SORGHUM AND MILLET BREEDING IN SOUTHERN AFRICA IN PRACTICE

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Sorghum and millet are important traditional cereal crops in southern Africa for food security and are largely grown by smallholder farmers. However, the crops face stiff competition from alternative crops such as maize in the production system. Invariably the main objectives of most breeding programmes are the development of improved varieties that are disease and pest resistant and management practises that promote the sustainable use of natural resources. A number of countries in the region have developed sorghum and millet varieties that have found wide appeal to farmers. Hybrid varieties have less emphasis. The achievements that the region has recorded can largely be attributed to germplasm that was acquired by SADC/ICRISAT both from outside the region and locally. This germplasm formed the foundation of breeding programmes of NARS.

Impact studies conducted in the region, however, show that adoption rates are largely low. Some of the reasons cited for this are lack of improved seed, information, alternative end uses, poor marketing strategies, poor grain quality and lack of fertiliser use. The challenges for the future lie in the various disciplines working closely together to address these concerns through participatory approaches and move these two crops from subsistence to a commercial level.

INTRODUCTION

Sorghum and millet are important traditional cereal crops in Africa. The crops are important in marginal areas of southern Africa where other cereal crops such as maize would normally fail[1]. These areas are characterised by high surface and soil temperatures, low and poorly distributed rainfall. The fertility of the soil is generally poor. Some sorghum in southern Africa and Finger millet are grown in high rainfall areas. In general, local landraces of sorghum and millet are characterised by lateness to maturity, poor harvest index, variable plant height, head and seed characteristics as well as being susceptible to diseases and insect pests like downy mildew, blast, smut, anthracnose, shootfly and armoured cricket.

The crops are largely grown at subsistence level and by small holder farmers. In South Africa sorghum is grown on a commercial level[2]. On a comparative basis Tanzania and South Africa utilise sorghum on a wider scale than other countries in the region[1,3]. There is no doubt that sorghum and millet are essential for the attainment of food security and for the establishment of sustainable production systems in the semi-arid regions of southern Africa.

In the beginning most of the breeding programmes placed emphasis on introductions, evaluating them and then selecting adapted lines. Later programmes embarked on hybridisation followed by evaluation and selection in segregating populations. Whatever method that was employed the main focus was on earliness, increasing grain yield and disease and pest resistance. Varieties such as Framida and Red Swazi were released with wide appeal from these initial efforts. However, without exception now, all the countries in southern Africa have breeding programme that are attempting to address problems affecting production by farmers. It is also true that these programmes are at varying levels of advancement in terms of funding and staffing and consequently effectiveness.

CROP IMPROVEMENT IN SOUTHERN AFRICA

In a concerted effort to improve the production and productivity of these crops, governments in southern Africa pooled their resources together and established Sorghum and Millet Improvement Programme (SMIP) in the early eighties. The programme was managed by ICRISAT. In early 1983 significant efforts were made through the regional programme SMIP to acquire new and enhanced germplasm from all possible sources. About 10,200 exotic gemplasm of sorghum and 6,163 of pearl millet and close to 3,000 finger millet lines were acquired and evaluated at the regional centre at Matopos[4]. In addition, the local collections from within the region formed the foundation of national breeding programmes.

In sorghum and finger millet, crop improvement activities have largely used the pedigree and backcross method to advance the breeding material. In pearl millet population improvement methods have been employed. Invariably most NARS breeding programmes in the region have the overall objective of increasing the productivity of these crops. The development of improved varieties that are disease and pest resistant and management practises that promote the sustainable use of natural resources has taken centre stage[4]. Lately there has been new emphasis placed on strategies for sustainable resource use and breeding for quality. These strategies

need to be identified and built into technologies designed to improve production and productivity of these crops.

However, unlike what is taking place in other research institutions in developed countries, for example Texas A&M University, in southern Africa (except South Africa) both at NARS and regional level scientists are largely working independently as opposed to collaboratively. Plant breeders, entomologists, pathologists and indeed food technologists rarely collaborate in sorghum and millet research. This scenario is partly due to poor structural arrangements and poor staffing in some of these countries. This results in delays in meeting set objectives and proves expensive in the long run. The phasing out of the food technologist, agronomist, pathologist and entomologist positions at SMIP is a classic example of this. The net effect of all this is to slowdown the identification of suitable lines for crosses and later selection for desirable traits for farmers.

If advances are to be made, collaboration in specific areas with other disciplines in a participatory manner, such as food science in producing composite flours, malt, stockfeed and forages, will need to be made to enhance product development and transfer. Obilana et al have listed a number of success stories that are using the breeding for impact approach[5].

Varieties released in the region

Through collaborative ventures among NARS, SMIP and INTSORMIL, most countries in the region have released a number of varieties to farmers with varying degrees of successes. Some of the varieties were released through NARS own efforts (Tables I and II).

A number of studies that have been taken in the region to study the impact of sorghum and millet research have shown that the results have been modest. Specific studies conducted in Botswana, Zimbabwe, Namibia, and Zambia have show modest internal rates of return[6-7]. Some of the reasons cited for this are lack of improved seed, lack of information, marketing and utilisation, poor grain quality and fertility management issues. In addition, a general perception that sorghum and pearl millet are crops of resource poor farmers in terms of production and consumption has not helped the promotion of the crops. These issues are discussed below.

LACK OF SUITABLE IMPROVED VARIETIES

With the introduction of elite germplasm, grain yields have been increased tremendously with both open pollinated varieties and hybrids. An average yield of 3-5 tons per hectare for a variety is not uncommon. Sorghum varieties such as Tegemeo in Tanzania, Macia in Mozambique, Phofu in Botswana, Kuyuma in Zambia etc., pearl millet varieties such as Okashana, Shibe, Okoa, Lubasi, Sepo and finger millet varieties such as Nyika and Senga in Zambia have been widely accepted by farmers at the village level. Hybrids too, have met with some success at the commercial level. Some sorghum hybrids have been accepted across borders such as MMSH-413 and 375. In

Country	Variety name	Hybrid/Variety	Year of release
Botswana	Phofu	V	1994
	Mahube	V	1994
	Mmabaitse	V	1994
	BSH1	H	1994
Malawi	Pirira 1	V	
	Pirira 2	V	
Mozambique	Macia	V	
	Mamonhe	V	
	Chokwe	V	
Tanzania	Tegemeo	V	1983
	Pato		
Zambia	Kuyuma	V	1989
	ZSV-15	V	1998
	Sima	V	1989
	WP-13	V	1996
	ZSV-12	V	1996
	MMSH-375	H	1992
	MMSH-413	H	1992
	MMSH-1324	H	1998
	MMSH-1257	H	1998
Zimbabwe	SV-1	V	1987
	SV-2	V	1987

Table I Sorghum varieties released by NARS in southern Africa

pearl millet single cross hybrids have shown 15-60% grain yield advantage over local landraces.

However, farmers and industrial end-users have raised concerns, about the quality of the grain. Smallholder farmers have taken issue with the milling and storage properties of the improved varieties. Industrial end-users have not been convinced with the nutritional properties of the crops. The presence of tannins is some sorghums and the quality of proteins which consist mainly of prolamin is a major drawback in its use in humans[8]. In addition the protein content is poor in lysine and threonine. Smallholder farmers prefer the local landraces to the improved varieties because of the hard corneous endosperm of the grain hence they pearl well. The challenge for plant breeders is to develop varieties that are targeted to end-users and bridge the gap between yield obtained at research centres and that obtained by smallholder farmers. There is need for material with outstanding kernel characteristics such as thin pericarp, weathering resistance, reduced discoloration of the endosperm, increased protein content with reduced prolamin, superior balance of essential amino acids such as lysine, improved flavour, and expanded diversity for food product development and greater digestibility .

Country	Variety name	Year of release
	Pearl millet	
Malawi	Tupatupa	1996
Namibia	Okashana 1	1989
	Okashana 2	
Mozambique	Kuphanjala	1999
	Kuphanjala	1999
	Changara	1999
Tanzania	Okoa	1994
	Shibe	1994
Zambia	Kaufela	1989
	Lubasi	1993
	Kuomboka	1999
	Sepo	1998
	Tuso	1998
Zimbabwe	PMV-1	1987
	PMV-2	1992
	PMV-3	1998
Finger millet		
Zambia	Lima	-
	Nyika	-
	Senga	-

Table II Pearl and finger millet varieties released by NARS in southern Africa

MARKETING AND UTILISATION

For sustainable production of these crops there is need to promote markets and utilisation of these crops beyond subsistence production. Studies undertaken in the region have shown that unless sorghum and millet can be produced at a competitive level with maize, commercialisation will be a difficult task to achieve. Industries have been known to refuse to purchase and utilise these crops because maize was readily available and cheaper. One reason for the uncompetitiveness of these crops is the low average grain yield. Whereas the genetic potential of the improved varieties is high the average yields achieved by smallholder farmers are below a tonne per hectare. Lack of credit facilities for sorghum and millet is also a major hindrance to their commercialisation. Research efforts need to be applied in product development and commercial outlets need to be established.

POOR SEED DELIVERY SYSTEMS

While improved varieties and hybrids have been released the seed of these is not readily available from the various seed producers. Except in South Africa, seed companies that were tasked to be conduits of government released varieties have failed to deliver, citing low demand and the high cost of distributing the seed in far flung areas. This has contributed to the low adoption of these varieties. There is

need to move beyond foundation seed and deliver seed to farmers. Generally programmes have embarked on on-farm seed production as a way of getting the seed to farmers. This has met with some success within the region. There is need to train smallholder farmers in ensuring that standards are kept high in seed production. The private sector's interest in these crops is not sufficiently high to warrant investment in open-pollinated varieties but hybrids. Hybrid varieties have proved to be popular with all the categories of farmers. The idea of purchasing seed of hybrid varieties can be a hindrance to smallholder farmers who are generally resource poor.

CROP MANAGEMENT

It has been shown that increased grain yields can be enhanced significantly by improving management practices. Most of the land grown to these crops is marginal in terms of fertility. Fertiliser use on sorghum and pearl millet is very little if at all, among smallholder farmers. In some cases smallholder farmers have used farmyard manure. The use of crop rotations, organic fertilisers, conservation methods and water harvesting techniques should be explored with vigour for the smallholder farmers. Recommended plant densities and planting practices are not followed resulting in poor grain yields. The findings of this research will add to the new efforts that are needed to ensure extension recommendations are relevant to the farming circumstances of most smallholder farmers. Another concept that will enhance the adoption of these technologies is on-farm research technology verification. The trials have a direct demonstration effect in the communities of participating farmers. The use of crop residues, rotations and intercropping could help small holder farmers.

CHALLENGES FOR THE FUTURE

It is generally agreed that advances have been made in germplasm enhancement in the region. It is also agreed that a lot needs to be done in terms of adding value to sorghum and millet. Smallholder farmers have raised issues of grain quality with the improved varieties. Farmers prefer their local landraces in terms of quality to the improved types. Milling and processing of the grains need to be improved to enhance utilisation by end-users. These methods need to be promoted by extension staff and NGO's.

There are other uses of these crops other than brewing and flour products. Development of forage sorghums and millet is one area that has not received a lot of attention in the region. I believe this is one area that these crops can have an added advantage over crops such as maize. Research in poultry and animal feed could be enhanced as well and should get more attention.

While grain yield is an important trait to breed for an equal amount of time should now be devoted to other important quality traits such as storage and milling properties, improvement of the quality of proteins of these grains. Though a lot of research has been done in this area, there is need to develop sorghum and millet that have less prolamin. High protein sorghums from Ethiopia and Sudan such as Karamaka need to be studied more to learn about the control and inheritance of this trait[9]. The use of RAPD and marker assisted selection in screening for this trait could be the first step in identifying lines for crosses.

However, I see the challenges for the future in the region lie in the various disciplines working closely together to address these concerns through participatory approaches and move these crops from subsistence to a commercial level as South Africa has done.

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