SORGHUM IMPROVEMENT IN EASTERN AFRICA

Proceedings of the

Regional Workshop on Sorghum Improvement in Eastern Africa
17–21 October, 1982
Nazareth and Debre Zeit, Ethiopia

Sponsored and Organized by

Ethiopian Sorghum Improvement Project (ESIP)
Addis Ababa University (AAU)
Institute of Agricultural Research (IAR)
International Development Research Centre (IDRC)
SORGHUM IMPROVEMENT IN EASTERN AFRICA

Proceedings of the

Regional Workshop on Sorghum Improvement in Eastern Africa
17-21 October 1982
Nazreth and Debre Zeit, Ethiopia

Sponsored and Organized by

Ethiopian Sorghum Improvement Project (ESIP)
Addis Ababa University (AAU)
Institute of Agricultural Research (IAR)
International Development Research Centre (IDRC)
Workshop Organizing Committee:

Brhane Gebrekidan, Chairman
Alem-Seged Mamuneh
Tessema Megenasa
Roger A. Kirkby

Editor:

Brhane Gebrekidan

Ethiopian Sorghum Improvement Project
Addis Ababa University
P.O. Box 414
Nazreth, Ethiopia
<table>
<thead>
<tr>
<th>Table of Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welcome Address</td>
<td></td>
</tr>
<tr>
<td>Brhane Gebrekidan</td>
<td>1</td>
</tr>
<tr>
<td>Welcome Note and Brief Description of Research at the Debre Zeit Research Center</td>
<td></td>
</tr>
<tr>
<td>Asfaw Zelleke</td>
<td>3</td>
</tr>
<tr>
<td>Objectives of the Workshop</td>
<td></td>
</tr>
<tr>
<td>Brhane Gebrekidan</td>
<td>6</td>
</tr>
<tr>
<td>The History of Sorghum Improvement in East Africa</td>
<td></td>
</tr>
<tr>
<td>Hugh Doggett</td>
<td>8</td>
</tr>
<tr>
<td>The Role of IDRC in Eastern Africa National Sorghum Improvement Programs</td>
<td></td>
</tr>
<tr>
<td>Roger A. Kirkby</td>
<td>16</td>
</tr>
<tr>
<td>Overview of ESIP</td>
<td></td>
</tr>
<tr>
<td>Brhane Gebrekidan</td>
<td>18</td>
</tr>
<tr>
<td>Brief Description of the Plant Genetic Resources Center/Ethiopia</td>
<td></td>
</tr>
<tr>
<td>Melaku Worede</td>
<td>24</td>
</tr>
<tr>
<td>The 1981 Activities of Plant Genetic Resources Center/Ethiopia on Sorghum Germplasm</td>
<td></td>
</tr>
<tr>
<td>Brooke Abebe and H. B. Wech</td>
<td>31</td>
</tr>
<tr>
<td>Title</td>
<td>Author</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Sorghum Diseases in Ethiopia</td>
<td>Mengistu Hulluka</td>
</tr>
<tr>
<td>Insect Pests of Sorghum in Ethiopia</td>
<td>Tessema Megenasa</td>
</tr>
<tr>
<td>Striga in Ethiopia</td>
<td>Taye Teferedeign and Rezene Fessehai</td>
</tr>
<tr>
<td>Nutritional and Consumer Preference Aspects of Sorghum</td>
<td>Belainesh Gebre-Hiwot</td>
</tr>
<tr>
<td>Report on Sorghum Improvement in Rwanda</td>
<td>Zenon Kabiro</td>
</tr>
<tr>
<td>The Status of Sorghum Improvement in Kenya - General</td>
<td>J. K. Rutto</td>
</tr>
<tr>
<td>The Present Status of Sorghum Breeding in Kenya with Special Emphasis on the Low Elevation Drylands</td>
<td>I. R. Karmali</td>
</tr>
<tr>
<td>Status of Sorghum Research in Rwanda</td>
<td>Celestin Sehene</td>
</tr>
<tr>
<td>Sorghum Improvement in Somalia</td>
<td>A. N. Alio</td>
</tr>
<tr>
<td>The Status of Sorghum Improvement Research in the Sudan</td>
<td>Gebisa Ejeta</td>
</tr>
</tbody>
</table>
The Status of Sorghum Improvement in Tanzania

C. S. Mushi .................................. 132

The Status of Sorghum Improvement in Uganda

Vincent Makumbi Zake .................... 141

The Status of Sorghum Improvement in Yemen Arab Republic

A. E. Kambal, H. Ali and
H. A. Gabbar ................................ 151

The Status of Sorghum Improvement in Yemen
Peoples' Democratic Republic

Abdul Aziz Ahmed Bawazir ................... 169

The Status of Sorghum Improvement in Zimbabwe

Joseph N. Mushonga ....................... 174

The Need for a Sorghum Improvement Network
in Eastern Africa - for Discussion

Liz Ngure ..................................... 185

Recommendations and Comments of the Regional
Workshop on Sorghum Improvement in
Eastern Africa

188

List of Participants

191

Workshop Program

194
PREFACE

Sorghum is by far the most important field crop in the Eastern Africa area and the Yemens. It is the traditional staple crop of the region and the vast genetic variability in sorghums found in the area is not paralleled by any other region. All the major sorghum ecological zones found worldwide are present in Eastern Africa and the Yemens. Therefore the sorghum germplasm and the crop improvement research in the region has worldwide interest.

The sorghum improvement efforts underway in each of the national programs of the region have been mostly done in isolation with very little interaction between them. This workshop was effective in bringing together most of the active researchers from the national programs of the region. The Ethiopian Sorghum Improvement Project (ESIP) of Addis Ababa University (AAU) was in many ways responsible for the initiation and successful implementation of this workshop. Through the papers presented and the discussions underway throughout the workshop, the participants were able to get a good overall picture of the sorghum improvement situation in the region.

These proceedings document the papers presented to and the recommendations passed by the workshop. It is hoped that these proceedings will be useful to all those interested in sorghum in Eastern Africa and the Yemens.

The financial contribution and the active interest of the International Development Research Centre (IDRC) made this workshop possible.

The Editor
Honoured Guests,

On behalf of the Ethiopian Sorghum Improvement Project it is my pleasure to welcome all of you to this regional workshop on Sorghum Improvement in Eastern Africa. I hope that you have all had good rest and are mentally and physically prepared for the workshop. Although the crop of the workshop is sorghum, neither this station, where most of our meetings will be held, nor Nazareth and Arsi Negelie, which we will visit, are specially noted for their sorghum production which means that you will not see as many sorghum fields as you would tef fields. The Debre Zeit area in particular is nationally famous for its tef production. For those of you who do not know much about tef, this is your chance to see the crop and learn something about it.

Much of the sorghum in Ethiopia is produced in Eastern and Northern parts of the country. Unfortunately, because of long distances and shortage of time, we will not have the chance of travelling through typical sorghum production zones of the country. However, you will have chance to see a wide variation of Ethiopian sorghums when we visit the Nazareth and Arsi Negelie research stations.

In this workshop, we are fortunate to have participants from the following countries: Burundi, Ethiopia, Rwanda, Tanzania, Uganda, Yemen Arab Republic, and Zimbabwe. We are also fortunate to have three representatives from IDRC and one from ICRISAT. We are, however, sorry to miss the official representatives of Kenya, Somalia, and Sudan who failed to come because of difficulties in finalizing their travel arrangements. To all of you who are here, again I extend my warmest welcome.

Although we are all here to concentrate on the sorghum crop throughout the workshop, in addition to sorghum, I invite and encourage you to find out about other interesting things this country has to offer: historically rich past and revolutionary present, souvenirs of all sorts which are uniquely Ethiopian, most pleasant climate reputedly accompanied by thirteen months of sunshine, a variety of native dishes typified by injera and wot, famous Ethiopian drinks including tej, tella, arekie, wine and beer which should not be missed, and a number of other interesting Ethiopian things details of which could be obtained from the Ethiopian colleagues of this workshop. For every participant that has come from abroad we have at least one Ethiopian counterpart participant. So we are well supplied with experts on Ethiopia.

Formerly Project Leader, Ethiopian Sorghum Improvement Project, Addis Ababa University, P.O. Box 414, Nazareth, Ethiopia, currently SAFGRAD Coordinator for Sorghum and Millets, Eastern and Southern Africa, OAU/STRC/SAFGRAD, P.O. Box 30786, Nairobi, Kenya.
Our attendance is good and I think the workshop organizing committee has prepared a good workshop program for us. IDRC has taken care of our financial worries. We also have all the backing we need from the AAU and IAR to make this workshop a success. We have exciting and informative four workshop days ahead of us and in the Ethiopian tradition I say again "Inquan Dehna Metachihoo" and have an enjoyable stay in Ethiopia.

Thank you.
Dear Colleagues,

I am honoured and privileged, indeed, to welcome you on behalf of the Debre Zeit Research Staff and on my behalf to the Debre Zeit Research Centre. Please allow me to briefly explain to you the location, history, and the research programmes of the Research Centre.

This Research Centre is located about one hour's drive south of the Capital at the eastern periphery of the town of Debre Zeit. Debre Zeit itself is a scenic location surrounded by crater lakes. The soils of the region are of volcanic origin and are especially suited to the production of cereal grains, pulses, and horticultural crops including ornamentals. The altitude is approximately 1800 meters above sea level. The annual mean precipitation is about 700 mm.

The Debre Zeit Research Centre was established about 25 years ago as a branch station of the Alemaya College of Agriculture. About a decade ago the overall outlook of the Centre was changed and more and more qualified staff were employed, and gradually it was recognized as a Research Centre of Addis Ababa University at a faculty level. Hence research on cereal grains, livestock & horticulture were initiated by the Ethiopians and substantial progress is being made on the breeding programmes of tef, wheat, dairy cattle and poultry. Consequently the Centre has now become the major research station of the central highlands. This is one of the largest farming regions in the country and the most important from the standpoint of cereals. The physical and chemical characteristics of the soil type at the Centre are representative of the vast area. In the Central highlands crops such as tef (Eragrostis tef) wheat, barley, sorghum ... etc. and pulse crops such as chickpeas, beans, lentils... etc. are cultivated.

Although the scope of the research programmes at the Centre is necessarily limited by lack of facilities and personnel in some departments, the research findings and the technological innovations generated by the Centre have made significant contributions in the increase of crop and animal production in this area and other areas of ecological similarity. Furthermore, the Centre is centrally located to provide technological services to agriculture and rural development in general.

Asfaw Zelleke

1Dean, Debre Zeit Junior College of Agriculture and Research Centre, Addis Ababa University, P.O. Box 32, Debre Zeit, Ethiopia.
In addition to the regular research programme the Research Centre:
- serves as a practical training centre in agricultural research;
- participates in the organization of agricultural cooperative in the area;
- disseminates results of agricultural research to farmers;
- distributes exotic poultry breeds to state farms, to other Agri. Colleges and farmers;
- collects and evaluates a large number of germplasm material of wheat, tef, and chickpeas to enhance the breeding programme;
- demonstrates to farmers through its Out-Reach Programme that various inputs (i.e. high yielding varieties, fertilizer, and other cultural practices) can increase crop yields.
- formulates various rations for dairy animals and poultry feed to improve the management practices of the livestock industry;
- generates new innovations that will eventually lead to an effective and integrated farming system, and
- identifies socio-economic and other constraints to rural development in this region.

At the moment the major research activities are limited to the following:

1. Durum Wheat - Since the advent of the research programmes research on wheat in general has been most prominent. However over the years experience has shown that this area is better suited to durum wheat, and hence large collections of germplasm that is of international interest have been made.

2. Tef - (Eragrostis tef) - One of the World's most nutritious, and preferred bread grains for most Ethiopians is predominantly growing in this region. Although research in this crop is almost in its infant-stage promising results have already been obtained and the objective of the breeding programme has been partially achieved. However every phase of research with this important bread grain is being explored and enlarged.

3. Pulses - The research on highland pulses include mainly the chickpeas and lentils. The various progenies that are on trial are in the process of segregation for desirable agronomic characteristics as well as resistance to diseases.

4. Vegetable Crops - Different varieties of some vegetable crops (tomatoes, onions, potatoes, garlic) are on adaptation trials. Promising results of these investigations are hoped to reach the rural areas through the College's Out-Reach Programme.

.../...
5. Other Research - Researches on grapevine adaptation and cultural system; Clonal Collection of Enset - a major staple food for over 6 million Ethiopians and an agrobotanical study of Phytolaca dodecandra - a potent mollusccide are in the initial stages.

In the livestock section, the research activities mainly focus on breeding, dairy cattle and poultry production. Research on feed rations is under way while the performance study of three exotic poultry breeds and local are in progress.

Dear Colleagues,

As you well know it is neither practical nor appropriate to attempt to cover the 25 years' experience of the Centre on this occasion. You will have the opportunity to visit the Centre before you leave. However, at this point I would like to mention one important point that has made a significant contribution to the Research Centre and enabled it to reach its goal. The close collaboration of the staff with local institutions such as: Institute of Agricultural Research (IAR), Colleges of Agriculture, Ministry of State Farms, Ministry of Agriculture, Plant Genetics Resource Center/Ethiopia (PGRC/E)... etc., and with that of International Organizations such as: CIMMYT (Mexico), ICRISAT (India), ICARDA (Syria) have given fame and recognition to Addis Ababa University through the Research Activities that are being carried here at the Centre.

I sincerely hope that your stay in Debre Zeit will be a memorable one, and also that the workshop will be a success.

Thank you for your attention.
OBJECTIVES OF THE WORKSHOP

Brhane Gebrekidan

Honoured Participants of the Workshop,

Before going into the objectives of this workshop, it appears proper to briefly describe the background of the Ethiopian Sorghum Improvement Project (ESIP) which in many ways is responsible for the convening of this workshop. ESIP, in its present form of operation, was initiated in May 1973 under an agreement between the Addis Ababa University (AAU) and the International Development Research Centre (IDRC). Since 1973, ESIP has gone through three successive phases each of which has been undertaken through contractual agreement between AAU and IDRC. Throughout the three phases, the bulk of the financial support for ESIP has been received from IDRC. All along, AAU provided all the administrative support as well as some staff salary in Phase I of the project. In Phase II and III ESIP also had the operational support of the Institute of Agricultural Research (IAR). So ESIP can be envisioned as a three way vigorous hybrid. At the end of this month, i.e. after 9½ years, IDRC will terminate all of its financial support to ESIP, and the Ethiopian government through IAR and AAU will continue the Sorghum Improvement Program. In the nine years of its operation, ESIP has attained the status of a national program and has gained experiences which hopefully will be relevant to other national programs in the Eastern African Region. With this sharing of experience in mind, IDRC has kindly financed and encouraged ESIP to organize this workshop.

Although the background of this workshop is tied to the background of ESIP and has been convened as a way of sharing the ESIP experience with the rest of the national sorghum programs of the member countries of the region, more important reason and purpose of this workshop is really to bring together active sorghum researchers of the Eastern Africa Sorghum Improvement Geographic Functional Region so that we can discuss the present status and future prospects of sorghum improvement in our Region. Personal acquaintances and interactions among sorghum workers of the region as in this workshop are expected to develop closer ties among professional colleagues which in turn is expected to facilitate free exchange of information and germplasm of sorghum among the countries of the region. Since there is a whole lot that we can learn from each other about sorghum improvement in the region, frequent getting together of sorghum workers of our region is obviously important.

Formerly Project Leader, Ethiopian Sorghum Improvement Project, Addis Ababa University, P.O. Box 414, Nazareth, Ethiopia, currently SAFGRAD Coordinator for Sorghum and Millets, Eastern and Southern Africa, OAU/STRC/SAFGRAD, P.O. Box 30786, Nairobi, Kenya.
Each of the national sorghum improvement programs in the region has some sorghum information and germplasm which could be useful in the other national sorghum improvement programs of the region. The lack of forum for sorghum workers of the region to meet and interact as a group has limited the dissemination of such information and germplasm. This workshop is expected to open the way and facilitate the gathering of overall information on sorghum improvement in the region. In the programming of the workshop, a whole day is allocated for country reports. Each of the country reports is expected to give a good picture of the status of sorghum improvement in the country of the report. Collectively these reports should give an overall picture of the status of sorghum improvement in the region.

Several papers in different disciplines of sorghum improvement are to be presented by Ethiopian participants of this workshop. These papers collectively will hopefully give an overall picture of sorghum research in Ethiopia.

Out of the four days for the workshop, one and half are scheduled for station visits and discussions in the sorghum fields. This will give us excellent opportunity to discuss and interact at the field level. In the station visits, we will have opportunity to visit one station (Nazareth) concentrating on lowland sorghums and another one (Arsi Negelie) working on highland sorghums. Since both of these groups of sorghums are important in most of the countries of our region, these visits will give us chance to discuss and exchange views right out in the fields in the midst of the sorghum plants.

The last half day of the workshop is scheduled for general discussions on strengthening the Eastern Africa Sorghum Improvement Network. Items to be considered in these discussions will be the initiation of sorghum regional trials and nurseries, exchange of germplasm and annual reports, the need for an establishment of a regional sorghum crossing block, training in sorghum, the desirability and possibility of having annual regional workshop, and other areas of regional cooperation. By the last day of the workshop, it is hoped that we have interacted and known each other sufficiently well so that we can develop joint strategies for future cooperative regional sorghum improvement work.

A regional cooperative sorghum improvement program could be as strong as we want it. Although there is no substitute for a strong national program no country in our region has all the necessary finance, trained manpower, and germplasm to enable it to stand alone and solve all of its sorghum improvement problems by itself. Jointly and on a regional basis, there are a number of areas where the different national programs could strengthen and assist each other. The workshop is expected to explore and discuss such areas of cooperation.
We know that several organizations such as IDRC, ICRISAT, and SAFGRAD have active interest in promoting and assisting regional cooperative research in sorghum. IDRC's financing of this workshop illustrates this point. It is hoped that we can strongly express our commitments to a solid regional cooperative sorghum improvement program so that we can attract the attentions of donor agencies.

Thank you for your attention.

THE HISTORY OF SORGHUM IMPROVEMENT

IN EAST AFRICA

Hugh Doggett

The philosophy governing the development of agricultural research and agriculture production in East Africa during the 1920's and the 1930's, when research stations were being established, was very different from that prevailing today. Money was in short supply, and there were needs for schools, hospitals, roads, police forces, administration etc., the people needed to earn money in order to purchase goods. The general concept was of a rural population, self-sufficient in their daily needs, but unable to purchase other requirements. Emphasis was therefore placed on introducing crops which would enable people to earn cash. This would benefit the growers, and the export of these crops would bring money into the country, and help to develop a cash economy. For this reason, the early Research Stations were established as cotton stations, or coffee stations or to deal with commodities such as Sisal. The population in those days was less than one quarter the size that it has reached today, and the problems of population growth were certainly not foreseen. Food crops were not considered as needing attention, people were already feeding themselves, all that had to be watched was the possibility of local food shortages caused by bad harvests, locusts, or similar reasons. There were exceptions to this: Policemen, prisoners, children at boarding schools, labourers on estates, needed to be fed. Everybody knew about maize and beans in America: maize growing was encouraged as the food for these groups.

The philosophy dies hard: I was in Tanzania six months back. Virtually the whole research effort on Ukiriguru station was going into the cotton crop inspite of the fact that production had not increased, over the past 7 years. ODA was giving assistance to two

1Associate Director, Crops and Cropping Systems, International Development Research Centre, P.O. Box 38, Peradeniya, Sri Lanka.
expatriate staff, vehicles, and money for cotton research. There was no food crop work on the station at all, except for Dr. Msabaha, just returned from IITA after taking his Ph.D. He was trying to put together a Cassava programme. Indeed, all that people seem to be growing as a food crop is cassava. I can only think that prices of other crops and the marketing problems make it a waste of effort to try to produce a surplus. Cassava is a subsistence crop par excellence.

Agricultural departments usually had one Botanist, he was often called an economist botanist, suggesting that his efforts were to give priority to cash producing crops. Among many other tasks, he was supposed to gather, tend and study most of the crops growing in the country.

In the late 1930's and early 1940's, efforts were being made to increase food production and more emphasis was placed upon food crops, mainly on maize among the cereals, but collections of other crops were begun. In Uganda, Kenya, and Tanzania, Sorghum collections and introductions were being made. The agricultural Departments gathered rather comprehensive collections of sorghums, looked through them on experiment station plantings and retained those which looked most interesting and had the best yields. This work was particularly thoroughly and well done in Uganda, A.S. Thomas deserves a lot of credit, as do his successors who continued. By 1954, sorghum breeding had begun at Serere, where Walter Hirst had started collecting and doing trials. He was working on several other crops at the same time. In Kenya, sorghum was receiving some attention between 1943 and 1956, and Beckley in 1950 collected and described many of the local types. Work was also going on in what was then the Congo and Rwanda-Burundi at the Rubona station. There was not much interaction between the Francophone and Anglophone countries and we knew little about the Belgian work.

I arrived in Tanzania as Botanist in May 1943, but after 3 months at Ukiriguru research station, was sent as an agricultural officer to Tanga. Staff were short, and food production was needed. This was not a popular move with me at the time, but it was good that it happened. I had to learn Kiswahili, and for 3½ years spent most of my time moving among the Tanzanian villages in a large area of N.E. Tanzania. It taught me a great deal about local situations and local farmers.

Returning to Ukiriguru at the end of 1948, I was charged with the responsibility of improving cassava, bulrush millet, finger millet, cowpea, green gram, groundnuts, sweet potatoes and almost any other dry land crop you care to name. There was one occasion when I was sent off to the Wembere Steppe in the middle of the country, to collect gum from Acacia trees, as manufacturers of Pharmaceuticals might offer an export market. I decided to put my main efforts into sorghum and do rice breeding on Fridays at the Mwabagole rice station about 8 miles away, as a subsidiary activity.
Sorghum and millets were widely grown on the heavy and light lands respectively, and rice was a rather new crop with a good potential. I aimed to do as little as possible with the other crops listed, but in the first few years, it was not possible to ditch all of them all the time. My 1948-49 report shows that a reference collection had already been gathered at Ukiriguru, which included types from the U.S.A., 3 from Swaziland, 2 from Kenya, one of which was Dobbs, and one from Australia. It also included local long term collections. The season was a bad one, and the short term introductions gave 600-800 kg/ha, the long term locals, 150-450 kg/ha. 950 sorghum selections were made and the technique of hot water emasculation mastered. Some of these selections came from a very mixed volunteer crop in a field which had carried sorghum the previous year. The season's results helped to establish the objectives. There was a need for short term sorghums which were missing in the local material. Introductions yielded well, but their grains were soft, floury, and often coloured, and did not keep when stored. We needed short term sorghums with grains that would keep in store, and of a quality similar to the best local types. The second objective was to do something about Striga. It took a little while to realise that the local people had already identified Striga resistant cultivars. Emphasis was placed on Striga control by uprooting, weeding, and using cattle manure, essentially as a nitrogen source. Those two objectives set the course for the following nine years.

Ukiriguru was a cotton station, James Peat, John Monro, and later Mike Arnold formed a good strong plant breeding team, which was a great help to a novice and I shall always be in their debt. However, all of them except James Peat were puzzled why I should be messing around with sorghum when I could have been working on a worthwhile crop like cotton. I received a lot of encouragement from Jack Hutchinson, Director of the Crop Research Station at Namulonge in Uganda at that time.

The cotton people had a good organization. There were district variety trial sites at specific centres and the system of operating with trained technicians was well worked out. These men were quite excellent, and made it possible to do a great deal. From the first season onwards, the programme became "we", Paul Thadao, Everest Mazula, Michael Juma, and several others with whose names I will not bore you, formed an excellent team and taught me a very great deal. There was little machinery: work on the station was done with ox-drawn implements until we were extravagant and invested in a small Ferguson Tractor for ploughing. Threshing was done by hand: single heads by ladies with wicker trays on their laps. Small bulks were beaten in gunny-bags with sticks, and then winnowed. Ordinary brown paper grocery bags from the local store were used for selfing and crossing. We later got a Kenya firm to make them with waterproof glue for us.
We soon discovered that the best quality grains were white throughout and tests revealed that the more corneous the endosperm the better the weevil resistance and the better the quality. Comparisons were made by burying net bags of counted grains in bulks of weevilly grains in tin containers, the old 4 gallon petrol tins. With ten replications, results were accurate. Counts were done once a fortnight, and there were lots of little boys willing to help with this. Crosses between the local high quality long-term weevil-resistant types, and introduced types especially BC 27 from the Congo, were made. A range of indigenous Tanzanian types and introductions were used in these crosses. The problems of the testa in the grain and of complementary factors arose. We never succeeded in finding brown grains in which a substantial part of the endosperm was corneous. It was easy to obtain short-term lines with weevil resistant grains: the problem was getting those characters combined with good yields, SUK-1 was produced, but we felt that its heads were too small, and its yields too low. Some of my old staff were asking me for seed of this line during my visit to Tanzania this July. They want that type of sorghum. However, SUK-1 did not seem good enough to put out, and in any case there was no seed multiplication and distribution system. Back-crossing gave rather improved types, 42 B was one of them, and it yielded quite well, but was rather susceptible to shoot-fly if planted late. We learnt the value of testing across locations, using the cotton test plot sites.

The short-term sorghums with white, high quality grains, showed up the bird problem. The local late types produced their grain after the birds had gone away to breed, at least in the Ukiriguru area. Further south in the Shinyanga district, there was a fairly sharp dividing line: in the east of the district, adjacent to the Wembero steppe where the Quelea birds bred, only brown grain types could be grown. In the west of the district, the white high quality grain types were grown. Thus, the problem of birds led to vain efforts to develop bird resistance. We tried goose necks, large glumes, long awns, in various combinations. These characters did reduce bird damage, but never to an economic extent. 50% of the grain was about all one could save.

The next few years were spent in crossing and selecting for grain quality with good weevil resistance and earliness of maturity using a much wider range of material as it became available, and in making the various crosses to put together the characters which might give bird resistance. Testing across locations was very useful, it helps a lot with borer and shoot-fly resistances and also with Striga resistance. By 1957, SUK-1 and 42 B were ready for farmers' trials. Various bulks had already been put out, and they were undoubtedly satisfactory types, but there was no seed multiplication machinery and no strong support for sorghum.
On the management side, trials on the basic agronomy of sorghum were run, and a lot more information gathered on Striga control and Striga resistance.

In 1957 the decision was taken to move the sorghum work down to Ilonga. The reason for this was that the cotton breeders felt that sorghum was breeding up the boll-worm Heliothis which affected their cotton yields. I was not impressed by Ilonga as a place to breed sorghum, or as a place to live with young children just reaching school age. I therefore accepted Walter Russell's offer as sorghum breeder for East Africa on the Serere research station in Uganda, and moved up there.

During the following years at Ukiriguru, the thrust was all directed towards maize, and a series of about 5 favourable seasons encouraged this, maize was grown all over Sukumaland. Then the drier seasons began again, and the maize acreage was much reduced. Cassava must have then been grown on a much more extensive scale. Bulrush millet largely disappeared. Incidentally, there are now few Quelea in Sukumaland. There is little food for them.

In Kenya, Brian Dowker begun work at Machakos Experiment station in 1954, to develop sorghums and/or millets for the dry areas of Kenya. He came to the conclusion that maize was a better crop because birds destroyed the palatable sorghums which people liked, and nobody really wanted to grow the brown ones. He developed some very useful Katumani short season maize, but a long series of comparisons with the sorghums which he ran for about 8 years, two seasons each year, showed that in every year the sorghum yields were better, excepting for one year in which shoot-fly was bad on the sorghum, as a result of additional rainfall in the dry season between the two rainy seasons. The maize yields were very good that year.

In Uganda during this period, the Department has been quietly screening and maintaining the best collection entries on their stations. These included a group of high altitude sorghums maintained at the Kachwekano station in Western Uganda. These became the donor parents for the successful high altitude sorghum programme at CIMMYT in Mexico. At Serere, Walter Hirst was dealing with several crops, but he had selected and multiplied good sorghum material, from introductions, local sources and selections from crosses.

The move up to Serere proved to be rather traumatic from the breeding point of view. My nursery was planted out during the March/April rains, and although there were no Quelea birds, there were yellow weaver birds. These would perch on the panicles, devouring the sorghum grains. The large glumed types did not defeat them; they just squeezed the glumes while the grain was still soft and pecked the germ from the grain as it popped out. I rescued very little. Walter Hirst's local types such as
L 28, were perfectly all right, and so were my brown grained types such as Dobbs, which had been designed for the Eastern Shinyanga district in Tanzania. A complete re-think was necessary; not only were birds devastating during the main rains, but people stored their sorghum on the head, threshing it daily as required. In this situation, weevil resistance was of no importance; the storage pest was grain moth, and that got into everything. We were not successful in identifying any resistance to this pest. Walter Hirst before me, had been equally unsuccessful. We soon learnt that quality grains could be grown in the second rains without bird damage, but very few people in Uganda were interested in growing those anyway. They used sorghum as a type of "beer", or else mixed with cassava flour. The main emphasis of the programme therefore swung towards the brown-grained types, shoot-fly resistance being an important factor.

David Jowett joined me at Serere for three valuable years. Benayo Majisu, who had been working with us during the long vacations from Makerere, then joined us. We had an East African programme, with a wide scatter of testing sites. Ukiriguru still cooperated, and it was possible to test at several other sites in Tanzania and several sites in Kenya, two or three at the Western end, and one at Kambiya Mawe, (Makueni), in Machakos district which became a very useful site. Uganda had an excellent system of variety trial centres. Each was operated by a variety trials observer (VTO) who came in to Serere before the beginning of the season, for a workshop to discuss results and plans. The centres were regularly visited by agricultural scientists from the Agricultural Department who would make field notes on the Trial files which were kept at the office of the centre. One of our group managed to get around the Uganda sites at least twice during the growing season. This was seldom possible in Kenya or Tanzania, but there was excellent cooperation from the people there.

This multilocational testing proved to be of the greatest value. Cultivars coming out of the Serere programme had broad adaptation, and reasonable levels of resistance to most of the disease and pest problems of East Africa.

Work at Serere went on to generate a lot of new material, from a wide range of introductions and local collections. This material later formed a good base for the programmes in Tanzania and in Kenya when the East African Community fell apart. "Serena" proved to be a well adapted cultivar, it came from a selection made in Tanzania of a cross between Swaziland sorghum and Dobbs, a Kenyan variety. Hybrid development was successful: there were types with brown grains and with white grains, which consistently outyielded the parent varieties over a wide range of conditions. A seed multiplication scheme was being developed in Uganda, but it collapsed under the Amin regime. The Kenya Seed Company did not find
production of hybrid sorghum sufficiently worthwhile, there was no market.

Reverting to the programme, a number of good brown grained types were developed, and comprehensively tested. (One of these, 5D x 135, was recently released both in Uganda and Kenya as a variety for the farmers, named "Seredo").

We then went back to the elite material produced in the Tanzanian programme and intercrossed it with the best material produced in the Ugandan programme, and quite a range of useful material was obtained. By 1970, a fairly good white grained corneous sorghum, Lulu, had been developed, but it was still only a step on the road.

Population breeding methods were developed, and a number of composite populations produced, which were of value when the ICRISAT programme was established. Many of us feel that these sorghum populations offer an effective way of utilizing the variability available in the crop, elite populations sent to national plant breeders should form a good source of selections for a national programme.

There were staff changes, Sam Mukuru came in and joined us, and Dr. Majisu was transferred to Muguga to become director of EAAFRo. Doggett left at the end of 1970, and for a year, John Kern of USAID was working in the programme, and made a valuable series of 2KX crosses. These all had Lulu as the female parent, with a wide range of high quality grain types as the male parent.

Sam Mukuru was back from Purdue soon afterwards, and was responsible for the selection and testing work of the 2KX crosses, as well as other crosses over the next few years. He kept the Serere programme running until he moved to ICRISAT, when it was taken over by Vincent Makumbi. There is still a good programme operating there, as I think that Dr. Brhane Gebrekidan will agree. Sam Mukuru came back under ICRISAT to Ilonga, and got an excellent programme established, which included some of the Serere material. For various reasons there was difficulty in continuing that project, and Sam Mukuru moved back to India.

To summarize, progress was made in developing sorghums of good agronomic type with brown grains, both varieties and hybrids. However, the grain quality was not good enough, even for brown grained types, (food uses) and the work is certainly not finished. Reasonable white types with good yield and good quality grains were also developed, both varieties and hybrids, but a good deal more improvement is required. In East Africa, production of the crop needs the encouragement of stable prices and a good marketing organization. Until good seed production machinery is developed and is operating, it is idle to think of introducing hybrids. Until sorghum farmers are making money out of farming, there is
not much incentive to buy improved seed of any kind, let alone hybrids. People will continue to save their own seed.

From the plant breeding viewpoint, two components are essential:

1. Continuity of staffing and funding. A national plant breeder in each territory is needed who will stay on the job for at least a seven year stint. That also gives him time to train up good support staff, who can keep the programme operating when a change of professional staff becomes necessary.

2. The development of good multilocalational testing sites. Many of these have now fallen into disuse.

I have dealt with the history of sorghum development strictly in East Africa, you are all aware of the outstanding programme which has been developed here in Ethiopia.

As a footnote, I shall always consider that one of the really valuable developments during the period under review was the creation of a plant breeders' workshop, soon to be joined by other disciplines, and then known as the Specialist Committee for Agricultural Botany (SCAB). This was Sir Joseph Hutchinson's creation, and it held a meeting every 18 months to 2 years, on a different station and in a different country each time. We found out what other workers were doing, and were able to interchange ideas and plant materials. At a time when many of us were operating in rather isolated places, with very limited access to the scientific literature, these workshops were invaluable.
THE ROLE OF IDRC IN EASTERN AFRICA
NATIONAL SORGHUM IMPROVEMENT PROGRAMS

Roger A. Kirkby

It is an honour for me, as the program officer presently responsible for IDRC support to crops research projects in this Region, to take part with you in this workshop in commemorating and assessing the past eight years of sorghum improvement work in Ethiopia.

For me this is also a humbling experience as I myself spent much of that time working on a certain crop that some of you may consider to be a competitor for the favours of small scale and subsistence farmers.

IDRC apparently has had no such problem in identifying an area of research well worthy of support. It has had a small role to play by way of financing research on a crop that is the staple of millions of people in the semi-arid regions of Africa. Since 1972 a total of 2.9 million dollars have been contributed towards the sorghum improvement programs of Ethiopia, Rwanda, Uganda, Somalia and Zimbabwe. A further 1.1 million dollars was used to support projects of a more agronomic nature in which sorghum was an important component, and smaller sums have been put towards research training at the Universities of Makerere and Dar es Salaam, and the development of services such as the Sorghum and Millet Information Centre at ICRISAT.

Most of the credit, however, must remain where it belongs, with the scientist and institutions, represented today by yourselves, who have considered the improvement of a low-input food crop to be a worthwhile undertaking. It is worthwhile, not because of the scientifically challenging problems facing the sorghum breeder who tries to combine higher yielding potential with tolerance to various adverse conditions, but because of the benefits that should accrue to the producers and consumers of the crop. The farming community, rather than the crop itself, is the clientele of a crop improvement program and it is only the verdict of farmers that ultimately counts in any evaluation of the effectiveness of a program.

In working to improve an indigenous crop you have set yourselves a particularly difficult task, as your clientele are already expert at the management of their locally available germplasm using resources at their disposal. Although you will know very much more

---

1Program Officer, Crops and Cropping Systems, International Development Research Centre, P.O. Box 62084, Nairobi, Kenya.
than they do of the characteristics of recently introduced exotic germplasm, you cannot hope to gain as much detailed information on, for example, micro environmental effects as many farmers acquire on their own land. You are therefore dependent to some extent on learning from those farmers, and upon your abilities and those of your colleagues in other disciplines to establish effective communication with farmers.

By testing your results on farms and sharing the task of evaluation with them both of you are likely to benefit. Farmers have the opportunity of a 'preview' of your work; you obtain an insight into their way of thinking so that new varieties will be more readily adopted. There is no reason to assume that farmers' criteria for judging a new variety or agronomic practice will necessarily coincide with yours every time; farmers vary among themselves, and it may be important to be able to identify groups of farmers who share certain characteristics and sets of requirements from a technical innovation. This is a technique which used to be used by social scientists, but one to which breeders and agronomists have a great deal to offer. IDRC has been supporting several institutions, particularly in Asia, where researchers are interested in improving the methodology for on-farm research and experimentation. More recently, support has been given to a group of crop scientists and agricultural economists at the University of Dar es Salaam to begin similar studies on dryland crops, especially sorghum.

Looking to the future, there is one area in which IDRC would be interested in giving added support to crop improvement researchers. This has to do with helping projects to develop further, and benefit more from, complementary research by other projects. IDRC has responded to requests from research institutions concerned with different aspects of sorghum. As a result, in some countries there are related projects concerned with the production, milling and utilization of sorghum. Close contact between these projects should allow the systems approach to be applied usefully to the design of technology that is appropriate to each step in the process from production to consumption.

I also look forward to a new area of regional contacts among researchers, of which this workshop perhaps represents the beginning. In this connection I wish Dr. Brhane much success in his new role in promoting scientific exchange through SAFGRAD.

Finally, on behalf of the IDRC staff in the region, I should like to express my thanks to Dr. Brhane, to the Ethiopian Sorghum Improvement Program personnel, and to the Institute of Agricultural Research and Alemaya Agricultural College for having made this meeting possible.
The Ethiopian Sorghum Improvement Project (ESIP) has been supported by Addis Ababa University (AAU), Institute of Agricultural Research (IAR), and International Development Research Centre (IDRC). Because of the unreserved backing ESIP has received from its three supporting organizations it has attained the status of a national program. ESIP has been primarily engaged in sorghum improvement activities although it has carried on other programs supportive to crop improvement.

Currently, in line with the set-up of the other major crops of the country, the National Sorghum Research Team is responsible for all research on sorghum in Ethiopia. The members of the National Sorghum Research Team represent all major disciplines relevant to the crop: breeding, agronomy, pathology, entomology, weed science, soil fertility and utilization. ESIP is a member and leader of the team.

The overall objectives of the ESIP are to develop sorghum varieties and hybrids along with the necessary packages of agronomic practices for getting a sustained high grain yield in the major sorghum growing zones of Ethiopia.

In trying to relate these objectives to the totality of sorghum improvement and production problems in the country, ESIP runs trials, nurseries and other operations in a series of stations representing the different sorghum ecological zones of Ethiopia. Consequently, ESIP operates at six different stations in the country. These are listed below:

<table>
<thead>
<tr>
<th>Station</th>
<th>Altitude (m)</th>
<th>Latitude</th>
<th>Normal Sorghum Planting Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Alemaya</td>
<td>1980</td>
<td>9° 30'</td>
<td>April</td>
</tr>
<tr>
<td>2. Arsi Negelie</td>
<td>1960</td>
<td>7° 20'</td>
<td>April</td>
</tr>
<tr>
<td>3. Mieso</td>
<td>1320</td>
<td>9° 20'</td>
<td>April</td>
</tr>
<tr>
<td>4. Nazareth (Melkasa)</td>
<td>1650</td>
<td>8° 30'</td>
<td>June</td>
</tr>
<tr>
<td>5. Kobo</td>
<td>1500</td>
<td>12° 10'</td>
<td>April</td>
</tr>
<tr>
<td>6. Melka Werer</td>
<td>850</td>
<td>9° 10'</td>
<td>December</td>
</tr>
</tbody>
</table>

Brief description of each of these stations is given below:

1. Alemaya - With its altitude of about 2000 m, Alemaya is ESIP's highest station and the major highland station. Its long term annual rainfall of 870 mm is typical of the good sorghum producing zones of this altitude. The growing season ranging from April to December represents the long season sorghum areas of the country. The most important sorghum producing area served by this station is the vast Chercher Highlands where the bulk of the Ethiopian highland sorghums are produced.

Formerly Project Leader, Ethiopian Sorghum Improvement Project, Addis Ababa University, P.O. Box 414, Nazareth, Ethiopia, currently SAFGRAD Coordinator for Sorghum and Millets, Eastern and Southern Africa, OAU/STRC/SAFGRAD, P.O. Box 30786, Nairobi, Kenya.
2. Arsi Negelie - This station is not located in a major sorghum producing zone. However, the yields from this station are often the highest among all Ethiopian sorghum stations. The altitude of Arsi Negelie is nearly the same as Alemaya. Growing conditions are also almost the same. Past results indicate that the pattern of varietal performance at the two sites is very much alike. Since this location is an optimum environment site for highland sorghums it gives ESIP chance to assess the real genetic potentials of highland breeding lines and varieties.

3. Mieso - It is located about mid-way between Nazareth and Alemaya on the main highway between Addis Ababa and Harar. The annual rainfall is estimated to be about 700 mm. This station is in the middle of an important lowland sorghum producing zone.

4. Nazareth (Melkasa) - The altitude of Nazareth is about 1650 m and that of Melkasa 1600 m. Almost all of our Nazareth plantings are done at Melkasa which is 15 km south of Nazareth. The rainfall averages about 800 mm. The station is centrally located and serves as a good coordinating and head quarter site for ESIP. Though sorghum is not a major crop here, the sorghum production potentials of the area are excellent. The first limiting factor to sorghum production here is undoubtedly Quelea. The bulk of ESIP's crossing work is done at this station. Seed preparation and packaging for almost all of ESIP's stations and other co-operators are done at Nazareth. Some off-season work is also done at Melkasa.

5. Kobo - This is ESIP's most important lowland site. It is situated in the vast Kobo-Alamata plain of the North Eastern lowlands where the dominant crop is sorghum. Because of the standard practice of farmers growing long season sorghums in the area, crop failures have become common place in this part of the country. The development of early maturing sorghums suitable for the area appears essential for reliable farming in the Kobo-Alamata plain and similar areas. Kobo has altitude of 1500 m and normal annual rainfall of 650 mm received in bimodally distributed short rains (March-April) and long rains (July-Sept.). Next to drought, a major sorghum production problem in this area is Striga.

6. Melka Werer - ESIP runs off-season programs at this station. Melka Werer is located along the Awash river (Middle Awash) where the major crop in the area is irrigated cotton. ESIP's primary sorghum work here is hybrid crossing, generation advancing and increasing seed of selections for the main season.

The core programs of ESIP in the sites mentioned above and also the sequential interrelationships of the different components of the program are shown in the "Schematic Diagram Summarizing the Interrelationships and Flow of ESIP's Programs" given below.
SCHEMATIC DIAGRAM SUMMARIZING THE INTERRELATIONSHIP AND FLOW OF ESIP'S PROGRAMS

COLLECTIONS

- Adv. Sorghum Selections (ASS)
- Maintain as Collection
- Parents for Crossing Block
- Male Sterile Lines
- Head Row Selections

CROSSING PROGRAM

- Backcross
- Pedigree Breeding
- DSBM* for Pop. IMrv't
- Hybrid Program

F₁ Off-Season
F₂ Keremt
Prelim. Yield Trial

National Yield Trial for High and Interm. Altitude

F₃ Keremt
F₄ Off-Season
F₅ Keremt
F₆ Off-Season

Prelim. Yield Trial

National Yield Trial for High, Interm. & Low Alt.

Initial Screening of Hybrid (ISH)

Adv. Selection Hybrid's (ASH)

Adv. Sorghum Selections (ASS)

Prelim. Yield Trial

National Yield Trial for Low Altitude

High Yielding Varieties and Hybrids

Microincreases

Field Demonstrations

Seed Production

Farm Level Production

* Dented Seed Breeding Method
For those who are interested in further information about any aspect of ESIP's programs, the annual reports of the project give ample details. Copies of ESIP Progress Reports No. 6-9 (1978-81) are still available on request.

**Staffing**
The personnel of ESIP at any one time has been composed of one or more professional with post graduate training, an administrative assistant, a secretary, and about eighteen technical assistants with only secondary school education. The technical assistants have received intensive on-the-job training in the ESIP in all aspects of sorghum improvement. With the guidance of the professional staff, the technical assistants are able to handle most aspects of ESIP's field and laboratory activities. Each of the stations mentioned above has one or more technical assistants assigned to it. Since much of the crossing and the coordination work is done at Nazareth, the most number of technical assistants are stationed at Nazareth.

**Centralized Activities in the ESIP**
Some key activities in the ESIP are centralized in that the coordinating office at Nazareth and the staff there are directly responsible for these activities. Such centralization has enabled ESIP to cover the major sorghum growing zones only with one or two senior staff members and a good supply of technical assistants with highschool education only. The centralized activities are:

1. **Planning and Seed Preparation** - The planning of all trials and nurseries at each of the ESIP sites as well as other cooperating stations is done at Nazareth by senior staff. Seeds are packaged and instructions prepared centrally. At the appropriate time, they are dispatched to the respective stations for planting by ESIP's technical assistants at each station or to other researchers at other cooperating stations.

2. **Crossing** - Decisions related to crossing work as well as the actual crossings are handled centrally at Nazareth. Parents for the crossing block are selected from each station at the time of evaluation and selection of materials at a given station. These are also functions of the coordinating station.

3. **Off-Season Nursery** - Both Melka Werer and Nazareth have served as off-season nursery stations. The off-season nursery is used for advancing generations and seed increase. Since all sites have need for this activity it is centrally handled for them by the coordinating station. All crossing for the hybrid program are also done in the off-season. At peak time, all technical assistants from all the ESIP sites are brought to the off-season nursery to handle the large crossing work of the hybrid program.
4. **Evaluation and Selection** - Overall evaluation and final selections of parents for the crossing block or entries to be advanced for further trials or release are made at each station by senior staff from the coordinating office. However, routine field and laboratory data recordings are done by the technical assistants permanently assigned to a site.

5. **Coordinating National Sorghum Research** - ESIP is now recognized and established as the leader and coordinator of the national sorghum research team sponsored and organized by the IAR. The professions represented in the team are breeding, agronomy, soil fertility, plant pathology, entomology, weed control, and utilization. There may be one or more researcher representing a discipline. The researchers are mostly from the Addis Ababa University and the Institute of Agricultural Research.

6. **Reporting and Data Handling** - All results and data collected from all ESIP stations are analyzed, summarized, interpreted, and written into formal reports by the coordinating office.

7. **Training** - The coordinating office handles all aspects of training. Locally, technical assistants assemble at Nazareth for about a month each year to participate in the review of results of the past year. They are also given classroom and field training by the project staff on the overall aspects of sorghum improvement.

8. **Equipment, Materials and Supplies** - Such essential items as tools, equipment, bags, tags, markers, notebooks, and related items are procured or made centrally and distributed to each station as needed.

9. **Administration and Guidance** - Constant communication with and regular visits to the various stations enables the coordinating office to give guidance and instruction to ESIP's technical assistants who are permanently assigned to the different stations.
Introduction

Ethiopia, with its wide range of agro-climatic conditions, is one of the centres for the domestication and diversification of several important crop plants. This was first recognized by Vavilov in the 1920's and later confirmed by various other scientists. Various concerned scientists have also indicated that the tremendous genetic diversity deserves much more attention than it has received so far. There are large relatively inaccessible areas that are still unexplored that could serve as important natural reservoirs of germplasm. Some of the areas like Yerer and Kereyu and many other highland regions of Ethiopia, ranging from 2600-4000 m (8000-12000ft) have been recognized as high crop diversity sources but have more or less been neglected by previous explorers.

The natural conservation of the germplasm of crop species in Ethiopia may also be attributed to the traditional farming system. The Ethiopian farmer has consciously or unconsciously been maintaining a highly heterogenous population of seed stock for many generations. The primitive farming methods have hardly interfered with the continued co-existence of the various crop species and their wild progenitors. This situation may not continue as the farmer is now looking for new and improved seeds and is adopting modern farming practices. While this is one important step in yield improvement, it involves the risk of losing the rich source of germplasm already in existence. It is a paradox that agricultural development is responsible for the loss of potentially valuable genetic material. This can be resolved only through a systematic effort to conserve the genetic stock already in existence.

The importance of collection, preservation and systematic utilization of plant genetic resources was recognized by scientists perhaps half a century ago. It is only recently, however, that due attention have been given to the problem.

In 1972, a group of experts from various international institutions recommended that action be taken to conserve and utilize the world's dwindling reserve of crop germplasm. Among the few countries identified as important centres of genetic diversity, Ethiopia was accorded a high priority for the collection, conservation and utilization of crop germplasm. Plant breeders have

---

1 Director, Plant Genetic Resources Centre/Ethiopia (PGRC/E), P.O. Box 30726, Addis Ababa, Ethiopia.
already identified highly desirable genetic characteristics in the relatively few collections they have made in Ethiopia. These include high lysine contents in either sorghum or barley and rust resistance in wheat. Some barley lines that were collected a few years ago in Ethiopia were found to be the only source of resistance in the world to certain virus diseases. Other characteristics for which Ethiopian crops are believed to be important future gene sources in varietal improvement include earliness, tolerance to drought and adaptability to adverse weather and soil conditions.

It is this recognition that attracted the attention of national and international institutions and the subsequent realization of the need for the establishment of a gene bank in Ethiopia.

Initiation of the Plant Genetic Resources Centre/Ethiopia

The Plant Genetic Resources Centre was established in 1976 as a bilateral technical and economic development program between the Ethiopian Government and the Government of the Federal Republic of Germany. It was formed with the following major objectives:

1. To promote the collection, evaluation, documentation and scientific studies of the crop plant germplasm materials.

2. To provide facilities for long-term storage and maintenance in order to make available valuable germplasm to breeding programs in the years to come.

3. To provide materials to be utilized in breeding programs aimed at the development of high yielding, disease and pest resistant cultivars with other qualities required of important crops grown in Ethiopia.

4. To supplement the Ethiopian crop plant germplasm by crop plant germplasm of other countries through co-operation and exchange of materials.

Organization

The Plant Genetic Resources Centre/Ethiopia (PGRC/E) is attached to the National Institute of Agricultural Research for budgetary and administrative purposes. It receives its guidelines from the PGRC/E Council which is composed of representatives from various professionally related institutions. The staff of the Centre is composed of national and international scientists (including short term visiting experts) and supportive personnel.

Resources and Facilities

The Centre is located in Addis Ababa at a 3 hectare site with a laboratory office building and long and medium term storage facilities. The long term storage equipment is maintained at -10°C.
and has a capacity of 75m³ storage space. The medium term storage operates at +4°C and 30% RH, with a capacity of 50m³. The available land area will also accommodate living collections of ornamentals and other plant types.

Activities

The main operational activities of the Plant Genetic Resources Centre include five major phases.

1. Collection of germplasm
2. Conservation-maintenance
3. Evaluation and documentation
4. Biosystematic studies
5. The exploitation of genetic variability

With only three years of effective period of operation, the PGRC/E has yet to claim major accomplishments in regards to these activities. The main involvement so far has been in the area of collection and conservation, carried out on the basis of some well defined priority of action.

For the collection, priority has been based on the economic importance, social importance and the degree to which genetic erosion is endangering the varieties. With regard to localities, priority is given to those regions where modern agriculture is expanding fast, that is, where the introduction of improved varieties and/or new cropping patterns threaten the existing germplasm and in areas where crops are endangered by natural disaster. So far some 20,763 samples of the major cereals (including 5,000 accessions of sorghum handed over by the Ethiopian Sorghum Improvement Project (ESIP)), pulses and oil crops have been collected mainly from the Central and Northern Highlands and the South and Southeastern parts of Ethiopia.

In the conservation and maintenance work the individual collections are brought to the PGRC/E Headquarters directly, cleaned and processed. Each collection is then divided into three parts: one part is kept for long term storage (base collection), the second part is to be used for evaluation and/or multiplication (active collection) and the third part is deposited at a cooperating Gene Bank abroad as a safety duplicate. The multiplication and evaluation of the germplasm material is carried out in collaboration with national and international breeders from both within and outside the country.

In summary, the future involvement of the PGRC/E will be an expansion of the exploration/collection, conservation, characterization/evaluation and effective utilization of the germplasm resources both inside and outside the country. Its future program is also aimed at developing the necessary scientific and supportive staff and improving facilities for training and research in relevant areas.
Fig. 1. Flow diagram showing the inter-relationships of the activities of the PGRC/E.
The Plant Genetic Resources Centre is to cater primarily as a nucleus for the above mentioned activities in Ethiopia. In years to come it will play leading role as a regional base for genetic conservation in Eastern Africa and neighbouring regions.

**PGRC/E CROP GERmplasm COLLECTION**

*(Position on 15th October, 1982)*

<table>
<thead>
<tr>
<th>Species</th>
<th>Total No. in the Collection</th>
<th>Total Collected by PGRC/E</th>
<th>PGRC/E Collection as % of Total Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Abelmoschus esculentus</em></td>
<td>3</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td><em>Aframomum korarima</em></td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td><em>Allium spp</em></td>
<td>9</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td><em>Amaranthus caudatus</em></td>
<td>5</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td><em>Arachis hypogaea</em></td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td><em>Avena abyssinica</em></td>
<td>20</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td><em>Brassica spp</em></td>
<td>556</td>
<td>387</td>
<td>69.6</td>
</tr>
<tr>
<td><em>Cajanus cajan</em></td>
<td>3</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td><em>Capsicum spp</em></td>
<td>70</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td><em>Carthamus tinctorius</em></td>
<td>42</td>
<td>28</td>
<td>66.7</td>
</tr>
<tr>
<td><em>Carum copticum</em></td>
<td>9</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td><em>Cicer arietinum</em></td>
<td>326</td>
<td>326</td>
<td>100</td>
</tr>
<tr>
<td><em>Coccinia abyssinica</em></td>
<td>3</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td><em>Coriandrum sativum</em></td>
<td>13</td>
<td>13</td>
<td>100</td>
</tr>
<tr>
<td><em>Cucurbita pepo</em></td>
<td>30</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td><em>Cuminum cyminum</em></td>
<td>5</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td><em>Dolichos lablab</em></td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td><em>Eleucine coracana</em></td>
<td>97</td>
<td>97</td>
<td>100</td>
</tr>
<tr>
<td><em>Eragrostis tef</em></td>
<td>347</td>
<td>347</td>
<td>100</td>
</tr>
<tr>
<td><em>Fagopyrum esculentum</em></td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td><em>Guizotia abyssinica</em></td>
<td>563</td>
<td>323</td>
<td>57.4</td>
</tr>
<tr>
<td><em>Helianthus annuus</em></td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em></td>
<td>5369</td>
<td>2353</td>
<td>43.8</td>
</tr>
<tr>
<td>Species</td>
<td>Total No. in the Collection</td>
<td>Total Collected by PGRC/E</td>
<td>PGRC/E Collection as % of Total Collection</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Lagenaria spp</td>
<td>8</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>Lathyrus sativus</td>
<td>170</td>
<td>109</td>
<td>64.1</td>
</tr>
<tr>
<td>Lens esculenta</td>
<td>169</td>
<td>169</td>
<td>100</td>
</tr>
<tr>
<td>Lepidium sativum</td>
<td>23</td>
<td>23</td>
<td>100</td>
</tr>
<tr>
<td>Linum usitatissimum</td>
<td>887</td>
<td>261</td>
<td>29.4</td>
</tr>
<tr>
<td>Lupinus spp.</td>
<td>18</td>
<td>18</td>
<td>100</td>
</tr>
<tr>
<td>Medicago sativa</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nicotiana tabacum</td>
<td>24</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nigella sativa</td>
<td>17</td>
<td>17</td>
<td>100</td>
</tr>
<tr>
<td>Ocimum graveolens</td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>Oryza spp</td>
<td>3</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>Pennisetum typhoides</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Phaseolus spp</td>
<td>87</td>
<td>87</td>
<td>100</td>
</tr>
<tr>
<td>Pisum sativum</td>
<td>822</td>
<td>405</td>
<td>49.3</td>
</tr>
<tr>
<td>Raphanus sativus</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Ricinus communis</td>
<td>138</td>
<td>95</td>
<td>68.8</td>
</tr>
<tr>
<td>Sesamum indicum</td>
<td>108</td>
<td>24</td>
<td>22.2</td>
</tr>
<tr>
<td>Sorghum bicolor</td>
<td>6127</td>
<td>568</td>
<td>9.3</td>
</tr>
<tr>
<td>Tamarindus indica</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Trigonella foenum-graecum</td>
<td>207</td>
<td>110</td>
<td>53.1</td>
</tr>
<tr>
<td>Triticum spp</td>
<td>3946</td>
<td>1575</td>
<td>39.9</td>
</tr>
<tr>
<td>Vicia faba</td>
<td>985</td>
<td>391</td>
<td>39.7</td>
</tr>
<tr>
<td>Voandzeia subterranea</td>
<td>1</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Zea mays</td>
<td>54</td>
<td>47</td>
<td>87</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>21281</strong></td>
<td><strong>7956</strong></td>
<td><strong>37.4%</strong></td>
</tr>
</tbody>
</table>
## PLANT GENETIC RESOURCES CENTRE/ETHIOPIA
### 1982 Multiplication & Characterization

<table>
<thead>
<tr>
<th>Common Name</th>
<th>No. Acc.</th>
<th>Planted Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEREALS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triticum spp</td>
<td>Wheat</td>
<td>2083</td>
</tr>
<tr>
<td>Hordeum spp</td>
<td>Barley</td>
<td>552</td>
</tr>
<tr>
<td>Sorghum bicolor</td>
<td>Sorghum</td>
<td>2035</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asmara/Holetta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Holetta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Debre Zeit/Bekoji</td>
</tr>
<tr>
<td>PULSES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicia faba</td>
<td>Horse bean</td>
<td>143</td>
</tr>
<tr>
<td>Pisum sativum</td>
<td>Field pea</td>
<td>100</td>
</tr>
<tr>
<td>Lens esculenta</td>
<td>Lentil</td>
<td>168</td>
</tr>
<tr>
<td>Cicer arietinum</td>
<td>Chickpea</td>
<td>325</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Debre Zeit/Bekoji</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Debre Zeit/Bekoji</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Debre Zeit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Debre Zeit</td>
</tr>
<tr>
<td>OIL CROPS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linum usitatissimum</td>
<td>Linseed</td>
<td>172</td>
</tr>
<tr>
<td>Guizotia abyssinica</td>
<td>Noog</td>
<td>218</td>
</tr>
<tr>
<td>Brassica spp</td>
<td>Rape seed</td>
<td>282</td>
</tr>
<tr>
<td>Carthamus tinctorius</td>
<td>Safflower</td>
<td>23</td>
</tr>
<tr>
<td>Sesamum indicum</td>
<td>Sesame</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Holetta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Holetta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Holetta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Debre Zeit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Melka Werer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VEGET./HORTIC.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allium spp</td>
<td>Onion</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Addis Ababa</td>
</tr>
</tbody>
</table>
THE 1981 ACTIVITIES OF PLANT GENETIC RESOURCES CENTRE/ETHIOPIA ON SORGHUM GERMPLASM

Brook Abebe and H.B. Wech

ABSTRACT

The Plant Genetic Resources Centre/Ethiopia is engaged in the maintenance and evaluation of more than 6000 accessions of sorghum germplasm which were collected throughout the country.

In the 1981 crop season, 5155 accessions were planted at Nazareth and Arsi Negelie for multiplication and rejuvenation. These materials were characterized and evaluated for eight morpho-agronomic characters. In addition to these, they were stratified geographically, taxonomically and agronomically. Data for their reaction to stalk borer and bacterial leaf streak were also collected.

Geographically, some regions of Ethiopia are adequately sampled, while others are not yet. Taxonomically, race durra and its intermediate type durra-bicolor are well represented whereas other races and wild relatives are not represented in the collection although their occurrence is reported. Forty-six morphotypes, as representatives of the overall genetic variability, were classified to the sub-race level. Agronomically, 50% of the materials were selected for characteristics that are desirable and important for plant breeders. Three hundred nine accessions which showed some degree of tolerance to stalk borer and/or bacterial leaf streak were identified. The agronomically elite and the stem borer and/or bacterial streak tolerant accessions were planted in the 1982 season at Arsi Negelie for multiplication and subsequent distribution.

Future efforts of PGRC/E will focus on making the collection of sorghum germplasm as representative as possible. Characterization and evaluation will continue to describe this genetic variation for further use in plant breeding.

1Assistant Research Officer, and Research Scientist, respectively, Plant Genetic Resources Centre/Ethiopia, P.O. Box 30726, Addis Ababa, Ethiopia
Introduction

The Ethiopian Centre of Origin of cultivated crops is rich in genetic diversity of cultivated sorghums and their wild relatives. This is the result of adaptation to the different ecological conditions of the country and of the long selection made by man in the early domestication of the crop (2, 6).

Sorghum, unlike other major food grains, shows a very wide range of ecological plasticity (4). In Ethiopia, it is grown in almost all the agro-ecological zones. Due to the topography of the country, these zones range from one extreme to the other, with respect to altitude, precipitation, temperature, soil type and so forth.

Taking into consideration these extreme conditions and the resulting genetic variation between and within the sorghum landraces, that are still planted, one can imagine the enormous importance of this Ethiopian germplasm for breeding programs.

Everyone of us is responsible for such a valuable treasure and we face two challenges:

1. Collect and maintain this germplasm to save the existing variation that is being threatened by the introduction of new uniform high yielders or by farmers' change to other crops.

2. Make this variation available to the breeder. Since the ultimate objective of collection and conservation of germplasm is its utilization as source of breeding material for crop improvement, the availability of information about germplasm is of paramount importance. To this effect, characterization and evaluation of the collection is imperative.

Material

The Plant Genetic Resources Centre/Ethiopia, being aware of these two tasks, is engaged in the maintenance and evaluation of a collection of 6127 accessions of sorghum germplasm at present. The accessions have been sampled from all over the country. They are stored in the germplasm centre in Addis Ababa as "Active Collection" at +4°C and 30% RH. Accessions with at least 12000 seeds are also stored as "Base Collection" at -10°C.

Almost all of this material was collected by the Ethiopian Sorghum Improvement Project (ESIP) and handed over to PGRC/E. Coordinated expeditions involving PGRC/E, ESIP, IBPGR and ICRISAT have also contributed to this collection.

In the 1981 crop season, 5155 accessions were planted both at Nazareth and Arsi Negelie for rejuvenation/multiplication and characterization/evaluation, in single unreplicated rows of 2 m length and a distance of 0.75 m between the rows.
Methods

The following activities were carried out on this material:
- Using data from our documentation section, informations about time and place of the original collection were summarized.
- All the materials planted were characterized for some important morpho-agronomic characters such as "Days to Flowering", "Days to Maturity", "Plant Height", "Panicle Exertion", "Head Type", "Midrib Color", "Basal Tillering" and "Synchrony of Flowering of Tillers".
- The agronomic desirability of every accessions was evaluated. A visual measuring system (i.e. Plant Aspect Score) with a 1-5 scale ranging from "very good" and "very poor" was used. Various agronomically important characters were combined for this measurement.
- Due to the prevalence of bacterial leaf streak and stalk borer at Arsi Negelie it was possible to evaluate the reaction of the materials to this pathogen and pest.
- After harvest the materials were classified taxonomically to the race level using the classification system suggested by Harlan and de Wet (1972). Additionally, 46 morphotypes were selected and described to represent the overall genetic variability that exists in the collection. Based on these descriptions all accessions were further classified to the sub-race level.

Results

The summing up of INFORMATION on the ORIGIN, existing in our documentation section, showed us that for almost 30% of the material we do not have the so called "passport data", indicating p.ex. place and date of collection. This calls for intensive tracing back of this accessions and we are hopeful to gather the missing details in due course of time with the help of the prior stock keepers.

Large quantities of our materials were collected in Tigrai, Gondar, Gojam, Wollo, Shoa, Illubabor, Gamo Gofa and Harrergha, whereas only very few accessions trace back to p.ex. Eritrea or Wollega. Nevertheless, these two regions are known as sorghum growing areas (1) and we expect to find their valuable and diversified landraces, due to the fact that the distribution of seeds of uniform varieties to the farmers in these regions is still limited. It is always very doubtful to say that the intensively sampled regions are already representatively collected, but

---

(1) PGRC/E highly appreciates and is grateful for the cooperation of K.E. Prasada Rao (ICRISAT), Dr. Mengistu Hulluka (AAU), and Dr. Tessema Megenasa (AAU).
it is without any doubt, that some regions are not yet adequately sampled.

The TAXONOMIC CLASSIFICATION showed us that the collection mainly consists of the race durra and the intermediate races durra-bicolor and durra-caudatum. Race durra shows the highest intra-racial variability represented by 25 sub-races. (The botanical description for the total of 46 sub-races, representing the overall variability in the collection, is given in the Appendix).

According to Harlan and de Wet (1971) all the cultivated races of sorghum occur in Ethiopia, except race Kafir and its intermediate races. For this reason we must take for granted that the two accessions of race guinea in our collection do not represent the variability of this race in Ethiopia. Similar is the situation for other races. A complete gap exists concerning the wild and weedy relatives of sorghum that occur in Ethiopia: race aethiopicum and race verticilliflorum (3, 9). Here is a great field for future sorghum collection activities.

A MORPHO-AGRONOMIC DESCRIPTION consisting of the above mentioned eight characters was made for each accession. The results were handed over to our documentation section. They are to be compiled and published as soon as possible in a catalogue.

THE PLANT ASPECT SCORE was visually measured between "1 = very good" and "5 = very poor", as a combination of various agronomically important characters. The better performing accessions (1.0 to 2.5) that are of preferential interest to the plant breeder were selected and replanted this season (1982) at Arsi Negelie for multiplication and subsequent distribution.

TOLERANCE to bacterial leaf streak and/or stalk borer was shown to some degree by 309 accessions (5%), a surprisingly high percentage of the collection. These accessions were also replanted this season (1982) at the same location for further checking and selection.

Outlook

Collection and conservation of Ethiopian sorghum germplasm will go on. We are aware of some geographic and taxonomic gaps in our collection. PGRC/E, for this reason, established contacts with agricultural stations and personnel in the target areas and prepared pointed collecting missions. Already this year a special expedition will be launched to Konso region in Gamo Gofa where the occurrence of race guinea is reported.

Availability of information about each accession is essential for the users of germplasm. PGRC/E will not deviate from its course and characterize and evaluate its material as intensively as practicable and, whenever possible, with the cooperation of specialized scientists.
NOTE

For any relevant information about PGRC/E (including seed exchange) please contact:

Dr. Melaku Worede  
Director  
Plant Genetic Resources Centre/Ethiopia (PGRC/E)  
P.O. Box 30726  
Addis Ababa  
Ethiopia

This review will be published with more details in one of the next PGRC/E - ILCA Newsletters. For subscription please contact:

Ato Tadesse Dadi  
Documentation Section  
Plant Genetic Resources Centre/Ethiopia (PGRC/E)  
P.O. Box 30726  
Addis Ababa  
Ethiopia

References


APPENDIX

Botanical Descriptions* for the Sub-Races
of the Ethiopian Sorghum Germplasm

Fourty six type representatives (morphotypes) were identified to represent the overall genetic variability in the collection. These specimens were given a type number and a name. In naming the morphotypes attempt was made to make the nomenclature as simple as possible. Thus, names were derived from shape of the panicle (eg. 'asama af') or from the place where it grows (eg. 'ambasel zengada') or from its local name (eg. 'myera'). After this procedure, botanical description for each of the 46 morphotypes was given and each morphotype was treated as distinct sub-race hereafter.

1. *S. bicolor*
   - ssp. bicolor
   - race durra (D)
   - sub-race 'goronjo'/*D-1*
     Peduncle erect. Panicle very loose to loose, elliptic, 60-64 cm long, 16-18 cm wide, branches bare at the base and seed setting starts near the tip, primary branches erect, secondary branches long, central rachis fully extended. Glumes slightly hairy, transvers wrinkling clearly visible. 3/4 of grain covered by glumes, grain color white, straw, yellow.
     (Type representative specimen: PGRC Acc. No. 73130)

2. *S. bicolor*
   - ssp. bicolor
   - race durra (D)
   - sub-race 'goronjo chibit'/*D-2*
     Peduncle erect. Panicle loose, elliptic, 40-45 cm long, 8-10 cm wide. Seed setting starts near the base of the branches, primary branches erect, secondary branches short, central rachis fully extended. Glumes glabrous. 3/4 of grain covered by glumes, grain color straw, yellow, or white.
     (Type representative specimen: PGRC Acc. No. 73131)

3. *S. bicolor*
   - ssp. bicolor
   - race durra (D)
   - sub-race 'goronjo netch'/*D-3*
     Peduncle erect. Panicle semi-loose to semi-compact, 35-40 cm long, 7-9 cm wide, primary branches erect, short secondary branches, central rachis fully extended. Glumes slightly hairy covering 3/4 of the grain, grain color yellow to light red.
     (Type representative specimen: PGRC Acc. No. 72579)

*Measurements of the panicle length & width is based on the type representative specimen only.
4. *S. bicolor*
   ssp. *bicolor*
   race durra (D)
   sub-race 'netch kondale'/'D-4'
   Peduncle erect. Panicle semi-compact, broadly elliptic to oval (oblong), 24-28 cm long, 7-9 cm wide. Central rachis fully extended. Glumes slightly hair, 3/4 of grain covered by glumes. Grain color very white, subcoat absent.
   (Type representative specimen: PGRC Acc. No. 72652)

5. *S. bicolor*
   ssp. *bicolor*
   race durra (D)
   sub-race 'ambasel zengada'/'D-5'
   Peduncle erect. Pancile compact, elliptic, 20-22 cm long, 8-10 cm wide. Central rachis fully extended. Glumes transversely wrinkled and depressed across the middle, awns present, 3/4 of grain covered by glumes. Grain color red brown with shiny pericarp, endosperm completely starchy.
   (Type representative specimen: PGRC Acc. No. 72454)

6. *S. bicolor*
   ssp. *bicolor*
   race durra (D)
   sub-race 'dogongof'/'D-6'
   Peduncle recurved. Panicle compact, broadly elliptic to oval, 20-23 cm long, 8-10 cm wide. Glumes reddish brown colored, base of the lower glumes depressed, awns present. 3/4 of the grain covered by glumes. Grains red brown with non-lustrous pericarp, endosperm almost starchy.
   (Type representative specimen: PGRC Acc. No. 70129)

7. *S. bicolor*
   ssp. *bicolor*
   race durra (D)
   sub-race 'wagare netch'/'D-7'
   Peduncle recurved. Panicles semi-loose to semi-compact, elliptic to oval, 25-33 cm long, 10-16 cm wide, tip of panicle pointed, 3/4 of grains covered by glumes. Grains straw colored or pearly white.
   (Type representative specimen: PGRC Acc. No. 70293)

8. *S. bicolor*
   ssp. *bicolor*
   race durra (D)
   sub-race 'wagare keye'/'D-8'
   Similar to 'wagare netch' except for the grain color which is red.
   (Type representative specimen: PGRC Acc. No. 70738)
9. *S. bicolor*
ssp. bicolor
race durra (D)
sub-race 'chibit wagare'/'D-9"
Similar as the above specimen, except that the panicle is compact and tip is pointed. Grain color is white or yellow.
(Type representative specimen: PGRC Acc. No. 72488)

10. *S. bicolor*
ssp. bicolor
race durra (D)
sub-race 'abdolot netch'/'D-10"
Peduncle recurved. Panicle extra large, semi-compact, oval with blunt tip, 12-16 cm long, 11-14 cm wide. Grain color yellowish white.
(Type representative specimen: PGRC Acc. No. 70223)

11. *S. bicolor*
ssp. bicolor
race durra (D)
sub-race 'abdolot keye'/'D-11"
Same as above, except that the grains are red in color.
(Type representative specimen: PGRC Acc. No. 72986)

12. *S. bicolor*
ssp. bicolor
race durra (D)
sub-race 'muyera netch'/'D-12"
Peduncle usually recurved but sometimes erect. Panicle very compact, conical with pointed tip, 12-15 cm long, 8-10 cm wide. Grain color yellowish white or pearly white.
(Type representative specimen: PGRC Acc. No. 74909)

13. *S. bicolor*
ssp. bicolor
race durra (D)
sub-race 'muyera keye'/'D-13"
Same as above, except that the grain color is red.
(Type representative specimen: PGRC Acc. No. 72046)

14. *S. bicolor*
ssp. bicolor
race durra (D)
sub-race 'asama af degalit netch'/'D-14"
Peduncle recurved. Panicle compact, conical with protruded tip which has found projections 12-16 cm long, 10-12 cm wide. Grain color yellowish white or pearly white.
(Type representative specimen: PGRC Acc. No. 72764)
15. *S. bicolor*

ssp. bicolor
race 'asama af degalit keye'/'D-15"
Same as above, except that the grain color is red.
(Type representative specimen: PGRC Acc. No. 72275)

16. *S. bicolor*

ssp. bicolor
race durra (D)
sub-race 'hafukagne'/'D-16"
Peduncle recurved but sometimes erect. Panicle loose to
semi-loose, elliptic, 20-23 cm long, 9-11 cm wide. Glumes
tementose (densely wooly). Grains extra large in size,
yellowish white in color.
(Type representative specimen: PGRC Acc. No. 72848)

17. *S. bicolor*

ssp. bicolor
race durra (D)
sub-race 'tefakoor'/'D-17"
Peduncle recurved. Panicle compact oval, 10-13 cm long,
7-9 cm wide. Grain multicolored, some red, some white and
some others white with red blotches.
(Type representative specimen: PGRC Acc. No. 72824)

18. *S. bicolor*

ssp. bicolor
race durra (D)
sub-race 'bitin menta'/'D-18"
Peduncle erect. Panicle very loose with erect primary
branches, oval, 16-18 cm long, 7-9 cm wide. Grains twin
seeded, grain color red.
(Type representative specimen: PGRC Acc. No. 73150)

19. *S. bicolor*

ssp. bicolor
race durra (D)
sub-race 'bicha menta'/'D-19"
Peduncle upright or recurved. Panicle compact, oval,
10-12 cm long, 4-6 cm wide. Glumes black in color. Grains
twin seeded, color of seeds distinctly yellow.
(Type representative specimen: PGRC Acc. No. 71994)
20. **S. bicolor**  
ssp. bicolor  
race durra (D)  
sub-race 'deerb keteto'/'D-20'  
Peduncle recurved. Panicle very compact, elliptic with pointed tip, 13-15 cm long, 6-8 cm wide. Glumes whitish in color, grains twin seeded, color of seeds yellowish.  
(Type representative specimen: PGRC Acc. No. 73098)

21. **S. bicolor**  
ssp. bicolor  
race durra (D)  
sub-race 'menta keye'/'D-21'  
(Type representative specimen: PGRC Acc. No. 73217)

22. **S. bicolor**  
ssp. bicolor  
race durra (D)  
sub-race 'wotet begunche'/'D-22'  
Peduncle upright. Panicle semi-loose with erect primary branches, elliptic, 40-43 cm long, 9-11 cm wide. Seeds dented (dimple), red in color.  
(Type representative specimen: PGRC Acc. No. 73006)

23. **S. bicolor**  
ssp. bicolor  
race durra (D)  
sub-race 'red marchuke'/'D-23'  
Peduncle erect or recurved. Panicle semi-compact, oval, 13-15 cm long, 4-6 cm wide. Seeds dented (dimple), red in color.  
(Type representative specimen: PGRC Acc. No. 72972)

24. **S. bicolor**  
ssp. bicolor  
race durra (D)  
sub-race 'yellow marchuke'/'D-24'  
Similar to the above except that the seeds are yellow in color.  
(Type representative specimen: PGRC Acc. No. 72625)
25. *S. bicolor*  
ssp. *bicolor*  
race *durra* (D)  
sub-race 'white marchuke'/'D-25'
Similar to the above two, except that the panicle is slightly bigger, 25-28 cm long, 9-11 cm wide. Seeds are white in color.  
(Type representative specimen: PGRC Acc. No. 72964)

26. *S. bicolor*  
ssp. *bicolor*  
race *bicolor* (B)  
sub-race "B-1"  
Peduncle generally straight. Panicle loose with drooping or erect primary branches. Shape of panicle elliptic or oblong. 30-34 cm long, 10-14 cm wide. Grains slender and blong usually brown in color. Glumes red, white or shiny black enclosing the grain completely. Pedicelled spikelets persistent after maturity.  
(Type representative specimen: PGRC Acc. No. 70252)

27. *S. bicolor*  
ssp. *bicolor*  
race *durra bicolor* (DB)  
sub-race "DB-1"  
Straight peduncle. Panicle very loose with erect branches. 38-41 cm long, 24-28 cm wide. Central rachis fully extended. Glumes almost covering the whole grain, transvers wrinkling slightly visible, color of glumes black.  
(Type representative specimen: PGRC Acc. No. 72723)

28. *S. bicolor*  
ssp. *bicolor*  
race *durra bicolor* (DB)  
sub-race "DB-2"  
Peduncle straight. Panicle very loose, elliptic. 40-43 cm long, 18-21 cm wide. Central rachis fully extended. Glumes almost covering the whole grain.  
(Type representative specimen: PGRC Acc. No. 72783)

29. *S. bicolor*  
ssp. *bicolor*  
race *durra bicolor* (DB)  
sub-race "DB-3"  
Peduncle straight. Panicle loose with erect branches, 38-42 cm long, 16-20 cm wide. Central rachis fully extended. Grains almost enclosed by glumes.  
(Type representative specimen: PGRC Acc. No. 70501)
30. **S. bicolor**
   ssp. bicolor
   race durra bicolor (DB)
   sub-race 'asfaw white'/'DB-4"
   Peduncle straight. Panicle loose with erect branches.
   Central rachis fully contracted, broom corn in shape,
   30-33 cm long, 10-14 cm wide. Glumes white in color almost
   cover the grains completely.
   (Type representative specimen: PGRC Acc. No. 72734)

31. **S. bicolor**
   ssp. bicolor
   race durra bicolor (DB)
   sub-race /"DB-5"
   Peduncle straight. Panicle loose with drooping branches.
   Half broom corn in shape, 26-30 cm long, 5-7 cm wide.
   Central rachis fully extended. Glumes black in color,
   transvers wrinkling slightly visible.
   (Type representative specimen: PGRC Acc. No. 70568)

32. **S. bicolor**
   ssp. bicolor
   race durra bicolor (DB)
   sub-race /"DB-6"
   Peduncle straight. Panicle semi-loose erect, elliptic,
   25-29 cm long, 6-8 cm wide. Central rachis partially
   extended. Glumes enclose the grains completely, transvers
   wrinkling slightly visible.
   (Type representative specimen: PGRC Acc. No. 74363)

33. **S. bicolor**
   ssp. bicolor
   race durra bicolor (DB)
   sub-race 'fendisha' /"DB-7"
   Peduncle straight or half recurved. Panicle loose to
   semi-loose with stiff primary branches. Central rachis
   fully contracted. Due to this panicle open at the top.
   Shape of panicle elliptic or oval, 15-18 cm long, 7-9 cm
   wide. Grain almost corneous, pearly white in color, can
   be popped like pop corn.
   (Type representative specimen: PGRC Acc. No. 73595)

34. **S. bicolor**
   ssp. bicolor
   race durra bicolor (DB)
   sub-race 'bishinga worrebesa' /"DB-8"
   Peduncle recurved. Panicle compact elliptic, 18-21 cm
   long, 10-12 cm wide. Grains completely covered by large
   glumes, pedicelled spikelets persistent and sometimes are
   fertile.
   (Type representative specimen: PGRC Acc. No. 72283)
35. *S. bicolor*
ssp. *bicolor*
race caudatum (C)
sub-race 'bobe adi' /"C-1"
Peduncle straight. Panicle loose spreading with drooping branches, 28-32 cm long, 16-20 cm wide. Central rachis fully contracted. Grains white without sub-coat. Glumes white in color.
(Type representative specimen: PGRC Acc. No. 72703)

36. *S. bicolor*
ssp. *bicolor*
race caudatum (C)
sub-race 'shotata cherekit' /"C-2"
Peduncle straight. Panicle semi-loose with erect branches, elliptic or cylindrical, 24-28 cm long, 6-8 cm wide. Central rachis fully extended. Grains chalky white with sub-coat. Glumes white in color.
(Type representative specimen: PGRC Acc. No. 72589)

37. *S. bicolor*
ssp. *bicolor*
race caudatum (C)
sub-race 'sibsib cherekit' /"C-3"
Similar to 'shotata cherekit' except that the panicle is semi-compact, oval, 22-26 cm long, 6-8 cm wide.
(Type representative specimen: PGRC Acc. No. 72571)

38. *S. bicolor*
ssp. *bicolor*
race caudatum bicolor (CB)
sub-race /"CB-1"
(Type representative specimen: PGRC Acc. No. 70335)

39. *S. bicolor*
ssp. *bicolor*
race durra caudatum (DC)
sub-race 'keradebia' /"DC-1"
Peduncle straight. Panicle very loose with drooping branches, 22-26 cm long, 18-20 cm wide. Central rachis fully extended. Glumes black in color. Grain color brown.
(Type representative specimen: PGRC Acc. No. 73157)
40. *S. bicolor*
   ssp. bicolor
   race durra caudatum (DC)
   sub-race /"DC-2"
   Peduncle straight. Panicle semi-loose with erect branches, elliptic, 32-36 cm long, 5-7 cm wide. Central rachis fully extended. Glumes black in color. Grains chalky white, with sub-coat.
   (Type representative specimen: PGRC Acc. No. 72925)

41. *S. bicolor*
   ssp. bicolor
   race durra caudatum (DC)
   sub-race /"DC-3"
   (Type representative specimen: PGRC Acc. No. 74022)

42. *S. bicolor*
   ssp. bicolor
   race guinea (G)
   sub-race 'roxburghii'/'G-1"
   Peduncle straight. Panicle loose with drooping branches, 32-35 cm long, 7-9 cm wide. Central rachis fully extended. Glumes completely open at maturity, straw colored. Grains completely uncovered by the glumes, color of grains white, size of grains medium.
   (Type representative specimen: PGRC Acc. No. 74700)

43. *S. bicolor*
   ssp. bicolor
   race guinea caudatum (GC)
   sub-race 'alengua' /"GC-1"
   Peduncle straight. Panicle semi-loose with erect branches, oval, 14-18 cm long, 8-10 cm wide. Central rachis fully extended. Glume reddish brown, enclose 1/4 of the grain. Grains brown, sub-coat absent.
   (Type representative specimen: PGRC Acc. No. 70050)

44. *S. bicolor*
   ssp. bicolor
   race guinea caudatum (GC)
   sub-race 'gangā' /"GC-2"
   Peduncle straight. Panicle semi-loose with erect branches to semi-compact, elliptic or oval, 16-20 cm long, 8-10 cm wide. Central rachis almost fully extended. Glumes black, cover 1/4 of the grain. Grains straw colored.
   (Type representative specimen: PGRC Acc. No. 74913)
45. *S. bicolor*
   ssp. *bicolor*
   race guinea caudatum (GC)
   sub-race 'zera-zera' /"GC-3"
   Peduncle straight. Panicle semi-loose with erect branches
to semi-compact, oval or elliptic. 18-22 cm long, 8-10 cm
wide. Central rachis almost fully extended. Glumes straw,
cover 1/4 of the grain. Grain straw colored, quality of
grain good.

(Type representative specimen: PGRC Acc. No. 74914)

46. *S. bicolor*
   ssp. *bicolor*
   race guinea durra (GD)
   sub-race /"GD-1"
   Peduncle straight. Panicle loose with erect branches,
elliptic, 27-31 cm long, 9-11 cm wide. Central rachis
fully extended. Glumes completely open. Grains almost
completely uncovered by glumes. Pedicelled spikelets
persistent.

(Type representative specimen: PGRC Acc. No. 70745)
SORGHUM DISEASES IN ETHIOPIA

Mengistu Hulluka

ABSTRACT

Major and minor disease assessments of sorghum have been undertaken mainly at ESIP (Ethiopian Sorghum Improvement Project) stations in Ethiopia i.e. Kobo, Nazareth, Arsi Negelie, Alemaya and Dakata.

Grain diseases, such as grain molds, smuts, and ergot were identified. Leaf diseases, mainly anthracnose, rust, Helminthosporium leaf blight, bacterial streak and downy mildews and leaf spots of various types were also commonly observed. Charcoal rot is the only stalk disease noted in this study. Among these diseases, the pathogens, Sphacelia sorghi McRae, Sclerospora sorghi Weston & Uppal, and Macrophomina phaseoli, causing diseases of ergot, downy mildew, and stalk rot, respectively, were not reported in earlier surveys probably because they are new introductions.

Introduction

Sorghum is one of the most important food crops in Ethiopia and is widely grown by peasants in the highland, lowland and semiarid regions of the country. About one million tones of sorghum grain produced on about 1.0 million ha, of which about 90% goes direct into human food and the rest into home-made beverages. Practically no sorghum grain is used as animal feed in Ethiopia.

In both groups, highland and lowland types, the range of genetic diversity is tremendous (2). In the country, the area growing improved and uniform varieties has been very small.

Despite its importance as food crop the overall national effort directed towards sorghum pathological work has been rather insignificant. Depending mainly on the environment, certain diseases are found to be economically important in some parts of the country.

The Ethiopian national program on sorghum improvement, though concentrating on breeding, considers sorghum diseases as one of the major criteria for selection. The large Ethiopian

Dean and Plant Pathologist, Alemaya College of Agriculture, Addis Ababa University, P.O. Box 138, Dire Dawa, Ethiopia.
sorghum germplasm holdings collected and maintained by the Ethiopian National Program have been evaluated for overall disease reaction.

The objective in this study was to assess the major diseases of sorghum and to determine their importance as potential problems in sorghum production.

Materials and Methods

Disease assessment covered mainly the five ESIP (Ethiopian Sorghum Improvement Project) sites, namely Kobo, Nazareth, Arsi Negelie, Alemaya and Dakata. The 5 stations represent different altitudinal zones as they are strategically located to get advantage of variabilities in climate. Kobo (North), Nazareth (Central), and Dakata (East), represent the lowland climatic conditions while Alemaya (East) and Arsi Negelie (Central) represent the highlands at differing altitudinal zones.

Table 1. The five stations of ESIP in which sorghum disease investigations were carried out.

<table>
<thead>
<tr>
<th>Location</th>
<th>Altitude (m)</th>
<th>Mean Annual Rainfall (mm)</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Kobo</td>
<td>1400</td>
<td>650</td>
<td>12°10'</td>
</tr>
<tr>
<td>2. Nazareth</td>
<td>1600</td>
<td>800</td>
<td>8°30'</td>
</tr>
<tr>
<td>3. Dakata</td>
<td>1550</td>
<td>700</td>
<td>9°10'</td>
</tr>
<tr>
<td>4. Alemaya</td>
<td>1980</td>
<td>870</td>
<td>9°30'</td>
</tr>
<tr>
<td>5. Arsi Negelie</td>
<td>1960</td>
<td>900</td>
<td>7°20'</td>
</tr>
</tbody>
</table>

Most studies were conducted in the months of August, September and October when crop maturity varied from heading to the soft dough stage of grain development.

Sorghum types at these stations were composed of many cultivars and breeding lines whose reaction to the various types of disease is as variable. The assessment of disease was carried out by recording the types of diseases prevalent in the area. In all cases, disease reaction was one of the factors for selecting promising lines and breeding stocks.
Specimen of infected plant material were taken to the laboratory for diagnostic work and confirmation for their authenticity was obtained from Common Wealth Mycological Institute.

Results and Discussion

Among the numerous sorghum diseases recorded in Ethiopia, a few alone are very important in limiting sorghum production. The important diseases in this category are grain mold, anthracnose, rust, leaf blight, bacterial streak, leaf spot, ergot, covered kernel smut, loose kernel smut, head smut, long smut, and downy mildew (Table 2).

Grain Diseases

Grain Molds

Sorghum grain filling and maturing under humid and rainy conditions were the ones normally infected with grain molds. Early maturing lines were generally affected by this disease. Though many types of fungi have been known to cause grain molds, the most common ones under the prevailing conditions were Phoma insidiosum spp., Stemphyllium spp., and Mycospharella spp. Curvularia spp., were rare. Other types of fungi have also been found on maturing grains. The most common ones were; Alternaria state of Pleospora infectoria Fuckal, Rhizopus stolonifer, Penicillium of the funiculsum - variable group, Fusarium moniliforme Sheld, Aspergillus niger group, Trichoderma koningii, Cunninghammella elegans Lendener, Helminthosporium spp., and Mucor spp. (7).

Grain molds have developed well at the two highland stations, Alemaya and Arsi Negelie.

Five of the genera identified in this study were similar to those isolated in India, Senegal, and Texas (4, 5, 9, 11). These are species of Alternaria, Fusarium, Penicillium, Aspergillus, and Rhizopus which have been reported to cause damage in stored products and reduce seed germination (3, 4, 5).

Sorghum Smuts

Smuts are prevalent in most of the sorghum growing regions and were particularly severe during high water stress condition. The extent of damage in grain crops varies ranging from traces to nearly 30%.

Generally four types of sorghum smuts have been confirmed in Ethiopia (8). Three of these, covered kernel smut (Sphacelotheca sorghi) clint, loose kernel smut (S. cruenta kuhn), and head smut (S. reiliana kuhn) are widely distributed. Altitude and climate
Table 2. Distribution of sorghum diseases in ESIP stations.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Kobo</th>
<th>Nazareth</th>
<th>Dakata</th>
<th>Alemaya</th>
<th>Arsi</th>
<th>Negelie</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain mold</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthracnose</td>
<td>x</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rust</td>
<td>x</td>
<td>x</td>
<td></td>
<td>xxx</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helminthosporium leaf blight</td>
<td>xxx</td>
<td>xxx</td>
<td>xx</td>
<td>x</td>
<td></td>
<td>xxx</td>
</tr>
<tr>
<td>Bacterial streak</td>
<td>xxx</td>
<td>xxx</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
</tr>
<tr>
<td>Ramulispora leaf spot</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Ergot</td>
<td></td>
<td>x</td>
<td></td>
<td>xxx</td>
<td></td>
<td>xxx</td>
</tr>
<tr>
<td>Covered kernel smut</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Loose kernel smut</td>
<td>xx</td>
<td>xx</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Head smut</td>
<td>xx</td>
<td>xx</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Long smut</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Downy mildew</td>
<td></td>
<td>xx</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

xxx high; xx intermediate; x low incidence
do not seem to be factors limiting the distribution of these three types of smuts. They were observed in both lowland and highland sorghum growing regions. Loose and covered kernel smuts were significant factors in reducing yield in some sorghum fields. Economically, however, head smut is probably more important on maize than on sorghum. This appears to be true particularly in many of the major maize producing areas of the Rift Valley. The fourth type of grain smut, long smut (Tolyposphorium ehrenbergii kuhn) is usually limited to lowland regions, mainly in Kobo and Dakata areas. In some areas of the country long smut has a wider distribution.

Ergot

Ergot or sugary disease (Sphacelia sorghi McRae) seems to be a relatively new disease in Ethiopia, as it was not reported by Stewart and Dagnatchew (10) in 1967. It was first recognized in 1972 in experimental plots at Alemaya. Since then ergot has been quite significant at the Arsi Negelie highland sorghum station and in some cases at Alemaya and Dakata. Infection seems to be initiated when rainfall period coincides with flowering sorghum. Late flowering types and ratoons are more commonly infected than early maturing types. There seems to be a good source of resistance against this disease in the breeding nursery. The Ethiopian Sorghum Improvement Project advances breeding lines at Arsi Negelie only if the heads are free of ergot.

Leaf Diseases

Numerous leaf diseases of sorghum have been identified at all stations and at the surrounding farms. In areas with high rainfall specially at Alemaya, Arsi Negelie and Dakata, anthracnose (Colletotrichium graminicola) has been the most common disease. The degree of infection varies with the type of sorghum. The ESIP has identified several resistant lines to this disease for incorporation in its breeding program. These lines are 15-2230, IS-158, Hafukagne x Hirna 305/547, NES-8827 and NES-8835 (8).

Leaf rust (Puccinia purpurea Cooke) was perhaps the second important sorghum disease. Observations through the past years indicate the sharp decrease is the distribution and extent of damage caused by this disease. The hyperparasite fungus (Eudarluca caricis) on Puccinia purpurea, which has been identified at Alemaya, may be a factor in the decrease of the distribution of this disease.

Leaf blight (Trichometasphaeria turcica (pass)) is also significant in several high rainfall areas. Of the Ethiopian sorghum experimental sites, Arsi Negelie and Alemaya have a much higher incidence of leaf diseases than the other areas. In 1976, the most prevalent disease at Arsi Negelie was the leaf blight. Some lines were completely wiped out by the
disease whereas some other lines showed variable degree of resistance.

On the other hand, bacterial streak (*Xanthomonas holcicola* (Elliot) Start & Burkholder) has been endemic in almost all regions from year to year and at all altitudes. Though its economic importance had not been assessed in Ethiopia, bacterial streak appears to be of minor importance. Under wet conditions, a high local incidence normally occurs at Arsi Negelie.

Another leaf disease gaining importance as of recent is downy mildew (*Sclerospora sorghi* Western & Uppal). The disease was first observed by the author in 1972 at Alemaya. Since then it had spread into Dakata and has been recently reported to be present in the western part of the country. Two types of symptoms were observed on plants attacked by sorghum downy mildew. At Alemaya infected seedlings were yellowed, stunted and had few white downy growth on the underside of the yellowed leaves. The other symptom that was observed in lowland sub-stations at Bisidimo and Dakata was large amounts of conidia and white downy growth on the foliage without signs of yellowing. Such plants remained stunted. Similar characteristic symptoms were also reported in Texas (1).

The other leaf diseases of sorghum are minimal in importance and sporadic in occurrence. These are leaf spot (*Ramulispora sorghicola* Harris), sooty stripe (*Ramulispora sorghi*) (Ellis and Everhart), bacterial leaf stripe (*Pseudomonas andropogoni* E.F. Smith), leaf spots caused by *Phoma sorghina*, *Mycosphaerella holci* Tehon, *Gleocercospora sorghi*, *Phyllosticta sorghiphila* Saccas, *P. sorghina* Sacc. and *Ascochyta* spp.

A virus disease has recently been detected at the Nazareth station though its identity has yet to be determined. Sugar cane mosaic virus or red stripe has been suspected.

Generally, leaf diseases are minimal on farmers fields as compared with experimental stations. The practice of removing sorghum leaves by some farmers for the purpose of usage as a fodder might have helped in reducing the source of inoculum for the subsequent cropping seasons.

**Stalk Diseases**

The major stalk disease so far observed in ESIP stations was charcoal rot (*Macrophomina phaseoli* (Maublance) Ashby). It is also a new disease, the incidence of which was first observed in 1977 at Asebot, a warm region, where it was severe and widespread. Since then the disease was also observed at Nazareth and Alemaya. At maturity, rotten stalks tend to break-over near the ground level with poorly developed heads. Drought or moisture
stress during maturity of the crop appears very conducive to the development of charcoal rot.

One ICRISAT line, RSI x VGCl, which looked excellent in several lowland Ethiopian locations, was very severely affected by the disease during the 1978 cropping season.

In this study it was possible to classify the major and minor diseases of sorghum. Some new diseases hitherto unreported in "Index of Plant diseases in Ethiopia", Stewart & Dagnatchew have been detected (10). There is a strong possibility that these might have been imported along with seeds from other countries. The recent occurrence of downy mildew, ergot, and charcoal rot might be enough to suspect new introductions of sorghum diseases. In farmers fields, generally diseases are sporadic in nature which could be attributed to variability of germplasm and other factors such as cultural practices. In Hararghe, for example, the practice of removing leaves after seed set may partially reduce the wide distribution of inoculum (6). Under this practice, very few plant residues are left on the ground at the end of the crop season.

Improved lines show various levels of resistance in the field. One could screen and select promising lines with good sources of resistance to many of the diseases listed earlier. Further detailed studies of each of the potentially dangerous diseases is highly desirable and advanced sorghum lines, by necessity, must pass through disease nurseries prior to their release for production.

Acknowledgement

This study was made possible by the support of the Ethiopian Sorghum Improvement Project, College of Agriculture, Addis Ababa University.

References


7. ________________. 1982. Fungi Recovered from seeds of sorghum (Sorghum bicolor L. Moench) and some studies on seed treatment. (unpublished).


Insect Pests of Sorghum in Ethiopia

Tessema Megenasa

Introduction

As it is true of most other crops produced under peasant holdings, the contribution of insect pest damage is reflected in the characteristically low output per unit area of sorghum production. Prior to the advent of the Ethiopian Sorghum Improvement Program, there was a kind of rough delineation of areas into those in which sorghum is part of a mixed cropping system and those in which it constitutes the principal staple food crop of the population. The intensity of its cultivation increased as one moved eastward on either side of the Rift Valley. Away from this valley we gain in altitude covering a span of from ca. 900 to 2500 meters above sea level. This variation in altitude has implications as regards temperature regularity and amount of rainfall all of which are linked to the species composition and intensity of pest damage to sorghum.

This crop is cultivated, by and large, on the basis of small holding which are subject to differences as regards date of planting, varieties, land management and amount and distribution of seasonal rainfall. As a result it is often difficult to ascertain whether a given low yield obtained is a consequence of pest damage, soil fertility, weather or a combined impact of all of these. It has been observed, Harris (1962), that any factor hindering normal development of a crop tends to intensify pest damage.

Research on sorghum and pest management have not progressed on equal footing in Africa. The latter has not only been unable to benefit from the rich genetic diversity of sorghum with respect to its relationship to pest biology, but also progress in the ecology of insect pests of sorghum in general has lagged behind the other advances made in the improvement of the crop. This disparity in the disciplines becomes even more glaring when sorghum pest management status in Africa is compared with those in North America and Asia.

As it has been pointed out earlier sorghum is produced predominantly under peasant system where the practice of pest management is either non-existent or, if any, has put a heavy emphasis on the use of insecticides. It has been observed that sorghum is attacked by only one or two key pests in each agroecosystem,

1 Director of Research and Entomologist, Debre Zeit Junior College of Agriculture and Research Centre, Addis Ababa University, P.O. Box 32, Debre Zeit, Ethiopia.
Young and Teetes (1977). In Ethiopia this crop is cultivated under a wide range of environments which incorporate low lands, middle highlands and highlands each of which constitutes one or two agro-ecosystems in each of which one or two insects hold key positions as pests of economic importance. The following are the more generally recognized forms:

1. **Stalk Borers**
   1.1. *Busseola fusca*

   The maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), the widely known sorghum and maize stalk borer is the single most notorious species of all borers attacking sorghum, maize and millet on the African continent, Jepson (1954). This insect is reported to be restricted to the Ethiopian region and is found in several sub-Saharan countries in eastern, southern and western parts of the continent, Tams and Bowden (1953) Schmutterer (1969), Jepson (1954). In Ethiopia it holds the number one position among pests of sorghum in the middle and highland areas of sorghum production. Despite such a broad range of distribution and importance, basic information on the biology, host relationship, role of natural enemies and physical factors is very limited. Perhaps it is the nature of the distribution of the insect, being strictly African, that is partly responsible for the scarcity of literature on this insect.

   Previous work on *B. fusca* dealt principally with its geographic distribution and chemical control efforts in peasant and/or plantation crops. Although the insect is generally reported to be the most destructive in the drier parts of the African Savanah, Tams and Bowden (1953), the possibility for the existence of types as regards altitude or temperature or tolerance to humidity cannot be ruled out. There are for instance differences in the reports with respect to the lower limit for *B. fusca*. Acland (1971) observed that this insect was seldom seen below 900 m in East Africa. Harris (1962) and Usua (1968) stated that high temperatures and low relative humidities are responsible for the absence of *B. fusca* below about 550 m altitude. On the other hand the occurrence of *B. fusca* is relatively rare below around 1200 m in Ethiopia. It usually phases out with *Chilo partellus* and *Sesamia calamistis* increasing as we drop to such an altitude. The severity of *B. fusca* often intensified during periods of relatively warmer temperature. In 1968 there was a one hundred percent destruction of the sorghum crop between Erer Valley and Babile in Harargie at which time there was a period of lull in rain fall and higher temperature during the rainy season (Tessema, unpub.). If one compared per unit area of crop damage at middle (1700 m) and highland (1800-2000 m) altitude one encounters a much higher level of destruction of sorghum at the lower altitude.
Following egg deposition, the larvae of *B. fusca* feed by scraping the leaf epidermis at which time the young instars are sedentary in habit. With the advancing development, the larvae migrate toward the leaf whorls from where entry into the shoots and eventually the stem is launched. The port of entry into the stalk, the larval frass and the ensuing injury are fairly diagnostic of *B. fusca* infestation. Few studies are available on the quantitative relationship between larval population or degree of injury and yield of sorghum. Blair and Read (1967), suggested, in maize, that the tunneling through the stem blocks the translocation of sap and mineral solutes, ultimately resulting in the loss of yield. It was observed, in Nigeria, that the development of a single larva of *B. fusca* in otherwise healthy stems reduced their yield capacity by 28% of the mean cob weight of a healthy stem, Harris (1962). Sevaine (1957) and Schmutterer (1962) attributed loss of yield, in maize, to the reduction in vigor of the young and older plants from larval feeding in the stems. We have observed that with the advancing maturity of sorghum the stalk borer moved both upward into the peduncle and downward into the base of the plant. This movement of the larvae into the base of the sorghum head, especially while development is still in progress, resulted in undersized head and a loss in gross weight, on average of 15%.

The larvae overseason in three different parts of the sorghum plant; the stub or the base which remains in the field, the main stem, and the base of the head or the peduncle. Harvested sorghum heads are stacked in a conical or cylindrical stacks either on the farm or close to a living quarter or a tukul. The stacked heads are covered with sorghum stalks which form a conical shell over the stacked heads. The whole thing is left in the field for varying lengths of time. Therefore it is not unusual to see fields in the whole region dotted with similar stacks for months. The stalks of sorghum play an important role in the economy of the peasant in that every crop residue is utilized not at one time but is conserved and gradually put to different uses over a period of months. Therefore the general recommendation that crop waste should be destroyed as a means of pest suppression is impractical.

To date two species of hymenopterous parasites of *B. fusca* and one unidentified tachinid fly have been recorded in addition to those observed by Harris (1962) in Nigeria, viz. *Tetrastichus atriclavus* Wtstn. and *Pediobius furvus* (Gah.). They are *Apanteles sesamiae* Cam. and *Procerochasmias nigromaculatus* (Ichneumoridae) Assefa (1981).

Among the few laternate host plants of importance recorded, maize, *Syperus* spp., *Typha* spp. sugar cane *Pennisetum purpureum* and wheat are reservoirs mainly due to the nature of their timing and distribution. The elephant grass, nut grass and the cat’s tail grow in abundance on the shores of the Rift Valley lakes and others while the sugar cane is grown in small plots in the backyards of peasant dwellings as an important cash crop. An infestation of the elephant grass reaching one hundred percent has been

Date of planting is often dictated by the onset of rainfall. The often repeated recommendation that sorghum should be planted early to escape borer injury becomes valid only in those instances when the rain comes when it is expected and its distribution is optimal. No two seasons in succession have been similar in terms of level of infestation of *B. fusca* in several areas of its distribution. Experiments designed on the basis of last year's experience fail to be carried out because of either delayed rainfall or insufficient infestation as a result of too much rain.

Experience with chemical insecticides to control *B. fusca* goes back many years in several countries of Africa Walker (1960) Schmutterer (1969) Duerdin (1953), Swaine (1957) Bohlen (1973). The principal difficulty, especially among peasants, has been the wrong timing of application. Sometimes an infestation affecting a whole region is reported so that costly resources are mobilized at a time when borer larvae are safely within the stalks of sorghum so that they are almost totally inaccessible to the chemicals. One recent study showed that good results are obtained when applications of carbaryl, endosulfan and DDT were made at between six and eight weeks after emergence of plants, Assefa (1981).

1.2. *Chilo partellus*

*Chilo partellus* (Swink) (Lepidoptera: pyralidae), the spotted stalk borer, occupies the lower warmer and drier areas of sorghum production. The area of overlap between *Chilo* and *Busseola* is rather narrow. An altitude of ca. 1700 m seems to be the upper limit for *Chilo partellus*. In parts of the Rift Valley within Hararge proper, *Chilo partellus* and *Sesamia calamistis*, the pink borer occupy the same territory. Infestation by *Chilo* is more regular from season to season compared with that of *Busseola*, because of the uncertainty of rainfall at the lower altitude where the former prevails. More 'dead heart' injuries are caused by *Chilo* than by *Busseola*. Such an injury is often confused with that caused by the sorghum shootfly, *Atherigona soccata* (Rond.), except that upon closer examination of lower portion of the stem a lesion caused by *Chilo* at the point of entry is more easily visible whereas an entrance caused by the shootfly is much smaller and not as easily seen. *Chilo* is the predominant species attacking sorghum in the Ogaden, in the eastern Rift Valley, the lower altitudes around Harar and Kobo Alamata area.

Total crop failure aggravated by rainfall scarcity is not unusual in the areas mentioned. However, data on the effects of *Chilo* on the yield of sorghum is lacking mainly due to the fact that the area of distribution of the insect is not accessible enough for frequent visits. It was demonstrated in East Africa that an infestation reaching 97% bored plants should occur for complete loss of yield, Ogwaro (1980).
Few attempts have been made locally to select resistant sorghum cultivars against Chilo. In one study the non acceptance of a cultivar was suggested as the mechanism involved in resistance to Chilo, Dabrowski et al (1980). Among varieties screened for resistance in East Africa, materials from Ethiopia were reported to have high tolerance both to Chilo and to drought.

1.3. Sesamia calamistis

*Sesamia calamistis* Hampson, (Lepidoptera: Noctuidae), the pink borer, is often confused with *Busseola fusca* during the larval stage. The distinction between the two borers is however more obvious in the adult stage. The adult Sesamia moth is smaller and consistently straw colored and has a prominent tuft of hair on the thorax when at rest. Schmutterer (1969) observed considerable variation in color in the various parts of its distribution. *Busseola fusca* moths are larger and somewhat metallic brown with no tufts of hair on the shoulder.

Sesamia is more or less restricted to the Rift Valley except as we go north into Eritrea and eastward into Somalia where it appears to be more generally distributed. The insect was first reported in 1973 in east central part of the Rift Valley around the Assebot plains (Tessema, unpub.). Crowe et al (1977) reported collecting specimens of the insect further south in Sidamo within the same valley. Two other species, *Sesamia cretica* and *Sesamia epunctifera* a major pest of sorghum and wheat, respectively, have been reported from Eritrea by Crow et al (1977).

Sorghum is the major host of *S. calamistis*. It inflicts heavy damage during seasons when rainfall is poor. Since both Chilo and Sesamia form mixed populations in any one area of their common distribution, at times the two infesting the same plant, it is usually difficult to tell which species is more responsible for an observed loss in yield of the crop. However in Assebot plain where both species are seen together, Chilo is numerically dominant to Sesamia roughly three to one. The numerical difference seems to be offset somewhat by the larger size of Sesamia.

All three stalk borers have similar biologies in so far as their overseasoning habits are concerned. With the decline in rainfall during the months of September and October, there is also a change in the host plant tissue. The larvae stage of the second or third generation go into a kind of facultative diapause within the stem, the stubble left in the field or the part of the stem at the base of the sorghum head.

A control recommendation common to all borers is that any crop residue which serves as a reservoir for future infestation should be destroyed either by burning or plowing under to ensure the destruction of the insect, de Pury (1968), Doggett (1970) Hill (1975). The situation in rural Ethiopia is such that no peasant could afford to destroy any part of the so-called crop
residue. The stems, as pointed out earlier, are stacked and left standing for beyond the time of adult insect emergence from dis-pause. These crop residues are conserved for fuel, home or fence construction.

2. Sorghum Shoot Fly

The presence of the sorghum shoot fly, Atherigona soccata (Rond.) (Diptera: Muscidae), on sorghum in Ethiopia was first identified by Professor Bunting from Reading University while on a tour of sorghum field plots in Alemaya around 1972. He observed the excessive tillering in sorghum seedlings in response to the insect's attack. The insect is endemic at a low population level in indigenous sorghum. Farmers knew the insect, but understood it to be an immature form of the stalk borer. Traditionally seedlings and tillers with 'dead heart' symptoms are rogued and fed to cattle. The importance of the shoot fly is generally recognized on research materials in experimental plots.

The population of the insect grows steadily beginning with the onset of the early rains. Minimal damage is experienced in early planted material so that sorghum planted in May suffered maximum 'dead heart' injury compared to that planted in March and April. Peak population of the shoot fly was observed in August in Alemaya, Teodros (1982). However the infestation level fluctuated from season to season.

An infestation may not necessarily result in 'dead heart'. Quite often a scar is left at the tip of the shoot which has recovered from an injury by a larva which has, for some reason, failed to establish itself. The number of eggs oviposited usually exceeds the number of larvae entering the shoot. Mortality is said to be high in the first instar larvae. This, as reported in East Africa, Delobel (1980), is due to the result of competition for the available sorghum stems during high population of the shootfly. Two most important mortality factors are competition (density-dependent) among first instar larvae and heavy rainfall (density-independent), Delobel (1980). The percentage of larvae pupating in the soil is said to increase with increasing humidity.

Insecticides, Carbofuran, Disulfoton and Aldicarb were applied in granular forms for three seasons on experimental plots as post-emergence treatments. The rates chosen were one and a half kg a.i. per hectare for Carbofuran and Disulfoton and one kg per hectare of Aldicarb per hectare. The last insecticide gave the lowest count of 'dead heart' injuries. The insecticide Phorate applied once at 2 kg per hectare apparently stimulated the growth of sorghum far in excess of a response expected from shootfly control.
3. **African Bollworm**
   Heliothis armigera (Lepidoptera: Noctuidae), the African bollworm, has a wide range of host plants. It has two peaks in population during the growing season under Alemaya condition. Early in the season heavy infestation of the leaves is observed. This usually takes place following a prolonged early rains. Damage to leaves is sustained, normally, without the use of insecticides. The second peak in population occurs from the time of blooming of sorghum heads, compact headed varieties are favored. In addition to feeding an accumulation of larval frass within the tight panicles leads to rotting by fungi and an almost total damage of the grain. This situation is frequently seen in Arsi Negelie which is close to the several state farms in which alternate host plants of the insect are cultivated in abundance.

4. **Sorghum Head Lygus**
   Taylorilygus vosseleri (Poppius) (Heteroptera: Miridae), the sorghum head lygus, is generally a pest of cotton, though not an important one as such locally. The adult bug is about 4 mm long, brown with greenish tinge and with the hind part of the wings bent sharply down over the end of the abdomen, Hill (1975).

   The eggs are very small and are inserted into the plant tissue. The insect is generally a pest of cotton, though not an important one as such locally. The adult bug is about 4 mm long, brown with greenish tinge and with the hind part of the wings bent sharply down over the end of the abdomen, Hill (1975).

   The eggs are very small and are inserted into the plant tissue. All the stages feed together on the same parts of the plant. The insect is found on a wide range of host plants in small numbers during the dry season. An infestation starts on the leaves of sorghum though damage at this stage is insignificant. The population builds up with the ripening of the head of sorghum. The nymphs and the adults feed on the milk of the grain by piercing with their sharp pointed mouth parts. The effect produced is failure of the grain to fill properly. An infestation continues until the grain is dry and no longer possible for the insect to pierce the hard surface. When infested sorghum heads are disturbed, hundreds of individuals either fly away or fall to the ground. Harvested grain from the bug infested heads can be identified by small necrotic stippling of the surface. The insect has at times badly damaged sorghum heads in experimental plots in low altitude areas like in Dakata area.

   Since T. vosseleri is generally regarded as a minor pest, few studies on the biology of the insect have been conducted. The insect is frequently attacked by a small predator probably Orius sp. which is found in fair number within the lygus infested head of sorghum.

5. **Cetoniid Bettles**
   Cetoniid beetles (Coleoptera: Scarabacidae). Interest in this insect was prompted following heavy infestation of indigenous tall sorghum during the months of September and October in the dry low altitude areas between Nazareth and Metahara. During bad outbreaks whole fields are completely destroyed, the adult beetles eating out
the contents of the grain in the milky stage, Clark and Crowe (undated). The species Pachnoda interrupta (Olivier) is also reported to attack pearl millet heads, and maize cobs, in the latter case first removing the silk and the chewing out the contents of the distal kernels.

Little or nothing is known about the life history of most African Cetoniids. The eggs are laid in a variety of places. Depending on the species they may be found in rotting wood, forest litter, ants nests, cow dung, compost heaps or in the soil which also constitute the substrate for larval development. The contrasting habits of the larvae and adults of the species of Pachnoda give rise to difficulties in the planning of their control, Clark and Crowe (undated). This particular area where repeated infestations of sorghum have been observed happens to be part of the region where large populations of cattle are found. Perhaps an abundant supply of manure could provide an opportunity for the observed build up of the beetle.

In the absence of adequate knowledge of the biology of the insect, methods used by the peasants are crude and ineffective. At times the heads of sorghum harboring the adult beetles are shaken into a bowl or bucket of water and then the insects destroyed. On a large acreage this method is obviously out of the question. Clark and Crowe (undated) recommend six different methods each with its own limitations. These consist of using dwarf varieties of sorghum, because P. internepta has been observed to prefer sorghum which is in the range of three to four meters in height. The fact that this is clearly unacceptable to the farmer makes it impractical as a recommendation. The rest comprise hand collection, use of screens if the value of a variety warrants it, planting diversionary crops with bright yellow flowers such as sunflower, non-living attractants and chemical control.

6. Aphids

6.1. Maize Aphid

Sorghum is one of the favored host plants of the maize aphid, Raopalosiphium maidis (Homoptera: Aphididae). The insect feeds upon a broad range of species in the gramineae which include Hordeum sp., Avena sp., Cynodon dactylon, Saccharum officinarum, Sorghum halepense, Snowdenia sp. Septoria sp., Digitaria sp. and others.

The aphid attacks sorghum, mainly the young leaves and the developing head, schmutterer (1969). In Ethiopia it is the most widely recognized species as the maize aphid. Species infesting other crops are quiet often erroneously referred to as the maize aphid. The insect has a high tolerance for moisture and is the predominant aphid during the rainy season even though it is not necessarily destructive during periods of rainfall. High population of the insect is observed during furing the dry interval between the short and the long rainy seasons.
The aphid is preyed upon by a large number of coccinellid predators of which Adonia variegata and Chilomenes lunata are very important. Parasites Aphidius setiger and Aphidius hortensis kill off a good number of the aphid, Adugna (1982).

6.2. Sorghum Aphid

Longuiguis sachari (Zhnt.), the sorghum aphid, is a sporadic pest which is more of a nuisance due to its heavy exudate of honeydew mainly on the leaves and stems of ripe sorghum late in the season. The aphid overseason on volunteer plants and ratoons of sorghum. Its presence is detected by a heavy population of attending ants which are attracted to the honeydew. The difference between the maize aphid and the sorghum aphid is that the latter is pale yellowish in color and is predominant largely during dry periods. The population of the insect builds up to a large number on infested plants but the uneven distribution of such an infestation and the unusually localized attack makes chemical control measures unnecessary. The insect is also partially checked by syphid flies and coccinellid beetles.

7. Sorghum Midge

The sorghum Midge, Contarinia sorghicola (Coquillett) (Diptera: Cecidomyidae), is minor pest of sorghum within Ethiopia proper. It was first reported, Anon (1967) from a survey of Setit Humera area. Part of the reason for the minor status of the pest in some localities could be due to the fact that the insect could easily escape detection. Chiaromonte (1933) declared it absent in his survey of the fauna of Ethiopia and Somalia.

8. Maize Weevil

The maize weevil, Sitophilus spp. (Coleoptera: Curculionidae), is one of the most important enemies of the farmer. The degree of damage to stored sorghum depends upon three factors, altitude (temperature), the type of storage structure used, and the length of storage period, McFarlane (1968). It has been found that the maximum damage levels reached in one year's storage vary from about 10% at 2500 m to about 70% at 1700 m. It should, however, be remembered that the majority of the farmers do not store their sorghum for more than six or seven months. Those farmers who do store their supply for more extended periods are those who are able to take advantage of improved, often reasonably airtight, underground silos and the relatively cooler temperatures of the higher altitudes.

The eggs of the weevil which are white and oval in shape are laid inside the grain into which the insect gains access by chewing a small hole. The entrance is plugged with a secretion from the female. The eggs hatch into tiny grubs which live and feed inside the grain and are said to be responsible for most of the damage. It is also quite common to see the adult insect occupying the cavity inside the grain of sorghum. Pupation of the larvae takes
place inside the grain from which the adult beetle emerges by
eating a circular hole through the cut layers of the grain,
Hill (1975).

Infestation starts at several possible sites. The weevil
makes its appearances late in the season on the leaves of sorghum
in the field. Whether it is the beginning of attractive stage of
the plant needs to be studied. With the formation of seed set and
the ensuing maturity the number of the weevils gradually builds up
to an infestation. Sorghum heads are often kept for a lengthy
period near threshing grounds from which there is a possibility
for cross infestation between last year's residues and this year's
harvest. The third source of infestation which is perhaps the
most important is from the carry over grain from last year's
harvest in infested bins or silos. As this grain is quite often
the source of seed for the succeeding season, the often observed
poor stand of sorghum plants in the farmers' fields could very
well be due to the poor germination resulting from weevil infest-
at ion.

References


borer Busseola fusca (Fuller in Ethiopia (M.Sc. thesis,
Addis Ababa Univ.)

the sex pheromone of male stalk borer, Busseola fusca (Fuller).

5. Chiaromonte, A. 1933. Aspetti entomologica della cultura...

6. __________, 1933 . Considerazioni entomologiche sulla

annotated list of insect pests of field crops in Ethiopia

8. Clark, R.O.O.S. and T.J. Crowe (undated). The genus Pachnoda
in Ethiopia, identification, pest status and control of the


17. Ogwar, K. 1980. Intensity levels and the effect on yield of stem borers in maize and sorghum under different intercropping patterns. In International Center of Insect Physiology and Ecology eight annual report.


ABSTRACT

Three species of Striga are present in Ethiopia of which Striga hermonthica (Del.) Benth is present in Eritrea, Gojam, Gondar, Harargie, Shoa, Tigray and Wollo Administrative Regions, S. asiatica (L.) Kuntze is found in Harargie and S. latercea Vatke has been detected in Shoa. The most wide spread and damaging species of these in Ethiopia is S. hermonthica.

Introduction

Belonging to the family Scrophulariaceae Striga is a semi-parasitic weed which causes very serious crop losses in several African countries as well as some parts of Asia, America and Australia. This genus is known to parasitize over 60 different species of the graminae family and some dicotyledons such as Arachis hypogea, Desmonium diffusum, Euphorbia abyssinica, Glycine max, Sudigofera spp., Ipomoea spp. and Nicotiana tabacum (Ivans, 1971). The presence of Striga has been recorded in Africa, Asia and Australia as early as 1790.

The most important species of this genus are:
2. S. hermonthica (Del.) Benth. in Africa.
3. S. densiflora Benth. in Asia particularly in India.
5. S. euphrasioides Benth. in Asia (India and Burma).

Symptoms of Striga attack include stunting, wilting, chlorosis, and in extreme cases a total collapse and death of the attacked crop follows. One single Striga plant could produce as much as 500,000 viable microscopic seeds which are easily dispersed by wind water and various agencies. One single Striga seed has an average length of 0.31 mm and 0.16 mm diameter weighing only 0.0045 mg. The Striga seed could germinate only in the presence of stimulating fluid.
produced by the host plant (Teferedeign, 1973 and 1978). It is also believed that the Striga seed could remain viable in soil for ca 20 years.

**Distribution and Surveys**

The occurrence in Ethiopia of purple witchweed (*Striga hermonthica* (Del.) Benth.), known as Akanchira, Atkur, Kitgn, Buda in Amharic and Mestselem in Tigrigna, Diesso, Mender Bukis in Oromogna was reported by C. Parker for the first time (Parker, 1970). It was found in the major sorghum growing regions of Northern Ethiopia including Eritrea, Tigray, Wollo, Gondar and Gojam. Its distribution and severity in Ethiopia varied being severe in some districts notably around Axum, Setit Humera and near Kobo but completely absent from other large sorghum growing areas of the country such as Harargie Administrative Region in the East, areas along the Awash River, the Southern rift valley and South Western Administrative Regions.

Following the report of the presence of witchweed in Ethiopia in 1969, surveys were initiated promptly by the Institute of Agricultural Research (IAR) to determine the extent and intensity of infestations and to provide information for the full assessment of the importance of this weed to Ethiopian Agriculture.

Surveys conducted by the IAR during the period of 1970-80 indicated that *S. hermonthica* succeeded in infesting the whole stretch of sorghum country from Kobo to Cheffa of Wollo administrative region as well as all of the central and northern lowlands of Shoa. Minor infestation of *S. hermonthica* was observed in areas around Birr valley of Gojam on maize fields and fallow land in which the host plants were unidentified grasses along with Sorghum *halapense*. Large acreage of land is abandoned in the Setit Humera area due to the severe infestation of *S. hermonthica* on sorghum.

Continued extensive surveys conducted in 1982 confirmed the spread of *S. hermonthica* to the Eastern part of Ethiopia, namely the highlands of Harargie. The occurrence of *S. asiatica* (L) Kuntze in Ethiopia for the first time on sorghum and maize in Habro Awraja from Garadema (approx. 18 km SE of Gelemso) to Belbeliti and South-wards upto Mechara has been confirmed in the 1982 IAR survey. Infestation of both *S. hermonthica* and *S. asiatica* was also reported on areas around Melkaye (RRC Site) approx. 50 km SE of Mechara (personal communication with ADD agent). Apart from minor infestation of *S. latercea* Vatke on sugar cane at the Methara Sugar Estate, which was recorded in 1977, no other major problem of Striga was encountered in the 1982 Striga survey to Eastern Ethiopia. The distribution of *Striga* in Ethiopia is shown in Fig.1.

Within the infested areas, the severity of Striga attack varies from field to field and this could be attributed particularly to differences in sowing date, since early sown fields tend to be more seriously affected. The sowing date effect is
Fig. 1 Distribution of Striga in Ethiopia.

- Striga hermonthica
- Striga asiatica
- Striga latercea
presumably due to temperature and soil moisture which in turn are probably responsible for the large scale uneven and patchy infestation of Striga.

In areas where Striga infestation occurred, its seriousness was recognized by farmers and there was keen interest in its control, but without success particularly in the Setit Humera area. Yield losses due to Striga can only by guessed and often are serious but the most severe infestations can cause up to complete crop failure. Removal of Striga plants soon after emergence before they flower is known to be beneficial not only to the host crop, but also as means of preventing further buildup of Striga seed in the soil. However, even the most conscientious hand-pulling cannot prevent some detrimental effect of the parasite. In most areas, although farmers are aware of the damaging effect of Striga, they make little or no effort to hand-pull the parasite to prevent it from seeding. Farmers often claim that they are "too busy" during the crop season to do the Striga weeding. Since this is seldom a very convincing explanation, more effort should be put into exploring ways of persuading farmers to accept this practice.

Striga Research Activities

A laboratory and field research program on screening of sorghum varieties for Striga resistance was initiated in 1978. This project has been handled jointly by IAR and ESIP. The field testing for Striga resistance has been conducted at Kobo. Lines which have been evaluated for Striga resistance in the field at Kobo since 1978 number in thousands. In conjunction with field evaluation, a Striga laboratory has been established at Addis Ababa University for estimating strigol production in screening sorghum lines for Striga resistance. This technique was developed at Weed Research Organization (WRO) (Johnson et al. 1976, Chancellor et al. 1971) Oxford and is very simple for screening large number of lines of sorghum. The technique in brief consists of:

1. Growing sorghum seedlings in ice-cream cup in sand-culture in the green-house for one week and then extracting the root exudate (Strigol).

2. Pre-treating Striga seeds on moist filter-paper at 25°C for 10-14 days to break dormancy, and

3. Germinating pre-treated Striga seeds with strigol at 33°C for 24 hours and counting % Striga seed germination.

The Striga laboratory is now well established and fully operational and has evaluated several hundred sorghum lines for strigol production. The main objectives of the joint field and laboratory screening are:
a) to develop a reliable and fast screening technique for identifying Striga resistant and/or tolerant sorghum lines.

b) to see if there is any correlation between the level of strigol production of sorghum lines tested in the laboratory and field reaction to Striga of the same lines.

In reference to the second objective, a laboratory and field trials of 120 sorghum lines were taken and a correlation analysis was run. The correlation between strigol production in the laboratory and field resistance of the same lines was only \( r = 0.02 \) and was not significant, indicating very little relationship between strigol production and field evaluation for Striga resistance. This finding is in agreement with results generally obtained by other workers elsewhere.

With respect to agronomically elite Striga resistant sorghums, based on field evaluation, N-13 (an Indian variety) has been identified as Striga resistant and/or tolerant for Kobo area. N-13 has also been found to be Striga resistant under West African and Indian conditions. N-13 was evaluated at Kobo for the last three years and has consistently shown to be resistant. In the 1981 crop season, based on 100 m² plot size, the grain yield potential of this variety was about 25 q/ha. It is worth mentioning at this point that this variety is also remarkably drought tolerant under Kobo conditions. Because of these desirable characters and the supporting results obtained elsewhere, ESIP is now in the process of multiplying the seed of this variety and will be recommended for release (ESIP, 1982).

Conclusion

Control method for this important parasitic weed is still generally inadequate. The known cultural methods are often impractical or difficult to put into practice in particular where the problems are serious. Therefore, it will be important in the future to study further the various aspects of cultural practices in our efforts to combat this devastating weed. Striga resistant varieties are already attracting much attention in countries dealing with similar problems. The long-term value of this approach has already been proven by the use of Orobanche resistant varieties such as sunflowers in the USSR (Pustovoit, 1967). Probably after 20-30 years more virulent strains could be built-up to overcome resistance. Whether equal success will be maintained with Striga remains to be seen, but the chances of success will depend on the development of new techniques for studying mechanisms of resistance and the host specificity of different strains of the parasite as fully as possible. The possibilities for chemical and biological control are still far from fully exploited and need further investigation to explore ways and means of making more use of them.
There will be little scope for improvement in Weed Science if the great majority of farmers, farm managers, agricultural scientists and decision makers feel that weeds are no problems for Ethiopia's agricultural development.

References


NUTRITIONAL AND CONSUMER PREFERENCE
ASPECTS OF SORGHUM

Belainesh Gebre-Hiwot

Introduction

Consumer preference is very important for any food grain to be accepted. Therefore, information on food quality of the different varieties of sorghum should be available for a successful adoption of cultivars by farmers. The food quality of a grain is assessed by the extent to which it can easily be preserved, processed, and prepared into known and best liked foods of the region concerned. In addition, the nutritional quality of the grain in terms of its contribution towards solving known nutritional shortcomings of the area is another important food quality aspect.

In Ethiopia, one of the nutritional problems is that energy intakes of the population falls below minimum requirements particularly during the two to three months before harvest. Except among ensete (Ensete ventricossum) and root crops eating areas, the protein intake reasonably meets the requirements. Vitamin A and Vitamin C deficiencies exist and Protein Energy Malnutrition (PEM) is highly prevalent among children. Baseline studies done by the Ethiopian Nutrition Institute (ENI) show that average calorie intake for the year fall 15-20% below recommended values for a large portion of the population (Selinus et al, 1971). The calorie intake was as low as 55% during the two to three months before harvest in some areas (Selinus et al, 1971). Recent studies conducted in the month of June in 44 market dependent urban areas also show that the mean calorie intake was only 67.14% of the FAO/WHO recommend values whereas protein intake was well above the recommended levels (ENI, 1980).

Thus the assessment of food quality of a cereal in Ethiopia has to take into account such identified nutritional problems.

Sorghum Utilization Studies in Ethiopia

Sorghum is the third major food crop in Ethiopia. Improvements in production, storage, and utilization can contribute towards filling the energy gap.

The Sorghum Utilization Project in Ethiopia was undertaken with the overall objective of encouraging increased utilization of sorghum in familiar and widely consumed foods. The project is

---

1Head of Nutrition Division, Ethiopian Nutrition Institute, P.O. Box 5654, Addis Ababa, Ethiopia.
partly financed by the International Development Research Centre (IDRC), Canada. Four major activities are undertaken in this project.

1. The utilization of sorghum composite flours in the local bread (injera), and bakery bread to lessen the strain on relatively scarce cereals such as teff (*Fragrostitis tef*) and wheat, particularly in urban areas.

2. Formulating the supplementary food FAFFA from sorghum to be distributed in sorghum producing areas.

3. Testing the acceptability of mechanically dehulled sorghum among sorghum eating population groups so that appropriate mechanical devices can be introduced into villages to ease the burden of works of the housewife.

4. Screening sorghum varieties for injera baking qualities which is the main food product made from sorghum in different households.

At the end of the project it is anticipated that:

1. Sorghum composite flours will be used in commercial injera and bakery bread. This wider utilization of sorghum in popular foods in urban areas will lessen the strain on the demand for teff for which periodical shortages are experienced. It will also save foreign exchange by reducing wheat imports. It is, in addition, hoped that a wider utilization of sorghum will further stimulate increased production of the crop.

2. The supplementary food Faffa will be formulated from sorghum to be distributed in sorghum producing areas. This will also lessen the demand for wheat and at the same time provide more children with high quality supplementary food.

3. The acceptability of mechanically dehulled sorghum flours by urban and rural consumers will be determined which in turn will provide information as to where such devices would be more useful.

4. Information on the food quality of the different cultivars of sorghum will be made available to breeders.

**Food Quality Trials**

Sorghum was tried out for its injera baking qualities as a large portion of the sorghum produced in Ethiopia is consumed in this form. Sorghum composite flour bread was also tried out and the supplementary food Faffa was formulated from sorghum.
1. Trials on Injera

The injera trials were made on one popular local variety ("Yemifeka Mashilla") and 6 varieties of sorghum obtained from the Ethiopian Sorghum Improvement Project (ESIP). All varieties were dehulled at 80% extraction rate using PRL RIIIC dehuller at Nazareth. The six varieties obtained from the ESIP were N-13, AL-70, MWS-5020, ETS-4946, ETS-3235 and Dobbs. Injera was prepared using 100% of the test samples (sorghum) as well as using the test samples in mixture with teff at 50% (composite flour).

Results showed:

(i) "Yemifeka Mashilla", N-13 and AL-70 gave acceptable injera on the first day of baking when 100% sorghum was used. The texture of the injeras deteriorated on the second day.

(ii) The varieties ETS-4946, ETS-3235, MWS-5020 and Dobbs did not give acceptable injera when 100% sorghum was used. Particularly the last two varieties were found unsuitable for injera preparation as the quality of their injeras were very poor and unacceptable by the consumer.

(iii) Acceptable injera could be prepared from all 7 varieties when composite flour (sorghum and teff) was used at 50%.

(iv) Additional trials were conducted to reduce the quantity of teff in the composite flour. The local variety "Ymeifeka Mashilla" dehulled at 80% extraction was used. Taste panel results showed that the addition of 25% teff to the sorghum flour improved the storing quality of the injera (Table 1).

Table 1. Acceptability of injera from a local sorghum variety¹ with varying quantities of teff added.

<table>
<thead>
<tr>
<th>Mixtures Used</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Appearance</td>
<td>Texture</td>
<td>Taste</td>
</tr>
<tr>
<td>Sorghum 100%</td>
<td>3.1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Sorghum 75%</td>
<td>4.0</td>
<td>4.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Teff 25%</td>
<td>4.8</td>
<td>4.8</td>
<td>4.6</td>
</tr>
<tr>
<td>Sorghum 50%</td>
<td>4.8</td>
<td>4.8</td>
<td>4.6</td>
</tr>
</tbody>
</table>

¹Local variety used was "Yemifeka Mashilla" bought from Addis Ababa Market. Scoring used: 5 excellent, <2.5 unacceptable, 1=poor.
2. Trials on Faffa

Six different varieties of sorghum which can easily be found in the market (Appendix II) were selected and used to formulate the supplementary food Faffa. These varieties were dehulled at different extraction rates and used to make 15 different formulations of Faffa. Some formulations had defatted soy flour and dry skim milk added in varying amounts while others were made without both imported ingredients. The formulations were tested for acceptability before they were sent for protein quality assessment to Uppsala University in Sweden.

The currently marketed Faffa made from wheat flour was used as a control. All sorghum Faffa formulations were found acceptable. Except for the red sorghum variety, all the other varieties used had scores similar to the control when used in some formulations (Table 2).

Table 2. Overall Acceptability Scores of Sorghum Faffa.

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Sorghum Variety Used</th>
<th>Extraction Rate (%)</th>
<th>Acceptability Scores*</th>
</tr>
</thead>
<tbody>
<tr>
<td>FI</td>
<td>Jiru</td>
<td>83</td>
<td>3.4</td>
</tr>
<tr>
<td>FI</td>
<td>Cherekit</td>
<td>85</td>
<td>3.3</td>
</tr>
<tr>
<td>FI</td>
<td>Gambella</td>
<td>85</td>
<td>3.2</td>
</tr>
<tr>
<td>FII</td>
<td>Jiru</td>
<td>83</td>
<td>3.4</td>
</tr>
<tr>
<td>FII</td>
<td>Gambella</td>
<td>83</td>
<td>3.9</td>
</tr>
<tr>
<td>FIII</td>
<td>Yemifeka Mashilla</td>
<td>82</td>
<td>4.4</td>
</tr>
<tr>
<td>FIII</td>
<td>Bicha</td>
<td>77</td>
<td>4.4</td>
</tr>
<tr>
<td>FIII</td>
<td>Jiru</td>
<td>83</td>
<td>4.2</td>
</tr>
<tr>
<td>FIII</td>
<td>Cherekit</td>
<td>85</td>
<td>4.1</td>
</tr>
<tr>
<td>FIII</td>
<td>Gambella</td>
<td>83</td>
<td>4.0</td>
</tr>
<tr>
<td>FIII</td>
<td>Zengada (red)</td>
<td>57</td>
<td>3.6</td>
</tr>
<tr>
<td>FIV</td>
<td>Gambella</td>
<td>83</td>
<td>3.3</td>
</tr>
<tr>
<td>FV</td>
<td>Gambella</td>
<td>83</td>
<td>4.0</td>
</tr>
<tr>
<td>FVI</td>
<td>Gambella</td>
<td>83</td>
<td>4.0</td>
</tr>
<tr>
<td>FVII</td>
<td>Gambella</td>
<td>83</td>
<td>3.0</td>
</tr>
<tr>
<td>Wheat Faffa (Control)</td>
<td>-</td>
<td>--</td>
<td>4.6</td>
</tr>
</tbody>
</table>

3. Composite Flour Bread

Trials on composite flour breads are also underway. So far 10% sorghum has successfully been added to wheat for bread baking. However, further trials are needed using hard wheat in order to incorporate 20% sorghum without seriously altering the quality of bread.

*Scoring used: 5=Excellent, 2.5 Unacceptable, 1=poor.
Nutritional Aspects

Sorghum flour contains 7-8% protein and lysine is known to be the limiting amino-acid (Agren and Gibson, 1968). The local bread made from sorghum (injera) is customarily eaten together with a sauce usually made from legumes. Thus in traditional use the amino-acid pattern is corrected by the use of legumes or other protein rich food. However, a better lysine content in sorghum would have a sparing effect on the quantities of legumes or other protein rich food to be used with it. No assessment of the food quality of the high lysine varieties have been made so far at the ENI. Trials will be made on this variety but it is anticipated that the dented seed and the softness of the endosperm will present processing problems.

The problem of digestibility of sorghum particularly for young children has been pointed out in earlier studies (Maclean et al, 1981). However findings of studies undertaken indicate that digestibility of sorghum is improved when the grain is dehulled. A supplementary food formulated from sorghum was sent to Uppsala University for assessment of protein quality. The sorghum was dehulled to 80% extraction before it was mixed with protein supplements, vitamins and minerals. (See Appendix I for Mixtures Used). Results showed that the digestibility of sorghum based Faffa was found to be high and the protein quality of sorghum Faffa was not significantly different from that of wheat based Faffa (Table 3). Further evaluation of the 15 sorghum samples will provide additional information on the quality of sorghum formulations for preschool children.

Table 3. Digestibility and protein utilization comparisons of wheat and sorghum Faffa.

<table>
<thead>
<tr>
<th>Sample</th>
<th>True Digestibility</th>
<th>Net Protein Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat Faffa</td>
<td>89.3</td>
<td>71.9</td>
</tr>
<tr>
<td>Sorghum Faffa</td>
<td>91.4</td>
<td>70.8</td>
</tr>
<tr>
<td>Casein</td>
<td>98.2</td>
<td>87.2</td>
</tr>
</tbody>
</table>

Conclusions

Sorghum is an important food crop in Ethiopia. All of the sorghum that is produced is consumed at the home level mostly in the form of injera. Sorghum is dehulled by most households before it is prepared into injera. The dehulling is done by hand using laborious and time consuming methods and equipment,
perhaps one of the factors discouraging urban consumers from preparing sorghum injera. Sorghum is, however, considered second only to teff as the best cereal for making injera.

The use of sorghum in highly populated cities is somewhat limited. Teff and wheat products are used in such cities and shortages of these cereals are periodically experience. So far no commercially prepared food products are made from sorghum.

However, sorghum is well adapted to a wide range of ecological conditions. Much work has already been done on sorghum breeding. Equivalent work needs to be done in assessing food quality to encourage adoption of new and promising cultivars. If consumer acceptable and high yielding varieties are successfully adopted, the increased production of grain will contribute towards solving the energy deficiency problem. The reduction of storage loses is also an area that needs attention. Studies to use sorghum in popular and widely consumed foods show encouraging results. Simple and time saving dehulling devices will also contribute to the acceptability of sorghum as the convenience and the taste acceptability of sorghum food products are improved with dehulling.

References

1. Agren, G., and Gibson, R. 1968. Food Composition Table For Use in Ethiopia. SIDA.


APPENDIX I

Faffa Formulations for which True Digestibility (TD) and Net Protein Utilization (NPU) were determined.

1. Wheat Based Faffa

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat flour</td>
<td>450</td>
</tr>
<tr>
<td>Chickpeas flour</td>
<td>195</td>
</tr>
<tr>
<td>Dry skim milk</td>
<td>37.5</td>
</tr>
<tr>
<td>Sugar</td>
<td>60</td>
</tr>
<tr>
<td>Iron</td>
<td>0.075</td>
</tr>
<tr>
<td>Iodized salt</td>
<td>7.51</td>
</tr>
<tr>
<td>Calcium D. Pantothenate</td>
<td>3.0</td>
</tr>
<tr>
<td>Vitamin Premix</td>
<td>1.2</td>
</tr>
</tbody>
</table>

2. Sorghum Based Faffa

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum (Gambella variety)*</td>
<td>450</td>
</tr>
<tr>
<td>Chickpeas</td>
<td>195</td>
</tr>
<tr>
<td>Dry skim milk</td>
<td>37.5</td>
</tr>
<tr>
<td>Sugar</td>
<td>60</td>
</tr>
<tr>
<td>Iron</td>
<td>0.075</td>
</tr>
<tr>
<td>Iodized salt</td>
<td>7.51</td>
</tr>
<tr>
<td>Calcium D. Pantothenate</td>
<td>3.0</td>
</tr>
<tr>
<td>Vitamin Premix</td>
<td>1.2</td>
</tr>
</tbody>
</table>

*Sorghum dehulled to 80% extraction.
APPENDIX II

Market Prices of Sorghum, Teff and Wheat in Addis Ababa for the years 1977–1982

Price in Birr for 100 kg of Grain

<table>
<thead>
<tr>
<th>Year</th>
<th>Sorghum</th>
<th>Teff</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>White</td>
<td>Sergenya</td>
<td>Yellow</td>
</tr>
<tr>
<td>1977</td>
<td>67</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>1978</td>
<td>80</td>
<td>80</td>
<td>--</td>
</tr>
<tr>
<td>1979</td>
<td>73.5</td>
<td>61</td>
<td>58</td>
</tr>
<tr>
<td>1980</td>
<td>77.5</td>
<td>71</td>
<td>71</td>
</tr>
<tr>
<td>1981</td>
<td>85</td>
<td>75</td>
<td>72.5</td>
</tr>
<tr>
<td>1982</td>
<td>90</td>
<td>85</td>
<td>85</td>
</tr>
</tbody>
</table>
REPORT ON SORGHUM IMPROVEMENT IN BURUNDI*

Zenon Kabiro¹

I. Geography

Burundi is a country of 27,834 km², situated in Eastern Africa between 2°45' and 4°28' latitude South, 28°50' and 30°53'30" longitude East. It is bordered by Rwanda in the North, Tanzania in the East and South, and Zaire in the West. Four main relief zones can be distinguished:

a) The Rusizi Plain and the riverain plains. The Rusizi Plain occupies the Northern extension of Lake Tanganyika and the upper part of the Graben substratum. Its altitude varies between 778 m and 1,100 m and it extends nearly 80 km to the North and South and 20 to 30 km to the East and West. The riverain plains have an altitude of between 778 and 900 m, narrower in the North (Bujumbura-Kabezi) and widening considerably in the South (Rumonge-Nyanza-lake).

b) The Zaire-Nile Crest. A mountainous chain crossing the South and North of the Country, parallel to Lake Tanganyika and Rusizi, and extending through Rwanda to the Virunga mountains. The average altitude is 2,300 m. In the South, the average altitude varies greatly, terminating in the Malagarazi Depression.

c) The High Central Plateau. East of the Crest, the relief declines slowly by a series of gradients. These areas are characterised by high plateaus divided by many small rivers with valleys dissecting the whole surface.

d) The Eastern Depression. Swampy regions due to lack of adequate water drainage, located as follows:

   i) In the North-East; the Bugesera Depression around Rwiinda, Cohoba, Rweru and Kanzigiri lakes.

   ii) In the Centre; the Ruvubu valley and depression.

   iii) In the South-East; the Malagali-Rumpungwe depression.

The altitude of all these depressions varies between 1,000 and 1,500 m.

¹Agronomist, ISAB, B.P. 795, Bujumbura, Burundi.

*Translated by Roger Kirkby from the original French text.
Diagrammatically, the Burundi relief is as follows:

![Diagram showing Burundi relief]

The climate is influenced by 3 zones:

A. **Tropical Zone**

The climate is characterised by a marked alternation between the long dry season and the long rainy season, the short dry season and the short rainy season. The average annual temperature is 25°C and the average annual precipitation varies around 800 mm. These are low altitude regions, with savannah in the West (Rusizi plain) and grass in the East (Mosso - Eastern depression).

B. **High Tropical Zone**

In the regions of the Central Plateau, precipitation is tropically distributed but the annual average, which is 1,200 mm, is higher than in the low regions. The short dry season becomes shorter and the temperature diminish gradually with altitude, reaching between 19° and 20°C. The native vegetation, forests and grass-land, has almost entirely disappeared due to cultivation.

C. **Harsh Climatic Zone of the Zaire-Nile Crest**

This climate is characterised by a very short dry season, frequent rains with sudden drops in temperature. The average annual precipitation and temperature is 1,400 mm and 17.3°C, respectively. This is a zone of high altitude forest which persists only on the Crest summits between Bugarama and the Northern countryside, and in the South-Western region of Bururi.

Diagrammatically, the principal climatic features of the three zones are presented below:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Average altitude (m)</th>
<th>Average Rainfall (mm)</th>
<th>Average annual Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low altitude Bujumbura</td>
<td>815</td>
<td>839</td>
<td>25</td>
</tr>
<tr>
<td>Intermediate altitude</td>
<td>1,692</td>
<td>1,062</td>
<td>20</td>
</tr>
<tr>
<td>High altitude</td>
<td>2,155</td>
<td>1,446</td>
<td>17</td>
</tr>
</tbody>
</table>
The following four seasons occur:—

Short rainy season (September-January), short dry season (January-February),
long rainy season (March-May) and long dry season (June-September).

II. Sorghum Farming in Burundi

Sorghum is mostly cultivated for its grain, which is pregerninated and
fermented for use in beer making. The grain is converted also into flour and
can be used in the preparation of porridges and dough. Grains which are not fit
for human consumption are fed to poultry. Sorghum stems are also used as animal
feed after harvest.

Sorghum farming extends over the whole territory of Burundi, excluding
the riverain plain and altitudes of more than 2,300 m. The relative importance
of sorghum, in terms of area and production, varies according to region. In the
regions of low altitude (800 to 1,000 m), sorghum comes after cassava, banana and
beans. On the Central Plateau (intermediate altitude, up to 1,800 m) due to the
diversity of land types, sorghum is relatively important and takes second place
after beans in Bweru and Bugeesa areas, second again after maize in Bututsie
region.

In the other natural regions of the Central Plateaus (Buragane, Buyogoma,
Mumirwa, Kirimiro, Buyenzi), it is difficult to estimate the importance of
sorghum because it is cultivated in association with other plants (eg. sweet
potato). In the areas of high altitude (more than 1,800 m) the plant is hardly
known. But experiments which have been done for the last two years in a station
situated at 2,150 m (Munanira) have shown that sorghum farming is possible, using
varieties which are resistant to low temperatures.

The relative importance of sorghum and of other crops is summarised
below:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area cultivated</th>
<th>Gross Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ha('000')</td>
<td>%</td>
</tr>
<tr>
<td>Legumes (non oilseed):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bean, pea</td>
<td>536</td>
<td>31</td>
</tr>
<tr>
<td>Cereals: maize, sorghum,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>millet, wheat, rice</td>
<td>505</td>
<td>30</td>
</tr>
<tr>
<td>Roots &amp; Tubers: potato,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cassava, sweet potato, yam</td>
<td>390</td>
<td>23</td>
</tr>
<tr>
<td>Banana &amp; Plantain</td>
<td>170</td>
<td>10</td>
</tr>
<tr>
<td>Cash crops: fruit and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>beverages</td>
<td>57</td>
<td>3</td>
</tr>
<tr>
<td>Oil crops: groundnut, oilpalm</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Total All Crops</td>
<td>1,691</td>
<td>100</td>
</tr>
</tbody>
</table>

In traditional farming the sorghum is sown from December to the beginning of January, either sown into maize fields established in October, or monocropped after ploughing. Fertile lands are generally set aside for sorghum farming. Broadcast sowing does not allow for good maintenance of fields (weeding & hilling up). Harvesting is done by panicle cutting and the seeds are separated from the panicle by threshing and winnowing. The vegetative cycle is approximately six months, and yields vary from 500 to 1,200 kg/ha. In modern farming 2 ploughings at 15 days' interval are done before sowing. Sowing is carried out up to 15 January at spacings of 40 x 60 cm with 5 to 8 seeds per hole, followed by thinning to 2 plants. Two weedings are done, the second being combined with thinning and hilling up. Organic manure is applied and covered at the time of the second weeding.

In organic fertilizer (NPK) is also applied, one part after ploughing (40-20-20) and the rest before flowering (40-0-0). On the research station the average yield is 2,000 kg/ha. The principal problem of sorghum cultivation in Burundi is disease and insect damage. According to Autrique, the principal diseases are rust (Puccinia purpurea), anthracnose (Colletotrichum graminicola), cercospora (Cercospora sorghii), Ramulispora sorgicola, blight (Helminthosporium turcicum), and smuts (Sphaecelotheca sorghi, S. cruenta, S. reiliana).

The effect of diseases on grain yield does not seem to be serious, but a study of this type would be difficult because up to the present time there has been no availability of chemicals capable of completely eradicating diseases. Insect species causing heavy losses are the stem borers (Eldana saccharina, Busseola fusca and Sesamia spp.), head pests (Sitotroga cerealella, Cryptophlebia leucoptera, Cymerea spp., Heliothis armigera, Eldana saccharina) and shootfly (Atherigona soccata). A major effort is envisaged in order to develop resistant varieties.

On small farms the other factors which contribute to limit yields are: the use of unimproved varieties, lack of inputs (fertilizers and plant protection products) and the use of unimproved agronomic practices (broadcast sowing, inadequate weeding and hilling up).

III. Research

In Burundi, agricultural research is done by ISABU (Institut des Sciences Agronomiques du Burundi). Two officers - one graduate agronomist and one technician ("A" level) - are responsible for the research program for sorghum and rice. The research is mostly applied. ISABU introduces varieties from research institutions or foreign countries and then selects the plants which are adapted to different ecological zones. The varieties introduced are first tested or put in a screening trial where their performance is observed (Vegetative cycle, disease and insect resistance, absence or presence of ergot or Sphaecelia and yield).
The following year the best varieties are compared with production varieties (checks). Here the main factor is yield. Afterwards, if there are one or two varieties which exceed the check treatment, these are tested in a comparative multilocal trial in different sorghum ecological zones. Later on, the seeds are multiplied and diffused.

There are three sorghum ecological areas in Burundi:—
- Low altitude zone (800 to 1,300 m), reserved for screening trials.
- Intermediate altitude zone (1,300 to 1,800 m).
- High altitude zone (1,800 m and above).

In variety development research, 3 varieties have been selected for these ecological zones:—
- 5Dx160 (originating from Uganda, transmitted by ICRISAT),
- SVR 8 (from Rwanda, transmitted by ISAR) and
- SVR 157 (from Rwanda, transmitted by ISAR).

These varieties are characterised by:—

<table>
<thead>
<tr>
<th>Variety</th>
<th>Altitude Zone</th>
<th>Plant Height in cm</th>
<th>Grain Yield t/ha</th>
<th>Stover Yield t/ha</th>
<th>Vegetative Cycle (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5Dx160</td>
<td>Low</td>
<td>110-120</td>
<td>2.0 to 2.5</td>
<td>6.0 to 9.0</td>
<td>120-130</td>
</tr>
<tr>
<td>SVR 8</td>
<td>Intermediate</td>
<td>180-200</td>
<td>1.9 to 2.6</td>
<td>2.7 to 6.0</td>
<td>145-155</td>
</tr>
<tr>
<td>SVR 157</td>
<td>High</td>
<td>250-300</td>
<td>2.0</td>
<td>9.5</td>
<td>180</td>
</tr>
</tbody>
</table>

Due to the intensity of stemborer attack, ISABU conducts under experimental conditions entomological studies. These studies are aimed at producing an inventory of Lepidopteran species involved, determining their relative importance, discovering their host plants and annual cycle of infestation in relation to environmental factors, as well as estimating their pest status in relation to the timing and intensity of the infestation. The study started in 1979 and some results have already been obtained. Eldana saccharina is shown to be the most important, Busseola fusca, Sesamia albivena and S. calamistis have been identified from sorghum. Infestation commences two months after sowing; the first attacks are due to Busseola fusca, white Eldana saccharina and Sesamia appear later.

In low altitude zone, the variety 5Dx160 matures in 4 months and it has been tested in a double cropping trial. Usually with local varieties, farmers sow sorghum in December and harvest it in June-July. Using 5Dx160, the first season starts in October, and the second season in March, in order for double cropping to succeed.
From 1971, ISABU has made 262 introductions from foreign research institutions (ISAR-Rwanda, ICRISAT-India, IRAT-West Africa, CIMMYT). These institutions in return get trial results from ISABU (variety performance of their materials). Very little information is available concerning the number of varieties cultivated in Burundi. But lately an expert from ICRISAT collected 113 sorghum samples for their gene bank. Part of every sample remained in Burundi, and this will enable us to test the value of our genetic resources.

In future, we will endeavour to look for varieties with resistance to low temperatures, thus allowing more intensive farming of this crop at high altitude. For each ecological zone we will endeavour to select varieties with high yield for use in beer and porridge making.

References

2. van der Velpen. Geography handbook of Burundi.
THE STATUS OF SORGHUM IMPROVEMENT
IN KENYA - GENERAL

J.K. Rutto

Background

Sorghum and millets have been important traditional food crops in Kenya, grown for subsistence by small holders, mainly in Western Kenya and Eastern Province. Though there has been a gradual decline in the hectarage under sorghum as a result of its substitution with other crops eg. maize, wheat, rice, sugar cane, etc. which have enjoyed more government support in terms of research and development, sorghum and millets still occupy an important position as food crops in the national economy (Table 1).

Factors which have been responsible for the decline in sorghum production include low yields and high labor requirements compared to maize, vulnerability to bird damage, limited alternative uses, low prices and general lack of outlets for disposal of surplus production, changing eating habits and lack of appropriate technology and government support services. The drastic decline in national production of sorghum is primarily due to reduction of hectarage under sorghum in Nyanza Province, in Western Kenya. For instance the area under sorghum production in Nyanza Province dropped from 91,000 ha in 1970 to about 20,000 ha in 1974 recovering to only about 51,800 by 1977 (Table 2).

Generally, the yields are low since the production technologies employed are relatively traditional and involve little or no use of improved seed, low level of mechanization and little or no usage of agro-chemicals. The yields in Eastern Province are generally lower than those in Western Kenya (Table 3).

In an attempt to reverse the downward trend of sorghum production and develop the crop, the Kenya Government requested the FAO for technical assistance in the development and improvement of sorghum. In 1977 the FAO/UNDP/Kenya Government Sorghum and Millets Development Project was approved. Phase I (KEN/76/020) from 1977 to 1978 followed on from the FAO/UNDP/Kenya Beef Industry Development Project at Lanet near Nakuru. It was intended to assist in developing and implementing a breeding, agronomy, and dissemination program mainly for the cold tolerant drought resistant sorghum for stockfeed in large farms in the semi-arid highlands. Phase II (KEN/78/016) from 1979 to 1981 called for a shift in emphasis to development of sorghum and millets for human food for the small scale farmers in the semi-arid areas and the wetter Lake Victoria Basin areas that were marginal for maize, wheat, and rice.

Senior Research Officer, Ministry of Agriculture, Western Agricultural Research Station, P.O. Box 169, Kakamega, Kenya.
Agro-ecological Zones

Pratt and Gwyane mapped Kenya into six districts or ecozones (numbered I to VI) depending on the moisture indices as given by the ratio of precipitation (rainfall) to potential evapotranspiration in different areas of Kenya.

Zone I covers about 800 sq. km and is of no agricultural potential being mountainous, high altitude, very rocky, and slopy. Zones II, III and IV each covers about 53,000 sq. km and is of high, medium, and marginal agricultural potential, respectively. Zones V and VI cover 300,000 and 112,000 sq. km and are of moderate and marginal range potential, respectively.

Sorghum could be and is produced in Zone III but this zone can produce other crops (eg. maize and beans) that are more competitive and more preferred as food by the consumer. Due to the ability of sorghum to withstand water logging and to tolerate Striga weed infestation better than maize, it is favored over maize in areas of Zone III where the above conditions exist in Western Kenya and at the Coastal area. Zones IV, V and VI generally cover the so-called arid and semi-arid lands of Kenya and are the zones in which sorghum is the appropriate food crop because of its tolerance to drought (Table 4).

The National Sorghum Improvement Program

In line with the National Food Policy, the Government of Kenya through the Ministry of Agriculture is now giving a great deal of attention to the research and development aspects of sorghum and millets in the country. Towards meeting this objective, a National Program for the Research Development of Sorghum and Millets has been established and the National Co-ordinator will be based at the Western Agricultural Research Station, Kakamega.

The general objectives of the program are:

1. To provide continuity of the sorghum and millet research and development at national level following the termination of the UNDP/FAO/Kenya Government Project in December 31st, 1981.

2. To develop and promote new sorghum and millet cultivars and hybrids suitable for grain production for human consumption and livestock feeding in the highland and lowland areas marginal for maize, wheat, or rice production.

3. To promote marketing, processing, and utilization of sorghum and millets in collaboration with institutions like the National Cereal and Produce Board and the Kenya Industrial Research Development Institute, etc.
Components of the National Program:

The National Program has five research components as follows:

1. The Lake Basin Component - based at Kakamega for the wetter lake region and part of the Rift Valley.
2. Katumani Based Component for marginal and drier areas of Eastern Kenya.
3. Coast Component based at Mtwapa and covering the Coast region.
4. High Altitude Cold Dry Areas Component based at Lanet (Beef Research Station) and covering the higher altitudes.
5. Food Technology and Processing Component based at the Kenya Industrial Research Development Institute (KIRDI), Nairobi, for processing of sorghum and millets.

Research Objectives of the National Program

1. **Crop Improvement**
   
   To develop stable cultivars and hybrids of sorghum and millets of high yield, appropriate maturity, disease and pest, resistance and of acceptable quality for human food and livestock feed and adapted to:
   
   a) marginal rainfall areas of high, medium and low altitude and
   b) high rainfall and impeded drainage and *Striga* infested areas of medium altitude.

2. **Agronomic Investigations**

   To identify the effects of various agronomic practices aimed at optimising and stabilising sorghum and millets yields in relation to water consumption, plant population, intercropping, time of planting and fertilizer use, etc.

3. **Agricultural Engineering**

   To develop simple implements (devices) applicable for field operations that would simplify sorghum and millets production in small scale.

4. **Crop Protection**

   To undertake studies into the protection of the sorghum and millets from damage by insect pests, disease, *Striga* and other weeds and birds.

5. **Crop Economics**

   To conduct studies on the economic aspects of sorghum and millet production on whole farm situation.
Research Priorities:

The research priorities are considered in relation to the five components identified corresponding to the different ecological zones, and according to the present status of research for both crops in each ecozone.

1. The Western Kenya (lake basin) Component

   Varietal screening and testing in the region has resulted in the identification of promising varieties whose husbandry practices have also been developed. Pre-extension trials based on these varieties are being conducted in some parts of the region and will be expanded to determine areas suitable for the crops.

   The present promising varieties have brown grain colour which is not widely preferred outside the growing areas. Thus, development of suitable white sorghums with particular emphasis on resistance to leaf disease and Striga is underway.

   An evaluation of a breeding nursery material involving a World Collection of about 1100 entries revealed that there was need for a breeding program to improve the existing promising varieties for yield, disease and insect pest resistance, lodging resistance, and appropriate maturity.

   Optimum agronomic practices for finger millet production are being developed at Kakamega.

2. Dryland Program:

   A lot of information on the growing of sorghum and millets under marginal rainfall areas is available. Some adaptive agronomic research with emphasis on appropriate cropping systems will be undertaken. Development of millets including bulrush, proso, and foxtail millets will continue. Improvement of sorghum through breeding and selection with emphasis on drought tolerance will continue.

3. Coast Program:

   Development of suitable varieties of sorghum and finger millet and appropriate agronomic practices will be the main thrust.

4. High Altitude Program:

   Expansion of adaptive agronomic research to determine the areas suitable for the crops and livestock feeding trials will be the main emphasis in this zone.

5. Processing and Utilization Program:

   The main thrust in this program will be to conduct milling, baking and utilization, and marketing studies of sorghum and millet production.
Production, Processing, and Marketing

These aspects of the national sorghum and millets development program aim at ensuring that promising varieties of sorghum and millets from research are bulked, multiplied, and the seed distributed to farmers to ensure that production targets are realized. Extension and visits for the provision of services (such as credit) in order to ensure success of the program are important activities here.

Research has aptly identified that the weakest link in the promotion and expansion of sorghum and millets in Kenya is the development of industrial products that are easily accepted by consumers. Effort will therefore be put on the identification of target groups of consumers, evaluation of their acceptance of different sorghum and millets based food products that are presently identified, and then the quantification of demand in order to determine what and how much to produce.

Presently, Kenya Industrial Research Development Institute (KIRDI) has identified "sorghum meal" and "pearled sorghum" as products with some good market potential, and plans are underway to develop these products. Projects to develop village dehullers (based on the PRL/RIIC model, developed at Saskatoon, Canada) and commercial sorghum mills will receive priority. KIRDI will play an active role in all these undertakings, but Unga Ltd (of the Marcat Group of Companies) is recognized as the market leader in the introduction of new food products that will be based on sorghum and millets. Dehulling should also improve palatability of sorghum and millets food products that are currently consumed in local diets.

The technology proposed for the processing of sorghum grain for livestock feeds is relatively simple. A straight forward grinding is now the only recommended process, and no evaluation program for large scale production technology is deemed necessary.

Just as the development of food products based on sorghum and millets that are acceptable to consumers is a major constraint to expand production of the two cereal crops plays a major role in depressing production. The marketing and processing components are interrelated to some extent. The National Cereals and Produce Board (NCPB) is the main buyer of sorghum. Since most of the sorghum purchased by the Board is red mix or brown it has been finding it difficult to dispose of the grain. There is, therefore, an urgent need to look for outlet for the produce if production is to be sustained or expanded.
Staff Requirements:

For proper functioning, the research components need full staff complement comprising of plant breeders, agronomists, agricultural economists, crop protectionists, food technologists and other supporting staff. At the moment, the program is very poorly staffed at Research Officers cadre. For example, at the main station (Kakamega) there is only one Research Officer besides the National Coordinator. The situation in other stations such as Alupe (Busia), Lanet (Nakuru) and Mtawapa (Kwale) is similar.

There is, therefore, a need to recruit qualified staff and post them urgently to the various stations for various duties. Table 5 gives the staff requirements for the program. Training for the identified staff is also very essential.

Achievements

Phase I

The project identified cold tolerant high yielding varieties suitable for grain production, dual grain and forage production for livestock feed in the marginal highlands. The forage type E6518 gave very high forage yields (approx. 30 tons/ha) while the dual grain-forage type gave about 20 tons/ha dry matter of forage and 10 tons/ha of grain under good management under Lanet conditions. Other promising grain types were BJ 128, 74LH3270 and BJ 28. The results from the regional trials conducted in 19 highland locations in 1979 showed that best variety for yield and stability was E1291 and was recommended for release under the name "Provenda" in 1979. Basic seed of all varieties was produced and is retained in cold storage at NARS, Kitale. Commercial seed is available from the Kenya Seed Company and the Beef Research Station, Lanet.

Recommendations on the agronomic requirements for these varieties were developed. These varieties have been successfully grown by some cattle feedlot operators and dairy farmers in Nakuru District and other parts of the Rift Valley Province.

Phase II

During Phase II, the Project headquarters moved from Lanet to the National Dryland Research Station, Katumani. This served the semi-arid areas with substations in the lowlands 1000 m, midlowlands (1000-1300 m), mid-highlands 1300-1500 m and highlands (1500-2000 m) where rainfall could have a monomodal or bimodal distribution pattern. A principal sub-station was established at Alupe, Busia in Western Kenya to develop an independent program for the wetter Lake Basin area (900-1300 m).
Sorghum in the Wet Lowlands

An extensive collection of 423 local collections was made in the wet lowlands. After extensive regional trials were conducted one brown variety 5 DX 135/13/1/3/1 was selected for multiplication and release. This variety has also performed well in Karamoja in Uganda and in Southern Sudan and a joint release in Kenya and Uganda is proposed under the name SEREDO.

One other promising brown variety is E525 H.R. Village approach extension production programs based on this variety have been very enthusiastically received by farmers in Western and Nyanza Provinces. During 1981 and 1982, over 1000 farmers with each planting 1 acre participated in the Village Approach Program in Busia, Siaya, Kisumu, South Nyanza and Bungoma Districts. The average yield of these new varieties in farmers fields is about 3 tons/ha compared to 1.5 tons/ha or less for the local varieties which are late maturing and contain higher levels of tannins.

Other brown varieties tested and found promising include MY146, Serena and 3 DX.

The performance of the white varieties tested has been unsatisfactory due mainly to susceptibility to Striga and high incidence of leaf blight. The best variety tested was 2KX 76/325 with an average yield of 2.5-4 tons per ha. in Busia and Siaya Districts.

Sorghum hybrid program was begun in 1980 but its progress was slowed down due to lack of a breeder.

Sorghum in the Semi-Arid Areas

Over 3000 cultivars, both local and introductions have been screened at Katumani. The best of the lowland varieties were multiplied and widely tested in farmers fields in Eastern Province. Six white varieties and Serena are currently being multiplied by the Kenya Seed Company, and are recommended for release as follows:

IS 8595 (white) and 566-14 (red) are recommended for lowlands below 1000 m and seasonal rainfall of 250-300 mm and these are appropriate for lower Embu, Rift Valley (eg. Barings), Kitui, Yatta, etc.

Serena (brown) is recommended for midlowlands of 1000-1300 m altitude and rainfall of 250-300 mm and it is suitable for Kampi-ya-mawe, and Tebere.

2KX17 (white) and 954063 (white) for mid-highlands 1300-1500 m for short rains (300 mm).

The hybrid development program was advanced simultaneously with the varietal program until 1981 but has been held until
other factors mainly price for better quality material is resolved. Some 1000 experimental hybrids have been made and tested for main yield and ratoonability.

Agronomy and Extension Activities

The agronomy program looked at many aspects including identification of frequency of crop failures and classification of season types based on seasonal rainfall and potential evaporation and storage of soil moisture under bare fallow system, and development of husbandry practices for the identified varieties.

The trials were laid down in farmers' farms and the technical supervision provided jointly by the research and extension staff. A pilot production program was also planned with Machakos Integrated Development Program (MIDP) support in Yatta.

Five Year (1984-1989) Development Plan

During the period each component of the program will be consolidated in terms of provision of full staff compliment (both technical and administrative), offices, laboratories, staff houses, transport, plant and equipment and other necessary facilities.

The research priorities are considered in relation to the five research components identified corresponding to the different ecological zones, and according to the present status of research for sorghum and millets in each ecozone.

1. The Western Kenya (Lake Basin) Component:

Varietal screening and testing in the region has resulted in the identification of promising varieties whose husbandry practices have also been developed. Pre-extension trials based on these varieties are conducted in some parts of the region and will be expanded to determine areas suitable for the crops.

The present promising varieties have brown grain colour which is not widely preferred outside the growing areas. Thus development of suitable white sorghums with particular emphasis on resistance on leaf disease and Striga is underway.

An evaluation of a breeding nursery material involving a World collection of about 1100 entries revealed that there was need for a breeding program to improve the existing promising varieties for yield, disease and insect pest resistance, lodging resistance, and appropriate maturing.
2. **Dryland Component:**
   In the 1984-89 plan, the program will expand its activities in the following areas:
   - Expansion of adaptive agronomic research with increased emphasis on appropriate cropping and farming system,
   - Development and improvement of millets including bulrush, proso, foxtail and finger millets,
   - Improvement of sorghum through breeding and selection with emphasis on earliness, drought tolerance and grain quality characters eg. tannin-free white type.

3. **Coast Component:**
   Work on the development and improvement of suitable varieties of sorghum and finger millet as well as development of optimal agronomic practices will continue.

4. **High Altitude Component:**
   Improvement work will continue for the sorghums while developing suitable millets for these areas emphasizing on cold tolerance, and forage quality and yield. Livestock (with beef and dairy cattle, poultry, etc.) feeding trials will be conducted on the sorghum and millets grain developed by the program to determine their feeding value. The on-going adaptive agronomic research will be expanded to determine the areas suitable for the crops in the highlands.

5. **Processing and Utilization of Sorghum and Millets for Human Food**
   This is the weakest link in the infrastructural chain for promotion of sorghum and millets. Attention will be given to the sorghum and millets grain to develop industrial products acceptable to the consumer. The identification of target consumer groups evaluating the acceptability of the products as well as quantifying the demand. The shelf-life of the products will be determined. Another important activity which will be undertaken during the period is the development and testing of the village and commercial technology for dehulling and milling the sorghum and millet grains.

   Details on the resource required especially on personnel, transport, buildings and finances required in order to realize the targets planned are given in the report of the Ad Hoc Committee on Sorghum and Millet Research and Development, Ministry of Agriculture, February 1982 chaired by Dr. F.J. Wang'ati.
References


Table 1. Food Crops Projections 1982-1985. (All hectarage and production figures in '000)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Year 1981 (Estimated)</th>
<th>Total Prod.</th>
<th>Annual growth rate in prod. (%)</th>
<th>Projected Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ha</td>
<td>Yield/Ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>1500.0</td>
<td>18 bags</td>
<td>27000.0</td>
<td>27845.0 28820.0 29828.7 30871.7 Bags (90 kg)</td>
</tr>
<tr>
<td>Wheat</td>
<td>134.3</td>
<td>20 &quot;</td>
<td>2686.0</td>
<td>2726.3 2767.2 2808.7 2850.8 &quot;</td>
</tr>
<tr>
<td>Triticale</td>
<td>10.0</td>
<td>22 &quot;</td>
<td>220.0</td>
<td>440.0 473.4 508.4 547.4 &quot;</td>
</tr>
<tr>
<td>Rice</td>
<td>12.2</td>
<td>25 &quot;</td>
<td>305.0</td>
<td>328.2 353.1 379.9 408.8 Bags (70 kg)</td>
</tr>
<tr>
<td>Sorghum/millet</td>
<td>154.4</td>
<td>8 &quot;</td>
<td>1315.2</td>
<td>1377.0 1441.7 1509.5 1580.4 &quot; (80 kg)</td>
</tr>
<tr>
<td>Beans</td>
<td>457.8</td>
<td>8 &quot;</td>
<td>3662.4</td>
<td>3844.5 4037.8 4239.7 4451.7 &quot; (90 kg)</td>
</tr>
<tr>
<td>Cowpeas</td>
<td>101.6</td>
<td>5 &quot;</td>
<td>508.0</td>
<td>533.4 560.1 588.1 617.5 &quot;</td>
</tr>
<tr>
<td>Pigeon Peas</td>
<td>164.5</td>
<td>6 &quot;</td>
<td>987.0</td>
<td>1036.3 1088.1 1132.5 1189.1 &quot;</td>
</tr>
<tr>
<td>Grams</td>
<td>46.1</td>
<td>5 &quot;</td>
<td>230.5</td>
<td>242.0 254.1 266.8 280.1 &quot;</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>14.0</td>
<td>10 &quot;</td>
<td>140.0</td>
<td>146.3 152.9 158.8 165.9 &quot; (80 kg)</td>
</tr>
<tr>
<td>E. Potatoes</td>
<td>63.2</td>
<td>110 &quot;</td>
<td>6052.0</td>
<td>7240.9 7562.7 7887.9 8227.1 Tons</td>
</tr>
<tr>
<td>Cassava</td>
<td>77.2</td>
<td>8 tons</td>
<td>617.6</td>
<td>654.7 694.0 735.6 779.7 &quot;</td>
</tr>
<tr>
<td>Yams/A.roots</td>
<td>3.4</td>
<td>9 tons</td>
<td>30.6</td>
<td>31.8 33.1 34.4 35.8 &quot;</td>
</tr>
<tr>
<td>S. Potatoes</td>
<td>40.9</td>
<td>6 tons</td>
<td>245.4</td>
<td>255.2 265.4 276.0 287.0 &quot;</td>
</tr>
<tr>
<td>Vegetables</td>
<td>60.0</td>
<td>8 tons</td>
<td>480.0</td>
<td>516.5 55.7 597.9 643.3 &quot;</td>
</tr>
<tr>
<td>Bananas</td>
<td>46.6</td>
<td>400 bunches</td>
<td>18649.0</td>
<td>10385.6 20161.0 20967.4 21806.1 Bunches</td>
</tr>
</tbody>
</table>

Source: Ministry of Agriculture, Crop Production Division, Food Crops Branch.
### Table 2. Area Under Sorghum by Province ('00 ha)

<table>
<thead>
<tr>
<th>Year</th>
<th>Province</th>
<th>1970/71 Average</th>
<th>1974/75 Average</th>
<th>1978/79 Average</th>
<th>1979/80 Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eastern</td>
<td>180</td>
<td>210</td>
<td>228</td>
<td>223</td>
</tr>
<tr>
<td></td>
<td>Nyanza</td>
<td>910</td>
<td>210</td>
<td>499</td>
<td>519</td>
</tr>
<tr>
<td></td>
<td>Western</td>
<td>185</td>
<td>170</td>
<td>181</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>Rift Valley</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Central</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Coast</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>National Total*</td>
<td>1283</td>
<td>599</td>
<td>919</td>
<td>928</td>
</tr>
</tbody>
</table>

*Production from North-Eastern Province is negligible, though efforts to promote production are being made.

Source: Calculations based on statistics from Ministry of Agriculture Provincial Annual Reports.

### Table 3. Average Maize, Sorghum and Millets Yields in Nyanza Province and Marginal Areas of Eastern Province.

(90 kg. Bags per Hectare)

<table>
<thead>
<tr>
<th></th>
<th>Nyanza Province</th>
<th>Eastern Province</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>29.5</td>
<td>12</td>
</tr>
<tr>
<td>Sorghum</td>
<td>12.2</td>
<td>5</td>
</tr>
<tr>
<td>Finger millet</td>
<td>6.0</td>
<td>3</td>
</tr>
<tr>
<td>Bulrush millet</td>
<td>-</td>
<td>3</td>
</tr>
</tbody>
</table>

*Average based on yields realized in Kitui, Machakos and drier areas of Embu and Meru Districts.

Source: Adapted from Ministry of Agriculture Annual Reports.
Table 4. Districts with Arid and Semi-arid Lands (i.e. Zones IV, V and VI) in Kenya (area given in thousands of hectares.

<table>
<thead>
<tr>
<th>Province &amp; District</th>
<th>Total ASAL Area (T)</th>
<th>Zone IV Area %T</th>
<th>Zone V Area %T</th>
<th>Zone VI Area %T</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North Eastern:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garrisa</td>
<td>4,393</td>
<td>534 12.2</td>
<td>3,595 81.8</td>
<td>244 5.6</td>
</tr>
<tr>
<td>Wajir</td>
<td>5,650</td>
<td>-</td>
<td>4,580 81.1</td>
<td>1,033 18.3</td>
</tr>
<tr>
<td>Mandera</td>
<td>2,647</td>
<td>-</td>
<td>45 1.7</td>
<td>2,603 98.2</td>
</tr>
<tr>
<td><strong>Eastern:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machakos</td>
<td>1,418</td>
<td>422 29.8</td>
<td>760 53.6</td>
<td>-</td>
</tr>
<tr>
<td>Kitui</td>
<td>3,116</td>
<td>161 5.2</td>
<td>2,859 91.8</td>
<td>-</td>
</tr>
<tr>
<td>Embu</td>
<td>271</td>
<td>27 10.0</td>
<td>159 58.7</td>
<td>-</td>
</tr>
<tr>
<td>Meru</td>
<td>992</td>
<td>81 8.2</td>
<td>538 54.2</td>
<td>-</td>
</tr>
<tr>
<td>Isiolo</td>
<td>2,561</td>
<td>-</td>
<td>1,177 46.0</td>
<td>1,384 54.0</td>
</tr>
<tr>
<td>Marsabit</td>
<td>7,273</td>
<td>147 2.0</td>
<td>1,723 23.7</td>
<td>5,372 73.9</td>
</tr>
<tr>
<td><strong>Coast:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kilifi</td>
<td>1,241</td>
<td>242 19.5</td>
<td>271 21.8</td>
<td>-</td>
</tr>
<tr>
<td>Kwale</td>
<td>826</td>
<td>370 44.8</td>
<td>113 13.7</td>
<td>-</td>
</tr>
<tr>
<td>Lamu</td>
<td>651</td>
<td>228 35.0</td>
<td>23 3.5</td>
<td>-</td>
</tr>
<tr>
<td>Taita</td>
<td>1,696</td>
<td>103 6.1</td>
<td>1,548 91.3</td>
<td>-</td>
</tr>
<tr>
<td>Tana River</td>
<td>3,869</td>
<td>139 3.6</td>
<td>3,593 92.9</td>
<td>-</td>
</tr>
<tr>
<td><strong>Central:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nyeri</td>
<td>328</td>
<td>16 4.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kiambu</td>
<td>245</td>
<td>32 9.4</td>
<td>2 0.08</td>
<td>-</td>
</tr>
<tr>
<td>Muranga</td>
<td>248</td>
<td>3 1.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kirinyaga</td>
<td>144</td>
<td>- 4.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Rift Valley:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kajiado</td>
<td>2,096</td>
<td>744 35.5</td>
<td>1,310 62.5</td>
<td>-</td>
</tr>
<tr>
<td>Narok</td>
<td>1,851</td>
<td>646 34.9</td>
<td>79 4.3</td>
<td>-</td>
</tr>
<tr>
<td>Nakuru</td>
<td>704</td>
<td>263 37.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Elgeyo-Marakwet</td>
<td>272</td>
<td>-</td>
<td>108 39.7</td>
<td>-</td>
</tr>
<tr>
<td>Baringo</td>
<td>1,063</td>
<td>205 19.3</td>
<td>647 60.9</td>
<td>10 0.09</td>
</tr>
<tr>
<td>West Pokot</td>
<td>508</td>
<td>69 17.5</td>
<td>194 38.2</td>
<td>-</td>
</tr>
<tr>
<td>Turkana</td>
<td>6,534</td>
<td>613 9.4</td>
<td>3,539 54.2</td>
<td>2,308 35.3</td>
</tr>
<tr>
<td>Samburu</td>
<td>2,081</td>
<td>240 11.5</td>
<td>1,433 68.9</td>
<td>137 6.6</td>
</tr>
<tr>
<td>Laikipia</td>
<td>972</td>
<td>497 51.1</td>
<td>107 11.0</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>53,650</td>
<td>5,800</td>
<td>28,403</td>
<td>13,090</td>
</tr>
</tbody>
</table>

i) Dash (-) implies "non-existent" or "data not available".
ii) T=total ASAL area and % is the area of a given zone expressed as percentage of total ASAL area.

Source: Ministry of Agriculture, Livestock and Meat Industry Study, 1977 (Nairobi, Kenya), Appendix II.
Table 5. Personnel Requirements.

<table>
<thead>
<tr>
<th>Component</th>
<th>Required</th>
<th>In post</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Western Component (Kakamega)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Co-ordinator</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Sorghum Breeders</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Millet Breeders</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Agronomists</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Entomologists</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Pathologists</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Agricultural Economists</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Technical Officers</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Technical Assistants</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Drivers</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Subordinate Staff</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>2. Eastern Component (Katumani)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum Breeders</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Millet Breeders</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Agronomists</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Agricultural Economists</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Technical Officers</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Technical Assistants</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Drivers</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Subordinate Staff</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>3. High Altitude Component (Lanet)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum Breeders</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Agronomists</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Technical Officers</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Technical Assistants</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Drivers</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Subordinate Staff</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>4. Coastal Component (Mtwapa)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum Breeders</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Millet Breeders</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Agronomists</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Technical Officers</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Technical Assistants</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Drivers</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Subordinate Staff</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>5. Cereal Technology (KIRDI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food Technologists</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Technical Officer (Food Technology)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Drivers</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

*The program should have access to the services of agricultural economists but it is expected that such specialists will be servicing other research programs as well.*
THE PRESENT STATUS OF SORGHUM BREEDING
IN KENYA WITH SPECIAL EMPHASIS ON
THE LOWELEVATION DRYLANDS

I.R. Kermali

Background
Towards the end of the FAO/UNDP Kenya Sorghum and Millet Development Project (KSMDP) in December 1981, the National Program for Research and Improvement of Sorghum and Millets (PRISM) was set up. PRISM comprises of five components, i.e. Improvement programs for the lake basin, for the high altitude areas, for the coastal zone, for the semi-arid drylands and a component dealing with processing and utilization. Except for the semi-arid dryland program all the others have been (temporarily) discontinued due to a number of reasons. An FAO consultancy is at present looking at the scope of sorghum and millet processing. Currently Katumani Dryland Sorghum Improvement Program (KDSIP) is the only viable breeding program which has continued with the work of KSMDP. However, the main emphasis now is on developing widely adapted cultivars which will fit into the farming systems packages suitable for the semi-arid regions of Kenya being developed by the (Dryland Farming Research and Development Project) DFRDP. At the same time, additional screening and limited breeding work is being carried out for the semi-arid highlands and the coastal hinterlands.

The Programs of KDSIP
This program is active in the semi-arid areas receiving bimodal rainfall. The region covers a greater part of the Eastern and Central Provinces and a part of the coastal hinterland and some of the monomodal regions of the Northern Provinces. In the bimodal regions, the annual rainfall is between 550 and 850 mm divided almost equally between the long rainy season (April to June) and the short rainy season (November to January). The major problems encountered include the short growing season (3 months or less), erratic onset and distribution of rain and high bird risk. Among insects and diseases, stemborer and storage pests and charcoal rot are very serious. In close collaboration with the other programs of the DFRDP, a systems approach rather than the commodity approach is being observed. Sorghum is being developed vis-a-vis other cereals and pulses. Equal priorities are being given to on-station and on-farm activities. At all levels of research, there is very

---

1Sorghum Breeder, FAO/UNDP Dryland Farming Research and Development Project, National Dryland Farming Research Station, Katumani, Ministry of Agriculture, P.O. Box 340, Machakos, Kenya.
close interaction of the agronomist, physiologist, plant protection unit, farm economist and the pre-extension unit. The major constraints to growing sorghums in these areas, which are dominated by the small-scale holders, are insufficient labour, technological level, market systems and consumer acceptance.

The KDSIP is also taking care, to a limited extent, of the semi-arid high-altitude and coastal programs. In the sub-humid coastal areas, the major problems in addition to very erratic rainfall are the insect pests and diseases. The breeding programs for the semi-arid highlands stresses on cold tolerance, earliness and resistance to diseases and pests. Good grain qualities for human consumption and grain and/or forage qualities for animal feed are taken into consideration.

**Breeding Objectives**

The current breeding objectives for the KDSIP are the following:

a) Early maturity (less than 100 days after emergence)
b) Tolerance to drought stress at different growth stages
c) Wide adaptation and stable yields
d) Tolerance to diseases and insect pests
e) Ability to ratoon well
f) Short to medium plant height
g) Acceptable grain quality

Selection of early genotypes (90 to 100 days maturity) is the main criteria. Such varieties can escape drought occurring towards the end of the season. In collaboration with the physiologists, traits which provide true drought resistance are being utilized. Selection is also biased towards stable genotypes which can give high average yields over seasons and locations. Such cultivars have wide adaptation, good disease and pest tolerance, and good agronomic properties. For the dry lowlands receiving bimodal rainfall, genotypes with good ratooning potential help to overcome the problems of low moisture availability, labour and production costs. Shorter plants are easier to manage, allow higher populations, prevent lodging and are easier for bird scaring.

The most serious disease in the semi-arid drylands is charcoal rot. Smuts are also common but at present no work is done on them. In the high altitude areas, in addition to cold tolerance, field screening against a range of diseases is very important. The grain moulds are serious both at the coast and in the highlands. Pathologists are closely involved in studying all these diseases. The most important economic pests which are retarding the progress of the sorghum in the country are birds. Stemborer is the major insect pest in the dryland region, while aphids, thrips and earhead worms are found sporadically. Several insect pests are a major problem
in the sub-humid coastal zone. Storage pests cause a major loss in all the zones. Screening under naturally infested conditions for all the insect pests is done. At present, stemborer and storage pests are being given the most attention. In future, in collaboration with the entomologists, additional screening will be conducted under artificially infested conditions.

The quality aspects of sorghum grain is getting also priority in the national sorghum improvement program. Cultivars with good food quality, especially those in which the pigmented tests is absent are being developed for human consumption as 'Ugali' and 'uji'. Varieties with pigmented testa will have good potential after processing (dehulling), especially in the high bird risk areas. Pearled products from both types, i.e. with or without pigmented testa can be marketed as rice substitutes. Other industrial uses taken into consideration include composite flour (with other cereals or cassava) and for animal (livestock or poultry) feed.

Breeding Procedures

For the KDSIP, the main research station is Katumani with substations at Kampi ya Mawe, Ithookwe, and Murinduko. The Lowland sites at Marimanti (Embu and Meru) and Voo (Southern Kitui) are still under development and are most representative of the currently sorghum growing areas in the Eastern Province. Only one semi-arid high altitude site is available at present (Lanet). In the coastal hinterland Magarimi and Matuga are used while Mtwapa and Msabaha on the coast are being utilized for the coast improvement program. A brief description of these sites is given in Table 1.

The breeding methods consist essentially of selection, hybridization and selection, crossing and backcrossing, hybrid production and population improvement as shown in Table 2 by means of flow chart. The main projects currently being emphasized are:

1. Dryland Varieties

The local cultivars are generally late, tall growing and have pigmented testa. These are not suitable for the drylands as they give very low or no yield during the drier seasons. Varieties recommended till now have been of exotic origin and are selections from various international testing nurseries and introductions. These varieties (2K x 17, 954063, 76T1#23, NES 7360, IS8595, SC566-14) are slightly early, high yielding, and of good grain quality. However, they are susceptible to Charcoal rot and do not perform well in the semi-arid lowlands (below 1000 meters) especially in drier seasons.

Recently, few excellent lines (tan, very early, fair resistance to charcoal rot and good grain quality) have been derived from the local populations. Since their yield potential, height,
Table 1. Brief description of the testing sites being used by KDSIP.

<table>
<thead>
<tr>
<th>Location</th>
<th>Zone</th>
<th>Altitude (m)</th>
<th>Rainfall (mm)</th>
<th>Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Katumani</td>
<td>Semi-arid</td>
<td>1575</td>
<td>718</td>
<td>Bimodal</td>
</tr>
<tr>
<td>(Machakos)</td>
<td>Mid highlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Kampi ya Mawe</td>
<td>Semi-arid</td>
<td>1125</td>
<td>721</td>
<td>Bimodal</td>
</tr>
<tr>
<td>(Machakos)</td>
<td>Mid lowlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Murinduko</td>
<td>Semi-arid</td>
<td>1380</td>
<td>1012</td>
<td>Bimodal</td>
</tr>
<tr>
<td>(Embu)</td>
<td>Mid highlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Ithookwe</td>
<td>Semi-arid</td>
<td>1130</td>
<td>1049</td>
<td>Bimodal</td>
</tr>
<tr>
<td>(Kitui)</td>
<td>Mid lowlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Lower Embu</td>
<td>Semi-arid</td>
<td>&gt;1000</td>
<td>400-600</td>
<td>Bimodal</td>
</tr>
<tr>
<td>(Meru, Kitui)</td>
<td>Lowlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Kiboko, Baringo</td>
<td>Dry</td>
<td>1000</td>
<td>300</td>
<td>Monodal</td>
</tr>
<tr>
<td>(Turkana)</td>
<td>Lowlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Lanet</td>
<td>Semi-arid</td>
<td>1860</td>
<td>850</td>
<td>Monodal</td>
</tr>
<tr>
<td>(Nakuru)</td>
<td>Highlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Matuga</td>
<td>Coastal</td>
<td>116</td>
<td>947</td>
<td>Bimodal</td>
</tr>
<tr>
<td>(Kwale)</td>
<td>Hinterlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Magarimi</td>
<td>Coastal</td>
<td></td>
<td>1000</td>
<td>Bimodal</td>
</tr>
<tr>
<td>(Kilifi)</td>
<td>Hinterlands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Msabaha</td>
<td>Coastal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Malindi)</td>
<td>Plains</td>
<td>91</td>
<td></td>
<td>Bimodal</td>
</tr>
<tr>
<td>11. Mtwapa</td>
<td>Coastal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Mombasa)</td>
<td>Plains</td>
<td>21</td>
<td>1267</td>
<td>Bimodal</td>
</tr>
</tbody>
</table>
Table 2. Flow Chart showing the (long term) sorghum breeding procedures being used in the Katumani Dryland Sorghum Improvement Program (KDSIP).

INTERNATIONAL TRIALS
INTERNATIONAL NURSERIES
EXOTIC VARIETIES INTRODUCTIONS
LOCAL COLLECTIONS

SPECIAL NURSERIES
1. DISEASE COMPLEX
   Charcoal rot, Smuts, Moulds leaf diseases, etc.
2. PEST COMPLEXES
   Shootfly, Stemborer, Midge Storage pests, etc.
3. PHYSIOLOGICAL STUDIES
   Drought resistance, cold tolerance, Ratooning ability, etc.
4. MORPHOLOGICAL STUDIES
   Grain quality, bird resistance, etc.

SINGLE PLANT PROGENIES
UNIFORM PROGENY BULKS
GERMLASM

TETRAPLOID PROGRAM
ELITE LINES
OFF TYPES

CROSSING NURSERIES
- Combining ability studies
- Backcrossing for specific traits, for male sterility, for A and B lines
- Classification into A and R lines
- Production of hybrids

R Lines Yield Tr.  B Lines Yield Tr.
R Lines Adap. Tr.  B Lines Adap. Tr.

Hyb. Pre. Yield Tr.
Hyb. Adapt. Tr.

Fl Progenies
Random mating Pop.
Pop. Improvement Cycles
Elite Populations

Pop. Eva. Nurs.
Pop. Pre. Yield Tr.
Pop. Adapt. Tr.

Pop. Derivatives

Pre. Var. Yield Tr.
Var. Adap. Tr.

Off Types
Microincreases

Processing and Utilization Studies
Crop Husbandry
Farming Systems

Varification Tr.
On Farm Tr.
Demonstrations
Production Plots
Release & Recommendations
disease and pest resistance need improvement, local x exotic and exotic x local crosses and backcrosses are made and in addition, a random mating population based on MS7 genetic system is being developed. Every season, selections are made from both the local and the exotic germplasm in addition to pedigrees from crosses between the parents having the desired traits and from population derivatives.

2. Dryland Populations (Composites)
For the past several seasons, the West African Early Bulk Population has been improved by female choice mass selection. The resulting, short, early, good grain quality, widely adapted, random mating population (Dryland Population 821) is performing very well. It is, however, not showing high degree of resistance to charcoal rot and lacks uniformity with respect to height and head shape and is being improved by SI recurrent selection techniques. Another population based on the local collections (Dryland Bulk 822) was synthesized last season. It is composed of slightly tall, very early lines with good grain quality, fair resistance to charcoal rot and a plant type which appears to be well adapted to the drier environments. Currently, new populations based on the local germplasm and exotic varieties with desirable traits is being reconstituted using the genetic MS7 system from the improved West African Early Bulk. Both Varieties and composites are to be derived from the population which will be simultaneously improved through recurrent selection.

3. Dryland Hybrids
The program had previously developed excellent hybrids based on the exotic steriles. Several promising restorer lines were also identified. But as soon as the current cycle of drier seasons started, all the available hybrids were found to be very susceptible to charcoal rot under drought stress and as far as the drylands were concerned, the on-going program had to be abandoned. A new hybrid program has been initiated with the main emphasis at present on selection of parents with desirable traits, especially with respect to drought, grain quality and resistance to charcoal rot. However, compared to varieties and composites, hybrids are being given low priority.

4. Bird Resistance
Mostly, the birds leave alone sorghums which have pigmented testa, but such cultivars produce poor quality food and their acceptance is low. Palatable corneous grain types are most susceptible. Genotypes in which it is awkward for the birds
to take the grains have been developed but have been generally unsuccessful in significantly reducing bird damage. The characters considered include goose-neck, large glumes enclosing the grain, long strong awns, and brightly coloured grains. Bird damage in loose, lax or drooping panicles and in varieties with pigmented pericarp (but pigmented testa is absent) is under investigation. There is apparently no genetic solution to this problem other than using varieties with pigmented testa. Further development of such genotypes will depend on the results of the investigations on grain processing (dehulling), utilization and marketing and programs will be developed accordingly. However, short statered cultivars in which the flowering of the tillers is synchronous are being selected to make bird scaring easier.

5. Drought Resistance
Currently, the emphasis is on genotypes which can escape drought by flowering early. An attempt is being made to identify the morphological and physiological traits which contribute to water use efficiency and give the plant true drought resistance at different growth stages. Such traits will be incorporated into the overall breeding objectives and will hopefully help to overcome the problems associated with erratic rainfall, especially during the seedling stage. An irrigatable nursery is being established and by means of line source irrigation such investigations are expected to be further facilitated. Few lines from the local germplasm have been identified which appear to be very promising as source of true drought resistance.

6. Charcoal Rot Resistance
As already mentioned, this problem is receiving high priority. Both charcoal rot and drought resistance are very closely associated. Charcoal rot susceptibility is generally very high during droughts. It has been observed that most of the available genotypes which flower early and those which build up large reserves of assimilates during early growth stages are generally very susceptible to charcoal rot under stress conditions late in the season. The susceptibility of non-senescent and partially senescent cultivars is under investigation vis-a-vis their drought resistance. In some of the local materials, lodging due to charcoal rot occurs when the grain is physiologically mature. Hence, as long as the crop is immediately harvested, the economic loss in yield may be low. Field screening against charcoal rot is facilitated in the normal trials in the lowland substations during the dry seasons especially when there has been ample rainfall initially in the season. These studies are also carried out under controlled irrigation with artificial inoculum. The resistant lines are utilized in the
varietal, composite and hybrid programs. One medium maturing variety (2K x 17) has shown complete resistance. The early maturing local population (Dryland Bulk 822) has shown fair resistance.

7. Resistance to Stem Borer and Storage Pests

Inspite of the seriousness of these problems, very little work is being done on them with respect to breeding due to lack of facilities. No suitable genotypes with stem borer and storage pest-resistance have been identified. A program to evaluate the whole working collection of local and exotic elite lines against stem borer has just been initiated. Until now we have not been able to evaluate resistant lines developed by other programs especially ICRISAT, AICSIP and ICIPE. Emphasis is on identifying lines with fair to complete resistance to borer damage. Investigations on resistance to storage pests have not been initiated.

8. Grain Quality

Very little information on consumer acceptance of the quality of existing and improved sorghum grains is available. The results of preliminary investigations on the quality parameters affecting post-harvest grain deterioration and traditional food preparations in addition to the milling, processing, utilization and marketing studies are just beginning to come in. Until precise criteria is established, a wide range of grain qualities are being produced especially with respect to grain size, shape and color; percarp and testa thickness, presence or absence of pigmented testa, endosperm texture and endosperm color.

9. Germplasm Conservation

Due to the lack of resources and facilities, KDSIP cannot at present undertake to collect, evaluate, document and maintain the local collections. However, in the absence of any other national agency undertaking this responsibility, selections from the 1980 local collections of Dr. Wood have been maintained. Several more collections from the local farmers in the target areas are at present being made and purified by single plant selection, after which they are added to the working germplasm, which also includes selections from all the exotic introductions and any other material which has some good breeding potential. This working germplasm is being documented and maintained at Katumani under field conditions. A portion of each of the local collections made through consultancy in 1977, 1978, and 1980 are in long term storage at Kitale. The documentation of these collections is not yet available and hence these collections are not being utilized at present.
10. Collaborative Programs

A. High-Altitude Program

The KDSIP is providing leadership to this program to a limited extent. The primary objective is to develop good quality cold tolerant varieties which can be used as human food and as annual feed. The main problems in these regions are diseases and to some extent pests. One variety (Provenda or E1291) has been recommended. It produces red grains with pigmented testa and is quite susceptible to leaf diseases. It is however high yielding. Field screening against bacterial stripe and streak, grey leaf spot, anthracnose, leaf blight, rust, honey-dew disease, and grain moulds is included a part of the normal program.

B. Coastal Program

This program is being run jointly with the coast Agricultural Research Station, Mtwapa, for the coastal plains and hinterlands. Insects (shootfly, stem borer, midge and storage pests) and Diseases (leaf blight and moulds) resistance are being given high priority. In addition, high and stable yields, wide adaptation and good grain quality for food and storage are emphasized. One variety (Mtwapa local population) is being recommended. It is very high yielding, but has a pigmented testa. Dryland population 821 performs well in this zone although disease and pest problems are high.

C. Lake Basin Program

This program was being handled separately at Alupe and has been temporarily halted. Sorghum is already very popular in this area. Most of the local grain sorghums are tall and late and produce high tanin brown grains which are able to resist moulds and bird damage. These cultivars are also able to tolerate Striga to quite an extent. One of the local genotypes has been purified and multiplied under the name Sabina. Among the improved cultivars, Serena and Seredo (5D x 135/13/1/31) are recommended. Both are short and early and have pigmented testa. All the breeding material for this zone is at present in cold store at Kitale.

D. International Collaboration

In the past, there has been very close cooperation with several institutes and programs, especially ICRISAT (India), AICSIP (India), TAES (Texas), ESIP (Ethiopia), CIMMYT (Mexico) and Purdue Univ. (U.S.A). Participation with these agencies and programs has been at the levels of International trials (replicated), International nurseries (unreplicated) and Introductions (on special requests). All these programs have been a very important sources of germplasm especially for the varieties, populations, and A and B lines. While most of the
materials received were planted, often the trials had to be broken down with each replicate planted at different locations. When the materials performed poorly, they were abandoned. In general, the data taking standards were poor, but, whenever any interesting genotypes were identified, they were retained for further evaluation. Subject to availability of resources, participation with these bodies will be increased. With experience and training obtained in the past, it is expected that the standards of data taking will be improved.
STATUS OF SORGHUM RESEARCH IN RWANDA

Celestin Sehene

Background

Rwanda is a central African country located between 1°5' and 2°50' south latitude and 28°50' and 30°50' east longitude. It is bordered by Uganda in the north, Tanzania in the east, Burundi in the south and Zaire in the west. The country is mostly mountainous and has a total area of about 26,338 km². The population of Rwanda is about 5 million of which 90% is engaged in agriculture. The climate of Rwanda allows its farmers to grow diverse crops including sorghum. According to statistics of 1979, sorghum occupied 16.7% of the total area in Rwanda devoted to food crops. If only cereals are considered sorghum takes first place in importance (Table 1 and 2).

Sorghum production in Rwanda is a traditional practice. More than 70% of the national sorghum production goes into fermented and unfermented beer making. The sorghum grain in Rwanda is also used for eating as boiled product or as ugali. Sometimes a mixture of sorghum flour and cassava flour is used for making ugali in Rwanda. The sorghum stem is used for house roofs and for making fences around houses. The stems are also used as mulch in coffee plantations and for fuel where it is difficult to get fire wood. The ratoons are often grazed by animals in the field. Ratoon crops are seldom harvested in Rwanda.

Sorghum is grown almost everywhere in the country, ranging from the lowlands up to highlands of about 2500 m altitude. The main areas for sorghum production in Rwanda are:

a) The Mayaga, including parts of Kigali, Gitarama and Butare districts. This area has medium rainfall ranging from 900 to 1200 mm annual rainfall. The altitude varies from 1200 m to around 1800 m. The area between the central and south eastern part of the country produces about 43% of the total national production.

b) The northern part including Gisenyi, Ruhengori and Byumba districts produces about 33% of the total national production. This northern part is mostly highland (medium to high) with some parts being volcanic. The rainfall is between 900 mm and 1200 mm annually.

1 Ingenieur Agronomc and Leader of the Rwandan Sorghum Improvement Program, ISAR Rwerere, BP 73, Ruhengeri, Republique Rwandaise.
c) The remaining parts of the country are relatively unimportant for sorghum production.

Generally, sorghum in Rwanda is grown for one season per year in a given area. However, the variations in sowing dates and rainfall patterns are so diverse that sorghum could be found growing somewhere in the country anytime of the year. The December-January sowing with its June-July harvesting is the main sorghum crop season of Rwanda. The June planting is dominant only in the north of the country and the harvesting time for this region is February.

Research Work on Sorghum

Selection

The selection work on sorghum in Rwanda has the main objective of producing high yielding cultivars adapted to the different agro-ecological conditions of the country. Such cultivars must be suitable both for growers and consumers of sorghum in Rwanda. The national sorghum program has worked on local and exotic materials. The exotic materials have been mostly received from neighbouring countries and international institutions dealing with sorghum research.

The selection work is mainly conducted in three stations of ISAR (Institute of Agronomic Sciences of Rwanda) situated in the three major ecological zones of sorghum. The Karama station represents the lowland and semi-arid areas, the Rubona of station typical of the medium altitude zone up to 2,000 m altitude and the Rwerere station is representative of the highland area of sorghum production in Rwanda (Table 3).

Collections

Our initial efforts concentrated on local collections from rural areas of Rwanda. At the same time, we made introductions from such countries as Nigeria, Chad, Cameroun, Tanzania, Ethiopia, and Uganda. All introductions were planted in Rubona station up to 1968. After that we started work with a collection in Karema station consisting of germplasm collected in the area surrounding the station and additional materials coming from Rubona. Then we received and grew ICRISAT and Ethiopian materials. In Rwerere, work on sorghum started only in 1975 and up to now we keep only local varieties. We have not been able to get exotic varieties doing well in the highland areas of Rwanda.

A comprehensive collection of Rwandan sorghum germplasm has been made by ICRISAT staff in July 1982. One part of the collection is kept by ICRISAT (Hyderabad) and a duplicate went to IBPGR (International Board for Plant Genetic Resources). There is a wide variation in our local sorghum germplasm but according to the report of the ICRISAT collections, all of them belong to Durra-Caudatum and Caudatum race.
Yield Trials
The varieties which have performed well in the collections are normally advanced to yield trials for further evaluations in comparison with a standard local check. Such trials started in 1957 in Rubona, in 1970 in Karema, and in 1979 in Rwerere. According to the number of available promising varieties in the collections, new yield trials have been started and sometimes they have been run multilocationally to identify varieties with broad adaptation for extension.

Agronomic Trials
Upto now, agronomic trials have been made on plant population, method of sowing, and fertilization. We normally use 10 kg seed per ha.

If we consider the use of chemical fertilizers, trials have been conducted in Rubona and Karama stations in order to see the response of our promising varieties to chemical fertilizers. The results we have do not allow us to say what the optimum level of different elements in a given area should be. The trial is going on in Rubona.

The plant population trials have shown that the best yields have been obtained with high density (+ 180,000 plants/ha). The plant density normally used by farmers is not known.

Some samples taken in the field gave numbers from 100,000 to 250,000 plants/ha. The high population levels have been associated with high lodging problems. For all of the agronomic trials in the different stations, the person in charge of the national sorghum program prepares all seeds and instructions including data sheets and sends them for execution to the appropriate stations. In such stations there is normally at least one scientist dealing with crops other than sorghum and a technician. These two persons follow up the execution of the program in their station. The person in charge of the national sorghum program visit his trials at each of the stations regularly and make further observations and evaluations.

Although there are other areas such as disease and insect resistance, grain quality, physiology in which investigations should be underway, because of lack of staff we do not have strong programs in these areas but we take observations in a general way.

Financially, our national sorghum program is being supported by IDRC. They started in 1976 with our highland program and now the IDRC support covers the whole country.
Extension

For the different ecological zones of Rwanda, selected varieties have been recommended and introduced to farmers.

a) Lowland area - The three recommended varieties are SVR 1, SVR 101, and SVR 157. All are local. These varieties are generally of five months duration and their experimental plot yields are about four tons grains per ha.

b) Medium altitude area - Five varieties are recommended and these are SVR 157, Ikinyaruka, Susa, Gahunda, and WS 1297. The last named variety is of Ethiopian origin and came to us through the ALAD program in Lebanon. The other four are local. The duration of these varieties is 5.5 to 6 months and the production potential is between 4.5 to 15 tons grain per ha.

c) Highland area - The two recommended varieties are BM 10 and BM 27 and both are local. The duration of these is 6 to 6.5 months and production potential is from 4.5 to 5 tons grain per ha.

d) Volcano Zone - The three recommended varieties, all local, are BM 1, BM 3, and N 10.

Future Plans

We will concentrate our efforts on getting varieties or populations which will give high yield under limited land availability. In general our varieties are too tall and lodging is a problem. We will try to develop varieties with medium height. These varieties must have sufficient resistance to disease especially leaf diseases.

Insects are important in the field, particularly shoot fly (Atherigona soccata) and stem borer. In storage, the main problem is the grain weevil (Sitophilus sp.) which may cause up to 80% damage after 6 months of storage especially in hot areas. Birds are also a problem for sorghum in the field but we do not plan any breeding program specific to birds.

We will continue to make introductions of exotic materials especially from such places as Ethiopia (ESIP) and India (ICRISAT). There is already good collaboration between them and us. We plan to participate more actively in international and regional programs. Generally, in the past, we did not introduce international and regional trials but only some varieties for selected areas. We have in the past grown the ICTSAN from CIMMYT in our highland areas but only one variety having a name similar to ours, Nyundo Original, appeared to be promising.

Beginning in 1983, we will start a breeding program using crossing approaches for pedigree selection and backcrossing especially for plant height and disease resistance. Additionally we plan to work on population improvement techniques using genetic male sterility. But as all of these methods are long term in nature, our selection work will continue to use mass selection and pure line selection in order to get new material for extension in a short time.
Table 1. Production statistics for the three major cereals of Rwanda.

<table>
<thead>
<tr>
<th>District (Prefecture)</th>
<th>Total area in ha</th>
<th>Production in tons</th>
<th>Yield in kg per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sorghum</td>
<td>Maize</td>
<td>Wheat</td>
</tr>
<tr>
<td>Kigali</td>
<td>25,888</td>
<td>8,471</td>
<td>4</td>
</tr>
<tr>
<td>Gitarama</td>
<td>11,064</td>
<td>3,600</td>
<td>-</td>
</tr>
<tr>
<td>Butare</td>
<td>25,129</td>
<td>2,531</td>
<td>-</td>
</tr>
<tr>
<td>Gikongoro</td>
<td>15,213</td>
<td>6,679</td>
<td>1,630</td>
</tr>
<tr>
<td>Cyangugu</td>
<td>3,207</td>
<td>7,903</td>
<td>1</td>
</tr>
<tr>
<td>Kibuye</td>
<td>7,029</td>
<td>5,217</td>
<td>56</td>
</tr>
<tr>
<td>Gisenyi</td>
<td>9,223</td>
<td>11,564</td>
<td>160</td>
</tr>
<tr>
<td>Ruhengeri</td>
<td>16,100</td>
<td>13,515</td>
<td>1,824</td>
</tr>
<tr>
<td>Byumba</td>
<td>20,963</td>
<td>10,517</td>
<td>276</td>
</tr>
<tr>
<td>Kibungo</td>
<td>13,602</td>
<td>7,942</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>147,418</td>
<td>77,759</td>
<td>3,951</td>
</tr>
</tbody>
</table>

The national average yields are:
- Sorghum = 1,102 kg/ha
- Maize = 1,077 kg/ha
- Wheat = 753 kg/ha

Sorghum occupied 64% of the total cereal area of the country.
Table 2. Main crop groups produced in Rwanda.

<table>
<thead>
<tr>
<th>Category</th>
<th>% of total crop area occupied</th>
<th>% of total production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>22</td>
<td>46.6</td>
</tr>
<tr>
<td>Legumes</td>
<td>35.3</td>
<td>5.6</td>
</tr>
<tr>
<td>Cereals</td>
<td>26.1</td>
<td>5.9</td>
</tr>
<tr>
<td>Tubers</td>
<td>16</td>
<td>40.9</td>
</tr>
<tr>
<td>Fruits &amp; Vegetables</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Rapport Annuel Minagri 1979

Table 3. Principal characteristics of the three sorghum stations of ISAR.

<table>
<thead>
<tr>
<th>Station</th>
<th>District</th>
<th>Altitude</th>
<th>Rainfall</th>
<th>Average temperature</th>
<th>No. of dry months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubona</td>
<td>Butare</td>
<td>1650 m</td>
<td>1171 mm</td>
<td>18.9°C</td>
<td>2-3</td>
</tr>
<tr>
<td>Karama</td>
<td>Kigali</td>
<td>1400 m</td>
<td>853 mm</td>
<td>20.8°C</td>
<td>3-4</td>
</tr>
<tr>
<td>Rwerere</td>
<td>Ruhongeri</td>
<td>2300 m</td>
<td>1166 mm</td>
<td>15.6°C</td>
<td>2-3</td>
</tr>
</tbody>
</table>

Source: ISAR - Activité 1974
SORGHUM IMPROVEMENT IN SOMALIA

A.N. Alio

Background

Sorghum has been grown as a cereal grain crop in Somalia since time immemorial, it still ranks highest in land area under cultivation, variously put as 300-350,000 ha. Most of the crop is grown under rainfed conditions in semi-arid areas. In the inter-riverine area of the Juba and Shabelli rivers, maize cultivation has really increased in popularity over sorghum because of its easier cultivation, higher yield and fewer problems with grain eating birds, such as Quelea quelea.

Sorghum is the main food and fodder crop of the country. Bay region is the Centre of Sorghum Production in Somalia. Bonka Agricultural Research Station is the dry-land experimental station. Since 1980, the station is administratively under Bay Region Agricultural Development Project Authority. Sorghum Improvement Program is coordinated by the sorghum team of ARI/IDRC. The Sorghum Improvement Project IDRC advisor has his centre at Bonka Station.

Afgoi Central Agricultural Research Station (CARS) is for irrigated as well as dry-land crops. As the humidity in Afgoi is high and this normally causes a high incidence of insects and pests, the sorghum trials have been shifted into Oil Seed Development Project Farm at Laba Garas, 60 km N.W. of Mogadishu. It is mainly dry-land farm and provides an additional testing site.

Aburein Agricultural Research Station is under N.W. Region Agricultural Development Authority. It is the highland rainfed crops experimental centre. The station is understaffed for the time being.

In Somalia, past meteorological data show that the amount of rain in the first season (Gu) is more reliable than the second of the year (Der). The normal of Gu is 350-400 mm and that of Der season is 200-300 mm. The main work carried out has been putting great emphasis on identifying varieties that can replace, advantageously, the local races, which normally are low yielders. Special attention has been given to the fact that the local races are drought tolerant and produce some yield even under severe water stress (shortage of rains).

1Director of Research, Agricultural Research Institute, Ministry of Agriculture, Mogadishu, Somalia.
Sorghum will continue to be the most important crop in Somalia for the following reasons:

- it is the most promising and adapted crop in the semi-arid climate where the little rain received is highly variable and generally unreliable;
- it is well accepted as the main staple of the people;
- research work done in Somalia and elsewhere in the world shows that new sorghum types or gradual improvement of existing varieties will most probably produce types that have grain qualities close to those of maize under similar semi-arid climatic conditions and;
- since Somalia will continue for a long time to come to be a livestock economy country, sorghum grain and stalks will be of major importance as livestock feed.

The sorghum varieties grown in the country are:

- late maturing types that take 6 months to maturity, commonly grown in the highland region of the North and North West, and
- early maturing ones of 3 to 4 months duration grown in the inter-riverine and southern parts of the country. These are low yielding varieties naturally selected by the moisture conditions in the field over many generations, the selection criterion seemingly being stable yield under the unfavourable moisture conditions. They have well accepted palatability and their grain stores well.

Research work conducted by the Agricultural Research Institute (ARI) shows that improved cultural practices such as timely planting, weeding, pest and disease control, soil moisture conservation and bird control, can more than triple sorghum yields in the country, hence, there is need for more research and extension work in the various agro-ecological zones.

Objectives

The broad objective of the national sorghum program is the improvement of sorghum for food production under rainfed conditions in different agro-ecological zones of Somalia.

The specific objectives as outlined in the national sorghum improvement program are:

1. The development of improved sorghum cultivars with the following characteristics: high yield, drought tolerance and early maturing, and acceptability to Somalia consumers.
2. The development of soil and crop management practices suitable for improved cultivars and the agro-ecological situations which are culturally adaptive, and

3. The strengthening of research-extension capability through training and improving physical facilities.

Methodology

The national sorghum program has been rejuvenated based on clearer objectives and with cooperation of different national agencies or development projects such as Bay Region Agricultural Development Project (BRADP) and North-West Agricultural Development Project (NWAP) with the support of the International Development Research Centre (IDRC).

A. Screening and selection of varieties using local as well as exotic germplasm:

Initially the trials included all the most promising local and introduced sorghum cultivars already tested in the country. Work is now concentrated in three target sorghum production areas at Central Agricultural Research Stations (CARS) at Afgoi with altitude of 200 m, Bonka Research Station at Baidoa with 400 m altitude, and Aburein in N.W. Region with 1500 m altitude. Local cultivars, partially collected in 1979, are put along with varieties received from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and from other sorghum improvement projects elsewhere for evaluation of their adaptability, yield and quality of grain under conditions of Somalia. The selected varieties are to be further evaluated before release or to be crossed with promising local lines to improve the local varieties. Selection within materials derived from the crosses is expected to give rise to promising lines for further testing and eventual release.

The major criteria for selection are:

- early maturity to escape and to minimize bird damage and to fit the moisture peaks during the short, low rainfall periods,
- shorter plant height to reduce lodging and moisture demand;
- higher yield,
- resistance to diseases such as smuts,
- resistance to pests such as shoot fly and stalk borer;
- consumer acceptability,
- resistance to bird damage, and
- better storage ability.

B. Breeding

The breeding program is initiated as part of varietal development program to incorporate desirable characteristics of the most promising introduced varieties into the best local varieties keeping the background of drought and pest tolerance. The actual hybridization is done at Bonka but selection is to be performed in the different locations.

The breeding work includes breeding for resistance to smut and resistance to stemborers. At present, we are in the stage of preliminary screening for resistant or tolerant varieties.

C. Cultural Practices

The national sorghum improvement program includes studies aimed at the development of a suitable package of cultural practices.

Date of Planting

Usually the farmers wait for the first rains to soften the soil before starting to sow. The time of planting is very important because the rainy period is a short one. Studies on date of planting will help growers to determine the appropriate time to sow to make maximum use of the moisture. Localized studies show that timely planting can increase the yield by 50 to 80%.

Plant Population

Plant populations seen in farmers fields are much lower than optimum. Preliminary studies show that populations of 30 to 50 thousand plants/ha are optimal. The farmers' practice of sowing 4 to 6 seeds per hill and not thinning is being discouraged. A better distribution of the plant population over the field is expected to increase yields by making more efficient use of the available moisture.

Moisture Conservation

A traditional way of accumulating moisture at the desirable place is the use of basins and bunds. Basins are made on sloping lands and their size varies from 2x2 m to 25x25 m depending on the slope. Bunds are built on parallel lines with distances of 25 to 30 from each other. Tests conducted in bunds and on open
land have shown significant differences in favour of the bunds.

D. Crop Protection

The most important disease in sorghum is the smut. Studies have shown that up to 60% reduction in yield can be attributed to attacks of smut. Research is going on to identify the best and safest seed treatment chemicals to prevent or reduce losses due to smut until such time as varieties with genetic resistance to smut are available. Of other diseases, anthracnose and leaf blight may cause some damage but their economical importance is rather low in the more arid regions. In the more humid regions, they cause comparatively larger losses but the evaluation of such losses is difficult.

Stem-borers and shoot fly cause very high losses. For the time being we combat these pests with the use of Diazinon or Basudin-10. Research is also going on to identify lines resistant or tolerant to these insects with the view to incorporating the resistance into the more desirable varieties. The work on disease and insect pests is being carried in cooperation with major centers as ICRISAT and Texas A&M University.

Protection from birds is another project going on. The Quelea is the most important among the birds causing harm. Studies are being conducted to find varieties which are nonpalatable to the birds. Some work on chemical repelants is also being done. The Quelea control program of FAO is going on to try to limit the population of these birds over the Eastern Africa Region.

Achievements

The results of old scattered experiments are being compiled, discussed, and prepared for release to the farming community with the help of the extension service.

Already the ties between research and extension are being strengthened with closer cooperation. Development of varieties adapted and suitable to the different regions of Somalia is going to take a while till concret results are achieved. The Agricultural Research Institute is hopeful that such varieties can be produced in the near future.
Sorghum (Sorghum bicolor) is the most important grain crop in the Sudanese economy and diet. It ranks first both in total tonnage of grain produced and total area cultivated, with over 1/3 of the total crop land in the country devoted to sorghum (Table 1). Every year, about 75% of the total cereal production in the Sudan is generated from sorghum. In 1978/79, for example, the total area under sorghum was over 3 million hectares and about 2.4 million metric tons of sorghum grain was produced, whereas, the total production from all other cereals (millet, wheat, rice, and maize) was less than one million metric ton (Table 1).

### Table 1. Area, production and average yield of major crops in the Sudan - 1978/79.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area in 1000 feddan*</th>
<th>Production in 1000 m.t.</th>
<th>Average yield, kg/feddan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>1036</td>
<td>400</td>
<td>272</td>
</tr>
<tr>
<td>Sorghum</td>
<td>7202</td>
<td>2408</td>
<td>334</td>
</tr>
<tr>
<td>Millet</td>
<td>3079</td>
<td>550</td>
<td>179</td>
</tr>
<tr>
<td>Wheat</td>
<td>586</td>
<td>177</td>
<td>302</td>
</tr>
<tr>
<td>Rice</td>
<td>20</td>
<td>10</td>
<td>500</td>
</tr>
<tr>
<td>Maize</td>
<td>145</td>
<td>45</td>
<td>310</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>2328</td>
<td>798</td>
<td>343</td>
</tr>
<tr>
<td>Sesame</td>
<td>2057</td>
<td>214</td>
<td>104</td>
</tr>
<tr>
<td>Horse Beans</td>
<td>31</td>
<td>21</td>
<td>677</td>
</tr>
<tr>
<td>Haricot Beans</td>
<td>6</td>
<td>4</td>
<td>666</td>
</tr>
</tbody>
</table>

Source: Department of Agri. Economics and Statistics, Ministry of Agriculture, Food and Natural Resources.

* One feddan = 0.42 hectare

1 Feb. 1980 report to the ICRISAT in-house review, Mombasa, Kenya.

2 Sorghum Breeder, ICRISAT - West African Cooperative Program, Gezira Research Station, Wad Medani, Sudan.
In Sudan, like in any other semi-arid tropical Africa, sorghum is the main staff of life for millions of people in the country. In many parts of the country, the crop is wholly utilized. The grain is used for making kisra (unleavened bread from fermented dough), a significant portion is also used as porridge, as locally popular beverage (abreih) and as local beer (marisa). The stalks are used as building material, animal feed, and as source of fuel. It is undoubtedly the nutritional backbone of the country.

Area, Production, Yield and Ecological Zones of Sorghum in the Sudan

Sudan is the largest country in Africa with about 2.5 million km² of land. It covers regions of vast ecological variation ranging from a typical desert climate in the North with little or no precipitation to tropical forest zones of the South region where precipitation up to 1500 mm is often recorded. With a significant portion of Sahelian Africa lying in the Sudan, it is of major importance in efforts to produce food for the poorest of the poor in the SAT.

Sorghum is grown in all corners of the country where it is possible to raise a crop. Table 2 shows that sorghum is produced in all provinces of the country, from the arid region of the North to the high rainfall climate of the Southern region. The bulk of the crop is grown mainly in the central clay plains which include the provinces of Kassale, Gezira, Blue Nile, White Nile and Southern Kordofan. This area which is essentially the sorghum-belt of the country accounts for over 65% of the total area under sorghum and 70% of the total sorghum production in the country. Over 90% of the total sorghum acreage is under rain and mostly mechanized.

It is interesting to note (Table 3) that the total area devoted to sorghum has been rapidly increasing whereas only a modest increase was possible in total production. Table 3 also shows the striking fluctuation and decrease in the average sorghum grain yield per hectare during the recent past decade. Many reasons are being cited as being responsible for both the drop in productivity and low total production. These include that the increase in acreage was mainly in the marginal lands with the irrigated component decreasing which resulted in a fall in productivity levels, poor management in the large mechanized farms, and high pressure on land in traditional farming areas which cuts short the length of the fallow period.

The length of the crop growing season ranges from about 2-3 months in the North to as long as 7-9 months in the South; this range is mainly dictated by the amount and distribution of rainfall. The type of soil in the sorghum growing areas of the Sudan also varies from sandy desert soils of the North where some sorghum is grown in the flood deltas of the river Nile to the dark, heavy, and cracking clays of the central rain lands.
### Table 2. Area, production, and average yield of sorghum by provinces - Sudan 1978/79.

<table>
<thead>
<tr>
<th>Province</th>
<th>Area in 1000 feddans</th>
<th>Production in 1000 m.t.</th>
<th>Average yield, kg/feddan</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Province</td>
<td>15</td>
<td>6</td>
<td>400</td>
</tr>
<tr>
<td>Nile Province</td>
<td>35</td>
<td>14</td>
<td>400</td>
</tr>
<tr>
<td>Red Sea Province</td>
<td>64</td>
<td>32</td>
<td>500</td>
</tr>
<tr>
<td>Kassala Province</td>
<td>2108</td>
<td>735</td>
<td>305</td>
</tr>
<tr>
<td>Gezira Province</td>
<td>604</td>
<td>273</td>
<td>446</td>
</tr>
<tr>
<td>Blue Nile Province</td>
<td>1242</td>
<td>430</td>
<td>339</td>
</tr>
<tr>
<td>White Nile Province</td>
<td>394</td>
<td>125</td>
<td>350</td>
</tr>
<tr>
<td>Khartoum Province</td>
<td>18</td>
<td>4</td>
<td>222</td>
</tr>
<tr>
<td>South Kordofan Province</td>
<td>616</td>
<td>201</td>
<td>320</td>
</tr>
<tr>
<td>South Darfur Province</td>
<td>410</td>
<td>123</td>
<td>300</td>
</tr>
<tr>
<td>Southern Region</td>
<td>1044</td>
<td>275</td>
<td>303</td>
</tr>
<tr>
<td>North Kordofan</td>
<td>600</td>
<td>180</td>
<td>300</td>
</tr>
<tr>
<td>North Darfur Province</td>
<td>52</td>
<td>10</td>
<td>192</td>
</tr>
</tbody>
</table>

Source: Department of Agricultural Economics and Statistics, Ministry of Agriculture, Food and Natural Resources.

### Table 3. Area, production, and average yield of sorghum in the Sudan 1969/70 - 1978/79.

<table>
<thead>
<tr>
<th>Year</th>
<th>Area in 1000 ha</th>
<th>Production in 1000 m.t.</th>
<th>Average yield, kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969-70</td>
<td>1776</td>
<td>1452</td>
<td>817</td>
</tr>
<tr>
<td>1970-71</td>
<td>1803</td>
<td>1534</td>
<td>745</td>
</tr>
<tr>
<td>1971-72</td>
<td>1913</td>
<td>1590</td>
<td>831</td>
</tr>
<tr>
<td>1972-73</td>
<td>1720</td>
<td>1300</td>
<td>755</td>
</tr>
<tr>
<td>1973-74</td>
<td>2226</td>
<td>1638</td>
<td>736</td>
</tr>
<tr>
<td>1974-75</td>
<td>2342</td>
<td>1704</td>
<td>729</td>
</tr>
<tr>
<td>1975-76</td>
<td>2651</td>
<td>1991</td>
<td>750</td>
</tr>
<tr>
<td>1976-77</td>
<td>2640</td>
<td>1800</td>
<td>683</td>
</tr>
<tr>
<td>1977-78</td>
<td>2798</td>
<td>2017</td>
<td>721</td>
</tr>
<tr>
<td>1978-79</td>
<td>3025</td>
<td>2408</td>
<td>795</td>
</tr>
</tbody>
</table>

Average 2289.4 1743.4 756.2

Source: Department of Agricultural Economics and Statistics, Ministry of Agriculture, Food and Natural Resources.
Development of Sorghum Research Program in Sudan

Sorghum improvement program in the Sudan is several years old. The Gezira Research Farm at Wad Medani was established in 1918 and although very little effort was spent on crops other than cotton, some attention was given to sorghum research owing to its role in the rotation of the cotton growing schemes in the nation. Most of the sorghum research activities in those early days included collection and evaluation of local sorghum germplasm and by the nineteen forties, some introduction of exotic sorghums had started. It was also soon after that Sudanese sorghum types found their ways to the United States where they have proven very useful.

A full fledged sorghum improvement program came into existence in 1952 with the establishment of the Central Rainland Research Station at Tozi. The national responsibility to undertake research on all aspects of sorghum improvement namely - breeding, agronomy, entomology and pathology was delegated to this station. It is probably beyond the scope of this paper to cite some of the early findings of sorghum research in the Sudan by C.H. Bacon, S.H. Evelyn, P.D. Walton, W.M. Tahir, and M.A. Mahmoud. However, one thing that appeared to have been very evident through the work of these scientists was that the traditional local varieties were too late, too tall, physiologically inefficient and unadaptable to the ever increasing mechanized farming. It was also reported that exotic introductions brought in at the time were not immediately adaptable. Hence, selection within local types for dwarf, early maturing, combine types was initiated by Walton and pursued by Tahir and then by M.A. Mahmoud.

The series of selection efforts in local sorghum types resulted in the isolation of such popular named varieties as Tozi Umbenis, Feterita Maatuk, Mugbash, Bahana, Dwarf White Milo, Gadam El Hamam, Dabar, Karkatib, etc. A number of these elite varieties from the sorghum research program are now in the hands of farmers' in the central clay plains. It was soon realized, however, that these improved local types, while physiologically efficient and well adapted to conditions intended for, possessed poor grain quality as many of the early selections were of high tannin types. This prompted change in orientation of the sorghum improvement program and emphasis was put instead on introduction of exotic sorghum types with good grain quality and further utilization of these elite introductions in hybridization with the local selections. At about the same time, in the 1960's some activity on hybrid sorghum program was also initiated. Nevertheless, only a limited success was possible from both the diversification and the planned hybrid program as this demanded more of the scare resources and more attention of the senior staff whose responsibilities included several other crops. Technical personnel were totally lacking, funds and facilities were limited.
Recent Achievements

A cooperative effort in sorghum improvement in the Sudan has made good progress in the following areas.

1. Diversification of Sudanese Sorghums

Much of the success of sorghum improvement in the Sudan had been realized only through individual plant selections among local types for short and combine types to meet demands of the increasing mechanized farms. Very little hybridization was done to diversify Sudanese types with exotic sorghums with better yield and grain quality characteristics. This was due to two important reasons. First the sorghum breeders had always had additional responsibilities in other crops or in administration. Secondly, the standard of the exotic introductions in the early days was poor, as many of them yielded lower than the local types.

Starting in 1972, in cooperation with ALAD and then in 1977 with the establishment of the ICRISAT cooperative program at Wad Medani both problems have been alleviated. The ALAD program is credited with the introduction of a wide array of useful potential and excellent grain quality characteristics. The ICRISAT program added on by continuing to introduce useful exotic types, utilize these in crosses with traditional and improved Sudanese types, and for the first time made possible the presence of a full time sorghum breeder in the country.

The improved local sorghum varieties released to farmers, while having good local adaptation, suffer from poor grain quality characteristics as many of them possess chalky white grain with high tannin content. In appreciation of this problem, several hundred crosses involving elite Sudanese types, adapted introductions mainly from ALAD and ICRISAT were planned for the winter of 1977/1978. A total of 984 crosses were made possible through this effort and the F_1's were grown in the rainy season of 1978.

In July of 1979 we space planted 514 F_2 populations from the crosses. The plot size was 12 m x 60 cm x 5 rows with spacing between plants being 20 cm thus resulting in approximately 300 plants per F_2 population. The stand establishment in general was fairly good and the crop expression was excellent under the optimum growing conditions provided at Wad Medani. Plant characteristics looked at as a tool for selection within each F_2 population included general adaptation, plant stature, head size, grain size and color, and disease resistance.

Owing to the unique and good combination of the traits of interest in each of the parents involved in the crosses and the good expression of the resulting segregates in the F_2
population, a mild selection pressure was used in selecting among the \( F_2 \)'s and a more intense selection was exercised within each \( F_2 \) population. A total of 1698 \( F_2 \) plants have been selected and these will be evaluated and selected in subsequent generations.

2. Development of a Hybrid Program

The potential for commercial sorghum hybrid production in the Sudan is very good and will perhaps be a natural development. For several years now, the national sorghum improvement program had been doing intensive selection for short combine types within the otherwise good local varieties to meet the demands of the rapidly expanding large mechanized farms. In the clay plains of Kassala, Gezira and Blue Nile provinces, which essentially constitute the sorghum belt of the Sudan, sorghum production has been mechanized. The average farm size being very large, short combinable types have been on good demand. In much of the rain lands, seasonal precipitation is usually unpredictable and unreliable that in some years yield reductions and even total crop failures do occur. It is believed that, superior hybrids identified under local conditions will have a rapid influence in increasing and stabilizing yield levels in the rain lands. In general \( F_1 \) sorghum hybrids, with their vigorous early growth, fast rate of growth, and ability to efficiently utilize limited moisture, are expected to produce higher and more stable yield under stress conditions than do varieties.

Efforts to develop commercial sorghum hybrids with increased and stabilized yield levels for the Sudan appears to be very timely and opportune with regard to the general structure of sorghum agriculture in the mechanized farming areas of the Sudan. The large mechanized farms are owned by farmers who are profit oriented and who understand the economics of the farm business fairly well. These farmers could easily be convinced to pay more for hybrid seed. At present, the production, distribution, and marketing of sorghum seed for the mechanized farms is the responsibility of the Plant Propagation Administration (PPA). This joint FAO/Government of Sudan venture is a well organized project, which, in the absence of commercial seed business, is ably supplying seed sorghum for much of the sorghum farms in the rain lands. With a potentially cultivable land area of 23,000 feddans and a number of trained technical staff, PPA could take up the task of hybrid seed production on a short term basis. In the long run, however, the hybrid seed market should open up new opportunity for interested Sudanese agriculturists who may decide to go into the seeds business.

With all these, however, we realize production of commercial hybrid sorghums and its impact on Sudanese agriculture and food
production is not very automatic. Agricultural development, being a systems deal, will require so many aspects to work well together for a program to succeed. On the aspect of crop improvement or breeding of hybrid sorghums for the Sudan, however, very little difficulty is anticipated. The ICRISAT cooperative program had already made a modest and good beginning. Several male sterile (A lines, female) sorghum types have been introduced from several sources - ICRISAT Center, ALAD, Purdue University etc. These collections of A Lines have been evaluated. In addition, equally important, a wide array of exotic materials have been introduced from similar sources, many of which are serving as good pollinators for hybrid sorghum production. The process of introducing exotic male sterile and restorer parents still continue. Several hundred experimental hybrids synthesized locally utilizing improved local and exotic germplasm were evaluated recently. The results were very encouraging with an average of 70% increase in yield over the best variety.

With regard to personnel, young Sudanese both trained and trainable, are available and can be motivated to fully participate. At experiment stations, the capability exists for production of experimental hybrids, their evaluation, and handling of nurseries. It is advisable, however, to start training staff in the technology of large scale hybrid seed production.

The program on hybrid seed development in the Sudan is expanding and efforts are put in introducing and evaluating A lines (female) and R-line (pollinator) parents, producing and evaluating an array of experimental hybrids in as many locations as possible, evaluating Sudanese sorghum collection for B-line (non restore) reaction, and develop well adapted and good yielding seed parents.

3. Collection, Evaluation and Maintenance of Sudanese Sorghum Germplasm

Over the years, several hundred sorghum cultivars have been collected from various parts of the Sudan. Many of the sorghum accessions from the Sudan have been introduced to many sorghum research programs around the world and were proven useful. This valuable set of germplasm had not been hitherto characterized and documented, however, because of limited funds and facilities within the national program. Several entries in this accession were either missing or had lost viability due to very poor storage facilities, where in addition to unfavourable temperature and humidity, insects and rats were obvious problems. As a result of such poor facilities and
unavoidable negligence by the staff whose responsibilities were thinly extended, the Sudanese sorghum germplasm had not been successfully maintained in the Sudan.

In June 1979, all IS entries of Sudanese origin maintained at ICRISAT Center along with the World Sorghum Collection (914 accessions) were retrieved from GRU and brought back to the Sudan for evaluation. At the suggestion of Dr. Mahmoud A. Mahmoud, most senior sorghum breeder in the Sudan, these retrieved accessions from ICRISAT and the original collection available at Wad Medani and/or Abu Naama were planted in paired rows for cross-comparison and checking of loss of identity. Some interesting results were obtained from this exercise.

A total of 2071 sorghum accessions were planted at Wad Medani for evaluation this past summer. The accessions were characterized for several agronomic characteristics including days to flowering, plant height, heat type, grain color, leaf disease reaction, glume color, etc.

Significant improvement was also made, this season, with respect to seed storage facilities at Wad Medani. Metal shelves have been put up, mouse-proof metal boxes have been purchased and a working air conditioner installed in the seed store. All these have greatly improved the condition that existed before.

A sorghum collection mission, financed by IBPGR and organized by GRU, ICRISAT, was undertaken here in November 1979. The mission successfully collected 158 wild and cultivated sorghum types from the provinces of Gezira, Kassla and Blue Nile. Several potentially useful accessions of cultivated sorghum were collected and some of them are already included in our 1979/80 winter crossing block.

Some areas in the Sudan, those within relatively easy access, have now been collected and fairly well represented in the Sudanese sorghum collection to be maintained at Wad Medani. However, many more sorghum growing areas have never been reached and thus are unrepresented in the present day collections. A concerted effort by all parties concerned, GRU at ICRISAT, IBPGR, and sorghum research programs in the Sudan, needs to be put to systematically collect the rich diversity of sorghum germplasm known to exist in the Sudan. It is not a simple project to undertake but undoubtedly a very essential one.

In no other African country is a complete erosion of the local genetic diversity more threatening than sorghums in the Sudan. In areas where new roads are opening and infrastructures improving, huge mechanized farms are rapidly expanding. The huge farms are owned by people who understand the economics of today's market. These farmers grow improved varieties from the
research program or one or two local varieties that have always been popular. It was learnt during the recent sorghum collection mission around Gedaref, for example, that a number of local land race types (Zera Zeras, Hegari, etc.) known to have existed in the area, before the advent of these mammoth mechanized farms, have now disappeared. This dramatizes that replacement of peasant cultivation is surely serving as a major factor in genetic erosion.

It is thus highly advisable that an effort be put to systematically collect local diversity in some of the presently remote areas of peasant cultivation where traditional land race varieties are still grown.

4. Expansion of the Germplasm Base with Introductions

In an attempt to expand the genetic base of the local germplasm, sorghum accessions have been introduced from various cooperative programs, with major consignments coming from the ICRISAT core program at Hyderabad, India. Such a massive, but careful, introduction is proving useful as accessions recently received are contributing important traits through diversification. Some materials are also showing good adaptation and these should have potential for direct use.

As an indication of the magnitude and range of introductions coming into the program, sorghum accessions received for observation during the Summer of 1979 are listed below:

<table>
<thead>
<tr>
<th>Accessions of 1979</th>
<th>Source</th>
<th>No. of Entries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Trials/Nurseries</td>
<td>ICRISAT</td>
<td>275</td>
</tr>
<tr>
<td>Karper Yellow Endosperm Nursery</td>
<td>ICRISAT</td>
<td>1808</td>
</tr>
<tr>
<td>Sorghum Accession-Sudanese</td>
<td>ICRISAT</td>
<td>914</td>
</tr>
<tr>
<td>Insect and Disease Nursery</td>
<td>ICRISAT</td>
<td>50</td>
</tr>
<tr>
<td>Striga Nursery</td>
<td>ICRISAT</td>
<td>961</td>
</tr>
<tr>
<td>Experimental Hybrids</td>
<td>ESIP, Ethiopia</td>
<td>75</td>
</tr>
<tr>
<td>Lines from Conversion Program</td>
<td>Texas A&amp;M University, USA</td>
<td>160</td>
</tr>
<tr>
<td>Zera Zera Selections</td>
<td>Purdue University, USA</td>
<td>16</td>
</tr>
</tbody>
</table>

5. Training of Technical Personnel

Through the ICRISAT training program, 8 technical assistants from the Sorghum and Millet Improvement Program in the Sudan have been trained for periods of 6-8 months at Hyderabad, India. This has greatly helped in strengthening the program by
providing skilled technicians with enthusiasm and appreciation of research in the field. We will continue to identify candidates to be trained at ICRISAT to satisfy technical personnel needs at outlying stations. Only two of the former ICRISAT trainees are working for the cooperative program outside Wad Medani.

Program Objectives

Current effort in sorghum improvement in the UNDP/ICRISAT Cooperative Program in the Sudan is perceived as a continuation of the existing national program. To realize the objective of enhancing profitable sorghum production and resolving food deficits in the Sudan, concerted effort needs to be put into accelerating sorghum improvement activities in the central clay plains, expand initially into the west and make a modest beginning in the south. This will only be achieved with increased staff strength locally, particularly through training of people for locations other than the main research station at Wad Medani.

The sorghum breeding thrust is slanted towards the following:

1. **Identify new good varieties:** To satisfy needs of the vast ecological variation in the Sudan, materials are evaluated in test locations of contrasting agro-climatic pattern. Plans are underway to obtain more test locations for the purpose of both identifying specific varieties for specific locations and also to attempt to isolate widely adaptable varieties. Sorghum germplasm for multilocation testing is to come from careful introduction from ICRISAT Centre and other cooperative programs and also from the diversification effort utilizing elite introductions and local germplasm with favorable traits. Improved grain quality is emphasized.

2. **Evaluate Elite Varieties in Hybrid Combination:** Elite introductions and superior varieties resulting from the local breeding program are evaluated in hybrid combinations on a large array of females (A lines) collected from various sources.

   In 1979 over 500 experimental hybrids produced locally were evaluated and fifty four of these were found to be superior. These are being reproduced for replicated yield trials to be conducted at several locations next season. It is also planned to produce several hundred experimental hybrids this off-season from parents found to be promising in multilocation testing in the rainy season of 1979. These will be evaluated in the coming rainy season.

   Programs are also underway to evaluate local germplasm for fertility reaction with the hope of isolating local types that could be converted to seed parents (A lines). Preliminary
results obtained from hybrids produced locally are very encourag-
ing and before long some of these hybrids may hopefully find
their way to farmers' fields.

3. Expand the Variability Available for Selection: As good and
promising introductions are identified, they are immediately
utilized in intercrossing with local types to diversify the
germplasm and expand the variability available for selection.
A very large scale intercrossing program initiated in the
winter of 1977/78 has already resulted in segregates combining
good yield potential, adaptability, and superior grain quality.

4. Major Priority on Striga Resistance: Striga hermonthica is a
noxious sorghum weed and a production problem of tremendous
importance, in all areas of the Sudan where sorghum is grown.
Even newly developed farm lands devoted to sorghum are often
seen with heavy infestation of Striga. In areas where there is
too little crop rotation activity and seasonal rainfall is low,
severe cases of Striga infestation are more noticeable, often
resulting in total crop failures. The problem of Striga has also
become a major factor for land abuse. Farms with intolerable
level of Striga infestation are said to be abandoned and reverted
to bush fallow, with the farmer procuring new farm land as there
seems to be no scarcity of land in the Sudan, at least for now.
In view of the magnitude of the Striga problem in the Sudan, there
are national and international research projects geared towards
alleviating this menacing sorghum production problem of the
country.

5. Evaluate Materials from Various Sources for Resistance to
Insects and Diseases: Sorghum diseases, in general, do not
appear to be a severe production problem in the Sudan. In
some places, particularly under peasant cultivation, smuts
(covered, long, loose, and head) could be very severe, how-
ever. In the south, Helminthosporium leaf blight has been
reported to cause serious yield reduction. Charcoal rot
has not been a major disease in the Sudan. Casual surveys
by the sorghum breeding crew, in the mechanized farms around
Gedarif, however, indicated some sporadic occurrence of the
disease. The experience in neighboring countries, (eg. Ethiopia),
also shows that the disease gets prominence as more and more
highly yielding exotic sorghum varieties are introduced. In
view of this, good interest is now developing here to expand
some work on screening for charcoal rot resistance. As lines
with reasonable tolerance are identified efforts will be made
to incorporate and utilize the genes for resistance through
breeding.

Insect pests, on the other hand, could be devastating.
With late planted sorghum, stem borers can cause complete crop
failures particularly in small, traditional and peasant farms
where insecticides are both unavailable and unaffordable. There
are reports that in some years shoot flies have been severe also.

6. **Yield Trial Evaluation of Advanced Materials:** Every effort would be put to evaluate selected materials in step-wise fashion following the well established existing procedure as much as possible.

7. **Seed Production and Extension:** Cooperative activities in seed production and extension will continue as new releases first reach the seed producer and the farmer. Well established seed release procedure and seed production and distribution system already exist in the country.

8. **Cooperation with Other Disciplines:** Efforts to develop a multi-disciplinary research approach involving local personnel are showing good signs. Capable Sudanese scientists are available in the areas of pathology, entomology, and agronomy and have been willing and anxious to help and participate in such team approach.

**Priority Areas**

1. **Intensify sorghum research activities in the central clay plains:** With an annual rainfall range of about 500-800 mm, rich soil, huge farms, capability for mechanized farming, this should be the area where technological change - improved varieties, improved cultural practices, tillage practices etc. will have an immediate impact and correct food deficit in the country.

2. **Expand and initiate sorghum research activities in the west and south, respectively:** These two areas have been farily neglected in the past. There is good interest developing for accelerated effort in crop improvement program in Western Sudan. We will cooperate with such effort in every possible way. Contacts are being established and a small sorghum breeding program has been initiated for South Sudan in cooperation with development agencies in the region.

3. **Accelerate research efforts in breeding and production of commercial hybrids.**

4. **Place a major priority on Striga resistance work:** Both national and international efforts are developing programs in this area, and with some coordination, it should be possible to get a handle in this major sorghum production problem.

5. **Agronomic studies under rainfed situation in the central clay plains and the more arid regions of the west deserve attentions.**

6. **Increase the number of test locations within a net work of sorghum improvement program on a national basis.**

7. **Continue to identify young technicians with good attitude to meet needs of locations other than Wad Medani.**
THE STATUS OF SORGHUM IMPROVEMENT
IN TANZANIA

C.S. Mushi

Introduction

Before the introduction of maize in Tanzania, sorghum was the most important cereal crop being cultivated. This was when the population density was low and shifting cultivation was predominant. Sorghum now ranks the second most important cereal in the country. The tremendous range of genetic diversity of sorghum has enabled it to thrive under wide range of ecological conditions in Tanzania, ranging from low to high altitude. The most important Tanzanian sorghum production areas are located in the semi-arid areas. These are characterized by variable rainfall of erratic distribution resulting in long dry periods of moisture stress during the cropping season. They include the central, northwestern parts of the country from Morogoro west through Tabora and northsouth from Mwanza to near Mbeya and to the southeast in the vicinity of Mtwar, Nachingwaea and Tunduru.

For the past few years, a marked change in rainfall pattern has lead to unreliable rainfall in those areas, necessitating the government to put more emphasis on sorghum production in the mentioned regions. This is in an effort to improve the overall food situation for thousands of people who live in these marginal and agricultural difficult areas which account for more than fifty percent of Tanzania. Intensification of the cultivation of sorghum within the semi-arid areas of the country would significantly increase the overall cereal production in Tanzania. Figures 1 and 2 show the rainfall probability and sorghum production areas of Tanzania.

Most of the sorghums grown and preferred for food are the local types. These are extremely tall, late maturing, and low yielding. However, these sorghums are palatable and have hard flinty grain which stores well. Available improved high yielding varieties have not been widely accepted by the traditional sorghum growers and consumers because they lack the hard flinty grains and store very poorly.

\^Coordinator and Agronomist, National Sorghum and Millets Research Program, A.R.I. Ilonga, P.O. Ilonga - Kilosa, Tanzania.
There are many serious insect and disease problems affecting sorghum production in Tanzania. Generally, stem borers, mainly Sesamia, Chilo, and Busseola, appear to be dominating throughout the sorghum production areas. Sucking insects, Calidea dregi, shootfly Anatrichus erinaceus and midge Contarinia sorghicola (Cog.) are known to cause great losses. There are several leaf and head diseases among which the most important are grey leaf spot (Cercospora sorghi), anthracnose (Colletotrichum graminicola), and smuts. For the semi-arid areas charcoal rot (Macrophomina phaseoli) appears to be serious.

Witchweeds, Striga hermonthica and Striga asiatica, cause heavy losses. S. hermonthica is common on heavy soils in Mwanza and Shinyanga regions and its severity forms a valid consideration of breeding for resistance. S. asiatica occupies the sandy soils in central and along the coastal areas.

Birds, particularly Quelea, are a serious problem to sorghum production in Tanzania and cause considerable losses annually. Palatable white seeded varieties preferred for food are severely damaged by the Quelea birds.

The sorghum research program of Tanzania could be divided into distinct periods. The first period covers 1948 to 1957, the time when Tanganyika government ran the sorghum breeding program at Ukiriguru - Mwanza. The second span was when the East African Agricultural and Forestry Research Organization assumed the responsibilities for sorghum and millets research for East African countries, 1958-1970. Establishment of field trials office in 1970 marked another period when extensive variety testing was conducted in collaboration with National Research Institutes and other international organizations.

In 1974, the Crop Development Division in the Ministry of Agriculture established crop coordinating committees with the intention of integrating the planning and implementation of research projects. Lastly, in 1978, the IITA/USAID/Tanzania Project expanded to include Sorghum and Millet Improvement Program.

National Sorghum and Millets Research Project

The National Sorghum and Millets Research Program initiated in early 1978 under the IITA/USAID/Tanzania Project has the main objective of promoting the production of sorghum in Tanzania through the provision of improved varieties with good yielding potential, excellent grain quality, desirable agronomic characteristics, and resistant to insect and pests of economic importance. In order for these improved varieties to be accepted by the traditional sorghum growers and consumers in Tanzania, they must have excellent grain quality, with prolonged grain storage life just like the long-term indigenous types.
To achieve these objectives the program has the following components:

1. **Breeding** - Aimed at accumulating germplasm materials and screening, testing, and recombining these materials to provide a continuous source material for the different ecological zones where these crops are cultivated.

2. **Agronomy** - Aimed at putting together packages of inputs and practices which the farmers can adopt to increase their production.

3. **Plant Protection** - Aimed at providing the basic information for breeders and agronomists for certain phases of their work and also provide recommendation on sorghum and millets insect pests and disease control which the farmers could adopt to increase and improve the production and quality of these crops.

In trying to relate these objectives to the totality of sorghum improvement and production problems in the country, the National Sorghum and Millets Research Project found it necessary to run trials and nurseries in other research stations representing the different sorghum ecological zones in the country; consequently, the trials and nurseries have been operating at different substations and regional centres in Tanzania.

**Varietal Development**

Most traditional sorghum growers and consumers in Tanzania continue to grow local sorghum types and prefer them for food to improved varieties. These local varieties are generally tall, about 3 to 5 metres high, mature in about six months or more and are always poor yielders. These long-term local varieties, however, possess superior grain that keeps extremely well as threshed grain.

When the breeding program was initiated much effort was directed to the introduction and evaluation of a wide range of sorghum germplasm, improved varieties from several countries, breeding lines from sorghum breeding programs all over the world and some indigenous sorghums.

A crossing program involving local sorghum varieties was initiated in 1978 with the main objective of incorporating desirable traits from the locals into the improved varieties.

In the 1979/80 cropping season, about 365 F₁ hybrids were planted at A.R.I. Ilònga and grain colour precorded. Usually for the segregating populations in F₂ and succeeding generations, they are evaluated and selected at Ilònga, Hombolo Experimental Station and Bihawana Agricultural Station. In this way selection pressure is applied to breeding stocks in a range of different environments and may be a way to approach the problem of simultaneous incorporation of traits of economic importance. An array of genetically
diverse materials generated from local and improved cultivars was produced in $F_2$ (69) and $F_4$ (924) generations.

During the 1980/81 cropping season, about 138 $F_2$ single plant selections were advanced to $F_3$ generation. Moreover, from the total of 924 progenies in the $F_2$ generation, 149 of them which showed agronomic eliteness were tested for yield performance. The yield tests were of two sets: a) Derivatives involving local x improved crosses and b) Progenies derived from crosses between improved cultivars. Data obtained from the first trials indicated that forty three percent of the progenies yielded above the mean grain yield of 1913 kg/ha. While data from the second trial had sixty five percent of the progenies yielding above the mean grain yield of 1725 kg/ha.

In the last season 1981/82 materials and $F_3$ and $F_4$ generations were planted and individual plant selections were made as shown in Table 1.

Table 1. Number of selections made at different generations.

<table>
<thead>
<tr>
<th>Generation</th>
<th>Selections Made</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_3$ Early</td>
<td>59</td>
</tr>
<tr>
<td>$F_3$ Late</td>
<td>318</td>
</tr>
<tr>
<td>$F_4$ Ilonga</td>
<td>80</td>
</tr>
<tr>
<td>$F_4$ Hombolo</td>
<td>351</td>
</tr>
<tr>
<td>Total...</td>
<td>808</td>
</tr>
</tbody>
</table>

From the progeny yield tests, two Preliminary Sorghum Variety Trials, one from each group, were conducted at A.R.I. Ilonga. Data from these trials have not been analysed but due to drought spells experienced in the past season, the stand was low in most of the entries.

National Variety Trials

Tanzania Sorghum Variety Trial

The trial consisting of 23 promising varieties, most of them developed to Serere, Uganda, has been conducted since 1978, in over 26 different locations in Tanzania where sorghum is grown. The main objective of this trial is to evaluate the performance, adaptability, and stability of improved varieties over a wide range of ecological zones in Tanzania in order to identify suitable varieties for release to the farmers.
So far, we have been able to identify four varieties viz: 5DX1 35/13/1/3/1 (brown seeded), 2KKX17/6, 2KKX17/B/1 and 2KK 89 all white seeded, for release to farmers pending their performance in our village trials which were conducted last season for the first time.

Preliminary Sorghum Variety Trial

The objective of this trial has been to evaluate the performance of promising sorghum introductions and advanced sorghum selections from the former EAAFRO Sorghum Breeding Program, India, Ethiopia, and ICRISAT. Four to five hybrids have been included each year and all of them have exhibited good and stable grain yields at all locations.

Hybridization Program

The objectives of the program are:

a) To evaluate the performance, adaptability, and combining ability of introduced and locally developed cytoplasmic male steriles and restorers.

b) To improve the grain quality, combining ability, and disease and insect resistance of promising local male steriles and restorers.

All sorghum breeding lines introduced and some local collections have been screened for genetic sources of desirable plant and grain type characteristics such as disease and insect resistance, tillering, good grain quality etc. Lines possessing one or more desirable characters were selected and used in the crossing program.

Sorghum Agronomy

Fertilizer and Manure Trials

Application of inorganic fertilizer and farm-yard manure and a combination of the two has given higher yields than the control. Application of farm-yard manure has had lower yields in comparison with inorganic fertilizers but not significantly different.

Trials on inorganic fertilizers performed in several locations in Tanzania have reflected that fertilizer use on sorghum is uneconomical (Tables 2, 3, 4). The deficiency of results for some of the regions precludes obvious conclusions about fertilizer levels. Further data from fertilizer trials in all regions of Tanzania will be necessary before any firm recommendations can be made to the farmers.
Table 2. Grain Yield (q/ha) for Tanzania Sorghum Fertilizer Trial - 1977-78

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ukiriguru</th>
<th>Mwanhala</th>
<th>Lubaga</th>
<th>Miwaleni</th>
<th>Mtopwa</th>
<th>Hombolo</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N_0P_0)</td>
<td>18.00</td>
<td>6.3</td>
<td>23.3</td>
<td>25.3</td>
<td>6.3</td>
<td>34.0</td>
</tr>
<tr>
<td>(N_0P_1)</td>
<td>16.7</td>
<td>11.3</td>
<td>28.0</td>
<td>20.2</td>
<td>7.5</td>
<td>35.7</td>
</tr>
<tr>
<td>(N_0P_2)</td>
<td>19.2</td>
<td>11.6</td>
<td>26.8</td>
<td>32.0</td>
<td>8.6</td>
<td>31.4</td>
</tr>
<tr>
<td>(N_1P_0)</td>
<td>25.4</td>
<td>10.0</td>
<td>16.0</td>
<td>35.0</td>
<td>6.3</td>
<td>36.0</td>
</tr>
<tr>
<td>(N_1P_1)</td>
<td>26.9</td>
<td>12.1</td>
<td>32.2</td>
<td>35.9</td>
<td>9.3</td>
<td>40.2</td>
</tr>
<tr>
<td>(N_1P_2)</td>
<td>32.5</td>
<td>12.0</td>
<td>34.6</td>
<td>36.8</td>
<td>9.6</td>
<td>39.9</td>
</tr>
<tr>
<td>(N_2P_0)</td>
<td>26.6</td>
<td>12.0</td>
<td>21.8</td>
<td>38.2</td>
<td>6.5</td>
<td>40.3</td>
</tr>
<tr>
<td>(N_2P_1)</td>
<td>31.7</td>
<td>12.6</td>
<td>26.7</td>
<td>42.1</td>
<td>6.6</td>
<td>34.8</td>
</tr>
<tr>
<td>(N_2P_2)</td>
<td>34.9</td>
<td>11.8</td>
<td>32.9</td>
<td>38.4</td>
<td>6.0</td>
<td>42.4</td>
</tr>
<tr>
<td>Loc. Mean</td>
<td>25.8</td>
<td>11.1</td>
<td>27.0</td>
<td>33.8</td>
<td>7.4</td>
<td>37.2</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>7.04</td>
<td>6.81</td>
<td>11.78</td>
<td>10.28</td>
<td>4.20</td>
<td>11.27</td>
</tr>
<tr>
<td>CV%</td>
<td>19</td>
<td>42</td>
<td>30</td>
<td>17</td>
<td>33</td>
<td>17</td>
</tr>
</tbody>
</table>
Table 3. Effects of N and P fertilization on the grain yield (q/ha) of Serena sorghum - 1977/78.

<table>
<thead>
<tr>
<th>Nitrogen Kg/ha</th>
<th>Phosphorus kg/ha</th>
<th>0</th>
<th>25</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>18.92</td>
<td>19.90</td>
<td>21.60</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>21.45</td>
<td>26.10</td>
<td>27.57</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>24.23</td>
<td>25.75</td>
<td>27.73</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Gross profit (Shs/ha) due to N and P fertilization of Serena sorghum - 1977/78.

<table>
<thead>
<tr>
<th>Nitrogen Kg/ha</th>
<th>Phosphorus kg/ha</th>
<th>0</th>
<th>25</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>-252</td>
<td>-432</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>-72</td>
<td>-7</td>
<td>-210</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>-219</td>
<td>-417</td>
<td>-569</td>
<td></td>
</tr>
</tbody>
</table>

Prices: Grain sorghum 100.00 per 100 kg
Nitrogen 12.50 per kg N
Phosphorus 14.00 per kg P$_2$O$_5$
Weed Control Studies in Sorghum

A sorghum hand weeding trial aimed at determining the optimum hand weeding frequency for grain sorghum under subsistance level of farming was concluded last year with recommendations that weeding is an important aspect in grain sorghum production, and early weeding at two weeks after planting should be the optimum early weeding time, followed by a second weeding at 30 to 45 days after planting depending on location.

Last season, a chemical weed control preliminary evaluation for sorghum was initiated with the objective of assessing the best type and level of herbicide or combination of herbicides for use on extensive production of grain sorghum so as to attain timely and economical weed control. Herbicides used were atrazine, 2, 4-D, Metolachlor and Dicamba. Data obtained from this trial have not been analysed, but most herbicides did a good job in controlling broad leaved weeds despite the heavy rainfall which followed after the application of herbicides.

Plant Populations Studies in Sorghum

Trials performed so far indicate that grain yields increase with an increase in plant population and that 160,000 plants/ha, the highest plant density included, would seem not to be the optimum density in most of the sorghum growing areas of Tanzania. A trial conducted last season included 200,000 plants per hectare but data have not been analysed for reporting.

Findings on planting pattern have pointed out that at higher plant population, increasing inter-row spacing tends to reduce yields.

Time of Planting Trial

This trial aimed at establishing the most optimum date to planting sorghum in various areas of Tanzania, has pointed out that planting of sorghum should be done on the onset of rains which means Central Zone mid-February to early March, Western and Southern Zones mid-December to mid-January.

Plant Protection Studies

Insect damage caused by shoot-fly and stalk borers is among the limiting factors to sorghum production. Investigations done so far rejected ineffectiveness of Thiodan which is the recommended insecticide to the control of shoot-fly. Other insecticides used include Carbofuran, Primifos and Fenitrothin. Further investigations have been carried out, but the data have not yet been analysed for confirmation.
Investigations on the effectiveness of Thodan to the control of stem borers have been conducted but data have not been analysed yet.

Future Work on Sorghum Improvement

Research plans for the future will continue to lay considerable emphasis on varietal development, multilocational variety testing, collection of local sorghum germplasm (in regions not yet collected in the main sorghum production areas of Tanzania), and continuation with the agronomy and plant protection studies with emphasis on screening for resistance.

References


The Status of Sorghum Improvement in Uganda

Vincent Makumbi Zake

Uganda is an overwhelmingly agricultural country, with over 90 percent of its population of 13 million living in the rural area and of even percentage relying on the agricultural sector for a living.

Sorghum is the third most important cereal crop grown in Uganda, after maize and finger millet, with an estimated area of 350,000 hectares and production of 450,000 metric tonnes. It is widely grown in the dry short grass area in the north and east as is particularly important in the drought prone Karamoja. In Karamoja, sorghum occupies over 80 percent of the total food crop hectarage. It is estimated that half of the total production of sorghum in Uganda is produced in Kigezi and Karamoja. In Kigezi, sorghum assumed great importance in the mid-1930s due to more labour requirements in finger millet, more sensitivity of finger millet than sorghum to declining fertility under conditions of land pressure, and rainfall distribution. In the banana growing areas of Bunyoro, Toro, Ankole, Buganda, Busoga and Bugisu, sorghum is planted twice a year or as a ratoon crop. Being a hardier crop, it is intersown with finger millet in the drier north-eastern portions of finger millet range as an "insurance" against climate hazards. Most farmers still grow sorghum in mixtures with maize, beans, pigeon peas etc. Because sorghum is grown at a subsistence level and is processed and consumed at home, production figures are difficult to document. Table 1 shows the production of the principal crops in Uganda. Nonetheless, sorghum has shown a steady increase in production over a period from 1970 to 1980, a factor which may be attributed to the success of research done to improve the seed. Although parts of Uganda did suffer from periodic food shortages, usually due to occasional failure of the rains, in general the country as a whole was never deficient in food, as production kept pace with the increase in population. There was, therefore, little incentive to devote much research effort to food crops, as large increases in production often proved very difficult to market. Sorghum is an important staple in the drier parts of Uganda such as Karamoja, Kigezi, parts of Teso and Acholi.

1Principal Research Officer-in-Charge and Geneticist/Plant Breeder, U.A.F.R.O., Sorghum and Millets, Serere Research Station, P.O. SOROTI, Uganda.
Uganda has an extensive sorghum genetic variability. The grain types vary in shape and colour from almost black, red to brown, and white to yellow. The plants are generally tall, late maturing, ratooning type, variable head shapes and prolific in tillering. White grain types are preferred for food and red types for brewing. It is, however, common to see brown-seeded types being used for food as well as for brewing purposes. In the banana growing areas, sorghum is used for yeast in the brewing of banana beer.

Local sorghum types are predominantly grown in Uganda. There are a number of improved varieties like Serena, Dobbs Bora, Lulu D and Lulu Tall and of recent, Seredo, but only Serena and Seredo are available to farmers through the Uganda Seed Multiplication Scheme (USMS). Sorghum hybrids like Hijack, Himidi, and Hibred which have been developed at Serere are not available to farmers as the USMS is not ready to produce hybrid sorghum seed at the moment. The improved varieties and hybrids yield two to three times more than local types. However, many of these improved cultivars are susceptible to bird damage indicating the preference of local sorghums to improved types by farmers on one hand and distribution by the USMS on the other. The USMS is facing the current economic squeeze and moreover it had lost considerable equipment due to the liberation war of 1979.

Sorghum improvement program in Uganda was initiated in 1958 by the former East African Agriculture and Forestry Research Organization (E.A.A.F.R.O.), a department of the former East African Community. The program had the responsibility of developing high yielding sorghum varieties and hybrids resistant to diseases and insect pests, and adaptable to Ugandan environment. While a number of improved varieties and hybrids have been released to the farming community of East Africa, the sorghum program has passed through difficult stages. In 1973, the project lost a number of research personnel due to the expulsion of Asians during the Amin regime. Due to the lack of senior research scientists on the station and experts within the country, the Serere station had to depend on services mainly from Kenya. The station had to depend on Muguga in matters dealing with pathology, soil physics/chemistry, agronomy, and quarantine services, on Nairobi University for analysis of data and recipe studies, on Kitale National Research Station in protein quality studies and use of cold room for maintenance of germplasm, on East African Industrial Research Organization Nairobi in grain milling studies, composite flour and utilization of sorghum and millets in industries. The success of the Serere program depended on these services. The East African Community formally collapsed on 30th June, 1977. Since then these services were no longer available to Serere and consequently to the Ugandan farmer, the baker, and the industrialist..

Despite the loss of these services and the loss of the senior research scientists in 1973, progress through plant breeding is appreciative and it may have contributed to the continued financial
assistance to the project by the International Development Research Centre (IDRC). The project has five senior research scientists who have post graduate experience and supporting staff who have a background of good training and experience. The station has made appreciable progress in identifying high yielding sorghum varieties for release to farmers.

In order to be able to release varieties to suit the farmer's environment, the Department of Agriculture has divided Uganda into eleven agricultural zones which are determined on rain seasons, amount of rainfall per annum, altitude and the basic agricultural and livestock management activities in such areas (Table 2) and it is in these zones where 46 district variety trial centres covering all districts, are established.

Presently the major broad objectives of the sorghum breeding program are:

a) To develop high yielding sorghums with white or brown grains suitable for food and brewing and resistant to disease and insect pests and weathering.

b) To develop drought escaping or tolerant sorghum varieties that could benefit the Karamoja farmers.

c) To evaluate the performance and adaptability of improved sorghum varieties and hybrids over a wide range of environments in Uganda with the objective of identifying suitable varieties for release to the farmers.

d) To develop high altitude sorghum that could benefit the Kigezi farmers.

Research Results

Population Improvement:

Population breeding methods are currently being utilized in the improvement of sorghum grain quality. Good grains population (Pop.II) which was composited from over 100 good grain quality lines and good grains population (Pop.I) composited from fewer lines were combined in 1974 to form one good grains population. More quality lines screened from the breeding program one and collections and short varieties were fed into the combined population to concentrate high quality and dwarfing genes in the population. Considerable progress has been achieved in increasing variability and stabilizing the population. In 1979, a random selection of short fertile plants was done in the population. One hundred eighteen selected plants were planted out during the first rains, 1980. Further selection was carried out and 98 selections were grown out and selfed during the second rains, 1980. Three hundred fifty five crosses using hot water emasculation were done utilizing 4MX derivatives, world collection white grain and red flinty grain on the
selected short fertile plants from the population. \(\text{F}_1\) crosses were grown in the first rains, 1982. \(\text{F}_2\)s of all the crosses have been grown during this season. The population was grown in isolation for random mating during this season.

High Lysine Derivatives:

In 1974, a number of Ethiopian lines having high lysine content were crossed to 2XX derivatives and adapted brown-seeded varieties. Crosses with desirable agronomic characters with and without plump seeds were selected. Advanced generations were screened in 9 x 9 simple lattice trial. Derivatives 4MX 35/48 and 4MX 11/9/3 significantly outyielded Seredo (5DX 135/13/1/3/1), E 525 Ht Red and Serena during the first rains season of 1980. Despite poor weather conditions that prevailed during the second rains of 1980, 4MX 35/53, 4MX 20/83, 4MX 11/9/3 and 4MX 37/101 outyielded Seredo and Simila though not significantly. While there are a number of promising derivatives in this program, it was observed that many were late flowering and were susceptible to leaf diseases. Nonetheless, most derivatives had strong stems with short internodes. The grains were mainly bright red or dark brown consisting of floury endosperm. Some of the materials have been selected for inclusion in the district variety trials in the country. With the collapse of the East African Community, it was not possible to screen these materials for lysine content on the Regional Protein Quality Laboratory, Kitale, Kenya, as originally intended. Further selection in 4MX high lysine derivatives was done and these were crossed to Serere improved brown-seeded varieties in the first rains of 1981. \(\text{F}_3\) progeny rows have been grown this season.

Improvement of White-Seeded Varieties:

Since 1969, considerable emphasis was directed to the development of high yielding white-seeded varieties with desirable grain quality and agronomic attributes. White-seeded sorghum types are liked for food as they do not have phenolic pigments which are normally associated with brown-seeded types. These pigments impart off-colour and unacceptable flavour to food products produced from these sorghum types. It has been observed that sorghum types with a hard and corneous endosperm are easier to polish and process than types with soft and floury endosperm. Further, sorghum types with hard and corneous endosperm are not as badly damaged by weevils in storage as types with soft and floury endosperm.

During the first rains of 1976, several white-seeded lines without testa screened from the world collection were crossed to 2XX derivatives and Pop.II. Advanced generations were screened in 7 x 7 and 8 x 8 simple lattice trials. The trials were grown
in Labori, Kumi, Arapai and Serere during the first rains, 1980. The trials at Arapai were grazed by cattle. In the 7 x 7 screening trials, location means were comparable. Average best performance was shown by 4MX 246, 4MX 249/1, 4MX 216/2 whose yields were above 50 q/ha as compared to Seredo (5DX 135/13/1/3/1). In the 8 x 8 lattice white-seeded screening trial, overall best performance was obtained in 4MX 95, 4MX 96/2 and 4MX 156. Similar trials were planted in the second rains season of 1980 but failed due to severe drought conditions.

Grain moulds were observed in a number of promising 4MX white-seeded derivatives. It was also observed that 4MX 172/1, 4MX 204/3, 4MX 106/1, 4MX 216/1, and the best white grain yielding derivative, 4MX 249/1, were highly corneous.

Grain moulding and weathering is a common problem in Uganda, especially on white-seeded varieties during wet and humid weather conditions. Grain moulds are not very important on the local sorghum varieties. Grains moulding and weathering considerably reduce the quality of the grain. Resistance to grain moulding and weathering has been identified in a few lines and is being incorporated into improved varieties. Advanced generations consisting of resistant materials to grain moulding and weathering were planted in a 6 x 6 triple lattice. There was high rainfall which favoured good environment for field assessment for resistance to grain moulding and weathering. The obtained results indicate that no cross had clean seed as compared to accession E 2804, one of the resistant parents, but there were however two crosses viz., 4MX 434/478 and 4MX 434/488/4/1 which combined good grain yield and intermediate resistance to grain moulds. White-seeded 2KX derivatives used in the crossing program were observed to be highly susceptible to grain moulding and weathering. More 4MX derivatives in advanced generations resistant to grain moulds were identified. During the first rains of 1982 more 4MX derivatives were screened in an 8 x 8 triple lattice against grain moulding and weathering.

Since the sources of resistance to grain moulding and weathering is mainly available in materials consisting of loose head-types and large glumes, a systematic crossing program has been devised utilizing sixty two selections in order to have an improved probability of having high yielding sorghums with clean lustrous grains free from moulds discoloration and weathering. The project is using the services of a plant pathologist who will work hand in hand with plant breeders in the field and laboratory in order to fulfill this goal.

Hybrid Improvement and Development of Drought Escaping Varieties:

Several male-steriles have been developed at Serere with the objective of finding an adaptable male-sterile to replace CK 60A. CK 60A is the female parent of the recommended hybrids in East Africa but is highly susceptible to shoot-fly. The three most promising
locally developed male-steriles are Kafinum A, 7DMS 7A and 8MSC 1A. During the first rains of 1982, short-sterile plants were selected from all the A lines and crossed with short plants selected from their corresponding B lines. Only uniform and short A x B crosses which have no partial sterility are selected and maintained with their corresponding B lines.

It has been often observed, however, that CK 60A hybrids when compared to Kafinum A and 7DMS 7A hybrids, are shorter and flower earlier. Hijack flowers earlier than most hybrids and Serena variety. Drought tolerant or escaping sorghum varieties and hybrids are vital in areas where rainfall is unpredictable and unreliable. Varieties and hybrids of short maturity duration have high potential in such areas since they are capable of efficiently utilizing the scanty and unreliable rainfall to produce a reasonable crop. Thirty genotypes of the 3KX crosses selected for early flowering were crossed CK 60A. The resulting hybrids were evaluated along with their corresponding restorer parents, two check varieties Serena and Seredo (5DX 135/13/1/3/1) and two check hybrids Hijack and Kafinum A x SB 65 in an 8 x 8 simple lattice. Generally, all restorers produced hybrids which had satisfactory grain yields averaging 45.19 q/ha and were higher than the variety checks. Ten hybrids outyielded Hijack, Highest grain yield was obtained on 3KX 76/3 and 3KX 71/1 hybrids and the obtained grain yields were significantly higher than those obtained in hybrids checks Hijack and Kafinum A x SB 65. Heterotic response in percent determined over restorer parent means was positive in all hybrids except in 3KX 73/1/1 and 3KX 76/4/2 and was significant (P = 0.05) in eight hybrids and highly significant (P = 0.01) in four hybrids.

These trials were sent to Kotido and Moroto during first rains 1980 and Arapai and Kumi during second rains of 1979. All trials failed due to extreme drought conditions. Trials for Karamoja area had been suspended due to security precautions. Nonetheless, more materials consisting of 120 F₄ and 104 F₅ crosses which are early maturing were grown in progeny rows during this season. Further, quick maturing sorghum materials were observed in the International Sorghum Disease and Insect Nursery. Four accessions SC-748-5-3, SC-170-6-17, SC-112-14 and SC-599-6-3 were crossed to Serena, Seredo, Lulu T, Lulu D, and Dobbs Bora to incorporate early maturity, prolific tillering, and resistance to shoot-fly. Early maturing derivatives with good agronomic characters derived from these crosses were yield tested in a screening trial of 8 x 8 triple lattice during the first rains, 1981. 7ZX 379/2, 7ZX 375/1, 7ZX 376/2 and 7Z 414 had lower grain yields than Serena but the difference was not significant. A number of derivatives will be yield tested with 3KX early maturing derivatives at Moroto, Kotido, Kumi and Arapai.
District Variety Trials:

Multilocational testing of experimental varieties and hybrids from the breeding program over a wide range of environment in Uganda is extremely important in order to estimate the performance and adaptability of improved varieties and hybrids. Recommendation to farmers in the area are based on the information obtained from these trials. There are forty six district variety trial centres in Uganda. The district variety trials for 1982 consisted of twenty four varieties and hybrids. Although twelve sets of these trials were sent out for growing during the first rain season, only four centres planted the experiment. Failure to grow these trials was mainly attributed to lack of oxen or fuel for field preparation. A set of fourteen sets has been sent out for growing during the second rains, 1982.

The performance of the variety trial at Serere is presented in Table 3. Obtained results indicate the consistent good performance of 9DX 5/F5/38/1, Serena, the recently released variety Seredo (5DX 135/13/I/3/1). Nonetheless, there were no significant differences in yield between 9DX 5/F5/38/1 and 4MX 11/9/3. Data from other centres have not been received.

Problems

In Uganda, consumption of bread made from wheat and beer from barley is high and very costly to the consumer and to the nation as available land for wheat and barley growing is very limited and involves foreign exchange which is meagre. Composite flour technology based on sorghum and millets and other cereals and potential supplements from oil seeds and grain legumes which are produced almost in every home, does not exist. Results obtained in utilization of grain can very greatly improve the standard of living of the farmers in marginal areas and can save and earn foreign exchange to the country. Laboratory investigations in utilization of grain at Serere will add impetus to the acceptance of improved varieties by the farmers. The project has no equipment.

The destruction of grain sorghum by Quelea birds and other grain eating birds in Uganda is posing great problems to sorghum growers. Improved varieties are especially vulnerable as these are palatable and are, therefore preferred by birds to the local bitter tasting types. Other problems experienced by farmers with regard to improved varieties include poor threshing and storability. There has also been a complaint on the poor brewing qualities of improved varieties. Clean threshing and better storability are being incorporated into varieties.

In wet and humid seasons, grain moulding and weathering are serious problems. It is however, the objective of the national sorghum program to breed varieties resistant to moulding and weathering.
### Table 1. Production of the principal crops of Uganda.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area Harvested (1000 ha)</th>
<th>Yield (Kg/ha)</th>
<th>Production (1000 MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals, Total</td>
<td>1401</td>
<td>1478 F</td>
<td>1080</td>
</tr>
<tr>
<td>Maize</td>
<td>343</td>
<td>550 F</td>
<td>1225</td>
</tr>
<tr>
<td>Millet</td>
<td>739</td>
<td>550 F</td>
<td>997</td>
</tr>
<tr>
<td>Sorghum</td>
<td>299</td>
<td>350 F</td>
<td>1127</td>
</tr>
<tr>
<td>Rice</td>
<td>16</td>
<td>18 F</td>
<td>723</td>
</tr>
<tr>
<td>Roots and Tubers, Total</td>
<td>427</td>
<td>564 F</td>
<td>4449</td>
</tr>
<tr>
<td>Potatoes</td>
<td>17</td>
<td>45 F</td>
<td>8800</td>
</tr>
<tr>
<td>Sweet Potatoes</td>
<td>133</td>
<td>139 F</td>
<td>5200</td>
</tr>
<tr>
<td>Cassava</td>
<td>277</td>
<td>380 F</td>
<td>3825</td>
</tr>
<tr>
<td>Pulses, Total</td>
<td>443</td>
<td>575 F</td>
<td>602</td>
</tr>
<tr>
<td>Beans</td>
<td>263</td>
<td>360 F</td>
<td>589</td>
</tr>
<tr>
<td>Oil Seeds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundnuts (in shell)</td>
<td>263</td>
<td>230 F</td>
<td>786</td>
</tr>
<tr>
<td>Sesame Seed</td>
<td>84</td>
<td>128 F</td>
<td>252</td>
</tr>
<tr>
<td>Cotton Seed</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Other Crops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>261</td>
<td>180 F</td>
<td>821</td>
</tr>
<tr>
<td>Cotton Seed</td>
<td>923</td>
<td>243 F</td>
<td>279</td>
</tr>
<tr>
<td>Tea</td>
<td>12</td>
<td>3 F</td>
<td>1524</td>
</tr>
<tr>
<td>Banana Plantains</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Sugar Cane</td>
<td>31</td>
<td>29 F</td>
<td>54055</td>
</tr>
<tr>
<td>Tobacco</td>
<td>7</td>
<td>3 F</td>
<td>721</td>
</tr>
</tbody>
</table>

Note:  
F = FAO estimate  
* = Unofficial figure

Source: FAO Production Yearbook 1980
<table>
<thead>
<tr>
<th>Zone</th>
<th>District</th>
<th>Agricultural System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone I</td>
<td>Busoga/Bukedi</td>
<td>Banana, Millet and Cotton System with outliers of the main coffee-banana system.</td>
</tr>
<tr>
<td>Zone II</td>
<td>Bugisu/Sebei</td>
<td>Montane system: Arabica Coffee, bananas (wheat and maize in Sebei)</td>
</tr>
<tr>
<td>Zone III</td>
<td>Teso</td>
<td>Teso system: finger millet, cotton and cattle keeping (mixed agriculture).</td>
</tr>
<tr>
<td>Zone IV</td>
<td>Karamoja</td>
<td>Pastoral system - cattle keeping.</td>
</tr>
<tr>
<td>Zone V</td>
<td>Lango/Zcholi</td>
<td>Northern system: finger millet, cotton tobacco (some mixed agriculture also).</td>
</tr>
<tr>
<td>Zone VI</td>
<td>West Nile/Madi</td>
<td>West Nile system: basic agriculture like zone V but predominance of cassava as staple food.</td>
</tr>
<tr>
<td>Zone VII</td>
<td>Bunyoro/Toro</td>
<td>Arabica and Robusta coffee and banana system: Montane system: heterogenous agriculture but basically bananas, coffee, tea.</td>
</tr>
<tr>
<td>Zone VIII</td>
<td>Ankole</td>
<td>Montane system in the west: Pastoral to the east: Arabica and Robusta coffee, tea, bananas and cattle.</td>
</tr>
<tr>
<td>Zone IX</td>
<td>Kigezi</td>
<td>Montane system but with larger annual crop acreage than other montane system. Sorghum is major staple. Arabica coffee, tea.</td>
</tr>
<tr>
<td>Zone X</td>
<td>Lake Victoria Crescent</td>
<td>Main Robusta coffee and banana system: Robusta coffee, bananas tea, sugar, cocoa.</td>
</tr>
<tr>
<td>Zone XI</td>
<td>Northern Buganda</td>
<td>West extension of the banana - millet - cotton system, but now largely taken up by big ranching projects.</td>
</tr>
</tbody>
</table>

Source: Planning Cell, Ministry of Agriculture.
Table 1. Average area and total production for the main crops in Yemen Arab Republic over the past ten years (1972-1981).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (1000 ha)</th>
<th>% of total</th>
<th>Total Production (1000 t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum and millet</td>
<td>802</td>
<td>72.1</td>
<td>666</td>
</tr>
<tr>
<td>Maize</td>
<td>28</td>
<td>2.5</td>
<td>43</td>
</tr>
<tr>
<td>Wheat</td>
<td>64</td>
<td>5.8</td>
<td>64</td>
</tr>
<tr>
<td>Barley</td>
<td>54</td>
<td>4.9</td>
<td>55</td>
</tr>
<tr>
<td>Dry legumes</td>
<td>72</td>
<td>6.5</td>
<td>75</td>
</tr>
<tr>
<td>Vegetables</td>
<td>23</td>
<td>2.0</td>
<td>212</td>
</tr>
<tr>
<td>Potatoes</td>
<td>9</td>
<td>0.8</td>
<td>99</td>
</tr>
<tr>
<td>Grapes</td>
<td>10</td>
<td>0.9</td>
<td>46</td>
</tr>
<tr>
<td>Coffee</td>
<td>8</td>
<td>0.7</td>
<td>3 (grain)</td>
</tr>
<tr>
<td>Other fruit trees</td>
<td>13</td>
<td>1.2</td>
<td>70</td>
</tr>
<tr>
<td>Alf Alfa</td>
<td>3</td>
<td>0.3</td>
<td>41</td>
</tr>
<tr>
<td>Cotton</td>
<td>11</td>
<td>1.0</td>
<td>11</td>
</tr>
<tr>
<td>Tobacco</td>
<td>5</td>
<td>0.4</td>
<td>6</td>
</tr>
<tr>
<td>Sesame</td>
<td>10</td>
<td>0.9</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>1112</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Source: Central Planning Organization
Table 2. Sorghum area, production and average yield in Yemen Arab Republic over the past ten years (1972-1981).

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (1000 ha)</th>
<th>Production (1000 t)</th>
<th>Yield (5/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>870</td>
<td>639</td>
<td>0.73</td>
</tr>
<tr>
<td>1973</td>
<td>870</td>
<td>584</td>
<td>0.67</td>
</tr>
<tr>
<td>1974</td>
<td>1056</td>
<td>921</td>
<td>0.87</td>
</tr>
<tr>
<td>1975</td>
<td>1060</td>
<td>785</td>
<td>0.74</td>
</tr>
<tr>
<td>1976</td>
<td>782</td>
<td>613</td>
<td>0.78</td>
</tr>
<tr>
<td>1977</td>
<td>644</td>
<td>585</td>
<td>1.91</td>
</tr>
<tr>
<td>1978</td>
<td>683</td>
<td>627</td>
<td>0.92</td>
</tr>
<tr>
<td>1979</td>
<td>673</td>
<td>632</td>
<td>0.94</td>
</tr>
<tr>
<td>1980</td>
<td>681</td>
<td>636</td>
<td>0.93</td>
</tr>
<tr>
<td>1981</td>
<td>697</td>
<td>635</td>
<td>0.91</td>
</tr>
<tr>
<td>Ave.</td>
<td>802</td>
<td>666</td>
<td>0.84</td>
</tr>
</tbody>
</table>

Source: Central Planning Organization, YAR, 1982.
Agroecological Zones

Being a mountainous country with altitudes ranging from sea level to 3760 m above, YAR is characterized by wide variations in topography and climatic conditions. Annual rainfall varies from as low as 50 mm at sea level to as high as 1200 mm in the southern uplands. Rainfed agriculture is predominant covering about 85% of the cultivated land. The remainder is irrigated, either by spate floods (7.5%) or from wells, springs and stream (7.5%).

In the highlands, the most widespread soils are calcareous silt loams and silty clay loams. On mountain slopes, stoney, colluvial soils of high clay content are found. In the lowlands, soils in wadi beds contain transported elements of both the above types of soils. All soils have a high pH.

Sorghum is grown all over the country. Considering topographic and climatic conditions, five agroecological zones may be discerned as follows:

a) Coastal Lowlands (Tihama Plain)

This region is a strip of land 30-60 km wide, stretching across the country from North to South between the Red Sea on the Western sides and the mountains on the East. The altitudes range from sea level to 200 m above. Tropical conditions of high temperature and humidity prevail. Strong winds cause sand storms throughout the year, particularly in summer.

Since rainfall is scarce (50-300 mm), agriculture depends mainly on spate irrigation from wadis (valleys) that traverse the plain carrying run-off water from the central mountain range on the eastern side to the Red Sea. Some irrigation from wells is also practised.

b) The Western Slopes

This region lies between Tihama Plain and the Central highlands with elevation ranging between 200 and 1500 m above sea level. The land scape is very rugged and cut by deep wadis. Cultivable slopes are transformed into terraces. Rainfall ranges from 300-500 mm.

c) The Southern Highlands

This region comprises the southern part of the central mountain range exceeding 1500 mm elevation above sea level. It is characterized by high rainfall that may reach upto 1200 mm.
d) The Central and Northern Highlands

This region includes the middle and northern parts of the central mountain range with elevations from 1500 m above sea level up to 3700 m. The rainfall varies considerably from 300 to 800 mm, increases from north to south and from east to west. The climate is of tropical highland type, with mild summer, and cool winter nights.

The cultivable land lies mainly in intermountain plains, with some on terraced mountain slopes and valleys. Rainfed cultivation predominates, but well irrigation is increasingly practised on the central plains.

e) The Eastern Plateau

This region falls between the central highlands and the desert (Al-Rub-al Khali). The rainfall is 100-200 mm. The climate is of hot subtropical desert. This region has little agricultural potential. Most cultivation occurs along the valleys that flow eastward from the highlands.

Genetic Variability in the Country

Sorghum is an ancient crop in YAR and is grown all over the country under environmental conditions that vary widely even within small distances. Over the years, different sorghum types have evolved to suit the diverse environmental conditions.

Rezania (1973) studied the variation in about 400 samples grown at two locations, Taiz (1350 m alt.) and Ibb (1900 m alt.). In this study, samples collected from high altitude (2200-2700 m) yielded higher at Ibb; those from low altitude (1000-1700 m) gave higher yields at Taiz, and types from medium altitude (1700-2200 m) yielded equally well at both locations. Plant height ranged from 78-288 cm. Types that matured in approximately 175-200 days at Ibb, matured in 150 days at Taiz.

Kambal et. al. (Unpublished data) studied the variation in a group of about 150 samples collected from different parts of Yemen and grown at Taiz during 1981. The ranges in some of the characters studied were as follows:

- Plant height, 80-360 cm
- Days to 50% flowering, 48-142 days
- Average head weight, 5-155 gm
- Weight/1000 grains, 20-70 gm

Whereas the samples collected from the Highlands were predominantly goose-necked, those from the lowlands had erect peduncles.
The group was classified into races using the system suggested by Harlan and deWet (1972). Seven races were identified, namely Durra, Durra-caudatum, Durra-Guinea, Durra-Bicolor, Bicolor, Bicolor-Guinea, Bicolor-Caudatum, and Caudatum-Guinea. Durra was the most prevalent race as about 50% of the samples belonged to it, followed in descending order of importance, by Durra-Caudatum, and Durra-Guinea. About 90% of the samples belonged to these three races, suggesting the preponderance of race Durra in the evolution of Yemen Sorghums.

Availability and Distribution of Improved Cultivars

Some introduced varieties have been recommended for different areas eg. Kadam-Al-Haman from Sudan for Tihama; Awash 1050 from Ethiopia for the Southern Uplands; and Dabar from Sudan for Taiz area. However, none of these varieties have been distributed to farmers on a large scale. Although these recommended varieties have a high yielding capacity, they do not match the local types in grain quality, and consequently they are not expected to spread on a large scale.

As a consequence of natural, as well as deliberate, selection by farmers, a few local sorghum varieties have emerged, and they are grown on a relatively large scale. These include:

Qairaa and Zeir which are grain-cum-forage varieties predominating in Tihama. They are characterized by fine stems, early maturity and ability to ratoon. Both belong to Race Durra - Guinea and the main difference between them is grain colour.

A type known as Gharib predominates on the Western Slopes. It belongs to Race Durra - Caudatum and is characterized by erect peduncle, early maturity, drought tolerance, and bold grains which are either chalky white or brownishe, with a brown subcoat. In the upper reaches of the Western Slopes, where rainfall is relatively higher, some goose-necked types of medium maturity with bold white grains, such as Tajarib and Thalathy are grown on a small scale in addition to Gharib.

In the Southern Upland Region, several types are grown but the dominant ones, such as Kadasi, Safari and Jura, are tall (3-4 m), late (6 months), goose-necked and have large panicles with bold high quality grains. Kadasi, with yellow endosperm, is predominant in Valleys of Sayani, Disufal and Wadi Sudan, and a selection from it has been released for multiplication by the Seed Production Project.
In the intermountain plains of the Central Highlands, a dwarf type with a compact small head and recurved peduncle is common. The seeds could be white, yellow or brown, the white is more predominant. In areas with higher rainfall, eg. in Anis area, other types such as Juraa and Monzala are also grown.

The seeds of these relatively widely spread local varieties are maintained by the growers.

Cultural Practices

Over the years, the Yemeni farmer has developed a lot of experience in farming a difficult terrain. This is amiably reflected in the construction and maintenance of the wonderful terraces that served to control erosion and harvest a maximum of water run-off. Despite the use of primitive tools and simple animal-drawn implements, the standard of husbandry is usually good, especially in the highlands. Land is ploughed after harvest, leaving a cloddy surface during the dry period that resists erosion, and permits percolation of water from early rain showers. Application of farm yard manure at the rate of about 10 t/ha every other year is a common practice in the highlands. Use of nitrogenous fertilizers has started in, but is not yet widespread.

Before sowing, the land is ploughed once or twice to control weeds and prepare a fine seed bed. Levelling is done when needed on the terraces. Sowing is done by dropping the seed in the furrow behind the plough. The seed rate is about 10-15 kg/ha. Sometimes legumes such as cowpea, Dolichos lablab and Vicia fabab are mixed with sorghum and are sown at the same time.

Thinning is practised at more than one stage to provide fodder and to ensure a good plant stand. Weeds are controlled by hand weeding, and at least one interrow cultivation is made to rectify furrows and ridges.

About 3-4 weeks before harvest, almost all the leaves except the flag leaf are stripped and fed to cattle. In case of tall varieties, plants are tied together to prevent lodging. At harvest, the stems are cut about 1/2 m above the soil surface. After harvest the long stubbles are uprooted and used as fuel. Threshing is done by hand beating, or recently, by running tractors or pick-ups backward and forward on dried sorghum heads.

In Tihama, most of the sorghum is produced under spate irrigation. The crop receives one or two irrigations during the season. The land is ploughed about 10 days after flooding.
Sowing is done by dropping the seeds in the furrow behind the plough and sometimes a long pipe funnel at the tip is attached to the plough to facilitate the placement of the seeds in the furrow. The distance between rows is about 60 cm compared to 70-90 cm in the Highland. Also a much higher seed rate, about 35 kg/ha, is used because of the interest in forage. Often the plants are harvested before maturity and sold with the head attached as forage. Usually, no weeding is done after sowing and the solid stand helps in reducing weed establishment. Ratooning is a common practice in Tihama.

Comments on National Average Yield

As indicated in Table 2, the national average yield is estimated as 0.84 t/ha. However, it should be emphasized that actual yields vary widely around this mean. The most important factor affecting sorghum productivity in YAR is moisture availability. Since most of the sorghum is rainfed, the amount and distribution of rains is of paramount importance. In some areas of the Southern Highland Region, where rainfall is adequate (1200 mm), and the growing season extends for about 6 months, yields in the order of 4 tons/ha can be achieved, and yields as high as 7 t/ha have been reported. By contrast, in areas where rainfall is low and the distribution is erratic, complete crop failure is not uncommon. Since most of the sorghum is grown in areas with inadequate rains, the yields are generally low.

The past five years (1977-81) witnessed a rise in the national yield average compared with the previous five years (1972-76), the mean for the two periods being 0.92 and 0.76 t/ha, respectively. This rise in average yield was associated with a reduction in the total sorghum area (Table 2), and may be attributed largely to the abandonment of marginal lands with extremely low yields and to a lesser extent to improvement in technology, particularly application of nitrogenous fertilizers.

Utilization of Sorghum in the Country

The sorghum plant is fully utilized in Yemen; the grain is used as a human food, the leaves are stripped and fed to animals, the stems provide animal feed and roofing material, and the stubbles are often uprooted and used as fuel.

Despite recent marked shift to wheat consumption in YAR, particularly in towns, sorghum is still the staple food for the majority of the inhabitants. It is consumed in different forms, either before or after fermentation. Some of sorghum preparations widely consumed in YAR include the following:
Aseed: A kind of a thick porridge prepared by adding sorghum flour to boiling water with continuous stirring until a thick jell is formed.

Lahuh: A leavened round flat bread made from sorghum to which some wheat flour is added. It is similar to the Ethiopian injera and comparable to the Sudanese kisra.

Fateer: Round flat bread from unfermented sorghum, baked in a special oven called Tannur.

Khameer: Made from fermented sorghum to which some wheat flour is added and is baked in a pan rubbed with some ghee or any vegetable oil.

Present Status of Sorghum Improvement Program

Organization and Coordination of the National Sorghum Improvement Program

Agricultural research is a recent activity in YAR. Prior to 1973, it was practically non-existent. In 1973, UNDP supported a project executed by FAO that helped in establishing an Agricultural Research Station (ARS) in Taiz, and in initiating research on the main crops in the Southern Upland Region, including sorghum. It was followed in 1974 by a research component in Wadi Zabid Development Project in Tihama. Subsequently, there has been some research on sorghum in the following projects executed with bilateral assistance.

- Sorghum and Millet Production Project at Bir-Al-Gahoom Farm in Sanaa, executed by USAID. This Project was phased out in 1981.

- Dhamar Agricultural Improvement Centre, run with British assistance.

- Agricultural Development Project at Al-Batina, executed through Chinese help.

- Radaa Rural Development Project, executed with Dutch aid.

The Agricultural Research Station at Taiz, in theory, is responsible for coordination of research on a national basis. However, in practice, very little has been achieved in this respect. Some cooperation is existing between ARS and the Research Division in Tihama, but contacts with other projects are
rather weak. Thus, at present, several agencies are involved in sorghum improvement in YAR but a national coordinated program is yet to be organized.

Stations and Staff Engaged in Sorghum Research

In Tihama there are two research farms, one at Zabid and the other at Surdud with good research facilities for sorghum research. An agronomist, assisted by 3 Yemeni graduates, is looking after improvement of sorghum, maize and millet, in addition to coordinating research activities in Tihama.

In the Southern Uplands region, there is a research station at Taiz. The station has two research farms, one at Taiz (16 ha) and the other at Ibb (8 ha). The staff in the sorghum section consists of an agronomist, three Yemeni counterparts, and one United Nations Volunteer. In addition to sorghum improvement, the section is responsible for carrying out research on maize and millet.

The Entomology, Pathology and Soil Fertility of ARS are conducting research on sorghum in their respective fields. Thus the main activity on sorghum improvement in Yemen is carried out by ARS.

Central Highlands

There are three research farms run with bilateral assistance at Radaa (Dutch) in the southern part, at Rasaba (British) in the central part and at Al Batina (Chinese) in the northern part of the region. The bilateral projects are concerned mainly with rural development and the research component is added to generate information necessary for their extension activities in the absence of proper research service. Thus, the effort devoted to sorghum improvement in these projects is very limited, as the limited staff available is looking after all important crops in their respective project areas. However, in the context of a coordinated national program, the farms run by these projects would be very useful as testing sites.

Sorghum Improvement Approaches Followed

The objective of the sorghum improvement research is to raise productivity through better varieties and better production technology. The approach followed hitherto in varietal improvement has concentrated on the evaluation of introduced and local material, with some selection practised in local types. The American Project in Sanaa started a hybridization program, but did not go very far
because the project was terminated in 1981.

At the beginning more emphasis was directed to introductions, but in view of the high quality of local types and their adaptation to local condition, the strategy at the present calls for giving more attention to the local types, without neglecting elite exotic material.

Experience has shown the importance of verification trials on farmers fields to verify, or otherwise, findings on the research station. These verification trials which are conducted with the cooperation of the Extension Service, are gradually becoming an integral part of the improvement program.

Even with the existing varieties, some improvement can be achieved through better technology. Research is therefore, conducted on agronomic practices (sowing date, plant population, fertilizer application, intercropping etc.) and protection measures against main pest and diseases.

**Germplasm Collection and Introduction**

A collection of about 4,500 accessions of local sorghums was made by ARS in collaboration with the USAID Project in Sanaa during 1975, 1976, and 1977. A sample was taken every 2 km. It was claimed by Voigt and Lakany (1979) that approximately 90% of the major sorghum areas has been collected. Among the main gaps were Hajja Governorate and the Eastern Plateau. Sub-samples of the collected seeds were sent to the University of Arizona, Tucson. Seeds of 2500 samples have been multiplied at Mayaguez, Puerto Rico, for later return to Yemen, but have not yet been returned.

IBPGR fielded two crop Germplasm Collecting Missions in Yemen Arab Republic in collaboration with ARS in 1980. About 200 samples were collected from different provinces, including Hajja. Sub-samples were sent to Rome and ICRISAT and one set was kept at Taiz.

Kambal collected about 50 accessions representing some of the main types grown. Some of the Yemeni material is of high yield potential and of good grain quality. It could be useful to other countries. The biggest collection is maintained by Arizona State University, as storage facilities at Taiz are inadequate. Requests for a breeder's supply of seeds should be addressed to the University of Arizona Coordinator for Title XII Sorghum and Millet Collaborative Research Program (CRSP).

Exotic material has been introduced and tested by the various projects, specially, ARS, USAID, and Tihama Development Authority. The material tested came mainly from USA, Sudan, Ethiopia, Egypt and ICRISAT.
c) **Lack of Research Coordination**

Absence of a definite nationally coordinated sorghum program and limited coordination among the different agencies conducting research precluded efficient utilization of the available resources.

d) **Weak Relations Between Research and Extension Service**

More organized cooperation between Research and Extension service is needed to facilitate clear understanding of the production constraints, to help in the verification of research findings on farmers fields, and to ease the flow of research findings on farmers fields.

**Steps Being Taken to Strengthen the National Program**

A new project designed to increase the agricultural research capabilities in YAR and remove the existing constraints on research programs has been formulated and will start by January 1983. The objectives of the project are to (a) establish and organization to manage the present diffuse and uncoordinated research programs, (b) strengthen existing adaptive research, (c) extend adaptive research and extension to a new region, namely the Central Highlands, and d) train Yemeni staff and improve their terms of service to attract qualified graduates and encourage them to remain in the research service.

The main features of the new phase of the agricultural research project will be: a) Establishment of an autonomous organization for research within the Ministry of Agriculture, to be known as the Agricultural Research and Development Authority (ARDA), b) ARDA will be responsible for coordination of all agricultural research in the country whether conducted by ARDA staff or by bilateral projects, c) Establishment of three Regional Research Stations: one for the Lowlands (Tihama) at Surdud, the second for the Southern Uplands at Taiz and a third for the Central Highland at Dhamar. Regional stations for the Northern Uplands and the Eastern Plateau will come up in the next phase. The Headquarters of ARDA will be at Dhamar, d) Extensinon of research activities to cover animal production, range management and forestry, e) Training of Yemeni research workers will be emphasized. Funds have been allocated to send 32 Yemeni graduates on scholarship for higher studies, 23 for M.Sc. Degree and 9 for Ph.D.

It is anticipated that the new development in the agricultural research service will have far reaching effects on sorghum research in Yemen. A national sorghum improvement program will be formulated for the different agroecological zones and will be coordinated from Taiz. A nationwide research
program would have short term and long term objectives. The short term objectives could be realized through identification of high yielding and high quality local and introduced varieties and suitable agronomic practices in the different agro-ecological zones. The long term goals could be achieved through the establishment of a hybridization program designed to breed new varieties.

More specifically, the research activities in sorghum during the next phase will include:

1. Screening of local material and elite introductions to identify superior ones. Selection within local types will be practised. In making selections it is important to keep in mind the criteria of the farmer: a) eating quality or market preference; b) reliability of performance; c) quantity and quality of forage; and d) disease and insect tolerance.

2. In depth research on fertilizers to determine the type of fertilizers needed and the optimum rate, time and method of application will be conducted.

3. Intercropping of sorghum with legumes will be investigated. Important pests will be surveyed and effective control measures will be recommended. Emphasis will be laid on pest avoidance rather than application of insecticides whenever possible.

4. The control of weeds will be sought by cultural as well as chemical means.

5. Research findings on improved varieties and production technology would be verified in farmers fields before making final recommendation. This aspect will be considered as an integral part of the research program. However, it should be emphasized that effective cooperation and coordination with the Extension Service is essential for the success of these trials.

6. To ensure continuity of the program, promising Yemeni graduates will be identified and sent on scholarships to study for higher degrees. The first one of these graduates is expected to leave for the USA in January 1983 to study for the M.Sc. Degree on Sorghum Improvement.
International Cooperation

Presently, large amount of material including hybrids obtained from ICRISAT, India and USA are under test. For spate irrigated areas, a separate program with introduced varieties having medium to tall plant heights has been initiated. At the same time, the program of improving the important local cultivars namely, Beini and Buker, has been started.

The first FAO Country Project was established in 1969 and ended in 1971. This was followed by the Agricultural Research and Training Project (Phase 2), 1972 to 1976. Since 1977, the project designated as Improvement of Crop Production has been established to assist the further improvement in research and establishing three demonstration farms. In addition, the country has a World Bank assisted national Project on Seed Multiplication. It is operating in Hedramout Governorate.

Training

The shortage of trained personnel is a major constraint in improving research capability in the country. The opportunities in this context given by the Regional Project as well as by the FAO Country Projects have been indeed very beneficial. However, it is felt that additional assistances is needed.

Constraints and Solutions

The following were the major constraints in production and dissemination of high yielding varieties of sorghums in the country.

1. Weeds have become increasingly serious. A research program on the use of herbicides was initiated.

2. High fertilizers prices hamper the use of recommended levels by the farmers.

3. The shortage of agricultural labour is becoming increasingly severe, affecting many agricultural operations adversely. Combines and seed drills and other machines for mechanization have been introduced in the country.

4. In much of the fields, land is still not levelled resulting in uneven distribution of water with consequent adverse effect on crop growth. The Government has started some investment projects for land levelling on a limited area.

5. The country has very limited number of trained technicians and research workers to carry research and demonstration programs at the required level. The Government is paying considerable attention to this fact. However, funds available are insufficient to meet the man-power requirement adequately.
Comments on the Future Plan

Selection program to improve the existing cultivars such as Beini and others belonging to different climatic regions would be continued. Some support is required to conserve the available germplasm of PDR Yemen.

The main emphasis in the sorghum improvement program in PDR Yemen should be in selecting short types with high grain potential for combine harvesting and tall or medium types for dual purposes of grain and forage under both tube-wells and spate irrigation. Such breeding program should lead to the replacement of the existing cultivars.

References


4. __________ and Bawazir, A.A. 1980. "Production of Breeder's and Foundation Seed of Sorghum", presented to the second National Training Course on Improved Seed Production, Giar, PDR Yemen.

THE STATUS OF SORGHUM IMPROVEMENT IN ZIMBABWE

Joseph N. Mushonga

Background

Documented research on grain sorghum did not start in Zimbabwe until in the early 1900s. The actual work started at Matopos Research Station. For the first time, several dwarf sorghum varieties were acquired from the United States of America in 1948. A program to inbreed these materials was started a season later. As a parallel programme, in 1948/49, the first variety yield trials were carried out to compare the yield potential of sorghum and maize varieties on different soil types. The results showed that under low moisture regimes, some sorghum varieties could outyield maize on heavy soils. During the subsequent years, more exotic sorghum varieties were introduced from the United States, Egypt, East and South Africa. Hence, more trials were carried out annually on both sandveld and clay soils. However, little information was obtained from these preliminary trials because the varieties were not suitable and the spacing used was incorrect.

The breeding work which was started in 1947 was reassessed and discontinued in 1955. This was due to the realisation that any specific breeding program would only be of value when locally adapted varieties are picked and included in the program. This decision necessitated a redress of the sorghum research program. This then involved the bulking up of sufficient seed on all the varieties in stock to enable proper comparison to be made in replicated variety trials. The trials were conducted in different ecological zones in the western part of the country which was then a traditional sorghum growing area. The main aim was to isolate the materials which were resistant to disease and birds, and those with desirable malting qualities.

The spacing trials started during the 1950s. There was indication that higher yields could be obtained from closer spacings than was used traditionally but yield superiority depended on the rainfall distribution pattern. Cackett (1960) found out that an inter-row spacing of 45-60 cm gave maximum yields and kept inter-plant competition to a minimum. During the subsequent years, additional work on spacing was done and high yields were obtained from 30 cm inter-row spacing.

The agronomy trials dominated the sorghum improvement program for some time until the 1969/70 season when sorghum breeding work was done on a much larger scale.

---

1Senior Sorghum and Pearl Millet Breeder, Department of Research and Specialist Services, Crop Breeding Institute, P.O. Box 8100, Causeway, Harare, Zimbabwe.
Distribution, Production and Ecological Zones

Matebeleland has been the major sorghum growing area in Zimbabwe until recently when emphasis shifted to Mashonaland and other parts of the country. Tattersfield (1982) linked this shift with the introduction of high yielding hybrids which have allowed profitable yields to be obtained in Mashonaland.

The total sorghum tonnage produced varies from one production section to the other. In the large scale commercial farming area, average yields are about 2.5 t/ha, while yields from small scale commercial and peasant farmers are of the order of 0.7 t/ha and 0.5 t/ha, respectively.

Sorghum is grown in different parts of Zimbabwe where other cereals are grown. Among the common grain crops grown in the country, sorghum ranks fourth in both total tonnage and area of production (Table 1). In Zimbabwe, maize is the leading cereal grain followed by wheat and pearl millet. However, the sorghum status changes when one moves from one region to another.

Sorghum grows and yields reasonably well on all soil types, however, better results are obtained when it is grown on medium to heavy soils. Previous research indicated that profitable yields could be achieved from growing sorghum on heavy soil (Cackett 1960). Although grain sorghum has been grown in all parts of the country, a large production area has recently been established in Mashonaland Central, in the Bindura-Glendale area, Mashonaland West, Norton-Chegutu and Kadoma areas. In the Masvingo province, sorghum is grown in Zaka. Peasant farmers are actively growing sorghum in Nyajena, Sengwe, Bikita, Matibi and Maronda. Although Matebeleland is no longer a major commercial sorghum growing area, peasant farmers are still growing some on a small scale in the North Lupane, Tsholotsho and Ntabazinduna areas. The other sorghum growing areas are Mutoko and Mundzi in Mashonaland East. It constitutes the basic diet for more than 60% of the inhabitants of this area. Generally, sorghum is grown everywhere in this region where it has proved possible to raise a crop, however, there are some areas where sorghum is grown on a large scale. Sorghum is also widely grown in the Zambezi valley area. This covers such areas as Mazarabani, Chiswiti and Mufumbura.

Zimbabwe is divided into three ecological zones, based on altitude and these are the lowveld, the middleveld, and highveld. The zone description is shown in Table 2. Although sorghum is found everywhere in the country, most of it comes from the low and middlevelds. The crop seems to perform well in areas of marginal rainfall where maize is an outright failure. The lowveld, where most of the crop is grown is characterised by exorbitant temperatures of about 25-33°C with low and erratic rainfall.

In spite of the harsh conditions, profitable yields are still obtained from this zone. Table 2 shows the January mean temperatures over ten years as an indication of how hot it becomes in the middle of the growing season. The month of July has been chosen because it has the lowest mean monthly temperatures during the year.
Table 1. Food crop production in Zimbabwe 1951 to 1955 and 1976 to 1980.

<table>
<thead>
<tr>
<th>Period</th>
<th>Large scale commercial farms (L.S.C.)</th>
<th>Small scale commercial farms (S.S.C.)</th>
<th>Peasant farms (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area ha</td>
<td>Production t</td>
<td>Yield kg/ha</td>
</tr>
<tr>
<td>Maize</td>
<td>1951-55</td>
<td>145,000</td>
<td>207,068</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>212,450</td>
<td>1,008,136</td>
</tr>
<tr>
<td>Munga</td>
<td>1951-55</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sorghum</td>
<td>1951-55</td>
<td>3,017</td>
<td>1,678</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>6,476</td>
<td>16,124</td>
</tr>
<tr>
<td>Rapoko</td>
<td>1951-55</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wheat</td>
<td>1951-55</td>
<td>494</td>
<td>634</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>37,234</td>
<td>163,165</td>
</tr>
<tr>
<td>Barley</td>
<td>1951-55</td>
<td>291</td>
<td>352</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>4,655</td>
<td>22,798</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>1951-55</td>
<td>1,216</td>
<td>19,467</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>25,091</td>
<td>2,583,306</td>
</tr>
<tr>
<td>Potatoes</td>
<td>1951-55</td>
<td>1,789</td>
<td>12,018</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>1,507</td>
<td>21,891</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>1951-55</td>
<td>2,908</td>
<td>1,562</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>3,394</td>
<td>7,980</td>
</tr>
<tr>
<td>Soyabean</td>
<td>1951-55</td>
<td>600</td>
<td>231</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>32,700</td>
<td>66,656</td>
</tr>
<tr>
<td>Edible beans</td>
<td>1951-55</td>
<td>2,912</td>
<td>815</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>1,098</td>
<td>459</td>
</tr>
<tr>
<td>Sunflowers</td>
<td>1951-55</td>
<td>2,195</td>
<td>929</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>3,074</td>
<td>1,688</td>
</tr>
<tr>
<td>Cotton</td>
<td>1951-55</td>
<td>5,102</td>
<td>1,428</td>
</tr>
<tr>
<td></td>
<td>1976-80</td>
<td>74,055</td>
<td>125,558</td>
</tr>
</tbody>
</table>

Table 2. Description of ecological zones of Zimbabwe with mean maximum temperatures for January and July recorded over ten years period.

<table>
<thead>
<tr>
<th>Area Name</th>
<th>Altitude</th>
<th>Mean annual rainfall</th>
<th>January temp. °C</th>
<th>July temp. °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mudzi</td>
<td>300 - 600 m</td>
<td>600 - 700 mm</td>
<td>27.5 - 30</td>
<td>22.5 - 30</td>
</tr>
<tr>
<td>Mukumbura</td>
<td>300 - 600 m</td>
<td>700 - 800 mm</td>
<td>30 - 32.5</td>
<td>27.5 - 30</td>
</tr>
<tr>
<td>Ndowoyo</td>
<td>300 - 600 m</td>
<td>500 - 600 mm</td>
<td>30 - 32.5</td>
<td>22.5 - 25</td>
</tr>
<tr>
<td>Ngorima</td>
<td>300 - 600 m</td>
<td>600 - 700 mm</td>
<td>27.5 - 30</td>
<td>25 - 27.5</td>
</tr>
<tr>
<td>Ngorima</td>
<td>300 - 600 m</td>
<td>600 - 700 mm</td>
<td>27.5 - 30</td>
<td>25 - 27.5</td>
</tr>
<tr>
<td>Mutoko</td>
<td>600 - 900 m</td>
<td>700 - 800 mm</td>
<td>25 - 27.5</td>
<td>20 - 22.5</td>
</tr>
<tr>
<td>Omuy</td>
<td>600 - 900 m</td>
<td>700 - 800 mm</td>
<td>30 - 32.5</td>
<td>25 - 27.5</td>
</tr>
<tr>
<td>Zaka</td>
<td>600 - 900 m</td>
<td>700 - 800 mm</td>
<td>27.5 - 30</td>
<td>22.5 - 25</td>
</tr>
<tr>
<td>Bikita Lowveld</td>
<td>600 - 900 m</td>
<td>700 - 800 mm</td>
<td>27.5 - 30</td>
<td>25 - 27.5</td>
</tr>
<tr>
<td>Binkura</td>
<td>900 - 1200 m</td>
<td>700 - 800 mm</td>
<td>27.5 - 30</td>
<td>22.5 - 25</td>
</tr>
<tr>
<td>Chegutu</td>
<td>900 - 1200 m</td>
<td>700 - 800 mm</td>
<td>27.5 - 30</td>
<td>22.5 - 25</td>
</tr>
<tr>
<td>Lupane</td>
<td>900 - 1200 m</td>
<td>600 - 700 mm</td>
<td>30 - 32.5</td>
<td>25 - 27.5</td>
</tr>
<tr>
<td>Tjolotjo Middleveld</td>
<td>900 - 1200 m</td>
<td>600 - 700 mm</td>
<td>27.5 - 30</td>
<td>22.5 - 25</td>
</tr>
<tr>
<td>Matopo Highveld</td>
<td>1200-1500 m</td>
<td>600 - 700 mm</td>
<td>25 - 27.5</td>
<td>20 - 22.5</td>
</tr>
<tr>
<td>Mutambara</td>
<td>1200-1500 m</td>
<td>600 - 700 mm</td>
<td>25 - 27.5</td>
<td>17.5 - 20</td>
</tr>
</tbody>
</table>
Probably the most common sorghum races which are found in Zimbabwe are kafir, bicolor and guinea. House (n.d.) associated the kafir race with Eastern and Southern Africa, the latter of which covers Zimbabwe. Traces of the wild sorghum spp Sorghum verticilliflorum have been reported by the germplasm collection team in 1982, however, the distribution has not been established.

During the past Zimbabwe depended heavily on foreign materials, therefore improved varieties from local stocks are limited. There are several local varieties established across the country but there has been no real attempt to improve them. In the past, Feterita and Framida were commonly grown varieties in the country, later came Red Swazi and Red Swazi 'A' which gave reasonable yields, but are now less popular because of the introduction of high yielding hybrids. However, these varieties are still grown commercially but on a much smaller scale. The more widely distributed varieties are the indigenous types which require improvement. These seem to be more widely grown in the peasant sector than in commercial sector.

Sorghum yields vary from one farming sector to the other. Tables 1, 3, and 4 show sorghum yields in Zimbabwe. Table 1 relates sorghum production to other crops grown in the country. Table 3 describes sorghum production in relation to other cereals while Table 4 shows the production by the small scale commercial and peasant farmers. The national average yield is estimated to be 2.5 t/ha. This is true when improved varieties are used and yields decline where farmers use traditional varieties.

Utilization of Sorghum

In Zimbabwe, grain sorghum is utilized in several ways, of which the most important are: human consumption, opaque beer brewing, and stock feeds. In most of the peasant farming areas where sorghum is the major grain produced, up to about 80% of the total grain produced is used for food preparations of which the most important are sadza (Shona) or itshwala (Sindebele), a thick paste consumed for lunch and dinner in most cases, soft porridge, bota (Shona) and ilambezi Sindebele. It is also used in traditional medical preparations. The white or red seeded types without a testa are preferred for thick porridge (Mukuru et al. 1981).

In the absence of sorghum, maize or pearl millet or finger millet may be used for the same purpose. While there was no real way of showing the amount of sorghum used for sadza preparations in 1980/81, about 55% of the total marketed produce was delivered to the Chibuku breweries. As a general rule, Chibuku uses the bulk of the red seeded sorghums while white types are used for human consumption. Out of the total sorghum produced, 74% of it came from the large scale commercial farmers, while 26% was delivered by small scale commercial and peasant farmers (Noakes 1982). About 5% of the total grain sorghum produced during the 1980/81 season was used for making stock feeds. This is utilized for feeding dairy animals, beef cattle, and other classes of livestock.
Table 3. Average sorghum production of large and small scale commercial and peasant farms as related to other cereal grain.

<table>
<thead>
<tr>
<th></th>
<th>Area</th>
<th>T</th>
<th>kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>980,675</td>
<td>1,576,199</td>
<td>2,402</td>
</tr>
<tr>
<td>Wheat</td>
<td>477,617</td>
<td>164,355</td>
<td>2,474</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>341,244</td>
<td>130,968</td>
<td>496</td>
</tr>
<tr>
<td>Sorghum</td>
<td>160,158</td>
<td>94,385</td>
<td>2,686</td>
</tr>
<tr>
<td>Finger millet</td>
<td>119,495</td>
<td>62,628</td>
<td>628</td>
</tr>
</tbody>
</table>

Table 4. Sorghum production in the small scale commercial and peasant farmers in Zimbabwe.

<table>
<thead>
<tr>
<th></th>
<th>Area</th>
<th>T</th>
<th>Kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>768,225</td>
<td>568,063</td>
<td>1,240</td>
</tr>
<tr>
<td>Wheat</td>
<td>823</td>
<td>1,190</td>
<td>1,513</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>341,244</td>
<td>130,968</td>
<td>496</td>
</tr>
<tr>
<td>Sorghum</td>
<td>153,682</td>
<td>78,261</td>
<td>588</td>
</tr>
<tr>
<td>Finger millet</td>
<td>119,495</td>
<td>62,628</td>
<td>628</td>
</tr>
</tbody>
</table>
Possible Objectives and functions of the Sorghum Improvement Network

1. Division of Labour
   - It was suggested that in view of the shortage of skilled manpower in any one country, a long term objective of the network could be to enable each country to concentrate in only selected aspects of sorghum improvement where the country concerned has comparative advantage. Information obtained, techniques and materials developed through such concentration should be available to all the other countries of the region.

2. Activity and Functional Areas for Regional Cooperation
   - Co-ordination of the crop improvement work so that each country is aware of the germplasm available in the other countries of the region.
   - Strengthening or setting up of a regional sorghum genetic resources unit along with a germplasm bank which would serve all countries of the region, speed up and facilitate the easy movement of germplasm within the region.
   - Setting up of a central crossing block to serve all those countries of the region needing such service.
   - Setting up of a central station for intensive research on Striga control.
   - Regional co-ordination of trials to which each national program contributes entries for the various major ecological zones found in the region.
   - Co-ordinated visits by groups of active sorghum researchers of the region to each national program for a more critical and comparative project assessment and exchange of information.
   - Facilitate a centre or centres for specialized physical and/or chemical analysis of sorghums for use by all projects.
   - Strengthening and/or facilitating the establishment of seed production services in the region.

3. Training
   - Facilitate training of technicians and research associates within the region for better familiarity with local and regional conditions.
   - Explore possibility of a co-ordinated training program for professional staff based on knowledge of the existing conditions in each country obtained through the network.
- Co-ordinate and facilitate consultancy services from within the region and possibly from outside the region.

4. Dissemination and Utilization of Information
   - Publication of a regional newsletter concentrating on various aspects of sorghum.
   - Initiating regular and co-ordinated seminars and workshops for sorghum workers of the region.

5. Sorghum Utilization Research
   - Establish links between projects involved in Sorghum Utilization research including Sorghum dehuller and production of composite flour in various countries.

Editor's Note

Recommendations and comments of the participants of the workshop on the points raised in this discussion paper as well as other related items are given in the next section.
RECOMMENDATIONS AND COMMENTS OF THE
REGIONAL WORKSHOP ON SORGHUM
IMPROVEMENT IN EASTERN AFRICA
NAZARETH AND DEBRE ZEIT, ETHIOPIA
17-21 OCTOBER, 1982

1. The workshop thanks the Institute of Agricultural Research (IAR), the Addis Ababa University (AAU) and the International Development Research Centre (IDRC) for so effectively and graciously hosting the workshop.

2. Participants of the workshop were interested in defining crop improvement. A proposed definition is: "Sorghum and millet improvement is defined as the development of commodity based technology that improves the farmer's situation in a way acceptable to him. This technology would include development and management aspects of high yielding varieties and hybrids, with food quality, and would involve control of major agronomic problems facing the farmers".

3. The conference recognizes with appreciation that SAFGRAD has established the position of coordinator for their sorghum and millets program for Eastern and Southern Africa.

4. It is recommended that the SAFGRAD coordinator in conjunction with ICRISAT develop a research and training base to assist in strengthening national programs in all component functions of crop improvement. To that end it is:
   a) Recommended that a regional research team include breeders for sorghum and for pearl and finger millets, and scientists across these crops in agronomy-physiology, entomology, pathology, and Striga.
   b) Recommended that the regional program have training activities including in-service research associates and technicians. The conference recognizes the training opportunities at ICRISAT and elsewhere but strongly encourages the establishment of practical applied type training by the regional program.
   c) Recommended that service activities are developed including a regional crossing block, regional off-season nursery, regional screening for resistance to yield limiting factors, and screening for food quality.
   d) Recommended that an annual regional workshop be organized at different locations in the region to review results of research and to organize research activities for the
following year. In this way scientists from the region help define the functions of the regional program. Annual progress reports of the national and regional programs should be available at the workshop to facilitate this progress.

e) It is recognized that these activities should be undertaken in the region on stations of national programs to ensure a close working relationship between national and regional programs.

5. *Striga* is recognized as a serious problem that continues to increase in importance in all countries of the region. It is strongly recommended that a scientist concentrating on the *Striga* problem be included on the regional team.

6. The region is defined to include Burundi, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Tanzania, Uganda, Yemen Arab Republic, and the Peoples Democratic Republic of Yemen.

7. The meeting recognizes that crop improvement necessarily involves interdisciplinary activities which require strong linkages between programs and institutions within a country. The establishment of linkages, for example between plant breeders, grain storage specialists and nutritionists, can be expected to enable the early identification of new varieties and hybrids that will be more rapidly accepted by farmers. Where these linkages are formalized, both nationally and regionally, continuity for this activity is more assured.

8. The meeting recognizes the importance of germplasm collection and maintenance for the continued development of improved varieties and hybrids throughout the region. The Plant Genetic Resources Centre/Ethiopia (PGRC/E) and ESIP are to be congratulated on their close cooperation, and are encouraged to contribute to this function on a regional basis.

9. The problem and complexity of controlling damage by birds is recognized. The conference strongly encourages increased cooperation with appropriate research centres such as Denver Wildlife Research Centre.

10. In order to initiate a regional program, the meeting agrees that the SAFGRAD Coordinator will organize a regional sorghum variety trial for each of four major agroecological zones. Trials would be based on entries contributed by national programs in the region. Additionally, an introduction nursery including entries from within and outside the region will be grown at one or two locations to begin the process of introduction and germplasm diversification in the region.
a) Participating countries are: Burundi, Ethiopia, Kenya*, Rwanda, Somalia*, Sudan*, Tanzania, Uganda, Yemen Arab Republic, and the Peoples Democratic Republic of Yemen*.
(*Representatives not at the meeting - their involvement with the yield trials program will be developed subsequently).

b) Four adaptation zones for the trials were identified:
1) High elevation (above 1800 meters)
2) Intermediate elevation (1500 to 1800 meters)
3) Low elevation (below 1500 meters)
4) Very dry lowlands (500 mm of rainfall or less)

c) Sowing dates for the yield trials which will follow local practice, will be approximately as follows:

<table>
<thead>
<tr>
<th>Country</th>
<th>High El.</th>
<th>Inter. El.</th>
<th>Low El.</th>
<th>Very Dry Lowlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burundi</td>
<td>Dec. 1</td>
<td>Jan. 1</td>
<td>Jan. 1</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>April 15</td>
<td>May 1</td>
<td>June 15</td>
<td>June 15</td>
</tr>
<tr>
<td>Kenya</td>
<td>April 1</td>
<td>April 1</td>
<td>March 1</td>
<td>April 1</td>
</tr>
<tr>
<td>Rwanda</td>
<td>Dec. 15</td>
<td>Jan. 1</td>
<td>Jan. 1</td>
<td>-</td>
</tr>
<tr>
<td>Sudan</td>
<td>-</td>
<td>-</td>
<td>July 1</td>
<td>July 1</td>
</tr>
<tr>
<td>Tanzania</td>
<td>-</td>
<td>March 1</td>
<td>Feb. 15</td>
<td>Dec. 15</td>
</tr>
<tr>
<td>Uganda</td>
<td>Mar 1 - Aug 1</td>
<td>Mar 1 - Aug 1</td>
<td>May 1</td>
<td>May 1</td>
</tr>
<tr>
<td>YAR</td>
<td>May 1</td>
<td>May 15</td>
<td>May 15</td>
<td>May 15</td>
</tr>
<tr>
<td>PDRY</td>
<td>May 1</td>
<td>March 1</td>
<td>Aug. 1</td>
<td></td>
</tr>
<tr>
<td>(Zimbabwe)</td>
<td></td>
<td>Dec. 1</td>
<td>Dec. 1</td>
<td></td>
</tr>
<tr>
<td>COUNTRY</td>
<td>NAME</td>
<td>ADDRESS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burundi</td>
<td>Mr. Zénon Kabiro</td>
<td>ISABU, B.P. 795 Bujumbura, Burundi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Ato Adugna Zerihun</td>
<td>Debre Zeit Junior College of Agriculture and Research Center P.O. Box 32 Debre Zeit, Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ato Alemseged Mamuneh</td>
<td>Ethiopian Sorghum Improvement Project P.O. Box 414 Nazareth, Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Aregay Waktola</td>
<td>Addis Ababa University P.O. Box 1176 Addis Ababa, Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Asfaw Zelleke</td>
<td>Debre Zeit Junior College of Agriculture and Research Center P.O. Box 32 Debre Zeit, Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ato Asgeliel Dibabe</td>
<td>Bako Research Station Institute of Agricultural Research P.O. Box 3 Bako (Shoa), Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>W/o Belainesh Gebre-Hiwot</td>
<td>Ethiopian Nutrition Institute P.O. Box 5654 Addis Ababa, Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ato Birhanu Kinfe</td>
<td>Debre Zeit Junior College of Agriculture and Research Center P.O. Box 32 Debre Zeit, Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Biru Abebe</td>
<td>Plant Genetic Resources Center/ Ethiopia c/o Institute of Agricultural Research P.O. Box 2003 Addis Ababa, Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ato Brooke Abebe</td>
<td>Plant Genetic Resources Center/ Ethiopia P.O. Box 30726 Addis Ababa, Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Dejene Makonnen</td>
<td>Alemaya College of Agriculture Addis Ababa University P.O. Box 138 Dire Dawa, Ethiopia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAME</td>
<td>ADDRESS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ato Gebremariam Shikour</td>
<td>Institute of Agricultural Research</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 192</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jimma, Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W/t Hirut Kebede</td>
<td>Debre Zeit Junior College of Agriculture and Research Center</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Debre Zeit, Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ato Kidane Giorgis</td>
<td>Institute of Agricultural Research</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 2003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addis Ababa, Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. Mengistu Hulluka</td>
<td>Alemaya College of Agriculture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 138</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dire Dawa, Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ato Mesfin Tesserra</td>
<td>Bako Research Station</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Institute of Agricultural Research</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bako (Shoa), Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ato Mulugetta Mekuria</td>
<td>Institute of Agricultural Research</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 2003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addis Ababa, Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. Tamirie Hawando</td>
<td>Alemaya College of Agriculture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addis Ababa University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 138</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dire Dawa, Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. Taye Teferedeg</td>
<td>Institute of Agricultural Research</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 2003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addis Ababa, Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ato Taye Worku</td>
<td>Institute of Agricultural Research</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 2003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Addis Ababa, Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. Tesfaye Tesemma</td>
<td>Debre Zeit Junior College of Agriculture and Research Center</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Debre Zeit, Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. Tessema Megenasa</td>
<td>Debre Zeit Junior College of Agriculture and Research Center</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Debre Zeit, Ethiopia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COUNTRY</td>
<td>NAME</td>
<td>ADDRESS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rwanda</td>
<td>Mr. Célestin Sehene</td>
<td>Sorghum Improvement Program c/o ISAR Rwerere</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ruhengeri, Rwanda</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanzania</td>
<td>Mr. Clemence S. Mushi</td>
<td>A.R.I. Ilonga</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.O. Ilonga-Kilosa</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tanzania</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>Mr. Vincent Makumbi-Zake</td>
<td>UAFRO-Serere</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.O. Soroti, Uganda</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yemen Arab Republic</td>
<td>Dr. Ali E. Kambal</td>
<td>Agricultural Research Station</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.O. Box 5788</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Taiz, Yemen Arab Republic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mr. Hamoud Ali Abdulla</td>
<td>Agricultural Research Station</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.O. Box 5788</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Taiz, Yemen Arab Republic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mr. Hazza Abdul Gabbar</td>
<td>Agricultural Research Station</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.O. Box 5788</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Taiz, Yemen Arab Republic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>Mr. Joseph N. Mushonga</td>
<td>Crop Breeding Institute</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.O. Box 8100, Causeway Harare, Zimbabwe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others:</td>
<td>Dr. Hugh Doggett</td>
<td>IDRC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.O. Box 38</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Peredeniya, Sri Lanka, India</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Brhane Gebrekidan</td>
<td>QAU/STRC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 31 SAFGRAD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.O. Box 30786</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nairobi, Kenya</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Leland R. House</td>
<td>ICRISAT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Patancheru P.O.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Andhra Pradesh 502 324</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>India</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Roger A. Kirkby</td>
<td>IDRC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.O. Box 62084</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nairobi, Kenya</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ms. Liz Ngure</td>
<td>IDRC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.O. Box 62084</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nairobi, Kenya</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
REGIONAL WORKSHOP ON SORGHUM IMPROVEMENT IN EASTERN AFRICA
Nazareth and Debre Zeit, Ethiopia 17-21 October 1982

PROGRAM

Sunday 17 October
- Arrival of Participants in Addis Ababa

Monday 18 October
- 08:30 - Registration (Debre Zeit Junior College of Agriculture and Research Centre)
  Chairman: Brhane Gebrekidan
  Rapporteur: Tesseraa Megenasa
- 09:00 - Welcome - Brhane Gebrekidan and Asfaw Zeleke
- 09:15 - Opening Address - Dr. Abiye Kifle, V.P. for Academic Affairs Addis Ababa University
- 09:30 - Objective of the Workshop - Brhane Gebrekidan
- 09:40 - Brief History of Sorghum Improvement in Eastern Africa - Hugh Doggett
- 10:00 - Role of IDRC in Eastern Africa National Sorghum Improvement Programs - Roger A. Kirkby
- 10:15 - Coffee Break
  Chairman: Biru Abebe
  Rapporteur: Mulugetta Mekuria
- 10:30 - Overview of ESIP - Brhane Gebrekidan
- 10:45 - Sorghum Germplasm at PGRC/E - Brooke Abebe
- 11:05 - Sorghum Diseases in Ethiopia - Mengistu Hulluka.
- 11:25 - Sorghum Insects in Ethiopia - Tessema Megenasa
Monday 18 October (continued)

- 11:45 - Striga in Ethiopia - Taye Teferedechn
- 12:05 - Nutritional and Consumer Preference Aspects of Sorghum - Belainesh Gebre-Hiwot
- 12:15 - General Discussions
- 13:00 - Lunch

14:00 - 16:30 - Country Reports
Chairman: Hugh Doggett
Rapporteur: Joseph Mushonga
(Burundi, Ethiopia, Kenya, Rwanda, Somalia)

Tuesday 19 October

08:30 - 11:30 - Country reports continued
Chairman: Vincent Makumbi
Rapporteur: Clemence Mushi
(Sudan, Tanzania, Uganda, Yemen Arab Republic, Yemen Peoples' Democratic Republic, Zimbabwe)

11:30 - 12:30 - General Discussions
Chairman: Roger Kirkby
Rapporteurs: Clemence Mushi and Joseph Mushonga

12:30 - Lunch Break

14:00 - 16:00 - Visit experimental fields at Debre Zeit
16:00 - Depart for Nazareth

Wednesday 20 October

07:00 - Depart for Arsi Negelie

10:00 - 12:30 - Visit experimental fields at Arsi Negelie
Wednesday 20 October (continued)

12:30 - 14:00  – Lunch at Langano
14:00  – Depart for Nazareth

Thursday 21 October

08:00 - 12:00  – Visit Sorghum Crossing Blocks and experimental fields at Nazareth

12:00 - 14:00  – Lunch Break
Chairman: Brhane Gebrekidan
Rapporteur: L. R. House

14:00 - 16:00  – General discussions on strengthening the Eastern Africa Sorghum Improvement Network
- Regional trials and nurseries
- Exchange of seeds and annual reports
- Regional crossing block
- Training
- Other areas of cooperation

16:00 - 18:00  – Recommendations and closing of workshop