ASARECA

Transforming Agriculture for Improved Livelihoods

Integrated sorghum and millet sector for increased economic growth and improved livelihoods in Eastern and Central Africa

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Integrated sorghum and millet sector for increased economic growth and improved livelihoods in Eastern and Central Africa

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FOREWORD

Sorghum and millets are major food crops in sub-Saharan Africa. The two grains account for 56% of the area planted to cereals in this region, and 41% of the region's cereal grain production. These are important staple crops in Eastern and Central Africa (ECA), particularly in semi-arid environments because they are tolerant of drought which often causes widespread crop failure of non-traditional food crops. Research and development of these crops in ECA has over the years been conducted through regional networks. In particular, since its inception in 2003 the Eastern and Central Africa Regional Sorghum and Millet Network (ECARSAM) coordinated the regional research for development activities. In 2007 the Staple Crops Programme of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) took over the activities of ECARSAM.

Despite their relative importance in regional food systems, very little sorghum and millet is commercially processed. Less than 5% of annual production is commercially processed by industry. Increased commercialisation of the sorghum and millet sector in ECA demands effective participation of key actors involved in the production-to-consumption chain. Research must first address the constraints these actors face, and secondly, foster linkages between them in a way that will achieve commercialisation. During the priority setting workshop in 2004, ECARSAM stakeholders defined projects of high, medium and low priority. The aim was to address research for development issues of the sorghum and millet production-to-consumption chain with the objective of enhancing sustainable productivity, value addition and competitiveness of the sector.

The stakeholders met again in 2006 to review progress made in tackling the priority constraints to increased production and commercialisation of the sector under the theme "Integrated sorghum and millet sector for improved economic growth and livelihoods in the Eastern and Central Africa". The workshop brought together various actors, envisaged to foster integration needed to increase the contribution of the sector to economic growth. The actors included: (i) farmers (sorghum and millet producers); (ii) researchers (who develop technology); (iii) the inputs and services providers (those actors who enhance access to available technologies, inputs and services); (iv) merchants and marketers; (v) processors; (vi) exporters; (vii) policy makers; and (viii) consumers (both primary and secondary). The action areas or domains emphasised in laying strategies for integration to achieve the twin results of growth and improved livelihoods included: (a) increased production and productivity; (b) increased processing and utilisation; (c) effective marketing; and (d) implementation of supportive policies. In each of these domains a keynote paper with broad perspectives of sorghum and millets in ECA was presented followed by specific papers on experiences from a diverse mix of actors within the region. Workshop participants discussed the papers in each domain and made recommendations which can be pursued to further enhance the sorghum and millets sector, and make it more effective in contributing to the region's economic growth.

The workshop was used to review and share research results and experiences on sorghum and millets in the ECA region and make recommendations necessary for commercialisation. The proceedings are published in this book for wider readership. We hope that it can serve as a source of information for those involved in the development of these crops in the region and beyond.

Seyfu Ketema
Executive Director, ASARECA

ACRONYMS

AKEFEMA	Association of Kenya Feed Manufacturers
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CSA	Central Statistical Authority
CTA	Technical Centre for Agricultural and Rural Cooperation
DFID	Department for International Development, UK
DRC	Democratic Republic of Congo
DSE	German Foundation for International Development
EARO	Ethiopian Agricultural Research Organization
ECA	Eastern and Central Africa
ECAPAPA	Eastern and Central Africa Programme for Agricultural Policy Analysis
ECARSAM	East and Central Africa Regional Sorghum and Millet Network
ESA	Eastern and Southern Africa
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FO	Farmer organisation
FRC	Food Research Centre
FYM	Farmyard manure
GDP	Gross domestic product
IARC	International agricultural research centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre
IFI	Institut Africain pour le Development Economique et Social Formation International
IFPRI	International Food Policy Research Institute
IFTz	Institut Africain pour le Development Economique et Social Formation Tanzania
INADES	Institut Africain pour le Development Economique et Social
INTSORMIL	International Sorghum and Millet (INTSORMIL) Collaborative Research Support Program
IMF	International Monetary Fund
KARI	Kenya Agricultural Research Institute
KIRDI	Kenya Industrial Research Development Institute

NARI	National agricultural research institute
NARO	National Agricultural Research Organization, Uganda
NARS	National agricultural research system
NCPB	National Cereals and Produce Board, Kenya
NGO	Non-governmental organisation
NMC	National Milling Corporation, Kenya
NBL	Nile Breweries Limited, Uganda
NPPs	Networks, Projects and Programmes
NRI	Natural Resources Institute, UK
ODA	Overseas Development Administration
OPV	Open-pollinated variety
QDS	Quality declared seed
ROR	Rate of return
SAARI	Serere Agricultural and Animal Production Research Institute, Uganda
SAB	South African Breweries
SADC	Southern African Development Community
SGR	Strategic grain reserve
SMIP	Sorghum and Millets Improvement Programme
TDRI	Tropical Development and Research Institute
TOB	Traditional opaque beer
TOSCI	Tanzania Official Seed Certification Institute
UNICEF	United Nations Children’s Fund
USAID	United States Agency for International Development
USSR	United Socialist Soviet Republic
WCA	Western and Central Africa
WFP	World Food Programme
ZRELOs	Zonal Research and Extension Liaison Offices

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OPENING REMARKS

Jeremiah Haki, Director of Research Development and Training, Ministry of Agriculture, Food Security and Cooperatives, Tanzania

I am greatly honoured and privileged to be here today to officiate at the opening of this important regional Stakeholders Workshop for Sorghum and Millets. On behalf of the Tanzania Ministry of Agriculture, Food Security and Cooperatives and on my own behalf I would like to take this opportunity to welcome all of you to our country and to the City of Dar es Salaam in particular. I wish you a warm and pleasant stay in our “Harbour of Peace”. I wish also to advise those of you who can spare time during your stay here to see some of the many tourist attractions within the city and around the countryside and in the spice islands of Zanzibar.

Let me commend the organisers for choosing Tanzania to host this workshop on sorghum and millets. Tanzania ranks third in sorghum production after Sudan and Ethiopia in the ASARECA region. Among the cereal crops grown in Tanzania sorghum ranks third after maize and rice and it is the major subsistence crop in the semi-arid areas of the country. More than 40% of the population live in chronic food-deficit regions including semi-arid zones where irregular rainfall causes recurring food shortages and the consequent malnutrition. This is also the area where sorghum and millets, due to their inherent drought resistance, are the main crops. These crops play a very important role as “food security” crops where other crops such as maize fail.

The area planted to sorghum in this country between 1986 and 2005 ranged from 380,000 to 890,000 ha. The annual sorghum production in Tanzania is only 0.61 million tonnes. World production is over 60 million tonnes (t) and that for Africa is about 20 million tonnes. Sorghum productivity is also very low, below 1 t/ha. This situation may be similar to that in some of your countries which may have the same climatic conditions as Tanzania.

Climate models in Tanzania predict that by 2100 rainfall will decrease by up to 20% in the central areas of the country and national grain production will fall by 10% by the year 2080, with particularly severe yield reductions in maize. Hence, increasing sorghum productivity in the semi-arid zones of the country is and will be a priority for both food security and household income. Among the factors which contribute to low sorghum productivity is decline in soil fertility, as farmers in these areas rarely use inorganic fertiliser because they are expensive. Most of our farmers in the dry areas of the country plant low yielding, traditional long season landraces. Adoption of improved cultivars, which occupied barely 5% of Tanzania's sorghum area in the early 1990s, had risen only to 36% of the area planted by 2002. Since most of the commercial companies are uninterested in investing in low volume crops like sorghum, farmers lack quality seed of improved varieties.

The sorghum and millet grain market is not well developed for both export and domestic markets. For example, despite huge potential, Tanzania exported very little sorghum and millet in the 1980s, and in 1990 only 233 tons of sorghum and millet were exported; no data exist on exports of these crops after 1990. In this era of market economy where demand stimulates production, deliberate effort to stimulate markets within and outside the region is important. The other factor may be that farmers are not motivated to grow sorghum because of their limited knowledge on how to use it. Sorghum is mainly used to make ugali (thick porridge) and local brew.

The impact of HIV/AIDS in rural areas has also led to the loss of productive labour force in most of the sorghum growing areas, leading to low production. Furthermore, the proportion of older people in rural areas is rising largely because the young people are migrating to cities to search for work. Therefore the number of adults in their prime working years (15–59 years) in rural areas is too small to produce enough food for their families and for household income.

To address some of these constraints the government, through the National Sorghum Research Programme, in collaboration with international institutions like the SADC Sorghum and Millets Improvement Programme (SMIP/ICRISAT), Purdue University through INTSORMIL-US and NRI-UK (with funding from DFID), has assisted in the testing and release of several improved sorghum varieties including Tegemeo, Pato, Macia and more recently Hakika and Wahi. These last two sorghum varieties are early maturing, drought tolerant and resistant to the Striga species found in Tanzania.

To deal with the issue of seed availability at farm and community level, the government has introduced what is called quality declared seed (QDS). This is a seed class where farmers at community level are taught how to produce quality seed. This is done using expertise from the Tanzania Official Seed Certification Institute (TOSCI). The conditions for production of this kind of seed are less strict than those for producing certified seed. This seed is sold at a cheaper price within the village where it is produced and in neighbouring villages. The government has also made efforts to use primary schools to produce seed. Furthermore, some of the district councils have seed farms where they produce seed and make it available to farmers at a reduced price.

As a policy, the government encourages and facilitates the establishment of formal private and informal seed production marketing arrangements within the country and importation of seed if there is deficit in the country. In addition, this year the government imported 255 metric tonnes of sorghum seed to distribute to farmers in drought prone areas of the country.

The government has now included sorghum in the National Strategic Grain Reserve (NSGR) in addition to maize. This will be a national buffer stock, to cater for emergency situations when supplies are low. Studies have shown that in sorghum consuming districts, sorghum that enters the market competes strongly with maize in price, particularly when purchases are made for NSGR. We hope this will motivate farmers in the dry areas to invest more in growing sorghum. The government is also encouraging farmers to form groups through which they can access credit and access markets beyond their villages such as the Darbrew in Dar es Salaam. The government provides farmers and traders with export marketing information through the media to promote the production of these crops.

I have been informed that the main objective and focus of this workshop is to review the progress made in tackling the priority constraints to increased production and commercialisation of the sorghum and millets sub-sector in the region. I hope that through your deliberations you will be able to make useful and practical recommendations for the future, long-term strategies on how to improve sorghum production and consumption along the lines of production and productivity, processing and value adding, marketing and policy issues. It is my hope that by the end of this workshop you will be able to come up with strategies and concrete recommendations on how to improve the current situation.

Although our knowledge base is sufficient with respect to human resource development, breeding and agronomic package recommendations, the average sorghum productivity in Tanzania is only 0.9 t/ha for sorghum and 0.5 t/ha for millets. This trend is the same elsewhere in the ASARECA region. These figures are significantly lower than the average production in Africa and the world. This is the challenge to you all workshop participants and you need to come up with answers: Why is this so? And what factors contribute to this? Are sorghum and millet production technologies not available? What are the missing links for increasing production and productivity? How long will sorghum remain a poor man's crop?

Last but not least, let me take this opportunity once more to thank all workshop participants for coming to Tanzania. I am sure you will enjoy both the workshop and the stay here at the ancient, beautiful and Swahili blended coastal city of Dar es Salaam. And I hope that the deliberations of the workshop will make significant contributions to the understanding of constraints and challenges that the sorghum and millet sub-sector faces and come up with recommendations to improve the situation.

With that said, I wish you a very inspiring and challenging workshop. I now have the pleasure to declare the Sorghum and Millet Stakeholders' Workshop officially opened.

CHAPTER ONE

PRODUCTION AND PRODUCTIVITY

1.1. An assessment of the sorghum and millet sub-sector in ECA: Towards better integration and exploitation of productivity enhancement and market opportunities

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Introduction

Sorghum and millets are the third most important crops in the Eastern and Central Africa (ECA) region after maize and beans in the research priorities of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) (ECARSAM 2005). The crops are grown on approximately 13 million ha in the region and are the most adaptable in the drought-prone areas where rainfall and water are among the major limiting factors to production. In Africa and Asia, sorghum and millets are grown primarily for human consumption, in contrast to developed countries where almost all sorghum production is used for animal feed. Much of these crops are grown by small-scale farming households operating at the margins of subsistence. Production in ECA, and Africa at large, remains characterised by low productivity and extensive, low-input cultivation.

Except in two countries in ECA, sorghum and millet production has not come close to fulfilling their potential as food crops. If these crops were produced consistently with adequate management practices, the result would be increased food and income for some of the most marginalised households in the region. In addition, intensifying production in already cultivated areas could relieve the pressure that some of the most marginal, drier tropical habitats in ECA face. Increasing production of sorghum and millets is inevitable. However, increasing productivity appears to be the most suitable means, as there is limited area under which acreage can be increased without pushing the two crops into the most marginal lands. Increased production and productivity are pre-requisites for commercialisation and hence for sustained contribution to economic growth and improved livelihoods. This paper assesses sorghum and millet production and productivity in the ECA region. The paper specifically examines the continuing importance of the crops in the semi-arid and drought-prone areas of ECA, trends in sorghum and millet production and productivity over time and factors contributing to the observed trend. It also examines identified production and productivity enhancing challenges, strategies put in place and progress in addressing the same and probable impacts. Finally, the paper highlights some new strategies in terms of technology development, dissemination, strategic partnerships, and other potential areas where sorghum and millets can play a key role in improving incomes and livelihoods of farming communities in the semi-arid tropics of ECA.

This work builds on information that is documented within the sorghum and millet sub-sector (ECARSAM 2005). Statistical documentation of sorghum production, trade and utilisation is generally good, especially in countries where production is commercialised (Obilana 2002). Data are less accurate in countries where sorghum is primarily a subsistence crop, grown in outlying areas. Although often discussed together, this paper, as much as possible, assesses the two crops separately and also tries to separate the millets category into finger millet and pearl millet.

Importance of sorghum and millets in ECA

The intensity of recurrent droughts in the Eastern and Southern Africa (ESA) region has increased the urgency with which national policy makers consider drought-resistant crops. Systems for agricultural research in many African countries would have to strengthen their programmes to improve sorghum and pearl millets to address this challenge. A food crop only becomes food when it is actually consumed. Efforts to increase food production must therefore be matched by corresponding post-harvest research. The absence of appropriate de-hulling equipment, especially for small grains, has been cited as one of the reasons for past national neglect of these cereals (Bassey and Schmidt 1989); this limited value addition capacities. Yet, sorghum and millets offer viable options in harsh environments where other crops do poorly.

Sorghum

Sorghum, *Sorghum bicolor* (L.) Moench, is the second major crop (after maize) across all ecologies in Africa and is one of the main staples for people in ESA. It is widely found in the drier areas of the region, as it can withstand droughts and periods of waterlogging. Globally, sorghum is currently grown on an area of 45 million ha. In ECA sorghum is grown on an area of approximately 10 million ha. The sorghum sub-sector is more developed in Sudan where the crop accounts for 70% of cereal production. Sudan accounts for 21.4% of Africa's sorghum production, second only to Nigeria which produces 33.8%. Ethiopia accounts for 7.3%, Tanzania 3.5%, Uganda 2%, Rwanda 0.8% and Kenya 0.6%. Sorghum is ranked as the third most important crop after maize and beans in the ASARECA research priorities (ASARECA 1995). The grain is the staple cereal in Eritrea and Sudan.

Pearl millet

Pearl millet (*Pennisetum glaucum* (L.) R. Br) is a niche crop in ESA, grown in localised areas where normal rainfall does not permit the reliable production of the preferred dryland cereals such as sorghum and maize. This is in contrast to Western and Central Africa (WCA) and South Asia where pearl millet is the major cereal in large contiguous areas. This difference is reflected in the much smaller area sown to the crop in ESA (approximately 2.6 million ha) in contrast to an estimated 12 million ha in WCA and 9 million ha in India.

The largest area of pearl millet in ECA (Sudan and bordering areas of Ethiopia and Eritrea) is a part of the Sahelian/Northern Sudanian ecosystem of WCA, leaving about 1.2 million ha of pearl millet grown in areas climatically unique to ESA. In ECA pearl millet is important in the low altitude areas of Kenya and the central plateau of Tanzania. Pearl millet yields are usually much lower than yields of other cereals (which are grown under more favourable conditions). Furthermore, yields are highly variable from one season to another.

Finger millet

Finger millet (*Eleusine coracana* L.), a widely grown cereal in the semi-arid areas of ESA and South Asia, is a staple food that generates income for millions of poor people (Takan et al. 2004; Sreenivasaprasad et al. 2005). It plays a key role in the livelihoods of smallholder farmers and their families and is an important food security crop. As production statistics for the nine cultivated millets are often combined, reliable estimates of the areas sown to individual species are difficult to find. The Consultative Group on International Agricultural Research (CGIAR) estimated that finger millet accounts for 10% of 38 million ha sown to millets globally (www.cgiar.org/impact/research/millet.html).

In East Africa, however, finger millet is the most important millet, cultivated over 50% of the area sown to millets (Obilana 2002), especially in Uganda, Tanzania and Kenya (Table 1). In addition, finger millet production in East Africa has risen by 25% over the past 30 years, driven by domestic demand, growing regional trade, and higher market prices than other cereals. Finger millet has outstanding properties as a subsistence food crop. Its small seeds can be stored safely for many years without insect damage, making it a traditional component of farmers' risk avoidance strategies in drought-prone regions of Eastern Africa and South Asia.

Table 1. Finger millet production and area harvested in East African countries, 2005

Country	Area harvested ('000 ha)	Production ('000 tonnes)
Uganda	400	700
Tanzania	200	155
Kenya	100	65

Source: FAO (2005).

Furthermore, finger millet is an excellent dietary source of calcium, iron, manganese, and methionine, an amino acid lacking in the diets of hundreds of millions of the poor who live on starchy foods such as cassava, plantain, polished rice and maize meal. Finger millet is also productive in a wide range of environments and growing conditions throughout the middle-elevation areas of ESA. However, , finger millet is affected by *Pyricularia* blight, a close relative of rice blast.

Finger millet is readily milled into acceptable flour (Obilana 2002). A growing number of small, medium and large commercial grain millers and processors in East Africa each mill 10–800 tonnes of finger millet per month, producing both pure finger millet flour or composite flour and porridge mixtures, mainly for the domestic market (Lenné 2005). Nutritionally, finger millet is equal to or superior to other staple cereals, especially in minerals (Table 2). Its exceptionally high calcium content makes it an important food for pregnant women, nursing mothers and children (Obilana 2002). In addition, it is being increasingly recognised as a quality food for the sick, especially diabetics. In East Africa, particularly Kenya and Tanzania, finger millet is primarily consumed as a thick porridge known as ugali, and as a thin porridge known as uji. It also has excellent malting properties and is used to make local beers. However, great potential also exists for further product diversification.

Trends in area, yield and productivity

Sorghum

Globally, as for most crops, sorghum yields have risen as new technologies (improved varieties, higher input use and to some extent better resource management and disease/pest control) were developed and disseminated. The exception is Africa, where yields fell by 14% during the 1980s before rising once more in the early 1990s (Figure 1). There are sharp contrasts in productivity between countries. The reason for these differences could range from climatic and crop management conditions, to the degree of commercialisation and the corresponding adoption of new technologies. Limited use of purchased inputs due to financial constraints characterises the situation in most countries.

Table 2. Comparison of nutrients in finger millet versus other common cereals

Nutrient	**Nutrient composition per 100 g of finger millet compared to other common cereals**				
Finger millet	Wheat	Maize	Rice	Sorghum	
Energy (kcal)	328	346	342	345	349
Protein (g)	7.3	11.8	11.1	6.8	10.4
Carbohydrate (g)	72.0	71.2	66.2	78.2	72.6
Fat (g)	1.3	1.5	3.6	0.5	1.9
Fibre (g)	3.6	1.2	2.7	0.2	1.6
Iron (mg)	12.6	5.3	2.3	0.7	4.1
Calcium (mg)	410	41	10	10	25

Sources:www.cine.mcgill.ca/data%20Tables/dalit/3%20dalit%20grain%20data%20tables; www.pfaf.org/database/plant.

However, a few countries (e.g., Sudan and Zimbabwe) produce part of their sorghum on large farms for commercial purposes, using high inputs and sometimes supplementary irrigation (FAO 1995, 1996, 2004). Large commercial farmers in Zimbabwe have a record of harvesting 2–3 t/ha compared to 400–600 kg/ha by traditional smallholders. One important factor underlying yield trends is the adoption of hybrids. Hybrids are most widely used in areas where sorghum is produced commercially and in countries with a well-developed private seed industry. Correspondingly, the use of hybrids is concentrated in developed countries. Sorghum production area has declined by 0.2%, but the cropped area is expanding in Africa.

Falling yields in Africa, where sorghum is a key food security crop, are a major cause for concern. Population growth has forced an expansion of the sorghum growing area, often into drier more marginal lands. In some countries, the government market policies have encouraged the reallocation of relatively productive sorghum fields to maize. To some extent, this is the result of market policies that have encouraged commercial trade and processing of maize, but not of sorghum. In areas where this change has not occurred, fallow periods have often become shorter, giving the land less time to replenish nutrients. Since fertiliser application is generally very low, the net result is a decline in soil fertility.

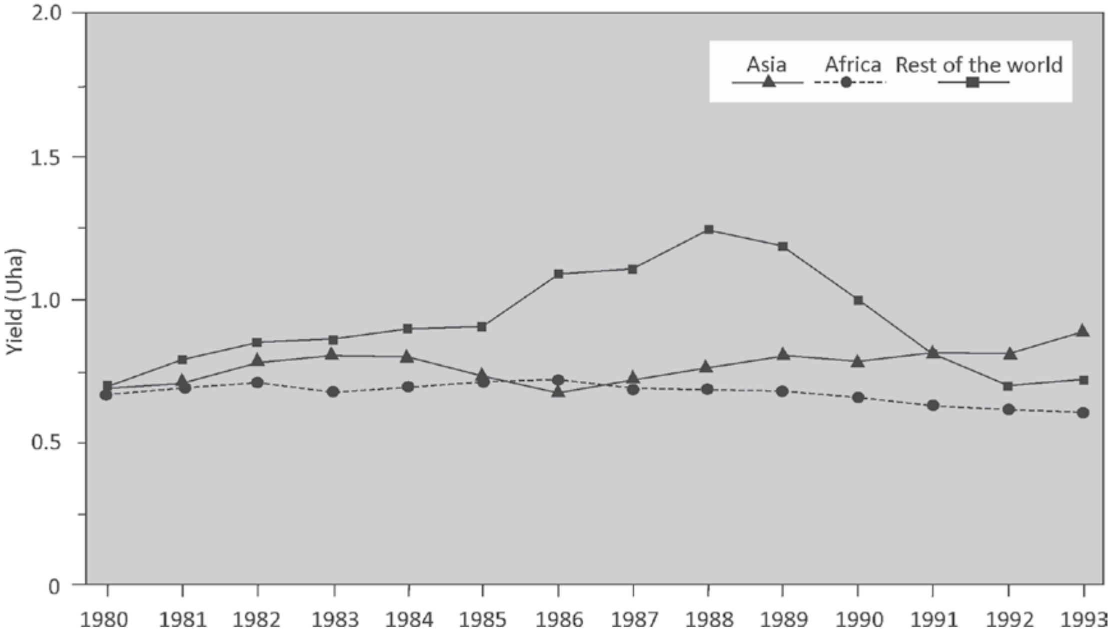

Figure 1. Sorghum yield trends, 1980–1993.

Millets

Production statistics for the various millets are often combined (sometimes with sorghum) so it is difficult to obtain reliable estimates of the areas sown to individual species. However, the most recent estimate suggests that about 50% of global millet grain production is pearl millet, with about 10% for finger millet. Two other millets, foxtail (Setaria italica) and proso (*Panicum miliaceum*), account for another 30% of global millet production, but most of this is confined to the temperate regions of China and the former USSR. The remaining portion of global millet production (less than 10% of the total) is mostly spread across eight species that are individually of limited regional importance.

Generally, Africa is the only region where millet production is growing, having risen from 8 million to more than 11 million tons between 1979–1981 and 1992–1994 (FAO 1996). In several countries, consumption levels of millet have been maintained only through area expansion. Even so, most millet production areas remain food insecure. As land constraints become more severe, productivity of this key staple must be increased to ensure at least minimal food security. Millet production stagnated between 1992 and 2002 in ECA. The global area under millets, however, dropped slightly from 38.1 million ha in 1981 to 37.6 million ha in the mid-1990s. Africa is becoming the world's leading producer of millets. Between the 1970s and 2000, harvests of millets in Africa increased by 22%, whereas other regions registered substantial declines.

Pearl millet

Pearl millet in ESA is primarily grown on soils that are sandy and light textured, too dry and too infertile for other cereals. The yields are low and average about three-quarters of the sorghum yields. Commercial pearl millet production is risky because of the absence of effective marketing opportunities, meaning that fluctuation in output causes significant price fluctuation, particularly in areas where it is the main food crop. For many African countries, millet yields have remained stagnant or fallen partly because much of the expansion has occurred into areas with poor soils and low, erratic rainfall.

Overall, pearl millet production has grown slightly faster than population with per caput production increasing by 0.6% per annum between 1979 and 1994. However, this situation is likely to be reversed in the near future.

Finger millet

Domestic demand for finger millet increasingly exceeds supply. Millers would produce more flour if more high-quality grain were available. Furthermore, the high nutritional quality and gluten-free characteristics of finger millet flour offer potential for export to Europe, USA and elsewhere where the demand for gluten-free products is increasing. However, despite (i) its importance to the livelihoods of millions of smallholder farmers in East Africa; (ii) its valuable nutritional and processing properties; (iii) the growing demand exceeding supply; and (iv) its regional and international trade potential, finger millet has largely been neglected by national and international research organisations and by major donors to agricultural research in sub-Saharan Africa. This neglect by mainstream research organisations and donors has contributed to a lack of realisation of the potential productivity of finger millet.

Research for development: Priority setting and constraints

Sorghum

In the main production regions of Africa, more than 70% of the sorghum crop is consumed as food. A large proportion of farm households aim simply to produce enough grain to meet household requirements—and many often fail to meet even this limited goal. Stakeholders within the region have conducted research for development on the analysed constraints and challenges from production to marketing and consumption. ECARSAM (2005) used constraint tree methodology to identify the root causes and infer the causal structure and relationships among seven constraints below. Productivity of sorghum remains low and many ESA countries lack consistent policy strategies to develop this crop. Low productivity is associated with the following constraints, most of which are common to all the countries in the region:

- Biophysical or environmental: Drought, soil fertility, post-flowering cold, Striga infestation and other pests (stem borer, midge and head bug) and diseases (leaf blight and grain mould);
- Management: Traditional modes of production and low levels of technology adoption, as depicted by poor agronomic practices, poor management of water resources, shortage of suitable varieties for different environments and poor management of biotic stresses (*Striga*, insects and diseases);
- Knowledge: Lack of knowledge on production technology of new varieties resulting from poor technology transfer and information barriers, and institutional bottlenecks such as research capacity and facilities; and
- Market: Poor market infrastructure for commercialisation of the crop, marketing hardships and policy impediments in the seed trade.

Biophysical or environmental constraints: Drought and post-flowering cold effects

Sorghum in ESA is grown in diverse agro-ecologies and production systems, and adaptation to these environments is important. The lowland, rainfed short-season environments require materials that mature within 100 days whereas the intermediate to long season to highland materials may take up to 180 days for the crop to reach maturity. Drought, as a common constraint in most production systems, is compounded by the effects of pests and diseases and by poor soil fertility and crop management. Drought is unpredictable and the intensity and frequency vary. In areas where the long rainy season supports photoperiod-sensitive sorghum, acidic soils can also be a production constraint.

Biotic stresses: Striga, *diseases and insect pests*

Among the biotic stresses, *Striga* remains a menace, with reported cases of up to 100% yield loss in the region. This is common where continuous cropping and limited soil fertility enhancement are practised (Mgonja et al. 2001). Sorghum in ESA is affected by several foliar diseases such as leaf blight (*Exserohilum turcicum*), sooty stripe (*Ramulispora sorghi*), gray leaf spot (*Cercospora sorghi*) and anthracnose (*Colletotrichum graminicola*). Among these, leaf blight is the most important constraint. In addition, grain mould and smuts are also important in the various production systems. Stem borers, head bug, midge and shoot fly are among the most important insect pests, causing significant economic losses in the different production systems.

Pearl millet

In recent years, pearl millet production in Africa in general and in the ESA sub-region in particular has expanded mainly due to an increase in crop area, as farm households aim to produce enough grain to meet household requirements. Yields have decreased because production is being pushed into more marginal areas and poorer soils, even in areas that are already prone to drought. Pearl millet yields in northern Namibia are already so low that it is cheaper for consumers to purchase imported maize. Productivity gains are unlikely to be obtained simply from improved varieties in marginal environments; meaningful yield gains require associated improvements in soil fertility and water management.

Productivity of pearl millet remains low in many ESA countries as there is a lack of consistent policies or strategies for its development. The low productivity in the region is associated with biotic and abiotic stresses prevailing in the region. Striga and drought remain high priorities among the biotic and abiotic constraints respectively.

Agro-climatic factors and the lack of resources in ESA pearl millet-growing areas severely constrain the adoption of improved technologies. A growing proportion of farmers are beginning to adopt new varieties because only a small investment is required to change seed. However, the rate of adoption is not encouraging owing to poor linkages between producers, consumers, processors, researchers and development workers. Moreover, the fact that most farmers in millet growing areas are resource poor exacerbates the problem of pearl millet production as an enterprise.

Constraints analysis for pearl millet

Constraints to the development of the millet sector in ESA were derived from stakeholders' responses at different times using various information gathering techniques such as meetings and questionnaires and also from research domains such as ECARSAM. Major constraints were identified in the production-to-consumption chain of sorghum and millet in the ECA region. These constraints constitute the major limitations in the sector: (i) low productivity; (ii) high post-harvest handling losses; (iii) limited processing and utilisation; (iv) limited marketing; (v) unfavourable government policies; (vi) limited capacity building and institutional development efforts; and (vii) limited knowledge and information exchange.

Sorghum and millets productivity enhancement

All agricultural development programmes seek to increase and sustain agricultural productivity as a means to improve overall growth, reduce poverty and promote food security. This goal is pursued by informing stakeholders of research results and products that are determinants of farm productivity. What increases it? What constraints it? What are the policies, institutional and technological approaches that can be taken to improve it?

The benefits of using improved management practices and inputs such as fertiliser and seeds have been recognised and have shaped investments in agricultural research. The determinants have been grouped into variables such as technologies, policies and institutions. Moreover, farmers' concerns and fears must be considered in the implementation of new practices. This is mainly because farmers' reactions to agricultural innovations will depend to a large extent on environmental factors. For subsistence farmers who live in marginal environments characterised by harsh climatic conditions, limited and erratic rainfall, poor soil nutrients, perpetual crop failures, and chronic famine, a bad crop means that some land or livestock must be sold to provide subsistence. In other cases, it could also mean starvation and death (O'Leary 1980). Furthermore, Scott (1976) and Ellis (1988) argued that the cost of failure for farmers near the subsistence margin is such that safety and reliability take precedence over long-term profit.

Technologies—Improved sorghum and millet varieties

Plant breeding programmes in ECA through the regional networks and collaboration with international agricultural research centres (IARCs) such as ICRISAT and other advanced research institutes have developed a number of improved cultivars. These improved varieties have increased or maintained productivity in the face of worsening environmental conditions. The number of released cultivars based on improved germplasm and hybrid parents bred at ICRISAT and other institutions have increased over the years in all countries. The number of cultivar releases has been highest in ESA (60), closely followed by Asia and WCA (50 each) and Latin America (34). Whereas released cultivars include both hybrids and varieties in Asia, mostly varieties are released in ECA and WCA (except for one hybrid released in Sudan).

Actual yields on farmers' fields remain much lower than on research stations across the ECA region. This can be attributed mainly to differences in crop management. Current yield increases achieved by farmers through adoption of the improved varieties alone range up to 50% (Heinrich and Rusike 2004). The new varieties offer several advantages over traditional landraces. They mature early, enabling farmers to produce a harvest even in years of end of season drought. This has a direct positive impact on food security. The varieties give substantially higher yields and greater stability as a result of disease/pest resistance. In a drier year they can produce double the yield of landraces.

In recent years an increasing number of studies have been undertaken to document agricultural research impacts and estimate rates of returns (RORs) to agricultural research investment in sub-Saharan Africa. These studies provide tangible evidence of the increasing availability of improved varieties of major food crops to farmers in Africa, increased food production in regions where adoption has occurred, and positive returns to research investment. This is seen in the widespread adoption of improved maize, wheat and rice varieties, with more than 50% of the area planted under these improved cereal crops by the early 1990s (Mazzucato and Ly 1994).

The growing body of evidence indicates that agricultural research in Africa has had productivity-increasing impacts. The generation and diffusion of improved, higher-yielding open-pollinated varieties (OPVs) of maize in western Africa and hybrids in ESA; higher-yielding wheat in ESA; hybrid sorghum in Sudan; semi-dwarf rice for irrigated regions in western Africa; early-maturing cowpeas in western Africa; and disease-resistant potatoes in the ECA highlands are cited as success stories of technological change in food crop production in sub-Saharan Africa. However, the results are patchy or uneven, by country and over time. The results also reflect wide variability as a result of differences in agroclimatic factors and the policy environment. Furthermore, the increasing availability of improved varieties is a necessary but insufficient condition for increasing agricultural productivity.

While crop improvement research in Africa can be regarded as a qualified success story, many important issues will need to be addressed if agricultural research is to continue to be a catalyst for modernising African agriculture. These include: the size of national agricultural research systems (NARS); commodity research programmes; relative emphasis on testing versus breeding; allocation of resources to different research activities and geographic regions; and low salaries and consequent high turnover among scientists. Considerable potential exists to improve research efficiency. Key to achieving this is to improve coordination among NARS and increase their collaboration with regional and international organisations. NARS should also strengthen their capacity to conduct impact assessments, since the results can influence agricultural policy formulation and guide the development of a national agricultural research agenda to enhance the impact of research on agricultural productivity.

The basic conclusion from these ROR studies is that returns to research are marginal when improved sorghum/millet is grown in a difficult environment without any other inputs. But returns are high and comparable with other commodities when the shift to new sorghum/millet varieties is combined with an increase in other inputs, especially in better environments where input use is less risky.

Yields of sorghum and millets increased at an annual rate of 0.7% and 1.0% respectively from 1971 to 1991. However, unless there is also a fairly rapid increase in input use, especially inorganic fertilisers, and a rapid increase in the supply of high quality seed, the adoption of new varieties of sorghum and millets has only a small impact on yields and incomes. Under the dry conditions of Sahelian countries such as Niger, improved millet varieties are estimated to increase yields by 22% or 200–14,500 kg/ha (Mazzucato and Ly 1994). At the extreme, *Striga* resistant sorghum varieties are estimated to increase yields by 59% in the *Striga* affected regions of Africa (Aghib and Lowenberg-DeBoer 1996).

Increased productivity and profitability

The largest productivity gains come from combining new varieties with improved crop management. Practical, low-risk, inexpensive technology options have been modified specifically for smallholders. Examples include ridges to conserve water and manure treatments to improve soil fertility. These options have been successfully tested in Tanzania and Zimbabwe and are now being scaled out to other areas. The question remaining, however, is how to mainstream low-risk crop and resource management methods into traditional extension services.

Sorghum and pearl millet generally receive little or no inorganic fertiliser. Research suggests that it is not economical to apply fertilisers due to their high costs and the relatively low prices for sorghum and pearl millet grain (Heinrich and Rusike 2004). Consequently, research must identify alternative cost-effective strategies for maintaining soil fertility. The options include rotations or intercropping with legumes and improving the quality and quantity of farmyard manure (FYM) by adding organic bedding to livestock pens and managing the manure to maximise available nutrients. Farmers also believe soil water management options are too labour intensive and uncertain in their payoffs. Therefore, adoption of these has been limited, except in a few areas.

Impacts of sorghum and millet research

The available evidence on the release and adoption of improved sorghum and millet varieties in Africa is still limited. Research programmes are under growing pressure to increase adoption of these varieties and quantify their impact to ensure continued donor and government support. The evidence suggests that the adoption of improved sorghum and millet varieties has been significant in some Southern African countries, notably Zambia and Zimbabwe. However, unlike other cereal crops, much of the adoption of improved sorghum and millet varieties in farmers' fields is recent, suggesting that the years of research and collaboration with IARCs on these crops are finally bearing fruit. Also, much of the recent adoption in Southern Africa resulted from the concerted efforts of national and international research programmes to disseminate improved varieties through drought relief programmes (Rohrbach and Mutiro 1997).

The available evidence on returns to investments in sorghum and millet improvement research indicates that the results are mixed (Appendixes 1, 2 and 3). The negative ROR reported for Niger's joint millet, sorghum and cowpea research investments is because of the lower yield potential of these crops. Niger's extremely harsh and variable climate discourages farmers from replacing their traditional varieties that give lower but assured yields each year with improved varieties that may yield higher in good years but perform poorly in bad years. Thus, during the severe droughts of 1985 and 1988 many farmers reverted to traditional varieties of millets and cowpeas, reducing the total area under improved varieties from the peak adoption percentage of 20% in 1984 to less than 12% by 1991 (Mazzucato and Ly 1994). However, projecting the benefits to 2011 on the assumption that adoption is no higher than it was in 1991, gives a positive return, in the range of 2–21% annually, to millet, sorghum and cowpea research in Niger.

In contrast, the overall returns to sorghum research in Cameroon were estimated to be about 1% for the period 1979–1988 (Sterns and Bernsten 1994). The improved variety, S-35, the only successful direct transfer from India into western Africa, out-yielded local varieties in years when the onset of the rainy season was late and when total rainfall was below average. Hence, the benefits from the development of S-35 in Cameroon were limited to drought years (which occur in one out of every three years, based on historical predictions) thus lowering the overall returns to sorghum research (Stern and Bernsten 1994).

The higher returns to other sorghum/millet research programmes reported are attributed to the following successful varieties: (i) Hageen Dura-1 in the irrigated regions of the Sudan, grown under higher levels of fertiliser inputs and better management practices; (ii) SV-2 in the semi-arid communal areas of Zimbabwe; (iii) Okashana-1 in the northern millet production strip of Namibia; and (iv) Striga resistant sorghum variety, P9401-8, which is expected to avert yield losses by more than 50% across the 10 countries of Eastern and western Africa.

Commercialisation of sorghum and millets

Linking technology development to markets

To transform sorghum and millet crops into economically viable enterprises, producing these crops must be profitable to smallholders and agro-enterprises along the value chain. One of the critical challenges facing the sorghum and millet sub-sector in the commercialisation process is the low level of production that primarily leads to high prices. The review in the previous section has shown that introducing new sorghum and millet cultivars in semi-arid sub-Saharan Africa has had minimum aggregate impact on yield (FAO and ICRISAT 1996). Vitale and Sanders (2005) attribute the low diffusion and lack of private investment in agriculture to reduced profitability of traditional food crops in Africa. This is mainly because: (i) cash-constrained farmers often have to sell at the low post-harvest prices; (ii) farmers are affected by weather conditions leading to major price fluctuations and failure to develop alternative markets for the crops; and (iii) price distortions result from policies to keep the prices of primary food commodities low.

If sorghum and millets are not sufficiently profitable because markets do not expand or governments continue to provide poor policy support, farmers will either not use inputs that enhance productivity or use small quantities just to produce enough for home consumption (Ahmed 2004). This means that research priorities will need to shift focus since release of cultivars alone is insufficient to improve yields. Low producer prices discourage farmers from using commercial inputs. The ability of input markets (seeds, fertiliser and credit) to respond to increasing demands will require measures that reduce prices paid by farmers for inputs or increase the prices received by farmers for the resulting output. Implementing such measures will strengthen farmers' incentives to adopt the new innovations and research products.

Other strategies that would facilitate the creation of opportunities for commercialisation of sorghum include government investments in market information, market infrastructure and input (seed and fertiliser) distribution and technology delivery systems. Public investment in marketing and transportation infrastructure would reduce input costs and increase producer prices by reducing transaction costs. Unfortunately, government investment in developing such infrastructure and market institutions in the semi-arid regions of ECA has been limited.

Attention to the evolution of new uses in the product market should potentially accelerate diffusion of new technologies by moderating the between-season collapses and partially offsetting the long-run price decline resulting from successful technology introduction. Market development, such as using domestic cereals to make bread and beer, can serve as an intermediate function to increase incomes to sufficient levels that will lead to a dietary change to animal products and therefore the shift to the accelerated use of sorghum and millets as feed.

Slow diffusion of improved varieties has further been linked to lack of improvement of yield (Ahmed 1995, 2004). In Sudan, for example, farmers' inability to access new varieties or inorganic fertilisers has been cited as the principal determinant of their inability to introduce new hybrids (Nichola 1994).

High costs and poor competitiveness

One of the critical challenges facing the sorghum and millet sub-sector in the commercialisation process is the low level of production that primarily leads to high prices. The high prices make the crops uncompetitive to alternative substitutes. For example, in Botswana Rohrbach et al. (2000) found that smallholder production of sorghum for commercial purposes is essentially unprofitable at an average of 250 kg/ha. The authors found that factors such as consistency and timeliness of supply, cleanliness, variety or grain quality and availability of short-term credit were found to influence grain purchases by processors. In addition, lack of transport was found to limit purchases by processors from large- and small-scale farmers. Furthermore, a lack of commercial market has limited farmers' interest in improving management practices in the crops. Available information from the Kenya Agricultural Commodity Exchange (KACE) shows that monthly sorghum prices were, on average, about KSh 8 above those of maize. Consequently, sorghum is likely to be a poor competitor to maize when the margins and costs of marketing are taken into account, yet maize can easily substitute for sorghum in alternative uses.

Nevertheless, opportunities for increased sorghum and millet production exist in the brewing, animal feed and milling industries. Lack of adequate quantities and quality are the critical constraints to realising the potential benefits to these sub-sectors. Contracting or extension programmes linked with seed production and distribution are likely to address the problem of consistent supply and quality. This requires alternative market arrangements with complementary institutional support.

From the perspective of the animal feed industry, the relatively higher sorghum and millet prices compared to those of other substitutes make sorghum less competitive. However, competitiveness can be increased by encouraging commercial production. According to Rohrbach et al. (2000), a short-term measure for improving competitiveness would require the industry to use sorghum post-harvest when prices are lowest relative to maize prices, and to switch to cheaper substitutes during the pre-harvest season. While these may seem to be rational adjustments from the processors' perspective, empirical evidence suggests that low prices without a corresponding reduction in production costs may be a disincentive to market participation by small-scale farmers. This is primarily because cash requirements at harvest or shortly after harvest tend to override the desire to put aside a stock of the commodity for subsistence or to maximise income (Vitale and Sanders 2005; Shiferaw et al. 2006). Institutional market support systems for these farmers would enable them overcome the constraints imposed by seasonality.

Grain milling provides another avenue through which competitiveness can be improved. The major constraints appear to be uncertainty about consumer preferences. The perception is mainly that sorghum meal is primarily used by the poor with the consequence that urban dwellers who can afford sorghum-related products tend to avoid them. Nevertheless, evidence shows that in some countries (e.g., Botswana) consumption of sorghum meal has expanded due to a change in the attitude that views sorghum as an inferior product, especially in the urban areas (Rohrbach et al. 2000). In Tanzania, however, uncertain demand, non-availability of grain, thin markets, and poor grain quality have been identified as the main constraints that appear to limit the use of sorghum and millets in the milling industry (Rohrbach and Kiriwaggulu 2001).

Strategies for stimulating demand: Targeting alternative uses

Demand for livestock products (mainly milk and meat) in sub-Saharan Africa is expected to double by 2020 (Delgado et al. 1999). While the overall per capita consumption in the region remains one of the lowest in the world, the expected doubling of the meat and milk demand requires increased availability of feed and fodder for livestock. Sorghum has the potential to meet some of this demand. However, the prospects for expanding sorghum use as a feed grain depend on several factors such as nutrition (energy content), anti-nutritional factors, costs and availability that jointly determine its competitiveness with maize. Whereas white sorghum has no tannins (anti-nutritional factors), brown sorghum and some of the red are known to have some amount of tannins that reduce digestibility. Using white sorghum as feed also competes with its preferred use in the food and brewing sectors.

In relation to compositeness, one of the issues to be considered is the location of the feed industry relative to production areas, and the speed of its expansion. Once food demands are met, the prospects for growth in feed demand are high. Despite the large interest generated in the use of sorghum for processed foods and bakery products, industrial utilisation remains limited. Small quantities of sorghum are used to produce beer malt, starch and flour in several African countries such as South Africa and Nigeria. However, food industries tend to be conservative in experimenting with alternative inputs, and in most countries the prospects for industrial use are sharply constrained by uncertain supplies and variable grain quality. Furthermore, in some countries, regulations make it illegal for the food industry to use sorghum as a low-cost alternative to other cereals (e.g., in Mexico it is illegal to use sorghum in tortilla manufacture in place of maize).

The pursuit of these productivity gains is particularly important because they will translate directly into income gains for some of the poorest rural households on the continent. In effect, productivity growth in sorghum represents a self-targeting source of poverty alleviation.

Higher yields are likely to translate into improved competitiveness for sorghum in Asia's industrial markets. Depending on the price and quality of competing inputs, prospects exist to expand sorghum's use as a source of starch, as an input in beer production and as a compositing agent in various types of bakery products. However, the greatest source of growth in utilisation will probably be the feed industry. As incomes rise throughout Asia, the demand for milk, meat and other animal products, and therefore for feed, is rising sharply. In some of the fastest growing economies this demand has been met by sorghum and maize grain imports. Domestic production could replace these imports. For major producers such as India, the feed market offers the prospect of large growth in demand for both grain and fodder products.

In the major feed-producing countries, sorghum production appears increasingly variable as a result of agricultural policy interventions, the relative demand for feed and the competitive market position of alternative feeds such as maize. Several developing countries with rapidly growing feed sectors have experienced a strong production growth, most of which has occurred in the modern, mechanised sector where yields usually exceed 3 t/ha. Although yields continue to grow in developed countries, the area sown has been variable. The decline in sorghum area in USA, the world's largest producer, could well be reversed as policy interventions favouring maize are terminated.

A key issue for the future is whether sorghum will remain competitive with maize in the feed grain market. This will depend primarily on the relative growth of productivity in the two crops. While maize breeders are working to develop more drought-tolerant varieties, the prospects for achieving the levels of tolerance inherent in sorghum are limited. Increasing global water constraints and rising water costs appear likely to encourage the allocation of a growing share of feed crop land to sorghum. This trend may be accelerated by improvements in the nutrient-use efficiency of the sorghum plant.

Summary and conclusions

The world sorghum economy consists of two distinct sectors: a traditional, subsistence-oriented, smallholder farming sector where most production is consumed directly as food (mainly in Africa and Asia), and a modern, mechanised, high-input, large-scale sector where output is used largely as animal feed (mainly in developed countries and Latin America). The future of the sorghum economy is linked with its continuing contribution to food security in Africa, diversification of agriculture and its emerging role in industrial use and as feed grain in Asia, and its vital role in the feedstock sector in the rest of the world. Along with its competitiveness with cereal substitutes (mainly maize), the future outlook for sorghum will also depend on the risk of climate change and the increasing economic scarcity of water and its efficient use in drought-prone regions.

Millet shares many of the characteristics of sorghum in Africa and worldwide, although its use as feed in the livestock industry is almost negligible. Millets remain important food crops for poor households in the semi-arid areas of Asia and Africa.

In large parts of Africa, sorghum and millets remain critically important for rural food security. Most production is consumed by the households producing the crop, and only a small proportion of harvests enters the commercial market. Since many sorghum-producing areas still experience periodic food deficits, farmers must increase production to improve household food security. Some projections have shown that the sorghum and millet area will continue to expand in Africa, mainly in response to population growth. Unfortunately, this expansion is pushing the production of these cereals into drier and more fragile ecosystems. Average sorghum yields, which have been falling by 1% per annum since the early 1980s, will need to be reversed for food production to keep pace with population growth. However, the continuing marginalisation of these crops into fragile areas where soil fertility and moisture are limiting factors for crop growth means that improving crop yields is going to be a serious challenge.

Improving sorghum and millet productivity in the ECA region and in sub-Saharan Africa in general depends on the development and availability of new technologies, on the institutional reforms needed to improve input flows to farmers, and on the availability of markets for sorghum and millets. Technological change is already being led by the introduction of new varieties that meet client needs in different parts of the region. Breeding programmes have offered a range of new varieties that improve yields and provide greater flexibility in sowing dates. However, in most countries, seed production and distribution constraints restrict the access of farmers to these new varieties. Private sector seed companies have proven reluctant to market open-pollinated sorghum varieties, and public sector seed industries either lack the capacity or mainly focus on other staples (e.g., maize and rice). The payoff to past investments in breeding depends on resolving these constraints. The sector increasingly needs a demand-led strategy that firmly links technology development with markets and farmer preferences.

The largest gains in sorghum and millet productivity will need to be found in technologies that improve the crops' access to water and nutrients. Throughout Africa these crops generally receive little or no fertiliser. Application of manure is restricted by limited supplies and the competition for this input among various crops. Farmers tend to judge water conservation technologies as too labour-intensive and uncertain in their payoff. The ECA region already has one of the highest population densities in Africa. Yet as land frontiers disappear and population densities rise, it will become even more critical for farmers to intensify production. Furthermore, available evidence shows that payoffs from using small quantities of nitrogen and phosphorous fertiliser with precision applications that enhance the efficiency of use can be significantly high. Complemented by proper management of soil moisture, the incremental use of micro-quantities of fertiliser can be a beneficial strategy for smallholders both in terms of risk management and increasing incomes from these cereals. Scientists and extension workers can encourage farmers to invest in technologies that offer a wider range of options for soil fertility and water management to fit variable investment strategies and risk preferences of small-scale producers.

Pest and disease pressures will need to be tackled through chemical, biological and management control. Losses due to *Striga* appear to be increasing. Whereas breeders are pursuing a solution through new resistant cultivars, more effective control will probably need to be obtained from management strategies. The most promising solution is fertility improvement, but this requires farmers to either invest in fertiliser or forego some sorghum by introducing a legume as a rotation crop. Researchers need to modify these solutions to make them less expensive. Similarly, further investment is required to develop integrated pest management strategies for major insect pests such as stem borer, midge and head bugs.

The limited trade in domestic markets for these cereals between deficit and surplus producing areas is mainly for food consumption. The use of sorghum and millets for feed and other industrial uses has been largely limited by poor competitiveness with maize. The prospects for greater sorghum and millet trade and commercialisation in the region are constrained by low volumes, the variability of supply, high collection costs and lack of transport from outlying production areas. The high costs of marketing and limited availability in domestic markets have often made sorghum costlier than substitutes such as maize, thereby limiting market opportunities for smallholder farmers. Issues related to availability and reliability of supply can be addressed by promoting the new high-yielding varieties or those that are tolerant of shocks (pest, disease and drought). However, one important strategy for stimulating the demand for these crops is to better link technology development with market demand. This would require breeding programmes to identify traits to meet the market demand for alternative uses. Varieties that better meet the quality requirements of different end-users (food, feed, bio-fuels, alcohol etc.) need to be identified and promoted. This requires actively engaging the industry to share information and demonstrate the potential of these crops. Increased use is, however, unlikely to occur as long as sorghum remains more costly, poorer in quality and more unreliable in supply in domestic and regional markets than other substitutes.

Government policy plays an important role in the process of making these crops more useful in the struggle of many poor rural populations to escape poverty and destitution. This ranges from establishing seed delivery networks to promoting promising varieties and developing market infrastructure that links the surplus growing areas for these crops. Given the important role that these crops play in terms of stimulating pro-poor economic growth in many less-favoured regions, governments may also consider subsidies for providing seeds and marketing facilities for these crops. Governments also need to create a level playing field and enable policy environments for agro-enterprises and smallholder producers of these crops to compete more effectively with those dealing with substitute crops. This means removing indirect subsidies that encourage expansion of alternative crops not suited to dryland regions and provision of price and other incentives for farmers to adopt sorghum and millet technologies. Drought relief and agricultural rehabilitation programmes—often operating in the semi-arid regions—should also target these crops and consider their inclusion as part of the rural food and nutritional security and safety net programmes. Another important policy issue is for governments in ECA to adopt trade policies that encourage the flow of sorghum and millets across borders from surplus to deficit areas. Given the limited surplus and unreliable supplies, opening such regional trade opportunities has the potential to attract private investment that uses these grains as key ingredients. This may involve strengthening market information systems and linking producers to exporters and subsequently processing industries. Such interventions would more than justify the investment required, because they are likely to significantly improve food security and offset drought relief costs in the future.

On balance, sorghum and millets will remain key food security crops in ECA for the foreseeable future. Productivity gains and improvements in grain quality are critical factors in improving the competitiveness of small-scale producers for expanding trade and commercialisation. This must be complemented by government policies that enhance the availability and increased utilisation of improved sorghum and millet technologies and marketing systems that provide better incentives for smallholder farmers growing these crops. As incomes increase and urbanisation expands in the region, the increasing consumption demand for livestock products is likely to boost the demand for these crops in the feed industry. The future strategy should aim to unlock such opportunities by developing varieties that support diversification and expansion of demand through alternative uses.

References

Aghib A, Lowenberg-DeBoer J. 1996. The regional impact of collaborative research and extension programs: The case of *Striga* resistant sorghum varieties developed by INTSORMIL. Mimeo, Purdue University.

Ahmed A. 2004. Challenges of agricultural technology transfer and productivity increase in the Sudan. *International Journal of Technology, Policy and Management* 4(2):136–150.

Ahmed MM, Masters WA, Sanders JH. 1995. Returns from research in economies with policy distortions: Hybrid sorghum in Sudan. *Agricultural Economic*s 12(2):183–192.

ASARECA [Association for Strengthening Agricultural Research in Eastern and Central Africa].1995. Regional agricultural research priorities for Eastern and Central African countries. ASARECA, Entebbe, Uganda.

Bassey MW, Schmidt OG. 1989. Abrasive-disk dehullers in Africa: From research to dissemination. International Development Research Centre, Ottawa, Canada.

Delgado C, Rosegrant M, Steinfeld H, Ehui S, Courbis C. 1999. Livestock to 2020: The next food revolution. Food, Agriculture and Environment Discussion Paper 28. International Food Policy Research Institute, Washington, DC.

ECARSAM [Eastern and Central Africa Sorghum and Millet Network]. 2005. Sorghum and Millet Research for Development in Eastern and Central Africa 2005–2010. Regional Priorities. Nairobi, Kenya.

Ellis F. 1988. Peasant economics: Farm households and agrarian development. Cambridge University Press, Cambridge, UK.

FAO [Food and Agricultural Organization of the United Nations]. 2005. FAOSTAT. Available at http://apps.fao.org.

FAO [Food and Agricultural Organization of the United Nations], ICRISAT [International Crops Research Institute for the Semi-Arid Tropics]. 1996. The world sorghum economies: Facts, trends and outlook. Rome, Italy: FAO, Rome, Italy and ICRISAT, Andhra Pradesh, India.

FAO [Food and Agricultural Organization of the United Nations]. 1995. Sorghum and millets in human nutrition. FAO Food and Nutrition Series 27. FAO, Rome, Italy.

Hall AJ, Sivamohan MVK, Clark N, Taylor S, Bockett G. 2001. Why research partnerships really matter: Innovation theory, institutional arrangements and implications for developing new technology for the poor. *World Development* 29(5):783–797.

Heinrich GM, Rusike J. 2004. Crop and resource management: Technology development and dissemination in SMIP Phase IV. In: p 49–77, ICRISAT [International Crops Research Institute for the Semi-Arid Tropics], ed, A foundation for the future: The sorghum and millet improvement program (SMIP) in Southern Africa. Proceedings of the SMIP Final Review and Reporting Workshop, 25-26 November 2003, ICRISAT, Bulawayo, Zimbabwe.

Mazzucato V, Ly S. 1994. An economic analysis of research and technology transfer of millet, sorghum, and cowpeas in Niger. MSU International Development Working Paper 40. Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, USA.

Mgonja MA, Chivinge OA, Monyo ES, eds. 2001. Striga research in southern Africa and strategies for regionalized control options. SADC/ICRISAT Sorghum and Millet Improvement Program. ICRISAT [International Crops Research Institute for the Semi-Arid Tropics], Bulawayo, Zimbabwe.

Nichola T. 1994. Adoption of hybrid sorghum at the farm level and regional levels in the Gezira Irrigation Scheme of the Sudan. Unpublished PhD dissertation. Purdue University, Department of Agricultural Economics, West Lafayette, Indiana.

Obilana AB. 2002. Overview: importance of millets in Africa. Available at: www.afripro.org.uk/papers/Paper02Obilana.pdf.

O'Leary M. 1980. Responses to drought in Kitui District, Kenya. Disaster 4(3):315–327.

Rohrbach DD, Mutiro K. 1997. Formal and informal channels of sorghum and millet seed supply in Zimbabwe. In: p 39–47, Proceedings of the workshop on Seed Polices in Zimbabwe: An Agenda for Action, 30–31 July 1996, Harare, Zimbabwe. Environmental and Development Activities, Zimbabwe.

Rohrbach DD, Kiriwaggulu JAB. 2001. Commercialization prospects for sorghum and pearl millet in Tanzania. Working Paper Series 7. ICRISAT [International Crops Research Institute for the Semi-Arid Tropics], Bulawayo, Zimbabwe.

Rohrbach DD, Mupanda K, Seleka T. 2000. Commercialization of sorghum milling in Botswana: Trends and prospects. Working Paper Series6. ICRISAT [International Crops Research Institute for the Semi-Arid Tropics], Bulawayo, Zimbabwe.

Scott CJ. 1976. The moral economy of the peasant. Yale University Press, New Haven, Connecticut, USA.

Shiferaw B, Obare G, Muricho G. 2006. Rural institutions and producer organizations in imperfect markets: Experiences from producer marketing groups in semi-arid eastern Kenya. Socioeconomics and Policy Working Paper 23. ICRISAT [International Crops Research Institute for the Semi-Arid Tropics], Andhra Pradesh, India.

Sreenivasaprasad S, Takan JP, Mgonja MA, Manyasa EO, Kaloki P, Wanyera NM, Okwadi J, Muthumeenakshi S, Brown AE, Lenné JM. 2005. Enhancing finger millet production and utilisation in East Africa through improved blast management and stakeholder connectivity. In: p 11–22, Harris D, Richards JI, Silverside P, Ward AF, Witcombe JR, eds, Pathways out of poverty. Aspects of Applied Biology Vol 75.

Stern JA, Bernsten RH. 1994. Assessing the impact of cowpea and sorghum research and extension in northern Cameroon. International Development Policy Syntheses 23. Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, USA.

Takan JP, Akello B, Esele JP, Manyasa OE, Obilana BA, Audi OP, Kibuka J, Odendo M, Oduori CA, Ajanga S, Bandyopadhyay R, Muthumeenakshi S, Coll R, Brown AE, Talbot NJ, Sreenivasaprasad S. 2004. Pathogen diversity and management of finger millet blast in East Africa: A summary of project activities and outputs. *International Sorghum and Millets Newsletter* 45:66–69.

Vitale JD, Sanders JH. 2005. New markets and technological change for the traditional cereals in the semi-arid sub-Saharan Africa: The Malian case. *Agricultural Economics* 32:111–129.

1.2. Production of sorghum and millets in highland Ethiopia

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Abstract
Sorghum and finger millet are among the major cereal crops of Ethiopia; they are grown in diverse environments. These crops annually occupy more than 1.5 million hectares of land and contribute significantly to the economy of the country. They are widely used to prepare traditional foods and drinks. Considerable research efforts have been directed towards improving the productivity of sorghum and finger millet. However, due to limited supply and limited use of major yield promoting inputs such as quality seeds of improved varieties, fertilisers and irrigation, yields remain low.

Introduction

Sorghum (Sorghum bicolor (L.) Moench)

Sorghum is believed to have originated and been domesticated in north-eastern tropical Africa, possibly in Ethiopia as early as 5000–3000 BC. It was subsequently distributed all over the continent and through shipping, was taken to the Middle East and India from where it later spread to China (Balole and Legwaila 2006). Sorghum is one of the major cereal crops in Ethiopia. It is grown on a wide range of soils and agro-ecologies ranging from dry lowland areas like Wello to high altitudes with high rainfall (Hailmicheal 1998). Ethiopian statistical reports (Table 1) show that area, productivity and production of sorghum have increased slowly since the 2000/2001 cropping season; this increase is attributed mainly to increase in area. Productivity increased from 11.54 quintals/ha in 2000/01 to more than 13 quintals/ha in 2001/2002 and thereafter. The estimated forecast for 2005/2006 was 16.06 quintals/ha with an area of 1,326,717 hectares of land and production of 21,316,260 quintals (Table 1). Although the productivity of sorghum was expected to increase due to available technological packages, it remained almost stagnant because major inputs (like improved seeds, fertilisers and irrigation) were unavailable. For example, in the 1997/1998 main cropping season, 1.54% of the sorghum area was covered by improved seeds compared with 38.41%, 29.37% and 20.22% of land planted to maize, wheat and teff (Eragrostis tef; Lovegrass)respectively. Similarly, there is a meagre use of fertilisers and irrigation for sorghum, maize, wheat and teff. The use of available technologies must be improved to increase the productivity and production of sorghum in Ethiopia.

Finger millet (Eleusine coracana (L.) *Gaertn*.)

Finger millet is grown mainly in the northern, north-western and south-western parts of Ethiopia. It is characterised as one of the hardiest crops grown in diverse environments from the dry lowlands to altitudes of up to 2400 metres above sea level (Agmas et al. 1998). Finger millet is grown for its multiple uses as human food and for preparation of local drinks known as *tella* and *arekie*. The grain is ground to make flour that is used to make porridge, *injera* and *kitta*. Finger millet fodder is highly valuable. The major advantage of growing millet is its high resistance to storage pests. The crop can be stored for decades and hence it can be used as a reserve crop for famine (Agmas et al. 1998).

Unfortunately, since farmers in Ethiopia do not use improved varieties of finger millets as production inputs, the crop is highly marginalised. Finger millet is particularly popular in the north-west and northern parts of the country, and its area and production has recently increased slightly (Table 2). Efforts to promote finger millet will bring significant changes in its production.

Table 1. Area, productivity and production of sorghum in Ethiopia

Year	Area (ha)	Yield (quintal)	Production (quintal)
1997/1998	954,740	11.20	10,697,400
1998/1999	1,042,390	12.67	
1999/2000	995,410	11.87	11,811,430
2000/2001	1,332,890	11.54	15,382,810
2001/2002	1,132,495	13.70	15,462,080
2002/2003	----	-----	----
2003/2004	1,283,453	13.57	17,463,753
2004/2005	1,256,509	13.69	17,200,831
2005/2006	1,326,717	16.06	21,310,260

Note: 1 ton = 10 quintals.

Does it pay to produce sorghum and millet in Ethiopia?

Sorghum and finger millet are grown in highly diversified environments and their yields differ from high potential area to lowlands (areas with low moisture stress). The overall productivity of sorghum and finger millet is relatively high (Table 3), provided that improved varieties and their recommended agronomic packages are properly used. The yield potential recorded even for the lowland areas of Ethiopia (<1600 m) are attractive enough for small-scale farmers. The yield of such varieties as Muyra-1 and Muyra-2 are very high in the highlands and attractive to both smallholder and commercial farmers (Table 3). Moreover, the availability of *Striga*-resistant varieties for the areas where Striga is a major production constraint will help farmers continue to produce sorghum. Another advantage of these crops is that the seed requirement is very low (5–10 kg/ha) and is cheaper than that of maize. Sorghum will continue to serve as a food security crop in the dry parts of the country since no cereal crop is better suited to tolerate drought.

Table 2. Area, productivity and production of finger millet in Ethiopia

Year	Area (ha)	Yield (quintal)	Production (quintal)
1997/1998	289,740	8.93	2,587,500
1998/1999	446,680	8.54	3,814,860
999/2000	360,230	8.87	3,195,090
2000/2001	346,780	9.12	3,161,660
2001/2002	281,455	10.88	3,061,839
2002/2003	-	-	-
2003/2004	304,772	10.01	3,051,608
2004/2005	312,988	10.64	3,328,663
2005/2006	324,505	12.26	3,985,589

Note: 1 ton = 10 quintals.

One major problem is that improved varieties have not been multiplied, distributed and used by producers. Furthermore, the Central Statistical Authority (CSA 2000, 2002) shows that none of the released varieties of finger millet have been used by growers. Generally, given the current yield potential of improved varieties of sorghum and finger millet and their market prices, both crops pay producers provided the extension service promotes them properly.

Available production technologies

The following are the most important production technologies for the different agro-climatic conditions of Ethiopia.

Table 3. Potential yield of some sorghum and millet varieties in Ethiopia

Variety	Year of release	Altitude (m)	Yield (quintal/ha)
Sorghum varieties			
Abshir	2000	<1600	14–24
Gubiye	2000	<1600	14–27
Muyra-1	2000	>1900	58–80
Muyra-2	2000	>1900	44–68
IS9302	1981	<1600	30–40
Birmash	1989	<1600	25–30
Gambella 1107	1976	<1500	25–50
76T1#23	1979	<1600	25–45
Serdo	1986	<1600	30–50
Meko-1	1997	<1600	30–40
Finger millet varieties			
Padet-1	1999	1600–1900	24
Tadesse	1999	1600–1900	25

Note: 1 ton = 10 quintals.

Varieties

The Sorghum and Finger Millet National Improvement Programme has been one of the strongest programmes in Ethiopia and has resulted in the development and release of sorghum and finger millet varieties suitable for the different agro-ecological zones of the country (Tables 3 and 4). The sorghum varieties released for different environments that are ready for use are listed in Table 4. Among the varieties released for the dry lowlands, 76T1#23 known as *wodiaker*, was widely used by farmers in Kobo area (Hailmicheal 1998). The yield potential of most of the sorghum varieties is very high and if these varieties are accompanied by improved management practices and an increased area, significant changes in the overall production of sorghum can be achieved. The two millet varieties are also performing well in the mid-altitudes where the growing environment is better. Finger millet can be promoted as a substitute in the areas where maize and sorghum (heavy feeders) are grown year after year, exhausting the soil nutrients. This possibility should be explored, particularly in the western parts of the country.

Table 4: Varieties of sorghum released for the three major agro-ecologies of Ethiopia

Highland varieties	Mid-altitude varieties	Lowland varieties
Alemaya 70	Baji	Serado
ETS2752	IS9302	Gambella1107
Chiro	Birrmash	Mako
Chelenko	Abba melko	76T23
Muyra1		Teshale
Muyra2		Gobiye
		Abshir
		Brihan

Agronomic recommendation

Various agronomic studies have been undertaken in different agro-ecological zones to address the management problems of crops under various situations. Wondimu and Getachew (1998) reviewed most production and soil and water management technologies in the marginal rainfall areas of Wello. Their paper indicates the results obtained from using tied-ridge/basin listing/furrow dikes, shilshallo (form of cultivation where a farmer uses an oxen plough to weed and apply fertiliser when the crop is at knee height), plant population density, planting date, planting depth and tillage to maximise the soil moisture during crop growing period. Similar studies have been undertaken at several testing sites and results have been documented in the annual reports of the Ethiopian Agricultural Research Institute.

Why are sorghum and finger millet yields low in Ethiopia?

The yields of sorghum and finger millet are relatively low in Ethiopia and in ECA, especially in comparison to crops such as teff, maize and wheat. The major reasons for this include the lack of availability of the seeds of improved varieties, low use of fertilisers and supplemental irrigation as compared to other cereal crops as shown below.

Lack of improved seed supply

Research institutions play a major role in advancing national agriculture since they are responsible for generating technologies including the development and release of improved varieties. These institutions provide breeders' seed to seed multiplying institutions such as national seed programmes and private seed companies. Research institutes in Ethiopia have released sorghum and finger millet varieties. The Ethiopian Seed Enterprise and some private companies are responsible for multiplying the seed. However, both the Enterprise and private companies are concentrating on more profitable crops, mainly hybrid seeds of maize followed by wheat and teff. Crops such as sorghum and millets have been neglected and improved seeds of these crops are not available to farmers (Table 5). Farmers are forced to grow local landraces that are inherently low yielding as compared to improved varieties. The low productivity of these crops indicates that research products have not been fully utilised and their impact remains unrealised. Unless the existing seed system is improved and the government takes responsibility for such crops, the prospects for sorghum and millets will be poor. National, regional and international institutions should invest in the development of efficient and effective seed systems that stimulate the key players to produce and market the seeds of these neglected crops..

Table 5. Area (ha) of input application and quantity of inputs used during 1997/1998 to 2000/2001

Crop	Total		Improved seed applied		Irrigated		Fertiliser applied	
	Area	%	Area	%	Area	%	Area	%
1997/1998								
Cereals	5601.88	74.01	134.9	90.2	34.56	54.31	2199.90	84.33
Teff	1747.19	23.09	30.24	20.22	11.54	18.13	837.13	32.09
Barley	681.5	9.01	0.99	0.66	4.3	6.65	288.80	11.07
Wheat	787.72	10.41	43.93	29.37	2.54	3.99	477.00	18.29
Maize	1100.61	14.54	57.44	38.41	12.14	19.08	368.17	14.11
Sorghum	954.74	12.61	2.30	1.54	3.69	5.80	99.33	3.81
Millet	289.74	3.83	-	-	-	-	116.42	4.46
Oats	39.93	0.52	-	-	-	-	13.05	0.50
1998/1999								
Cereals	6744.71	75.57	218.00	91.21	30.11	47.67	2936.85	85.25
Teff	2091.34	23.43	22.41	9.38	2.89	4.57	1074.29	31.49
Barley	830.18	9.30	-	-	3.58	5.67	368.27	10.69
Wheat	987.07	11.06	59.33	24.82	2.57	4.07	648.78	18.83
Maize	1303.10	14.60	131.78	55.13	13.65	21.61	499.93	14.51
Sorghum	1042.39	11.68	1.99	0.83	7.24	11.46	126.75	3.68

Crop	Total		Improved seed applied		Irrigated		Fertiliser applied	
	Area	%	Area	%	Area	%	Area	%
Millet	446.68	5.00	-	-	-	-	201.38	5.85
Oats	43.97	0.49	-	-	-	-	17.45	0.51
1999/2000								
Cereals	6746.46	73.86	302.80	91.93	42.85	52.82	3004.01	84.75
Teff	2123.47	23.25	25.4	7.71	5.23	6.45	1124.80	31.73
Barley	794.10	8.69	6.27	0.08	4.63	5.71	320.28	9.04
Wheat	1025.31	11.23	57.42	17.43	1.78	2.19	669.45	18.89
Maize	1407.27	15.41	216.8	65.83	18.56	22.88	640.7	18.08
Sorghum	995.41	10.9	2.87	0.87	11.51	14.19	101.31	2.86
Millet	360.23	3.94	-	-	1.07	1.32	134.22	3.79
Oats	41.67	0.46	-	-	-	-	13.25	0.37
2000/01								
Cereals	7636.62	73.18	415.27	94.32	45.77	56.03	3339.73	84.56
Teff	2182.53	20.91	14.52	3.30	5.68	6.92	1146.46	29.03
Barley	874.00	8.38	0.9	0.2	3.68	4.50	315.39	7.99
Wheat	1139.72	10.92	53.95	12.25	1.33	1.63	746.76	18.91
Maize	1719.73	16.48	344.6	78.26	18.96	23.21	843.64	21.36
Sorghum	1332.86	12.77	1.33	0.30	15.91	19.48	131.94	3.34
Millet	346.78	3.32	-	-	-	-	143.04	3.62
Oats	40.98	0.39	-	-	-	-	12.51	0.32

Source: CSA (2002).

Limited use of irrigation

Ethiopia is a source of many international rivers such as the Blue Nile and Wabi Sheble. The country has great potential to develop irrigation schemes in the dry areas where crops such as sorghum are predominantly grown. However, data obtained from Ethiopian Central Statistical Authority (CSA 2002) reports indicate that the area of irrigated sorghum and millet is much lower than that of other cereal crops (Table 5). Provision of supplemental irrigation to sorghum particularly in the dry areas will help increase the productivity and production of these crops. This needs to be considered in line with the government's national food self-sufficiency plan.

Limited use of fertiliser

Sorghum is a traditional Ethiopian crop that is grown in diverse environments from dry to wet high rainfall areas. However, it is primarily suited to hot, semi-arid tropical environments that are too dry for maize and other cereals. Hence, this crop is grown mainly under conditions of low moisture stress, which affects its efficiency of fertiliser uptake. Moreover, the dry areas increase the risk of crop failure and, because of this, Ethiopian farmers are reluctant to apply fertiliser to sorghum (Tables 5).

In general, the productivity of sorghum and finger millet in Ethiopia is low due to insignificant use of yield promoting inputs such as seeds of improved varieties, use of fertiliser and irrigation. For example, in the main cropping season of 1997/1998, 1.54% of the sorghum area was covered by improved seeds as compared to 38.41%, 29.37% and 20.22% of land planted to improved varieties of maize, wheat and teff respectively. In the same season, 5.80% of the sorghum area was irrigated compared to 19.08% of maize area under irrigation. Similarly, the use of fertilisers on sorghum was very low (3.81%) compared to the area of land fertilised for maize (14.11%), teff (32.09%), wheat (18.29%) and barley (11.07%). All these figures show that sorghum is marginalised compared to other major cereal crops grown in Ethiopia. Also, the use of inputs on sorghum declined after 1997/1998. In 1999/2000, only 0.87% of the land used for sorghum was fertilised as compared to that of maize (65.83%), wheat (17.43%) and teff (7.71%) respectively.

Diseases and pests

Diseases

Many major diseases cause substantial grain loss in sorghum under different environments in Ethiopia. Among these are seedling rot diseases, downy mildew, anthracnose, loose and covered kernel smuts, head and long smuts, and other fungal diseases affect grain during its development and contribute to the low yield.

Insects

Insects such as shoot fly, stem borers, army worms, sorghum midge, head bugs and others are recorded in Ethiopia as major yield reducers. In recent years, sorghum chaffer beetle (Pachnoda interupta) has become a serious insect pest in the central highlands of the country.

Birds

Various birds feed on sorghum grain, but Quelea quelea causes the most damage in the Rift Valley of Ethiopia where sorghum is mostly grown.

Missing links

The Ethiopian Government has been trying to strengthen the link between research and extension. In 2010, the Federal Research Institute and Extension Department were merged within the Ministry of Agriculture and Rural Development to serve under one office. However, the links between research, extension, technology multipliers and farmers are missing since seed multiplication, marketing and distribution to address the national seed demand is very weak. Links between research and agroprocessors are also missing. Sorghum is used as a raw material in breweries and feed processing in many countries, but it has never been taken up as an industrial crop in Ethiopia. This requires serious attention and promotion.

What should be done?

Sorghum and finger millet, which should be promoted as industrial crops, remain as traditional crops, grown only by small-scale farmers. Sorghum is considered to be a poor man's crop. Sweet sorghum is used as a raw material for sugar and ethanol production. Sorghum is also successfully used to produce modern beer in some countries like Uganda. Therefore, in Ethiopia sorghum should be promoted by:

- Developing new products at research level,
- Involving agro-industries to take up the new products for large-scale production,
- Stimulating producers with good prices for sustainable supply to industries,
- Supporting seed systems for sorghum and millet to become competitive against hybrid maize, and
- Bringing all stakeholders to work together using proved appropriate technologies to industrialise these crops.

References

Agmas S, Desalegn Y, Mengest M. 1998. Production status, limitation and research achievements of barley, maize, and finger millet in north western Ethiopia. In: p 27–39, Seboka B, Deressa A, eds. Agricultural research and technology transfer attempts and achievements in northern Ethiopia. Proceedings of the Fourth Technology Generation, Transfer and Gap Analysis Workshop, 18–21 March 1997, Bahir Dar, Ethiopia.

Balole TV, Legwaila GM. 2006. Sorghum bicolor (L.) Moench. In: p 165–175, Brink M, Belay G, eds. Plant resources of tropical Africa 1. Cereals and pulses. PROTA Foundation, Wageningen and Backhuys Publishers, Leiden, the Netherlands.

CSA [Central Statistical Authority]. 2000. Ethiopia statistical abstract 2000. Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

CSA [Central Statistical Authority]. 2002. Ethiopia statistical abstract 2002. Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

CSA [Central Statistical Authority]. 2004. Agricultural sample survey 2003/04 (1996 EC), Report on farm management practices (private peasant holdings, Meher Season). In: p 15–17 Statistical Bulletin 305, Vol. 3. Federal Democratic Republic of Ethiopia, Addis Ababa.

Hailmicheal. 1998. Crop breeding activities and achievements in northern Ethiopia, Welo. In: p 17–21, Seboka B and Deressa A, eds. Agricultural research and technology transfer attempts and achievements in northern Ethiopia. Proceedings of the Fourth Technology Generation, Transfer and Gap Analysis Workshop, 18–21 March 1997, Bahir Dar, Ethiopia.

Wondimu B, Getachew A.1998. Soil management and crop technologies for improved crop production in marginal rainfall areas of Welo. In: p 3–10, Seboka B and Deressa A, eds. Agricultural research and technology transfer attempts and achievements in northern Ethiopia. Proceedings of the Fourth Technology Generation, Transfer and Gap Analysis Workshop, 18–21 March 1997, Bahir Dar, Ethiopia.

1.3. Experience of sorghum and millet production in Sudan

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Area of production

Sudan has an area of 2.5 million km2 of which 2.37 million km^2 is land and water occupies 0.13 million km^2. A total of 84 million ha of land is arable while forests and national parks occupy 117 million ha. Sorghum is the main staple food crop produced and consumed in Sudan, especially in the rural areas. It contributes about 65% of grains consumed in the country providing 70% of the calories in the diet and a considerable amount of protein. The average sorghum per capita consumption is estimated at about 92 kg. Sorghum is used in composite flours with wheat and also in animal feeds; some of the crop is exported to earn foreign exchange.

Sorghum is produced all over the country under all farming systems. It is mainly produced in the rainfed sector under both mechanised and traditional systems. The rainfed sector produces 90% of the country's total production of which 75% is from mechanised sector. Only 10% of the sorghum is produced from the irrigated sector for food security, mainly to guard against risk of drought. Sorghums are better adapted to the growing conditions in the country than maize is. The sorghums are also preferred over other cereals by consumers. Pearl millet is produced in the traditional sector mainly in western Sudan. Table 1 shows the sorghum and millet production in the area between 1999 and 2005.

Table 1. Sorghum and millet production area ('000 ha), 1999/2000–2004/2005

Crops	1999/2000	2000/2001	2001/2002	2002/2003	2003/2004	2004/2005
Sorghum	4635	4537	5925	5003	7081	4286
Millet	2383	2087	2922	2437	2570	1568

Sorghum and millet productivity

The sorghum and pearl millet yields are as shown in Table 2. The constraints limiting production and marketing are:

1. Shortage of irrigation water (for sorghum) and fluctuation of rainfall for both crops.
2. Striga infestation.
3. Insufficiency of quality seeds of improved varieties and cultivation of traditional varieties.

4. Low adoption rates of the recommended technologies.
5. Unavailability of inputs (fertiliser and seeds) as a result of the absence of private markets.
6. Inefficient marketing system.

Table 2. Productivity of sorghum and pearl millet, 1980–2005

	Sorghum (kg/ha)	Pearl millet (kg/ha)
Minimum	329	187
Maximum	850	307
Average	586	230
Standard deviation	56	30
CV	23%	31%

A10% drop in annual rainfall results in a fall in yield of 5.4% for sorghum and 1.6% for millet. The same drop in rainfall, however, would cause a 7% and 3% drop in the total sorghum and millet production respectively.

A 10% increase in the price of sorghum was estimated to result in a 5% increase in sorghum production. This variability will have serious implications both on chronic and transitory food insecurity.

Technologies available to alleviate constraints and improve production include:

- Improved varieties and hybrids
- Land preparation
- Sowing date
- Sowing methods
- Plant population
- Irrigation regime
- Thinning
- Fertilisation
- Weed control
- Pests and diseases management
- Post-harvest handling

The impact of improved technologies has been well demonstrated as described below:

- A grain and fodder yield increment of more than 100% due to adoption of improved varieties and hybrids under irrigation.
- A grain and fodder yield increment of more than 200% due to use of fertilisers under irrigation.
- Adoption of optimum sowing date demarcates the difference between economical and non-economical grain and fodder yield.

Although the technology adoption rate is low at national level (20%), the improved technologies have increased food security and improved livelihood.

Government policies for food security include adoption of high level technology (vertical expansion), government interventions in areas such as input markets, credit, improvement of market systems, stabilisation of prices and provision of grain reserves.

Marketing

Sudan has no clear policies on sorghum exports. The country may export and import during the same year. The forecast of supply and demand for sorghum and millet for the period 2006/2007 to 2010/2011 shows that for sorghum, supply is almost equal to demand while for millet, demand exceeds supply (Table 3) The lack of competitiveness of Sudanese sorghum in the world market makes national consumption fluctuate and consequently leads to seasonal variation in sorghum prices. The average price of sorghum is higher than that in the world market.

Table 3. Forecast supply and demand for sorghum and millet (2006/2007–2010/2011)

Season	Sorghum supply*	Sorghum demand	Millet supply
Millet demand			
2006/2007	3.82	3.46	0.682 0.781
2007/2008	3.84	3.74	0.694 0.789
2008/2009	3.85	3.79	0.700 0.797
2009/2010	3.87	3.84	0.705 0.805
2010/2011	3.88	3.88	0.710 0.811

* Quantities in million tons.

Conclusion

To increase production and productivity of sorghum and millet in Sudan and in ECA, clear and sound agricultural strategies are required including transfer of improved technologies to the rainfed zones, improving marketing and pricing policies, delivery of services, credit and inputs at the right time, strengthening collaboration between researchers, extension agents and stakeholders, and creating partnership between scientists in the region, networks and research institutions.

1.4. Sorghum and millet production in the Tanzanian lowlands: Experience of Institut Africain pour le Development Economique et Social (INADES)

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Introduction

Institut Africain pour le Development Economique et Social (INADES) is an autonomous, not-for-profit, non-governmental organisation (NGO) affiliated to the network of INADES-Formation International (IFI). It has a philosophy of development based on empowering people in the rural areas to bring about self-advancement by focusing on their participation in facing their development challenges and transforming their societies. This paper presents the experiences of INADES-Formation Tanzania (IFTz) in its mission to support farmers growing sorghum and millet. IFTz covers the semi-arid areas of central Tanzania where most of its activities are conducted in northern Kongwa, Dodoma Rural and Urban and Singida Rural districts. As a result of interventions to promote sustainable agriculture, participating farmers have increased sorghum yields from 0.7 t/ha to 3.75 t/ha and millet yields from 0.3 t/ha to 2 t/ha. These increases have been achieved by training farmers to mobilise local resources to improve soil fertility and soil water balance in the root zones of the crop. However, IFTz has only managed to reach a few farmers and this paper is also a call for collaboration with other stakeholders to reach more farmers.

Background to sorghum and millet production in Tanzania

Sorghum and millet are important cereal crops produced in the Central, semi-arid zones (Dodoma and Singida) of Tanzania. The crops are also grown in the Lake Zone (Mwanza, Shinyanga and Tabora), western parts of Tanzania in Kigoma, and in the Southern Zone in Mtwara and Lindi regions.

Sorghum and millet are a staple food for many people in semi-arid central Tanzania, as these crops grow well in poor rainfall areas. They also serve as a cash crop in the area. In Central Zone the average rainfall is about 500 to 600 mm per year, but rainfall in the last three years has been lower than that. Some areas recorded rainfall of 300 to 400 mm. Rainfall in central, semi-arid Tanzania is low, erratic, unreliable and unpredictable. Such climate necessitates the growing of drought-resistant crops such as sorghum, millet, groundnuts and sunflower.

In these areas smallholder farmers are growing the crop mainly for subsistence. The average family farm size is 2 to 5 acres for a household of 5 to 7 (2002 census) people on average. Farmers grow both local varieties like Langi langa and new varieties like Lulu, Pato, Wahi and Hakika. These local varieties have a long maturity period and low yields. Whereas new varieties seemed to perform better in terms of yield and drought resistance, they seem to lack some farmer-preferred qualities such as palatability and storage. Yields have been low in most farmer fields—0.7 t/ha and 0.5 t/ha for sorghum and millet respectively. This is significantly lower than the world and African averages of 5 t/ha and 3.7 t/ha for sorghum millet respectively (ECARSAM 2005).

Sorghum and millet production as practised by farmers in the Central Zone of Tanzania

Land preparation

The land is prepared by removing all the previous year's crop remains and weeds which are then collected and burned. This is followed by dry sowing, most often before the rains by digging a small pit (just one hole cut of a hand hoe) on uncultivated cleared land in November or December.

Weeding

Inter-cultivation, without touching the growing roots, is done after germination and during the first weeding. In this operation, small weeds are usually left in the field to die under the sun. A few farmers in Singida grow sorghum and millet in contour ridges and have better performance, as they can attain a yield of up to1.5 t/ha of sorghum and 1.3 t/ha of millet. A second weeding is done when the crop is at about booting stage. This is done in the same manner as the first weeding.

Crop protection

The main pest and diseases of sorghum and millet in this area are smuts, leaf blight and to a large extent birds such as Quelea quelea. Also, grain borer is a major problem when storing sorghum for extended periods of time. The majority of farmers have not been using agrochemicals or medicinal plants to control pest and diseases of sorghum and millet. However, a few farmer groups, who have been working with certain projects, have been using some agrochemicals and indigenous knowledge to control smuts and Striga in their fields.

Harvesting

Sorghum is harvested when it is mature. This is done by cutting either the head or the plant and drying in a heap. For millet, only the heads are cut and heaped to dry under the sun.

Threshing and winnowing

In most cases, threshing and winnowing are done on clean ground smeared with cattle dung. Threshing is normally done by beating a heap of heads with sticks for sorghum and in a local mortar for millet. Some farmers who received training thresh on elevated structures to avoid sand and other impurities mixing with the grain. Winnowing is usually done locally by women using basins.

Storage

Traditionally, crops are stored in granaries. The granaries are made of sticks interwoven into a cylindrical structure smeared with a mixture of soil and cow dung, and can hold up to five bags of sorghum or millet. After filling the granary, farmers usually cover the top with a lid that is also made of a mixture of soil and cow dung. A small outlet hole is usually inserted at the bottom of the granary for unloading. However, nowadays farmers' store their grains in sisal sacks or sulphate bags (that previously held fertiliser).

Why the low production?

Sorghum and millet husbandry

Zero tillage is not an encouraging production technique for sorghum and millet in the Central Zone of Tanzania. For a successful crop, sorghum requires 500 mm of rains per year and millet requires 400 mm of rainfall per year. In areas where the rainfall is less than this, soil water conservation techniques are required.

Deep tillage

Deep tillage increases soil porosity which retains more moisture in the root zones to meet the water requirements of a given crop. However, farmers do not till deep enough into the soil, resulting in a small water reserve which does not meet crop water requirements. In places where farmers practise deep tillage using magoe rippers, sorghum yield has increased by 100%.

Poor soil fertility

Poor soil fertility has been attributed to the continued depletion of soil nutrients by crops grown over hundreds of years. As a result, the low nutrients can only support a low yields (0.7 t/ha for sorghum and 0.5 t/ha for millet).

According to food chain analysis, crop and animal remains are decomposed by micro-organisms to release nutrients for crop production. However, these micro-organisms have been threatened by bush fire, zero tillage, clearing of all organic matter from the soil and excessive use of agrochemicals. Therefore nutrients are continually extracted from the soil without being replenished, resulting in poor soil fertility.

Poor soil water balance

The water requirements for sorghum and millet are greater than the average rainfall. This means that additional moisture must be acquired from rainwater harvesting practices to add to the deficit required to reach crop water requirements. The rainwater harvesting practices include: contour bunds, contour-tied ridges, pit cultivation, trench cultivation and sand river cultivation in drylands. To most farmers in the Central Zone these practices are arduous although in the North-Eastern Zone they are usual practice.

Deforestation

The area is heavily deforested and farmers have no culture of growing trees. As a result, the local area contributes little to evapotranspiration to encourage condensation for rainfall development.

Poor crop protection practices

Experience shows that due to low yields farmers cannot afford to protect their crops using agrochemicals. As a result, crops are often attacked by pests and diseases, leading to low production.

Poor crop storage practices

Farmers in the area use no crop storage protection practices. As a result, after three months most of sorghum and millet is attacked by storage pests.

Poor processing practices

Most sorghum from the Central Zone is processed on the ground and therefore contains an appreciable amount of sand and other impurities. The grain must therefore be further processed using a de-stoning machine before it can be used in the brewing industry.

Poor attitude of farmers to sorghum and millet

Millet and sorghum are generally regarded as famine crops and as food for the poor. Farmers are therefore uninterested in growing them. Even those farmers who grow sorghum and millet usually sell their crop and buy maize for their own consumption.

What are the consequences?

Cost justification

Due to low yields, sorghum and millet production is not profitable. Costs are incurred from land clearing, sowing, weeding by inter-cultivation, second weeding, bird scaring, harvesting and primary processing. A single harvest of 0.7 t/ha for sorghum and 0.5 t/ha for millet cannot justify these costs. Hence, farmers consider these as crops with a low rate of return.

Are sorghum and millet poor man's crops?

In Tanzania sorghum and millet are considered as poor man's crops. However, in other countries such as Burkina Faso, sorghum and millet are the main food crops. Stakeholders have made little effort to improve the status/position of these crops. Good quality sorghum and millet can be utilised in the brewing industry. Also, a variety of foodstuffs such as biscuits, cake and buns can be made from the crops.

Are sorghum and millet production technologies available?

Production technologies for millet and sorghum are available. They range from improved varieties, agrochemicals, organic farming, indigenous knowledge, tools and equipment, farmyard manure, soil and water conservation practices and animal power. Of all these technologies, only farmyard manure is used by at least some farmers. Unfortunately, the rest of the technologies are used only where extension services are provided through projects; this benefits only a few groups of farmers. Farmers who can be reached with these technologies often cannot afford them due to low yield. In semi-arid areas all the technologies are appropriate except agrochemicals which are hazardous to sorghum and millet production as they degrade the physical and chemical characteristics of soil and hamper the natural food chain by destroying micro-organisms in the soil (Heinrich and Rusike 2004).

Extent of impact of these technologies

- Research, training, demonstrations and exchange visits: these have been conducted at various times and in different places. Farmers have been trained and encouraged to deep till their land and as a result their crop yields have doubled.
- Preparing Mapambano compost: this is a technique innovated by a woman farmer from Haubi village in Kondoa District to improve soil fertility. Yields increased to 2.5 t/ha for sorghum and 1.5 t/ha for millet using this technology.
- Rainwater harvesting systems: These include using tie contour ridges, contour bunds, pit cultivation and trench cultivation. Tree planting has also been encouraged in the area to improve soil water balance through roots, and to increase contribution of evapotranspiration for increased condensation and local rainfall. However, progress is slow.

All the above technologies require a committed extension service delivery system that ensures quality extension services and packages that reach farmers who are organised in groups and networks. However, performance is still poor as these efforts only reach a few farmers.

Missing links

There are many reasons for the missing links. However, most stakeholders supporting farmers conduct their activities in isolation and tackle only a small part of the problem. Thus, the missing links include finding a way for the stakeholders to work in partnerships and complement each other's efforts while still talking the same language in supporting farmers. Partnership must include all stakeholders—research, liaison offices, extension, private sector, input suppliers, middlemen, processors, buyers, policy makers and consumers—involved in a crop value chain system. In that way, many problems, experiences and shortcomings can be shared, analysed and addressed. This will ensure the relevance of the services to farmers.

Necessary linkages/partnerships to ensure increased production and productivity

Research–extension–farmer linkages

Due to new research and extension setup, the zonal research and extension liaison offices (ZRELOs) take research information and products from research, translate them into farmer language and then take them to the district extension services. In turn, the district extension takes the information and products to farmers, collects feedback and forwards this to research via the ZRELOs. In return, the researchers respond to the feedback and the process continues.

Farmer, middlemen and buyers (processors and consumers) and input suppliers
These linkages are also important for sorghum and millet production, as they will help farmers know how much to produce, when to produce, what qualities to consider, where best to sell, and what varieties to grow.

National policy makers, financial institutions and multinational corporations
These links will facilitate an enabling environment for farmers to produce and access financial capital (credits) and reach foreign markets.

Annual forums of all stakeholders
All the above partnerships need at least two forums per year to share and exchange experiences.

Conclusion

To address the above problems, the government and all other stakeholders, and more specifically agriculture sectors, must organise themselves to provide extension services to rural people to improve their crop production by:

- Identifying, recognising, respecting and building on farmer experiences (participatory approach).
- Identifying and promoting use of locally available resources so as to reduce production costs (e.g., Mapambano compost instead of industrial fertilisers).
- Building capacity of farmers to economically control pests and diseases of the crops (indigenous knowledge and agrochemicals).
- Building capacity of farmers on marketing information and strategies to access markets and attain better prices.
- Forging active partnerships among all stakeholders to support farmer initiatives in producing sorghum and millet and reducing the barriers that have been hindering farmers to produce enough.

References

ECARSAM [Eastern and Central Africa Sorghum and Millet Network]. 2005. Sorghum and millet research for development in Eastern and Central Africa 2005–2010. Regional priorities. ECARSAM, Nairobi, Kenya.

Heinrich GM, Rusike J. 2004. Crop and resource management: Technology development and dissemination in SMIP Phase IV. In: p 49–77, A foundation for the future: The Sorghum and Millet Improvement Programme (SMIP) in Southern Africa. Proceedings of the SMIP Final Review and Reporting Workshop, 25–26 November 2003, Bulawayo, Zimbabwe. ICRISAT [International Crops Research Institute for the Semi-Arid Tropics], Bulawayo, Zimbabwe.

1.5. Farmers' experience in utilisation of sorghum and millet production technologies—The case of Tanzania

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Introduction

Singida is one of the regions in the Central Zone of Tanzania. It is characterised by mono-modal rainfall ranging from 400–800 mm a year. Rainfall in recent years has been unreliable, short and unevenly distributed. The rainy season occurs between December and April. The severe drought of 1974/1975 resulted in a serious food deficit and hunger in the region. Sorghum is an important crop for food security in the semi-arid areas of Singida and other dry areas of the country including Dodoma, Mara, Mwanza, and Shinyanga regions.

In the past, farmers in Singida grew more local sorghum varieties. Recently, consumers have changed their food preference from sorghum to maize and farmers naturally followed suit by growing maize rather than sorghum and millets. Farmers also prefer to grow maize because when food shortages occur the government provides maize as food aid rather than sorghum.

Local landraces

Local sorghum landraces grown in Singida include Langi langa, Kakera, Nkhasa, Inkumba and Ntora. A characteristic of these varieties is that they take a long time (6–7 months) to mature. Moreover, they do not change their characteristics through crossing as do improved varieties. The local landraces are more susceptible to bird attacks in the field than are improved varieties, perhaps due to their loose heads. Their most important characteristic is that they have hard grains, which makes them less vulnerable to storage pests. The yields range from 3–5 bags per acre (1 bag = 100 kg).

Improved sorghum varieties

Improved sorghum varieties include Serena, Tegemeo, Pato, Macia, and most recently Hakika and Wahi. These last two varieties were introduced in Singida in 2004. The government introduced Serena to Singida in 1974/1975. Unfortunately, the variety tastes bitter when eaten as ugali and local brew made from it is inferior that of local landraces. Serena is no longer available, as most farmers rejected it.

Tegemeo was also introduced in the 1980s, but it has almost disappeared. The main problem with this variety is that it does not make ugali and local brew that are as good as those from local varieties. Furthermore, the purity of the seeds changes over time, forcing farmers to buy new seed within three years. The seed is usually unavailable and its price is too high compared to the value of the crop. Therefore most farmers are unwilling to invest in sorghum seed because the crop does not pay.

Agronomic practices

Farmers use limited quantities of animal manure to increase soil fertility. They typically broadcast the manure on the field before the rains start. The extension service introduced a planting pattern which, unfortunately, has proved laborious. The pattern requires the farmer to buy a rope and find another person to assist in making the rows; at planting labour is very critical and it is expensive.

Yield performance of improved varieties

To date, it has been very difficult to determine the actual figure of improved sorghum grain yields versus local landrace sorghum varieties. Generally, evidence indicates that areas occupied by local landrace sorghum varieties are relatively larger than those occupied by improved sorghum varieties.

The yield, especially from the new varieties such as Macia, Hakika and Wahi, range from 8–10 bags per acre. Farmers prefer these varieties because of their early maturing, and drought- and Striga-resistant characteristics. The quality of ugali and local brew from these varieties is better or equal to that of the local landraces. Hakika and Wahi have the added advantage of producing a lot of leaves which stay green for animal feed.

Utilisation

Sorghum is the major food crop in the dry areas of Singida. Sorghum flour is mainly used for preparing stiff porridge traditionally known as Ugali. However, the sorghum flour can also be mixed with maize flour, cassava flour etc. to prepare Ugali. The varieties of products that can be made from sorghum are not known to a majority of the rural communities. Perhaps the existing knowledge barrier on sorghum utilisation has caused sorghum to remain typical rural food in drought-prone areas of rural Singida. One cannot find sorghum food in any of the restaurants in Singida town.

Sorghum grain is also used to prepare a local brew known as komoni. However, farmers lack the technical knowledge in utilising sorghum grain for preparing local beer and other products from sorghum grains.

Some of the local varieties like Langi langa, manyia ya Ng'ombe and Ntora have stems with high sugar content and are chewed as sugar cane. These stems are also good for animal feed. Farmers also use local sorghum stalks as building materials and as firewood.

Reasons for low sorghum production

- Low and erratic rainfall followed by prolonged drought conditions during the cropping season
- Decline in soil fertility, as crop rotation is not normally practised and animal manure is not available in large quantities.
- Use of rudimentary tillage implements, such as the hand hoe.
- Vermin attack, e.g., birds cause considerable grain damage especially on short-duration improved sorghum varieties.
- Striga infestation—this has been an issue for a long time, but now it has increased and become a serious threat to sorghum production. Some fields have been abandoned due to high infestation of Striga.
- Government distribution of maize as relief food instead of sorghum has changed consumption patterns from sorghum to maize.
- Generally, sorghum grain fetches a very low price (TSh 1000–1500 per 20-litre tin) compared to maize (TSh 2000–3000 per tin).

Reasons for low uptake or acceptance of improved sorghum varieties

- The purity of the improved seeds deteriorates over time. This means that after three years farmers have to buy new seed.
- The improved varieties are more susceptible to storage insect pests than local varieties are and sometimes infestation starts in the field.
- These varieties are more likely to be attacked by birds than local landraces are.
- Seed for improved sorghum varieties is unavailable in the villages and, if found, is too expensive for farmers to afford.
- Sorghum grain, unlike maize, has no formal market.

Recommendations

1. Sorghum should be promoted for both consumption and increased commercialisation.
2. The government should buy sorghum for grain reserves and distribute it to farmers during food/seed shortages.
3. Investors should establish a brewing industry in Singida. This will encourage farmers to grow more sorghum and supply it to the nearby factory, as happened with the sunflower factory at Singida.
4. The government should create credit facilities for farmers to enable them invest in sorghum production and processing of high-quality sorghum grain.
5. The government should improve rural roads to enable farmers transport the crop from their villages to the market place.

1.6. Farmer experience with productivity enhancing technology uptake: A case study of pearl millet in Eritrea

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Introduction

Eritrea is a country where 80% of the population are subsistence farmers and pastoralists who derive their livelihoods in marginal and risk-prone environments characterised by recurrent drought and widespread land degradation. This sector of the population only contributes to approximately 20% of the country's gross domestic product (GDP). In good years, the country produces only 60% of its total food (cereals) requirements and in poor years it produces no more than 25%.

About 95% of crop production depends on rainfall and 5% depends on supplementary irrigation using spate and river diversion to grow horticultural and field crops.

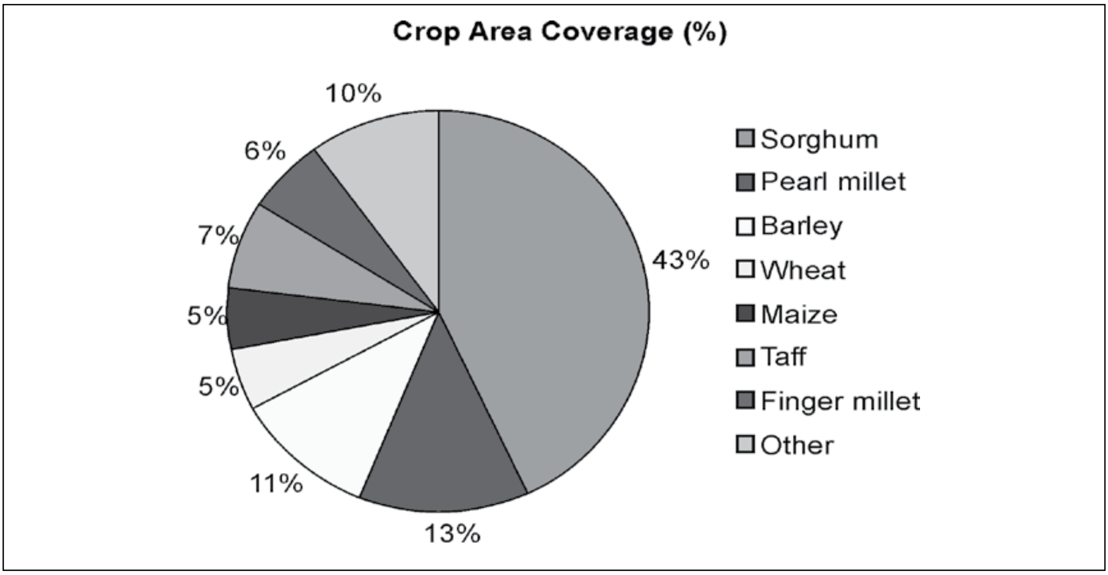

Figure 1. Crop area coverage in Eritrea (based on data from Singh and Haile 2004).

As can be seen in Figure 1, pearl millet is the second most important cereal crop in Eritrea by crop coverage. It is the most preferred crop in the arid lowlands and arid highlands which are characterised by low rainfall and high evapotranspiration, and account for the largest percentage of land cover in these agro-ecological zones. For example, in Zoba Anseba, one of the six administrative regions of the country, pearl millet accounts for approximately 40% of area coverage (MoA Zoba Anseba 2005).

Main constraints to pearl millet production

Production of pearl millet in Eritrea faces several major constraints. Abiotic limiting factors to production are drought, high temperatures, low soil fertility and poor cultural practices. Biotic constraints include diseases (downy mildew and smut) and insect pests (stem borer, chaffer beetle, grasshoppers, locusts, caterpillars, ants and termites). The lack of inputs to the farming system, namely quality and improved seeds, fertilisers, pesticides and herbicides also limit production.

Technology solutions

The Pearl Millet Improvement Programme works towards improving and diversifying the Eritrean landraces to increase production and productivity. The importance of improved varieties in increasing production and productivity cannot be underestimated. When compared to other technology solutions, such as soil and water conservation, quality seed has the capacity to make a quick impact, with a minimum amount of supplementary input at the farmer level. The impact can be seen within one season and hence allows vulnerable groups to quickly develop their capital base.

As a response to farmers' demands to reduce the incidence of downy mildew, the Ministry of Agriculture National Agricultural Research Institute (NARI), in collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), worked towards introducing improved pearl millet varieties. The first variety to be introduced in 2001 was material developed by ICRISAT: ICMV 221 (Kona), which is only 3% susceptible to the effects of downy mildew. The variety performed well in the field. However, farmers were concerned about the low biomass and poor taste of this variety. Further research therefore was conducted to breed a new variety to address farmers' concerns. A local landrace with superior traits, high biomass and preferred taste, was crossed with ICMV 221, and this resulted in a new Eritrean variety called Hagaz (Box 1).

Box 1. Characteristics of Kona and Hagaz

KONA: Kona was developed by ICRISAT, Patancheru, Andhra Pradesh, India, as ICMV 221 in 1993 (Witcombe et al. 1997). Under a collaborative programme with ICRISAT, this variety was identified and released as Kona in Eritrea in 2000. Kona is early maturing (70–75 days) short to medium in plant height (160–200 cm), with 2–5 tillers. It also has a bold attractive panicle and is drought tolerant and resistant to downy mildew (less than 3% susceptible). Kona's grain yield is 2.0–2.8 t/ha. It is recommended for the drier areas of Zoba Anseba and Gash Barka or when rainfall starts in late July.

HAGAZ: This variety was developed by crossing Kona with the local landrace Tokroray at NARI under a collaborative programme with ICRISAT. Hagaz is intermediate maturing (75–85 days), with medium to tall plant height (200–230 cm), with 2–5 tillers, bold, attractive panicles, drought tolerant and resistant to downy mildew (less than 5% susceptible) (Abraha et al. unpublished). Its grain yield is 2.2–3.0 t/ha. It is recommended for the wetter areas of Zoba Anseba, Gash Barka or when rainfall starts late June.

Development of seed technology

The Pearl Millet Improvement Programme adopted a participatory approach that involves NARI, Ministry of Agriculture extension services and farmers. The programme undertakes all the breeding and selection activities. Testing of local, exotic and newly developed populations takes place on station and the final testing and selection takes place in the farmers' fields. Foundation seed multiplication is carried out on station and distribution and multiplication of certified seed production by the extension service, NGOs and farmers.

Planning and evaluation of the programme is carried out through multi-stakeholder workshops and through participatory impact appraisals (2004 and 2006).
The steps followed are:

1. Collection of germplasm
2. On-station evaluation of breeding materials
3. On-farm evaluation of promising materials
4. Field days to identify the best material
5. Foundation seed multiplication by NARI
6. Certified seed multiplication by select farmers, the extension service and NGOs
7. Distribution of seed through the Ministry of Agriculture and NGOs
8. Impact appraisal conducted by NARI and the Ministry of Agriculture

To date, seven improved varieties of sorghum and two pearl millet varieties have been released (Table 1).

Table 1. Released varieties of sorghum and pearl millet

Crop type	Variety	Agro-ecological zones		
		Western Lowlands	Midlands	Eastern Lowlands
	Shambuko (PP 290)			
	Bushuka (ICSV 210)			
	ICSV 111 IN			
	Macia			
Sorghum	Gedam Hama			
	P-9401			
	IESV 92029			
	Shieb (89MW5056) Laba (89MW5003)			
Pearl millet	Kona (ICMV 221) Hagaz			

Figure 2 shows the contributions of different actors in certified seed multiplication for sorghum and pearl millet in 2006.

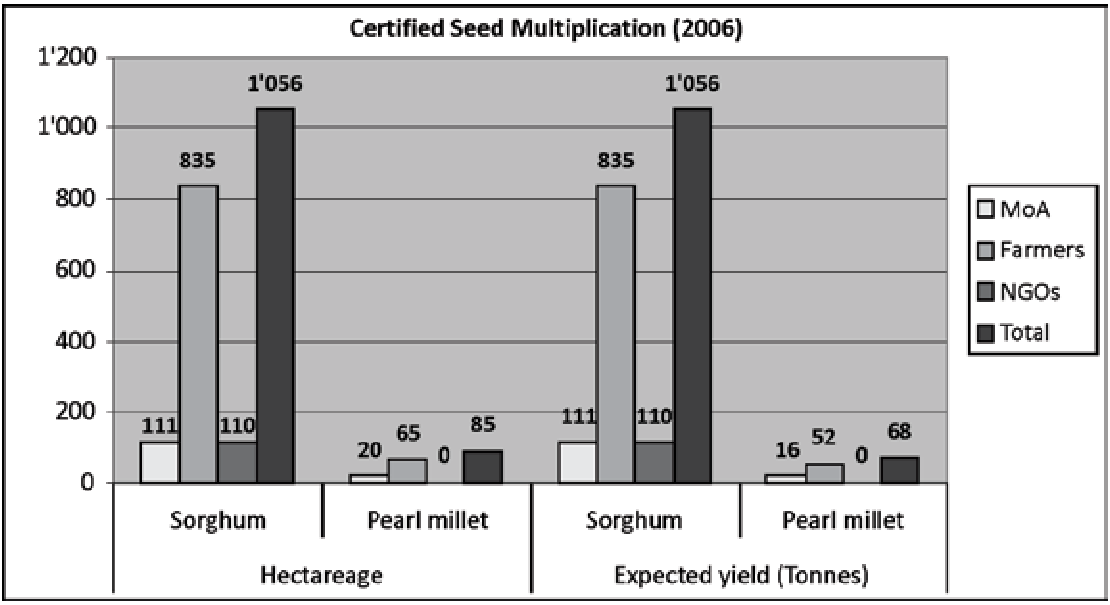

Figure 2. Certified seed multiplication: 2006 rainy season.

Figure 3 shows quantities of foundation seed distributed by NARI to produce certifiable seed starting from 2000 to 2006. The overall rising trend is an indicator of the increased demand for improved varieties.

Comprehensive impact appraisals on released pearl millet varieties were conducted in late 2004 and 2006 (Roden et al. 2006). The study aimed to assess the suitability and accessibility of the two new released varieties. It also gave the researchers the opportunity to share their knowledge, obtain indigenous knowledge, assess the total costs and benefits, and help plan for the future. This participatory process also engenders ownership of the research findings and so increased the likelihood that the research will have an impact.

These studies assessed the farmers' (men and women) perception of new pearl millet varieties (Kona and Hagaz) and attempted to determine what socio-economic impact the varieties may have had on livelihoods, and whether farmers were willing to plant them again. Comparisons were made between the released varieties and local landraces.

The three sample sites for the appraisal were originally selected on the basis of the different pearl millet growing agro-ecological zones. The sites included different ethnic groups to address the different cultural requirements that might have been present.

Results

All the farmers rated yield, early maturity, drought resistance, disease (downy mildew) and pest (chaffer beetle) resistance as their most important priority attributes. To some extent these factors were all present in the Kona and Hagaz varieties. Farmers were not so concerned

Purpose

with biomass production of pearl millet, but they recognised that Hagaz had a higher biomass than Kona. They also recognised that Kona was susceptible to wind damage. Generally, the results showed that male farmers were pleased with the results of the released varieties and were clear that they would like to receive them again the following year (Figure 4).

Women tended to have a rich knowledge of the palatability and culinary characteristics of the different varieties. They were more concerned with the cultural rather than the production factors of pearl millet. They also appeared to be more traditional in their decision making than the men were. In all three villages women chose the local varieties over the new NARI-released varieties. The team concluded that a more in-depth participatory analysis was necessary to determine why and how women selected their preferred varieties. This information would allow for more informed decision making for future planned breeding activities.

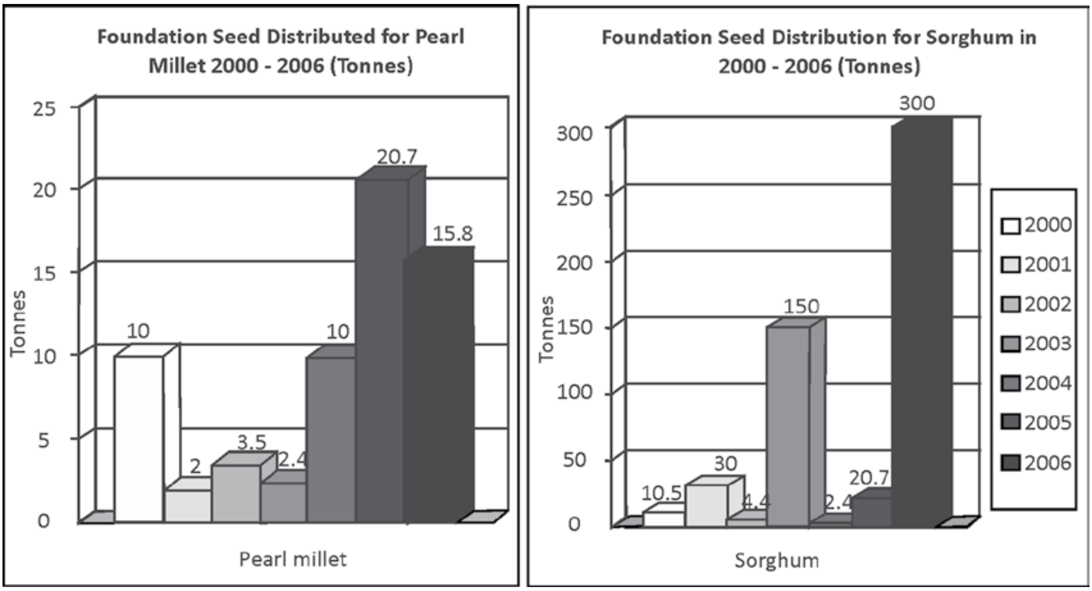

Figure 3. Foundation seed distributed for sorghum and pearl millet (2000–2006).

Case study: Shebek village, Zoba Anseba

Shebek village is located in Sub Zoba Hagaz, Zoba Anseba. It is in the arid lowland zone, at an altitude of 956 m, and receives rainfall of between 200 to 500 mm per annum. The potential evapotranspiration is 1800 to 2000 mm and the average temperature ranges from 21°C to 29°C.

The community of Shebek consists of mainly low external input subsistence farmers. These farmers originally only grew their local landrace until the new improved varieties were introduced in 2001. The crops grown in Shebek are pearl millet, groundnuts, sorghum and cowpea (Figure 5). Pearl millet represents the community's main staple crop.

In this village the two released varieties and the local landrace (Bultug) were compared. Figure 6 shows the people's main priority attributes and the ranks that they gave for the three different types. Kona consistently ranked high for all their priority attributes (Figure 6).

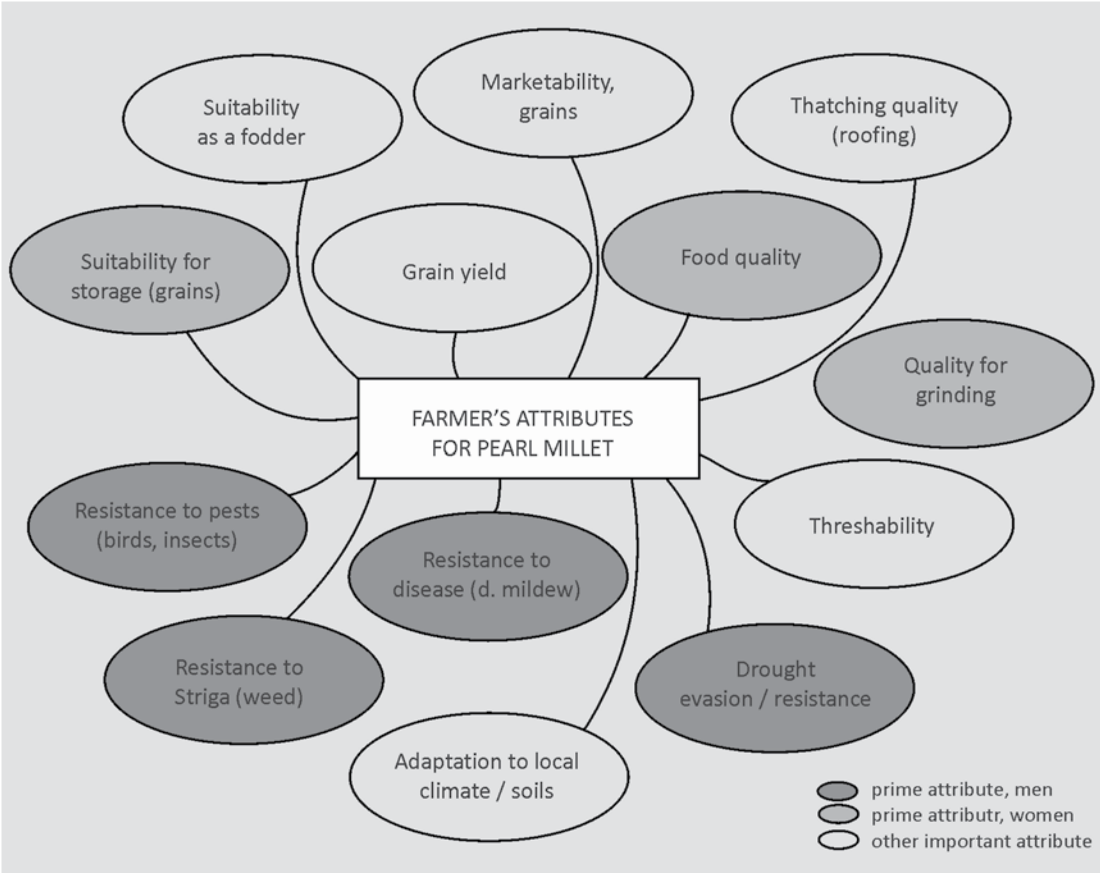

Figure 4. Farmers' preferred attributes.

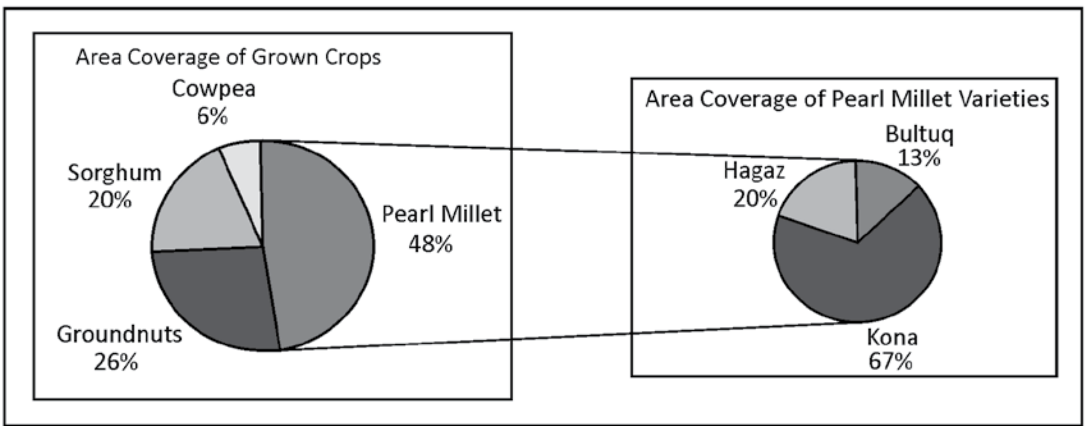

Figure 5. Percentage area coverage of crops grown.

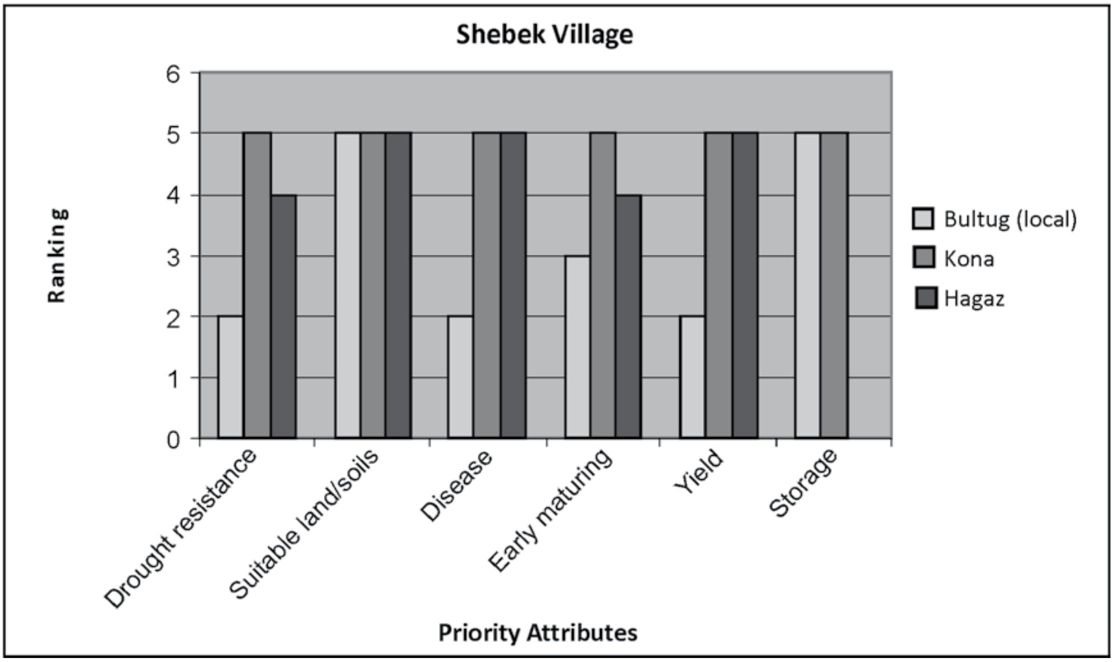

Figure 6. Comparisons between local and improved varieties.

Farmers overall expressed their satisfaction with the improved varieties and planned to continue growing them for the foreseeable future. They stated that the improved varieties doubled their yields in comparison to the local landrace: from 0.3 to 0.5 tons with the local to 0.7 to 1.1 tons per hectare per year with the improved varieties.

A pioneer farmer: Ato Teweldemedhin Ali

Ato Teweldemedhin was the first and only farmer to accept the variety Kona from the Ministry of Agriculture in 2001. The first yield that he harvested more than satisfied his annual subsistence needs and he sold his surplus to the Ministry of Agriculture. With the proceeds he was able to improve his living standards.

Village-based seed enterprises

To ensure long-term sustainability and self-reliance, in 2006 the Ministry of Agriculture initiated a project that would develop, test and demonstrate a pilot model for organising a village-based seed enterprise. This was in response to the demand for improved varieties that outstripped the supply. This would enhance or encourage the production of certified seed by the farmers with the Ministry of Agriculture providing technical assistance.

Before the introduction of the new technology

After the introduction of the new technology

Conclusion

The Pearl Millet Improvement Programme has successfully introduced two improved varieties in Eritrea. The success of this depended largely on meeting the needs of the farmers by working closely with them in the identification to selection stages of the breeding materials. Overall, farmers seek to meet their immediate household food security needs and these two new varieties contributed greatly to this. What remains is to increase the value of the new grain through commercialisation and to identify value addition products.

A wider uptake of the new technology, however, has been hampered by the currently low availability and accessibility of improved seed. To meet this demand sustainably would mean that the production of certified seed would have to be placed largely in the hands of the farmers themselves. The possibility of this is being explored through the establishment of the village-based seed enterprises.

References

Abraha N, Bidinger FR, Bhasker Raj AG. 2004. First in-house research bred pearl millet variety to reach Eritrean farmers. Unpublished report.

Government of the State of Eritrea. 2004. Food Security Strategy. Asmara, Eritrea.

Ministry of Agriculture. 2001. Ten years report in brief. The State of Eritrea, Asmara, Eritrea.

Ministry of Agriculture. 2005. Annual Report. The State of Eritrea, Asmara, Eritrea.

NARI [National Agricultural Research Institute]. 2006. Annual Report. NARI, Asmara, Eritrea.

Roden P, Abraha N, Tesfay E, Kohler T. 2006. Participatory on-farm appraisal of improved pearl millet varieties in Eritrea. Ministry of Agriculture, The State of Eritrea, Asmara, Eritrea

Singh SR, Haile S. 2004. Material for Mid-Term Agricultural Sector Development Plan. Ministry of Agriculture, The State of Eritrea, Asmara, Eritrea.

Witcombe JR, Rao MNVR, Raj AGB, Hash CT. 1997. Registration of 'ICMV 88904' pearl millet. Crop Science 37:1022–1023.

1.7. Integrated *Striga* management for improved sorghum productivity in Eastern and Central Africa

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Striga species are noxious weeds that are widespread constraints to the production of staple cereal crops in semi-arid areas. The weeds have been estimated to infest 40% of the cereal producing areas of sub-Saharan Africa. *Striga hermonthica* alone may now infest over 10 million hectares in the region. The yield of sorghum can be reduced from 45% to 100% depending on the level of infestation and other interrelated factors such as susceptibility of varieties, declining soil fertility and drought. Striga species of economic importance observed in Tanzania include *S. asiatica, S. hermonthica* and *S. forbesii,* principally infesting finger millet, maize, sorghum and upland rice.

Some of the control options include hand pulling before *Striga* sets seed to avoid seed accumulation in the soil. The seed can remain viable in the soil for up to 20 years. Planting legumes provides an alternative approach to *Striga* suppression and soil fertility enhancement. Using animal manure, green manure and inorganic fertilisers significantly enhances the sorghum yield and reduces *Striga* infestation. These control options work effectively when they are integrated. Combining more than one control option may include *Striga* resistant sorghum variety, tied ridges for moisture conservation and animal manure as compared to the traditional method of growing local sorghum varieties without ridges or fertiliser.

Following extensive laboratory testing and participatory evaluation by farmers on land infested by *Striga* (*S. hermonthica, S. asiatica* and *S. forbesii*) in the Lake, Central and Eastern zones of Tanzania, two white grained, early maturing and Striga-resistant sorghum cultivars were approved and released by the national seed registration authority in 2002. Both lines were developed at Purdue University, USA. Line P9405 was registered under the Swahili name 'Hakika' (meaning 'be sure', i.e., the farmer is sure to harvest something even from *Striga* infested fields) and P9406 was named 'Wahi' (meaning 'early' to indicate the early maturity of this material). Both cultivars are early maturing and fulfil producer and consumer preferences.

Yields of the new cultivars can be improved when they are grown in an integrated *Striga* management system using animal manure or inorganic fertiliser and planted on tied ridges to ensure soil moisture conservation. The early maturity, drought tolerance, grain quality and taste of these lines have also impressed farmers. The yield produced on farmers' fields indicates potential for locally produced sorghum to replace the imported grain currently used by commercial processors.

1.8. Blast control in finger millet

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Finger millet is an important source of income and it is used in many forms as human food in East Africa. In Kenya and Uganda it is used to make porridge, *ugali,* and local brews. Finger millet porridge is valuable as a weaning food and also for breast-feeding mothers, as it contains high levels of iron, calcium, manganese and fibre (Obilana 2002). It is also an excellent source of methionine and has been recognised as a quality food for people with diabetes and for those who cannot tolerate gluten. Despite its importance, the crop's production and productivity is limited by several constraints that reduce yield. These include high labour demand, blast disease, use of poor seed, lack of improved varieties, poor processing technologies and a poor production–supply chain that is non-responsive to producer, processor and consumer needs (ECARSAM 2005).

Blast disease is the most important biotic constraint leading to yield losses of more than 40%. Although several options are available for blast control, host plant resistance is the most cost effective and significant research effort that has been made in East Africa. Studies have established that the same pathogen strain causes leaf, neck and finger blast and that resistance is quantitative (Takan et al. 2004). Blast pathogen isolates from wild finger millet were found to be genetically similar to those that cause finger millet blast. This explains the existence of cross infection potential which calls for proper weed management. Finger millet varieties that are resistant to blast and have good agronomic traits have been identified and released or are being promoted on farmers' fields in Ethiopia, Kenya and Uganda. Farmer field days and demonstrations in Kenya and Uganda have enabled interactions between researchers, social scientists and farmers and helped build capacity in understanding blast disease, select blast resistant varieties, use of clean seed and weed management practices.

To enhance finger millet production and productivity, there is need to step up promotion of identified and farmer-selected blast resistant varieties, promotion of crop management and husbandry techniques to reduce drudgery and continued evaluation/exchange of regional and international germplasm for blast resistance, screening variety adaptation and agronomic traits. There is also need to transfer identified blast resistance to susceptible farmer preferred varieties, educate farmers on post-harvest handling, especially to eliminate grain contamination (stones, soil and sand), promote quality and grading standards and improve market linkages by strengthening links between research and industry to increase use of finger millet and value addition in processed products.

References

ECARSAM [Eastern and Central Africa Sorghum and Millet Network]. 2005. Sorghum and millet research for development in Eastern and Central Africa 2005–2010. Regional priorities. ECARSAM, Nairobi, Kenya.

Obilana AB. 2002. Overview: importance of millets in Africa. Available at: www.afripro.org.uk/papers/Paper02Obilana.pdf.

Takan JP, Akello B, Esele JP, Manyasa OE, Obilana BA, Audi OP, Kibuka J, Odendo M, Oduori CA, Ajanga S, Bandyopadhyay R, Muthumeenakshi S, Coll R, Brown AE, Talbot NJ, Sreenivasaprasad S. 2004. Pathogen diversity and management of finger millet blast in East Africa: A summary of project activities and outputs. International Sorghum and Millets Newsletter 45:66–69.

1.9. Recommendations to improve sorghum and millet production and productivity in Eastern and Central Africa

The current status and recommendations to improve sorghum and millet production and productivity in ECA were derived by group work as follows:

Current status

- The productivity and production of sorghum and millets in ECA remain among the lowest in the world.
- Production and productivity are limited by poor adoption of available options or lack of appropriate productivity-enhancing technologies.

Recommendation 1

To increase productivity and production of sorghum and millets high priority should be given to integrated approaches that link improved varieties with best-bet crop and natural resource management practices.

Recommendation 2

Promote promising technologies for sorghum and millets through innovative partnerships that effectively link research, extension, farmers and private sector actors.

Recommendation 3

Governments must support the development of viable seed supply and technology delivery systems for sorghum and millets to improve availability and utilisation of improved seeds, fertiliser and other productivity enhancing technologies.

Recommendation 4

Whereas some improved varieties have been developed, countries in the region must identify gaps and support development of improved open pollinated varieties and hybrids that fit into the identified agro-ecologies, addressing biotic and abiotic stresses and meet end user requirements. The countries should place more emphasis on developing cultivars with resistance to drought and Striga, and on validation of water management techniques.

Recommendation 5

Governments and actors along the supply chain should prioritise improving competitiveness of sorghum and millets with respect to other substitutes through strategies that increase quality, quantity and reliability of supply for alternative uses.

Recommendation 6

Information and knowledge sharing at different levels should be emphasised to better understand the strategic opportunities available to improve the sub-sector across the region (data on price trends, adoption, production costs, quality requirements, and inter-regional trade).

CHAPTER TWO

PROCESSING AND UTILISATION

2.1. Application of processing technologies to promote sorghum and millets utilisation in ECA

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Introduction

The potential for sorghum and millets in Africa

The cultivation and production of sorghum and millets in East Africa and in Africa has great potential, given the ecological conditions of the region. Traditionally in most countries in Africa, these cereals have been the staple foods. The colonial governments introduced maize to Africa and contributed to the neglect of sorghum and millets particularly within the Eastern, Central and Southern regions of the continent, where food production policies emphasised maize at the expense of the small grains. Accurate statistics on cultivation and production of these cereals in many countries are therefore non-existent, especially where cultivation is still carried out for subsistence scale. The data in Table 1 shows the production and yield of millet and sorghum in Asia and Africa.

Table 1. Production and yields of cereals in Africa, Asia and the world (’000 tons)

Crop	Africa’s production	Yield (kg/ha)	Asia’s production	Yield (kg/ha)	World production	Yield (kg/ha)
Cereals	66,980	918	629,984	1,831	1,553,076	2,041
Sorghum	11,960	951	20,168	962	72,228	1,493
Millet	10,294	620	17,040	724	29,127	676

Sources: Mbugua (1988); Bassey and Schmidt (1989).

The low production figures for Africa can be explained partly by the low yields which are roughly half those in Asia and the world’s average figure. This implies that Africa has to catch up on many fronts affecting these crops, namely in crop improvement and management, reassessment of the macro-economic policies necessary to boost production of these crops, and creation of an appropriate driving force in their utilisation in the market. The availability of improved genotypes in yields and other agronomic traits, however, imply that production of these crops can easily be doubled provided appropriate macro-economic incentives and market opportunities are developed. In Nigeria, for example, production of locally grown cereals increased from 8 to 12 million tons in 1987 following the Babangida Decree.

Given the drought-resistant characteristics of these crops, and the ability of some cultivars to grow in wetlands, sorghum and millets have great potential to alleviate hunger in Africa. The erratic droughts and food insecurity in the region has prompted several African governments to revise their policies on grain production by emphasising dryland farming, and creating new impetus and initiatives in sorghum and millets production (Corinne and Dendy 1984; Bassey and Schmidt 1989).

Processing and utilisation of cereals in Africa

Food processing as a technology varies in terms of food modification, and whether these modifications are through physical or chemical means. On this basis, it is convenient to classify processed cereals into those that have undergone primary or secondary processing, depending on the degree of their modification. Those that undergo primary processing maintain some resemblance to the raw materials from which they are processed. Primary processing requires minimal preparations such as heat treatment, size reduction and other physical means of processing, and even investment. Such are the processing technologies that characterise traditional and household-level technologies. They are compatible with the traditional mode of utilisation of food raw materials in question such as millets and sorghum. As such, the end products of such technologies are not only affordable due to the low-cost technology, but they are familiar, as they imitate the traditional ones. These products are therefore likely to succeed in the market.

Conversely, secondary processing results in products with little or no resemblance to the original materials. The end products of such technologies may be products of primary processing of such raw materials as sorghum and millets. Secondary processed products have also been referred to as consumer-oriented products in relation to those which are primary processed or preserved in near fresh form like flours, which are referred to as agriculturally oriented products (Mbatia 1985). The secondary processed products are usually more demanding in terms of technology, skills and investment. Such products can be based on simple imitational or even innovative brand proliferation, and since they require high levels of investment both in skills and monetary forms, large production volumes are required to take advantage of economy of scale and succeed. Unfortunately, the products are also risky, expensive and more difficult to introduce in the market. Most of these products are said to fail in the market because of the application of technological approach in their development, rather than the market demand approach (Bruinsma 1999; CTA 2000).

Primary processed products from sorghum and millets in Africa

Dehulling and milling are the common traditional processing technologies for sorghum and millets in Africa. Traditionally, dehulling of cereals was done by pounding using pestle and mortar. Dehulling sorghum and millets is vital to remove the sources of bitter taste and improve various aspects of quality of the milled products (Bassey and Schmidt 1989). Hand pounding or dehulling is arduous and wasteful, with extraction rates of 60–70% (Bagachwa 1991). Mechanical dehullers have a less wasteful extraction rate (75–95% in 1–6 min) than hand pounding does (Bassey and Schmidt 1989).

The International Development Research Centre (IDRC) of Canada began introducing small-scale mechanical dehullers and mills to several African countries in the 1970s. The technology quickly spread to other countries, mainly as an initiative by either research donors or national research organisations in various countries. Table 2 shows the extent to which this technology was introduced and tested in different African countries.

Dehulling and milling basically yield flour of different quality from the cereals, suitable for preparation of different food products. Initially, success was reported in Botswana. In Kenya, pearl sorghum was developed at the Kenya Industrial Research Development Institute (KIRDI), and test marketed, but it later vanished from the market (KIRDI 1990).

Recent studies, however, have shown that service milling of cereals in many African countries including those in Eastern and Central Africa has grown tremendously since the early 1990s as a result of market liberalisation introduced through the World Bank's structural adjustment programmes (Mbugua and Omungo 2002). Unfortunately, the beneficiary cereal for this technology has been maize, whereas the major casualties due to this technology have been large millers using large-scale roller mills because of the competition created against them by service millers.

Table 2. Abrasive disk dehullers in Africa

Country	Date	Type of dehullers	Application
Botswana	1976 1978– 1978– 1985 1979	2PRL designs from Canada Development of RIIC design, and manufacture of 36 for Botswana; and export of 50 to neighbouring countries 1 mini-PRL from Canada	Sorghum Sorghum Sorghum, experimental
Burkina Faso	1980	1 mini-PRL from Canada	Sorghum, cowpea, millet research
Egypt	1982	1 Mini-PRL from Canada	Faba beans, laboratory
Ethiopia	1980 1981, 1983 1983 1984 1985	1 RIIC design from Canada 2 Mini-PRL from Canada RIIC design from Canada 1 RIIC design from Canada 2 Mini-PRL from Canada 1 Mini-PRL locally manufactured	Sorghum improvement 1 rural, 1 laboratory sorghum, maize, barley in rural mill Weaning food Rural mill Rural location, barley, lentils
The Gambia	1982 1985– 1986	1 mini-PRL from Canada Several modified Mini-CRS locally produced	Millet, sorghum Millet, sorghum
Ghana	1977	1PRL designs from Canada	Cowpeas
Kenya	1981 1983	1 RIIC design from Canada 5 locally built from RIIC drawings	Sorghum Sorghum, maize, grain legumes
Malawi	1986	2 RIIC from Botswana 1 Mini-ENDA from Zimbabwe	Maize, sorghum Maize, sorghum
Mali	1982 1987	1 Mini-PRL from Canada 1 RIIC from Canada 1 Mini-CRS from Gambia	Sorghum research Sorghum, millet Sorghum, millet

Country	Date	Type of dehullers	Application
Nigeria	1972–1976 1978	2PRL designs from Canada in Maiduguri 2PRL designs from Canada	Sorghum, millet, cowpeas, maize Maize in factory in Kaduna
Senegal Somali	1973 1985 1987 1985	1PRL designs from Canada 2PRL designs from Canada 10 Mini-SISMAR/ISRA I designs built in Senegal 1 Mini-SISMAR/ISRA II designs built in Senegal Mini-PRL from Canada	Sorghum, millet, maize Sorghum, millet, maize Sorghum, millet, maize Sorghum, millet, maize Sorghum
Sudan	1980 1980 1980	1PRL designs from Canada 1 RIIC design from Canada 1 Mini-PRL from Canada	Sorghum
Tanzania	1979–1982 1981 1985	2 RIIC type from Canada 4 RIIC designs locally built 1 mini-PRL from Canada 10 RIIC designs bought from Botswana	Sorghum, some maize Sorghum Sorghum utilisation at university Sorghum
Uganda	1985 1986	Mini-PRL from Canada 1 RIIC from Canada	Sorghum, millet improvement Maize, sorghum
Zimbabwe	1984 1985–1986	1 RIIC from Botswana 1 Mini-PRL from Canada 7 Mini-ENDA locally built	Millet Sorghum, millet Sorghum, millet, rural milling

Source: Bassey and Schmidt (1989).

Small-scale cereal milling systems are growing in popularity because of the following reasons:

- 80% of Africa's population are in the rural areas, are relatively poor and rely on subsistence agriculture.
- Substantial quantities of the food produced remain on farm for household consumption, especially sorghum and millets which lack demand for surplus production.
- The rapid socio-economic and demographic changes in Africa leading to rapid urbanisation have witnessed proliferation of service milling in urban and rural areas as well.

One would have expected the above developments to favour sorghum and millets, given the emerging food insecurity, and the need for large millers to embrace sorghum and millets in their product portfolio to safeguard their economic survival. However, this is not the case. Table 3 shows data on milling capacities by the National Milling Corporation of Tanzania; the Corporation handles maize, paddy and wheat.

Table 3. National Milling Corporation annual installed milling capacity by region (tons)

Region	Maize	Paddy	Wheat
Dar es Salaam	65,400	68,400	75,000
Arusha	43,200	-	21,600
Mbeya	-	6,600	-
Mwanza	14,400	14,400	-
Dodoma	18,000	-	-
Iringa	15,000	-	-
Kigoma	9,000	-	-
Shinyanga	-	36,00	-
Morogoro	-	6,600	-
Kagera	7,200	-	-
Tabora	-	10,800	-

Source: Bagachwa (1991).

Large-scale millers in Kenya and Uganda also deal mainly with maize and wheat, whereas sorghum and millets are handled by service millers using hammer mills and occasionally mechanical dehullers. A study in Mombasa District of Kenya, however, showed that the majority of these millers were also handling maize and at times cassava chips, but very little, if any, sorghum and millet (Mbugua and Omungo 2002).

Secondary processed products from cereals in Africa

A diversity of secondary processed products from cereals, including from sorghum and millets exist in Africa. The majority of these products are similar, although they are referred to by different local names. They are processed from a variety of cereals like rice, maize, sorghum and millets. Cereal-based processed products can be grouped into porridges, baked products, alcoholic beverages, lactic fermented beverages and miscellaneous snacks (Vogel and Graham 1978; Mbugua 1988). Tables 4, 5 and 6 show lists of commonly processed foods, alcoholic beverages and baked products in Africa, most of which use sorghum and millets.

Table 4. Some common foods prepared from sorghum and millet selected African countries

Local name	Processed product	Description	Country
Dafa duka, ewa, dahuwa, oka baba Burabusko	Undehulled whole sorghum Undehulled whole millet	Boiled sorghum with beans, oil, pepper, onion Boiled millet with beans, oil, pepper, onion	Nigeria Nigeria
Kande	Dehulled whole sorghum	Boiled sorghum, salt and seasoning, and legumes	Tanzania
Mtama mu bufuke	Dehulled whole/cracked millet or sorghum	Boiled mashed with cowpeas and sweet potatoes banana, or cassava	Kenya
Pate	Undehulled/ dehulled cracked millet or sorghum	Boiled with pepper, tomatoes, onion, salt, spinach, condiments	Nigeria
Pearled dura	Dehulled sorghum or millet	Boiled or steamed grain	Sudan
Uji	Fermented or unfermented millet or sorghum flour	Thin porridge with sugar, milk (or lemon juice)	Kenya Tanzania
Obungi bwa kalo	Fermented millet flour	Thin porridge (prepared in banana juice)	Uganda
Obushera	Coarse, malted sorghum flour	Thin porridge with sugar, fruit juice, mashed banana, or milk	Uganda

Local name	Processed product	Description	Country
Edi	Coarse unfermented sorghum flour	Thin porridge with sugar, fruit juice, mashed banana, or milk	Uganda
Akamu, eko, ogi	Fermented millet or sorghum flour	Thin porridge with sugar, milk (or lemon juice)	Nigeria
Koko	Fermented millet or sorghum flour	Thin porridge with flour balls	Nigeria
Nasha	Fermented sorghum flour	Thin porridge with sugar	Sudan
Ugali	Sorghum or millet flour	Stiff porridge (eaten with sauce)	Kenya Tanzania Uganda
Tuwo	Sorghum flour	Stiff porridge (eaten with sauce)	Nigeria
Saina	Cracked sorghum	Stiff porridge (eaten with sauce)	Nigeria
Dalaki	Sorghum starch	Stiff porridge (eaten with sauce)	Nigeria
Kafa, eku tutu	Sorghum flour	Stiff (slightly softer) porridge wrapped in leaves	Nigeria
Kuni zaki	Sorghum flour	Stiff porridge (made from unfermented flour paste) mixed with sweet potato flour after cooking and left overnight	Nigeria
Teso, atap, karo, kwon, kalo	Sorghum or millet flour	Stiff porridge (may be mixed with groundnut paste, sesame paste, banana, sugar, or boiled	Uganda
Aceda	Sorghum or millet flour	Stiff porridge	Sudan

Local name	Processed product	Description	Country
Waina	Sorghum flour	Leavened thin bread (spiced and fried)	Nigeria
Kisra	Sorghum flour	Leavened thin bread (baked)	Sudan
Injera	Sorghum flour	Leavened thin bread (baked)	Ethiopia
Masa Mugabi	Sorghum flour Millet flour	Leavened bread (fried) Leavened bread (from mixture of millet and wheat flour	Nigeria Uganda

Source: Bassey and Schmidt (1989).

Some products in Table 4 are prepared from mixtures of maize and sorghum or millet flours. In contrast, the majority of alcoholic beverages are prepared from malted sorghum and millets (Mbugua 1989). The majority of baked products are listed in Table 6. The bulk of them use imported wheat.

Because of the need to save foreign exchange, much research has been done to substitute wheat flour in baked products with composite flour containing other cereals such as maize, rice, sorghum and millets. This composite flour technology has been available for some time now, but very few bakeries (small or large) in Africa, except in Nigeria, have used it. In Nigeria, a law requiring incorporation of certain quantities of cassava flour in bread has contributed to the adoption of the composite flour technology, thus saving on imported wheat flour. In certain countries, composite flour technology has been used at cottage or household levels to minimise costs where wheat flour is expensive or unavailable. Local food processing industries in Africa cite several constraints to adopting composite flour technology (NCPB 1991; Dendy 1993). These include:

- Lack of clear policy and commitment on composite flour and small cereals production which limits their availability to potential users.
- Engaging in a top-down approach (technology driven) in its adoption, initiated by researchers with donor funding without the corresponding enthusiasm among the potential beneficiaries, namely the food industry sector which receives little or no government support.

- Availability of concessionary, donated and tariff free (subsidised) wheat which is sold to consumers, hence earning "government" or "individuals" revenue. This pre-empts the need for composite flour.

Table 5. List of local beverages

Local name	Description	Country
Beer		
Ajon	Opaque	Uganda
Amaarwa	Opaque	Uganda
Burukuru	Opaque	Nigeria
Busaa	Opaque	Kenya
Bojalwa	Opaque	Botswana
Chipumu	Opaque	Zambia
Dohlou	Opaque	Upper Volta
Embush	Opaque	Ethiopia
Katata	Opaque	Zambia
Kongo	Opaque	Uganda
Kwete	Opaque millet and maize	Uganda
Marisa	Opaque millet and maize	Ethiopia, Sudan
Marwa	Opaque millet and maize	Uganda
Munkoyo	Opaque millet and maize	Zambia
Pito	Opaque millet and maize	Ghana, Nigeria
Pombe	Opaque millet and maize	Tanzania
Omukimba	Opaque millet and maize	Uganda
Omulamba	Opaque millet and maize	Uganda
Seven day beer	Opaque millet and maize	Zambia
Sibamu	Opaque millet and maize	Zambia
Talla	Opaque millet and maize	Ethiopia
Umbugug	Opaque millet and maize	Sudan
Yarobu kunya	Opaque millet and maize	Nigeria
Distilled spirits		
Araka	Clear	Ethiopia, Sudan
Kachasu	Clear	Zambia
Warangi	Clear	Uganda

Source: Bassey and Schmidt (1989).

Table 6. List of baked products

Local name	Description	Country
Chapati	Unleavened from wheat	Kenya, Tanzania
Waina	Unleavened fried	Nigeria
Gahlet	Leavened cakes	Upper Volta
Injera	Sour pancake	Ethiopia
Kisra	Leavened sour thin sheet	Sudan
Maasa	Leavened sour cakes	Ghana
Masa	Sour leavened cakes	Nigeria
Masa wana	Sour cakes	Nigeria
Mugabi	Yeast bread	Uganda
Sinasin	Leavened millet cakes	Nigeria

Source: Bassey and Schmidt (1989).

Constraints against commercialisation and processing technologies for sorghum and millets
Despite the wealth of traditionally processed products from sorghum and millets shown in Tables 4, 5 and 6, very few of them have been successfully commercialised. Most of them are produced at cottage or household level. This is despite the considerable amount of research done on technology development for industrialisation and commercialisation of some of these processes. Table 7 shows a list of constraints reported in some countries in Africa against commercial industrialisation of processed cereal products.

These constraining factors can be grouped into (a) government policy; (b) inputs (mainly raw materials); (c) marketing; and (d) finance (credit) (Mbugua and Omungo 2002). Few are based on technology or processing.

Similar data from a study on problems faced by maize processors in Mombasa, Kenya (Table 8), showed that most problems were in (a) inputs, where poor availability of raw materials both in quantity and quality was reported, and (b) marketing, where inaccessibility to profitable markets and inadequate consumer demand were reported (Mbugua and Omungo 2002). No important problems in processing, which could not be coped with, were reported.

In Southern Africa (Malawi, South Africa, Zambia and Zimbabwe), some traditional products, namely mahewu (*magou*) and *chibuku*, which are lactic fermented porridge and opaque beer respectively, have been successfully industrialised and commercialised. *Chibuku* was at one time manufactured and marketed in Kenya under different brands namely, *chibuku*, *nyuki* and *kibuku*, but was discontinued for statutory reasons. A similar product called busaa is commercially brewed under the traditional liquor licensing act in the slums of Nairobi or as illicit brew in households and villages both in urban and rural areas. Production of such products, which utilise millets or sorghum flours, cannot be successfully industrialised and commercialised without addressing the legal and statutory issues affecting them.

Table 7. List of constraints against commercial industrialisation of processed cereal products

Country	Constraint
Africa	Unreliable grain supply
Africa	Lack of incentives for grain production by government and official marketing agencies
Africa	Lack of clear government policy and support for post-harvest, utilisation and marketing research
Africa	Lack of sufficient donor funding support in post-harvest, utilisation and marketing research
Benin	Limited technical know-how and capital investment
Benin	Long arduous and strenuous processing operations
Benin	Unavailable institutional credit
Botswana	High variability in quality of local or imported grain
Botswana	Dumping of cheap imported products from South Africa
Kenya	Lack of appropriate dehulling and milling technology for millets
Tanzania	Limited interaction, cooperation and exchange of notes between researchers, policy makers and commercialisation industries
Kenya	High import duties on processing equipment and packaging material, and
Tanzania	problems of maintenance, and imported spare parts
Lesotho	Negative attitudes, conservative attitude and bias against traditional
Zimbabwe	foods by health and nutrition officials
Zambia	Lack of organised, and adequate capacity milling industry

Africa = Reported by most countries.

Mahewu was also introduced in the Kenyan market in the early 1980s by the Kenya Cooperative Creameries. The product, however, failed mainly due to technical reasons, namely erratic quality in consistency and short shelf life.

Table 8. The importance of problems faced by maize enterprises and their coping strategies

Problems with inputs coping strategy	Important, but no coping strategies	Important with	Not important
1. Availability of sufficient quantities of inputs	55 (45.8%)	0 (0.0%)	37 (30.8%)
2. Cannot always afford to buy inputs	17 (14.2%)	0 (0.0%)	52 (43.3%)
3. Inputs are of poor quality	30 (35%)	0 (0.0%)	57 (47.5%)
4. Difficult to transport	12 (10.0%)	16 (13.3%)	92 (76.7%)
5. Don't always receive inputs on time	24 (20.0%)	6 (5.0%)	90 (75.0%)
6. Inadequate water supply	0 (0.0%)	18 (15%)	102 (85%)
7. Work stoppage due to power failure	32 (26.7%)	15 (12.5%)	73 (60.8%)
8. Difficult to acquire packaging /containers	4 (3.3%)	3 (2.5%)	113 (94.2%)
Problems in maize processing			
1. Availability of spare parts	10 (8.3%)	18 (15%)	92 (76.7%)
2. Frequent equipment breakdowns	6 (5.0%)	18 (15%)	96 (80%)
3. Maintaining machinery	12 (10.0%)	22 (18.0%)	86 (71.7%)
4. Machine requires a lot of effort to operate	0 (0.0%)	0 (0.0%)	120 (100%)
5. Achieving product quality acceptable to consumers	10 (8.3%)	36 (30%)	74 (61.7%)
6. Difficult to dispose of waste	1 (0.8%)	4 (3.3%)	115 (95.8%)
7. Labour does not have adequate skills	1 (0.8%)	6 (5.0%)	113 (94.2%)

Problems with inputs	Important, but no coping strategy	Important with coping strategies	Not important
8. Labour is too costly	6 (5.0%)	5 (4.25%)	109 (90.8%)
Problems in maize marketing			
1. Cannot access more profitable	68	15	37
markets for products/services 2. Inadequate consumer demands	(56.7) 41 (34.2%)	(12.5%) 11 (9.0%)	(30.8%) 52 (43.3%)
3. Lack of knowledge of consumer requirements	6 (5.0%)	9 (7.5%)	105 (87.5%)
4. Demand is seasonal	45 (37.5%)	17 (14.2)	58 48.3%)
5. Inability to meet customer demand	31 (25.8%)	9 (7.5%)	80 (66.7%)
6. Difficult to access transport to move products to market	5 (4.2%)	1 (0.8%)	114 (95.0%)
7. Poor consumer perception of product/service	14 (11.7%)	103 (85.5%)	3 (2.5%)
8. High levels of competition from other businesses. Total	26 (21.7%) 120	48 (40%) 120	46 (38.3%) 120

Source: Mbugua and Omungo (2002).

In Nigeria, lager and Guinness beers from brewed using sorghum and a popular drink, Bournvita, were developed, but reportedly without creating significant enthusiasm among potential industrial investors (Dendy 1993). Lactic fermented porridge containing red sorghum both in liquid and powder forms has been test marketed in Kenya. Red sorghum was used rather than millet because of its lower cost and its colour is the consumer preferred brown chocolate, similar to that of millet. However, inclusion of sorghum had to be discontinued because of erratic bitterness in some flours available in the market, which could not be controlled. Millet flour is profitably marketed as germinated flour for *busaa* manufacturers and because of this it is expensive and rarely used on its own for porridge, although consumers prefer it as porridge flour.

New products and opportunities

The refugee influx in ECA plus the ensuing demand for balanced emergency rations has created new product opportunities for health-enhancing products. Thus, the situation lead to the development of UNImix, a micro-fortified and protein-enriched extruded-cooked porridge and other fortified extruded-cooked cereal flour blends made of primarily maize and soy bean flours (Mbugua and Keya 1992). More niche market opportunities are in the form of innovative health enhancing products to take care of special nutritional requirement demands by clinically malnourished populations in Africa consisting of HIV/AIDS positive individuals and other malnourished and vulnerable people (Mbugua and Keya 1992; Mbugua 1997). These problems have created new challenges in the area of nutritionally functional foods, and led to the proliferation of expensive imported nutritional supplements. Currently, sorghum and millets are locked out from benefiting as raw materials in these products because of their poor nutritional qualities. These qualities affect protein digestibility and micro-nutrient bio-availability attributed to their high level contents of anti-nutrients like anti-trypsin factors and phytic acids.

The local Kenyan market has witnessed a proliferation of porridge flours comprising mixtures of flours made from sorghum, millets, legumes and fish (Rastrineobola argentea; silver cyprinid; local name omena) (Aleke 2003). These products have become extremely popular and are consumed in the form of nutritious porridges. The common consumer belief that the millets in particular are more nutritious has contributed to a tremendous increase in demand for millet flour for porridges. Unfortunately, sorghum flour has not attracted similar attention, presumably because of the bitter taste associated with the brown cultivars, whose flour is popular for porridge.

References

Aleke MPW. 2003. *Nutrient adequacy of porridges used for complementary feeding in Kangemi, Nairobi.* MSc dissertation. Department of Food Science, Nutrition and Technology, College of Agriculture and Veterinary Science, Kabete Campus, University of Nairobi, Kenya.

Bagachwa MSD. 1991. Choice of technology in industry. The economics of grain milling industry in Tanzania. IDRC 279e.

Bassey MW, Schmidt OG. 1989. Abrusive disc dehullers in Africa. IDRC270e.

Bruinsma D. 1999. Adding value to cereals, roots and tubers. Developments and opportunities in small-scale enterprise development in Africa. A study commissioned by the Technical Centre for Agricultural and Rural Cooperation (CTA).

Corinne J, Dendy DAV. 1984. Report on a visit to Kenya to study the potential for new sorghum based products; R 1226(s). A joint KIRDI/TDRI Project. TDR, ODA London UK.

CTA [Technical Centre for Agricultural and Rural Cooperation]. 2000. Strategies for strengthening small-scale food processing in Eastern and Southern Africa. Proceedings of a workshop organized by CTA, DSE, NARO and FAKT. Entebbe, Uganda, November 1998.

Dendy DAV. 1993. Review of composite flour technology in the context of Tanzania. Workshop: Sorghum and Millets marketing and Utilization, 3–5 May, Arusha, Tanzania.

KIRDI [Kenya Industrial Research and Development Institute]. 1990. Pearled sorghum market survey—Kenya. Final report. KIRDI, Kenya.

Mbatia OLE. 1985. Development of Kenya's foodstuff and beverage industries in decennium 1975–84, development trends and prospects for 1985–2000. Department of Agricultural Economics, University of Nairobi, Kenya.

Mbugua SK. 1988. Food products prepared in Africa from ICRISAT mandate crops and scope for improved utilization. Proceedings of the International Biotechnology Workshop, 12–15 January, ICRISAT Center, India.

Mbugua SK. 1997. The role of fermentation in weaning foods in Africa. 30th European Society of Paediatric Gastroenterology and Nutrition (ESPGAN), 22 May 1997, Thessaloniki, Greece.

Mbugua SK, Keya EL.1992. UNIMIX quality evaluation and development. A consultancy report for UNICEF Somalia Country Office, Nairobi, Kenya.

Mbugua SK, Omungo R. 2002. Kenya Processors' Survey Report for EU on Removing constraints to the Development of small scale food processing enterprises in sub-Saharan Africa. Small Food Project. EC No. ERB351PL972857.

NCPB [National Cereals and Produce Board]. 1991. Proceedings of the workshop on Composite flours, formulation, processing and usage, 18–19 April, Utalii College, Nairobi, Kenya.

Vogel S, Graham M. 1978. Sorghum and millets: Food production and use. IDRC-123e.

2.2. Aspects of sorghum milling and marketing in Tanzania

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Introduction

Sorghum is a traditional cereal crop in many parts of Tanzania. It is mainly grown in the Central Zone; Lake Zone; Southern highlands; Northern highlands, Southern and Coastal regions. The government is encouraging farmers to grow early-maturing sorghum varieties in the semi-arid areas to curb food shortages. The government has also started buying sorghum grain for strategic grain reserves (SGR).

Uses of sorghum

Use of sorghum varies traditionally from region to region. Many tribes in Tanzania have traditionally used sorghum for food and brewing. In many areas of Tanzania where sorghum is grown, it is a food security crop and is mainly for home consumption due to frustration resulting from lack of reliable markets for surplus production. Another major constraint to production is the availability of storage facilities since sorghum is vulnerable to insect pests. Generally, the crop has been traded in its raw state; no significant processed products are found in the market.

Milled sorghum (flour) has been looked on with suspicion by interested customers. Processed sorghum flour can be used in various ways, such as preparation of thin and stiff porridges, cakes and biscuits. Sorghum grain is also used to prepare local brew and industrially processed opaque beer. Other uses include preparation of traditionally non-alcoholic beer (*togwa*).

Processed sorghum and millet products

Nyirefami Limited pioneered the production of packed finger millet in Tanzania. The success of finger millet in the market encouraged the company to introduce yet another product, sorghum, in the market. The sorghum processed by the company is from different parts of the country and grain varieties supplied also vary. The main sources of sorghum grain to Nyirefami Ltd are:

1. Singida—Tegemeo and Langi langa
2. Dodoma—Lugugu, Wahi and Hakika
3. Morogoro—Langalanga and Mbagala

4. Mbulu—Lulu and Tegemeo
5. Arusha—Macia and Pato

The main markets for the company's commercially processed sorghum products are in Dar es Salaam, Zanzibar, Morogoro, Mwanza and Arusha. All the products are channelled through agencies. Nyirefami Ltd operates in a price sensitive market. Sorghum products compete with those of its sister grain finger millet; the price of sorghum varies from season to season. The selling price of the finished product (flour) ranges from TSh650 to TSh800 which is less than a dollar. Experience shows that people Dar and Zanzibar prefer sorghum more than those from Arusha. However, doctors recommend sorghum flour to patients with diabetes; this increases the company's sorghum sales.

Quality control and monitoring

The selling advantage for sorghum flour milled at Nyirefami Limited is the quality. This is derived through careful purification of raw sorghum by sedimenting sand and other impurities which are common contaminants added during post-harvest processes.

The company is careful to ensure that any product leaving the factory gate is sand free, has the right weight, texture and aroma. These attributes are appreciated by different consumers and the consistent quality has established loyalty in the brand. The secret behind consistency in quality and efficiency lies in the preparation process which is lengthy, time consuming, tedious and expensive. All these processes are done manually. The company plans to buy machinery to speed up the process of purification. New companies are entering the sorghum processing field, but they are yet to threaten the Nyirefami market as their production is limited and their quality inconsistent.

Major constraint

The constraint to this new venture is lack of support from almost all institutions which should have been popularising sorghum as a source of nutrition and not as a food substitute during drought. This has limited the company's efforts to expand. For example, at times Nyirefami Ltd has received false information/data from district agricultural officers and stakeholders on availability of sorghum in their locations.

Support in promoting sorghum consumption and marketing

It is time to support the promotion of more nutritional and functional foods, especially indigenous cereals such as sorghum and millet which have nutritional advantages over other cereals. Despite this potential, sorghum production has been declining in Tanzania. The country does not need to be food insecure, as is the case currently. Industry must deliberately improve the way in which it presents the existing traditional foods by, for example, packaging sorghum and pearl millet flour and many others. Research papers and reports do not reach farmers, and therefore do not contribute to promoting agri-products and business in the country.

2.3. Finger millet processing in Uganda

Mary Tamale

Maganjo Grain Millers Ltd, Kampala, Uganda

Introduction

In many parts of Uganda, finger millet is a traditional cereal crop. Many tribes have traditionally used finger millet for consumption as porridge, meal food or brew. Our focus is to strengthen the performance of both the farmer and the millet processor in the small, medium and large scale to promote the growth of the millet sector in the East and Central Africa region.

Before examining the growth of millet in Uganda, this paper first introduces Maganjo Grain Millers Ltd, Uganda's leading grain processing company. The company is located 10 km from Kampala along the Kampala–Gulu highway (Bombo Road). Maganjo was registered as a private limited company in 1984, as part of the food processing industry. It has a reputation as the largest and longest surviving private company in this line of trade. The vision is to be a leading food processing firm in ECA. The company is on a mission to produce highly nutritious, affordable and quality products that are available at all times. The aim is to exhibit a leading culture of providing customer oriented services while protecting and supporting the environment in the quest to feed nations.

Millet processing in Uganda can be grouped under three broad categories:

1. Household level
2. Small and medium scale
3. Large scale

Household level

At household level, farmers harvest the millet directly from their small home gardens and winnow it. The millet is processed at a nearby milling facility.

Small and medium scale

Uganda has several small-scale millet processors who produce between 500 kg and 20 tonnes per month. Most of the country's millet processing falls into this category.

Large scale

Very few processors produce an average of 20 to 100 tonnes per month. They are, to some extent, involved in research and development (R&D), mainly for product development.

Maganjo's contribution

Maganjo Ltd contributes to this industry directly through:

1. Supporting the local and commercial farmers by buying their produce (millet grain).
2. Processing millet by adding value to millet-based products, for example, millet blended porridges.
3. Supporting middlemen to carry out some intermediate activities.

Large-scale processing firms use more advanced technology to process the millet immediately after it is received from the stores. De-stoners grade the millet into its varying particle sizes. The machines automatically sort the stones from the millet grains, producing a fine, clean and uniform grain that meets the processors' requirements.

Milling to add value

Milling is the industrial process of turning a cereal/coarse particle into fine flour. This adds value to the millet cereal in terms of its marketability, acceptability and profitability. The process of milling is common to both the small- and large-scale processors. Depending on their market strategies and their customers' demands, processors in Uganda pack their millet-based products in different ways.

Corporate social responsibility

Maganjo is aware of its corporate social responsibility. The company engages members of the public to promote itself, open opportunities for its brands, and to share profits with the community. The company interacts at various levels with the government, institutional settings, NGOs and the public.

Why does a Ugandan processor venture into millet processing?

1. There is growing demand for processed millet as compared to millet in its raw form.
2. Millet has high nutritional value as shown in the table below.

3. Millet is a good bakery/confectionery blend/mix.

Millet yields high-quality bread, cakes and buns when it is mixed with baking wheat flour in average ratios. One of Uganda's leading bakeries promotes millet-based bread.

Iron (mg)	Calcium (mg)	Fibre (g)	Protein (g)	Energy (Kcal)
Millet	12.6	410	3.6	7 328
Maize	2.3	26	2.8	9 342

4. Long shelf life.

Even though milled millet has a short shelf life, it has a comparatively longer shelf life than competing cereals such as wheat flour and maize flour. It also has a longer shelf life than bean flour.

5. Millet has less than 2% waste.

During the processing stage millet waste in terms of stones and dust particles is far less than waste from maize etc. Millet residue is used to produce local brew. It is also used in feed mills to produce animal feed.

Challenges of using millet

Millet has certain disadvantages over competing cereals when it is used in processing:

1. Most of the millet that is brought in from the farms is contaminated with soil/stone particles, making it laborious to process.
2. Availability of the product from farmers is unreliable (undermining existing markets).
3. Information on market and product specification is lacking.
4. Poor organisation of farmers and processors has caused inconsistency in product quality in the market.

Summary

Opportunity exists for millets and millet-based products, considering their nutritional advantage over other cereals. On my behalf and on behalf of the Ugandan millet processor I thank this partnership that seeks to focus on issues of linkages to spearhead development of the millet industry in our region. I invite researchers and the donor community to collaborate in strengthening the economies of scale for the large-scale farmers and processors and improving the performance of the small/medium-scale farmers/processors in the region.

Way forward

1. A uniting body, for example, a Uganda Millet Processors Association, would coalesce the interests of millet consumers and processors to enable continued growth of millet processing and consumption.

2. Governments working in partnership with NGOs must set favourable policies to promote millet (enabling and supporting the building of linkages).
3. NGOs must work with farmers and farmer groups to enable them produce quality millet.
4. An umbrella organisation for farmers, processors, consumers and researchers must be created.
5. Researchers must develop new millet varieties. For example, the Food and Agriculture Organization of the United Nations (FAO) is spearheading support for post-harvest initiatives that enable farmers/processors to produce a fine product through post-harvest technologies.
6. Donors must promote awareness of new millet varieties.
7. Donors must also support new millet products, for example, millet flakes, baby/infant formulas etc. This would involve partial support for acquiring technology to produce new millet-based products.
8. Processors must partner with donors and researchers to educate the public about the nutritional benefits of millet over other cereals.
9. Supporting the millet processor to access product market. This would involve sensitisation in particular forums or seminars on the issues that would be required by the market, for example, packaging, branding and efficiency.

2.4. Sorghum injera and bread in Ethiopia

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Injera is the fermented, leavened Ethiopian traditional flat bread made from cereals. The procedure involves milling decorticated sorghum into flour, preparing the dough and fermenting it (after adding starter culture, a batter from a previous batch), at room temperature for about 48 hours. After fermentation, about 25% of the fermented dough is thinned with 30 ml water and cooked in 200 ml boiling water for 1 min. The gelatinised batter is cooled to about 45°C at room temperature and returned to the fermenting dough. After thorough mixing, 100 ml of water is added and the batter is further fermented at room temperature for 2–3 hours. About 500 g of the fermented batter is poured on a 50 cm diameter hot clay griddle (*mitad*), covered and baked for about 2 min as shown on Figure 1.

Teff is preferred for the best quality *injera*. Studies have shown that sorghum type has an influence on both *injera* making and preservation (Yetneberk et al. 2004). Endosperm texture has been identified as the factor that most consistently affects the processing and food making properties of sorghum. The endosperm consists of an outer translucent vitreous area and an inner opaque floury area. The proportions of the two vary from cultivar to cultivar. Sorghum cultivars with floury endosperm texture give soft *injera* which remains relatively softer than that of other cultivars after 48 hours of storage. In Ethiopia sorghum is relatively cheap, raising interest in improving sorghum *injera* quality through processing and cultivar selection for both home consumption and commercialisation.

Bread is generally made from medium to hard wheat. Gluten, a protein in wheat, makes visco-elastic dough when hydrated. It retains the gas produced during fermentation and baking. Conversely, sorghum is a non-gluten cereal and does not retain gas and its bread volume is low with a dense crumb structure. Composite bread is made from blends of wheat and non-wheat flours. When sorghum flour is included in composite flours it gives a drier, grittier and faster firming crumb. However, acceptable quality bread can be made from blends containing up to 30% sorghum flour provided that strong wheat flour and fine and bran-free sorghum flours are used (FAO 1995). Sorghum flour has a neutral flavour which provides an opportunity for blending.

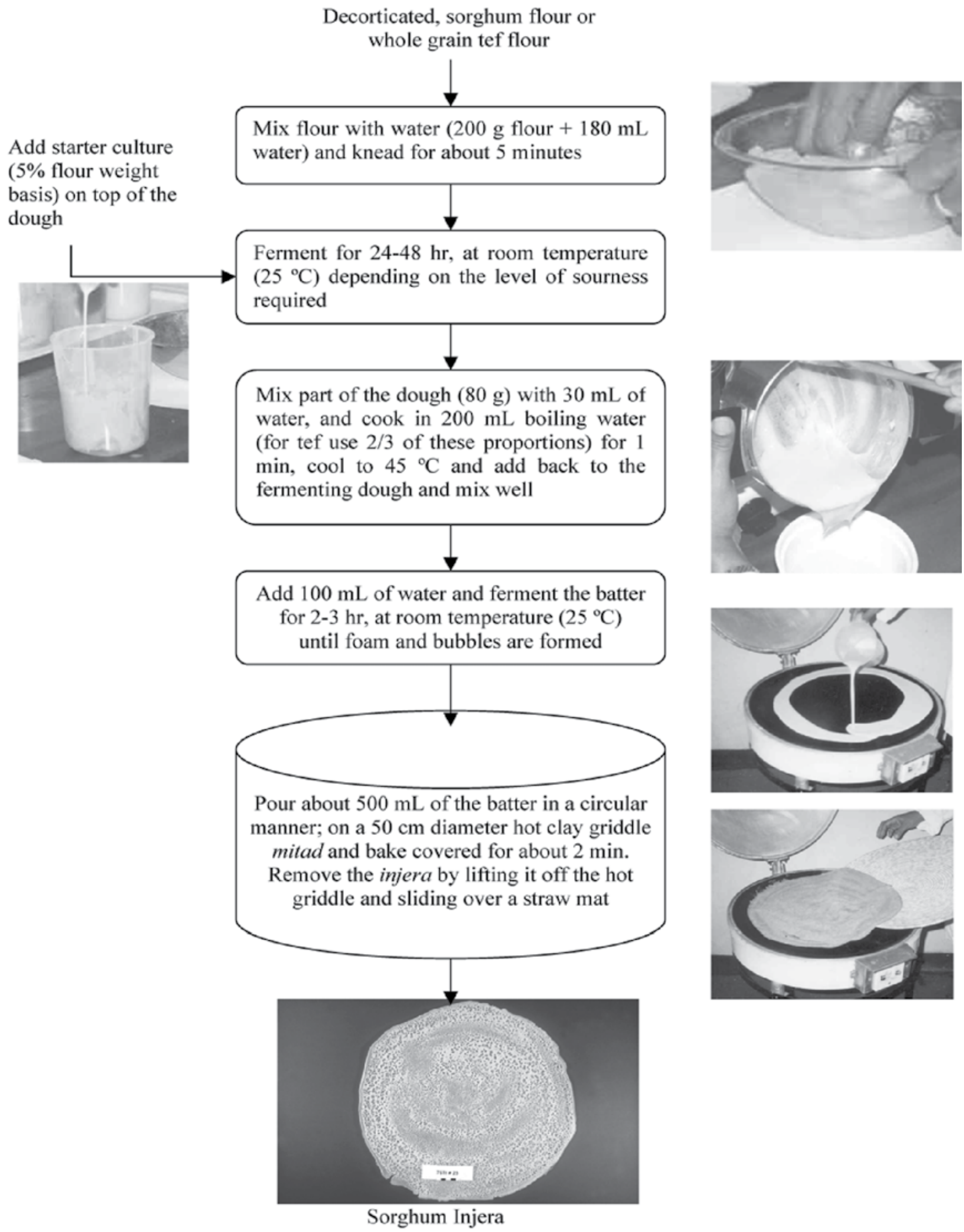

Figure 1. Injera making procedure.

In conclusion, sorghum in Ethiopia is mainly used for injera and composite flours for production of different products including bread.

References

FAO [Food and Agriculture Organization of the United Nations]. 1995. Sorghum and millets in human nutrition. FAO Food and Nutrition Series27. FAO, Rome, Italy. Available at: http://www.fao.org/DOCREP/T0818e/T0818E00.htm#Contentsates.html.

Yetneberk S, Kock HL, Rooney LW, Taylor JRN. 2004. Effects of sorghum cultivar on injera quality. Cereal *Chemistry* 81:314–321.

2.5. Processed sorghum and millet products in Sudan

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Food Research Centre, Sudan

Approximately 90% of cereal grain area in Sudan is planted to sorghum or pearl millet. Annual sorghum production is about 4.2 million tons which accounts for 20% of Africa's production and about 10% of world production. Sorghum is generally consumed as fermented flat bread (*kisra*), thick porridge (*aceda, madida*), thin fermented gruel (*nasha*) and boiled grain (*balela*). It is also used to make alcoholic and non-alcoholic beverages.

A United Nations Development Programme (UNDP)/ FAO project promoted research on milling technology for sorghum at the Food Processing Centre (1974–1980). A pilot plant including a decorticator was installed. The milling characteristics of breeders' samples were studied. The study concluded that the technology for milling wheat is not optimal for milling sorghum and millet since the sorghum milling technique requires removal of the seed coat before the endosperm is crushed. The evaluation of breeder samples for milling continued under the umbrella of the International Sorghum and Millet (INTSORMIL) Collaborative Research Support Program. INTSORMIL found that it is possible to make good quality bread based on 30% wheat and 10–20% sorghum flour. The technology was partially implemented in some commercial bakeries in Khartoum. Other such efforts were frustrated by the open market policy.

The Food Research Centre (FRC) started to produce the fine white sorghum flour for the Sudanese urban market. Four commercial mills (2.5 ton/ha) were then installed by the private sector. Soon after this, several small-scale sorghum dehullers and hammer mills were introduced. Currently, the country has several commercial sorghum brands throughout the country, but their quality is very variable. Commercial grain milling provides urban migrants from sorghum production zones with a familiar food product.
Traditional methods of preparing sorghum flour, such as hand-pounding using wooden or stone mortar and pestle and dried hand grinding using a stone (*quern, murhaka*), are still popular in rural areas.

Hullu-murr and *abreh* are important traditional sorghum flakes prepared from malted sorghum in the Sudan. The variety 'feterita' is usually preferred for malting. A Sudanese company took the initiative to innovate a *kisra* production line using natural gas. Several of these machines were installed in different areas of Khartoum. However, these products are marketed traditionally and in small-scale industries. For large-scale commercialisation, further research in process standardisation, improvement of baking quality and shelf life is needed.

2.6. Processing of sorghum and millet based animal feed products in Kenya

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Abstract

After maize, sorghum is the second most important grain used in feed processing in Kenya. Millets are rarely used in animal feed processing. Using sorghum as an energy source in animal feed is influenced by three main factors: price, quality and availability. When the price of sorghum is substantially lower than that of maize, the former will qualify to be used as an energy source (AKEFEMA 2006). Low tannin (white) sorghum is a versatile substitute for maize and is preferred to the high tannin (brown) varieties. The all-year round availability of cost-effective sorghum varieties for feed processing would be desirable, as this would ensure consistency of the quality of the final products. Ways to shorten the marketing chain between the producers and the processors must be identified so that processors receive the material at a price that would be competitive enough to ensure its utilisation.

Introduction

The total annual compounded feed production in Kenya is about 0.47 million tons (Government of Kenya 2005). The world total annual production stands at about 600 million tons (FAO 2004). Feed milling capacity in Kenya ranges from about 1000 tons per year for the smallest mill to about 90,000 tons for the largest (Association of Kenya Feed Manufacturers 2006). Feed milling activity is confined to the high potential areas of central Kenya and within major towns and cities. More than 50% of the total feed produced is poultry feed.

Figure 1 shows the classes of ingredients used in the processing of animal feeds in Kenya. Industry sources estimate the annual grain consumption for the manufacture of animal feed to be about 90,000 tons per year (Association of Kenya Feed Manufacturers, unpublished). Compounded feeds are for the most part fairly deficient in energy as they are based on low energy cereal by-products.

Maize, the most commonly used grain in feed processing, is either too expensive or unavailable for most of the year. The need for alternative energy sources that would replace maize partly or fully is evident.

Sorghum and millets are used occasionally to cater for this energy shortfall. This paper examines the use of sorghum and millets in animal feed processing in Kenya in respect to sources, quality considerations, constraints and cost-effectiveness.

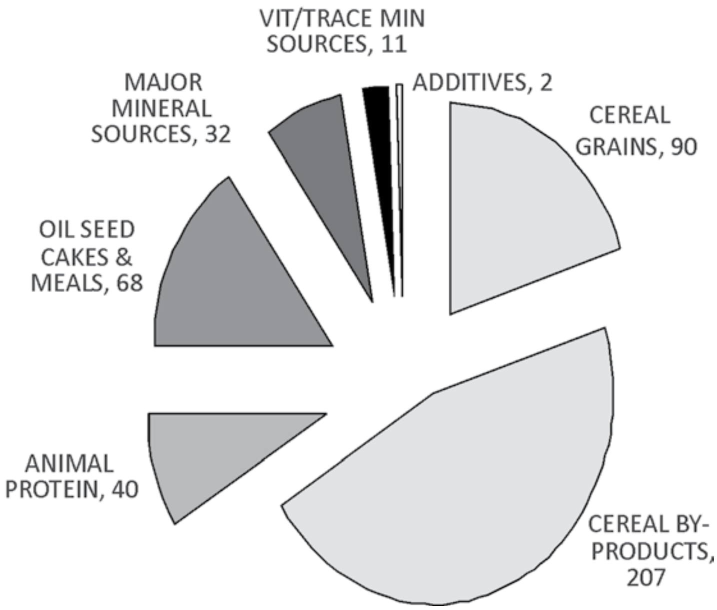

Figure 1. Feed ingredient usage in Kenya (tonnes/year).

Use of sorghum and millets in feed processing

Comparative usage of cereal grains in feed processing in Kenya

Sorghum is the second most important grain after maize in feed processing. Though no official figures are available, the industry consumes more sorghum than barley, wheat or millet. The use of millets in feed processing is in total so little and inconsistent that its use can be considered insignificant.

Sources of sorghum and millets

Feed processors receive their supply of sorghum from traders who source the material either locally or from Uganda and Tanzania (Figure 2). The National Cereals and Produce Board (NCPB) is sometimes a source of the same. Over time, the Western and Eastern provinces of Kenya have become good sources of the material.

Rarely do sorghum farmers deal directly with feed processors. Farmers usually sell the crop to small-scale traders located in nearby markets who in turn sell it to larger-scale traders located in towns and cities. It is from large-scale traders that the material is bought by the feed manufacturers. This protracted marketing chain has had a negative impact on intake prices. Fall-outs from food aid also sometimes enter the market chain.

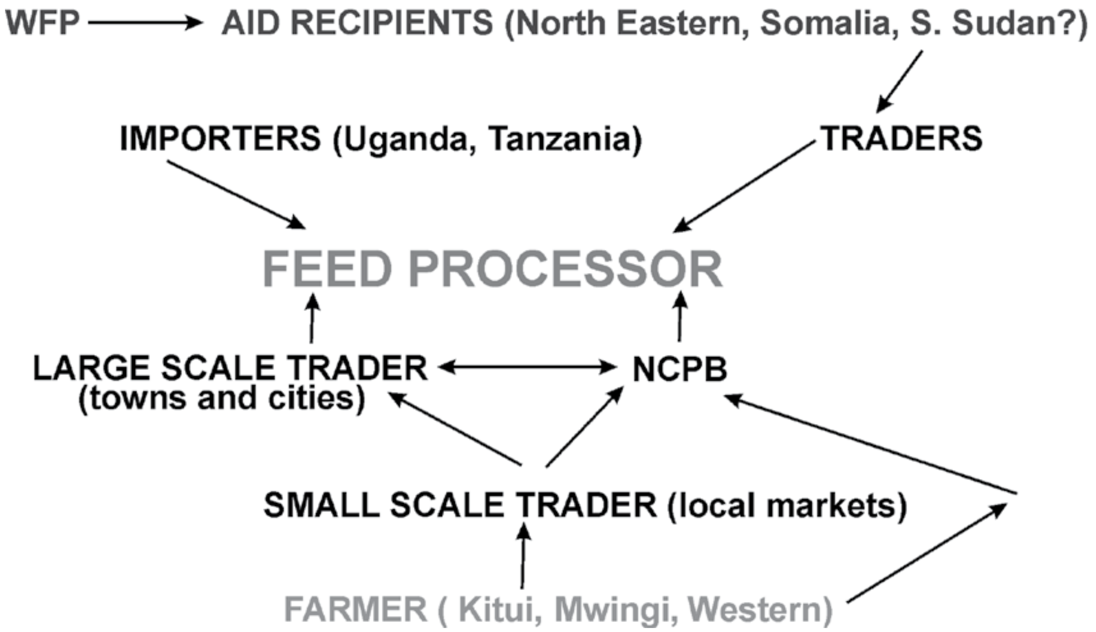

Figure 2. Sources of sorghum and millets.

Quality considerations and preferences

Varieties

White and brown varieties of sorghums are used in the feed processing industry. However, the white variety is preferred.

Grain size

Larger grains are preferred to smaller ones. In general, the small size of sorghum and millet grains poses a challenge during grinding, as they can easily pass through the screens.

Extraneous material

Sorghum is usually contaminated with soil, stalks, stones etc. High quality means that the material must be free of such contaminants.

Moisture content

Moisture content must not exceed 10%.

Insect damage

The material must not be infested with weevils. Weevil damage must not exceed 10%.

Cost effectiveness of sorghum as a substitute for maize

The price of sorghum is the most important factor in determining whether it will be an economical substitute for maize. To demonstrate this, sorghum and maize were compared at different price levels encountered between May and November 2006 (Table 1). Three commercially viable broiler finisher diets were formulated using a least-cost linear program (Table 2).

Table 1. Sorghum and maize prices between May and November 2006

	Period 2006	**Sorghum (KSh)**	**Maize (KSh)**	**Remarks**
Diet I	May	16.25	18.90	Tail end of drought. Maize prices high. Sorghum available at KSh1300 per 80-kg bag.
Diet II	August	15.00	14.45	Cheap maize from western Kenya and Uganda. Sorghum prices now lower at KSh1200 per 80-kg bag.
Diet III	November	11.90	14.45	Sorghum prices lowered even further by influx of supplies from North Eastern Province. Price now at KSh950 per 80-kg bag.

From this study we can conclude that whenever the price of sorghum is substantially lower than that of maize, sorghum will be preferentially chosen as an energy source (Diet III). However, where only small differences in price exist between the two, maize will be preferentially taken (Diet II).

General conclusions and recommendations

1. Sorghum is a good substitute for maize in commercial feed formulations. However, this is contingent on three main factors: price, quality and availability. The price of sorghum must always be lower than that of maize for it to be used as an economical source of energy in feeds. Low tannin sorghums would be the preferred varieties, as certain levels of tannins have been shown to depress the growth of broilers (Jacobs 1993). An all-year

round availability of sorghum and millets would be desirable in commercial animal feed enterprises for the consistency of the quality of their final products.

2. Linkages must now be developed between sorghum and millets producers, traders, processors, researchers and consumers to enhance production and utilisation. The aim would be to give sorghum and millets a competitive edge over other grains, especially maize. Apart from developing high-yielding and drought-resistant varieties, it would be prudent to identify and promote market channels that would ensure that sorghum and millets reach the feed processor at a competitive price.

Table 2. Broiler finisher diets at different sorghum and maize prices

	Diet I **Sorghum 16.25 KSh/kg** **Maize 18.90 KSh/kg**	**Diet II** **Sorghum 15.00 KSh/kg** **Maize 14.45 KSh/kg**	**Diet III** **Sorghum 11.90 KSh/kg** **Maize 14.45 KSh/ kg**
Sorghum	390.0	-	439.0
Maize	-	348.0	-
Others*	610.0	352.0	561
Total	1000	1000	1000
Me Kcal/kSg	3000	3000	3000
Crude fibre (%)	6.80	6.97	7.00
Protein (%)	23.5	23.5	23.5
Lysine (%)	1.18	1.20	1.16
Methionine (%)	0.47	0.45	0.46
Calcium (%)	0.78	0.78	0.78
Av. phosph (%)	0.49	0.50	0.49
Cost, KSh/kg	19.00	18.40	17.30

*Others include soybean meal, sunflower seed cake, cotton seed cake, steamed fish meal, rice polish, wheat pollard, vitamin/mineral premixes, coccidiostat and salt.

KSh 72 = US$ 1.

References

Association of Kenya Feed Manufacturers. 2006. The role of Association of Kenya Feed Manufacturers Association (AKEFEMA) in the Kenyan feed industry. Paper presented at the FAO/IFIF/GoK conference on Good Practices for Animal Feed and Livestock Industry in East and South Africa, 26–28 June 2006, Nairobi, Kenya.

Association of Kenya Feed Manufacturers. Unpublished estimates collected from within the industry.

FAO [Food and Agriculture Organization of the United Nations]. 2004. The world animal feed industry. In: p 1–8, FAO Animal Production and Health Proceedings on Protein Sources for the Animal Feed Industry, Expert consultation and workshop, Bangkok. FAO, Rome, Italy.

Government of Kenya. 2005. Annual report. Ministry of Livestock and Fisheries Development, Animal Production Division.

Jacobs JP. 1993. *The feeding value of Kenyan sorghum, sunflower seed cake and sesame seed cake for poultry*. PhD thesis. University of British Columbia, Canada.

2.7. Processing of clear Eagle Lager beer: Case of Nile Breweries Limited, Uganda

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Abstract

The improved sorghum variety, Epuripur, released by the National Agricultural Research Organization (NARO)/Serere Agricultural and Animal Production Research Institute (SAARI) project in 1994 has excellent grain brewing qualities. NARO/SAARI in collaboration with private sector (Nile Breweries Ltd (NBL) and FICA Seed Company) and farmers have successfully promoted the use of Epuripur in commercial beer processing to produce clear Eagle Lager beer that meets international standards. Direct sales of Epuripur to NBL have enabled farmers to improve their incomes and their standards of living. Eagle Lager beer is the third best-selling beer brand after Nile Special and Club in Uganda beer market.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is the third most important staple cereal food crop after maize and millet in Uganda. It occupies 265,000 ha of arable land. The crop is grown mainly in the south-western highlands and in the lowland areas of the Central, East and Northern regions of Uganda. However, sorghum is mainly used in small quantities for food (*atap*), thin porridge (*bushera*), local brew (*ajon/omuramba*) and potent local gin (*waragi*).

Sorghum research in Uganda has been going on for the last five decades. Since then NARO/SAARI has released 10 improved sorghum varieties for the farming communities. In 1994 the project released the Epuripur variety. Table 1 lists the grain qualities of this variety.

The above results confirmed that Epuripur has excellent brewing qualities for the production of high quality clear beer. However, the NARO/SAARI project faced the challenge of disseminating its research outputs to benefit the poor. Furthermore, farmers faced marketing problems. This initiated and cemented the collaboration between NARO/SAARI and Nile Breweries Limited (NBL) and it provided a ready market for Epuripur farmers. NARO in partnership with NGOs, the National Agricultural Advisory Services (NAADS), private sector seed companies and farmers has been able to provide NBL with good quality grain for commercial production of

Eagle Lager beer to supply local markets. The project hopes that once enough volumes of the Eagle Lager beer is produced, it will be available for export to countries like the Democratic Republic of Congo, Rwanda and South Sudan.

Table 1. Results of analysis of Ugandan sorghum grain, variety Epuripur

Parameter	Results	Minimum brewing requirements
Fat (%)	3.8	Acceptable range 3–4%
Protein (%)	10.98	Acceptable range 9–11%
Starch (%)	75.6	Minimum of 70%
Tannins (%)	0.01	Below 1%
100 kernel mass (g)	2.4	Above 2 kernel size
Foreign matter (%)	0.2	Good
Unthreshed grain (%)	3.6	Good
Total defective and small kernel (%)	6.0	Good
Weather stained (%)	2.4	Good
Ergot (%)	0	No contamination
Mould infected kernels (%)	0	No contamination

Source: Odendaal (2002).

Process of brewing Eagle beer

Primary processing of Epuripur begins at house level using locally available equipment. Middlemen buy Epuripur from farmers. If the grain is not clean enough, farmers have to clean it further. The middlemen then sell the sorghum to the NBL agent, who finally cleans, weighs and transports the grain to the brewery. NBL stores the sorghum until it is required for secondary processing: production of Eagle Lager beer.

Five basic ingredients are used to brew Eagle Lager beer: (1) Epuripur sorghum grain, (2) hops, (3) yeast, (4) malted barley and (5) water. Epuripur sorghum grain contains starch which is converted into fermentable sugars by external enzymes at malting. It also provides beer with flavour, colour, body and texture. Hops (Humulus lupulus L.) are small, green cone-shaped flowers from the hop plant, a vine related to the nettle plant. Hops provide beer with a spicy, bitter flavour and contribute natural substances that prevent bacteria from spoiling the beer. Yeast facilitates fermentation. Water constitutes as much as 95% of the ingredients used in the brewing process.

The brewing steps

Cleaned sorghum grain is received from the buying agent. It is stored by NBL and milled as needed.

Step 1

The unmalted sorghum grain is milled into a grist powdered product using a hammer mill. The grist is mixed with water to form mash and boiled in a cereal cooker. Malted barley and enzymes are added into the mash run at raised temperatures of 58°C and 85°C for 1½ hours. Starch complex sugars in the grain are then turned into sugar. The mash is pushed into mash filter to produce wort which is in form of a sugar solution.

Step 2

In this step, the wort is transferred to a large boiling vessel and boiled for up to 2 hours. Boiling effectively sterilises the wort and kills any bacteria that may spoil the wort during fermentation. The hops are added to provide a spicy flavour and bitterness that balances the sweetness of the wort. The wort is cooled to 12^{o}C and strained to remove the hop powder and other residue. The brewer transfers the wort to a uni tank containers in which it can ferment. Yeast (bottom fermenting yeast) is added or pitched into the wort as the cold wort is being transferred to the uni tanks to begin fermentation at 12^{o}C to 14°C under controlled temperatures. Bottom fermenting yeast is yeast which can withstand low temperatures. The first fermentation lasts 7 days. When the yeast has consumed most of the fermentable sugar, it is removed and the beer is left in the same tank to undergo secondary fermentation (maturing) for 7 days at 0°C.

Step 3

After secondary fermentation, the beer is filtered to remove the remaining yeast. Carbon dioxide is added and the beer is sent to bright beer tanks, where it is kept at 0^{o}C for about 8 hours before bottling.

Step 4

After 8 hours the beer is bottled, crumbed and pasteurised at 60°C to kill off any remaining yeast and beer spoiling bacteria. The beer is then labelled and coded with the manufacturing date and best before date, packed into crates and stored. For local consumption the best before date is after 4 months while for export it is after 6 months.

Other uses

In Western Uganda, Lake Albert region, Epuripur grain is used to fertilise fish ponds. Some farmers use the grain as chicken feed. Around NBL, dairy farmers use sorghum mash by-products as animal feed.

The future

Clearly, using Epuripur to brew beer has been a success. Eagle Lager has risen to be the third largest beer brand sold in Uganda. However, this is not just about a beer; it is also about economic empowerment driven by the extent to which the project has handled itself. True success can only be measured by the extent to which the project is tackling poverty (Figure 8) and this will take time. The sustainability of this triumph, and for similar ventures down the road, depends entirely on the continued cooperative effort between government and the private sector.

Though NARO has yet to analyse the research cost of developing Epuripur, farmers are already making money from its sales (Table 2). Farmers have substantially improved their incomes and standards of living at household level through the incomes they get directly from the growing and selling of Epuripur to NBL.

Table 2. Epuripur production and income earned by farmers, 2001–2004

Year	Epuripur production
B 2001	12 tonnes of foundation seed at SAARI
A 2002	200 tonnes, farmers earned USh60 million
B 2002	400 tonnes, farmers earned USh120 million
2003	1462 tonnes, farmers earned USh438.5 million
2004	1677 tonnes, farmers earned USh503 million
2005	2371 tonnes, farmers earned USh711 million
2006 A	6000 tonnes, farmers earned USh1.8 billions

A = after harvest; B = before harvest.

Source: Nile Breweries Ltd, Jinja.

Conclusion and recommendations

NARO/SAARI in collaboration with the private sector (NBL) has successfully disseminated its outputs to uptake pathways and end users. The Eagle Lager project clearly demonstrates the impact of NARO/SAARI technologies among the rural communities (Box 1).

Box 1: Mr Ojamal steps out of poverty using Epuripur

In 2002 Mr Ojamal, a prominent farmer in Okulonyo Parish, Olio Sub-county, Serere County, Soroti District, harvested and sold over 100 bags of Epuripur to NBL. He earned USh3 million cash. He bought a bicycle for transport, clothing and bedding for his family, a pair of oxen and a plough. He also bought a plot in the nearby trading centre and built a semi-permanent iron-roofed house, where he is now operating a shop.

Nile Breweries can now fully develop a more affordable product, without compromising the high quality set by its more established standard lager brands, Nile Special and Club Pilsner. The Eagle project provided a perfect model for the Poverty Eradication Action Plan (PEAP). Moreover, NBL guarantees an immediate market for Epuripur:

1. Subsistence farmers have moved to commercial production of Epuripur, thus generating sustainable income.
2. New income derived from Epuripur sales enables rural families to afford basics such as education, health and housing.
3. South African Breweries Miller Multinational is working hand-in-hand with NARO, local government authorities NGOs and the private sector.
4. The Eagle project is a clear example of the benefits that a partnership between research (NARO), private sector (NBL, seed companies), NGOs and farmers can bring to rural communities.

Reference

Odendaal D. 2002. *Results of Epuripur grain analysis. Shared services, the South African Breweries* in NASARI programme reports

2.8. Traditional opaque beer brewing: The Tanzanian experience

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Background

People all over the world have their own traditional alcohol, and brewing is one of mankind's oldest sciences. Traditional opaque beer is indigenous African beer (Hardwick 1995). African beer has had two main influences on its development. The first influence, often overlooked, has been indigenous knowledge. Africans were brewing forms of sorghum beer as far back as 1000 BC, before any European arrived in Africa. The second influence occurred after 1650 and was introduced by Europeans who colonised the region, bringing with them their own expertise and knowledge of beer (Wayne and Richard 2000).

Traditional opaque beer

Traditional opaque beer in Eastern and Central Africa is known by various names such as *chibuku, mbege, komoni* (Tanzania), *impek*e (Burundi), *marwa* (Uganda) and *busaa* (Kenya). It is a characteristically sour, reddish brown, opaque/colloidal beverage containing suspended solids with an alcoholic content of about 4% and pH of 3.4 to 3.6. Traditional opaque beer is consumed in an active state of fermentation (i.e., fresh or within 2 to 3 days). The commercial traditional beer sector is more developed in southern African countries than it is in Tanzania (Table 1).

Table 1. Consumption of opaque beer in Southern Africa

Country	Population (millions)	Number of breweries	Total litres sold per year (million)	Litres per head per year
Botswana	1.5	4	125	83
Malawi	12	5	110	8
South Africa	42	14	540	13
Zambia	10	12	176	17
Zimbabwe	12	16	510	42
Tanzania	35	2	20	0.6

Source: SABMiller.

Nutritional value

Traditional opaque beer is more a food than a beverage. It contains high proportions of starch in the form of dextrin and sugars besides proteins, fat, vitamins and minerals. Sorghum-based traditional opaque beer was found to be nutritionally superior to sorghum flour (www.fao.org), as it provides additional riboflavin, thiamine and niacin. Wayne and Richard (2000) found that iron absorption from sorghum and maize beer was more than 12 times higher than constituents that were used to prepare the beer. In traditional sorghum beer most thiamine and about half the riboflavin and niacin are associated with beer solids that contain yeast (Okgabue 1998).

Affordability

In informal and formal markets, TOB pricing is fragile and elastic to cope with the vagaries of the supply and demand of raw materials/cereals. However, the pricing accommodates low-income earners. About 50% of the Tanzanian population of 35 million is currently living close to the poverty line, which is US$1 a day (www.tanzania.go.tz). In Tanzania, the beer is fairly affordable at US$0.3 per litre.

Traditional opaque beer industry in Tanzania

Darbrew and another small plant (Mwamba Breweries) in Mbeya region are the only traditional opaque beer processors at industry/corporate level in Tanzania. The bulk is still in the hands of informal home and small brewers. Darbrew manufactures and markets affordable traditional opaque beer of consistent quality under the registered brand name of *Chibuku* in the Eastern Zone of Tanzania, especially in Dar es Salaam, the Coast and Morogoro regions. The raw materials used for brewing are white maize and sorghum. Mostly, white sorghum is used for brewing, though red sorghum is also used in small quantities to give the right colour. The annual consumption is not less than 1200 tons of sorghum. The major source of sorghum is the local market; sorghum importation is rare.

External environment

<u>Sorghum supply</u>

Quality: Almost all the sorghum supplied locally does not meet the minimum condition for quality required by industrial users. The sorghum comes with plenty of sand, stones and other foreign matter. This is either introduced deliberately into the consignment to increase the weight of the bags or is the result of primitive threshing methods used by farmers. The cost of cleaning the sorghum before processing adds to the production costs and eventually translates into either higher prices for the consumer or a reduced profit for the industrialist.

Darbrew's business growth has been influenced by the external and internal environment in which the plant operates (Table 2).

Table 2. Financial, production volume and sorghum consumption (US$ 1 = TSh 1300)

Year	F01	F02	F03	F04
Beer volume (hectolitres)	160,000	188,000	190,000	129,000
Sorghum purchased (tons)	1,000	1,200	1,250	1,200
Turnover (US$)	1,550,000	1,840,000	1,940,000	1,800,000
Gross margin (US$)	742,500	1,000,000	1,300,000	1,080,000
Earnings before income tax (US$)	212,000	400,000	500,000	300,000
Taxation (US$)	90,000	200,000	125,000	100,000
Earnings after taxation (US$)	122,000	200,000	375,000	200,000
Dividends (US$)	100,000	425,000	360,000	204,000

F01 = Financial year 1.

Courtesy: Darbrew Finance Department, 2005.

Prices: Sorghum prices are unpredictable, and wide fluctuations are common. The difference between farm-gate and landed prices suggests that suppliers (middlemen) do reap profits at the expense of the farmers and industrial users.

Reliability: Even where a contract of supply has been arranged, total certainty that the agreed tonnages will be supplied at the stipulated time cannot be guaranteed. Stocks are often not internally adequate at source, and marketing imperfections further complicate the situation. Often Darbrew has to hedge against non-delivery by investing in excess stock, sometimes through importation.

Customer satisfaction

Consumers of *Chibuku* prefer a slightly reddish or pinkish creamy opaque beer. They link perceived qualities to the grain function properties, thus providing a basis for setting the required standards of sorghum and maize from suppliers/farmers.

The customer requires the product to be reliable, available, of consistent quality, stable and affordable. Darbrew's customers are wholesalers (20%) who benefit from company credit facility (payment is on a load-over-load basis) and retailers (80%) who trade with final consumers.

Government, competitors and market share

The estimated national traditional beer consumption in Tanzania is about 5 times the volume of clear beer. The current commercial consumption share is 25% and 75% of the consumption share is in the hands of small-scale opaque beer producers, who are, of course, not economically viable. The potential for growth of the opaque beer industry is obvious and would automatically generate an increased demand for sorghum.

Darbrew's major competitors are small-scale brewers who sell their beer relatively cheap. The prevailing taxation policy requires Darbrew products to be taxed. Small-scale brewers have lower production costs, as they pay no taxes. Although these products are often of low quality and are produced through unhygienic processes, consumers are attracted by the cheaper price. In case of outbreaks such as cholera and food shortages, all home-made brews are officially banned, unlike Darbrew products. This restriction reveals two major facts: first, that industrial opaque beer is superior to home-made brews and, second, that from an economic and health welfare perspective, the authorities are aware of the disadvantages of an uncontrolled opaque beer brewing sector. As is the situation in other southern African countries, brewing on a small scale should be deliberately restricted to promote and support traditional beer brewing at industry/corporate level. The traditional beer brewing policy should be consistent with a broader national policy (that must be set) to support and promote sorghum and millet production. Small-scale brewers could be viable if they were converted to participate at distribution level as wholesalers or retailers.

Internal environment

Despite unfavourable external forces, Darbrew has remained in the business mainly due to its internal environment in terms of mission, vision, and stated values. Darbrew was incorporated as a Limited Liability Company in 1966 and became operational in 1967.The company has around 40 years of experience in opaque beer brewing. The current maximum production capacity per year is 200,000 hectolitres, which is only 65% of the plant's production capacity.

Impact on national economy

With reference to the Darbrew perspective, several economic opportunities exist for commercialised opaque beer in Tanzania. These may contribute toward answering the need for improved economic growth and livelihood of the people. Darbrew employs around 84 people and another 1500 jobs are created through a group of stakeholders, such as wholesalers, retailers and input suppliers. Darbrew's tax revenues to the central and local government are around US$125,000 per year.

Remarks

A successful industrialisation/commercialisation of traditional beer in Tanzania would offer the following merits:

- Monetisation of the rural economy by providing consistent demand for sorghum and thereby ensuring the availability of a market for the produce.
- Discouraging substantial consumption of unhealthy and unhygienic brews in favour of better traditional beverages.
- Industrial production of traditional beer is environmentally friendly. No trees are cut down to provide cooking energy.
- Employment creation.
- Capital formation.

References

Hardwick WA. 1995. Hand book of brewing. MarcelDekker Publishers.

Okagabue RN. 1998. The role of African government and institutions in development of traditional food fermentation technology. *The African Technologist* 2

Wayne CS, Richard AF. 2000. Sorghum: Origin, history, technology and production. Wiley and Sons.

2.9. Recommendations on processing and utilisation

Sorghum and millets are traditional crops in ECA and have advantages over other cereals in terms of drought tolerance. They are used for food, feed and brewing. Sorghum and millets products are processed at household level and on small-, medium- and large-scale commercial basis. The main constraints to processing and product diversification of these small grains include: contamination with sand, soil and other impurities; lack of appropriate and affordable processing machines; low volumes of grain production; laborious processing; lack of information on product diversification; weak value chain linkages; lack of quality seed technology; and lack of common values standards.

Recommendations to improve processing and product diversification of sorghum and millets were made as follows:

- Development and accessibility of appropriate processing machines and storage facilities.
- Increased volume of production through improved seed technologies and crop management.
- Payment of premium prices for quality sorghum and millet grains.
- Strengthening value chain linkages of all stakeholders.
- Adoption of integrated value addition research for products diversification.
- Establishment of efficient competitive market structure systems to improve farmers' bargaining power.
- Contractual arrangements between organised farmers and processors.
- Training farmers and traders and other stakeholders on grain quality control and management.

CHAPTER THREE

MARKETING AND MARKETS

3.1. Marketing of sorghum and millets in ECA—An overview

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Introduction

Sorghum and millets are historically the major food staples in the semi-arid regions of Eastern, Central and Southern Africa (Minde and Rohrbach 1993). In Eastern and Central Africa alone, sorghum is grown on approximately 10 million ha and millets on more than 3 million ha; this is about 50% of the cereal acreage (ECARSAM 2005). But technological advances leading to improvements in maize productivity, the installation of hammer mills and the rising value of farm labour have encouraged a shift in production and consumption to maize. The preponderance of maize in areas formerly dominated by sorghum and millets has increased the level of food insecurity.

This paper examines the past performance of marketing of sorghum and millets in the Eastern and Central African region (ECA). However, whenever relevant, references to other countries are drawn.

Do we have markets for sorghum and millet produced in ECA?

Markets for sorghum and millets exist, but they vary from season to season. More than half of the sorghum and millet produced is consumed on farm. In good years, the proportion marketed can reach up to 40% (ECARSAM 2005). During a few years of surplus farmers fail to sell the extra crop and, if they do, they dispose of the grain at prices lower than what they would have received during a normal season. In general, and unlike for crops such as maize, sorghum and millet have no organised marketing system in the region. To solve such problems, some forms of contracts have been introduced in a few countries. However, frustrations often occur because industry is sometimes unable to clear the amounts offered or claims that there is not enough of the product available.

Better access to output markets will encourage technology adoption to increase productivity and meet market demands. Effective markets increase the potential profit from higher production, reduce the risk of financial loss, and provide the incentive for farmers to make the necessary investment. However, when food consumption needs are clearly in deficit, farmers will also adopt new production practices to meet that need even in the absence of strong output markets.

Do we have a sustainable supply of quality sorghum and millet grain for industrial use in ECA?

The lack of a sustainable supply of quality sorghum and millet grain is arguably the main factor constraining growth of the sub-sector. It is also responsible for the subsequent failure to effectively contribute to economic growth and increased livelihoods.

Many factors contribute to the unstable supply of these crops in ECA. Productivity is low—about 600 kg per ha at times—and variable (Table 1). Usually a bumper harvest of sorghum follows a dry season and the reverse is true when the season in the previous year was good. Market participants are therefore faced with a fluctuating trend and processors are also hard hit because they cannot afford to constantly change their investment decisions.

The supply constraint is further associated with two major factors:

1. Average productivity remains low compared with that of the chief alternative grain input in most commercial grain processing. In this circumstance, it is cheaper to import maize from relatively high rainfall areas than it is to depend on the low and sporadically available sorghum.

2. Production levels are too inconsistent to support the development of a commercial product. Processors cannot afford to depend on a product that is available only in years of good rain. Obviously the same applies to maize, but maize can be sourced from across the border. With sorghum and millets, however, cross-border trade hardly occurs. In 2002/2003, for example, drought in many countries in ECA affected many sorghum processors because they could not find sufficient grain. Cross-border supplies can help solve the problem, but the success of this remains a function of trade links, supportive cross-border policies etc.

ICRISAT, working with representatives from the milling, brewing and stock-feed industries in Eastern and Southern Africa noted several other issues. First, while the development of trade linkages with sorghum or pearl millet processors remain useful, this alone will not encourage farmers to invest in new technologies. Demands for cheap grain that can compete with the costs of maize obtained from higher rainfall zones have left farm-gate prices relatively low. Productivity gains have to be obtained from relatively low-cost investments such as micro-dosing of fertiliser, more efficient use of manure and timelier weeding (Table 1).

Table 1. Contribution of different technology components to increasing sorghum and millet yields as observed in on-farm trials in Zimbabwe, 1998

Category	Yield per ha	Percentage increase
Traditional variety	600	-
Improved variety	800	30
Improved variety and improved management	1600	50

Source: Adapted from Heinrich (2003).

Second, further improvements in farm-gate prices require the pursuit of greater efficiencies in grain trading leading to lower trading costs. These include the improvement of grain assembly allowing longer hauls by 30-ton truckloads or transport by rail. Sorghum and pearl millet are unlikely to be commercially competitive if traders have to collect many small lots from isolated producers. Different kinds of contracting or collection point operations can facilitate this trade (Rohrbach et al. 2004).

Third, governments need to carefully judge the impacts of their market interventions on the relative competitiveness of alternative crops. Governments should be aware that any subsidies they introduce that favour maize hurt the sorghum and millet sector because these subsidies essentially represent income shifts from sorghum and millets to maize. In addition, attempts to continue to maintain market controls that place maize at a competitive price advantage, have a negative impact on the sorghum and millet sub-sector. During the sudden reintroduction of subsidies in Tanzania in 2005, for example, it should have been clear that the crop that stood to benefit was maize.

Fourth, the successful commercialisation of sorghum and pearl millet requires consistent investment by the private sector. Private companies will only have a vested interest in new sorghum- or pearl millet-based products if they invest their own resources in product development and test marketing. These companies must similarly invest in developing trade channels to assure themselves of a consistent grain supply. Commercialisation cannot be obtained through product development in research stations and university laboratories. Nor can this be derived from public investments in grain supply (Rohrbach and Obilana 2003).

Finally, building new markets usually takes time and requires a capacity to flexibly respond to a shifting array of problems. At various times, ICRISAT researchers have worried about the choice of variety, the appropriateness of grain cleaning technologies, the effectiveness of alternative grain assembly procedures, the value of alternative packaging and market promotion strategies, policy analysis relating to grain stockholding and food aid, the establishment of grain quality standards, and the usefulness of market information systems. The resolution of one problem commonly led to the recognition of another. This implies the need for a much more flexible process of linking research and development. But, in addition, technology adoption and research success depends on an ongoing dialogue with public and private stakeholders willing to co-invest in market development.

More evidence on sorghum and millet competitiveness

Botswana

Botswana, a country rich in sorghum and millet, is an interesting case. An investigation conducted by the Botswana College of Agriculture (Rohrbach et al. 2000) revealed that there had been a sharp increase in the number of commercial mills that process sorghum since 1989. The quantities of sorghum processed had increased from 16,000 to 60,000 t per year between 1989 and 1999. What caused these impressive changes?

First, the license restrictions on imports had been lifted. In 1989, the government allowed only limited imports to encourage local industry to purchase the domestic crop first. But the domestic crop was little and the grain more expensive than imported maize. When the import restrictions were lifted, sorghum imports from South Africa quickly increased. Local millers established contracts with South African traders willing to supply grain of acceptable quality on a regular basis throughout the year. Gradually, this created regular supplies of grain of known quality at a competitive price. A closer look at the quantities being milled indicated that more than 90% of the grain was imported. Small-scale farmers supplied almost no grain to the industry partly because productivity was low (<300 kg/ha) and production levels highly variable. A few simple enterprise calculations revealed that the returns to farm labour were too low relative to average wage rates in the larger national economy. The Botswana study indicated the importance of steady grain supply and competitive prices for the growth of commercial processing of crops such as sorghum and millet. The returns to crop production were too low, relative to non-farm opportunities, to attract investment in technologies capable of improving average yields. Grain imports were cheaper and more consistently available than domestic production.

Tanzania

In 1999, the Ministry of Agriculture and Cooperatives, in collaboration with the Sorghum and Millet Improvement Program (SMIP), examined the prospects of commercialising sorghum and pearl millet in Tanzania (Heinrich 2003). A diagnostic survey was conducted to assess the utilisation in the milling and brewing industries. One project evaluated the market for sorghum meal in Dar es Salaam with the help of a miller, Power Foods. The other evaluated a strategy to ensure delivery of high-quality sorghum to Darbrew Ltd.

Consumer interest in sorghum meal

Consumer preferences for maize and sorghum meal were evaluated as were sales in paper versus plastic bags. In addition, the project promoted a pricing strategy to reduce the price of sorghum to bring it close to that of maize. Results showed that consumers in Dar es Salaam preferred whiter and finer sorghum meal. The taste of improved variety Pato was preferred for *ugali* and *uji* (stiff and thin porridge respectively). Whereas in the sensory tests most consumers preferred maize to sorghum, these preferences were not strong, implying that sorghum was accepted provided that the prices were reduced (Rohrbach and Kiriwaggulu 2001). The question remains: what strategies can be put in place to bring the price of processed sorghum down?

Darbrew's experience of sorghum use is instructive. Darbrew stopped using sorghum in 1995 when it failed to obtain clean grain either from the company's own farm in Morogoro or from the market. The brewery continued the production of 100% maize-based *Chibuku* (opaque beer). Under a pilot project, Darbrew worked with grain traders in Dodoma to purchase sorghum grain of brewing quality. Links were established between Darbrew and traders and between traders and village communities committed to producing grain for sale. Ultimately, the brewery obtained more than enough quality sorghum to meet its consumption needs. The traders and farmers were disappointed that only limited quantities—approximately 300 t by Darbrew and more than 400 t by Fidda Hussein Ltd for export—were purchased (Rohrbach and Kiriwaggulu 2001).

The development of supply chains is difficult because of the variable supply and tendency of supply to be based in the more isolated parts of countries. Grain assembly and transportation costs are high. Because of the variability of sorghum, any given delivery of white sorghum may include many varieties with different seed sizes, colours, shapes and hardness. But is the market differentiating the sorghums through premium prices for the good ones? Food and feed processors had little incentive to shift from maize. This substitute grain (maize) was readily and competitively available in both domestic and regional markets. Due to the lack of competitiveness on the side of sorghum and pearl millet, these crops are difficult to find in cross-border trade.

Main actors in the sorghum and millets markets in ECA

In identifying the main actors in the sub-sector, it is imperative to understand the locus that is addressed in the marketing chain. There are five main market types: village, near urban, urban, regional (within country) and cross border.

Village markets: These are mainly farmers who may also be using a barter exchange system at a significant level and trading sorghum, millets or both with other commodities and services including labour.

Near urban markets: At this locus, farmers, transporters and traders interact with each other. Rules and roles at play are essentially rural based and government intervention is minimal save for a few taxes that may be demanded by the local administration.

Urban markets: These involve farmers who are able to send their sorghum and millet loads to urban centres and who may also participate directly in the urban market. Researchers, policy makers and traders—retail and wholesalers, processors and transporters—are found here. Taxes are more visible and the business has to take place in administratively designated areas.

Regional (within country) market: These markets could be districts (as in the case of Uganda) or regions, as in the case of Tanzania. Farmers, researchers, policy makers and traders (all categories) interact at this level. Apparently, as opposed to maize, sorghum and millet have not yet caught the attention of regulators. This makes it possible for sorghum and millet to be allowed to cross district or regional boundaries even in periods of food shortage.

Although data are not available, quantities moving across regions are huge, particularly following years of good rainfall. The actors here are farmers, transporters, wholesalers and traders interacting with policy makers and regulators.

Cross-border markets: Key players in this segment of sorghum and millet marketing are farmers and traders (all categories). Again, data are not available but processors (from Kenya, Sudan and Tanzania) in verbal communications in meetings have indicated that they have access to raw materials from across the border. Although quantities of imports and exports are small, national statistics in the region rarely report this and when they do, the accuracy remains questionable.

Characterisation of actors is important because it is only through this categorisation that we can identify and strategise on interventions to assist the sector to grow and contribute to economic growth and improved livelihoods. At each level, the actors face different challenges in terms of:

- Information
- Price determination
- Degree of competitiveness
- Policies, rules and regulations

Appropriate partnerships between actors

The preceding section addressed the question of who the actors are. If actors work independently without deliberate attempts to form strategic partnerships, a number of lost opportunities arise. In such circumstances, there are losses in efficient information exchange, economies of scale and decreased competitiveness.

Usually, partnerships across the market participants—farmer and trader, trader and transporter and wholesaler and retailer listed above—are weak and largely informal in character. One also finds that these partnerships tend to be firmer as one climbs the marketing chain: very weak at the farm level and stronger as one climbs higher up the marketing chain.

Partnerships help create market links that are necessary and key to increasing production and food security because they provide a powerful incentive for smallholder farmers to invest in productivity-enhancing technologies. Unfortunately, strong partnerships between these actors do not exist. Where they do, they are short term—temporary and not binding. No one organisation can address all the factors necessary for stimulating adoption and marketing. Thus, the full range of actors—researchers, extension specialists, NGOs, farmers, farmer organisations, traders, transporters, processors, exporters and consumers—must work together.

It is a fallacy to assume that all farmers have access to markets. In most cases, in remote rural areas or those that are subject to large production variations (usually because of drought and poor technology adoption), smallholder farmers do not have access to markets. Neither do commercial firms have the incentive to invest in developing linkages with such farmers. The "invisible hand" will not operate in such circumstances; too many market imperfections constrain the notion of perfect market competition. Partnerships or links do not form automatically, they must be facilitated to form and function.

Gaps in and recommendations for marketing sorghum and millets

The sorghum and millet sub-sector is potentially an active contributor to improved livelihoods of millions of farm families, particularly those in the marginal areas. To facilitate this contribution four action points must be heeded by stakeholder participants in the sub-sector. These are discussed below.

Expand efforts towards utilisation of sorghum and millet

Although millet and sorghum face difficulties with competitiveness, it is possible to come up with innovative approaches through lobbying for increased utilisation of these crops, for example, in key institutions such as hospitals, prisons and schools. For example, in 2002 Tanzania requested the World Food Programme (WFP) to consider using sorghum for a school feeding programme with a view to stimulate the demand for the crop. WFP agreed and floated a tender that was won by Power Foods. About 400 t of sorghum were supplied to schools in Dodoma and Singida (Rohrbach et al. 2002).

Yield-enhancing technologies

We have not been serious enough in developing integrated technologies meant to improve yields of sorghum and millets. High-yielding varieties have to go hand-in-hand with crop management technologies. Simple technologies to increase water holding capacity etc. are needed. This is particularly important in regions of countries where sorghum and millet are important crops.

Innovative approaches to more effectively and strategically link different participants in the marketing chain

In the past there have been positive efforts in this direction (Shiferaw et al. 2006). However, these efforts have been sporadic. These efforts should be documented to determine the reasons for success and failure. There seem to be opportunities in the food, feed and brewing industry. However, there is need for a facility like ECARSAM to launch a short- to medium-term strategy for linking key participants together. A key issue here is to explore contractual arrangement options suited to different types of farmers with different groups of food, feed and brewing entrepreneurs.

Enhanced efforts to organise farmers in the sorghum and millet sector

Sorghum and millet have a solid future provided farmers organise themselves in various ways. One way is through small farmer groups organised for a specific function such as production, assembling, processing, selling, rural finance access, marketing etc. The challenge is where to begin; who would organise this; and who would remain committed to make sure that whatever the farmers propose happens.

Conclusion

The main points from the synthesis and documentation of SMIP and several efforts from the region, such as ECARSAM and other national efforts, in promoting sorghum and millet are:

- Commercial processing of sorghum is technically viable.
- Consumer demand for a series of sorghum products is evident.
- Erratic supplies caused largely by variability in rainfall continue to restrict the viability of commercial sorghum processing.

Remarkable improvements in the sub-sector are possible. These could come from yield-enhancing technologies, innovative approaches through linking farmers to markets more effectively and enhanced efforts to organise farmers in the sorghum and millet sector.

References

ECARSAM [Eastern and Central Africa Regional Sorghum and Millet Network] . 2005. Sorghum and Millet Research for Development in Eastern and Central Africa 2005–2010. Regional priorities. ECARSAM, Nairobi, Kenya.

Heinrich GM. 2004. A foundation for the future: The Sorghum and Millet Improvement Program (SMIP) in Southern Africa. Proceedings of the SMIP Final Review and Reporting Workshop, 25–26 November 2003, Bulawayo, Zimbabwe.

Heinrich GM 2003. The SADC/ICRISAT Sorghum and Millet Improvement Program: An overview. In: Heinrich GM, ed. 2004. A foundation for the future: The Sorghum and Millet Improvement Program (SMIP) in Southern Africa. Proceedings of the SMIP Final Review and Reporting Workshop, 25–26 November 2003, Bulawayo, Zimbabwe.

Minde IJ, Rohrbach DD. eds. 1993. Sorghum and millet marketing and utilization for food security and development. Proceedings of a national workshop, 3–5 May 1993, Arusha, Tanzania. p 130

Rohrbach DD, Mupanda K, Seleka T. 2000. Commercialization of sorghum in Botswana: Trends and prospects. SEPP Working Paper Series No. 5. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India.

Rohrbach DD, Kiriwaggulu JAB. 2001. Testing the demand for sorghum meal in Tanzania: A case study with Power Foods. *SMINET* Newsletter 3:14–15.

Rohrbach DD, Obilana AB. 2003. The commercialization of sorghum and pearl millet in Africa: Traditional and alternative foods, and industrial uses in perspective. Presented at the Expert Meeting on Alternative Uses of Sorghum and Pearl Millet, 1–4 July 2003, ICRISAT. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India.

Rohrbach DD, Mupeti ZJ, Ncube B, Mwaippyana H, Ngowi P. 2004. Commercialization of sorghum and millet in Southern Africa. In: p 78–95. Heinrich GM, eds. A foundation for the future: The Sorghum and Millet Improvement Program (SMIP) in Southern Africa. Proceedings of the SMIP Final Review and Reporting Workshop, 25–26 November 2003, Bulawayo, Zimbabwe.

Shiferaw B, Obare G, Muricho G. 2006. Rural institutions and producer organizations in imperfect markets: Experiences from producer marketing groups in semi-arid eastern Kenya. Socio-economics and Policy Working Paper 23. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India.

3.2. Experiences in farmer collective action in marketing of sorghum and millet in Uganda: A case study on Masindi Seed and Grain Growers Limited

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Introduction

Uganda is one of the countries in the Eastern and Central Africa (ECA) sub-region; it has a population of about 26 million. Uganda's economy is based on agriculture which accounts for 80% of the GDP. A total of 95% of the rural communities derive their livelihoods from this sector. Sorghum and millet form the main staple food for people in the rural areas. Masindi Seed and Grain Growers Limited is based in Masindi District, 1 of the 76 districts in the country.

Challenges

Since 1986 the Ugandan economy has gone through many economic reforms due to the influence of the International Monetary Fund (IMF) and the World Bank. This has led to:

1. The collapse of the cooperative movement that formed the engine of rural transformation in terms of organising smallholders around specific crops, for example, coffee, cotton, tobacco, tea, and, of late, non-traditional cash crops such as maize, beans and sesame. Marketing boards that were specific for crops were in place, therefore, assuring the farmers of a market for their products.
2. Complete liberalisation of the economy that introduced the theory of market forces.
3. Divestiture of government parastatals.
4. Introduction of a new economic system like the:
    - Private sector
    - Modernisation of agriculture
    - Rural development strategy

Opportunities

The challenges that called for a concerted effort to address and alleviate farmers' problems ranging from agronomy to marketing were enormous. Masindi Seed and Grain Growers Limited was therefore founded in 1987 to organise seed contract growers for a Uganda seeds project, a government parastatal.

Collaboration

As a way to enhance its capacities, the organisation has had several development partners since 1987. Table 1 shows the number of development partners and their various contributions.

Table 1. Partners of Masindi Seed and Grain Growers Ltd and their contributions

No.	Collaborator	Period	Role
1	Uganda Seed Project (USP, Government of Uganda)	1987-2003	- Seed multiplication - Training
2	America Development Foundation (ADF, USA)	1995-1998	- Infrastructure development - Storage/processing Machinery
3	Agricultural Cooperative Development International/ Volunteers in Overseas Cooperative Assistance (ACDI/VOCA, USAID)	1995-1997	- Technical assistance - Business planning - Post-harvest handling
4	Uganda National Farmers Federation (UNFFE)	1997	- Training - Farm management - Marketing - Group dynamics
5	Agricultural Sector Programme Support (ASPS, DANIDA)	2004	- Capacity building - Infrastructure enhancement - Grain processing machinery
6	Agricultural Productivity Enhancement Programme (APEP)	2003	- Training
7	United Nations Development Programme (MNPS, UNDP)	2004	- Training in financial mobilisation/ formation of SACCOS
8	Uganda National Agro-input Dealers Association (UNADA)	2005	- Input supply
9	National Agricultural Research organisation-Serere Semi Arid Resources Research Institute (NARO/SAARI, National Semi Arid Resources Research Institute)	2004	- Promotion of technologies - Epuripur - Finger millet-Sereme
10	Eastern and Central Africa Regional Sorghum and Millet Network (ECARSAM)	2006	- Training - Workshop - Exposure
11	World Food Programme (WFP)	1999	-Marketing/standards

The growth of the capacity of Masindi Seed and Grain Growers Limited, ranging from human resources to physical infrastructure development, has been achieved through the aid of collaborators. Therefore the most critical factors affecting smallholders and farming, in general, are being tackled collectively.

Production

Before addressing the issue of marketing, production of the target crop has first to be planned for.

Pre-season seminar

Farmers are trained twice a year on enterprise selection. At the seminar, many crops are examined in terms of production cost and yield performance. Other issues such as farm management, post-harvest handling and storage, and contracts are discussed. These discussions are critical for effective marketing since the following factors are agreed upon:

- Variety
- Period
- Quantity/quality
- Terms of the contract

Marketing

Marketing is part of the supply chain where quantity and quality issues are critically addressed.

Processing

Semi-processing such as threshing, winnowing, drying and bagging is done at farm level.

Bulking

Bags of produce are carried to established collection centres and then the supplies from the collection centres are delivered to an agent in Kampala. The farmer is required to cooperate and be fully committed because these processes determine the final price for the farmer.

Finance

- Linking farmers to financial services is part of Masindi Seed and Grain Growers Limited activities. The management negotiates financial packages with credit agencies (such as banks, microfinance institutions) and encourages individual farmers to access them. Repayment of loans is done after the sale of proceeds and the payments are channelled back to the credit agencies through the company.

- Farmers are also encouraged to save with Masindi District Farmers Association's Savings and Credit Cooperative (SACCO). After accumulating funds, farmers are able to borrow funds from the SACCO at an interest rate of 13% p.a.

Extension services

Extension service providers (public and private) provide Masindi District Farmers Association (MADFA) with support to extend extension services (such as pre-season training, farm visits, field days etc.) on demand.

Cost–benefit analysis

A cost–benefit analysis using the data provided in Tables 2 and 3 shows that there is a profit margin of USh106,000 (52%) to growing one acre of sorghum.

Table 2. Sorghum production analysis for Masindi Seed and Grain Growers Ltd (2004-2006)

Period	No. of farmers	Acreage	Tons	Rate (USh)	Amount (USh)
2004/B	150	275	210	300	63,000,000
2005/A	235	353	247	300	74,100,000
2005/B	278	400	176	310	54,560,000
2006/A	342	706	720	310	223,200,000
2006/B	436	860	-	-	-

A = March to June season; B = September to December season.

USh 1725 = US$ 1.

Conclusion

Farmers' collective marketing has proved to be viable and effective. The number of farmers growing sorghum has continued to grow since 2004 when Masindi Seed and Grain Growers Limited started promoting it. Yields have improved from 700 kg in 2004 to 1000 kg in 2006/A. The ASARECA Staple Crops Programme should therefore adopt this model and, where appropriate, replicate it in the ECA region.

Way forward

- Establish strong viable linkages to network among farmers, service providers, researchers, processors, industrialists and policy makers.
- Strengthen the lead role of the ASARECA Staple Crops Programme in coordination of research and information dissemination on sorghum and millet.

Table 3. Production cost for 1 acre of sorghum (season A, 2005)

No.	Activity	Period	Rate (USh)	Amount (USh)
1	Land preparation:			
	- Slashing	February	15,000	15,000
	- Ploughing 1st	February	50,000	50,000
	- Ploughing 2nd	March	30,000	30,000
2	Seed purchasing	March	800	4,000
3	Planting/sowing	March		15,000
4	Weeding	April		20,000
5	Bird scare	May		20,000
6	Harvesting	May/June		20,000
7	Threshing	June/July		10,000
8	Winnowing	June/July		5,000
9	Drying/bagging	June/July		5,000
10	Bulking	July		10,000
	Total			204,000

USh 1725 = US$ 1.

Cost–benefit analysis for one acre

Yield: 1000 kg

Production cost: USh 204,000

Therefore: 1000 kg at 310/kg = 310,000

Less production cost: 310,000-204,000 = 106,000

C.B.A. = 106,000 ÷ 204,000 = 52%

There is a gross margin of USh 106,000, which is 52%.

3.3. Marketing of sorghum grain in Kenya: A case study

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Introduction

Since independence, Kenya has relied heavily on the agriculture sector as the basis for economic growth, employment creation and foreign exchange generation. Agriculture accounts for about 30% of GDP (Table 1). The sector is also a major source of the country's food security and a stimulant to the growth of off-farm employment, thereby contributing to 80% of Kenya's work force.

Table 1. Contribution of agriculture sector to Kenya's GDP

Economic indicator	Year							
	1990	1995	2000	2001	2002	2003	2004	2005
Annual GDP growth (%)	4.2	4.4	-0.2	1.1	1	1.3	2.5	4.3
Contribution of agricultural sector (%)	29.1	31.1	19.7	18.6	16.4	25.3	24.3	24.2

Source: Economic surveys (1990–2005).

Table 1 shows that growth in the agriculture sector is closely linked to the overall economic growth in Kenya. Improving the performance of the sector will help reduce poverty since approximately 80% of the country's population lives in rural areas and depends on agriculture for their livelihood.

Production trends and marketing of sorghum in Kenya

Sorghum is an important source of food and additional income to most of the farm households in the arid and semi-arid lands (ASALs). These areas have the potential to produce sorghum and other drought-tolerant crops, which have a major role to play in poverty alleviation (FAO 1996). However, the broader comparative agro-ecological advantage of these crops remains unexploited.

In Kenya sorghum is largely a subsistence crop grown in marginal lands, where farmers value and grow the crop due to its tolerance to low and poorly distributed rainfall (Sutherland and Songa 2002). Despite its adaptation to poor soils and low rainfall areas, sorghum production and the acreage under sorghum appear to have remained static over the years (Figures 1 and 2). This indicates that production of sorghum is lower than that of maize and yet the crop has an agro-ecological advantage in the ASALs of Kenya.

Annual rainfall in Kenya's ASALs is unreliable and erratic and crop failures occur on a regular basis. The increased dominance of maize and the shift away from traditional drought-resistant crops has increased the risk of crop failure. Nevertheless, maize has continued to be the dominant crop taking the place of sorghum, with farmers growing less of the drought-tolerant crop year after year.

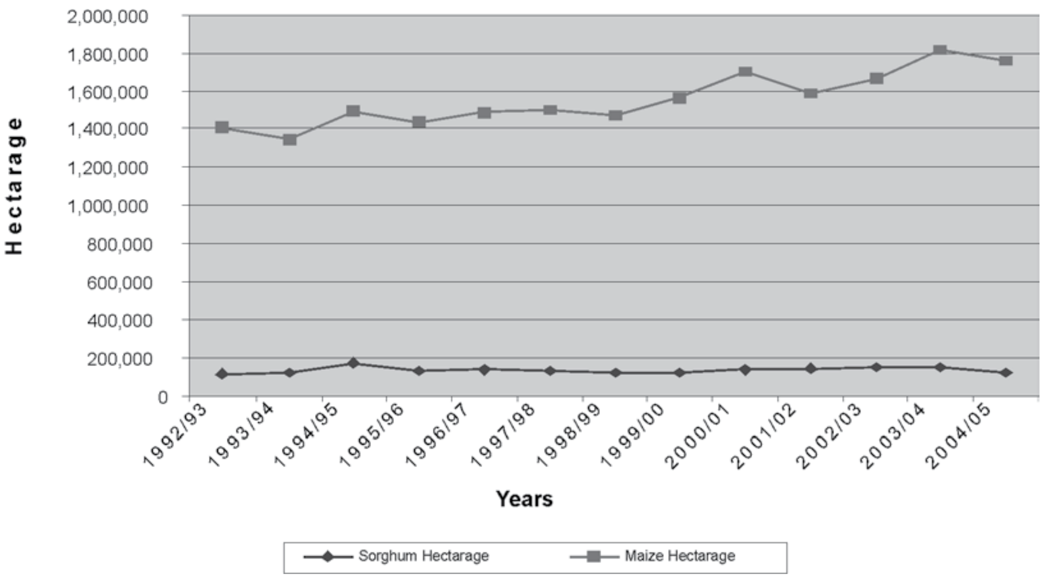

Figure 1. Hectares of sorghum and maize, 1991–2005.
Source: Ministry of Agriculture (2006).

Comparison of production trends for sorghum and maize in Kenya
The downward trend in sorghum production can be attributed to:

- A decline in the consumption of sorghum as food due to changing consumer preferences.
- The well-developed marketing system for maize unlike that for sorghum. Farmers can easily sell their surplus maize, but there is less demand for sorghum at farm level. Hence, farmers have been discouraged from producing sorghum due to the low prices that the grain fetches in the market.

- Unfavourable government policies have also led to a decline in sorghum production. Before the mid-1980s the policy environment was less than supportive of the food grains suited to semi-arid areas.

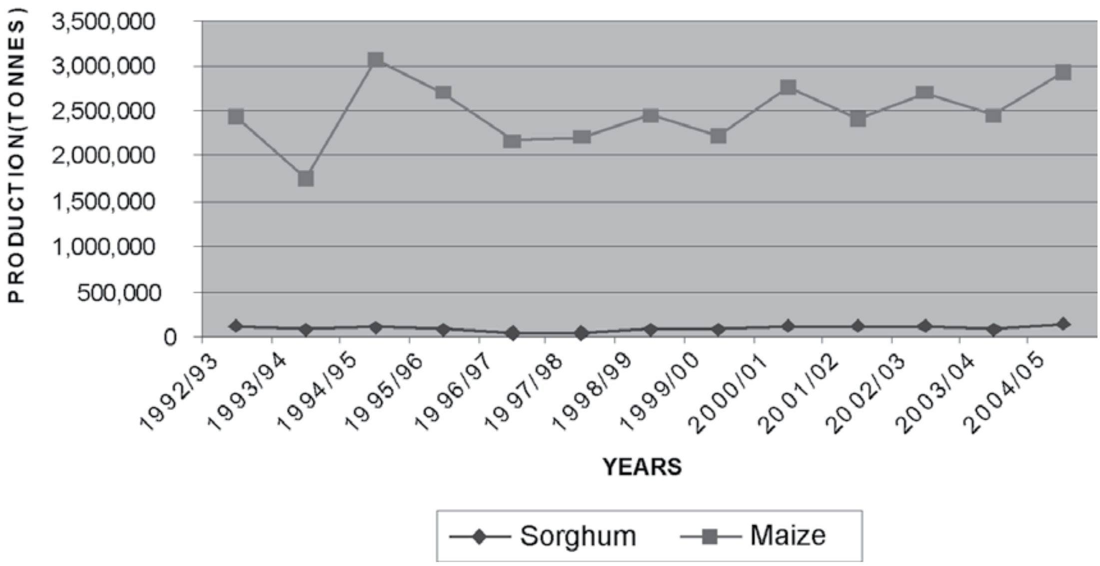

Figure 2. Production trends for sorghum and maize (1991–2005).
Source: Ministry of Agriculture (2006).

Government market policies encouraged commercial trade and processing of other crops such as maize, but not sorghum (Maritim 1984). Most policy documents on agriculture and food, for example, the five-year development plans in Kenya, tended to ignore sorghum in previous years. The fact that food aid has been provided almost exclusively in the form of maize and beans may also have contributed to the shift in consumption preferences towards foods that may not be suitable for growing in drought-prone areas. In the long run, these policies had two effects: they changed the food preferences of consumers in the dry areas away from semi-arid food grains to maize and altered farming skills. Farmers thus switched to maize production in response to strong market incentives. That maize was less drought resistant made farmers in the ASALs far more vulnerable to drought and thus more impoverished.

The absence of adequate pricing and marketing incentives as evidenced by low producer prices at the end of the growing season have discouraged sorghum farmers from producing surplus grain (FAO 1996; Kavoi, 2003). The low productivity has thus resulted in inconsistent supply of the grain to processors.

Given the important contribution of agricultural production to household incomes, expanding crop sales is a potential strategy for increasing cash incomes. Since most sorghum is still grown by poorer small-scale farmers in the ASALs, improving the efficiency of marketing the grain would ensure efficient prices and thus increased marketed output. Efforts must therefore be made to exploit whatever potential exists in the agriculturally marginal areas of Kenya.

Furthermore, information is limited on the existing marketing system within the district and on the opportunities for marketing the grain in Kenya, which is necessary if the market for sorghum grain is to be successfully developed. The purpose of this study was to generate information on sorghum marketing to guide policy makers and other relevant stakeholders make decisions geared towards the success of commercialising the sorghum industry in Kenya. This paper details the different channels of movement of grain from farm gate to major urban centres. The profit margin for each of the channels is also presented.

Area of study

Mwingi District in the Eastern Province of Kenya was the focus of this study. The district was considered for the study because it lies in the ASALs and it is one of the districts where sorghum is widely grown by small-scale farmers.

Mwingi covers about 9719 km2. The population is currently estimated at 355,000 people with an average population density of 37 persons per km2 (Government of Kenya 2000). The altitude ranges from 177 to 477 metres above sea level.

Rainfall

Rainfall ranges from 300 to 1000 mm per year and is bimodal in pattern. The district has two cropping seasons: the long rains (which are less reliable) that run from March to May and the more reliable short rains, which run from October to November. The long rainy season is characterised by low and poorly distributed rainfall, often resulting in crop failure (Ministry of Agriculture 2005). Most farmers mainly grow cereals such as maize, sorghum and millet. Beans and green grams are mainly grown as cash crops though other foods are also sources of income for many households.

Soils

Soils are mainly sandy loams with few patches of clay and black cotton soil.

Sampling procedure

Traders

Two major sorghum markets, Nguni and Mwingi, in the district were purposely sampled and all traders dealing with sorghum in each of the market centres were targeted for the survey. Twelve traders were interviewed in Mwingi market and 13 traders were interviewed at Nguni market.

Processors

Major urban centres (Machakos, Mombasa, Nairobi and Thika) were also sampled. One livestock feed industry and one food industry were purposely sampled for the survey in Nairobi, one food industry in Machakos, one livestock feed industry in Thika, and one feed processor in Mombasa.

Data collection

Before the survey, the author trained three enumerators who would assist in the main exercise. The team conducted the survey in April and May 2005. Single visit, personal interviews were used to collect data from each of the sampled groups using pre-tested structured questionnaires.

Results and discussion

Sorghum marketing system

According to the survey findings, private traders move traded sorghum from rural supplying areas to major urban centres. A visit to the cereals and produce board at the Mwingi District headquarters confirmed that no sorghum has been bought in the past 10 years.

The amount of sorghum transacted by different traders varied widely. In Nguni, the lowest transaction was 2 bags and the largest was 100 bags, whereas in Mwingi the lowest was 2 bags and the largest 2500 bags.

The following section details the existing marketing channels for the grain, the functions at the various marketing channels and the profit margins. Figure 3 presents the various marketing channels for the grain in Mwingi.

Functions and profit margins at the various marketing levels

Producers

At this level each farmer markets the crop individually at the nearest local shopping centre. The produce is usually sold immediately after harvest due to household financial constraints. The grain is ferried to the market using personal donkeys or bicycles. During this period, agents of store owners and wholesalers flock to the market centres to purchase various types of grain, sorghum included. Buyers take advantage of increased supply at harvesting time and purchase the grain at an average price of KSh 5 per kg.

Local agents

The local agents are based at the local shopping centres and at the divisional market centres. They are middlemen or agents who are given money by store owners/wholesalers at the divisional or district headquarters to assemble large quantities of the grain and are paid on a fixed commission per kilogram of grain assembled. They negotiate a lower price with producers to reap more benefit from the sales. Transport is hired or provided by the wholesaler/store owner at the rural urban centres.

Store owners

Store owners could be either resident grain assemblers or rural/urban business people who have the financial ability to purchase and store produce. They own or rent storage space for grain trading. They buy produce from either local agents or in small lots from individual farmers at their stores and sell either to the wholesalers, retailers or local consumers. The store owners may store the grain for long periods of time in anticipation of more favourable prices. The average storage period is 4 months.

Wholesalers

Wholesalers rely on agents and storeowners to purchase sorghum grain from producers. They provide the required funds, transport and bags to the agents to buy the produce. When the wholesalers do not have a ready market for the grain, they store it in warehouses for in anticipation of more favourable prices. They also buy produce from store owners at a small discount when they discover a favourable market outlet. Most of the grain at this level is destined for market outlets in major urban centres, especially Nairobi, Thika and Mombasa.

Retailers

Retailers are mainly shopkeepers dealing with various types of merchandise. They are based at local shopping centres, divisional market centres or at rural urban centres. They purchase their stock directly from producers at the peak of harvesting time. They sell their grain mainly to local consumers who purchase the grain in small quantities.

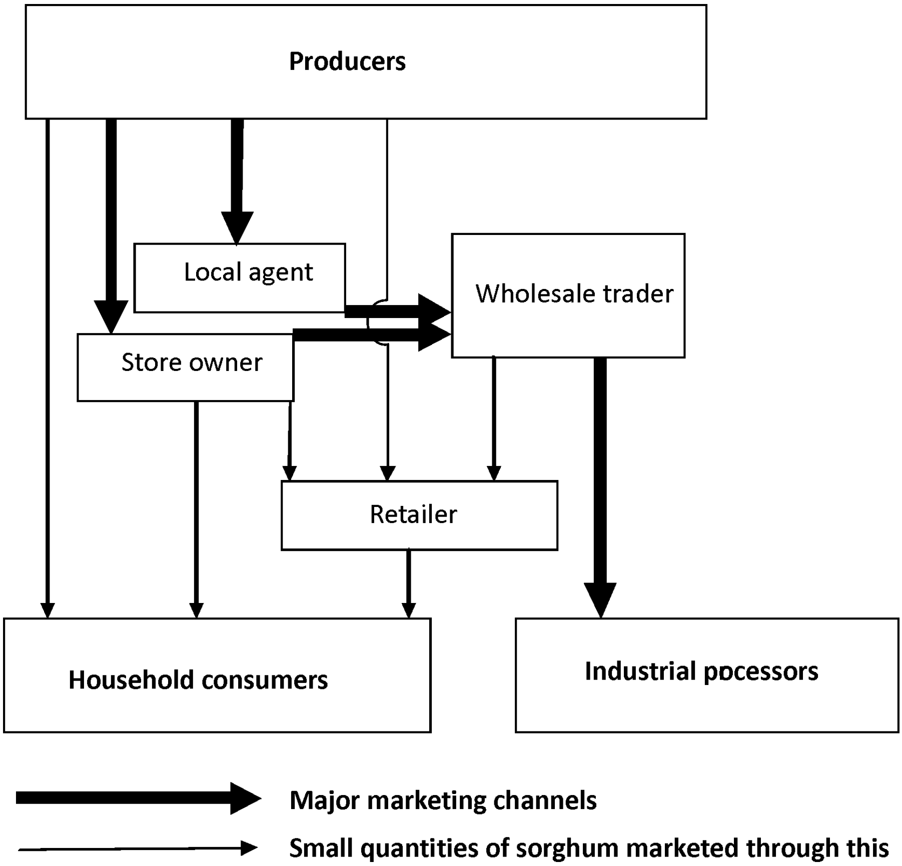

Figure 3. Marketing channels for sorghum in Mwingi District.

Consumers

Consumers are grouped into two categories:

i. Household consumers: Most household consumers purchase the grain in small quantities from their nearest shopping centres for home consumption. They can also be producers who sold off their produce earlier on who wish to buy grain seed.

ii. Industrial consumers or processors: Industrial consumers purchase the grain in large quantities and are based outside the district in Thika, Nairobi and Mombasa. The grain is usually utilised for human food and animal feeds. Traders from outside the district may either collect the grain from store owners or wholesalers or sometimes the grain is delivered to processor and the cost borne by the buyer as agreed.

Channel-01

Producer → Local agent → Wholesale trader → Industrial processor

Percentage of produce marketed through this channel—50%

		KSh/bag	% of selling price
Local agent	Purchase price	320	
	Selling price	400	
	Gross margin	80	20%
Wholesale trader	Purchase price	400	
	Selling price	1200	
	Gross margin	800	
Costs			
Transport costs		150	
Handling (weighing, loading, unload, reloading)		20	
Packaging material		25	
Overhead costs plus			
Storage costs		15	
Total cost		210	
Net margin		590	49%

Channel-02

Producer → Local agent → Store owner → Wholesale trader → Industrial processor

Percentage of produce marketed through this channel—30%

		KSh/bag	% of selling price
Local agent	Purchase price	320	
	Selling price	400	
	Gross margin	80	20%
Store owner	Purchase price	400	
	Selling price	800	
	Gross margin	400	
Costs			
Transport costs		50	
Handling (weighing, loading, unloading, reloading)		20	

Packaging material		25	
Overhead costs plus			
Storage costs		10	
Total cost		105	
Net margin		295	37%
Wholesale trader	Purchase price	800	
	Selling price	1200	
	Gross margin	400	
Costs			
Transport costs		100	
Handling (weighing, loading, unloading, reloading)		10	
Overhead costs plus			
Storage costs		15	
Total costs		125	
Net margin		215	18%

Other minor channels

Percentage of produce marketed through other minor channels—10%

The above analysis indicates that local agents are involved in the marketing of more than half of the total volume of marketed sorghum. It also indicates that wholesalers and store owners enjoy excessive profits in the sorghum trading chain.

Constraints experienced in sorghum marketing

- Supply shortage: The results also showed that none of the traders traded sorghum grain entirely. All traders indicated that they only sold a small percentage of the sorghum grain as compared to other cereals due to unreliability of market outlets and prices, and the vulnerability of the grain to weevils.
- Lack of transparency in obtaining market information.
- Inadequate information on market outlets and prices was a major barrier into entry into this business.

Channel-03

Producer → Store owner → Wholesale trader → Industrial processor

Percentage of produce marketed through this channel—10%

		KSh/bag	% of selling price
Store owner	Purchase price	400	
	Selling price	640	
	Gross margin	240	
Costs			
Transport costs		50	
Handling (weighing,			
loading, unloading, reloading)		20	
Packaging material		25	
Overhead costs plus			
Storage costs		10	
Total costs		105	
Net margin		135	24%
Wholesale trader	Purchase price	640	
	Selling price	1200	
	Gross margin	560	
Costs			
Transport costs		100	
Handling (weighing,			
loading, unloading, reloading)		10	
Overhead costs plus			
Storage costs		15	
Total costs		125	
Net margin		435	36%

Constraints experienced in use of sorghum by processors

According to the study, constraints experienced in the use of grain sorghum as raw material in the food and feed industry include:

- Unfavourable prices.
- Unreliable supply of the grain. Sorghum grain is not as readily available as maize. Small quantities are held/stored by traders at any given time.
- High tannin content which makes the grain unfavourable for use as feed.
- High waste due to fine dust, sand and stones.
- High vulnerability of the grain to infestations.

Conclusion and recommendations

Increased production of sorghum is based on improved efficiency and increased industrial use, which will enhance its demand within and outside the country. However, promoting the industrial use of sorghum grain in Kenya will depend on the competitiveness of the grain as an industrial input. The following are some possible recommendations for improving the sorghum trade.

- The increase in demand for the grain has to go hand-in-hand with increased production. Increased production will ensure an adequate and reliable supply of the grain throughout the year.
- Formation of institutions at the local level such as farmers' groups/associations to increase bargaining power and avoid exploitation by middlemen.
- Market information is needed at all stages of the marketing chain to enable participants to make informed decisions on production, marketing and consumption. Lack of market information reduces producers' bargaining capacity and ability, resulting in low prices for the grain and disincentives to increased sorghum production. Better consumer information about various industrial products from the grain could contribute to the growth of the demand. This implies a need for consumer information regarding utilisation of processed sorghum grain with respect to foods and feed.
- Information dissemination on market outlets should be enhanced among farmers and other relevant stakeholders within the grain marketing chain.
- The government and private lending agencies should readily avail credit, especially for storage facilities.
- Improvements in the quality and cleanliness of the grain would reduce cleaning and milling costs. Thus the grain will fetch a higher price at the industrial level. Training is also needed on post-harvest handling.
- The possibility of exporting sorghum should be explored. Studies to determine the level of demand for the grain in neighbouring countries should be undertaken in an effort to increase the demand for the grain.

References

FAO [Food and Agriculture Organization of the United Nations]. 1996. *The world sorghum and millet economies: Facts, trends and outlook.* FAO, Rome, Italy.

Government of Kenya. 2000. Population Census.1999. Central Bureau of Statistics, Government of Kenya.

Kavoi J. 2003. Crop protection contribution towards improved livelihoods in Semi Arid Eastern Kenya: Challenges and opportunities. MSc thesis. University of Greenwich.

Maritim HK. 1984. The economics of sorghum processing and marketing in Kenya. An appraisal of producer-consumer cost linkages of pearled sorghum, sorghum meal, sorghum flour and sorghum grain. Department of Agricultural Economics, University of Nairobi, Kenya.

Ministry of Agriculture. 2005. Annual Report 2005. Ministry of Agriculture, Nairobi, Kenya.

Sutherland J, Songa J. 2002. Sorghum project mid-term review report. Natural Resources Institute, Chatham, UK.

3.4. Tanzanian experience in international sorghum trade

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Introduction

World trade in sorghum is strongly linked to demand for livestock products, dominated by feed requirements and prices in developed countries. Since trade is primarily for animal feed, volumes are sensitive to sorghum/maize price differentials and can fluctuate considerably. Only small per cent of world sorghum trade is for use as food. This is mainly imported by countries in Africa. Some estimate that it might be between 6% and 10% of the total trade of sorghum, which was about 8 million tons in 1994.

Price factor in sorghum trade

Grain merchants in Tanzania export small quantities of sorghum in the very competitive international market. The factors that contribute directly to the price in sorghum trade include:

1. The narrowed export price gap between maize and sorghum during the 1990s which made sorghum less competitive as a feed ingredient.
2. The major exporters are Argentina, Australia, China and USA, which together ship more than 90% of the global export volume.
3. Imports are concentrated in a few countries—Japan and Mexico alone account for about 80% of international imports. China might become a net importer of sorghum as well.
4. International market prices for sorghum are largely determined by the supply and demand situation in USA, and export prices are based on the reference sorghum, US Milo no. 2, yellow. Since sorghum is almost exclusively traded for feed, market quotations are closely related to price movements for other feed-quality grains, mainly maize, wheat and barley.
5. One important trend is that sorghum imports by developed countries have fallen sharply, while those by developing countries have increased considerably in response to growth in livestock production. As a result, the share of developing countries in world sorghum imports has increased substantially, from 3–4% percent in the early 1960s to about 55% in 2005.

Constraints to sorghum trade

Tanzania in particular and developing countries in general face a number of problems in exporting sorghum. The reasons for this are:

1. The volume they have for sale is usually small and not available regularly.
2. The quality is variable.
3. Yields are low.
4. High costs of inputs and inland transport.
5. Overvalued currencies which make exports uncompetitive in the highly competitive international market.
6. Strong competition on international grain markets.
7. High assembly and transportation costs make it difficult for these countries to export.
8. International sorghum prices move very closely with those of maize, the world's most important feed grain, but are usually slightly lower.
9. Prices vary during the year; they are lowest immediately after the harvest, when supplies are abundant, and increase as the year progresses. This variation in price is greatest in countries where sorghum is the main staple, and results in price unreliability.
10. Limited use of sorghum in food industries in ECA countries.

Way forward for regional and international sorghum trade

On balance, sorghum will remain a key food security crop in Africa for the foreseeable future. Productivity gains are essential to offset the prospects of continuing food production shortfalls in most semi-arid regions and the prospects of periodic famine.

The world sorghum price increased in 2006/2007 to US$105 per tonne, as production decreased more than consumption.

Developing countries already have an un-organised volume of trade between them. This is limited and often restricted to cross-border and triangular food aid transactions. However, official statistics underestimate trade volumes in some regions. Intra-regional trade in western Africa, for example, is believed to be considerably larger than officially recorded. A substantial portion of the trade between the Sahelian countries, and between some of them and their coastal neighbours is unrecorded. Similarly, much of the trade between Sudan and its neighbours is unrecorded. This substantial, unofficial trade is caused chiefly by differences in policies (e.g., support prices, foreign exchange rates and government restrictions on trade) between the trading partners.

3.5. Recommendations on marketing and markets

The issues on markets are mainly on improvement of both input and output markets. The first issue is to link farmers with input markets to produce demand-driven products and the second is to link farmers with traders and processors. Recommendations made included:

- Enhancing seed multiplication and adoption of appropriate technology to improve seed availability.
- Supporting research on micro-finance and credit systems in the region and make the information available.
- Forming farmers' groups to enhance production and marketing of sorghum and millet for various end users.
- Establishing/strengthening linkages or partnerships between farmers, processors and marketers.
- Government intervention in infrastructure, security and supportive policies to enhance sorghum and millet marketing
- Enhancing market information systems for all stakeholders.
- Training in quality control along the sorghum and millets production and processing chain.

CHAPTER FOUR

POLICY ISSUES

4.1. The policy environment for sorghum and millets in Eastern and Central Africa: An overview

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Introduction

What is policy?

The term "policy" is used by different people and at different times to mean different things. The simplest definition though is "a policy is a statement of intent aimed at providing a general direction on how business should operate" (Minde and Waithaka 2006). This could be public or private business. Certain effects are a result of economic, institutional and political processes and not a result of policy. For example, globalisation is not a policy issue, but rather a result of economic processes which, in turn, are a result of increasing interdependence amongst nations made possible through trade liberalisation, advanced information and communication technology. The desire for a policy formulation is to improve the way business is done. A policy can be judged to be right or wrong or it can be felt to be good or bad (Idachaba 2002). From the foregoing definition and description, it can be said that one should expect a policy formulation to be a process involving several stages and also involving more than one person. This is because "wants" differ from one person to another and from one group to the other. What a range of individuals and groups input into the process is therefore paramount. But, more often than not, what we experience in the real world of politics and interest groups is a situation full of policy changes and reversals. We also find that more often than not, policies are simply pronouncements by individuals. These pronouncements are made without inputs from others including those that the policies are expected to affect.

The outcome of any given policy is expected to be positive from the point of view of the formulator, the ones to be affected by the policy, and of society. However, as it usually turns out, there are always winners and losers. A policy that stipulates marketing of agricultural products through cooperatives may reduce the profit margins of individual traders, whereas for farmers such a policy may translate into higher farm gate prices.

The contribution of policy research to policy making is long on prescriptions of what needs to be done to spur agricultural growth, but falls short on how such prescriptions might be implemented in practise. The dominant model that has been used several times and seems to work in the region is the rational model whose underlying metaphor is the policy cycle. The policy cycle comprises problem definition and agenda setting, formal decision making and policy implementation, evaluation and back to problem definition and agenda setting. It assumes a balanced, objective and analysis-based process. Although it has been criticised as being too simplistic and unrealistic, it remains the dominant framework guiding attempts to bridge the gap between researchers and policy makers and has borne fruit in many instances.

Some of the policies from the colonial era that exist to date have been overtaken by rapid changes in sectoral, national, regional and world dynamics including high population growth rates, effects of structural adjustment, rapid urbanisation, liberalisation and globalisation. Major reversals have taken place in the roles of the state in key economic activities such as marketing to providing an enabling environment. While the private sector has discovered its rightful roles in some areas, many glaring gaps wait to be filled. The policy environment is thus often characterised by a disconnect between key actors, policy makers, enforcement agents, and researchers. In practise, policies are implemented in a haphazard manner and are weakly enforced. Furthermore, the response time is slow between policy reforms and implementation.

Overall, most policies address single components (such as water policy, natural resource policy, land use policy, grain production and marketing policy) and are not enveloped in wider systems frameworks, which would imply multi-institutional and sectoral strategies to govern formulation of solutions. This has resulted in frequent conflicts in sectoral policies. For example, a policy to subsidise maize producers leads to a non-level playing field for sorghum farmers.

How are policies made?

Based on strong government control in the past, policy making has often been left to the governments. We also note that policies can be formulated hurriedly or they can also involve a protracted process. Policies can simply be declarations or pronouncements or can also be a process involving several stages. A policy process can also be orderly or chaotic and, in the extreme, we can also have them in unwritten form. But their richness, relevance, ownership and ability to be implemented is a function of the degree of participation and inclusiveness of those who will implement and those who will be affected by those policies (ECAPAPA 2004).

The process of policy formulation is slowly changing with wider stakeholder participation in driving for policy reforms.

In an ideal world, participatory ways of encouraging dialogues are needed to identify constraints, prioritise them and come up with informed mechanisms for developing economically sound, technically feasible and culturally acceptable solutions (ECAPAPA 2002). Potential tools in this process include use of collective action approaches such as community-driven development, sub-sector stakeholders, farmer participatory research, promotion of community innovations responding to the challenges at hand, and policy cycle in dialogue and communication. Ex ante assessments of different policy options are needed. Sadly, insufficient time is allocated for this despite its importance.

Theoretically, we talk of four stages of policy making: policy formulation and design, policy trials, policy implementation and, finally, policy impact assessment (ECAPAPA 2002). In practise though, we rarely see that orderly sequence. The most common feature is a random pronouncement and haphazard implementation of policies. Rarely do we see assessment of policy impacts arising from such policies.

A sequential process of policy formulation would follow a policy change cycle as depicted in Figure 1. This framework pursues a policy change process through a four-stage procedure of data collection, analysis of data collected, which then leads to policy dialogue process of key stakeholders from both the public and private sector. The intent is that policy dialogue would lead to the fourth step, which is policy action.

The policy change cycle can be viewed as a model for a multi-stakeholder, multi-disciplinary and cross-institutional approach for transforming research and analysis recommendations into policy actions. It thus acts as a loop (bridge) between agricultural policy research findings and practice.

The main features of the policy change cycle

Identification of the problem

A key determinant of the success of any given policy is the degree to which the problem at hand is common and the extent to which it is consultatively developed. In the sorghum and millet sub-sector, for example, policies made will be most meaningful if the problem is common from the point of view of the stakeholder participants who are farmers, traders, processors and consumers.

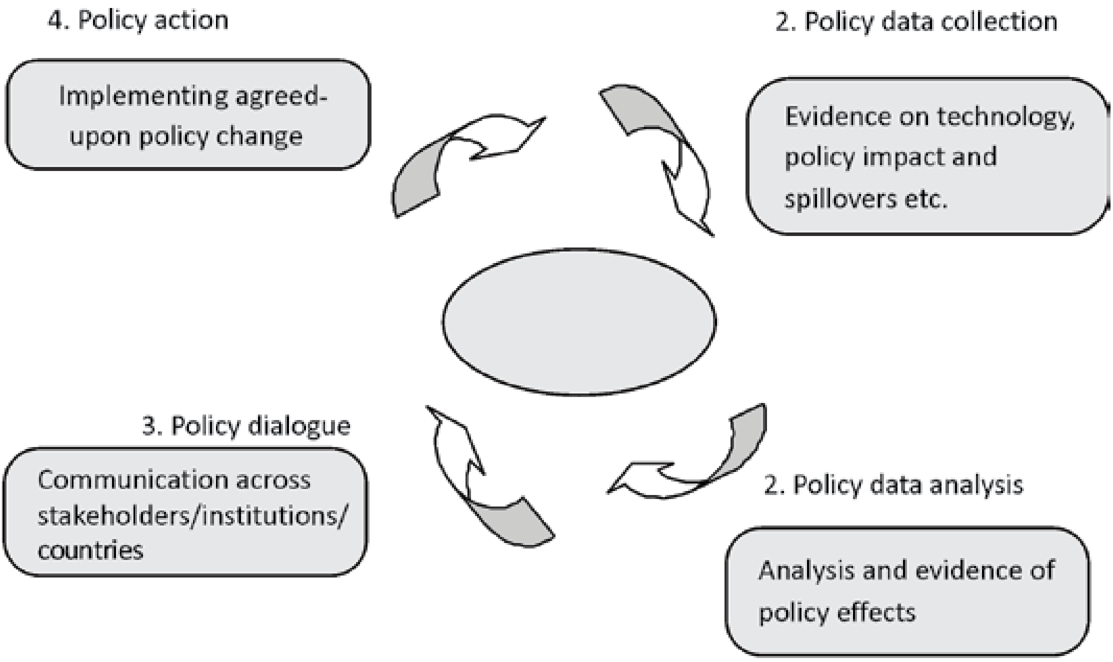

Figure 1. Policy change cycle (ECAPAPA 2002).

As depicted in Figure 2, researchers must continuously communicate with the decision makers, frontline workers and groups not only to identify and describe the problem but also to share intermediate and final outputs of the research. Communities, groups and individuals in essence are on the demand side of policy formulation; they are the main implementers of the resultant policy and they face the consequences—negative or positive—of the policy. Yet, they are frequently neglected in the consultations.

Policy data collection

The types of data collected must be relevant to the problem and must be collected by competent authorities that are also accepted by the communities from which data and information are being gathered. In situations where data are collected on the same problem but in different districts, regions or countries, efforts must be made to finally come up with comparable data.

Policy data analyses

The main purpose of policy analysis is to strengthen knowledge that will inform policy choices. Analysis ought to come up with informed policy options that show the economic (these are often times referred to as social or societal) and financial costs and benefits of undertaking each of the options. For each policy option, there are winners and losers and varying magnitudes of the loss or gain. It is paramount that the corresponding values are laid out clearly including the distributive impacts across different social and economic groups. The challenge in policy data analysis is to avoid rushing into advising on policy without a solid research base (ECAPAPA 2004). To overcome this, it is advisable to subject the resulting policy options to a peer review process with a view to ensure that the whole exercise is thorough and scientific. Sufficient preparations must be made before walking to the dialogue phase.

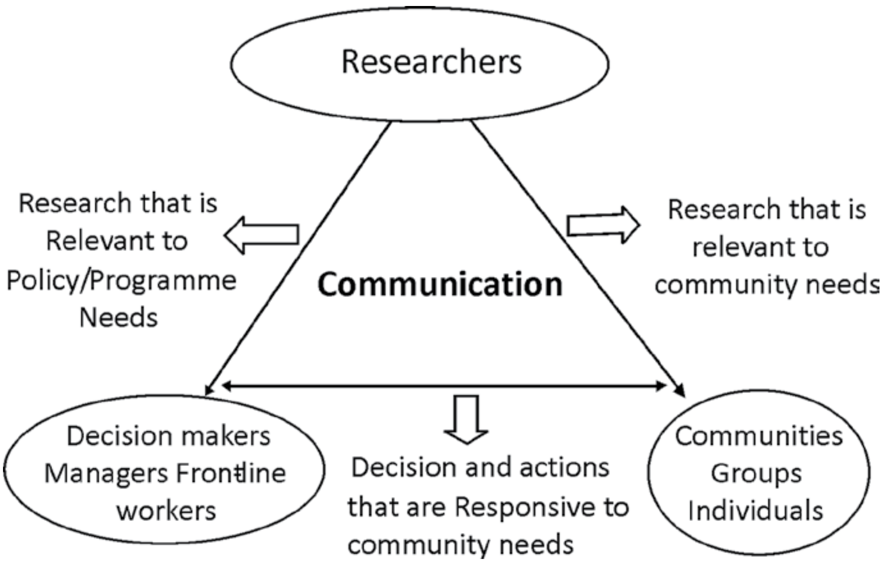

Figure 2. Research, community, and policy makers interactions (ECAPAPA 2002).

The analyst, before the dialogue, must have done sufficient homework to determine whether the proposed changes/options are in line with the existing legislation. For example, some options may simply require administrative procedural changes whereas others may demand repeal or modification of existing laws.

Policy analysis tools must be sound and should be applied to problems that the policy makers consider important. In particular, the policy analyst must be objective and must present the policy maker with both sides of the issue (ECAPAPA 2002). The policy analysts in the public domain should not have any hidden agenda and neither should they be out to please the policy maker or the client.

Policy dialogue

Policy dialogue involves strengthening links between analysis and action. The process involves creating forums where key stakeholders come together to discuss recommendations emanating from policy data analysis.

Policy action

Experience shows that to have an effective policy change the following characteristics need to be in place throughout the entire process:

i. facilitation, building and empowering of public–private partnerships; bringing private sector and public/regulatory authorities to the table to discuss and reach a consensus on what has to change, why and how on key issues for the sub-sector under study
ii. observation of the importance and differences amongst technical (technical personnel to discuss issues based on science), political (get a buy-in on the proposed changes from different parties, including civil society) and legislative (once agreement is reached to have legal protection to guard against backsliding) stages in the process of reform
iii. nurturing of transparency, participatory inter-institutionality and multi-disciplinarity in the whole process
iv. differentiation between administrative/procedural and legislative issues in discussions and consensus building; for administrative/procedural issues, implementation of desired changes can proceed under existing legislation, but in situations where the changes proposed are in the legislation, desired changes have to wait until requisite laws are considered and accommodated in the existing legislation

It is imperative to emphasise the point that the situation described above is indeed in an ideal world. It is extremely rare that processes flow in such smooth and distinct stages.

The objective of this paper

This paper reviews and provides a framework for examining supportive sorghum and millet policy packages aimed at enhancing commercialisation of the sub-sector. The Eastern and Central Sorghum and Millet Network (ECARSAM) network realises that policy is a cross-cutting issue affecting the entire production-to-consumption chain. The following questions were posed by the coordinator of ECARSAM. Although the paper attempts to respond to some of them, an argument is made that thorough attention to the questions is only possible if we invest sufficient time to research the issues.

The questions are as follows:

i. What are the policy issues affecting the sorghum and millet supply chain?
ii. Why have sorghum and millet not caught the attention of policy makers (bureaucrats) as an important strategic crop worthy of support by government programmes particularly in areas less favourable for other major crops?
iii. Have the stakeholders involved in sorghum and millet research really advocated for recognition of these crops?
iv. What are the policy issues regarding human resource development in addressing sorghum and millet sector constraints?
v. Is there objectivity and optimism for stakeholders working in sorghum and millets?

Policy issues affecting sorghum and millet supply chain

We often talk about the policy environment not being conducive for a particular sub-system or sub-sector. For example, among the stakeholders of sorghum and millets we often hear of "sorghum and millets facing unfair competition from other cereals in the market, retaining these crops at subsistence level in most ECA countries" (Rohrbach and Kiriwaggulu 2001). It is important, however, to examine the different components of the supply chain to make sure that pro- and anti-policies are properly identified.

The main contribution of this paper is therefore a matrix or a framework suggesting a process of gauging the policies that are in place—directly or indirectly—for sorghum and millet, and more specifically to establish the extent to which the same policies are likely to be more or less favourable when compared with other competing commodities. With the exception of very few "political" food crops such as maize and rice, most crops in Africa do not have clear stand-alone policies with regard to their production, marketing, exports/imports and consumption (ECARSAM 2005). Most policy effects on sorghum and millet happen to be indirect, as caused by the influence on sorghum and millet following the policies of related crops such as maize (Table 1).

For each country, it would be useful to examine and establish the position of sorghum in terms of policies in relation to other close commodities (grain), such as pearl millet, finger millet, maize and rice.

Policy advocacy in favour of sorghum and millets in the ECA region

A question was asked about why sorghum and millet crops have not caught the attention of policy makers (bureaucrats) as important strategic crops worth being supported by government programmes particularly in the areas less favourable for other major crops. Certain issues have a bearing on how we respond to this question. The region is not homogeneous in terms of the importance attached to sorghum and millet vis-à-vis other crops. In Sudan and Eritrea, for example, the sub-sector features more prominently than in other countries. Correspondingly, governments in these countries place more importance on sorghum and millets than in the other countries.

Table 1. A matrix for identifying policy factors

Policy issue	Factors for investigation
Research policy	Relative investment in research US$ in relation to other crops: maize, legumes etc.
Production policy	Relative subsidies in various forms in relation to competitive crops
Processing policy	Standards in processing of sorghum as opposed to those of other crops such as maize
Packaging policy	Standards: Are there any standards in the types of packages used? Are these standards achievable?
Taxation policy	Level of taxation compared with other crops
Strategic Grain Reserve (SGR)	Admission to SGR. In the case of Tanzania, for example, attempts to admit sorghum in the SGR began as far back as 1990, but it is only in 2005 that a pronouncement was made to admit sorghum to the strategic reserve (Minde and Rohrbach 1993).
Import and export policy	Can sub-sector participants freely participate in export and import trade for sorghum and millet? What specific barriers are there in terms of imports? Botswana, a country rich in sorghum and millet gives us a case. See Chapter 3.
Sorghum utilisation policy	What are the existing or promotion policies for sorghum in: • Food—policies to promote the understanding of the energy and protein content of sorghum; policies to promote the understanding that sorghum is in fact a drought tolerant crop? • Component in baking—advocating for the maximum percentage of sorghum that can be accommodated in the baking of bread where the main ingredient is wheat? • Brewing—policies to promote the fact that sorghum brew is more food than alcohol. • Feed—policies to promote the use of sorghum (locally produced grain) in the manufacture of animal feed. What special campaigns have been in place to promote the utilisation of sorghum and how successful have they been?

In the rest of the countries, sorghum and millet are grown by farmers in marginal areas with lower per capita income. Partly because of their low income levels, their political stature is also relatively low. Lobby groups in these marginal areas are rare.

One can argue that stakeholders of the crops in question have not promoted these crops consistently. It would appear that forums such as “sorghum and millet stakeholders’ workshops” are likely to be important mechanisms for boosting these crops because of their ability to bring together a large array of sub-sector participants. Human resource development in the sorghum and millet sector has also not been given the seriousness it deserves: apart from Sudan and Eritrea, relatively few scientists devote their time to sorghum and millet (agronomy, breeding etc.).

Some of the reasons for the relatively low status of sorghum and millet are attributed to the stakeholders themselves. For example, why should sorghum and millet be considered as one crop in terms of statistics, discussions etc., while these are entirely two different crops in terms of their breeding, production, processing, milling requirements and utilisation. To further complicate matters, when we talk of “millets” it is unclear which millet (bulrush or finger) we are referring to. All these issues tend to undermine the importance of these crops.

Way forward

A key policy objective is to shift small-scale sorghum and millet producers from extensive production practices in the semi-arid tropics. Sorghum and millet per se may not be able to pull farmers out of poverty. But focusing attention on the sorghum and millet-based farming system is important because that is where the people we are targeting live. The point is that to improve livelihoods and incomes farmers in the sorghum and millet-based farming systems may need strategies that are outside sorghum and millet improvement such as livestock.
A multi-faceted approach for the sorghum and millet areas would therefore be a good idea. A proposal is thus advanced to study the sub-sector and increase the knowledge and understanding of its nature, types and dimensions. This will be followed by identifying strategies and mechanisms that are most efficient in pulling farmers in the sorghum and millet-based systems out of poverty.

Conclusion

The usefulness, implementation, relevance and the long-term sustainability of any policy is a function of how well it was nurtured in its formulation in terms of clearly following the four-stage cycle. For a successful policy formulation process some key values must be observed. These are consultativeness, participatoriness, transparency, inclusiveness, respect of opinion from all participants in the process and aiming at reaching decision by consensus. The more common the problem is to stakeholders, the friendlier and more enthusiastic the policy formulation process will be.

This paper proposes a framework to be used to better understand the functioning of policies in the sorghum and millet sub-sector and the type of policies that could be introduced to foster the functioning of a sub-sector.

References

ECAPAPA [Eastern and Central Africa Programme for Agricultural Policy Analysis]. 2002. Harmonization of Seed Policies and Regulations in Eastern Africa: Results and Agreements. ECAPAPA, Entebbe, Uganda.

ECAPAPA [Eastern and Central Africa Programme for Agricultural Policy Analysis]. 2004. Harmonizing seed policies and regulations in Eastern Africa. ECAPAPA, Entebbe, Uganda.

ECARSAM [Eastern and Central Africa Regional Sorghum and Millet Network]. 2005. Sorghum and Millet Research for Development in Eastern and Central Africa 2005–2010. Regional Priorities. Nairobi, Kenya.

Heinrich GM. 2004. A foundation for the future: The Sorghum and Millet Improvement Program (SMIP) in Southern Africa. Proceedings of the SMIP Final Review and Reporting Workshop, 25–26 November 2003, Bulawayo, Zimbabwe.

Minde IJ, Rohrbach DD. eds. 1993. Sorghum and millet marketing and utilization for food security and development. Proceedings of a national workshop, Arusha, Tanzania, 3–5 May, 1993. pp130.

Minde IJ, Waithaka M. 2006. Policy dialogue and formulation processes for adaptive policy framework in agricultural water management. Paper presented at the 2nd Annual Conference of Improved Management of Agricultural Water in Eastern and Southern Africa (IMAWESA), Maputo, Mozambique, 18–22 September 2006.

Rohrbach DD, Mupanda K, Seleka T. 2000. Commercialization of sorghum in Botswana: Trends and prospects. SEPP Working Paper Series 5. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India.

Rohrbach DD, Kiriwaggulu JAB. 2001. Testing the demand for sorghum meal in Tanzania: A case study with Power Foods.

4.2. Recommendations on policy issues

The recommendations were made along the value chain, covering production, processing and markets. The regional policy options recommended were:

- Harmonisation of seed research and release in the regional countries.
- Enhancement of cross-border trade in seeds, grain and industrial products of sorghum and millets.
- Purchase of sorghum/millets in strategic grain reserves for food and seed security.
- Regional governments, WFP and NGOs should be encouraged to have a policy of distributing sorghum/millet instead of maize during drought/famine.
- Policy to be developed that allows and enforces blending sorghum/millet with other grain in bakeries and other food establishments.
- Countries in the region to encourage free trade of sorghum/millet without barriers.
- Policies for strengthening farmers, farmer organisations and rural agro-enterprises for value addition. Governments should encourage farmer organisations in all forms like production, financial, marketing.

APPENDICES

Appendix 1: Released and available varieties of sorghum in the ECA to 2005

Country	Cultivar	Year of release	Special attributes
Uganda	Epuripur (Tegemeo)	1995	
	Serena 5DX160	1967	
	Seredo	1982	
	Sekedo	1995	
	5 others	1960–1995	
Burundi	IS 9198		
	Gambella 1107		
Kenya	KARI Mtama 1	1994	• Semi-tall; large grain; good food quality
	KARI Mtama 3 (ICSV III - (PGRC/E 216740)	2001	• Semi-tall; bold red grain
	KARI Mtama 2 (IS 8193)	2001	Semi-dwarf; excellent *ugali* and *uji* quality
	Serena	1972	• Good *ugali*; good malting
	Seredo	1982	• Good *ugali*; poor malting
	Gadam Hamam	2000	• Pre-released short; early; good for *ugali*, *uji* and malt
	E 2191	2000	For cool highlands
	E 6518	1994	Tall, brown seed; forage; for cool highlands
	Ikinyaruka	1996	Dual purpose; for cool highlands
	BJ 28	1978	• For cool highlands; short, early
	2Kx 17	1981	• Not available
	IS 76	1981	• Not available
	IS 8595	1981	• Not available
	E525H Red	1981	• Not available

Country	Cultivar	Year of release	Special attributes
Eritrea	BUSHUKA (ICSV 210)	2000	
	SHAMBUKO (PP 290)	2000	
	SHIEB (89 MW 5003)	2000	
	LABA (89 MW 5056)	2000	
	SHIKETI (IS 29415)	2000	
Ethiopia	Gambella 1107	1980–1998	
	Dinkmash	1980–1998	
	Seredo	1980–1998	
	76 Ti # 23	1980–1998	
	M-36121	1980–1998	
	IS 9302	1980–1998	
	Birmash	1980–1998	
	Baji (85MW 5334)	1980–1998	
	Alemaya 70	1980–1998	
	ETS 2752	1980–1998	
	ETS 5946	1980–1998	
	Herarghe Coll #4	1980–1998	
Sudan	Hageen Durra 1 (Hybrid) SRN 39	1983	
	Ingazi		
	Gadam el Hamam Ten others		
Rwanda	5DX 160	2000	
	IS 25395	2002	
	IS 25377	2002	
	IS 21219	2002	
	IS 8193	2002	
	Seredo		
Tanzania	Pato	1995	
	Macia	1999	

Appendix 2: Released and available varieties of pearl millet (PM) in the ECA

Country	Cultivar	Year of release	Special attributes	Remarks
Uganda	Serere Composite 1	1982		
	Serere Composite 2	1982		
	ICMV 221	1995		
Kenya	KAT/PM 1	1998		
	KAT/PM 2	1985		
	KAT/PM 3 (ICMV 221)	1991**		
Eritrea	ICMV 221	1999		
Sudan	Okashana 2	2000		
Tanzania	Okoa	1994		
	Shibe	1994		
	Serere 17	1960s		

Appendix 3: Released and available varieties of finger millet in ECA

Country	Cultivar	Year of release	Special attributes	Remarks
Uganda	Gulu E	1970		
	Serere 1	1995		
	Pese 1	1995		
	Seremi 1 (Pese II)	1998		
	Seremi 2 (U 15)	1998		
	Seremi 3 (Sx17 - 88)	1998		
Kenya	KAT/FM 1	1998		
	Nakuru FM 1	1996		
	P224			

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