

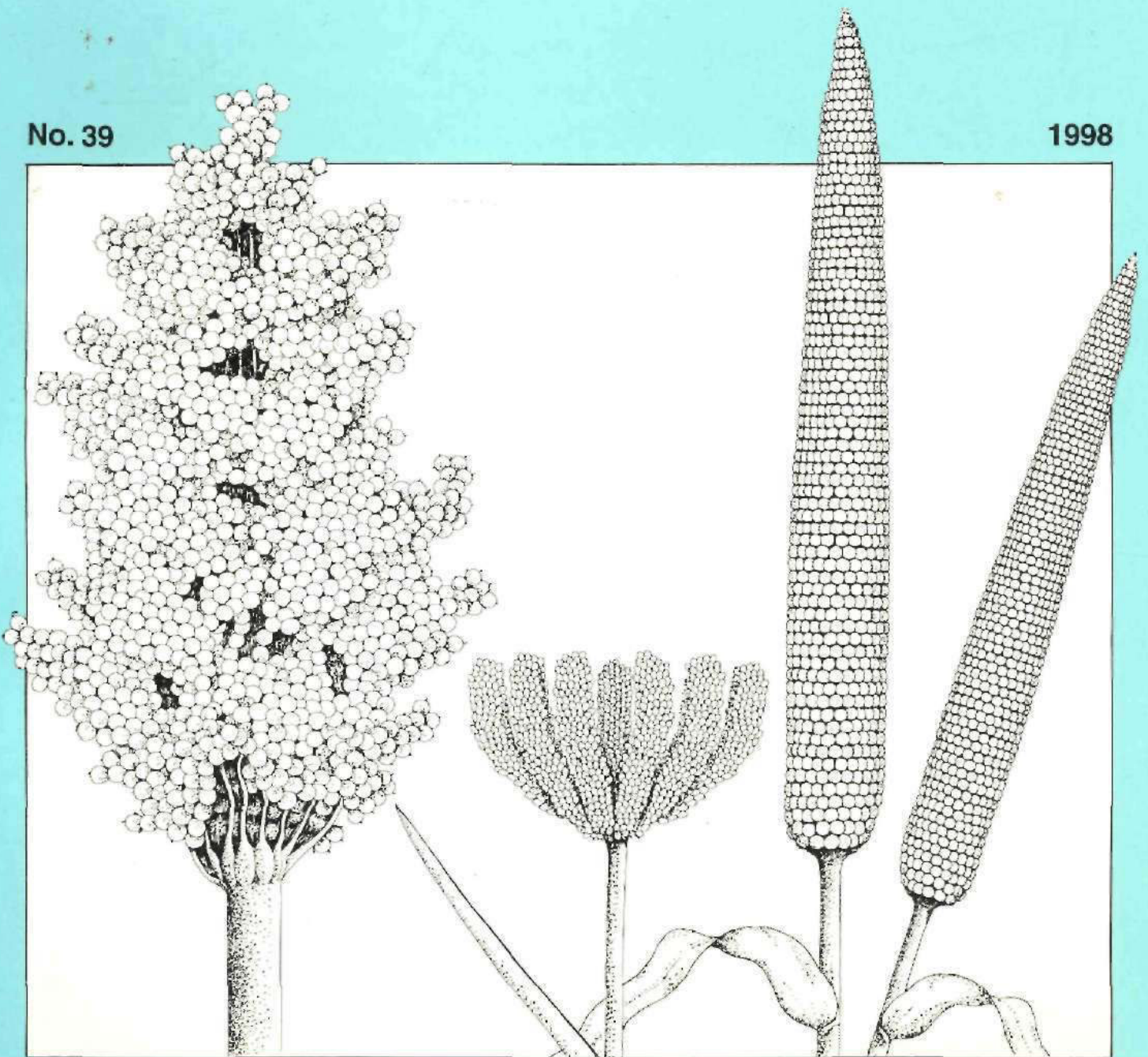


SICNA

# International Sorghum and Millets Newsletter

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# International Sorghum and Millets Newsletter

Co-publishers

**SICNA**  
Sorghum Improvement Conference  
of North America

  
**ICRISAT**  
International Crops Research Institute  
for the Semi-Arid Tropics

## About SICNA

In 1947, sorghum breeders formed an informal working group to meet and review items of interest in sorghum breeding and genetics. This organization was named 'Sorghum Research Committee'. In the 1960s, with the advent of a number of severe disease and insect problems, special half-day sessions, particularly on diseases, became a part of the Sorghum Research Committee. In 1973, a concept was put forward that all sorghum workers, irrespective of discipline and employer, should meet twice a year to discuss mutual concerns with sorghum research and development. The Sorghum Improvement Conference of North America was that new organization. It is composed of eight disciplinary committees, dealing with genetics and breeding, pathology, entomology, chemistry and nutrition, physiology and agronomy, biotechnology, utilization and marketing, and agribusiness and commerce. SICNA meets formally once a year in conjunction with the National Grain Sorghum Producers Board. A general program of research, education, and developmental activities is prepared by the disciplinary committees. Funding is through membership participation and contributions from commercial donors. Essentially, SICNA represents the United States sorghum activities but accepts reports and encourages memberships from sorghum and millet researchers worldwide.

## About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the SAT. ICRISAT's mission is to conduct research that can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 16 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors; it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the World Bank, the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP).

ISMN Scientific Editors 1998

J A Dahlberg

C T Hash

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## **Socioeconomics in SMIP: Research Highlights, Impacts, and Implications**

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### **Abstract**

Economics research under the SADC/ICRISAT Sorghum and Millet Improvement Program (SMIP) has targeted an evolving diagnosis of the main constraints to improving productivity in the sorghum and pearl millet based cropping systems of southern Africa. The research began by examining whether product market constraints limited the incentives to produce sorghum and pearl millet.

These investigations considered policy, institutional, and technological factors influencing industry demand for these crops. The results provided analytical input into national debates about grain market liberalization. Since more than 95% of sorghum and pearl millet trade was in the rural market, SMIP's analyses evolved to consider opportunities for improving grain flows from surplus to deficit rural regions.

Most market analyses indicated the importance of productivity growth in order for sorghum and pearl millet to become competitive with maize. Such analyses encouraged the allocation of greater resources in the third phase of the SMIP project toward technology transfer—in particular, the dissemination of new varieties developed during the previous project phases. Complementary analyses were initiated on seed market policies, and alternative strategies for seed multiplication and distribution. Results from these studies are contributing to the search for more sustainable methods of seed supply for open-pollinated varieties.

SMIP-supported assessments of the impacts of variety adoption offered mixed evidence of productivity gains. The yield gaps between on-station and on-farm trials and farmers' fields remain large. These analyses encouraged greater emphasis on the development of complementary, yet practical, fertility management options suited to the investment capabilities of small-scale farmers.

This review of some of the major products of SMIP's economics research highlights the difficulties of technological change and productivity improvement in the semi-arid cropping system. This has set the basis for the emphasis of the fourth phase of the SMIP project on developing more sustainable seed delivery systems, facilitating improvements in sorghum and pearl millet management, and exploiting market opportunities where these crops are most competitive. Priorities for economic analysis during this coming phase of the project are briefly summarized.

### **Economics research mandate**

In 1988, an economist was hired under the Southern African Development Community (SADC)/International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Sorghum and Millet Improvement Program (SMIP) to conduct studies of sorghum (*Sorghum bicolor* (L.) Moench) and millet marketing and utilization. SMIP hypothesized that the main constraint to the adoption of improved sorghum and millet technologies was the lack of demand for these crops. The evidence of mounting sorghum and pearl millet (*Pennisetum glaucum* (L.) R. Br.)

stocks held by Zimbabwe's Grain Marketing Board was used to justify this claim. The primary mandate of the economist was correspondingly to diagnose marketing and associated policy constraints to industry use of sorghum and pearl millet. These analyses were to complement the efforts of a food technologist hired to develop alternative sorghum and pearl millet based food products.

Preliminary analyses of national food and feed markets highlighted high sorghum and pearl millet prices as the main factor limiting industrial demand—maize (*Zea mays* L.) grain was generally cheaper and more consistently available on national markets. Improvements in productivity were viewed necessary to increase the competitiveness of these crops. Correspondingly, the focus of economics research during SMIP Phase 111 shifted toward impact assessment and the evaluation of constraints to technology transfer. Particular emphasis was placed on diagnosing constraints to seed distribution and adoption of new sorghum and pearl millet varieties. Variety adoption rates and impacts were evaluated in countries where these new varieties had been grown for several years.

However, early analyses of impact revealed that only limited productivity gains would be achieved from the introduction of new varieties. These also highlighted the gap between yields being achieved on experiment stations and in on-farm trials, compared with those achieved by small-scale farmers in their own fields. SMIP's initial efforts were correspondingly directed toward diagnosing constraints to investments in improved crop management practices—fertility management in particular.

This evolving research agenda was matched by efforts to improve the research capacity of economists in the region. Early training programs targeted policy analysis. Later ones targeted the strengthening of skills in crop management modeling. SMIP funding for postgraduate degree training was complemented by the pursuit of collaborative research and data analysis with young scientists throughout the SADC region.

## Grain market research

SMIP-sponsored analyses of grain market policies and performance sought first to assess opportunities for expanding industrial demand for sorghum and pearl millet. One objective was to advise governments on options for improving the competitive position of sorghum and millet through market-related institutional and policy reforms. Some of these results provided input into ongoing national discussions about grain market liberalization.

As market policy reforms were implemented, the research focus shifted toward analysis of the competitive position of sorghum and millet in the rural grain market. This included consideration of the impact of grain dehullers on incentives to produce these crops.

Collaborative studies on grain marketing and competitiveness were conducted in Botswana, Lesotho, Namibia, Swaziland, Tanzania, Zambia, and Zimbabwe.

## Evaluating industry demand

**Zimbabwe.** Early research examined the potential demand for sorghum and pearl millet by the national food and feed industry (Rohrbach and Mbwanda 1989). This revealed that the apparent surplus of sorghum and pearl millet on the national market was largely a result of unfavorable product pricing. The national Grain Marketing Board selling price for sorghum and pearl millet was higher than the selling price for maize. In consequence, only the opaque brewing industry purchased sorghum, and these purchases were limited to the 15 000 t per year necessary to make beer malt. The remainder of the food and feed industry used maize, the cheaper grain. The companies interviewed indicated that sorghum prices would have to drop 10-50% below the price of maize before they would buy any significant quantities. This and related analyses were used in discussions about grain market liberalization with the United States Agency for International Development (USAID) and the Government of Zimbabwe. Partly as a result of these discussions, Zimbabwe started its grain market reforms by liberalizing the trading of sorghum and pearl millet.

**Zambia.** SMIP's economist organized a related study, under the auspices of Zambia's National Commission for Development Planning, to evaluate opportunities for expanding industrial use of sorghum and pearl millet. This objective was viewed as a means to encourage diversification of the nation's agricultural economy and reduce grain imports. The analysis highlighted the opportunity to use 15 000 t of sorghum in the national baking industry as a partial (15%) replacement for wheat flour (Ministry of Finance and National Commission for Development Planning 1989; Rohrbach and Mwila 1989). The study also identified the opportunity for using up to 88 000 t of sorghum in the brewing industry, and 55 000 t of sorghum or pearl millet in the livestock feed industry. The main constraints to industrial use of sorghum and pearl millet were high subsidies on maize marketing and

wheat imports. Recommendations were provided for reducing these subsidies and promoting the processing and marketing of sorghum and pearl millet. The report encouraged liberalization of grain trading.

**Botswana.** SMIP's economist also contributed an analysis of the market demand for sorghum in Botswana (Rohrbach 1988) in the context of a USAID-funded Agricultural Sector Assessment. The analysis highlighted the growing importance of maize imports in this sorghum-based economy, and recommended policy options for improving the competitiveness of sorghum in the domestic food processing industry. These included the need to maintain import parity pricing for all major grains, and to reduce parastatal marketing costs. The report advised the Botswana government to lift restrictions on sorghum imports in order to encourage use of this grain in the milling industry. Botswana's grain market has now essentially been liberalized, though the Botswana Agricultural Marketing Board (BAMB) remains a high-cost operation. The small-scale milling industry has sharply grown during the past few years, largely on the basis of sorghum imports. The low productivity of domestic sorghum production remains a problem. Average sorghum yields in Botswana are only 10-20% of those achieved in neighboring South Africa.

**Tanzania.** SMIP's economist developed a collaborative project with the Sokoine University of Agriculture, examining the prospects for expanding the marketing and utilization of sorghum, pearl millet, and finger millet in Tanzania. The research highlighted the fact that less than 1% of the national harvest flows into the commercial market. Approximately 5000 t per year of red sorghum is used by the opaque brewing industry. Only around 1000 t per year is used by the livestock feed industry. Once again, the main constraint to the expansion of industrial utilization was the high grain price, itself due to low productivity and high marketing costs. While the liberalization of national grain markets during the late 1980s increased the number of traders and grain transporters serving the sorghum- and millet-growing areas, most transactions remained small. The research culminated in a national conference on sorghum and millet utilization (Minde and Rohrbach 1993) and the establishment of a national committee of research, extension, and industry representatives to liaise on subsector development.

**Swaziland.** A sorghum subsector reconnaissance was conducted in 1990 with representatives of the Research

Division of the Swaziland Ministry of Agriculture (Rohrbach and Malaza 1993). This reviewed production and market trends and discussed the competitive position of sorghum with farmers and representatives of the milling and livestock feed industries. The analysis highlighted the fact that only 1500 ha of sorghum is now grown in Swaziland. This is unlikely to increase without significant improvements in the productivity of the crop relative to maize. The analysis indicated that the best prospect for promoting sorghum use is to improve the productivity of higher-tannin red sorghum for brewing. This analysis encouraged the thesis research of M Malaza on "The displacement of sorghum as a major staple food crop in Swaziland."

**Namibia.** SMIP worked with Namibia's Directorate of Planning, Pricing, Marketing and Cooperatives to analyze the competitive position of pearl millet. Prospects for the commercialization of pearl millet were also assessed during the study (Keyler 1995b). The analysis highlighted two main constraints to expanding the production and sale of pearl millet flour. First, pearl millet yields are extremely low—generally less than 300 kg ha<sup>-1</sup> on average. Low and variable rainfall limits productivity growth, and causes high variability in production levels. Second, maize can be readily imported at competitive prices. In effect, the price of imported maize sets a floor under the pearl millet market. The preferred local grain generally sells for a 20-45% price premium over maize, depending on the levels of government purchases and local stocks. As a result, households facing a grain supply and income constraint purchase the cheaper imported maize. The study again concludes that the competitiveness of pearl millet on the domestic market can be improved primarily by increasing productivity (Rohrbach 1995a). This increase will have to be derived from improvements in water-use efficiency and soil fertility. Yet investments in new technology will have to be competitive with the returns to investments in livestock production, or the pursuit of off-farm employment.

## Rural markets

Recognizing that more than 95% of sorghum and pearl millet in the SADC region never reaches the commercial market, several of these analyses of grain demand were extended to include assessments of grain flows through rural markets. These include the trade of grain between neighboring farm households and between rural communities. This analysis was particularly concerned with the fact that most sorghum and pearl millet farmers

are net grain buyers in most years. Much of the grain being purchased in various communities is industrially milled maize. A logical first target for the marketing of surplus sorghum and pearl millet is then the rural consumer who is unable to produce enough to meet household food security requirements.

**Zimbabwe.** A SMTP review of the sorghum and pearl millet production in Zimbabwe showed that at least two-thirds of the farm households producing these crops face a consistent grain production deficit (Hedden-Dunkhorst 1993). In drier years, roughly half of all households farming in semi-arid regions have to reduce their calorie intake. Virtually all farmers rely heavily on purchases of maize meal to meet production deficits (Rohrbach et al. 1990). These analyses proposed the development of intrarural grain markets as a good means to encourage trade in sorghum and pearl millet. Regions with sorghum and pearl millet grain surpluses need to be linked with regions experiencing grain deficits. Grain trade restrictions prior to grain market liberalization prevented the development of these trading patterns. The national Grain Marketing Board was advised to become more actively involved in selling grain back into rural markets.

Shortly after Zimbabwe's grain markets were liberalized, SMIP examined the impact of the market reforms on sorghum and millet trade (Mazvimavi 1995a,b). The underlying hypothesis was that the removal of maize subsidies and associated restrictions on grain movements would encourage private traders to invest in grain trade. In semi-arid areas, private investment would be led by small-scale commercial grain millers. We found, however, that small-scale millers face strong competition from large-scale millers capable of negotiating favorable terms on input costs and exploiting economies of scale. Further, the profitability of small-scale milling operations depends highly on the costs and consistency of their grain input. Correspondingly, the most successful operations are based in peri-urban areas. At the time of the study these were only milling maize. Small-scale millers interviewed did not believe there was a market for sorghum or pearl millet flour. A key problem underlying the development of this market was the inconsistency of grain supplies. These findings have generally been confirmed by investment patterns in small-scale milling since 1985. However, one Bulawayo-based entrepreneur has initiated milling of sorghum flour.

**Zambia.** SMIP worked with the National Commission for Development Planning to examine the competitive

position of sorghum, pearl millet, and finger millet on the rural market (National Commission for Development Planning 1991). This study highlighted the dependence of rural consumers on purchases of industrially processed maize meal. National maize subsidies encouraged the production of maize in drought-prone regions. The costs of low and variable maize productivity in these areas were offset by the low costs and consistent availability of industrially manufactured maize meal. The study recommended policy support for the development of private sector markets, particularly markets facilitating grain trade from surplus to deficit rural areas, and the removal of maize subsidies. A set of 26 recommendations were provided to the government relating to production support, grain processing, storage, transport, and trade. These recommendations and the underlying baseline information on rural grain trade provided an input into national discussions on grain market liberalization.

**Tanzania.** The analysis of sorghum and pearl millet marketing and utilization with Sokoine University of Agriculture also examined grain flows on the rural market. Farm surveys revealed that, like Zimbabwe, more than three-quarters of Tanzania's sorghum and pearl millet producers face grain production deficits almost every year. Grain purchases are funded through the sale of household labor, livestock, and through involvement in petty retail trade. This reduces the labor and cash available for investment in the farming system. The reliance on grain imports into sorghum and pearl millet growing areas is problematic because of the high transaction costs associated with grain movements from surplus to deficit regions. Grain prices commonly differ by 200-400% across distances of 500-1000 km. In addition, price margins are higher for less heavily traded grains like sorghum and pearl millet. This encourages households growing sorghum and pearl millet to resolve their production deficits by purchasing maize. The study concluded that the first priority for improving food security in most sorghum and pearl millet producing zones must be to improve productivity. More than three-quarters of sorghum and pearl millet growers have never tried improved varieties. Less than 5% have ever tried chemical fertilizer.

**Namibia.** The analyses of commercialization prospects in Namibia were similarly complemented by a review of the prospects for expanding intrarural trade of pearl millet. As in the case of Zimbabwe and Zambia, the objective would be to replace purchases of imported maize with purchases of domestically produced grain. The study



indicated that most of Namibia's small farmers are net buyers of grain. In the principal pearl millet growing region of Ovambo, 74% of small farmers indicate they never sell grain, most commonly because they never produce a surplus. Most of those sales occurring are in the form of small transactions (averaging only 16 kg) between neighboring households. While most households express a taste preference for pearl millet, limited availability and relatively high prices encourage consumption of maize. Options for facilitating greater private sector millet trade are offered (Keyler 1995b). The primary efforts need to be directed toward improving grain flows from surplus to deficit regions and improving productivity (Rohrbach 1995a). This study provided the first major database on pearl millet production and marketing in the country (Keyler 1995a).

### **Impact of sorghum and pearl millet dehuliers**

**Zimbabwe.** During the late 1980s and early 1990s, sorghum and pearl millet dehuliers were being promoted in Zimbabwe (as well as Botswana, Zambia, Tanzania, and Swaziland) in the view that processing constraints were the main deterrent to the expansion of sorghum or pearl millet production. These correspondingly discouraged the adoption of improved cropping technologies. However, an assessment of the impact of dehuliers in Zimbabwe found they had little effect on sorghum or pearl millet production (Mazvimavi 1993). Most of the throughput for these dehuliers was maize. While farmers commonly stated a taste preference for mechanically dehulled and pounded sorghum and pearl millet, many were unwilling to pay the extra costs of dehulling. Over 50% of respondents within a 10 km radius of a dehuller still manually dehull their sorghum or pearl millet grain before taking it to a hammermill for pounding. The study found no significant change in the area sown to alternative crops associated with the introduction of dehuliers. The analysis concluded that the prices of dehulling services may need to drop relative to the opportunity cost of female labor in order to encourage greater use of these machines. In addition, the study suggested that improvements in sorghum and pearl millet productivity will be required before these crops begin replacing maize in the local cropping system.

**Lesotho.** SMIP worked with representatives of the Agricultural Research Division to conduct a reconnaissance of the coarse grains market, to help set the terms of

reference for an International Development Research Centre (IDRC)-funded analysis of the demand for dehulled sorghum and the financial viability of sorghum dehuliers. The preliminary analysis indicated that dehuliers were unlikely to reduce reliance on imports of maize, wheat, and sorghum from South Africa (Rohrbach et al. 1989). However, dehulling services could encourage expansion of sorghum production relative to maize in the southern parts of the country, where sorghum has a productivity advantage. The analysis encouraged complementary research on the competitiveness of sorghum by a national economist, N Moletsane, working on a Masters degree with SMIP funding.

### **Adoption and impact studies**

A series of adoption and impact studies were conducted in Botswana, Malawi, Namibia, and Zimbabwe. These studies assessed the justification for further investments in the crop breeding programs while highlighting targets for future breeding efforts.

### **Drought relief seed**

SMIP first assessed the impact of the free distribution of sorghum and pearl millet seed in response to the severe 1991/92 drought in southern Africa (Friis-Hansen and Rohrbach 1993). With special USAID funding, ICRISAT contributed to the production of more than 490 t of white sorghum seed and 160 t of pearl millet seed for Zimbabwe, Namibia, and Malawi. This investigation highlighted the value of the emergency production of varieties well adapted to the region. Farm surveys revealed that much of the seed being imported into southern Africa by donors and NGOs for drought relief was poorly adapted to the region. Though expensive, the effort to produce locally adapted varieties under winter irrigation provided large numbers of farmers (including 30% of sorghum growers and 20% of pearl millet growers in Zimbabwe) with initial access to newly released varieties of sorghum and pearl millet. The locally developed sorghum varieties offered grain yields five times greater than ill-suited sorghum seed imports. The study also revealed that, contrary to government and donor perceptions, rural seed stocks were not wiped out by the drought. Most farmers had retained sorghum or pearl millet seed in stock. Seven recommendations were provided for future seed distribution schemes associated with drought relief.

### **Zimbabwe's sorghum and pearl millet breeding**

SMIP, in collaboration with a national economist, conducted a follow-up assessment of the impact of sorghum and pearl millet breeding in Zimbabwe. This calculated an internal rate of return (IRR) of 27-34%, and a stream of net benefits ranging from US\$ 7.8-28.9 million, on the combined investments of the Zimbabwe national program and ICRISAT in the development and dissemination of two varieties, SV-2 sorghum and PMV-2 pearl millet. This IRR is competitive with the returns to other investments in the Zimbabwe economy and compares favorably with the returns to agricultural research calculated elsewhere in Africa. Additional benefits accrue in the form of enhanced food security to some of the most drought-prone regions of the country. Interestingly, however, farmers do not cite productivity gains as the main reason for adopting these new varieties. According to on-farm trials, the yield gains from changes in variety average less than 20%. Farmers indicate the earlier maturity of these varieties is the main justification for their adoption. This offers a better chance of a harvest when rains fail. If larger or more consistent yield gains are to be achieved, improvements are necessary in crop management practices, particularly in fertility management.

### **Namibia's pearl millet breeding**

A SMIP-led impact assessment of Namibia's breeding program (Rohrbach et al., in press) indicates the IRR to public investments in the development and dissemination of new pearl millet varieties in this country has been 60%. This high rate of return reflects the importance of pearl millet in the Namibian cropping system, and the rapid delivery and acceptance of the Okashana 1 variety. Research costs were low because of the timely evaluation of a wide range of germplasm delivered by ICRISAT through SMIP. The returns were also improved by the quick release of Okashana 1 in response to farmer interest expressed during early participatory evaluations of this cultivar. In addition, seed was delivered rapidly to farmers because of complementary public investments in building a semicommercial seed multiplication and distribution facility. Most Namibian farmers are now well aware of the opportunity to obtain new varieties of pearl millet. Correspondingly, the prospects for adoption of two additional pearl millet varieties released in April 1998 are favorable.

### **Botswana's sorghum breeding**

A recent assessment of the adoption of newly released sorghum varieties in Botswana highlights the need to link improvements in sorghum productivity with the exploitation of the commercial grain market (Rohrbach and Makwaje, in press). Botswana released three open-pollinated sorghum varieties and one sorghum hybrid in 1994. One of the varieties, Phofu, has already been widely disseminated. Within 2 years of its release, more than 90% of the nation's small-scale farmers were aware of this cultivar, and almost 50% had planted it. This success is attributable to government support for the multiplication of this variety, and the distribution of Phofu under national drought relief programs. Much smaller quantities of the other three cultivars (Mahube, Mmabaitse, and BSH 1) were produced and distributed. However, farm surveys and a review of variety trial data indicate no yield gains are offered by three of the four cultivars. The hybrid cultivar offers the promise of yield gains, but Botswana has been unable to produce the seed of this hybrid. The study highlights the fact that larger gains in productivity will only be derived from improvements in crop management. However, these are unlikely to occur without stronger efforts to commercialize production. The country now imports most of the sorghum used by its milling and brewing industries. Research and extension need to work with these industries to pursue a strategy explicitly linking technology change and commercial grain market demand.

### **Zambia' sorghum breeding**

SMIP provided assistance to the Department of Research and Specialist Services in Zambia for an impact assessment of its sorghum research program (Chisi et al. 1997). Since 1987, seven new sorghum varieties and hybrids were released for distribution to farmers. According to survey results, adoption levels for new sorghum varieties reached 20% in 1993 and 35% in 1995. Adoption in the smallholder sector is largely the result of the initiatives of nongovernmental organizations and public drought relief schemes to distribute the seed of released cultivars. Most of this distribution was free of charge. The calculation of the IRR depends critically on assumptions regarding future rates of adoption and the ceiling level at which adoption peaks. If the 1995 adoption rate continues without farther expansion, the returns to sorghum

research in Zambia will be marginal. However, this appears unlikely given the level of acceptance of the new varieties. An adoption rate of 50% would yield an IRR of 15.4% and a net present value (NPV) at a 5% discount rate of US\$ 6.4 million. This study also highlights the fact that the level of research costs can significantly influence the returns to these investments. In Zambia, considerable manpower and capital expenditure through special project support contributed by an external donor reduces the average rate of return. The relative cost of these investments was particularly high given that Zambia produces less than 50 000 ha of sorghum. Nonetheless, Zambia benefited from exploitation of a range of sorghum germplasm already characterized and initially developed by ICRISAT and other international breeding programs. By implication, returns to future research investments may improve with further exploitation of this international technology base.

### **Seed market analysis**

By the beginning of Phase 111, SMIP's collaborative research and development efforts had stimulated the release of more than 20 sorghum and pearl millet varieties in southern Africa. Yet few farmers had access to this seed. Correspondingly, several regional studies, and more detailed investigations in Zimbabwe, targeted the diagnosis of constraints to sorghum and pearl millet seed production in the formal seed sector, and opportunities for expanding seed flows through informal seed markets. SMIP also organized a major international conference reviewing alternative seed supply strategies.

### **Formal seed markets**

Surveys of variety adoption, and associated efforts to monitor seed multiplication and distribution through commercial seed markets indicate few small-scale farmers have consistent access to sorghum or pearl millet seed varieties released by national agricultural research systems (NARS) in southern Africa (cf. Rohrbach 1995b; Rohrbach et al. 1997). Most of the seed distributed during the past 10 years has been given out free of charge under government and donor funded drought relief or refugee resettlement programs. This includes over 3 000 t of sorghum and pearl millet seed produced for the 1995/96 cropping season. Commercial companies consistently express doubts about the existence of significant retail market demand for open-pollinated varieties. They expect that once farmers obtain new

varieties from drought relief programs, they will continue to retain this seed from their harvests. In consequence, the returns to investment in building retail market channels are perceived to be low. Farmers still complain about the lack of sorghum and pearl millet seed in local markets. But private companies remain unconvinced about the size and consistency of this demand.

The persistence of seed delivery under national drought relief and resettlement programs has, however, encouraged private companies to multiply large stocks of sorghum and pearl millet seed for sale to the public sector. A review of SADC seed stocks conducted in early 1998 revealed a regional seed surplus of more than 7000 t of sorghum and 2500 t of pearl millet (Rusike and Rohrbach 1998). Most of this is held by seed companies in South Africa, Zimbabwe, and Zambia. The stocks were built up in anticipation of donor support for seed distribution following the 1997/98 season *el nino* drought.

Interest in drought alleviation strategies has also encouraged nongovernmental organizations (NGOs) to initiate small-scale seed production projects in Zimbabwe, Zambia, Malawi, Mozambique, and Tanzania (Mitti 1997; Msimuko 1997). Early evidence indicates, however, that the efficiency and financial sustainability of many of these efforts is questionable.

### **Informal seed markets**

The limited commercial interest in the development of retail markets for sorghum and pearl millet seed encouraged SMIP to investigate the structure and conduct of informal, village seed markets. Studies in Zimbabwe (Rohrbach and Mutiro 1997; Rohrbach 1997) reveal that roughly one-third of all farm households participate in the local trade of seed. The largest share of these transactions take the form of gifts to neighboring households and to relatives in more distant villages. However, the degree of quality control in this seed market is limited. Much of the seed being traded is derived from household grain stocks.

The surveys provide virtually no evidence of field isolations to maintain varietal purity. While most farmers select seed in the field prior to harvest, the tendency to sow multiple varieties leads to genetic mixtures. Seed prices do not appear related to clear quality standards. These analyses have encouraged a PhD study on the impact of commercialization and seed market development on sorghum varietal diversity in Zimbabwe. SMIP is providing advisory assistance for this study.

## Regional seed policies

A SMIP-sponsored regional study of constraints to the release, production, and distribution for sorghum and pearl millet seed provides a comparative review of the structure and performance of seed sectors in Tanzania, Malawi, Zambia, Botswana, Mozambique, and Zimbabwe (Musa and Rusike 1997). The report notes that intellectual property rights have been used to preclude the entry of small-scale seed producers into the seed industries of some countries. Parastatal companies linked with government research units have sought to retain monopoly control over seed production, but failed to broadly market sorghum or pearl millet seed. Private seed companies are starting to compete with public agencies, but the lack of enforceable plant breeders rights discourages multiplication by some of these companies. In addition, mandatory certification of seed restricts multiplication of varieties by NGOs and farmers' groups. In some countries, mandatory varietal registration has also limited seed release and multiplication. The report provides recommendations on variety release procedures, intellectual property rights, seed inspection procedures, seed registration and certification procedures, the role of NGOs, and highlights the opportunities for further developing a competitive private seed sector. Shortly after the preparation of this report, sorghum and pearl millet seed trade was liberalized in Zimbabwe.

This analysis led to SMIP leadership in organizing an international conference on Alternative Strategies for Smallholder Seed Supply in March 1997. Twenty-seven papers on alternative public and private sector seed supply strategies were presented and discussed. The conference offered recommendations for further development of seed systems in southern Africa and for the establishment of a regional seed network. The procedures for establishing this network are currently under discussion.

## Fertility management research

Survey evidence has consistently revealed that less than 5% of the farmers in the semi-arid regions of southern Africa use chemical fertilizer (Rohrbach and Makwaje, in press; J Doughty, Rural Development Support Programme, personal communication; Minde and Mbiha 1993). Yet significant productivity gains are unlikely without this input. Studies in Zimbabwe are evaluating the range of factors influencing technology adoption and strategies for defining more practical fertility management recommendations.

## Diagnosing the problem

A reconnaissance survey on fertility management by small-scale farmers in semi-arid areas of Zimbabwe (Ahmed et al. 1997) indicates that while manure use is widespread, the rates of application are declining due to the loss of cattle during recent years of drought. Increases in the harvesting and selective feeding of crop stover have reduced the availability of residues to the soil. While farmers are aware of the value of some crop rotations, the application of these rotations is restricted by the need to sow most land to cereals. Many farmers are also using anthill soil as a nutrient supplement. But this has contributed to a rapid decline in the number of anthills in some areas. Use of humus and leaves from nearby wooded areas has also increased. Farmers commonly complain about the high cost of fertilizer. Some claim that fertilizer use may be detrimental to their soils. Such findings suggest knowledge and education constraints may be as severe as cash constraints in limiting the adoption of chemical fertilizer.

## The evolving use of crop residues

The analysis of crop management practices at a single point in time commonly neglects the fact that practices are constantly changing. In semi-arid areas with semisubsistence cropping systems, some of the largest changes are resulting from growing pressures on limited resources. For example, the growth of rural populations has led to the reallocation of grazing land to crop production across much of southern Africa. But cattle numbers have continued increasing and land degradation due to over-grazing represents a rising threat. An investigation of resource use trends in Zimbabwe (Takavarasha 1993) reveals that farmers have responded to growing land pressures by sharply increasing the collection and use of crop residues. During the past three decades the amount of grazing land per livestock unit has declined by 50%. During this same period the proportion of households beginning to collect and selectively feed crop residues has more than doubled. According to cross-sectional survey data, by the early 1990s over 90% of small farmers had started collecting crop residues from their fields. Correspondingly, the relative value of grain stover has sharply increased. The value of sorghum, pearl millet, and finger millet stover ranged from 38 to 53% of the value of the respective grain harvests over the 1988-1992 period. These results suggest the value of considering stover yields in national breeding

programs. They also highlight growing pressures on limited soil resources. When residues were openly grazed, crop fields gained both a portion of the stover and manure from the feeding animals. The incorporation of both sets of resources into crop soils has declined.

### **Modeling fertility options**

SMIP's farm surveys reveal that few farmers receive extension advice related to soil and water management, and most of the limited advice being offered is ignored. This advice is largely irrelevant to the investment priorities of most small-scale farmers. In a pilot exercise, economic and bio-physical modeling are being combined with field surveys to develop more practical extension recommendations for fertility management in Zimbabwe (Ahmed and Rohrbach, in press; Rohrbach, in press). The initial analyses emphasize fertility management options for households facing severe cash constraints. Rather than evaluating how to maximize crop yields or profits, these analyses target improvements in the returns to application of the limited quantities of fertilizer or manure farmers have available. If a farmer is only able to purchase one bag of chemical fertilizer, what should be the nutrient mix and how should this be applied in order to maximize returns to this limited investment? The modeling also aims to ask how the contributions of legume rotations and intercrops can be maximized in these drought-prone environments.

This research is only at an initial stage. However, the early results are promising. These suggest that farmers can increase average sorghum yields by 25% simply by better targeting the fertilizer received under recent drought relief programs. Farmers can also increase the returns to manure use by combining this input with small quantities of chemical fertilizer (Ahmed and Rohrbach, in press). While further work is needed to verify the accuracy of simulations with manure, the results are promising enough to encourage initial testing of such low input (but high return) management options with small-scale farmers.

### **Human resource development**

During Phase II and the first part of Phase III, SMIP provided degree training for seven economists through INTSORMIL-related programs in the United States. These have now returned to research and development programs in southern Africa. Three have returned to posts in national agricultural research institutes and two

are in university positions. The whereabouts of the remaining two are unknown. Two of these economists are still working on sorghum and millet related issues at least part of their time. The high mobility of economists, and strong, varied demand for their services, results in limited attention being directed toward economic analysis relating to sorghum and pearl millet.

A SMIP-led analysis of economics research capabilities reviewed this situation in 1993 (Heisey and Rohrbach 1995). This identified 37 economists employed in 8 of the 10 NARS in the SADC region (not including South Africa). More than half of these economists were employed in Tanzania alone. Several countries, including Namibia and Mozambique, had no economists in their agricultural research institutes. There were no economists in the SADC NARS with PhD degrees. Only one-third of these economists had MSc degrees. The survey indicated there are no consistent sources of in-service training for economists in the region. Economists in all countries sought assistance with applied techniques of economic analysis. There was particular interest in training in methods of technology adoption and impact assessment.

SMIP, in collaboration with the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), established a Policy Analysis Initiative (PAI) in 1990 as a pilot program designed to encourage economists from NARS to incorporate policy analysis into their work. The PAI sought to encourage consideration of how agricultural policies affect technology adoption and use. The PAI also provided a mechanism for economists based in the NARS of eastern and southern Africa to discuss technology and policy issues of common concern, examine common analytical problems, and to learn from the work of their peers in other national programs. The PAI was launched with a planning and methodology workshop for 15 economists from eastern and southern Africa in late September of 1990. These included participants from Botswana, Ethiopia, Kenya, Malawi, Swaziland, Tanzania, Zambia, and Zimbabwe. During this workshop, analytical methods for evaluating technology adoption, fertilizer use, grain marketing, and research resource allocation policy were outlined. Over the next year, the PAI provided analytical support for these sorts of studies and, in a few cases, small research grants. In March of 1992, the PAI sponsored a reporting workshop incorporating the presentation of 15 papers and a seminar on methods of fertilizer policy analysis. The papers were published in a book (Mwangi et al. 1993).

Efforts to extend this PAI were hindered by disagreement about what institutions should take charge of policy analysis training in southern Africa. The SADC Food

Security Unit eventually established its own policy analysis training program. The University of Zimbabwe is working to establish a policy analysis network.

SMIP worked with the Southern African Centre for Cooperation in Agriculture and Natural Resources Research and Training (SACCAR) to provide training in methods of impact assessment during regional workshops held in 1994, 1995, and 1996. Over 40 socioeconomics and biophysical scientists from all SADC countries were trained in techniques of impact assessment.

### **Implications for the future**

Analyses of the demand for sorghum and pearl millet in the product market consistently highlight the need for these crops to be competitive in price and availability with maize. Sorghum and pearl millet commonly cost more than maize or are only inconsistently available to industry buyers. The quality of grain available on national markets tends to be highly variable. Industries requiring sorghum for particular products, such as opaque beer, have learned the value of contracting with farmers for varieties and grain quality standards meeting their requirements. When maize cannot be used, sorghum contracts may even attract a premium price. Where substitution is possible, sorghum must be available at prices 10-30% below the price of maize. This requires that sorghum be produced and transported to the factory at costs lower than those for maize.

Sorghum and pearl millet trade is also disadvantaged by the fact that most producers are small in scale and distantly located from industrial consumers. Further, production levels are highly variable due to the frequency of drought. This raises the costs of grain assembly and transport, relative to competing inputs like maize. Industry in South Africa and Zimbabwe has sought to reduce this uncertainty by contracting for its needs. However, efforts to minimize contracting costs encourage transactions with fewer larger scale farmers. We know little about opportunities for extending these contracts to small-scale farmers.

A small premium market exists for sorghum and pearl millet grain or flour priced higher than the costs of maize. This is evident in the sale of sorghum flour by a small miller in Zimbabwe and the prevailing costs of pearl millet grain and flour on the Namibian market. Sorghum flour often sells for more than the price of maize flour in Botswana. However, little information is available about the size of this market and the potential for market expansion.

The main determinant of the competitiveness of sorghum and pearl millet, both in the rural food system and the industrial market, is the productivity of these crops. Prior to the liberalization of national grain markets in southern Africa, sorghum and pearl millet were often disadvantaged by a range of implicit and explicit subsidies on the trade of maize. Now that these markets have been largely liberalized, the relative competitiveness of alternative crops in domestic production and regional trade has become even more important. If Botswana, for example, can import sorghum from South Africa more cheaply than it can produce this grain, comparative advantage suggests domestic resources ought to be allocated to more productive farm enterprises like livestock. Farmers in southern Zimbabwe may be better off producing cotton and buying their grain supply. While sorghum and pearl millet production may remain essential for household food security, low yields will inhibit trade on domestic and regional markets.

Assessments of the adoption of new varieties reveal strong interest in adopting new sorghum varieties offering earlier maturity than traditionally grown cultivars. This trait improved the probability of grain harvests in years of drought. However, the average yield gains being achieved with the new cultivars are smaller than expected. These range from zero to 35%. Survey evidence indicates farmers are not changing their crop management practices as they adopt new varieties. In effect, they are failing to take advantage of the greater responsiveness of new cultivars to improvements in fertility and water management. This remains a challenge for sorghum and pearl millet technologists.

In most SADC countries, the main determinant of variety adoption has been the free distribution of sorghum or pearl millet seed for the purposes of disaster relief. Indeed, commercial seed companies in Zimbabwe, Zambia, and South Africa have geared up production to feed the emergency market. Virtually all sorghum and pearl millet seed distribution north of South Africa has been subsidized, and little seed flows through retail trade channels. The lack of commercial interest in developing rural seed trade and continuing demand for seed for emergency relief has encouraged a range of NGOs to pursue village seed production projects. However, the sustainability of these efforts, once donor subsidies are withdrawn, remains open to question.

The economics research funded during the early stages of SMIP encouraged the pursuit of grain market liberalization. As markets were being liberalized, this research argued for continuing support for the development of intrarural grain trade promoting the movement

of grain from surplus to deficit regions. But most liberalization strategies simply targeted the reduction of market regulation and public investments. The economic research highlighted the value of continuing public support for seed production in order to promote the rapid dissemination of new varieties. At the same time, this has started to outline a range of alternative seed supply mechanisms. Finally, recognizing that larger productivity gains will only be achieved with improvements in crop management, the economics unit has initiated pilot analyses of how to better orient advice on alternative fertility management strategies to the investment matrix farmers are willing to consider. The target is to maximize returns on the more limited investments farmers are willing to make. This, too, remains a challenge for continuing work.

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## Technology Exchange in Phase III of SMIP

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### Abstract

The first two phases of SMIP led to the development of a range of improved technologies. During Phase III (1993-98), the priority was therefore to promote the transfer of these technologies (primarily improved sorghum and pearl millet varieties) to smallholder farmers. The three key components of technology exchange activities were: verification of technology under farmers' conditions; backstop support for national seed production and distribution; and review and revision of extension recommendations. These activities were implemented largely by the national research and extension programs. SMIP acted as catalyst and facilitator, focusing on areas where the regional program could be of greatest assistance to national initiatives.

On-farm variety trials involving national research and extension staff, NGOs, SMIP, and farmers were conducted in nine SADC countries to evaluate varieties developed during the previous two phases of SMIP. In five countries (Botswana, Namibia, Malawi, Mozambique, and Tanzania), the trials led directly to national recommendations for release of sorghum and/or pearl millet varieties. In Swaziland, Zambia, and Zimbabwe the trials served to verify performance and farmer acceptance of varieties that had been released but not widely tested on farmers' fields.

SMIP provided training in seed production techniques to research, extension, and/or NGO staff in five countries (Botswana, Malawi, Mozambique, Namibia, and Zimbabwe), and financial support for national seed production efforts in Tanzania, Zambia, and Lesotho. Seed availability, though still a major constraint to variety adoption, has improved considerably. Regional seed stocks (excluding seed retained by farmers) at the end of the 1997/98 season were over 4400 t for improved sorghum varieties and 965 t for improved pearl millet varieties.

Another key area was the review of extension recommendations. SMIP cosponsored a major regional workshop that examined current management recommendations in each country, and reviewed available information on farmers' production systems, adoption levels, and constraints to the adoption of crop management