularity of the plants used was judged by statistical analysis of the number of people who have reported on the use of the plants.

■ **Traditional Medicine and its Impact on Livelihoods**
Ameenah Gurib-Fakim

The plants that have been used by the maximum number of people constituted a useful database and guided efforts for validation work against common ailments such as diarrhoea—fever and dysentery were among the most common infectious diseases reported as treated by traditional herbal remedies. Herbal remedies were also used to treat non-communicable diseases such as diabetes, and cardiac-related ailments (e.g. hypertension).

Validation of the Traditional Uses

Existing standard protocols as reported in the literature were used for testing antimicrobial, anti-diabetic and antihypertensive properties of the herbal products. The results were compared, as far as possible, with those obtained and published in the monographs of ESCOP (2003) and of the WHO (1999, 2004, 2007).

RESULTS

Documentation of Medicinal Plants of Mauritius and the Indian Ocean Islands The inventory and study of aromatic and medicinal plants of Mauritius, which benefitted from funding from the European Development Fund (EDF) between 1989 and 1994, has resulted in the identification of 634 medicinal plants used in Mauritius and Rodrigues. Of these, 15% were indigenous/endemic (previous reports—Bouton, 1864; Daruty, 1886—reported only one indigenous/endemic plant used in the local pharmacopeia). This substantial increase in less than 200 years has prompted research projects, especially as the inventory has highlighted the conservation status of these plants ranging from vulnerable to highly threatened. Subsequently, this inventory was extended to the other Indian Ocean Islands and 2 CD-ROMs have been published in English and French (Gurib-Fakim et al., 1994, 1995, 1996, 1997; Gurib-Fakim and Gueho 2000, 2001; Gurib-Fakim and Brendler, 2003).

Documentation of Plant Resources of Tropical Africa

The African continent is considered to be the cradle of humankind, with a rich biological and cultural diversity and with marked regional differences in healing practices. African traditional medicine is known to be holistic, and is perhaps the oldest and most diverse of all medicine systems. Unfortunately, the systems of medicines remain poorly recorded. It is also worth noting that tropical and subtropical Africa has 40–45 thousand higher plant species that potentially hold considerable industrial value. This represents at least 25% of the global pool of plant genetic resources and has contributed significantly to the world's trade in genetic material.

The documentation of African plants and associated medicinal uses is therefore becoming increasingly urgent—heightened by the rapid loss of the natural habitats of some of these plants essentially due to anthropogenic activities. Habitat conversion threatens not only the loss of plant resources, but also traditional community life and cultural diversity along with accompanying knowledge of the medicinal value of several endemic species. The African continent is reported to have one of the highest rates of deforestation in the world. The paradox has it that it is also the continent with the highest rate of endemism. The Republic of Madagascar tops the list at 82%.

The project Plant Resources of Tropical Africa (PROTA) takes on board traditional and modern uses, phytochemical and pharmacological properties, describes the most convenient collection (harvest),

■ **Traditional Medicine and its Impact on Livelihoods**
Ameenah Gurib-Fakim

cultivation and application methods, and indicates the research and conservation status of the plants. This largest commodity group will eventually describe some 3,222 species used medicinally. The first volume, published in September 2008, describes 894 species of plants comprehensively. The remaining volumes will deal with the rest (Schmelzer and Gurib-Fakim, 2008).

Among the famous and important African medicinal plants documented are *Acacia senegal* (gum arabic), *Agathosma betulina* (buchu), *Aloe ferox* (Cape aloe), *Aloe vera*, *Artemisia afra* and *Commiphora myrrha* (myrrh).

PROTA has proposed a three-step approach in bridging the gap between scientific information and end-user impact. A few workshops have been organized around some important commodity groups, such as vegetables and dyes, tannins and vegetable oils. One of the results of this has been to showcase and highlight the need for the domestication of the important African plant, *Allanblackia* sp., as an edible and highvalue oil plant.

Extension work on other commodity groups (timber, vegetables, dye plants, cereals, etc.) will be useful for increasing the food base of under-utilized plants, promoting stakeholder consultations for special products, promoting end-user impact in pilot projects, and promoting capacity-building in knowledge synthesis or in rural development dynamics.

Documentation and Publication on Flora in General with Special Emphasis on Under-utilized Plant Resources and Poisonous Plants

The Mascarene region, which embraces the islands of Mauritius, Rodrigues and Réunion (France), is a biodiversity hotspot. Yet many species of plants and animals have been introduced during the various waves of colonization and especially with the arrival of the indentured labourers in the early 19th century. Trees and plants, whether they are indigenous or exotic, fulfil important social, economic and cultural functions. Their global economic values cannot be overlooked either. As on the mainland, the forests in these regions are fragile and irreplaceable repositories of ingredients basic to the treatment of a surprising number of human ailments.

All conservation efforts will be to no avail unless the public at large is kept informed and understands and appreciates this unique vegetation. With this challenge, several publications targeted at the lay public have been prepared in the form of books both in English and French, so as to reach the maximum number of people (Gurib-Fakim, 2002a, b, 2003, 2004).

The small medicinal plant gardens created both in the grounds of the Office of the President of the Republic of Mauritius and in a local primary school under the GEFUNDP small grant scheme, as well as television programmes destined for the general public have helped to showcase the importance and relevance of medicinal plants. The need for conservation has been addressed all along. Once the garden was created, the plants were tagged and their uniqueness described to the students by the teachers. The students were then given the responsibility of looking after the garden, collecting the seeds and replanting them. At the UN Offices in New York, this project was awarded the prize for best community-based project. In addition, plant

■ **Traditional Medicine and its Impact on Livelihoods**
Ameenah Gurib-Fakim

genetic resources are a reservoir of genetic adaptability that acts as a buffer against potentially harmful environmental and economic change. The erosion of these resources poses a severe threat to the world's food security in the long term.

Although often undervalued, there is an urgent need to conserve and utilize plant genetic resources as a safeguard against an unpredictable future, especially with the challenges posed by climate change.

It is estimated that there are 300,000–500,000 species of higher plants, of which only 240,000 have been identified and described. Some 30,000 are edible, while 7,000 have been cultivated or collected by human beings for food at one time or another. Thus, several thousand species may be considered to contribute to food security. Nonetheless, only about 120 are important on a national scale in any one country and 30 of these crops 'feed the world', providing 95% of the dietary energy (calories) or proteins (Anon., 1989).

The importance of gene banks and conservation efforts can also no longer be under-estimated, as the wild relatives of crops and weedy forms are important sources of genes for disease resistance, environmental adaptation and other traits that are useful in crop improvement programmes. Given the importance of the relatively small numbers of crops for global food security, it is particularly important that the diversity within major crops is conserved effectively, made available for use and managed wisely. The publications *Lesser Known and Under-utilised Plant Resources* both in English and French help to draw the attention of the public at large on these marginalized crops (Gurib-Fakim, 2005a, b).

Poisonous plants account for many garden and house plants. They grow everywhere and are generally accepted for their beautiful foliage or flowers. It is almost impossible to eradicate them. Hence, it is more practical to help people identify them and to teach how best to avoid them. However, in the event that there has been an accident, information should be at hand so as to limit any further damage. *Natural Toxins and Poisonous Plants of Mauritius*, published under the aegis of the United Nations, has been a useful and informative guide towards prevention of poisoning by plants, especially in a country with no toxicology centre (Gurib-Fakim, 1998).

Validation of Traditional Knowledge with a View to Developing Safe and Effective Medications

Plant drugs, also known as phytomedicines or phytopharmaceuticals, are plant-derived medicines that contain a chemical compound or more usually mixtures of chemical compounds that either act individually or in combination on the human body to prevent disorder and to restore and maintain health.

Pure compounds are made either synthetically or isolated from natural products. Herbal teas, decoction and alcoholic extracts are also traditional ways of using medicinal plants. Validation and standardization not only bring credibility to this practice, but also ensure access to cheap, safe and efficacious medications respecting the cultural heritage of the people of the country and of the continent.

Standardization is critical as the concentration or dosages are important, because herbal medicines (in common with conventional medicines) contain biologically active substances that may produce non-trivial side effects when taken in excessive doses, while at low doses they may not have any therapeutic value. Once they are registered, phytodrugs become medicines that need to comply with the basic standards

■ **Traditional Medicine and its Impact on Livelihoods**
Ameenah Gurib-Fakim

required for a drug. Standardization allows comparison of the clinical effectiveness, pharmacological effects and side effects of a series of products. Standardized products provide more security and increase the level of trust people have in the herbal drug.

Such information is usually regrouped in pharmacopeia. For any product, especially a medicinal product, to obtain marketing authorization, the ingredients or the medicinal products must generally comply with a pharmacopoeia standard. While the WHO (1999, 2002, 2007) and ESCOP (2003) have been preparing monographs for herbal ingredients, we noted that there was little documentation on the trading standards of medicinal plants.

Standardization coupled with trading standards make a powerful combination to ensure that there is not only acceptance by the general public on potent medicinal plants, but also ensures that these African medicinal plants can penetrate the market and achieve visibility at the international level.

There are direct and indirect impacts of this initiative. One of the direct impacts will be increased sustainable cultivation of these plants under good agricultural practices. This has been one of the reasons why the Association of African Medicinal Plants Standards (<http://www.aamps.org>) has come into being. One of its main objectives is to promote important African medicinal plants.

African Herbal Pharmacopeia - Promoting African Medicinal plants

Africa is blessed with a unique biodiversity. Although Sub-Saharan Africa and the Indian Ocean Islands contain approximately 60,000 plant species—roughly 25% of the world’s total—only 83 of the world’s 1100 leading commercial medicinal plants are African in origin (Iwu, 1993).

In the course of the Medicinal Plants Forum for Commonwealth Africa, one of the major constraints that has prevented the penetration of African plants in the world market was identified as the lack of suitable technical specifications and quality control standards for African medicinal plants and herbal medicine. The lack of such standards was considered to be a major barrier to regional and international trade, and an important reason why traditional medicine has not been widely integrated into African primary healthcare. Another key issue is that despite the fact that more than 80% of Africans rely on plant-based medicine, governments in only a handful of African countries give official recognition and support to this important sector.

It was in this context that the Association of African Medicinal Plant Standards (AAMPS) was born. Among the many objectives of the Association are the following:

- to develop quality standards and quality assurance for African medicinal plants and herbal medicine; and
- to prepare and publish an African herbal pharmacopeia as a living database drawn initially from the 52 herbal profiles deemed important for Africa.

The AAMPS Monographs, along with the live database, provide in-depth and upto- date botanical, phytochemical, pharmacological and commercial information on some of the most important medicinal plants of Africa. These plants (e.g. *Adansonia digitata*, *Aframomum melegueta*, *Nauclea latifolia*) have been selected on the basis of a systematic review of published and unpublished literature and extensive consultation across the continent. These monographs also contain technical data required by growers,

■ **Traditional Medicine and its Impact on Livelihoods**
Ameenah Gurib-Fakim

collectors, traders and practitioners, researchers and manufacturers of African medicinal plants and herbal products. They have gone through a rigorous peer-review process and hence the scope and accuracy of these monographs are equal to those prepared internationally on comparable issues.

Each AAMPS monograph contains the following information: general aspects (general description; origin and preparation of plant material); identification and quality control; use and efficacy (formulation, dosage, medicinal uses; clinical evidence for efficacy, etc.); safety (toxicity according to literature; laboratory assay; evaluation of probable safety and efficacy). One sample monograph, as edited, is annexed in the Pharmacopeia (Gurib-Fakim et al., 2008).

Emphasis has been put on the international standards required, so that some of these important plants can be commercialized. Toxicity and efficacy data, as well as the permitted microbial levels and permitted pesticide residue levels have been incorporated. Standard protocols have also been used for these evaluations.

Production of Herbal Teas in Mauritius

Finally, the private sector in Mauritius has started to develop a line of herbal teas, produced along the guidelines of good agricultural practices and good manufacturing processes, which are being commercialized locally. The product is highly appreciated especially for its freshness, quality and affordability, as well as its efficacy. Recognizing the importance of this line of work, one NGO of formerly unemployed women, has started to operate 'small kitchen gardens', where medicinal plants are being grown. The women's association has been relying greatly on the locally available publications, in lay language, to further their activities and hence promote the quality of life of women generally.

It is hoped that both the PROTA project on Medicinal Plants and the African Herbal Pharmacopeia will have the same impact as those on Mauritius in promoting the African cause.

CONCLUSION

Africa is known to be perhaps the biggest consumer of medicinal plants. One of the main reasons for this is their affordability. Another feature that is worth pointing out here is that the continent is witnessing a renaissance. Medicinal Plants help to bridge the gap in reconciling economics, traditions with cultural heritage.

Traditional medicine has another advantage—it is highly sought after for the development of new drugs, new foods, etc. This is an area that the continent can and should take advantage of, so as to improve the livelihoods of its citizens, both men and women.

Acknowledgements

The author acknowledges donors such as the EU, UN (FAO), ACP under the ProInvest, CDE portfolios (Brussels) for their financial support, without whose contributions these projects would not have been possible.

Literature Cited

- Akerele, O., Heywood, V. and Synge, H. 1991.* Conservation of Medicinal Plants. Cambridge University Press, Cambridge, UK.
- Anon. 1989.* Lost Crops of the Andes. Little known plants of the Andes with promise for worldwide cultivation. National Academy Press, Washington, DC.
- Bouton, L. 1864.* Plantes Medicinales de Maurice. Port Louis, Mauritius.
- Daruty, D.C. 1886.* Plantes Medicinales de Maurice. Port Louis, Mauritius.
- ESCO (European Scientific Cooperative on Phytotherapy) 2003.* ESCOP Monographs: The Scientific Foundation for Herbal Medicinal Products (2nd Edn). Thieme, Stuttgart and New York.
- Gurib-Fakim, A. 1998.* Natural Toxins and Poisonous Plants of Mauritius. Editions Le Printemps/United Nations Development Programme, Mauritius.
- Gurib-Fakim, A. 2002a.* Maurice a Travers ses Plantes Medicinales. Editions LaPrintemps, Vacoas, Mauritius.
- Gurib-Fakim, A. 2002b.* Mauritius Through its Medicinal Plants. Editions La Printemps, Vacoas, Mauritius.
- Gurib-Fakim, A. 2003.* Illustrated Guide to the Flora of Mauritius and the Indian Ocean Islands. A. Gurib-Fakim Ed., Mauritius.
- Gurib-Fakim, A. 2004.* Guide Illustre de la Flore de Maurice et des Iles de l'Ocean Indien. A. Gurib-Fakim Ed., Mauritius.
- Gurib-Fakim, A. 2005a.* Lesser Known and Under-utilised Plant Resources. A. Gurib-Fakim Ed., Mauritius.
- Gurib-Fakim, A. 2005b.* Ressources Vegetales moins Connues et Sous-utilisees. A. Gurib-Fakim Ed., Mauritius.
- Gurib-Fakim, A. and Brendler, T. 2003.* Medicinal Plants of the Indian Ocean Islands. MedPharm Scientific Publishers, Stuttgart.

Policy Issues for Small-holder Farmers' Productivity

Joy M. Kiiru¹

Keywords: Policy options, Small-holder farmers, gender budgeting, microfinance

Abstract

The small-holder sector in developing countries is faced with three major challenges: low productivity, poor access to markets, and low welfare status (poverty) among the majority of farmers. Policies designed for this sector have in one way or another been geared towards addressing one or more of these challenges. By means of statistical analysis, this study tackles several policies that are addressed to the small-holder agriculture sector. The study pays special attention to budgetary allocation (fiscal policy) and microfinance (empowerment tool). The results indicate that access to programmes supported by the Malawi agriculture sector budget (2001/2002) was gender biased. Women who mainly participated in subsistence farming and were the majority in the sector (over 52%) on average accessed less than 50% of the overall sector budget. The proportion of budget accruing to male farmers is over one-and-a-half times that accruing to female farmers. Results on the impact of microfinance on household welfare show that despite microfinance having the potential to improve people's welfare, it cannot be effectively used to fight poverty and moreover it does not reach the poorest that will normally be discriminated against during borrowing-group formations. The study recommends that no single policy is a panacea for addressing all the challenges of small-holder farmers, but rather different policies—e.g. technology adoption, microfinance, social protection—could be integrated appropriately. The key thing on policy design and implementation is that policy implementation should be based on evidence from credible research.

¹ *University of Nairobi and Kenya Institute of Public Policy Analysis and Research, PO Box 75674, Nairobi 00200, Kenya.*

INTRODUCTION

Low productivity and lack of access to markets are major constraints to small-holder farmers in developing countries. Low productivity has been attributed to several causes, including lack of farm inputs, little use of technology and over-reliance on rain-fed agriculture. Even for the small-holder farmers who manage to be productive, the issue of where to sell their surplus and how much it fetches is still a problem. The consequences of all this has been poverty and low human capital development for small-holder farmers. Many studies on participation in agriculture show that, in nearly all cases, women do most of the agricultural work. In her pioneering work, Boserup (1970) found that in some cases women performed about 70% and in one case nearly 80% of the total agricultural work. Studies have also shown that reducing gender inequality could significantly increase agricultural yields. For instance, giving women farmers in Kenya the same level of agricultural inputs and education as men farmers could increase yields obtained by women farmers by more than 20% (Saito and Spurling, 1992). If gender inequalities impact growth, reducing these by consciously targeting women and girls should be a strategy for accelerating sectoral production (Elson, 1999). Much as policymakers generally acknowledge the important role played by women in agriculture, it has been difficult to design gender-sensitive programmes that maximize on building female farmers' capacity as the primary food producers. In particular, targeting the poor and vulnerable small-holder farmers for the purposes of empowering and improving their productivity has been a major problem.

This paper draws from my own previous research on issues touching on smallholder rural farmers. The motivation for the studies was the observation that, despite government efforts to empower the poor, the challenges facing small-holder farmers are ever increasing; and hence the need to review policies within the sector. Research Objectives The general objective of this paper is to highlight some key policies that have been used to address the problems facing the small-holder farmers.

The specific objectives were:

1. To analyse the agriculture-sector budget in order to see if there are gender biases in access to budgetary benefits by small-holder farmers;
2. To review the role of commercially driven microfinance in addressing the issues of access to capital by poor small-holder farmers;
3. To review other policy issues addressing the issue of productivity and wellbeing of small-holder farmers.

METHODOLOGY

The methodologies used in this study included:

1. Calculation of engendered agriculture-sector budget benefit incidence for the Malawi agriculture sector (2001/2002);
2. Econometric analysis of the impact of microfinance on rural household incomes;
3. Qualitative analysis of other policy options that target small-holder farmers.

Data

The data used for the analysis of the impact of microfinance covered 200 microfinance participants and

another 200 non-participants. The participants were randomly selected in Makueni district, Kenya. The data were collected in three crosssections over a period of 18 months giving 1200 units of analysis. The data used for the gender analysis of the Malawi agriculture budget were collected in Malawi at the Blantyre Agricultural Development Division. It covered 200 rural farmers who were randomly selected. Data used for social protection analysis was mainly secondary and qualitative. We carried out a qualitative survey in the form of focus-group discussion with key stakeholders in social protection. Beneficiaries for social protection were also included. The exercise covered three districts in Kenya.

RESULTS AND DISCUSSION

National budgets have for a long time purported gender neutrality, which in reality is at best described as 'gender blindness'. A national budget is an indicator of the sectors that a country needs to 'reward', depending on the expected output and productivity of that sector. If there are gender inequalities that impact on women's productivity, then it is likely that national budgets will not allocate adequate resources to sectors dominated by women. This may not happen as a deliberate effort to marginalize women, but rather by the mere principle of rewards.² Even for the budget that allocates adequate resources where women's labour is dominant, there have to be efforts to empower both men and women for equitable access to the benefits from the budgetary allocation.

Table 1 gives the results of the engendered benefit incidence of the Malawi agriculture-sector budget, 2001/2002.

Table 1: Engendered benefit incidence of the Malawi agriculture-sector budget of 2001-2002 (Kiiru, 2002)

Table 1 shows that in all the government-funded programmes in the agriculture sector, women received less of the expenditure than their share in total small-holder population - women constitute over 52% of all small-

Programme	Budget (Malawi Kwacha) ¹	Accruing to female farmers (%)	Accruing to male farmers (%)	Average incidence per female farmer (MK) ¹	Average incidence per male farmer (MK) ¹
Agricultural extension	11,312,909	46	54	39.3	63.6
Animal husbandry	3,105,677	46	54	10.8	17.4
Land resources	1,581,926	51	49	6.1	8.1
Irrigation	1,865,161	46	54	6.5	10.5
Crop husbandry	2,682,607	51	49	10.3	13.7
Overall budget	20,548,283	48	52	73	113.3

¹ 100 Malawi Kwacha = 1 Euro.

holder subsistence farmers in Malawi (NSO, 2000). The overall benefit incidence for male farmers was over one-and-a-half times that of female farmers. Despite male farmers being the minority in the sector, they enjoyed a bigger portion of the budgetary benefits; but unlike their female counterparts, who produced basic food crops for the household, the male farmers concentrated on small-scale cash-crop farming that included tobacco, sugarcane and tea. Studies on intra-household allocation of resources have shown that income accruing to women has a greater impact on children's education, nutrition, health and household food security than income accruing to males (Haddad et al., 1998).

A budget is also a political tool and women with less political voice may not influence the budgeting process.

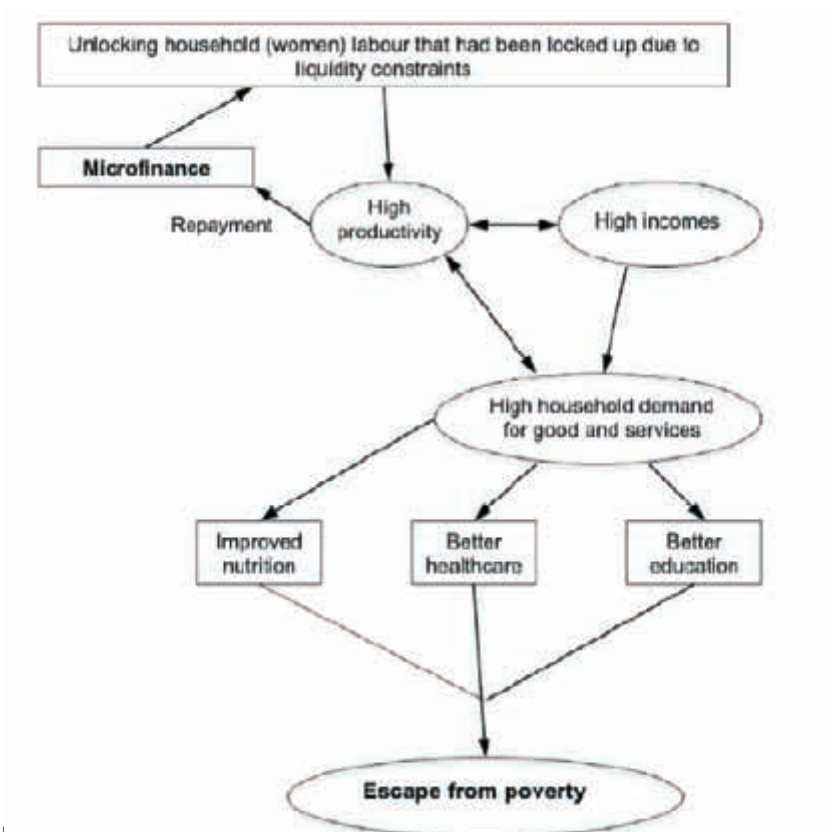
Table 2: Household credit allocation (Kiiru,2007)

Borrowers (%)	Domestic uses (repayment of debts, food, bills) (% of total loan)	Entrepreneurship use (% of total loan)
5	100	0
5	75	25
37	25	75
20	20	80
Int 33	~0	100

For a long time, policy makers have recognized the need for gender equity and empowerment for all vulnerable groups. Key among the empowerment policy issues has been access to finance. The role of microfinance in development is demonstrated through the crucial role that savings and credit play in economic growth. When low-income economies attempted to develop their economies after World War II, rural finance emerged as a big concern. Large state agricultural banks were given the responsibility of allocating funds with the hope that by availing subsidized credit, farmers would be induced to irrigate, apply fertilizers, and adopt new crop varieties and technologies. The aim was to increase land productivity, increase labour demand and thereby increase agricultural wages (Armendáriz de Aghion and Morduch, 2005). Unfortunately, the noble idea of subsidized credit failed in most cases due to several factors including politicizing of state loans and high default rates.

Recently, there has been a microfinance revolution in which innovative methods have been used to lend to the very poor without collateral. This sort of microfinancing uses innovative market-driven and commercial approaches in order to reach their target clients, of which the majority are women. Eighty per cent of all the clients of the largest microfinance institutions worldwide are women; 96% of all the clients of the Grameen Bank (the largest microfinance institution) are women (Roodman and Qureshi, 2006). In our study, 75% of the microfinance participants were women. Figure 1 illustrates the potential of microfinance to empower the poor and reduce poverty.

Fig. 1: The microfinance 'promise' (Kiiru, 2007)



The model illustrates how microfinance can help households escape poverty. It starts with unlocking household (women) labour that had been locked up due to liquidity constraints. This leads to high productivity and high incomes. High productivity leads to repayment and high household demand for goods and services. High incomes also lead to high household demand for goods and services. High household demand for goods and services leads to improved nutrition, better healthcare, and better education. All three of these lead to escape from poverty.

Forty-seven per cent of the households used 25–100% of the total loan amount on non-productive activities (Table 2). The next question relates to how the participants were repaying the loans, given that many of the borrowers did not use them for the expected productive purposes (Table 3).

Only 17% of the borrowers repaid the loans out of returns from some investment (Table 3). If any member of a borrowing group threatened to default on their loans, the rest of the group resorted to excessive pressure, threats and even property impounding— 99% of all loans borrowed through group loans are normally repaid. Econometric results on the impact of microfinance indicated that microfinance will attract the poor in society though not the poorest. The results also showed that if the impact of microfinance on household income was measured within a short period after the start of borrowing, there was a possibility of obtaining

biased results. However, given time it is possible for households participating in microfinance programmes to experience positive impacts on their incomes, as long as they still find it worthwhile to continue participating in the microfinance programmes. In our study, there was a 33% drop out of borrowers.

Table 3: Household loan repayment (Kiiru, 2007)

Method of loan repayment	Borrowers affected (%)
Duress (due to excessive pressure)	62
Property confiscation by peers	4
Sale of pre-existing property	17
Poten Business profits	17

In the e generally agreed among researchers that microfinance can have a good impact on welfare improvement, but it is not meant for the very poor. As long as microfinance focuses on the issues of sustainability (which it should), then there is a limit to which microfinance could be used to reach the very poorest who may not be able to pay the high interest rates.

In the late 1990s and early 2000s, other interventions in the small-scale agricultural sector focused on the promotion of simple technology like agroforestry, water-harvesting and irrigation. However, the level of adoption of these technologies has been low. Other interventions that have a potential to improve life for small-scale farmers, but are least used, include solar and wind energy. These energy options need to be explored, as they are not only cleaner for the environment, but there is also a good endowment of sun and wind in Africa south of the Sahara.

Other areas of intervention for poverty have included social protection in the form of safety nets and cash transfers. Kenya is currently piloting more ambitious socialprotection projects like cash transfers, subsidized secondary education, and free primary education. Rigorous research on the impact of programmes like cash transfers has yet to be carried out. In conclusion, no single policy is a panacea to address all the challenges of the small-holder sector; rather there is need to identify a good mix of policies mainly through research. More importantly, there has to be a stronger participatory approach between small-holder farmers and policy-makers in solving problems in the sector.

Acknowledgements

The studies cited in this paper have benefited from financial support by various organizations including: African Economic Research Consortium (AERC), DFIDMalawi, German Academic Exchange (DAAD), and GTZ. I also acknowledge support by the University of Nairobi, and the Kenya Institute for Public Policy Research and Analysis (KIPPRA).

Literature Cited

Armendáriz de Aghion, B. and Morduch, J. 2005. The Economics of Microfinance. The MIT Press,

■ **Policy Issues for Small-holder Farmers' Productivity**
Joy M. Kiiru

Cambridge, MA and London. Boserup, E. 1970. *Woman's Role in Economic Development*. St Martins Press, New York.

Elson, D. 1999. Gender Budget Initiative. Commonwealth Secretariat, Abacus Direct. Haddad, L., Hoddinott, J. and Alderman, H. 1998. Intra household resource allocation in developing countries: Models methods and policies. *The United Nations University Food and Nutrition Bulletin* 19(1).

Kiiru, J. 2002. Engendered Benefit Incidence Analysis of the Malawi Agriculture Sector Budget 2001/2002. Case of Blantyre Agricultural Development Division. MA Thesis, University of Malawi, Chancellor College.

Kiiru, J. 2007. The Impact of Microfinance on Rural Poor Households' Income and Vulnerability to Poverty: Case study of Makueni District, Kenya. PhD Dissertation,

Bonn University, Faculty of Agriculture. http://hss.ulb.uni-bonn.de/diss_online. NSO 2000. Malawi Agriculture Sector Survey. National Statistics Office, Zomba, Malawi.

Roodman, D. and Qureshi, U. 2006. *Microfinance as Business*. Centre for Global Development Working Paper No. 101, Washington, DC. Saito, K. and Spurling, D. 1992. *Developing Agricultural Extension for Women Farmers*. World Bank Discussion Paper 156. The World Bank, Washington, DC.

Published by the African Technology Policy Studies Network (ATPS) with support from CTA, AGRA, FARA, NEPAD and RUFORUM. These Competitions seek to promote scientific excellence and reward outstanding African women professionals undertaking innovative research or technology development, and communicating the outputs to improve agricultural performance in Sub-Saharan Africa.

For More Information Contact

African Technology Policy Studies Network (ATPS)
The Chancery, 3rd Floor, Valley Road
P. O. Box 10081-00100 Nairobi, Kenya
Tel: +254-20-271 4092/ 168/ 498
Fax: +254-20-271 4028
Website: www.atpsnet.org



Alliance
for a Green Revolution
in Africa

