International Crops Research Institute for the Semi-Arid Tropics

ICRISAT
Eastern and Southern Africa Region
2006 Highlights

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ICRISAT–Nairobi
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About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Future Harvest Centers of the Consultative Group on International Agricultural Research (CGIAR).

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Cover photo: Innovative farmer Koos Koopman tries out new technologies on his rooibos tea plantation in the Suidbokkeveld in South Africa.

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Preface

2006 has been a momentous year for agriculture with new avenues to explore as well as new challenges demanding creative solutions. The high price of oil for example has resulted in massive investments in the production of crops for biofuel. Researchers around the world are taking the impacts of global warming on agriculture into consideration.

The repercussions of our decisions as producers, consumers, and players in the field of international development continue to be far-reaching. Earlier in the year some British supermarkets started to differentiate fresh produce that had been air-freighted to the UK because of environmental concerns of aircraft emissions on the atmosphere. What seemed like a responsible action to British consumers sent shock waves through the Kenyan economy where horticulture employs tens of thousands and is now the country's second largest foreign exchange earner. The quick intervention by the Secretary of State for International Development highlighted not only the simplistic argument behind this particular campaign, but also showed the vulnerability of poor smallholder farmers to factors beyond their control.

This, ICRISAT-ESA's second annual report, highlights the Institute's work in the region and our attempts to address the needs of the smallholder farmer for improved seeds, varieties and inputs such as fertilizer, better access to information, markets and new technologies. Researchers recognize the need to not only do good science but to be proactive in supporting the development of innovation systems so that livelihoods of poor people benefit from public investment in international agricultural research.

We hope that these eight stories give you a feel for the trials of a smallholder farmer in ESA as well as an understanding of ICRISAT and partner work to alleviate these challenges, giving new meaning to our motto "Science with a Human Face."

William D Dar

Director General

Said Silim

Regional Director for Eastern and Southern Africa

Highlights

Pills for Plants

"We used to be better off," says Nyepai Matsuro, 32, looking at her brick and asbestos-sheeted house, a luxury compared to her neighbors' traditional homesteads with thatched roofs. "But now my husband is sick and the economic situation here [in Zimbabwe] means that there is not much hope for me."

On her two-hectare farm in Muzarira village near the Mutirikwi (formerly Lake Kyle) dam in western Zimbabwe, Matsuro grows maize, sunflowers, and groundnuts with seeds that were given to her as part of a conservation agriculture package. As a subsistence farmer, she often does not manage to grow enough food to sustain her husband and four children and sometimes works in neighbors' fields in exchange for maize. Matsuro has been working with ICRISAT for the last two years on testing microdosing technology and the latest development – the nitrogen fertilizer pill.

The challenge

Soils in Zimbabwe, as in much of Eastern and Southern Africa (ESA), are poor in

Matsuro, one of the farmers helping ICRISAT test the efficacy of the nitrogen pill, takes a well-earned break in front of her house.

essential nutrients. Nitrogen is often the most limiting factor. "We took soil samples from farmers and tested them for various nutrients," says Nester Mashingaidze, a scientific officer at ICRISAT. "One farmer in Chivi district had 0% nitrogen and 0.002% phosphorous. His soil was completely depleted."

The obvious solution in situations like this is to start using fertilizer, but farmers in the semi-arid tropics (SAT) of Africa are often dealing unsuccessfully with the twin challenges of availability and access. "I have no idea, but I know I can't afford it," Matsuro says when asked for the price of fertilizer. She adds that fertilizer is not even available at the local retail outlets near her village, though she thinks she may be able to find it in Masvingo, the nearest town about 40 km away.

Microdosing: More for less

Research in both West Africa and ESA has shown that microdosing, or the practice of applying small amounts (one-third of a bottle cap) of ammonium nitrate fertilizer, can improve yields anywhere from 30–100%.

"ICRISAT's microdosing approach starts from the premise that resource constraints prevent farmers from applying the rates recommended by national extension agencies," says Stephen Twomlow, Global Theme Leader at ICRISAT. Whereas traditional extension recommendations call for 150–200 kg/ha of ammonium nitrate, microdosing requires farmers to use only around 50 kg/ha on their fields. "Microdosing gives a quick response to the farmer and has an immediate impact on food security and is easy on the pocket," Twomlow adds.

The results of microdosing are evident on Matsuro's farm. She has planted two 50 × 10 m^2 plots with maize and fertilized only one. From the plot with no fertilizer she got one bag (50 kg) of maize whereas from the plot with granular fertilizer she got two.

Although it provides good results, microdosing is not easy. A field of maize has between 30,000 and 40,000 plants per hectare. Imagine trying to pour a third of a bottle cap of fertilizer in granular form near the base of each plant and the words 'backbreaking' and 'time-consuming' take on new meaning. The situation is made worse by the fact that farmers are advised to fertilize their fields between 4 and 6 weeks after crop emergence – the same time they are planting their late crop and weeding their early crop.

The solution: Put your plant on the pill

In order to address some of these issues, ICRISAT, in collaboration with Agricultural Seeds & Services, a commercial input supplier, has developed a pill consisting of one-third of a bottle cap of ammonium nitrate fertilizer. " The advantages of the pill are that less labor is involved and it is more accurate because we know that farmers are putting on exactly a third of a bottle cap per plant," says Mashingaidze. Farmers can simply place the pill on a wet soil surface, which is sufficient to dissolve it, or if rainfall is limited, push the pill into the soil.

The pill is less labor-intensive as farmers can simply place it on a wet soil surface.

Tests over the past two seasons have found that yields with the pill are similar or better than ordinary granular fertilizer known as prill (Figure 1). Matsuro, for example, obtained two and a half bags with the pill compared to two bags with the granules.

Farmers have also observed that it takes longer for the pill to dissolve, which may mean that the negative effect of leaching following heavy rain is less. Laboratory tests showed that the granules take 4 minutes to dissolve in water compared to 19 for the pill. In practical terms this means that if it rains after fertilizer has been applied, the granular form of ammonium nitrate will dissolve faster and may be washed away before the plant can use it. As the pill takes longer to dissolve, the effect of leaching is reduced.

Mashingaidze and Twomlow have also conducted experiments to measure the agronomic nitrogen-use efficiency, or the amount of extra grain harvested for each kilogram of nitrogen applied, assuming that all the applied nitrogen is used only by the plant. Measuring agronomic nitrogen-use efficiency is a quick way to determine whether more nitrogen was available to the plants with the pill than with the granules. They found that this was indeed the case; a higher agronomic nitrogen-use efficiency for the pills revealed that more nitrogen is available to the plant when using pills than the granular form of ammonium nitrate.

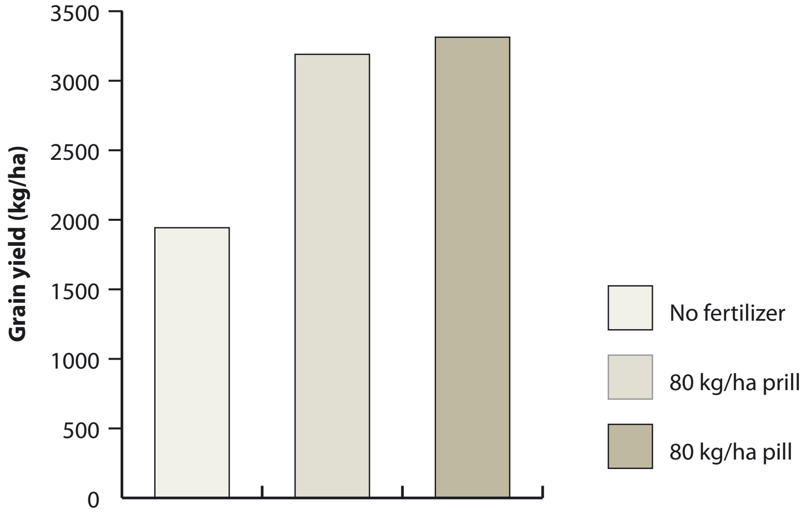


Figure 1.
There is no significant difference between yields obtained with the pill and granular forms of fertilizer (prill).

For the future

A technology has to be tested for at least three seasons to be found worthy. By those standards, more testing than that which ICRISAT has conducted over the last two seasons needs to be done to ensure that the yield increases obtained with the pills are consistent. Once testing is complete, commercializing pill production can begin.

The question of affordability however still remains. Farmers who cannot afford fertilizer in granular form may not necessarily be able to afford the pill, especially when the costs associated with making the pill may hike up the price of the final product. For farmers such as Matsuro, solutions to the issues of pricing and access will still need to be found.

Chickpea – From One Continent to Another

Breeding: From Asia to Africa

Chickpea is grown in more than 40 countries around the world. But, India, with 64% production, dominates the scene, more than justifying ICRISAT Headquarters' focus on one of its mandate crops. In fact, since ICRISAT's founding, 25 of the 50 varieties based on improved germplasm developed by the Institute have been released in India.

When ICRISAT–Nairobi decided to begin breeding chickpea for the ESA region in the late 1990s, scientists at the regional office were faced with an important question: should they start a breeding program from scratch or try to capitalize on ICRISAT's previous work instead? Given ICRISAT's history with chickpea in India, the question was not all that difficult to answer.

In 1999, scientists at ICRISAT–Nairobi requested and received a number of varieties from ICRISAT–Asia that they believed had the potential of doing well in ESA. Preliminary results of field evaluations in Kenya were quite promising. "After that initial project we decided to bring a larger number of accessions for evaluation for a variety of traits," says Said Silim, ICRISAT scientist and Regional Director for ESA.

The transfer

The traits Silim chose included mainly short and medium-duration growth, establishment, drought tolerance, grain size with a preference for medium to large grain, and ease of cooking. Emphasis was on the cream-seeded *Kabuli* type that commands higher demand and fetches a higher price than the brown-seeded *Desi* type. Silim also focused on the two diseases that plague chickpea varieties in ESA: fusarium wilt and root rot. All the material brought from India was either tolerant or resistant to both diseases.

Varieties with preferred traits were then selected and shared for further evaluation and potential release by national programs, non-governmental organizations (NGOs), universities and the private sector in Ethiopia, Kenya, Malawi, Mozambique and Tanzania.

A quick payoff

"Breeding normally takes up to 10 years or more," says Silim. "Bringing material over from ICRISAT in India has resulted in a quick payoff." In the 7 years since the initial transfer of material the chickpea breeding program in ESA has had some impressive results.

More than seven varieties have been identified as suitable in the five countries (Table 1). Large tracts of land in these countries are already sown to the improved varieties, indicating that farmers are satisfied, even though many varieties are yet to be formally released by their governments. For example, in Ethiopia, Kenya and Sudan the area sown to chickpea

Table 1.
Popular chickpea varieties officially released or being grown by farmers

	Country				
Variety	Ethiopia	Kenya	Malawi	Mozambique	Tanzania
ICCV 93512	X				
ICCV 92318	X	X	X	X	
ICCV 96329	X	X	X	X	
ICCV 92311		X		X	X
ICCV 95423		X			X
ICCV 2		X		X	
ICCV 97105		X	X		X

has increased from 0.24 to 0.42 million hectares with a corresponding increase in production from 0.14 to 0.27 million tons from 1987 to 2003.

In Kenya, Mozambique and Tanzania chickpea is now grown in non-traditional areas as a cash crop. Farmers in Tanzania and in the Rift Valley of Kenya used to grow only one crop per year. But they now plant chickpea as a second crop after the harvest of maize. Farmers in Mozambique now grow chickpea after rice.

Farmers in Kenya (left) and Tanzania (right) have started to grow chickpea as a cash crop.

Export: From Africa to Europe

The country that has received the biggest payoff as a result of this research has been Ethiopia. The Ethiopian Government released five varieties between 1999 and 2006. Ethiopia has been exporting increasing quantities of chickpea to Asia (Bangladesh, India, Pakistan, and Singapore), the Middle East (Saudi Arabia, United Arab Emirates, and Yemen), Europe (Germany, Switzerland, and the UK), and North America (Canada and USA). Chickpea, especially *Kabuli* type, fetches an attractive US$400–800 per ton on the international market. Ethiopia exported 31,583 tons of chickpea in 2001, and 48,753 tons in 2002, thus demonstrating the benefits of transferring technology and research results from one continent to another.

Harnessing the Power of Collective Action

The challenges of a smallholder farmer do not stop at harvest. The farmer has to find ways to access the market and sell the grain for the best price to secure a cash income, and it is often at these last stages that the farmer loses out. "A smallholder farmer in the semi-arid areas typically has two hectares of largely infertile land," says Bekele Shiferaw, Senior Economist at ICRISAT. "More than half of the land is allocated to subsistence crops, leaving little room for diversification into marketable crops. He or she really has no way of becoming competitive by individually marketing the small volumes produced from a small area of land."

Hampered by high transaction costs and limited market information, smallholders are unable to consistently supply quality products to the market and often accept low prices for their grain. But this can change if they join up to form groups with other smallholder farmers. ICRISAT took a closer look at farmer organizations in Kenya to assess the benefits and costs to farmers of belonging to such groups.

Priscilla Mawewu in her pigeonpea field with fellow members of the Emali marketing group, Kenya.

PMGs – a good or bad idea?

In 2002 and 2003, ICRISAT along with partners: Catholic Relief Services (CRS), Technoserve and the Kenya Agricultural Commodity Exchange and supported by the United States Agency for International Development (USAID), facilitated the formation of ten producer marketing groups (PMGs) in Mbeere and Makueni, two semi-arid districts in Eastern Province, Kenya. Each farmer paid the equivalent of US$1 to join a PMG and each PMG had an average of 100 members. The PMGs were listed as welfare societies according to Kenyan law and each had well-defined objectives, bylaws, and an elected body that led the group.

After giving them a few years to get established, ICRISAT conducted a study in 2005–2006 on smallholder marketing patterns to determine prevalent practices and assess whether or not farmers received tangible benefits from belonging to a PMG.

The study found that 90% of the grain was sold at the farm gate or in village markets less than 5 km from the farm gate. At this distance grain prices are not likely to increase much. However, when selling grain 10 km away, each farmer on average gained about US$3.5/100 kg sold. This showed that unless farmers market the produce jointly and share in transport costs the incentive for farmers to transport their grain over long distances is very low, despite the higher prices they may receive. Since most of the produce is sold at the farm gate farmers were forced to depend on rural wholesalers and brokers/assemblers, who together purchase more than 80% of the grain sold by farmers. As farmers have limited access to market information, these buyers are able to determine prices at the farm gate and often offer low prices to farmers.

The study also found that farmers sell 75% of the grain immediately after harvest when there is an abundance of local supply and prices are significantly lower. If farmers could manage to find a way to store their grain for 3–5 months and sell at a later date, they could earn much more (Table 1).

Shiferaw found that membership to a PMG did tangibly benefit farmers. "Collective marketing improved prices by 20–25%," says Shiferaw. "Usually wholesale prices in larger marketing centers are high, but farm gate prices are low. But through collective marketing a higher percentage of the consumer price flows back to the farmer." On average, PMG members received Ksh 6 more per kilogram of grain than the price offered by brokers and middlemen.

Most rural buyers do not pay a premium for grain of superior quality, which reduces farmers' incentive to supply the market with diverse and high-quality products. However, farmers participating in PMGs exploited the power of collective action by agreeing to sort and grade their grain together, adding an extra 5–10% to the price they received. The PMGs then consolidated the grain delivered by members and sold it to buyers beyond the village at better prices.

Table 1.
The effect of PMGs on pigeonpea prices in Eastern Province, Kenya

Buyer	Season	Point of sale	Price (Ksh/kg)	PMG price advantage (%)
PMG	Immediately after harvest	Farm gate	29.81	24.00
Broker	Immediately after harvest	Farm gate	24.04	
PMG	Immediately after harvest	5 km	29.93	23.88
Broker	Immediately after harvest	5 km	24.16	
PMG	4–5 months after harvest	Farm gate	31.16	22.72
Broker	4–5 months after harvest	Farm gate	25.39	
PMG	4–5 months after harvest	5 km	31.29	22.62
Broker	4–5 months after harvest	5 km	25.52	

Collective marketing helps farmers take advantage of economies of scale.

The PMGs also had some unforeseen benefits even to non-member farmers in the villages. "Once brokers and assemblers realized that other channels had opened up, they started to increase the prices they offered to farmers. This has had a real spillover effect which we didn't expect," says Shiferaw. Farmers in the two districts are also going beyond just selling pigeonpea grain and are now marketing maize, beans and chickpea through PMGs. In addition, the PMGs facilitated farmer access to improved seeds, which in turn increases production and marketable surplus and create incentives for commercialization. This has shown that if properly organized and supported, farmer groups can catalyze technology adoption and commercialization of otherwise subsistence-oriented production in the semi-arid areas.

Capital constraints

While joining a PMG may in the end earn a smallholder more money for his/her grain, the disadvantage is that it may take up to 35 days to get the money after the produce has been sold. Most other buyers pay cash immediately or within 2 days at the most. The reason for this is that PMGs operate only on the small funds raised by membership fees. As a result of only being allowed to legally register as welfare groups, PMGs are not eligible for bank loans and have limited access to other essential business services.

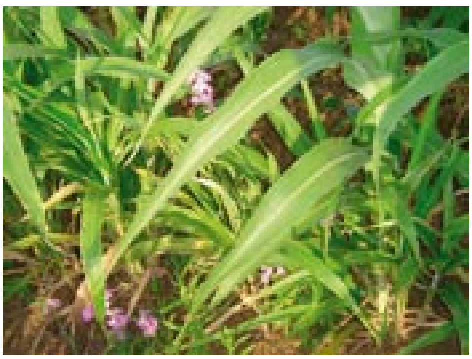
For a farmer who needs cash right away a wait of 35 days is an unacceptable delay. But Shiferaw says with the right environment the effects of this delay can be reduced. "One solution is to pay farmers a portion, for example 25%, of the money upfront and pay the rest later," he says. Surveys show that Kenyan farmers are often willing to wait for the rest of their money if they can be paid a third of the grain value at the time of delivery. This would allow poor farmers to get cash to pay for immediate needs such as school fees.

A better legal and policy framework would also help. If PMGs were recognized as legal entities it would ease their transition into viable commercial enterprises and allow them access to credit services and even the ability to rent warehouses to store grain. With proper storage facilities, farmer groups could also exploit other innovations such as warehouse receipt systems that allow farmers to access credit using the grain delivered as collateral. These small changes can go a long way in creating the right environment for PMGs to function optimally. As Shiferaw says, "there's not much that you need to do in order to make a difference." Institutional and organizational innovations that help the poor can be considered useful 'soft infrastructure' needed to make markets work for farmers. By providing this soft infrastructure, governments and other development partners can play an important role in creating new opportunities for farmers in isolated areas with limited market infrastructure.

Striga-free Sorghum: One Step Away from Reality

Underground robbery

It may look innocuous with delicate purple flowers growing amidst the green sorghum stalks but *Striga* – a deadly parasitic weed – is little more than a thief with a treacherous mode of attack. *Striga* grows a haustorium, or an extension that produces chemicals that break into the sorghum root and suck out essential water and minerals, causing yield losses of up to 100% during drought years in the SAT.



Striga *flowers amongst sorghum stalks.*

So far, the solutions to this problem have been rather disappointing. Farmers are advised to uproot the weed before *Striga* matures and produces seeds. Unfortunately, this process is quite tedious and does not necessarily show immediate results as *Striga* produces thousands of seeds upon maturity. These seeds can germinate even after lying dormant in the soil for 20 years; farmers can literally spend entire lifetimes trying to eradicate *Striga* from their fields. Those who use fertilizer and manure are more protected since fertilizers encourage the rapid growth of a crop's roots. This means that by the time the haustorium develops, the sorghum roots are deep and strong, making them better able to withstand *Striga*'s poaching. But the majority of farmers in the SAT do not use fertilizer due to access and pricing issues, leaving their crops acutely exposed to the effects of *Striga*.

Scientists have searched for the solution through conventional breeding, but without much success. Now, Marker Assisted Selection (MAS) – a genetic technique that uses markers to verify whether segments of a plant's nuclear material known to confer resistance to *Striga* have been introduced into the genome of farmer-preferred varieties through conventional breeding – is providing much more promising results.

From donor to farmer-preferred varieties

Although the sorghum variety N13 is neither high-yielding nor drought-resistant, it has caught scientists' attention because it is resistant to *Striga*. A decade of research by ICRISAT and the University of Hohenheim

The local variety Ochuti carries three QTLs for Striga *resistance and demonstrates strong resistance despite the heavy* Striga *infestation.*

A sorghum line showing partial resistance to Striga.

Maintaining *Striga* Resistance

It is not enough to create crops that are resistant to *Striga*; crops must be able to maintain that resistance over time in successive seasons. To study this, a PhD student, Ismail Rabbi, has been examining the outcrossing rate or, in other words, measuring the amount of pollen from an individual plant that successfully pollinates another. Outcrossing rates are different for each crop and the results show that the rates are actually pretty low for sorghum. "The rate is 4% for sorghum," Kiambi says. "So for every 100 grains of pollen only four will pollinate other flowers, making it easy to maintain resistance to *Striga*."

Rabbi has also been assessing the geneflow, basically a measure of how far sorghum pollen travels. If a farmer grows *Striga*-resistant sorghum, will the genetic material travel from his fields to his neighbors'? To determine this, male-sterile sorghum, or sorghum that does not make pollen, is planted in the shape of a cross in a field. The center of the cross is planted with sorghum that does make pollen. A check along the legs of the cross will reveal whether or not a plant has been fertilized, a sign that the pollen has traveled that distance. Results of these experiments show that sorghum pollen travels anywhere between 40 and a maximum of 100 m from the point of planting.

Once the *Striga*-resistant varieties are officially released the only remaining challenge is to determine whether or not the seed systems in the various countries will be able to handle the demand they will generate. Kiambi's team is also enhancing the widespread distribution and effective assimilation of *Striga*-resistant varieties into the agricultural production systems through studies of sorghum seed supply systems in the partner countries. Netra Bhandari, another PhD student, is working to identify appropriate entry points and the major potential constraints of seed supply systems.

has identified five genomic regions (known as Qualitative Trait Loci or QTLs) in N13 that are associated with resistance to *Striga*. They have also identified a number of molecular markers that flank these QTLs. "We cross N13 with a local variety and then check whether the *Striga* resistance QTL has been transferred to the local variety through genotyping," says Dan Kiambi, an ICRISAT biotechnologist. This check for the presence of the resistant genetic material from N13 is known as foreground selection.

"We can check for the QTLs when the sorghum plant is only 2 weeks old and only advance the plants that have the QTL to the next backcross generation," Kiambi says. By not having to wait for the whole plant to grow to maturity to verify whether resistance to *Striga* has been conferred, Kiambi is able to significantly reduce the time required to develop a *Striga*-resistant farmer-preferred variety.

Kiambi also does what he calls a 'background noise check'. "We have to make sure that other genetic information from N13 is not transferred along with the QTLs that we want," he says. To make sure that this does not occur, Kiambi checks for the presence of a number of other markers besides those flanking the five resistance-conferring QTLs. "These technologies are very precise," he says. "We are not replacing any genetic components of the farmer variety. We are just adding to it. The resulting cross is almost identical to the original farmer variety and only a little component that provides resistance is added."

Through a 3-year project entitled 'Arresting the scourge of *Striga* on sorghum in Africa by combining the strengths of marker-assisted backcrossing and farmer-participatory selection' funded by the German Federal Ministry for Economic Cooperation and Development, BMZ, Kiambi and his team are working on creating six resistant varieties: two in Sudan, two in Mali, and one each in Kenya and Eritrea. The team will soon be conducting field tests of resistant varieties in the first three countries.

Tracks in the Sand: Technology Transfer in the Desert Margins

Long dry periods, unremitting winds, and the consequent erosion make the desert margins one of the harshest farming environments in the world. Arguably technology adoption in these areas is therefore even more important than in less harsh areas. In an attempt to promote technology adoption and information exchange to reduce the effects of wind erosion, the Desert Margins Program (DMP) facilitated field visits between scientists, extension officers and farmers from different areas and found that a first-hand view is crucial to spreading the message.

Farmers without borders

"People operating in desert margin areas such as livestock farmers or Rooibos tea farmers often face similar challenges," says André van Rooyen, DMP Regional Coordinator. "The value of taking people from one area to another is that they can see the technologies in action." For example, although from different agricultural regions and engaging in different agricultural activities, Rooibos tea farmers from the Suidbokkeveld in South Africa and livestock farmers in the southern Kalahari share a common problem – wind erosion. Whereas much research has been done in the southern Kalahari to reduce wind erosion and protect exposed areas, very little work has been done to protect tea plantations from the physical damage from sand particles during strong winds.

There are many technologies used to stabilize sandy soils, but to do it in a way that is economically viable and using available natural resources is not always easy. Such techniques have been developed and refined by the DMP in the Mier area of South Africa where extensive livestock farmers need to stabilize dunes that have become active as a result of overgrazing. One of the effective techniques is to cut and pack abundant unpalatable shrubs in very specific star-shaped formations. These 'stars' reduce wind erosion and trap nutrients and seeds, thereby initiating a re-vegetation process.

Dead shrubs packed in star-shaped formations trap nutrients and seeds and stabilize sand dunes in the Kalahari.

During their visit to Mier the farmers from Suidbokkeveld learned about this technology and discussed their challenges with the local Kalahari farmers who encouraged them to actively address their wind erosion problem. "Farmers don't often articulate to scientists what they need," says van Rooyen. "But two farmers will sit around and talk to each other. I was pretty amazed at how much they learned from each other about a whole range of issues."

That the visit was successful shows in the changing face of tea plantations in the Suidbokkeveld. For example, Koos Koopman, an innovative tea farmer, adopted the technology on his tea plantation. Koopman modified the technology by using Restio, an abundant reed-like plant available locally. He packed Restio in star shapes, similar to those he saw in the Kalahari, between tea plants and alongside conventional wind breaks. As a result, Koopman has stabilized large areas of previously mobile sand among and surrounding his tea plantation. Local experimentation to improve this technique is in progress.

Global DMP Coordinator, Saidou Koala, (left) discusses the effects of wind erosion with Rooibos tea farmer, Koos Koopman.

Back home: Innovative farmer Koos Koopman and his dog.

Beyond farmers

"We decided this sort of thing shouldn't just happen between farmers," says van Rooyen. "We should actively facilitate continued dialogue between farmers, extension personnel and scientists." As a result of these efforts technologies such as Local Level Monitoring and the Forum for Integrated Resource Management (FIRM) approach developed by the Namibian DMP team are now being implemented in Botswana and South Africa after exchange visits between scientists and extension officers.

While this level of information sharing can be expensive because of the direct costs incurred by travel and other logistics, the potential impact is high. Once technologies are adopted locally, the trend of copying, adapting and improving for local conditions is continuous. As the old Kalahari adage goes: "Once there are tracks in the sand, people will follow."

Managing Blast in Finger Millet: Finding Host Plant Resistance

Blast (*Magnaporthe grisea*), the most serious and widely spread disease of finger millet, affects the crop at all growth stages. It causes lesions and premature drying of young leaves. Blast can also affect the whole panicle or just a few fingers, preventing the seed from setting or causing the grain to shrivel. Whereas farmers are aware of the disease and its impacts on finger millet productivity, none of them know of an efficient coping strategy. The use of cultural (uprooting and burning infected plants) and chemical options to mitigate the effects of blast, though plausible, is limited by efficiency and cost implications. However, growing blast-resistant varieties of finger millet is a better, more cost-effective method of blast control;

The effects of blast – poor seed setting and shriveled grain.

ICRISAT has been working to develop these varieties.

From 2001 to 2004, ICRISAT, the Serere Agricultural and Animal Husbandry Research Institute (SAARI) in Uganda and the Kenya Agricultural Research Institute (KARI) conducted a study funded by the British Government's Department for International Development (DFID) on the pathogen diversity and management of blast. "The study characterized pathogen populations based on a collection of more than 300 isolates," says Mary Mgonja, Principal Scientist at ICRISAT. Results revealed limited diversity among the populations, though there was a considerable range of aggressiveness within the pathogen. The study also screened and identified 14 finger millet varieties that were resistant/tolerant to blast and suitable for growing in Uganda and Kenya.

Experimental design: The mother/baby approach

An experiment's design often determines its success. It can also determine the extent of farmers' involvement in the process and ownership of the product. In 2005 and 2006, ICRISAT, SAARI and KARI partnered up once again. This time they used the mother/baby trial design to evaluate resistance to blast and farmer perceptions of improved finger millet varieties in western Kenya and Uganda (Figure 1).

The mother/baby approach involves establishing 'mother' trials, which are completely managed by researchers and replicated two to four times per site. These trials are designed to compare different 'best bet' technologies in the same field both in the same season and also over several years.

The 'baby' trials are located around the mother trial. Farmers are allocated carefully selected treatments from the mother trial to test on their individual farms. These trials are not replicated. Baby trials provide farmers an opportunity to observe at first hand the performance of treatments at different trial sites and allow for faster, larger-scale testing at different locations under different management conditions. Put together the mother and baby trials provide a data set that is a good mix of variables and allows comparison of farmer practice with researcher-managed trials that vary over time and space.

The mother/baby trials then tested those previously identified varieties in selected villages in three districts in Uganda, and four in Kenya. Each mother trial consisted of one local and seven improved varieties. One of the seven improved varieties was a commercial variety. Each baby trial consisted of four of the above-mentioned varieties including a farmer's local check and the commercial variety.

The mother trials provided data on blast on the leaf, neck and fingers of the crop, days to 50% flowering, agronomic scores, plant height, lodging, panicle mass, threshing percentage, 100-grain mass and grain yield. The data were analyzed for each mother trial and also combined across sites. The results of the study were used to assess farmers' preferences and determine which varieties with high productivity and low reaction to blast on farmers' fields were suitable for western Kenya and Uganda.

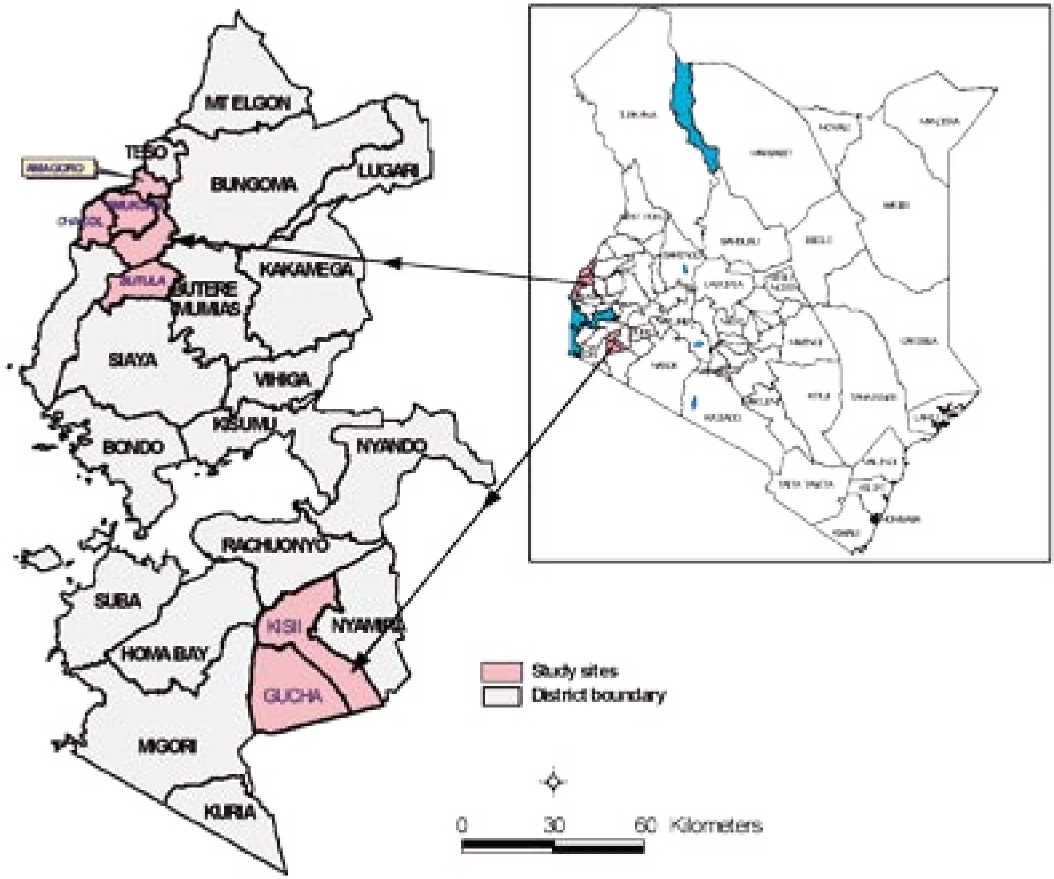


Figure 1.
Trial sites in Kenya for the 5 mother and 81 baby trials.

Identifying varieties for disticts

Overall, Mgonja and her team of breeders found that the average yield from the baby trials (1.52 t/ha) was almost the same as the average yield from the mother trial (1.58 t/ha) in Kenya. This showed that, in general, farmers managed their fields just as well as the researchers did. In Uganda, the improved varieties with a mean grain yield of 2.55 t/ha were far superior to the local varieties that yielded 1.45 t/ha. The farmers rated the varieties based on various traits such as the size of the panicle, yield, resistance to blast, and the color of the grain (most farmers preferred brown). The study found that in Kenya the varieties KNE688, KNE1149, KNE814 and Acc14 were suitable for Busia and Teso districts whereas varieties KNE 814, KNE 688 and Acc14 were

Finger millet facts

- Finger millet (*Eleusine coracana*) originated in the highlands of eastern/central Africa from where it moved to the Indian subcontinent around 3000 BC.
- Finger millet accounts for 8% of planted area and 11% of the production of all millets worldwide.
- In Eastern Africa it is grown mainly in the lake regions and highlands of Burundi, Democratic Republic of Congo, Kenya, Rwanda, Tanzania, and Uganda.
- Finger millet has a high production potential, reaching up to 4 t/ha under optimum conditions. However, average grain yields on farmer's fields are low, ranging from 500 kg/ha to 750 kg/ha.
- Rich in calcium, iron, manganese and fiber, finger millet is known for being more nutritious than other cereals. It is an excellent source of methionine, an amino acid often lacking in the diets of the millions of poor people who live on starchy foods such as cassava, plantain, polished rice and maize meal.
- Finger millet can be stored for long periods without being attacked by insects or mold, a critical trait in ensuring food security for poor households in drought-prone areas.

Finger millet in Kenya.

suitable for Kisii and Gucha districts. In Uganda varieties Seremi 1, Seremi 2 and SX 8 were selected for their blast resistance and productivity.

Besides identifying suitable varieties, farmers were also able to learn methods of integrating appropriate agronomic practices to improve productivity. They identified methods of postharvest handling to increase grain quality and cleanliness and ultimately improve the market value of their product.

According to Mgonja, "finger millet was not always given the same prominence as other cereal crops such as sorghum and pearl millet. But the crop is widely grown because it stores well, tastes good, and fetches up to three or four times the price of other cereals." ICRISAT is working closely with partners in National Agricultural Research Systems (NARS), large-, medium- and small-scale processors and the seed industry to facilitate easy access to disease-resistant varieties, promote knowledge sharing to enhance productivity and create better links to markets in order to improve food and nutrition security and ultimately to put more cash in farmers' pockets.

SEEDS to Success

Moving improved varieties from the research fields into the hands of farmers continues to pose a challenge despite the heavy investment in the development of seed industries. "The problem is that seed system development has been uncoordinated and has led to conflict between different components rather than a sustainable seed industry," says Richard Jones, Assistant Director for ICRISAT in ESA, based in Nairobi. "Our challenge is how to link the formal breeding system to an informal seed system."

According to Jones, it is regular demand for fresh seed that drives the development of a commercial seed industry and he believes that this demand exists in many countries in ESA. "Strong breeding programs are pumping out new varieties and the marketing of those materials stimulates farmers to go try new seed," he says. The problem is that the public sector has failed in providing foundation seed of the new varieties.

One of the problems facing the commercial seed sector is the restrictive regulatory environment that often hampers trade and marketing across national borders, necessitating duplication of research. For example, varieties are proposed for release after three years of testing in a country. However, the same variety will need to be tested again for another three years to be released in a neighboring country, even though they may share the same agro-ecologies. A new Southern African Development Community (SADC) agreement proposes that if a variety is released in two countries it can be entered into a regional catalog and marketed in all 14 SADC countries. This will reduce the time needed from research to commercialization and allow seed companies to exploit economies of scale. "The size of the seed market in Zimbabwe is not large, and neither is Malawi's. But if we put them together, then it becomes interesting," says Jones.

With the right enabling environment, seed companies of various sizes may be able to fix the shortage of high-quality seed of improved publicly developed varieties. Smaller seed companies may even have an advantage as they do not have research overheads and can deliver seeds that are preferred at the local level. ICRISAT and partners including the Seed Science Center of Iowa State University, CNFA, Inc., and the African Seed Trade Association (AFSTA) are working to develop local seed companies through the establishment of the Seed Enterprise Enhancement and Development Service (SEEDS). SEEDS will provide such services as identifying potential seed entrepreneurs, promoting knowledge of a formal seed industry, facilitating access to foundation seed for the production of certified seed, and providing technical support to these fledgling businesses. In addition, SEEDS will identify, train and certify agridealers with expertise from CNFA for both input supply and output marketing.

SEEDS in Practice

Relief agencies handed out seeds and tools to refugees returning to Mozambique from neighboring countries after the war. Even after the agriculture sector started to pick itself up, agencies continued to hand out seeds, essentially quashing the development of an independent seed industry. Companies sold their seed in bulk to NGOs, who distributed it among target farmers. As Mozambique received less and less aid, the demand for seed from NGOs diminished and many seed companies went out of business.

Groundnut has long been an important crop for small-scale farmers in Nampula Province, Mozambique. Recently, an association of small-scale groundnut producers created IKURU, a commercial company that is responsible for identifying market opportunities for their product. One of the opportunities IKURU identified was through Twin Trading, a UK-based company that would distribute Mozambican groundnuts through major supermarket chains in the

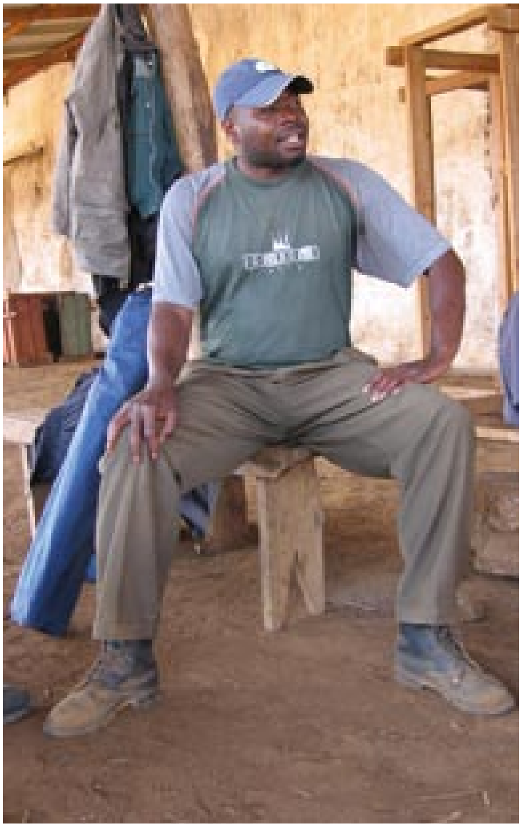
Seed processing facility in Nampula, Mozambique.

UK. IKURU also decided to tap into the organic groundnut market.

In 2004, IKURU bought 500 kg of basic seed of a well-established variety (ICGV 12991), known as 'Nametil' in Mozambique from Unidade de Semente Básica de Moçambique (USEBA). "USEBA was founded as the result of a project implemented by ICRISAT with funding from the Mozambican Government to produce and market basic seed of a number of different crops," says Carlos Dominguez, ICRISAT Country Representative in Mozambique. USEBA is formally part of the National Agricultural Research Institute (IIAM, Instituto de Investigação Agraria de Moçambique), but will eventually become self-sustaining through seed sales.

Through farmer clubs, IKURU multiplied the 500 kg to obtain certified seed that was then planted commercially by small-scale farmers to produce 500 tons of exportable groundnut. In areas where it was possible, farmers also produced 100 tons of organic groundnut that are ready to be sent to the international market after being certified by ECOCERT-Afrisco PTY Ltd, a South African company, providing a good example of what partnership and strategic market analysis can achieve. As Jones says, "Mozambique is the model to draw upon."

Another example of public–private partnership is ICRISAT's work with Moçambique Leaf Tobacco (MLT), a company that employs numerous tobacco growers all over the country. Lemson David has worked for MLT for 7 years as a leaf technician providing services and information to farmers on all stages of growing tobacco. David is one of the technicians who played a role in ICRISAT's groundnut seed distribution program. Each farmer in his area (around 2000 farmers in all) was typically given 40 kg of groundnut seed and asked to sell the remainder of their yield after keeping enough seed for the subsequent season.



Lemson David, tobacco leaf technician, describes ICRISAT's partnership with MLT.

As a nitrogen-fixing crop, groundnut is a good choice to grow after tobacco. "Farmers are starting to notice differences in soil fertility," David says. "Tobacco only provides a monetary benefit, but with

Growing groundnuts for the first time, Miguel Gideon Moyo managed to produce 6 tons of unshelled groundnuts.

groundnut they benefit from soil fertility and food as well."

Miguel Gideon Moyo has grown groundnuts for the first time on 4 hectares of his 55 hectare farm. He received 150 kg of seed of Mamane, an improved variety, and has so far sold 350 kg to ICRISAT. In total, he produced 6 tons of unshelled groundnut. Moyo is pleased with the experiment and wishes to increase his area sown to groundnut. "Come in December next year," he invites. "We will talk in the groundnut field."

Making the Best of a Changing Climate

Losing out in the good seasons

A common refrain when discussing the SAT is the high variability in rainfall. Typically, rainfall varies from about a third to two and half times the normal amount during a cropping season, making it exceedingly difficult for farmers to plan in advance and make investment decisions. For example, farmers in Machakos district, Kenya, rarely buy fertilizer or other inputs because the high probability of inadequate rainfall and subsequent crop failure makes using inputs a high-risk activity.

As far as risk mitigation strategies go, the farmers in Machakos have the right idea. By minimizing their costs and using other conservative management strategies, they minimize their risk in poor seasons. But adopting this strategy comes at a high price. "These farmers are unable to capitalize on the opportunities created by good seasons," says KPC Rao, Senior Scientist at ICRISAT. "Farmers in Machakos harvest only 600–700 kg/ha in seasons with good rainfall as opposed to more than 2 t/ha with carefully planned investments in low-risk technologies."

Perception is reality

Most of us make decisions based on our perception of the world around us. A farmer is no different. Most farming decisions are based on careful consideration of risk and benefits, and often have to be made well in advance of the actual cropping season. The key question then is how accurate are farmers in gauging risk?

A survey conducted in Mwala division of Machakos shows that farmers actually tend to overestimate their risk. On average they rated nearly 47% of the crop seasons as poor and believe that they suffer yield losses as a result of insufficient or poor distribution of rainfall. However, historical climate data indicates that only 27% of the seasons received less than 200 mm of rainfall – the minimum amount required to harvest maize. "If farmers can learn to better assess their risk then they will be able to make better management decisions," says Rao.

Forecasts make a difference

Advances in our understanding of and ability to model the global climate system have resulted in vast improvements in the reliability of forecasts. But farmers still remain unaware of using climate forecasting as a method of reducing risk and improving productivity. ICRISAT has been collaborating with the Kenya Meteorological Department (KMD), KARI, the International Research Institute for Climate Prediction (IRI) and the University of Nairobi (UoN) to explore opportunities for promoting the use of climate forecasts among farmers in Kenya.

Most farmers in Machakos district said they would base their farming decisions on forecasts provided they were true in at least four out of every five seasons. Do the currently available seasonal forecasts meet this standard?

Two institutions, IRI and KMD, provide long-term/seasonal climate forecasts for the region. The KMD forecast was 90% accurate whereas the IRI forecast was accurate for nearly 80% of the seasons. Both forecasts meet the farmers' expectations of being accurate for four out of five seasons.

Workshops and discussions with farmers have resulted in a deeper understanding of what kinds of information farmers say they need, and the types of decisions they would make based on that information. Farmers requested information on the amount of rainfall, its distribution, as well as the onset and end of the rainy season. They have also identified some potential decisions that could be made based on forecasts (Table 1).

For example, in seasons with below-normal rainfall, farmers said they would not use any fertilizer and grow around 22,000 maize plants per hectare. In seasons of normal or above-normal rainfall farmers said they would use 40 kg of nitrogen fertilizer per hectare and grow 35,000 plants per hectare. Conducting a scenario analysis using the Agricultural Production Systems Simulator (APSIM) shows that if farmers carried out these decisions based on forecasts, they could obtain an overall yield gain of 175% (Table 2).

The work so far has proved that by using climate forecasts farmers can make substantial gains in productivity without

Table 1.
Farmer-identified management options for below- and normal to above-normal seasons

Management decisions	
Below-normal seasons	**Normal to above-normal seasons**
1. Use low plant density (22,000 plants/ha)	1. Use higher plant density (35,000 to 45,000 plants/ha)
2. Reduce labor and other input use	2. Apply recommended dose of fertilizer (40 kg N/ha)
3. Increase use of drought-tolerant crops such as sorghum, millet, green gram and cassava	3. Plant hybrid maize varieties
4. Plow and plant early before the start of the rain	4. Adopt intercropping
5. Adopt water conservation measures	5. Strengthen terraces
6. Reduce area under cultivation	6. Increase area under cultivation

Table 2.
Expected gain in maize yield (kg/ha) with forecast-based adjustments

Short rains season	Farmer practice	Forecast-based practices (40 kg N and 35,000 plants/ha)	Gain/loss (%)
Dry (16)	610	911	49
Normal to wet (27)	666	2286	243
All (43)	645	1774	175

Note: The numbers in parentheses indicate the number of seasons in that category.

increasing their risk. However, the challenge of communicating this information to farmers still remains. In 2006, ICRISAT and partner institutions attempted to address this through developing and disseminating weather-based advisory services. Immediately after the release of KMD's forecast, KARI convened a meeting of agricultural, meteorological and extension personnel to discuss the agricultural implications of the forecast and then to develop a location-specific advisory service with expert advice (see box). This was translated into the local language, Kikamba, and distributed to extension personnel for wider dissemination in the target areas. So far, farmers have rated this service as extremely useful in planning various farm activities, making this an example of how changes in access to information can have major impact.

ICRISAT scientist, KPC Rao, interacting with farmers in Machakos district, Kenya.

Excerpt from weather-based advisory service

Agricultural implications of forecast:
With an average seasonal rainfall of 399 mm, the location can be classified as medium risk area for growing maize in general during the long rains season. Based on the forecast, the risk of growing maize during the 2007 long rains season seems to be higher than normal. Farmers are encouraged to plant such short-duration crops as cowpea, beans, and green gram and/or drought-tolerant crops like sorghum, pearl millet and finger millet. For those opting to plant maize, short-duration drought-tolerant KCB and DLC1 maize varieties are more suitable than others. Planting of cassava and pumpkins along bunds in small trenches can also be tried. Farmers may also plant other varieties of maize, sweet potatoes, short-duration pigeonpea and dolichos, but the chances of success are predictably low. For maize, the recommended spacing is one plant per hill at 90 × 30 cm or two plants per hill at 90 × 60 cm. Cowpea may be planted at 60 × 20 cm, beans at 45 × 20 cm, sorghum at 60 × 20 cm for sole crop and 120 × 15 cm when intercropped with a row of legume, pearl millet at 60 × 15 cm for sole crop and 120 cm × 15 cm when intercropped with a row of legume, finger millet at 30 × 10 cm and green gram at 45 × 15 cm.

Farmers are advised to plant the crops of their choice at the earliest opportunity either by dry planting immediately after harvesting the previous crop or by planting into the standing crop if the harvest is yet to be done. Further, they are advised to conserve as much moisture as possible by harvesting run-off from roads and other uncultivated areas, constructing tied ridges or contour furrows, and by covering the soil with residues where possible. Application of farmyard manure (FYM) can be practiced but use of inorganic fertilizer should be carried out after carefully assessing the available moisture in the soil. The season presents high risk and fertilizer application should be done with caution. Regarding crop protection, farmers are advised to watch out for a build-up in termite population, and to apply fungicides/pesticides especially on legumes depending on the situation.

Farmers measuring out water to demonstrate the positive benefits of residue application on soil water infiltration.

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Acronyms

AFSTA	African Seed Trade Association
APSIM	Agricultural Production Systems Simulator
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (Federal Ministry for Economic Cooperation and Development, Germany)
CRS	Catholic Relief Services
DFID	Department for International Development (UK)
DMP	Desert Margins Program
ESA	Eastern and Southern Africa
FIRM	Forum for Integrated Resource Management
FYM	farmyard manure
IIAM	Instituto de Investigação Agraria de Moçambique (National Agricultural Research Institute)
IRI	International Research Institute for Climate Prediction
KARI	Kenya Agricultural Research Institute
KMD	Kenya Meteorological Department
MAS	Marker-Assisted Selection
MLT	Moçambique Leaf Tobacco
NARS	National Agricultural Research System
NGO	non-governmental organization
PMG	Producer Marketing Group
QTL	qualitative trait loci
SAARI	Serere Agricultural and Animal Husbandry Research Institute
SADC	Southern African Development Community
SAT	semi-arid tropics
SEEDS	Seed Enterprise Enhancement and Development Service
UoN	University of Nairobi
USEBA	Unidade de Semente Básica de Moçambique (Basic Seed Supply Unit)

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