This program ensures small-scale farmers' access to extension support, input supplies, infrastructure development, training, agricultural information, and markets. Progress Mill is committed to buying sorghum from small-scale farmers and has the infrastructure to accommodate 7000 t. A follow-up meeting was held by PM on 23 August 2001 and a work plan has been developed that will model marketing as a stimulant to the use of improved technology. A number of organizations have indicated their interest in participating in this work

- ICRISAT-SMINET will assist in organizing an exposure trip for a selected group of collaborators [Tompe Seleka, PM, SANSOR, Northern Province Department of Agriculture and Evironment (NPDAE), South Africa] to Namibia to study smallholder seed production by the Northern Namibia Seed Growers Association in order to develop a seed system that will help the small-scale farmers of NP.
- ICRISAT-SMIP is leading the development of a concept note that will address *Challenges and opportunities to increase smallholder benefits from sorghum and millet production system in the semi-arid areas of the Northern Province of South Africa'.* This will be submitted through the USAID Regional Centre for Southern Africa (RCSA) support on good governance for RSA
- In three districts of NP field activities were initiated during the 2001/2 season to introduce improved technology for sorghum and millet and strengthen links with the output markets. The objective is to test the hypothesis that output markets will stimulate small-scale farmers to adopt and use improved technology. This work is implemented in collaboration with public and private partnerships within and outside NP.

Five SMIP non-pilot countries were exposed to the seed system models practiced in pilot countries. Follow-up meetings in RSA helped in developing work plans and strategies to link grain markets with the use of improved sorghum and millet technologies. The primary school seed production model is being emulated in Malawi.

Field days have proved effective in efficient regional technology exchange in that various models can be developed in a few pilot countries for adaptation across the region depending on similarity of constraints, and socioeconomic and policy systems.

Regional Collaboration for Research Impact: the Case for SADC Regional Development and Adaptability of Improved Sorghum and Pearl Millet Varieties

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Introduction

Public and private investments in technology development offer high payoffs if the resulting technologies are distributed and applied regionally across national borders. Economies of scale are commonly being sought in the private sector and in public-funded, international agricultural research systems. The international application of technology and associated scale economies are readily apparent in the experience of the ICRISAT/ Southern African Development Community (SADC)-Sorghum and Millet Improvement Program (SMIP), which has shown that regional collaboration in crop breeding makes good agricultural and economic sense. Recent analyses of the adaptation of sorghum and pearl millet varieties in southern Africa provide a scientific justification for strengthening regional collaboration in breeding. This evidence is reinforced by the fact that countries throughout southern Africa have clearly benefited from spillovers in crop varieties. The regionaiization of seed markets has provided a foundation for seed delivery to flood- and drought-relief programs. The implications of these findings merit further discussion.

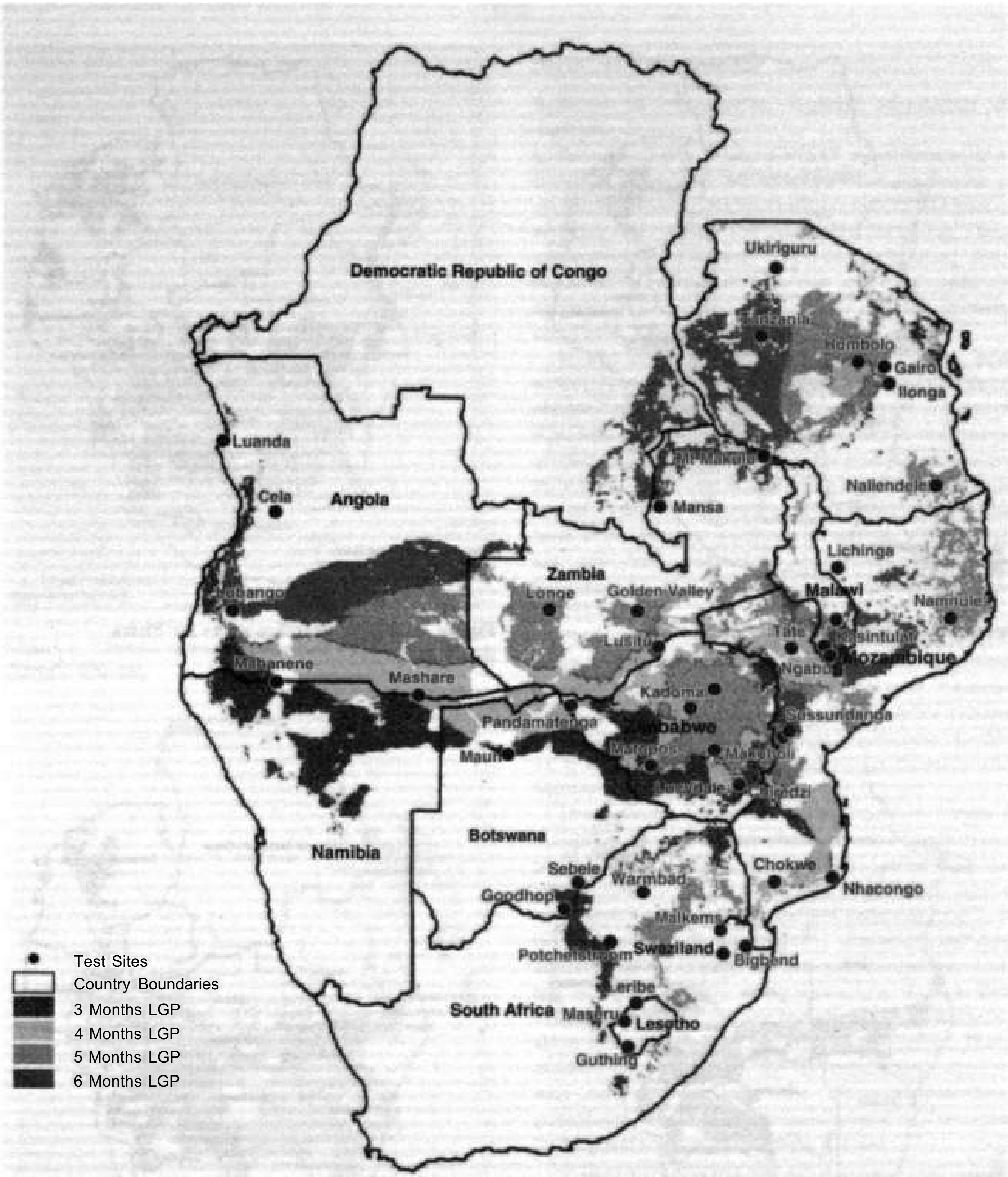

Figure 1. Geographical information systems (CIS) on lengths of growing period in southern African countries

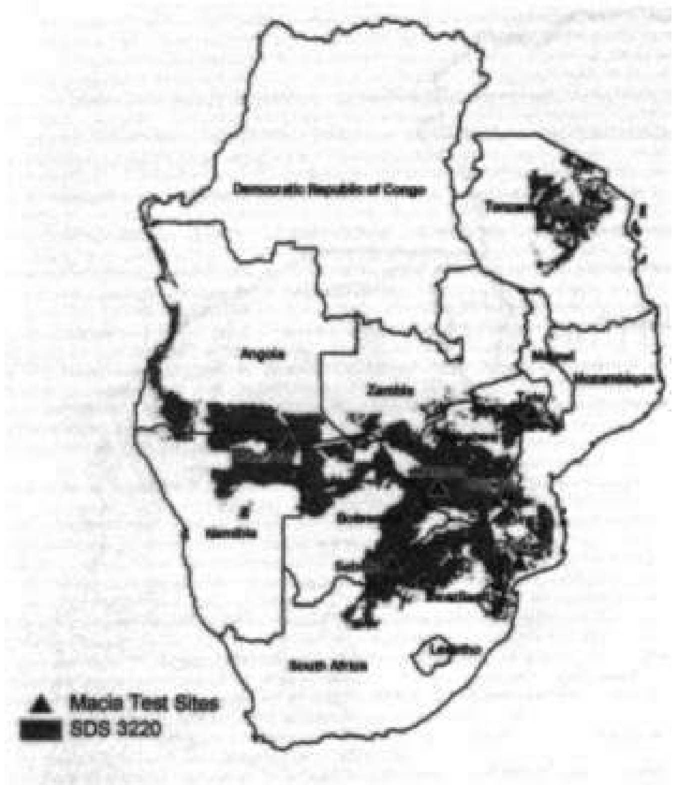

Figure 2. Regional adaptability of Macia

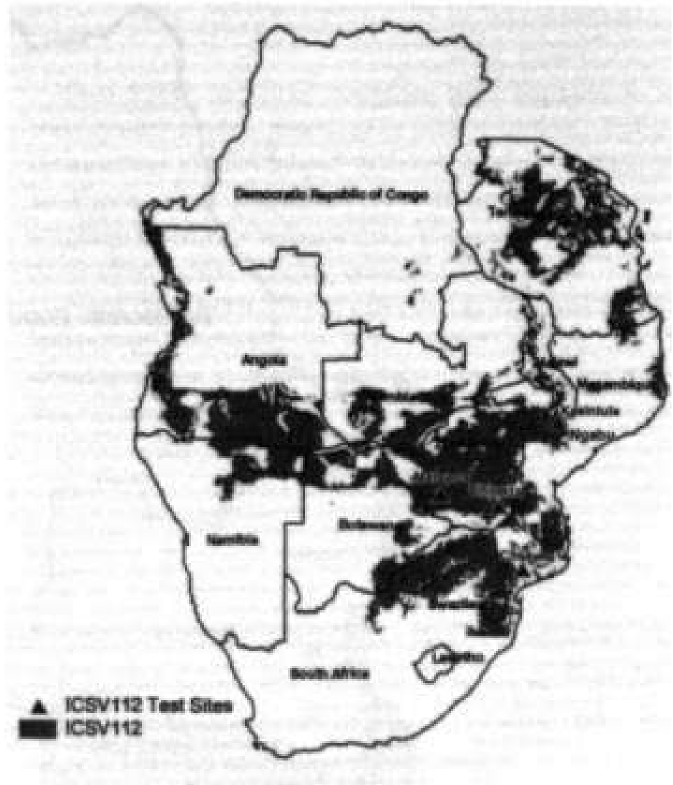

Figure 3. Climate adaption zones for Pirira (ICSV 112)

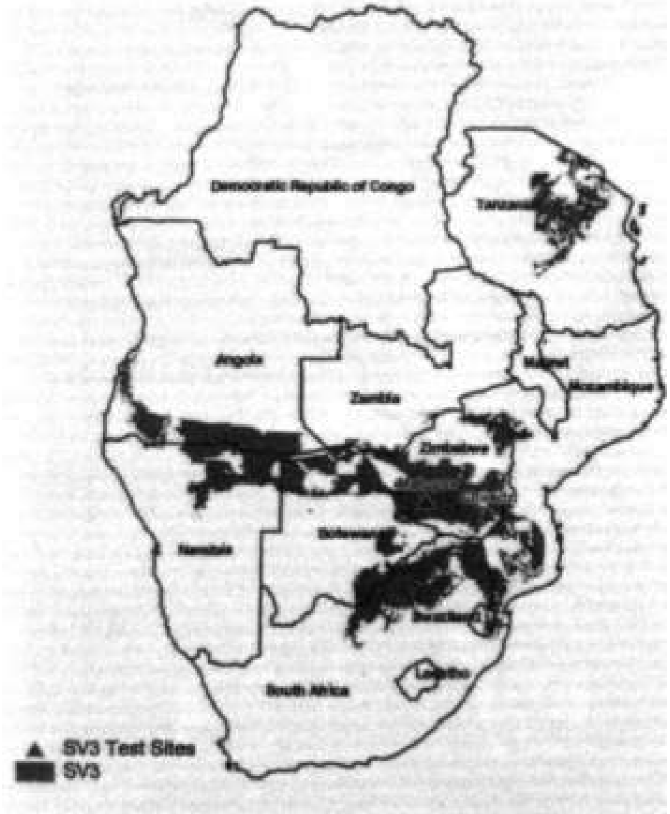

Figure 4. Climate adaption zones for SV 3

Figure 5. Climate adaption zones for SV 4

Figure 6. Climate adaption zones for PMV 3 (SDMV 920-40)

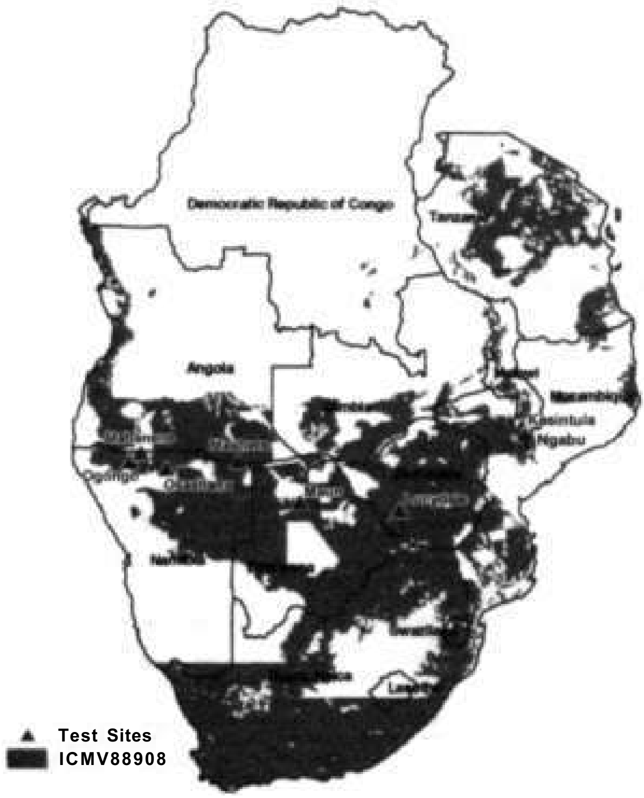

Figure 7. Climate adaption zones for Okashana 1 (ICMV 88908)

SADC/ICRISAT SMIP

Spillover of technologies: regional adaptability of varieties

In the early 1980s, when ICRISAT established a crop-breeding program at the Matopos Research Station in southern Zimbabwe, it imported more than 12,343 lines of sorghum and 7000 lines of pearl millet for testing. These encompassed germplasm collections originating from hundreds of sources. A portion of these materials appeared well-adapted to southern Africa's growing conditions.

In one famous case, the Okashana 1 variety, now widely grown in Namibia, originated from germplasm obtained in northern Togo. This was tested and selected in ICRISAT's program in central India, and distributed to southern Africa via SMIP, where it proved its productivity in trials in Zimbabwe before being sent to Namibia for testing. Namibian farmers then selected this variety on the basis of its favorable yield and plant traits. Okashana 1 has now been released in four SADC counties—Botswana, Malawi, Namibia, and Zimbabwe (as Nyan-khombo).

Similar patterns have emerged from ICRISAT's sorghum breeding program. The variety Macia has proved productive enough to be released in Botswana, Mozambique, Namibia, Tanzania, and Zimbabwe. ICSV 112 has been released under various names; in Zimbabwe (as SV 1), Swaziland (as MRS 12), Malawi (as Pirira 2), and Mozambique (as Chokwe).

These patterns of release led ICRISAT to initiate a statistical analysis of zones of adaptation of sorghum and pearl millet germplasm. This analysis started with the characterization of agroecological similarities across breeding test sites using the Spatial Characterization Tool (SCT) developed by Texas A&M. Geo-referenced data on rainfall, minimum temperature, maximum temperature, and the length of the growing season (Fig. 1) were first used to identify approximate boundaries of suitability for alternative populations of sorghum and pearl millet. These included early-, medium-, and late-maturing varieties, as well as areas suitable for photoperiod-sensitive germplasm. The SADC regional domains of adaptation for sorghum and pearl millet were defined.

A follow up analysis was done, using Geographical Information Systems (GIS) to delineate areas in the SADC region where popular multiple-released sorghum and pearl millet improved varieties might be adapted. The major test sites and areas of adaptation for each variety were characterized, values of the climatic variables were tabulated, and the ranges of the values determined. The

SADC GIS databases were queried using the SCT to search for all areas with characteristics falling within the specified ranges (Table 1). These areas were delineated as SADC regional domains for adaptation of a particular variety. Maps were developed that delineate regional adaptation of the multiple-released varieties of sorghum, e.g., Macia, ICSV 112, SV 3, and SV 4, and pearl millet varieties PMV 3 and Okashana 1 (Figs. 2-7).

Efficiency in regional crop improvement strategies

After proving potential application of spillover of improved technologies/varieties, the next step was to add a biological and statistical basis to justify pursuance of methodical and efficient regionalized crop improvement strategies. The number and location of testing sites are critical factors that affect the efficiency of, and potential gains from breeding. The selected test sites must be representative of the conditions of the target production areas for objective targeting of varieties.

The sequential retrospective pattern analysis, exploiting available long-term Multi-Environment Trial (MET) data from trials conducted in the SADC region over the past decade provided a unique opportunity and an objective basis for stratifying and grouping test sites. The stratification was based on similarity of sites' variety yield differentiation and has facilitated selection of a few representative test sites for future regional testing of varieties and hybrids (Mgonja et al. 2002). One inference is that breeding selections can be performed at a subset of sites picked from within each of the identified site groups that are also characteristic of broader agroecological domains.

The results were presented at various SADC regional fora such as the SADC Seed Security Network (SSSN), and also at national meetings. Based on the results of this work, there is justification for spillover of varieties across the region and this also supports the initiation of formalized regional seed marketing of small and coarse grains. These analyses have led sorghum and pearl millet breeders in southern Africa to endorse formal initiatives for regional variety development and release of new varieties. The implications of these agreements are substantial:

- One corollary is that every national agricultural research program need not maintain its own independent sorghum or pearl millet breeding program.
- National breeders can be confident about using trial results obtained from neighbors with similar breeding ecologies.
- By inference, countries with larger or more diverse areas of sorghum or pearl millet may be justified in maintaining larger investments in breeding programs for these crops. Countries with smaller crop areas that are similar to the ecologies of their neighbors may be justified in maintaining only small investments, aiming to simply confirm the testing results obtained from their neighbors.

Table 1. Ranges of climatic variables for delineating SADC regional adaptation of sorghum and pearl millet varieties

Variety	Annual rainfall (mm)	Minimum temperature (ºC)	Maximum temperature (ºC)
Sorghum			
Macia = Phofu = SDS 3220	396 - 775	10-23	20 - 40
Kuyutna = SDS 3136-2/WSV387	473 - 758	10-23	20 - 38
Pirira 1 =	602-961	10-22	20 - 38
ICSV 112 (Chokwe, MRS 12, SV 1, Pirira 2	435-951	10-23	20-38
ICSV 88060 = (SV 2)	435 - 709	10-18	20 - 36
SV 3	435 - 709	10-18	20 - 36
SV 4	435 - 709	10-18	20-36
Pearl millet			
ICMV 88908 (Okashana 1 and Nyankombo)	322 - 952	10-23	20-38
Okashana 2 = SDMV 93032	357 - 754	10-18	20-37
SDMV 92040 = Kangara, PMV 3	404-709	10-16	20-35
PMV 2 = SDMV 89004	435 - 754	10-18	20-36
SDMV 89005 (Kuphanjala 1 and Tupatupa)	602 961	10 23	20 - 38

- Ultimately, countries can concentrate their resources on crops and agroecologies for which they maintain higher or more unique needs.

- A second corollary of these findings is the justification for regional, as opposed to national, variety release. Regional releases allow the prospect of rapidly delivering new varieties to large numbers of farmers. Multiple rounds of variety testing across national borders can be replaced with a single round that covers a wider region.

- A third result is the potential opening of regional seed markets.

- Commercial incentives are limited for the multiplication of most open- and self-pollinated varieties.

- National markets are too small to justify any scale of investment. However, regional seed markets offer the prospects of larger, and perhaps steadier, investment returns. In fact, much of the multiplication of open- and self-pollinated varieties currently being pursued in southern Africa is aimed toward the regional market for flood and drought-relief seed.

- The regionalization of variety release would simply strengthen the justification for investments in these seed markets.

- The SADC Seed Committee has agreed to examine the case for the regionalization of releases for sorghum and pearl millet

Reference

Mgonja, M.A., Monyo, E.S., Chandra, S., Rohrbach, D.D., Murambadoro, D., and Mpande, C. 2002. Stratification of SADC regional pearl millet testing sites based on variety grain yield. Field Crops Research 72: 143-151.

Potential Use of Sorghum in School Feeding Programs

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Each year, up to 10,000 t of maize *(Zea mays* L.) are being used in primary school feeding programs in the Dodoma and Singida Regions of central Tanzania under an initiative supported by the World Food Programme (WFP) of the United Nations. This encourages the consumption of maize in areas where sorghum *[Sorghum bicolor* (L.) Moench] is the main staple food. These programs also reinforce the perception that maize is a high-quality, modern food, whereas sorghum is a poor man's traditional food.

Tanzania's school feeding program also biases domestic grain markets. In most years the maize used in the program is derived from domestic grain stocks. Much of it is purchased in high rainfall regions of the country. But when rains are favorable, maize supplies are also obtained from small-scale farmers in such low rainfall areas as Dodoma and Singida. As a result, farmers are being encouraged to plant more maize, and traders are being encouraged to amass this product. In contrast, more drought-tolerant crops like sorghum are delegated to the status of subsistence crops.

ICRISAT and a local miller, Power Foods Ltd., approached the WFP to determine whether locally produced sorghum could replace a portion of the maize used in these school-feeding programs. We determined that the immediate constraint was skepticism about the acceptability of sorghum among school children. ICRISAT then asked the Tanzania Food and Nutrition Centre (TFNC) to implement an independent set of sensory taste trials to evaluate the acceptability of sorghum in breakfast porridge *(uji)* and stiff porridge *(ugali)* used for lunches. Power Foods agreed to provide the sorghum meal for these tests.

Three schools currently receiving maize for their feeding programs were nominated by Dodoma's regional authorities to participate in the taste trials. A sample of 106 students participated in the trials. Each student received soft sorghum porridge *(uji)* made from both dehulled and undehulled grain. On a different day, each