SORGHUM AND MILLET IMPROVEMENT IN EASTERN AFRICA

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Sorghum and Millet Improvement in Eastern Africa
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A. Doto

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Brhane Gebrekidan
SAFGRAD/ICRISAT Program, Kenya
OAU/STRC JP 31 SAFGRAD
P.O. Box 30786
Nairobi, Kenya

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PREFACE

The sorghum and millet workers of eastern Africa have continued to meet annually for the third time now, this time in Morogoro, Tanzania. These meetings have been the focal points for fostering professional co-operation and strengthening the eastern Africa network in sorghum and millet research. The contributions of the Tanzanian Agricultural Research Organization (TARO), the International Development Research Centre (IDRC), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and the Semi-Arid Food Grains Research and Development (SAFGRAD) of the Organization of African Unity (OAU) made this workshop possible. As in the last two workshops the bulk of the finances for the workshop was provided by IDRC for which we are grateful.

These proceedings contain papers which were presented to the workshop as well as discussions and recommendations of the workshop. The proceedings, in addition to the previous two, should serve as good references on sorghum and millet improvement and related research in eastern Africa including the Yemens and Zimbabwe. The results of the Eastern Co-operative Sorghum Regional Trials were presented and discussed for the first time in these workshops. Based on the results of the trials the participants made agreements and devised strategies for continuing the regional trials and setting up regional sorghum nurseries.

The assistance of Mrs Caroline Agola in editing and that of Miss Alice N. Mwaniki in typing the papers is acknowledged with appreciation.

The Editor

WELCOME ADDRESS

H.M. Saadan*

On behalf of the National Sorghum and Millet Improvement Project it is my pleasure to welcome all of you to this third Regional Workshop on Sorghum Improvement in Eastern Africa. I hope you have had a good rest after travelling all the way from your homes to Dar es Salaam and from there to Morogoro. As you might have seen while driving towards Morogoro, the area has enough rainfall to raise crops like rice, maize and sorghum. Rice is grown in the valley bottoms while maize and sorghum are grown in most places where any crop can be grown.

Probably most of you have noted sisal plantations while driving towards Morogoro. Sisal was one of the most important cash crops in the national economy in the early 1970s, but many farms were abandoned when world market prices went down. However, a few sisal farms are still in existence.

A number of you will have seen the mountain ranges as you were approaching Morogoro. These are the Uluguru Mountains. Up in the mountains the weather conditions are different with low temperatures and high humidity during the rainy season. People living on the slopes provide Morogoro market with different types of fruits and vegetables. Morogoro is famous for the production of sweet oranges.

I extend my thanks to the staff of Sokoine University of Agricultural Sciences and Centre for Continuing Education for their co-operation. Special gratitude goes to IDRC for their financial support. Again I would thank all the participants who have attended the workshop and wish you an enjoyable stay in Morogoro and Tanzania as a whole. Thank you.

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*Co-ordinator and Sorghum Breeder, National Sorghum and Millet Research Program, TARO, Ilonga, P.O. Ilonga, Kilosa, Tanzania.

INTRODUCTORY ADDRESS

J.N.R. Kasembe*

This workshop has been organized under the auspices of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Semi-Arid Food Grains Research and Development (SAFGRAD), the International Development Research Centre (IDRC) and the Tanzania Agricultural Research Organization (TARO). The first meeting of this kind was held in Addis Ababa in 1982, the second in Rwanda in 1983 and this third one is now being held here. All these three workshops have been financed by IDRC. For the purpose of sorghum and millet improvement, as agreed at the 1982 workshop, the Eastern Africa Region includes Burundi, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Tanzania, Uganda, Yemen AR, Yemen PDR and Zimbabwe, and I understand all these countries are represented here.

I would now like to take an objective and critical look at sorghum and millet improvement work and production in the region.

1. Meetings and workshops of SAFGRAD, whose headquarters are in Ouagadougou, Upper Volta, were not, until today, directly linked with the ones mentioned earlier. I am glad that today we have with us a delegate from SAFGRAD. This is an indication that such a network was desired and efforts have been made to link the international agricultural research centre (i.e. ICRISAT) with the OAU institution (i.e. SAFGRAD).

2. The second workshop welcomed the addition of millets in the discussions, therefore the sorghum and millets programs of ICRISAT should feature in this workshop.

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*Director General, Tanzania Agricultural Research Organization and Africa Representative Consultative Group on International Agricultural Research.

3. Sorghum production in the host country of this workshop (Tanzania) is steadily increasing from an estimated 3,000 tons in 1976/77 to an estimated 21,000 tons purchased by the National Milling Corporation in 1979/80. This trend, I hope, is prevalent in all member countries. The increased production is mainly a result of increased area and not increased yield.

4. The mandate of ICRISAT, as far as sorghum and millets are concerned, should clearly show in:

   (a) Germplasm conservation and evaluation;
   (b) Breeding varieties for use by several national programs;
   (c) Offering consultancy in sorghum and millet technology and its transfer to needy areas;
   (d) Training of manpower for sorghum and millet research and development at all levels.

5. The member countries in the region have the task of learning from each other the advances made by every country where the workshops are held. This task has several aspects:

   (a) Regional co-operation in areas of common interest such as the problem of droughts or water stress and germplasm exchange. Now Tanzania is putting a lot of emphasis on drought resistant crops and sorghum and millets are at the top of the list;
   (b) Learning from each other;
   (c) Avoiding mistakes made by others.

I would therefore urge you to give only very brief and precise country reports limited to new activities which have taken place since the last workshop. In other words, the

written reports should be distributed in the hall and authors should give a summary or oral synopsis of the more important points which can then be discussed.

Before I close my introductory address I would like to state in strong terms that the international agricultural research centres (in this case ICRISAT) and the OAU institutions (in this case SAFGRAD) help the national agricultural research systems in member states in our region to improve their capabilities in production of the crops in question. Most important in this case are our own efforts to that end. As your representative for Anglophone Africa in the Consultative Group on International Agricultural Research I urge you to forge a closer network in the region and to increase efforts to overcome environmental constraints and eliminate biological, managerial and socio-economic problems which hinder higher production of crops.

May I take this opportunity to thank IDRC for financing the workshop, the SAFGRAD Co-ordinator for Sorghum and Millets and ICRISAT for their assistance in organizing the meeting and the Centre for Continuing Education of the University of Dar es Salaam, and the Faculty of Agriculture, Forestry and Veterinary Science, Morogoro for facilities for the workshop.

I hope everyone will contribute effectively to the objectives of the workshop and that all our countries will benefit in some way. I wish the workshop success in this challenging task. Thank you.

BACKGROUND AND PURPOSE OF THE WORKSHOP

Brhane Gebrekidan*

The last two regional workshops on Sorghum and Millet Improvement in Eastern Africa, financed by IDRC, were held in Ethiopia and Rwanda in 1982 and 1983, respectively. Both workshops were attended by active sorghum and millet researchers of the region as well as the representatives of IDRC, ICRISAT and SAFGRAD. The proceedings of the first workshop have been published and those of the second are being released during this workshop. The publication costs of both workshops have been paid for by IDRC.

At the Rwanda workshop, the participants recommended holding the 1984 Sorghum and Millet Regional Workshop in Tanzania. Since the second workshop those institutions involved in sponsoring and organizing the Tanzania workshop (the Tanzania Agricultural Research Organization (TARO), the International Development Research Centre (IDRC), the Eastern and Southern Africa Co-operative Program of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Semi-Arid Food Grains Research and Development (SAFGRAD) JP 31 of the Organization of African Unity) have interacted and co-operated in making this workshop possible. Consistent with our past practice of holding our meetings at a stage when it is best to see the crop in the field, the timing of our workshop in June coincides with the maturity of the crops of our interest in Tanzania. We therefore hope to get a good look at Tanzanian sorghums and millets in the field. The venues for the workshop (Morogoro and Ilonga) give us a unique opportunity to learn about sorghum research in

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*SAFGRAD Co-ordinator for Sorghum and Millets, Eastern and Southern Africa, ICRISAT SAFGRAD Regional Program, OAU/STRC/ SAFGRAD JP 31, P.O. Box 30786, Nairobi, Kenya.

Tanzania both at the TARO and the University level.

As agreed in our 1982 workshop in Ethiopia, for the purpose of sorghum and millet improvement the Eastern Africa Region is understood to include Burundi, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Tanzania, Uganda, Yemen AR and Yemen PDR. This coincides with ICRISAT's Eastern Africa Geographical Functional Region. Zimbabwe continues to participate in the workshop because of the desire of their national program to do so and IDRC's encouragement and support for their participation. They have continued to participate in the regional activities since 1982.

As in the last two workshops, the financial sponsor of this workshop is IDRC. Their regular support of this important regional activity is gratefully acknowledged. I am sure that all the national programs of the region join me in expressing this appreciation.

The main purpose of this regional workshop is, as in the past, to enable the sorghum and millet researchers of the region to continue to effectively share experiences and to give them further opportunity to interact with each other. The workshop is an appropriate forum to discuss the problems, solutions and prospects for sorghum and millet improvement in the region. The workshop is also expected to further strengthen the existing links between the sorghum and millet workers of the region so that the flow of information and germplasm in all directions is facilitated.

The first workshop concentrated on assessing and collecting information on the current status of sorghum improvement in each country of the region. This has been done effectively and the proceedings of the workshop have been published and distributed to all of you. Additional copies are still available from the SAFGRAD Co-ordinator in Nairobi.

In the second workshop the emphasis was on presentation of reports of the sorghum and millet research and extension activities of each national program in the region for the 1982/83 crop season. Invited papers on Striga, stem borers, and breeding strategies were also presented.

The third workshop has been organized following the general format of the second workshop but with the addition of a special section on the results and discussions of the 1983 Eastern Africa Co-operative Sorghum Regional Trials. We would like to exchange views on how useful the regional trials have been, what changes, if any, should be made in future regional trials, and what contributions are to be made from the national programs.

During this workshop the main centre of interest will be the Tanzania national program on sorghum and millets. Placing special emphasis on the national program of the host country of the workshop is consistent with our past methods. As you can see from the workshop program, several of our Tanzanian colleagues are scheduled to give papers on areas of interest to all of us, such as breeding, agronomy, farming systems, entomology, pathology, processing and utilization. I trust, therefore, that we will get a good understanding and comprehensive picture of sorghum and millet research in Tanzania. Our scheduled visits to the experimental fields and laboratories at Morogoro and Ilonga should give us the opportunity to see and study sorghum and millet in the field.

Finally, at this time when our region of Africa is in the grip of one of the worst droughts of recent times, the importance of sorghums and millets is once again highlighted. There is a challenge and opportunity for each one of us to contribute to improved food production in each of our countries. In this effort, co-operation and free exchange of information and germ-

plasm will go a long way towards strengthening each of our national programs. This workshop is one of the ways of strengthening the inter-country linkages in our region.

We look foward to four interesting and informative workshop days and know that our Tanzania hosts have spared no effort to make our stay in Tanzania a very enjoyable one.

Thank you for your attention.

AN OVERVIEW OF THE SORGHUM AND MILLET IMPROVEMENT PROGRAM IN TANZANIA

H.M. Saadan*

INTRODUCTION

Tanzania has a vast range of ecological conditions from lowlands to high altitude areas. Sorghum and millets are important traditional food crops being grown all over the country where it is possible to raise a crop. They have been grown for subsistence by small holders, mainly in areas with limited precipitation, especially in central and western Tanzania. However, in those areas which have suitable climatic conditions, farmers substitute sorghum and millet with crops like maize and rice. Although there has been a gradual decline in hectarage under sorghum as a result of this substitution, sorghum and millet are important food crops in the national economy. Low grain yields, low market prices and changes in eating habits are among factors which contributed to declining sorghum production.

AREAS OF SORGHUM PRODUCTION

Sorghum and millets are widely grown in Tanzania. However, distinct agro-ecological zones have been identified.

Coastal and eastern belt

Generally this zone is wet, hot and humid. Along the coast there is a bimodal rainfall pattern with short and long rains. The short rains begin in October and farmers grow short

*Co-ordinator and Sorghum Breeder, National Sorghum and Millet Research Project, TARO, Ilonga, P.O. Ilonga, Kilosa, Tanzania

maturing crops and harvest in January. Full-season crops are planted during the long rains which begin in February. Sorghum is among the crops planted during the long rains. Full-season crops are harvested in June/July.

In the Eastern region there is a monomodal rainfall pattern and farmers grow their crops in early December and January. Local sorghums are planted at the beginning of the rains after rice and maize. These sorghums are late maturing (4-5 months), tall (3-4 metres), and have loose panicles with white grains. Red or brown sorghums are used for brewing.

Central and western zone

This is a zone which is typical of the semi-arid areas of Tanzania. It is characterized by little and unreliable rainfall. Usually these rains fall heavily in a short period of time (about 2-3 months) resulting in soil erosion. This zone, which receives an annual rainfall of 500-800mm, includes Dodoma, Singida, Shinyanga and part of Tabora region. In the semi-arid areas sorghum and millets provide the bulk of calories to small holders. These farmers grow a mixture of crops, including maize, cowpeas and bulrush millet. Under prolonged rainfall conditions all crops can be harvested. The existence of relatively short maturing local sorghum is known but most farmers prefer late maturing varieties as they fit in with their farming pattern.

North-west (lake basin) zone

In these areas the rains have changed from reliable to unreliable creating more emphasis on drought tolerant crops. Around the lake area sorghums are widely grown because of

their tolerance to waterlogging on the black *mbuga* soils. However, certain cultivars with brown/red grains seem to have resistance to *Striga* infestation.

High altitude zone (above 1,500m)

This zone is mainly the Southern Highlands which include Mbeya, Iringa and Sumbawanga regions. The importance of sorghum in these areas is for brewing purposes while in marginal rainfall areas production of finger millet and sorghums is encouraged.

In line with the importance of sorghum and millet as human food in Tanzania, a National Sorghum and Millet Research program was established. The Government, through the Ministry of Agriculture, developed a National Agricultural Policy aimed at setting agricultural goals and strategies which would improve the well-being of the people whose principal occupation and way of life is based on agriculture. The sorghum and millet improvement program emphasizes the development and promotion of new sorghum varieties with suitable grain qualities for food and livestock feed. The program promotes the processing, marketing and utilization of sorghum and millet in collaboration with other national institutes such as the Small Industry Development Organization (SIDO, supported by IDRC), the Tanzania Food and Nutrition Centre (TFNC), the University of Dar es Salaam (Faculty of Agriculture, Morogoro) and the National Milling Corporation. The national sorghum and millet improvement program liaises with regional and international institutes in order to strengthen and provide continuity of research activities in the country.

RESEARCH OBJECTIVES FOR THE NATIONAL SORGHUM AND MILLET IMPROVEMENT PROGRAM

Crop improvement

Crop improvement programs are aimed at developing stable

cultivars and hybrids of sorghum and millet with high grain yield, disease and pest tolerance, appropriate maturity and acceptable grain quality for human food and, possibly, feed for livestock.

Agronomic investigations

These are aimed at developing and identifying the effect of various agronomic packages for farmers in order to stabilize and optimize sorghum yields in relation to water requirements, plant densities, intercropping, planting dates, crop management (weeding, fertilizer use, etc.).

Cereal technology

This is aimed at identifying various processing methods which would produce high yields of decorticated grain and different methods of food preparation which would diversify the use of the crop and increase its demand as food and livestock feed.

Agricultural marketing

The relative lack of sorghum food products that are acceptable to consumers is a major constraint to increased production. Marketing and processing are interrelated to a certain extent and the National Milling Corporation is the main buyer of sorghum, mainly of the mixed or brown types. NMC has been finding it difficult to dispose of the grain except as a hunger relief food during famine. Therefore there is a need to look for an alternative use or outlet for the produce if production is to be expanded.

Agricultural engineering and economics

There is a need to develop implements or devices for field

use that would simplify and increase sorghum and millet production under small-scale farming conditions. Ubungo Farm Implements (UFI) is among the institutes that designs and produces simple implements for small-scale production. Certainly, conducting studies on the economic aspects of sorghum production would promote efficient use of farm inputs such as fertilizers, herbicides, pesticides and other chemicals.

CENTRAL ACTIVITIES IN THE NATIONAL SORGHUM AND MILLET RESEARCH PROJECT

Ilonga is the co-ordinating centre and is responsible for all research activities of the sorghum growing zones. These activities include:

Seed packaging

Planning of all trials and nurseries at all sites as well as other co-operating stations is done at Ilonga by senior officers. Seed packaging and preparation of instruction and data sheets is done at Ilonga. Seed packages are dispatched to respective stations for planting which is done by technical assistants.

Crossing nursery

In line with the program's objectives decisions and actual crossing work are handled at Ilonga. Selection of parents for the crossing block is done at each station at the time of evaluation.

Selection and evaluation

Selection of parents to be used in the crossing program and overall evaluation is done by scientific officers from the co-ordinating station. However, routine field work and data

recording is done either by technical officers or technical assistants assigned to a site.

Dry season nursery

Currently Ilonga is the only station providing an off-season nursery for seed increase and advanced generations for selected materials. Crossing for experimental hybrids is again done during the off-season.

Materials and supplies

Items like harvesting bags, measuring scales, tape measures, note books and related items are bought at the co-ordinating office and distributed to respective stations, as requested.

Co-ordinating sorghum and millet research activities

The National Sorghum and Millet Improvement Research Program has been given the mandate to co-ordinate and develop relevant research activities related to sorghum and millet improvement. In order to broaden its spectrum of activities the program is working in collaboration with other National Institutes in developing interdisciplinary activities. Evaluation of sorghum research projects and proposals for future projects related to sorghum and millet is done annually by the co-ordinating committees.

Reports and data processing

Data collected from all stations are compiled, analysed, interpreted and written into formal reports at Ilonga.

Training of personnel

The co-ordinating office is involved in planning and selection

of personnel who are already in the program for further training. On-the-job training is given to technical assistants when they join the program.

Administration

There is constant communication, and whenever possible regular visits to other stations are made to give guidance to technical officers and technical assistants involved in the program. The National Sorghum and Millet Co-ordinator is responsible for the reallocation of the funds for Ilonga and other sub-stations.

ACHIEVEMENTS

When the sorghum and millet research program was initiated in 1978 emphasis was on collection and evaluation of breeding materials at Ilonga. Most of the materials came from Ethiopia, Sudan, ICRISAT, Texas A & M University, Purdue University, Kenya and Serere, Uganda. Extensive selection and evaluation for adaptation was made at Ilonga Research Station. During the period 1979-1983 a number of Serere materials known to be adapted were tested in different locations and some had high yields with good grain characteristics. 2KX 17/B/1, 2KX 89 and 2KX 97 were among the cultivars which had good grain qualities and in 1982/83 2KX 17/B/1 was released as a recommended variety to farmers bearing the name of 'Tegemeo'. Although 5DX 135/13/1/3/1 had an overall high yield performance in relation to other cultivars, it was not released to farmers since brown sorghums are not acceptable for human consumption.

FUTURE PLANS

The sorghum and millet research program needs to be consolidated in terms of the provision of a full staff complement, offices, laboratories, transport, staff quarters, field equipment and other facilities. The present program considers research priorities along with identified sorghum production zones.

Central and western zone

There is a lot of information available for the semi-arid areas and the breeding program will continue to emphasize sorghum and millet improvement through screening and selection for earliness, drought tolerance and acceptable grain quality. Promotion and development of improved bulrush millet and finger millet will continue. The program will expand its activities to incorporate adaptive agronomic research with major emphasis on cropping systems.

North-west (lake basin) zone

Extensive screening and testing of promising cultivars will continue to identify areas suitable for sorghum and millet production. Currently 'Serena', a brown sorghum variety, is being grown but is not readily acceptable to consumers. Therefore white sorghums that have tolerance to diseases, pests and Striga infestation need to be developed.

Coastal and eastern belt

The breeding program will emphasize the development of suitable varieties of sorghum that would fit in with farmer's farming patterns. In areas with bimodal rains, short maturing varieties that would utilize the short rains need to be developed.

High-altitude zone

Very little work has been done on high-altitude sorghum. However, work will continue on developing suitable sorghum varieties that are cold tolerant and also to determine areas suitable for sorghum production at high elevation. Livestock feeds are in short supply, therefore forage sorghum needs to be developed. Presently the sorghum improvement program is working very closely with the Uyole Agricultural Centre.

Cereal technology

Daily milling of sorghum and millet has been part of life for most communities living in the rural areas. Processing and utilization has been the weakest link in promotion of increased sorghum production. Considerable attention will need to be given to collaborating with other institutes in order to develop industrial products acceptable to consumers in the urban areas. However, the Small Industry Development Organization (SIDO), supported by IDRC is already undertaking the development and testing of village technology for dehulling and milling sorghum and millet grains. Hopefully this might improve the quality of dehulled products and hence promote the production of sorghum and millets.

STAFF REQUIREMENTS

In order to develop a strong national research program, the research component requires a full staff complement consisting of plant breeders, agronomists, food technologists, crop protectionists, agricultural engineers, agricultural economists and supporting staff. Currently, the sorghum and millet improvement program is poorly staffed. There are three

scientific officers, of whom one is an expatriate (INTSORMIL) sorghum breeder, while two are Tanzanian scientists. All have been stationed at Ilonga, the centre for food crops research. Two agronomists and one breeder are on training. The program has seven sub-stations and Ilonga is the only station with scientific officers. Therefore there is a need to strengthen the program.

The stations which need strengthening with breeders, agronomists, entomologists, pathologists, agricultural economists, food technologists, and technical officers and assistants are Ilonga, Ukiriguru (Mwanza), Naliendele (Mtwara), Mlingano (Tanga), Miwaleni (Moshi), Tumbi (Tabora), and Uyole (Mbeya).

THE HISTORY OF SORGHUM IMPROVEMENT IN TANZANIA

A.L. Doto*

ODUCTION

rghum bicolor (L.) Moench, occupies the fourth place in nportance among the world's cereal crops. The importance f sorghum increases as one moves into arid zones due to its drought tolerance. In Tanzania sorghum had been rapidly loosing ground to maize even in areas where rainfall was inadequate and erratic. The year 1975 was the turning point when sorghum production made a dramatic come back.

While in real terms the increase in sorghum production has not been so dramatic, sorghum (mtama) has recently become increasingly popular (Table 1). In the United States and other developed countries sorghum is produced primarily for stockfeeding and its value as human food is minimal. In Tanzania, on the other hand, sorghum production is mainly for human consumption as in many other developing countries. Sorghum research and breeding in Tanzania have therefore always been directed at improving sorghum production for direct human consumption.

Recent emphasis on the development of crop and animal production in Tanzania recognizes the role of sorghum in the country's agricultural sector. Up until last year, Serena, Dobbs Bora, and Lulu (tall and dwarf) had been the recommended

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*Faculty of Agriculture, Forestry and Veterinary Science,
Morogoro, Tanzania

Table 1. Sorghum Production 1971/72 - 1978/79 (000 tons)

Year	Production
1971/72	175.2
1972/73	192.4
1973/74	1,974.5
1974/75	277.4
1975/76	400.3
1976/77	558.2
1977/78	614.0
1978/79	761.3

Source: S.V. Mukuru and F.R. Miller. 1982. Current status and recommendations for sorghum breeding and improvement in Tanzania.

varieties in Tanzania. While the four varieties have not commanded acceptance by the farmers/consumers, their replacement has been rather too slow. The low rate of varietal replacement in Tanzania, particularly in sorghum, can be attributed to the lack of continuity in breeding work.

IMPROVEMENT WORK UP TO 1978

Sorghum improvement work started at Ukiriguru in 1932 with screening and evaluation of the local sorghums. In 1949, Dr H. Doggett initiated a comprehensive breeding program which aimed at developing sorghum varieties with early maturity, high yield potential, palatable grains, good storing

properties and resistance to birds, smuts and *Striga*. These early efforts were soon rewarded by the release of an improved variety, Dobbs. Dobbs, which was selected in Western Kenya, is a brown-seeded variety with a high yield which matures in about 120 days. The variety also displays some resistance to *Striga*. It is, however, deficient in storing properties.

By the year 1956, a sound breeding program had been developed at Ukiriguru. In 1957, when the leader of the program, Dr H. Doggett, left for Serere (Uganda) the work at Ukiriguru came to a stand still. This poor state of affairs remained until 1967 when breeding work was reactivated.

The revived breeding program embarked on selection work using recurrent selection. Working populations were supplied from Serere, and the COES MS_3 genetic male sterility was used to effect recombination. It is interesting to note here that sorghum variety trials, which covered most of the sorghum growing sub-stations in the country, were initiated at the time. These trials were a result of the joint effort by the research organization in Tanzania and EAAFRO. Subsequent to these variety evaluation efforts, the variety Serena was released.

The variety was bred at Serere through crossing Dobbs and P127 from Swaziland. Serena is an early maturing and stable brown-seeded variety which also possesses a certain degree of resistance to shootfly and *Striga*.

Other breeding aspects which received high priority at more or less the same time were:

(i) Hybrid variety development;
(ii) Development of bird resistance; and
(iii) Development of *Striga* resistance.

While the yield advantage of some of the available hybrids has been in the order of 20-50 per cent over the conventional varieties, lack of cheap hybrid seed has retarded their wide utilization in East Africa in general.

The period 1967 to 1970 could be described as one where sorghum research work in Tanzania depended on individual initiative and co-operation with the sorghum unit at Serere. In general, there were no co-ordinated national research efforts. The picture changed in 1970/71, however, when the Cereals Project Field Trials Officer was appointed. On his appointment breeding work related to the development of high yielding and palatable varieties continued. In addition, work aimed at determining the adaptability of varieties to various ecological regions of Tanzania was given a new push.

Serious sorghum breeding work started at Morogoro in 1973 under the Intercropping Project based at the then Faculty of Agriculture. Under the project the co-operative EAAFRO sorghum variety trials were continued. In addition a number of breeding populations were advanced through population improvement methods.

Studies related to breeding methods were also carried out. A significant contribution of the sorghum work under the project was the generation of information regarding the applicability of results from monoculture conditions to intercrop conditions.

Currently sorghum breeding work is carried out at Ilonga Research Station and the following paper highlights the work from 1978.

DISCUSSION

A detailed treatment of the entire history of sorghum breeding in Tanzania would be too lengthy and serve no good purpose at this workshop. It is, however, important to take note of the main features for the period under consideration.

First it may be desirable to note that the work done during the period was carried out with limited trained personnel and other resources. In spite of this, sorghum breeding work continued and resulted in new varieties being developed and released. This should assist us in recognizing what can be achieved with proper planning and dedication.

The second aspect which comes out was the value attached to co-ordinated regional effort, through EAAFRO. In most cases breeding work continued in Tanzania even in the absence of trained breeders. The genetic material made available through EAAFRO Serere made it possible for work to continue in Tanzania and in the sister countries. Much could therefore be achieved through co-ordinated regional effort now that trained personnel and research infrastructures are available in each of the countries of the region.

Another aspect which needs to be given due attention is that of sorghum quality. Improved varieties such as Serena and Dobbs have been available in the country for some time now. However, these have not been widely adopted by farmers/consumers mainly as a result of their poor milling and storage properties. Any varieties to be developed for the future should therefore accommodate desirable quality aspects if improved sorghum varieties are to gain popularity.

PRESENT STATUS OF SORGHUM BREEDING IN TANZANIA

H.M. Saadan*

INTRODUCTION

In the past few years there has been a marked change in weather conditions in Tanzania. The rainfall distribution has changed from reliable to unreliable resulting in a considerable reduction in total production of cereal crops. This made the Government, through the Ministry of Agriculture, give more attention to the expansion of sorghum and millet production.

In 1978, the National Sorghum and Millet Improvement Program was established when the IITA/USAID Tanzania project expanded its activities to include sorghum and millet research, with ICRISAT providing the technical assistance. The improvement progam covers the whole country, but major emphasis is on the marginal rainfall and semi-arid areas. Early maturing varieties which have stable yields and acceptable grain quality need to be developed.

Pests and diseases create considerable problems for increased production of sorghum. Insect pests of sorghum attack the crop at all stages of growth. Shootfly, stem-borers and sorghum midge cause heavy losses. Diseases include leaf rust, grey leaf spot, smut, anthracnose, sooty stripe, downy mildew and charcoal rot.

Both *Striga asiatica* and *S. hermonthica* cause serious losses and affect the expansion of sorghum production in areas of infestation. *S. hermonthica* dominates the black

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*Co-ordinator and Sorghum Breeder, National Sorghum and Millet Research Program, TARO, Ilonga, P.O. Ilonga, Kilosa, Tanzania

mbuga soils of Mwanza and Shinyanga regions, whereas the light sandy soil areas of the Coast and Mtwara Regions are heavily infested by *S. asiatica*.

NATIONAL SORGHUM AND MILLET RESEARCH PROJECT

The importance of sorghum cannot be over-emphasized in Tanzania as it provides the bulk of calories in areas where frequent drought conditions rule out the possibility of producing other cereal crops.

Before establishment of the Sorghum and Millet Improvement Project, Ilonga was the co-ordinating centre of maize, grain and legume research. As the IITA/USAID project expanded to incorporate sorghum and millet improvement Ilonga developed as the headquarters and co-ordinating centre for maize, grains, legumes and sorghum and millet. Although Ilonga is not typical of major sorghum growing areas, it is centrally located. Moreover, Ilonga has facilities which would enhance and accelerate the improvement of sorghum in the country. It is also very close to the major sorghum growing areas of Dodoma and Singida. Therefore screening and evaluation of breeding materials is done near the areas of intended use.

Breeding objectives

The sorghum breeding program aims to develop varieties with the following characteristics:

1. Early maturity;
2. Tolerance to drought stress at different stages of plant growth;
3. Adaptability and high yields;
4. Tolerance to major pests and diseases;

5. Tolerance to high altitude and cold;
6. Acceptable grain quality in a tan plant background.

The program will also cover food technology.

In areas of marginal rainfall, rains are known to be erratic. The breeding program decided to put more emphasis on early maturing genotypes that are drought tolerant. These early maturing varieties can be grown during the short rains in areas with a bimodal rainfall pattern.

The sorghum improvement program is working towards developing varieties and hybrids which have wide adaptability characteristics and the ability to produce stable yields.

At present the emphasis is on developing varieties rather than hybrids because the majority of small farmers do not have the ability to purchase hybrid seeds annually. However, parental lines which have a good hybrid combination are in the process of selection.

The processing and utilization of sorghum as human food is one of the major constraints to increased sorghum production. Very little information is available on various processing methods which would produce acceptable sorghum products.

Breeding activities at Ilonga

When the National Sorghum and Millet Project was established all breeding activities were centralized at Ilonga. Breeding lines from different places were acquired. These were Ethiopia, Sudan, Kenya, ICRISAT, Purdue University, Texas A & M and Serere, Uganda. All these lines were planted during the rainy season and evaluated for adaptation. Among the

parameters taken include days to 50 per cent anthesis, plant height and grain colour, as well as other agronomic characteristics. Few crosses were made among introductions in order to exploit their yield potentials. However, crosses with local sorghum were necessary in order to incorporate the good food qualities of the local varieties.

Crossing Programs

As the program continued two crossing blocks were developed. The first one dealt with hand emasculation crossing for pedigree breeding. Since the sorghum improvement program was focused on the semi-arid areas, parents were selected according to their yield potential, tolerance to drought conditions and good grain qualities. Most of the introductions had most of the characters except for the corneous grain characteristics. Therefore crosses were made between selected introductions and local varieties. The handling procedure of these crosses in subsequent generations was as follows. Those crosses made during the rainy season in 1978 were planted under irrigation in the off-season of the same year. F_2 seeds were harvested and planted at Ilonga and two other locations (Hombolo and Bihawana) during the rainy season of 1979. Hombolo and Bihawana are typical of areas of sorghum production in Tanzania. At each site, selected F_2 plants were harvested separately and grouped together. These were grown as F_3 families on the same sites during the next growing season. The distribution of these families was limited to Ilonga, Hombolo and Bihawana because these were the only sub-stations the program had in Dodoma region.

After the 1980 growing season, Dr S.Z. Mukuru, a sorghum breeder, departed for ICRISAT and a second scientist went for further studies in the US, which resulted in all the

selected material from the two sub-stations being moved to Ilonga. However, Dr Mukuru came to Tanzania at planting and harvesting time. The progenies are now in F_5, F_6 and F_7 generations.

In the improvement program production of hybrids did not receive high priority. However, it was essential to identify parents that would combine to make good hybrids, therefore the second crossing program involved the production of hybrids. The 1978 program had about 178 pairs of A and B lines from different institutes: Serere, Uganda (52), ICRISAT (10), Texas A & M University (8) and Purdue University (108). The choice of pollinators was based on the degree of agronomic superiority and yield potential of the line. Crosses for experimental hybrids were made under irrigation during the off-season and the hybrids were sent to different sites for evaluation purposes.

Sorghum yield nurseries

There were several yield nurseries developed and tested at Ilonga as well as at other stations. Progeny yield nurseries of F_4 and F_5 families were tested for their yield performances in simple lattice design with two replications. Preliminary yield nurseries and advanced variety trials had more locations for evaluation.

National sorghum variety trial

Usually comprised of 24 yield varieties with three replications. The trial was sent to all sub-stations and other experimental sites. This trial covered most of the ecological zones.

Grain mould resistant nursery

Comprised of 40 entries in two replications. These nurseries

were grown in areas of high rainfall for screening purposes.

Striga resistant nursery

These nurseries were grown in grass areas that are heavily infested with *Striga*.

International trials

Trials from ICRISAT, Texas A & M University and other institutes were grown at Ilonga and other locations.

Germplasm collection

Apart from developing crossing nurseries, the sorghum improvement program was involved in the collection of local sorghums. To date we have 316 collections but there is still much work ahead.

FUTURE PLANS

Presently the Sorghum and Millet Improvement Program is poorly staffed. In the absence of adequate senior staff in the program all the breeding activities were centralized at Ilonga. However, this location facilitated proper supervision and distribution of breeding materials to other stations.

In order to achieve the required breeding objectives, consideration should be given to strengthening manpower requirements. The program needs to expand its activities to cover all ecological zones and also establish three other breeding stations. Proposed stations are: Ukiriguru for north-west (lake basin) zone, Naliendele, Mtwara for the

southern region and Uyole for the high altitude zone. Two pearl millet breeders and one for finger millet need to be stationed at Ilonga, Ukiriguru and Uyole, respectively. It is important to strengthen the activities of the program so that we can promote sorghum and millet productivity in the country.

AGRONOMIC RESEARCH ON SORGHUM AND MILLETS IN TANZANIA

C.S. Mushi*

INTRODUCTION

Sorghum and millets are still grown under subsistence farming methods and low yields are the major constraint to food supplies in the country. This is partly due to the genetic constitution of the crop having low yielding potential, especially the local cultivars, but on the other hand agronomic packages have not been acquired by most of our peasant farmers.

The agronomy sub-program has, therefore, the responsibility for developing an economical package of practices that can be recommended to sorghum and millet growers. The scope of agronomic research covered in this paper involves plant density and planting pattern studies, planting dates, fertilizer application, herbicide screening and management research. This paper briefly covers the following: (1) concluded experiments, (2) on-going experiments, (3) newly initiated experiments, and (4) future plans. Table 1 shows the ecological zone in which the trials were conducted.

CONCLUDED EXPERIMENTS

Sorghum variety and plant population studies

The optimum plant population for any particular area depends

*Agronomist, Sorghum and Millets Research Program, ARI, Ilonga, Tanzania.

Table 1. Ecological zones in which trials were conducted

Ecological zone	Region	Mean annual rainfall	Total days of rain/ annum	Temperature	Probable parent material	Soil texture and colour
A	Pwani/Tanga	1,000m (bimodal)	75	70-85^{o}F	Marine deposits	Dark reddish brown loamy sands
B	Mtwara Lindi	750-1,000mm (monomodal) (Oct.-May)	50-75	70-80^{o}F	Marine deposits	Dark reddish brown loamy sands
C	Morogoro Tanga	750-2,250mm (bimodal)	50-125	60-85^{o}F	Gneisses and schists	Reddish brown loamy sands to sandy loam
Cl	Morogoro	750-1,250mm (monomodal)	50-125	60-85^{o}F	Gneisses and schists	Reddish brown loamy sands with red subsoils
F	Dodoma Singida	600m	75	-	Gneisses and schists	Reddish brown to yellowish sandy clay loam
I	Tabora Shinyanga	750-1,000mm	75-100	60-85^{o}F	Granites and banded ironstone	Dark brown dark reddish brown loamy sands to sandy loams
K	Mwanza	1,000-2,000 (bimodal)	-	-	Granitic	_

upon the amount of available moisture, the fertility status of the soil and the variety being grown. In Tanzania, a blanket recommendation has been given of 60cm x 15cm for all varieties grown. It is known that Tanzania has different ecological zones with different rainfall patterns and also crop water requirements differ with species and within the crop depending on the phenology of its cultivars. It is therefore believed that uniform spacing cannot be optimal for the different ecological zones. For this reason a sorghum variety X plant population trial was initiated in 1977/78 cropping season with the objective of developing plant density recommendations for different varieties in specific ecological zones and to find out the extent to which row spacing could be manipulated for developing intercropping systems.

The trial set consisted of two varieties (Lulu D and 5DX 135/13/1/3/1) and four plant densities (40, 100, 160, and 200 thousand plants/ha). The trial was conducted at eight different locations in Tanzania, but reliable data for at least three consecutive years were obtained and analysed for only four sites. These data are presented in Table 2. From the data it can be noted that a plant density of 160,000 plants/ha gave the highest grain yield at all sites and for both varieties. Previous reports have indicated that plant height and days to flowering were the same for all densities used. A population of 160,000 plants/ha, spacings of 50 x 13 cm and 80 x 8 cm gave the highest grain yield for Lulu D and 5DX 135/13/1/3/1, respectively (Table 2).

The findings of this three year trial tend to agree with some of the earlier work done at Ukiriguru (Doggett, 1952). This trial suggests, therefore, that a stand density of 160,000 plants/ha would be optimum for the two varieties Lulu D and 5DX 135/13/1/3/1 respectively in the regions of Morogoro, Tanga, Mtwara, Mwanza, Tabora and Shinyanga.

Table 2. Mean grain yield data (kg/ha) obtained in the sorghum variety x plant population trial

Variety	Plants/ ha in thousands	Spacing	Locations				
			Ilonga	Ukiri-guru	Tumbi	Mtwara	Mean
Lulu D	40	50 x 50cm	1,836	993	1,420	1,481	1,433
Lulu D	40	80 x 31cm	1,879	906	1,459	1,645	1,472
Lulu D	40	100 x 25cm	1,649	747	1,065	1,602	1,250
Lulu D	100	50 x 20cm	3,155	1,107	1,806	1,744	1,961
Lulu D	100	80 x 12.5cm	2,674	827	1,640	1,489	1,638
Lulu D	100	100 x 10cm	2,437	983	1,618	1,842	1,720
Lulu D	160	50 x 13cm	4,012	1,137	1,555	2,597	2,325
Lulu D	160	80 x 8cm	3,441	1,075	2,067	1,821	2,101
Lulu D	160	100 x 6cm	2,616	935	2,020	1,986	1,889
Lulu D	200	50 x 10cm	3,983	901	1,311	1,466	1,915
Lulu D	200	80 x 6.5cm	2,998	997	1,219	2,249	1,869
Lulu D	200	100 x 5cm	2,913	1,054	1,368	2,417	1,938
5DX 135/13/1/3/1	40	50 x 50cm	2,682	765	1,513	2,134	1,774
5DX 135/13/1/3/1	40	80 x 31cm	2,401	1,008	1,510	2,836	1,939
5DX 135/13/1/3/1	40	100 x 25cm	2,334	845	2,096	2,869	2,037
5DX 135/13/1/3/1	100	50 x 20cm	4,366	1,122	2,117	2,581	2,547
5DX 135/13/1/3/1	100	80 x 12.5cm	3,772	1,126	1,832	2,632	2,341
5DX 135/13/1/3/1	100	100 x 10cm	3,246	1,016	2,319	3,090	2,418
5DX 135/13/1/3/1	160	50 x 13cm	5,205	1,025	2,312	2,570	2,778
5DX 135/13/1/3/1	160	80 x 8cm	4,159	1,270	2,620	3,340	2,847
5DX 135/13/1/3/1	160	100 x 6cm	3,348	1,076	2,363	2,542	2,394
5DX 135/13/1/3/1	200	50 x 10cm	4,962	914	1,076	2,183	2,284
5DX 135/13/1/3/1	200	80 x 6.5cm	3,966	898	1,174	3,279	2,329
5DX 135/13/1/3/1	200	100 x 5cm	3,288	973	1,370	2,660	2,073
Mean			3,180	990	1,743	2,278	-

Time of planting x sorghum variety trial

This trial was started in 1978/79 cropping season with the major objective of determining the optimum time for planting sorghum in various areas of Tanzania.

The trial consisted of four planting dates, namely (i) two weeks before the normal planting date, (ii) the normal planting date, (iii) two weeks after the normal planting date, and (iv) four weeks after the normal planting date. Two varieties Lulu D and 5DX 135/13/1/3/1, were used. The trial was sent to over 11 different locations in Tanzania, but reliable data for three consecutive years were received from only six sites. Grain yield data from these trials are presented in Table 3.

Table 3. Mean grain yield (kg/ha) obtained in the sorghum variety x time of planting trial

Treatment	Locations						
	Ilonga	Hombolo	Ukiriguru	Lubaga	Tumbi	Mptopwa	Mean
V1 D1	3,253	1,574	1,313	1,787	1,912	2,285	2,020
V1 D2	2,865	1,053	929	1,912	1,372	1,810	1,656
V1 D3	2,267	588	209	1,255	1,112	611	1,007
V1 D4	1,920	389	200	1,073	1,041	484	851
V2 D1	3,880	2,167	1,747	2,060	2,243	3,051	2,524
V2 D2	2,850	1,383	764	1,390	1,653	2,715	1,792
V2 D3	2,218	1,015	415	1,429	1,228	1,413	1,286
V2 D4	1,667	725	292	1,049	1,166	649	924
Mean	2,615	1,112	734	1,494	1,035	1,621	1,435

Key: VI = Lulu D
V2 = 5DX 135/13/1/3/1
D1 = two weeks before n.p.d.
D2 = normal planting date (n.p.d.)
D3 = two weeks after n.p.d.
D4 = four weeks after n.p.d.

First planting dates

Season	Ilonga	Hombolo	Ukiruguru	Lubaga	Tumbi	Mtopwa
1978/80	12/1/80	27/12/79	27/12/79	27/12/79	18/1/80	18/1/80
1980/81	25/1/81	22/12/80	28/12/80	23/1/81	8/12/80	24/12/80
1982/83	21/2/83	9/1/83	24/12/82	24/12/82	1/1/83	21/1/83

Yield data indicated that the first planting date gave the highest mean grain yield in all locations and in both varieties, except Lulu D at Lubaga.

In the early 1950s Doggett conducted the first trial on time of planting sorghum in the western zone. In his report (Annual Report of the Botanist, Ukiriguru, 1950) he stressed the importance of planting early at the onset of rains. Similar findings have been obtained in this trial. It is therefore suggested that the best times for planting early maturing (100-120 days) sorghum in different regions would be as shown in Table 4.

Table 4. Summary of best time for sorghum planting in six regions of Tanzania

Region	Approximate time of planting
1. Morogoro	Mid-January to late February
2. Dodoma	Late December to early January
3. Mwanza	Late December to early January
4. Shinyanga	Late December to late January
5. Tabora	Early December to early January
6. Mtwara	Late December to late January

Note: 'Best' is defined here as the optimal time to plant assuming the expected rains arrive on time, adequate soil moisture is available for germination, and, of course, the soil is warm enough for germination.

Sorghum management trial

In order to determine the most critical single factor or combination of factors affecting grain yield, a sorghum management trial was conducted for three years commencing in the 1980/81 season.

The trial consisted of two density levels (100,000 and 160,000 plants/ha), two nitrogen levels (30kg N/ha and 60kg N/ha), and three weeding regimes (weeding once at 15 days after planting (d.a.p.)), weeding twice at 15 and 45 d.a.p. and weeding once at 45 d.a.p.

Grain yield data obtained in the three-year trial are presented in Table 5.

Table 5. Mean grain yield obtained in the sorghum management trial (kg/ha)

Treatment	Locations				
	Ilonga	Ismani	Ukiriguru	Mtwara	Mean
D1 N1 W1	2,808	3,871	1,150	2,110	2,485
D1 N1 W2	2,969	3,922	1,372	2,255	2,630
D1 N1 W3	2,579	3,188	800	2,611	2,293
D1 N2 W1	3,512	3,512	1,419	2,428	2,733
D1 N2 W2	3,561	3,616	1,194	2,219	2,729
D1 N2 W3	3,330	3,699	1,075	2,427	2,633
D2 N1 W1	3,041	3,362	1,096	2,364	2,466
D2 N1 W2	3,172	3,330	1,296	2,455	2,563
D2 N1 W3	2,717	2,857	782	2,207	2,141
D2 N2 W1	4,265	3,152	1,283	2,614	2,747
D2 N2 W2	4,073	3,152	1,419	1,876	2,630
D2 N2 W3	3,206	2,872	932	2,037	2,262
Mean	3,269	3,382	1,151	2,316	2,530
L.S.D. (0.05)	856	549	603	782	-

Key: D1 = 100,000 plants/ha
D2 = 160,000 plants/ha
N1 = 30 kg N/ha
N2 = 60 kg N/ha

W1 = Weeding once 15 d.a.p.
W2 = Weeding at 15 and 30 d.a.p.
W3 = Weeding once 45 d.a.p.

Significant differences in grain yield were obtained at all locations. From Table 5 it is evident that early weeding (15 d.a.p.) is very important in sorghum grain production. It was also interesting to note that a higher dose of nitrogen resulted in a higher grain yield.

The findings of this trial suggest that a plant density of 160,000 plants/ha and 60 kg N/ha with the first weeding done two weeks after planting followed by a second weeding done at 45 d.a.p. should be the recommended practice.

ON-GOING EXPERIMENTS

Sorghum variety x plant distribution pattern

Most of our peasant farmers continue to sow several seeds per hole with holes spaced more than one metre apart. Before recommending our normal practice of sowing one seed per hole at very small intra-row spacing it was found proper to establish this trial in order to find out the effect of number of plants per hole on the performance of different varieties of sorghum.

The trial, initiated in the 1981/82 season, consisted of two varieties, 2KX 17/B/1 and 5DX 135/13/1/3/1, and the number of plants per hole included one, two, three and four at spacings of 15, 30, 45 and 60 cm apart.

Data obtained in the 1982/83 season indicate that there is no uniform trend in plant height as the number of plants per hole is increased. The difference in the days to maturity of both varieties was insignificant. The number of plants per hole had no significant effect on grain yield, however. Leaving two plants per hole gave the highest mean grain yield of 2,603 kg/ha for 5DX 135/13/1/3/1 while leaving three plants

per hole gave the highest mean grain yield of 2,530 with 2KX 17/B/1 (Tegemeo).

Taking into consideration that planting and weeding operations using the hand hoe are easier when you have more than one plant per hole, the findings of this trial suggest that three plants per hole with an intra-row spacing of 30 cm would be optimal. The trial is being conducted for the third time this season after which viable recommendations will be made.

<u>Preliminary evaluation of chemical weed control for sorghum</u>

This trial was conducted for the second time last season with the same objective of assessing the best type and rate of herbicides or combination of herbicides for use with extensive production of grain sorghum.

Six herbicides, atrazine, metalachlor, alachlor, 2-4D, dicamba and linuron were applied in different combinations, rates and times. Two hand weeding regimes (weeding at 15 and 45 d.a.p. and weeding every week) were included together with unweeded treatment as a control.

A mixture of atrazine and 2-4D at the rate of 2.0 kg a.i./ha and 0.5 kg a.i./ha, respectively was the most effective followed by atrazine mixed with alachlor at the rate of 2 kg a.i./ha each.

Observations made in this trial suggest that where mechanical or manual weeding is not feasible pre-emergence application of atrazine (Gesaprim 80) at the rate of 2 kg a.i./ha followed by a post-emergence application of 2-4D (Fernamine 720) at the rate of 0.5 kg a.i./ha could be used.

The trial is being conducted for the third time this season.

Village sorghum variety trial

The yield potential and response to fertilizer application on commercially available varieties, new varieties under research development, and existing local varieties was studied in various farmers' fields in the sorghum growing areas of Tanzania.

Data obtained in this trial in the last season indicated that the improved varieties maintained their high yielding potential over the indigenous varieties. Application of nitrogenous fertilizer increased grain yield in both improved and indigenous varieties.

Weed control studies in pearl millet

In the 1982/83 season, a weed control experiment to determine the critical weed competition period on the grain yield of pearl millet, and to determine optimum weeding frequency, was conducted at five different sites in Tanzania.

Data obtained indicate the importance of weeding, and particularly early weeding, in pearl millet production. The trial is being conducted for the second time this season.

NEW EXPERIMENTS

Effect of seed placement and land preparation methods

The major problem in the semi-arid areas of the country where sorghum and millets are grown is not only shortage of precipitation but also the erratic nature of its distribution. In these areas crop failure due to drought is the rule rather than the exception. Hence adequate methods of soil moisture

conservation are essential in order to produce enough grain in these areas. The trial has been initiated with the specific objective of finding out the most effective land preparation method for conserving moisture in different sorghum production areas of Tanzania.

Control of *Striga* by cultural methods

The objective of this trial is to study the impact of crop rotation on the growth of sorghum and *Striga* in the western and coastal zone.

FUTURE PLANS

In the future the agronomy sub-program plans to:

(a) Continue with on-going research;
(b) Develop production packages for new varieties and hybrids so that every variety or hybrid is accompanied by its production package when it is released; and
(c) Develop cropping systems which will provide a continuum of productive crop growth from the onset of the rainy season as far as possible into the post-rainy season.

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DISEASES OF SORGHUM IN TANZANIA

F.M. Shao*

INTRODUCTION

In Tanzania, sorghum (Sorghum bicolor (L.) Moench) now ranks second to maize in importance as a cereal crop. It is grown mainly by smallholder farmers who use it for food and home-made beverages in the semi-arid areas of the country.

The broad-based genetic diversity of the crop has enabled it to be grown under a wide range of agro-ecological conditions in the country, ranging from low to high altitude areas. To the smallholder farmer, yield stability and good quality, leading higher production of a more processable and palatable sorghum, are very important. These characteristics are variable and can be achieved through breeding, selection and testing in different locations. They can also be realized by the control of diseases, insect and weed pests.

Over the years, our National Sorghum Improvement Program has taken yield stability very seriously, but to some extent it has overlooked quality. Thus a very small area is planted with the improved sorghum varieties by smallholder farmers. The National Program has also directed very little effort to pathological studies on sorghum. However, some diseases of economic importance do occur in the various agro-ecological zones in which sorghum is grown in Tanzania. According to Wallace (1953 & 1953a), Riley (1960), Clinton (1961), Ebbels (1974) and Ebbels and Allen (1979), some of these diseases include:

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*Director and Plant Pathologist, TARO Research Institute, P.O. Ilonga, Kilosa, Tanzania

(a) Root and stalk rot diseases, e.g. Gibberella fujikuroi and charcoal rot, Macrophomina phaseolina (Tassi) Goid.

(b) The smuts, especially the covered-kernel smut, headsmut and loose smut, and earhead diseases such as the grain moulds complex of fungi, including Fusarium, Curvularia and Alternaria.

(c) The leaf diseases such as leaf rust, various leaf spots, anthracnose, sooty stripe and leaf blight.

(d) Bacterial diseases, specifically bacterial stripe.

(e) Phanerogamous parasites, particularly the witchweed, Striga hermonthica and S. asiatica.

So far none of the known viral and nematode diseases of sorghum have been reported in Tanzania.

The National Sorghum Improvement Program has considered some of the sorghum diseases as criteria for selection by evaluating breeding materials for overall disease reactions. Some work has also been conducted to assess the major diseases of sorghum and their importance as potential pathogens.

MATERIALS AND METHODS

Sorghum disease assessment work has been confined to the major agro-ecological zones where the multilocation Tanzania Sorghum Variety Trials are located. These are conducted at six different stations covering five zones as follows: Ilonga in central zone, Ukiriguru and Mwanhala in the western, Mlingano in the north-east coastal and Naliendele in the southern zones, respectively.

Disease assessments were also made in the International Pest and Disease Nurseries and other introduced germplasm collections at Ilonga Research Station (see Table 1).

Table 1. Sites for the Tanzania Sorghum Variety Trials where disease assessments were carried out

Location	Altitude (m)	Mean annual rainfall (mm)	Latitude
Ilonga	506	1,045	06° 42'S
Ukiriguru	1,198	923	02° 42'S
Mwanhala	1,343	767	04° 24'S
Mlingano	184	1,100	05° 09'S
Naliendele	120	1,050	10° 22'S

Most of the assessments were conducted in the months of May and June when the crop is in the early stages of heading and dough stages. Disease assessments are based on scales of 0 to 5 where zero indicates that there is no disease symptom and five indicates severe disease to the extent of killing the plant. Rating was done on the different diseases individually taking an average score of five plants scored per treatment. This information not only gives us an overview of the severity of different diseases but also the different levels of resistance in the breeding materials.

RESULTS AND DISCUSSION

Of the many diseases of sorghum recorded in Tanzania (Table 2) the most important ones limiting the production of the crop

have been the smuts and earhead diseases, especially the grain moulds, some of the leaf diseases, especially leaf rust, anthracnose, grey leaf spot, leaf blight, zonate leaf spot, sooty stripe and bacterial stripe.

Table 2. Incidence of some of the sorghum diseases recorded in Tanzania in the different agro-ecological zones in the 1982/83

Disease	Ilonga	Ukiriguru	Mwanhala	Mlingano	Naliendele
Grain moulds	3.5	NR	NR	NR	NR
Grey leaf spot	2.3 (3.3)	NR	NR	3.0	NR
Anthracnose	1.3 (1.4)	NR	NR	2.6	NR
Leaf rust	2.1 (2.6)	1.8	0.3	NR	NR
Zonate leaf spot	2.1 (1.1)	NR	0.5	NR	NR
Leaf blight	1.2 (1.2)	1.5	2.4	2.9	NR
Sooty stripe	1.8 (1.5)	NR	0.4	NR	NR
Bacterial stripe	1.8 (1.4)	NR	NR	NR	NR
Downy mildew	1.2 (1.2)	NR	NR	NR	NR
Covered kernel smut	NR	NR	NR	NR	3.0*

NR = not recorded
*Reported on local sorghum in the southern zone.

These are means of scores of 24 entries of the 1982/83 Tanzania Sorghum Variety Trial. The numbers in brackets are mean disease scores of 30 entries from the International Disease Nursery.

Earhead diseases

Earhead diseases reported in Tanzania include ergot 'Asali Disease' (*Sphacelia sorghi* McRae) and false smut (*Cerebella*

sorghi - vulgaris Subramanian) C. andropogonis cesati (Wallace and Wallace, 1949). Both these diseases are of minor importance to the crop in Tanzania. Pink ear (Fusarium heterosporium Nees ex Fr.) was also reported at Bwanga in Biharamulo (Ebbels and Allen, 1979).

Sorghum smuts

Covered kernel smut (Sphacelotheca sorghi (Link) Clint.) was first reported to be serious in Tanzania by Wallace (1940). He quoted percentage diseased heads in mixed local varieties of sorghum varying from 8 to 43 per cent with an average of 25 per cent. In one field he reported 100 per cent infected heads. Padwick (1956) estimated 5 per cent loss due to this disease, about 48,500 ha out of 970,000 ha. The disease is still the most important of the smuts, especially on local sorghums where seed dressing is not practised. In the 1982/83 season a severe case of covered smut was reported on local sorghums in the southern zone of the country (Mkoka, 1983). Fungicidal seed treatment reduces the incidence of this disease tremendously. Doggett (1980) observed that the disease was sufficiently important on local cultivars to warrant seed treatment. Sulphur dust was recommended in the early days but thiram (0.1 per cent) and some organic fungicides, arasan spergon and phygon at 0.15 per cent, give better control (Anon., 1971).

Both loose smut (Sphacelotheca cruenta (Kühn) Potter) and long smut (Tolyposporium ehrenbergii (Kühn) Pat.) have been reported in Tanzania (Wallace, 1949) but long smut is of little significance.

Head smut (Sphacelotheca reiliana (Kühn) Clint.) occurs on sorghum at most elevations but it is probably more economically important on maize at altitudes above 1,500 (Wallace and Wallace, 1953).

Grain moulds

Continuous wet or cloudy weather and high humidity at Ilonga, particularly in the months of April to May when the sorghum grain is between the milk stage and maturity, leads to infection by a number of the grain mould fungi. Besides identification of some of the fungi causing the moulds no other research has been done on these moulds. Some of the fungi are saprophytic while others are pathogenic. Some of the fungi isolated from sorghum heads include Choanephora cucurbitarum (Berk. and Rav.) Thaxt., Alternaria tenuis Nees ex. Pers group, Curvularia lunata (Walker) Boedijn, Fusarium sp., Rhinotrichum tenellum Berk & Curt, Trichothecium roseum (Pers) Link ex. Fr. (Riley, 1960); Cladosporium sp. and Epicoccum purpurascens Ehnenb. ex. Schlecht at Ukiriguru (Ebbels and Allen 1979). Curvularia sp., Fusarium sp. and Colletotrichum sp. were isolated by the author at Ilonga in the 1982/83 season. Other fungi such as Aspergillus, Alternaria and Penicillium spp. may also occur as saprophytes.

The mouldy seeds usually have very poor germination and even those that germinate have very low seedling survival. Besides, some of the fungi like Aspergillus flavus and Penicillium sp., if they invade the endorsperm, may form toxins, especially aflatoxin, which are toxic to humans and livestock. Some of the varieties and breeding lines in our breeding program have some resistance to the grain mould fungi. However, no fungicidal treatment has been tried in Tanzania. A combination of this and the resistance would probably alleviate the problem, especially in the more humid areas.

Leaf diseases

A good number of the leaf diseases of sorghum have been identified in different agro-ecological zones of Tanzania. In the areas with high rainfall, like Ilonga and Mlingano, grey leaf spot

(Cercospora sorghi Ell. et Everth, anthracnose (Colletotrichum graminicola (Ces.) Wils.) and leaf blight (Helminthosporium turcicum Pass.) are the most serious. Practically none of the materials in the Tanzania sorghum variety trial showed good resistance to grey leaf spot both at Ilonga and Mlingano. The materials from the International Pest and Disease Nursery were even more seriously affected by this disease. Some of the entries in the Tanzania Sorghum Variety Trial showed resistance to anthracnose and leaf blight at Ilonga but not at Mlingano. Helminthosporium leaf blight was serious in some sorghum lines at Mlingano and Mwanhala and to a certain extent at Ukiriguru. In addition to host resistance, some fungicidal seed treatment, e.g. with thiram or zinab, has been recommended to reduce the incidence of these diseases.

Leaf rust (Puccinia purpurea Cooke) is the next most important leaf disease, especially at Ukiriguru and Ilonga. Two of the materials in the TSVT (2KX 14/57-59 and 2KX 9) showed some resistance to this disease. None of the materials in the International Pest and Disease Nursery showed any promise of being sources of resistance to this disease.

Zonate leaf spot (Gloeocercospora sorghi Bain and Edgerton) was also moderately severe at Ilonga. This disease is capable of causing serious losses as the mycelia may be carried through the seed coat and cause fresh infection in young seedlings. However, some of the materials in the International Pest and Disease Nursery showed some resistance. Fungicidal seed treatment with organo-mercurials or spergon may be used to reduce this disease in endemic areas.

Sooty stripe (Ramulispora sorghi Ell. et Evert). Olive and Lefebvre is also an important disease in Tanzania. However, it occurs rather too late in the season to cause serious yield reduction. Seed treatment with organo-mercurial fungicides may reduce the incidence of the disease.

Bacterial leaf stripe (Pseudomonas andropogon (E.F. Smith) Stapp.) is the only bacterial disease of economic importance recorded in Tanzania. It has only been recently reported at Ilonga and does not appear in earlier plant disease lists. Some of the materials from the International Pest and Disease Nursery may have some resistance and also planting of healthy seed coupled with fungicidal seed treatment with organo-mercurials or thiram may reduce incidence of the disease.

Downy mildew (Sclerospora sorghi Weston & Uppal) seems to be of minor importance at Ilonga and both the materials of the Tanzania Sorghum Variety Trial and the International Pest and Disease Nursery seem to have some resistance to the disease.

Other leaf diseases of minor importance reported in Tanzania include ascochyta leaf spot (Ascochyta sorghina Sacc.), phoma leaf spot (Phoma insidiosa Tassi) (Riley, 1960), alternaria leaf spot (Alternaria alternata (Fr.) Keissler, cladosporium leaf spot (Cladosporium tennissimum Cooke) and a leaf spot Acremonium zonata (Sawada) Gams was also reported at Mlingano (Ebbels and Allen, 1979).

Root and stalk diseases

Three serious stalk rot diseases have been recorded on sorghums which include red rot (Colletotrichum graminicola (Ces.) Wils.), charcoal rot (Macrophomina phaseolina (Tassi) (Goid.) and fusarium rot (Gibberella fujikuroi = Fusarium moniliforme (Saw.) (Wr.) (Tarr, 1962).

In Tanzania, two of these, charcoal rot and fusarium rot, have been reported (Riley, 1960).

Charcoal rot (Macrophomina phaseolina or Sclerotium bataticola is the more serious one. The disease was unknown in Tanzania until a susceptible dwarf Lulu was grown on light

soil in 1952 (Doggett, 1980). Clinton (1961) observed that the damage due to this disease is not usually apparent until late in the plant's life when the head development may be suspiciously reduced. The plants may lodge very easily and longitudinal sections of the stem may reveal black pin-head-like spots which are the sclerotia of the fungus. Due to its wide host range, the disease is very difficult to contain. It is soil borne and has a wide host range including beans, cotton, maize and other vegetable crops. Where the disease is severe the only answer is resistant varieties. Fortunately, most of the local tall sweet sorghums grown in Tanzania have some resistance to this disease. There is a need to examine improved varieties and introduced materials for resistance to the disease.

Fusarium rot is not as serious. Where it occurs, the stalk may break near the soil surface. The fungus Gibberella fujikuroi (= Fusarium moniliforme) is probably more serious on sorghum heads.

Phanerogamous parasites

This aspect of sorghum problems will probably be mentioned elsewhere. However, witchweed (Striga spp.) has been a serious parasite causing disease conditions on sorghum leading to reduced grain yield. Yield reduction of up to 40 per cent due to this parasite is not uncommon in the western zone where Striga hermonthica (Del.) Benth.) and S. asiatic (L.) O. Kuntze are common. There are also recent reports of this parasitic weed in the central zone in the Dodoma area (Mushi, 1984).

Doggett (1970) observed that in addition to the direct control of the parasite by herbicides like 2-4D and MCPA, greater attention should be given to the search for resistant varieties. Some of the local varieties are known to farmers to be resistant and tests at Ukiriguru indicated that Dobbs had an excellent level of Striga resistance (Doggett, 1970).

CONCLUSION

This paper is a preliminary report on the sorghum diseases of major and minor importance in Tanzania. The work being done to screen the breeding materials for disease resistance needs to be intensified and more use made of seed treatments, disease-free seed and rotation of susceptible sorghum cultivars with non-susceptible crops. The large number of introduced materials being tested in the International Pest and Disease Nursery and also introduced breeding materials may provide good sources for improving our sorghum yields, quality and pest and disease resistance. However, extra care must be taken to ensure that these materials do not bring in new diseases and pests which may be more devastating than those we already have.

Finally, a number of mentions have been made concerning disease resistance observed in local materials by farmers. These, together with the farmer's quality preferences should not be overlooked in our sorghum research program. This fact was also stressed by Doggett (1980).

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INTERCROPPING SORGHUM AND LEGUMES WITH PARTICULAR REFERENCE TO PLANT POPULATION AND TIME OF LEGUME PLANTING

F.F.A. Mbowe*

INTRODUCTION

Intercropping is a cropping system involving the growing of two or more crops on the same piece of land at the same time. This farming practice is the most popular crop production system used in subsistence tropical agriculture and is very common in the semi-arid areas of Africa. In Tanzania intercropping mostly involves a combination of a cereal and a legume, with the cereal being considered as the main crop (Nnko and Doto, 1980). In the semi-arid areas of Tanzania intercropping mainly involves a combination of sorghum or bulrush millet as the main cereal crop, and cowpea, greengram or pigeonpea as the legume crop.

Several advantages accrue from intercropping. For example, it provides a balanced diet, reduces labour peaks, minimizes crop failure risks, can reduce the adverse effects of pests, provide higher returns and protect soil against erosion (Okigbo, 1979).

Various researchers have reported considerably higher yields risulting from intercropping as compared to pure stands. Singh (1979) reported an 8-34% sorghum yield increase in a sorghum/legume intercrop system over monocropped sorghum. Also Osiru and Wiley (1976) reported up to 25% higher yields of the mixtures than could be achieved by growing the two crops (maize or beans) separately. However he noted that these advantages of the mixture decreased markedly with delayed

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*Agronomist, TARO, P.O. Ilonga, Kilosa, Tanzania

planting of beans, and concluded that the difference in the maturity period of the component crops is probably the major contributing factor to the yield advantages in the mixtures.

Choice of type of crops or varieties adapted for intercropping has been discussed by various scientists (Makena and Doto 1980; Hill, 1974; Singh, 1980). Thus crop compatibility is an important factor to consider in an intercropping system. Crops which do not compete with each other by way of differences in growth rhythm, duration, nutrients and water requirements, may better use available resources if intercropped (Singh, 1983). In a study to investigate yield advantage and competition caused by intercropping, Singh (1983) reported up to 9% sorghum yield reduction when sorghum was intercropped with pigeonpea, and showed that greengram, cowpea and blackgram did not compete with sorghum, and there was a 33-63% yield advantage resulting from the different intercrops. Time of planting a given component in relation to the other components partly influences the effect of competition between the component crops for resources (Nnko and Doto, 1980). The objective of this study was to determine the combination of factors in an intercrop of sorghum (Sorghum bicolor), cowpea (Vigna unguiculata) and greengram (Vigna radiata), that would give the best combination of cereal and legume yields. Particular reference was given to plant populations of both sorghum and legumes as well as time of planting the legume.

MATERIALS AND METHODS

An experiment was conducted at Ilonga Agricultural Research Institute during the main rainy season of 1983 to determine the combination of factors in a sorghum/cowpea/greengram intercrop system that give the best combination of sorghum and legume yields. This station is located at approximately 7°S and is at an altitude of 500m above sea level, with a bimodal

rainfall pattern totalling about 1,100mm annually.

Sixteen treatment combinations consisting of four factors each at two levels were studied in a randomized block design arranged in 2^4 factorial:

1. Sorghum plant populations: 60,000 and 100,000 plants/ha.
2. Legume type: Cowpea and greengram
3. Legume plant populations: 100,000 and 200,000 plants/ha.
4. Legume time of planting: planted same day as sorghum and planted three weeks after sorghum.

Additional sorghum and legume monocrop treatments, planted at the recommended optimum plant density, were included.

The intercropped plots consisted of 6 rows of sorghum and 5 rows of legume (alternate single rows) or 10 rows (alternate double rows) of legume. All plots were 6 metres long. The monocrop plots consisted of 7 rows for both sorghum and the legumes. At planting, 60kg P_2O_5/ha (as triple superphosphate) and 30kg N/ha (as calcium-ammonium nitrate) were applied. About four weeks later an additional 30kg N/ha were applied to the sorghum plants as side dressing. Other management practices, e.g. weeding and insect control were followed as normal.

Required data were taken from the sample area only. A few selected variables for sorghum and the two legumes were analysed. These included grain yield, land equivalent ratio (LER) and economic returns. LER was calculated as:

$$LER = \frac{\text{Sorghum yield in mixture}}{\text{Sorghum yield in pure stand}} + \frac{\text{Legume yield in mixture}}{\text{Legume yield in pure stand}}$$

RESULTS AND DISCUSSION

The main effects of the four factors on grain yields of sorghum and legumes are shown in Table 1. As indicated in this table, none of the four factors had a significant effect on the grain yield of sorghum. However, planting legumes three weeks later gave the highest sorghum yield, while significantly reducing the legume yields. In general, greengram yields were higher than cowpea yields. From Table 1 it is evident that the most significant factors affecting the legume yields were the type of legume and planting time. Thus, planting the legume on the same day as sorghum gave the highest legume yields, while insignificantly reducing the sorghum yield.

Table 1. Main effects of the four factors on the yield of sorghum and legume

Factor/variable	Grain yield (kg/ha)	
	Sorghum	Legume
Sorghum plant population		
60,000 plants/ha	2437a*	812a
100,000 plants/ha	2439a	959a
Legume type		
Cowpea	2381a	659b
Greengram	2557a	1106a
Legume plant populations		
100,000 plants/ha	2637a	881a
200,000 plants/ha	2226a	885a
Legume time of planting		
Planted same day as sorghum	2254a	1373a
Planted three weeks after sorghum	2609a	393b

*Paired means followed by the same letter do not differ significantly at the 5% level.

Table 2 shows the actual sorghum and legume yields obtained for the different treatments in this experiment. As is evident from this table, the highest sorghum yield (3,262 kg/ha) was achieved when cowpea at a density of 100,000 plants/ha was intercropped with sorghum at 60,000 plants/ha, the cowpea being sown three weeks after sorghum.

Table 2. Mean grain yield (kg/ha) for sorghum, cowpea and greengram

Sorghum plant population (plants/ha)	Type	Legume plant population (plants/ha)	Time of planting	Yield (kg/ha) Sorghum	Legume
60,000	Cowpea	100,000	T_1	2,122d*	1,014f
60,000	Cowpea	100,000	T_2	3,262a	171i
60,000	Cowpea	200,000	T_1	2,117d	1,130ef
60,000	Cowpea	200,000	T_2	1,317e	170i
60,000	Greengram	100,000	T_1	2,403cd	1,389c-e
60,000	Greengram	100,000	T_2	3,257ab	539gh
60,000	Greengram	200,000	T_1	1,904de	1,493b-d
60,000	Greengram	200,000	T_2	2,457cd	592g
100,000	Cowpea	100,000	T_1	2,539cd	1,173d-f
100,000	Cowpea	100,000	T_2	2,493b-d	298g-i
100,000	Cowpea	200,000	T_1	1,919d	1,122ef
100,000	Cowpea	200,000	T_2	2,803a-c	198hi
100,000	Greengram	100,000	T_1	2,839a-c	1,864a
100,000	Greengram	100,000	T_2	2,361cd	599g
100,000	Greengram	200,000	T_1	2,369cd	1,798ab
100,000	Greengram	200,000	T_2	2,868a-c	5,769
110,000	-	-	T_1	2,848a-c	-
-	Cowpea	200,000	T_1	-	1,613a-c
-	Cowpea	200,000	T_2	-	202hi
-	Greengram	200,000	T_1	-	1,701a-c
-	Greengram	200,000	T_2	-	331g-i

Notes

T_1 = Legume planted same day as sorghum

T_2 = Legume planted about 3 weeks after sorghum

* Means followed by same letter do not differ significantly at the 5% level (using Duncan's Multiple Range Test).

However, this combination gave the lowest cowpea yield (171 kg/ha), and a farmer would most likely not accept this combination if seed yields were of primary concern. In this case it is very important to note that any treatment that would maintain a high sorghum yield and give an appreciable yield of the legume crop (regarded as a minor crop), would be acceptable to the farmer (Nnko and Doto, 1980).

Compared to the sole crops, there was no significant yield reduction in both the sorghum and greengram when both crops were planted on the same day at 100,000 plants/ha each (Table 2). This combination will most likely be accepted by farmers, provided there are no labour constraints during planting. The same treatment also gave the highest gross return of TSh 10,804 (Table 3).

Land equivalent ratios (LERs) and gross returns are shown in Table 3. This intercropping system consistently showed LERs which are greater than 1. The results of this experiment indicate a 31-175% yield advantage accruing from this crop association compared to the monoculture. However, the LER values seem abnormally high. The same experiment has been repeated at more locations which are representative of sorghum growing areas in Tanzania to confirm these findings. In general, the sorghum/greengram mixture out-performed the sorghum/cowpea combination, both in terms of LER and economic advantage (Table 3). It is important to note that such a combination may not necessarily be the most suitable and acceptable to the farmer due to the fact that the farmer's choice of the crop combination depends on the final use (that is, his requirements). In Tanzania most farmers use cowpea in two forms, the leaves as a vegetable and seeds (fresh or dry) as a source of protein. Thus a farmer would probably accept a lower sorghum yield (compared to monocrop) in return for an appreciable cowpea yield. In this case a farmer would probably accept intercropping of sorghum with

Table 3. Effects of treatments on land equivalent ratios (LERs) and economic returns

	LEGUME				
Sorghum plant density (plants/ha)	Type	Plant density (plants/ha)	Time of planting	LER	Gross return (TSh)
60,000	Cowpea	100,000	T_1	1.38de*	7,032
60,000	Cowpea	100,000	T_2	2.00cd	6,994
60,000	Cowpea	200,000	T_1	1.45c-e	7,341
60,000	Cowpea	200,000	T_2	1.31e	3,209
60,000	Greengram	100,000	T_1	1.66c-e	8,626
60,000	Greengram	100,000	T_2	2.75a	7,996
60,000	Greengram	200,000	T_1	1.55c-e	7,914
60,000	Greengram	200,000	T_2	2.69ab	6,542
100,000	Cowpea	100,000	T_1	1.56c-e	7,944
100,000	Cowpea	100,000	T_2	1.85c-e	5,805
100,000	Cowpea	200,000	T_1	1.36de	6,923
100,000	Cowpea	200,000	T_2	1.98cd	6,150
100,000	Greengram	100,000	T_1	2.10bc	10,804
100,000	Greengram	100,000	T_2	2.65ab	6,369
100,000	Greengram	200,000	T_1	1.90c-e	9,682
100,000	Greengram	200,000	T_2	2.74a	7,320
110,000	-	-	-	-	5,696
-	Cowpea	200,000	T_2	-	4,436
-	Cowpea	200,000	T_1	-	555
-	Greengram	200,000	T_2	-	4,678
-	Greengram	200,000	T_1	-	910

Notes

T_1 = Legume planted same day as sorghum

T_2 = Legume planted about three weeks after sorghum

* Means followed by same letter do not differ significantly at 5% level (using Duncan's Multiple Range Test).

cowpea, both crops planted on the same day at 100,000 plants/ha. This combination would give the farmer a reasonable yield of sorghum (2,359 kg/ha) and an appreciable cowpea yield of about 1,173 kg/ha, with a slightly lower gross return (TSh 7,914) than that obtained from the sorghum/greengram combination (TSh 10,804). Results of this experiment indicate that the best combination of sorghum and legume yields could be achieved by intercropping sorghum with either greengram or cowpea (depending on farmer's preferences), both crops being planted on the same day at a density of about 100,0000 plants/ha for both crops. In this case the sorghum is maintained at about full density while the legume is at half the optimum density for the single crop.

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SORGHUM PROCESSING AND UTILIZATION IN TANZANIA: CONSTRAINTS AND POTENTIAL

M. Seenappa and N.T.A. Bangu*

INTRODUCTION

Sorghum is one of the major cereals in Tanzania. In the last decades there has been a shift in food habits and consequently most of the country tended to grow maize rather than sorghum. However, considering the continuing drought and uneven rainfall in many areas, Vogel and Graham (1979) predicted a switch back to sorghum and millets in the near future, especially in the semi-arid areas in the country. Most of the sorghum in the country is now cultivated in the semi-arid central zone comprising of Singida, Shinyanga, Dodoma, Mtwara and the semi-arid areas of Iringa and Morogoro regions. Meagre and unpredictable rainfall in the country in the last few years has prompted peasant farmers to shift to sorghum cultivation. A total devastation of maize in most of Iringa Region this cropping season due to drought is a further hardship for the peasants of that area and it will be understandable if they shift to sorghum in the next cropping year. Appropriate Government bodies have intervened to alleviate unforeseen food shortages by directing the peasants to grow drought resistant crops in these areas. In fact, it is deemed illegal to cultivate maize in drought-prone areas such as Isumani in Iringa.

Apart from the predominance of maize which has been suppressing sorghum cultivation, traditional labour-intensive processing and problems in palatability have also impeded

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*Department of Food Science and Technology, University of Dar es Salaam, Morogoro, Tanzania.

sorghum cultivation. The present paper summarizes the traditional processing of sorghum, the introduction of sorghum dehullers and discusses the nutritional character of dehulled sorghums in the country.

TRADITIONAL PROCESSING OF SORGHUM

A wide variety of sorghum is grown in the country. Basically these are either red or white. Traditional varieties include Lugugu, Konza, Msumbiji, Udo Msonga and Sagana. Improved varieties include Serena, Lulu Dwarf, Lulu Tall, ET-35, 5DX 135/13/3/1 and Dobbs Bora. After four years of evaluation the Agricultural Research Institute at Ilonga released better adapted and high yielding cultivars of sorghum in 1982. The food quality characters of all these varieties depend both on cryptic as well as evident features. The most favoured characters of a good quality sorghum are free threshing, white, shiny, thick corneous outer endosperm, hard so as to be insect resistant and with good cooking qualities and flavour (Doggett, 1977). The red and bitter types have always been time-consuming for traditional processing as compared with the other varieties. Pounding sorghum has always been women's work. It is pounded to flour employing a wooden mortar and wooden pestle, often supplemented with granite and a rolling stone, at the rate of 1 to 1½ kg flour per hour per woman. The traditional extraction rate is around 60% of the grain. The women are engaged in this activity for a minimum of 3 to 4 hours per day, usually starting at 4.00 a.m. The traditional wet pounding produces a very moist (around 30-40%) flour that only has a shelf life of one to two weeks. Laborious home-processing of sorghum has, therefore, been one of the main reasons for the decline in sorghum cultivation in the country.

THE INTRODUCTION OF MECHANICAL PEARLING OF SORGHUM

Mechanical pearling (dehulling) technology for sorghum is of

recent introduction to Tanzania. A petrol-driven Cecoco polisher of the East Africa Industrial Research Organization installed at Mati, Morogoro by 1972, and later tested at Ilonga, was a useful demonstration. Unfortunately only the Lulu variety was tested (Kapasi-Kama et al., 1972). In October 1980 the Small Industries Development Organization (SIDO), with the support of the Canadian based International Development Research Centre (IDRC) installed, on a pilot basis, a milling system package at Chanzuru village in Kilosa District (Eastman) 1980). The package consisted of a sorghum dehuller (the Prairie Research Laboratory (PRL) type modified by Rural Industries Innovation Centre (RIIC, Botswana), a hammer mill, an automatic weighing and bagging system and appropriate 32 hp diesel engines. Although in the first two years starting in 1980 the sorghum harvests in the area were low, and the mill did not run to its full capacity, subsequent harvests of sorghum have been sufficient for the economic viability of the mill. It is estimated that the mill should process at least 5 tons of grain per day in order to be economically viable. A milling system of this capacity would be the most suitable had the surrounding area had bulk producers and bulk customers. Despite these constraints, the introduction of the sorghum milling system has been technologically viable and has had a very positive impact in the adjoining areas prompting extensive cultivation of sorghum.

VILLAGIZATION OF SORGHUM PEARLING

A survey was conducted in Iringa Region during August-September 1983 pertaining to food processing and security of supplies in relation to nutrition and child care under

the joint WHO/UNICEF project 'Improvement of Nutrition in Iringa Region'. It was found that in Pawaga Division, with its nine villages, slightly more than 50% of the children were underweight and the mothers spent most of their time hand processing a local red cultivar of sorghum. This work needed 24-26 hours per women per household per week thus depriving the women of time for other household activities and care of the children. As part of technology development support in the Division, Kimande and Ilolo villages were recommended as potential sites for introduction of appropriate sorghum milling technology (Seenappa, 1983). There are 2,316 households in the Division and each household produces an average of 10 bags (x 100kgs) sorghum per year. In order to be economically viable, a mini sorghum dehuller of the type designed by PRL in Canada is recommended for integration into the grain milling system (Seenappa et al., 1984).

As a follow-up of this recommendation, ten villagers, comprising both men and women, from Ilolo, Mkombilenga and Magozi, with Mr Msema, the ward secretary, as the team leader, were given a demonstration of the mini-dehuller installed at the University (at Morogoro) under an IDRC supported sorghum project. The villagers dehulled the red sorghum they had brought along with them. The team was convinced that the mechanical processing would greatly relieve the women of their daily ordeal of hand pounding. The pearled sorghum was later milled in a maize hammer mill and the village team used this flour for cooking ugali (stiff porridge) and evaluated it as lighter in colour, very soft and free from bitterness when compared with ugali made from undehulled red sorghum.

The village governments of Ilolo, Mkombilenga and Magozi in a joint meeting held at Ilolo have decided to purchase a milling system with a sorghum mini-dehuller. It is proposed that the milling system is installed at Ilolo as a community service mill for all the three villages. Since the mini-

dehuller is not currently available in the country, it has been suggested that UNICEF and IDRC may help in procuring the dehuller from Canada initially. Wangingombe is another Division in Iringa that will soon be needing a similar system. As the demand for mini-dehullers is expected to increase in the immediate future, it will become feasible to fabricate them locally (perhaps at the SIDO workshops where they had succeeded with the PRL/RIIC dehüllers) so that they become easily available.

UTILIZATION AND NUTRITIONAL QUALITY OF PEARLED SORGHUM

Pearling or polishing (dehulling) removes the seed coat from the endosperm. Fortunately most of the nutrients are contained in the endosperm and the germ. Together they contain nearly 93% of the minerals, 86% of the protein and 46% of the crude fibre (Reichert and Young, 1977). Dehulled sorghum is mainly used for preparing ugali. Earlier studies, employing whole sorghum flour rather than that made from dehulled sorghum, have indicated that, among the Tanzania cultivars of sorghum, the white type produced generally good ugali and that IS-1475 (ICRISAT collection), despite being red, also produced better ugali (Mukuru et al., 1981).

The effect of pearling on the nutritional quality of Serena has been studied employing the PRL/RIIC dehuller (Bangu and Laswani, 1982). The results (Table 1) indicate that the total ash, protein and minerals such as Mg, Fe and P were only slightly affected and that the crude fibre content of the polished product was markedly low. Detailed studies on the availability of protein and iron from Tanzania sorghum varieties have been recently carried out in Sweden using rat feeding trials (Mosha and Haq, 1983a, 1983b) and in Denmark

Table 1. Approximate Composition of Sorghum of Different Extraction Rates

Variety	Extraction rate %	Dry matter %	Ash %	Crude protein &	Crude fibre %	Phosphorus %	Iron %	Magnesium %	Calcium %
Lulu	83	85.39	1.35	9.50	0.96	0.38	0.0214	0.110	0.025
	86	86.35	1.23	10.31	1.20	0.20	0.0120	0.114	0.012
	95	89.59	1.30	10.26	1.31	0.29	0.0102	0.106	0.016
	100	89.81	1.28	10.29	1.50	0.31	0.0196	0.096	0.016
Serena	76	86.36	1.40	8.70	0.09	0.35	0.0079	0.104	0.010
	80	86.83	1.33	9.00	1.12	0.35	0.0090	0.116	0.010
	86	87.14	1.41	9.50	1.50	0.32	0.0093	0.112	0.012
	100	88.10	1.46	10.24	1.67	0.35	0.0160	0.100	0.012

studies have been done on digestibility of Tanzania sorghums by Eggum et al. (1981).

Use of sorghum as a base in weaning and supplementary foods is becoming increasingly popular (Desikachar, 1977). Studies in India have demonstrated the usefulness and implications of using sorghum-based infant foods (Pushpamma et al., 1979a, 1979b). Mosha and Svanberg (1983) have demonstrated the preparation of high-nutrient-density weaning gruels employing Tanzania sorghums and the technique involves the addition of some 'power flour' to the ready-to-eat gruel. Both complete and dehulled sorghums can be germinated and dried to produce 'power flour'. However, the tannins in the coloured varieties are known to reduce the amylase activity of the 'power flour'.

Sorghum-based composite flours with various proportions of maize and cassava have been developed both at the Tanzania Food and Nutrition Centre and the Department of Food Science Technology at Morogoro and are intended for making ugali, bread and pastry. Successful adoption of these into the villages will require appropriate extension work and facilities. The increasing demand for sorghum, introduction of new cultivars and a gradual increase in sorghum cultivation indicate a dire need for appropriate milling technologies and utilization methods.

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RESEARCH ACTIVITIES OF THE ETHIOPIAN SORGHUM IMPROVEMENT PROGRAM, 1983/84

Yilma Kebede*
Abebe Menkir**

INTRODUCTION

Sorghum bicolor (L.) Moench is one of the leading traditional food crops of Ethiopia comprising 15-20 per cent of the total cereal production in the country. As an *injera* (leavened, flat and round Ethiopian traditional bread) source, it ranks second to *tef* (*Eragrostis tef* (Zucc.) Trotter) in consumer preference.

In the different ecological zones of the country major research efforts are geared to improving and stabilizing sorghum yields. The various aspects of sorghum improvement research are handled through a multidisciplinary team in order to solve the pressing sorghum production problems most efficiently and economically.

The overall objective of sorghum research in Ethiopia is the development of good grain quality sorghum varieties and, to a limited extent, the development of hybrids along with the necessary packages of production technology for obtaining sustained high grain yields in the major sorghum growing zones of the country.

A summary of national sorghum research work carried out in 1983 is presented in Table 1. These include various yield trials, segregating populations, seed increases, crossing, and off-season activities, along with complementary

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*Team Leader, Sorghum Research

**Research Officer, Sorghum Research, Institute of Agricultural Research, P.O. Box 103, Nazreth, Ethiopia.

work with other disciplines, as indicated in the table. There were a total of 52 research activities planned under the different disciplines with the largest number in agronomy (12) and breeding (15). For various reasons (lack of personnel, material, co-operators, etc.) four of the planned activities were not carried out. Major findings from all the other trials were presented at our review meeting. Five trials in soil fertility and one in weed control have been completed and the conclusions and recommendations from each of these trials are available.

Table 1. Summary of sorghum research program for 1983/84 season

Research project	Total no. of research activities	On-going	Completed	Discon-tinued	No result	Not executed
Striga	1					1
Weed control	2	1	1			
Breeding	15	13(5)*		1		1
Agronomy	12	10(4)			1	1
Soil fertility	9	3(1)	5	1		
Entomology	8	1			6	1
Pathology	4	4				
Utilization	1					1
Total	52	32	6	2	7	5

*Figures in parentheses are the number of projects which failed at Kobo due to shortage of moisture.

The 1983 season and long-term rainfall data for the stations where sorghum research was carried out are presented in Annex 1. At Kobo (north-central), moisture shortage resulted in total crop loss. In the western region (Bako, Didessa, Jimma) there was adequate rainfall for crop production. At Melkassa (central), poor rainfall distribution resulted in sub-optimal crop performance. In the eastern region of the country (Alemaya, Mieso) above-average rainfall was recorded and was reflected in the satisfactory grain yields obtained from these locations.

CROP IMPROVEMENT

Introduced trials and observations

In the 1983 crop season, a total of five field trials and a nursery (stem borer) were received from the regional SAFGRAD Co-ordinator and ICRISAT. Although they were designed to be planted at different locations all were planted at Nazareth (Melkassa) under irrigation due to the existing quarantine regulations. Based on visual evaluation for disease reaction and overall performance most of the entries were harvested. The entries will be replanted in their respective areas of adaptation this coming season. Some entries will also be used as parents in our 1984 crossing block.

In addition, a 1982 introduced trial and a Striga nursery from ICRISAT, initially grown at Melkassa, were repeated at Kobo and Mieso. From Mieso nine entries were advanced for further evaluation. Nothing was recovered from the Kobo planting as a result of severe drought.

Sorghum crossing program

Crossing block

The objective in the crossing block is to make crosses among selected sorghum parents possessing desirable traits to

improve yield, maturity, plant height, disease and insect resistance, grain quality, etc. for the various sorghum growing zones.

During the 1983 keremt, crosses for various ecological zones were made. A total of 71 parents were involved in various combinations. F_1 seeds of 307 successfully completed crosses have been sown in the off-season at Melka-Werer and the F_2 seeds have already been harvested for distribution to various sites.

Hybrid sorghum

This program was started in 1977 and has been geared to the needs of the dry lowland areas and to some extent the intermediate altitude and high-rainfall areas where there is a potential need for use by state-run farms.

Since the start of this program over 170 A and B line pairs have been evaluated and some 25 had been selected for tests at one time or another. The best female parents identified so far are IS 10360A, IS 10468A, and ATx 623. Moreover, some 350 pollinator lines have been evaluated for their combining ability. A number of yellow endosperm pollinator lines have been found to possess good combining ability.

The crossing is done during the off-season and evaluation is done in the immediately following regular season.

B-line conversion

Pollinator lines with B-line reaction and possessing good general combining ability have been identified during

the course of the hybrid program and thus a program to convert such B-lines and develop counterpart A-lines had been initiated earlier using a backcross procedure.

Twenty nine A-lines of Melkamash 79 origin have been selected and have undergone three backcrosses. Out of these, six entries, along with another five of YE-88 origin, have been selected and put into a preliminary test-cross in the off-season.

The hybrids with Melkamash A and suitable intermediate pollinators will be tested for use by the state-run farms in the high rainfall and intermediate altitude zones of Ethiopia.

Population improvement program

Outcrosses between high-lysine type dented seed (female) rows and selected normal seed sources (male) result in about 10 per cent plump F_1 seeds. Such plump seeds from panicles selected at Alemaya (high elevation location) were hand picked and handled as crossed seeds and have already been planted in the off-season at Melka-Werer. Dented seeds from segregating panicles in the Melka-Werer 1984 harvest will be taken to Alemaya and Arsi-Negele in keremt 1984 to serve as female rows.

The program has gone through five cycles of selection. Single plant selections have been put in progeny rows and subsequently into yield trials.

For the low elevation areas, genetic male-sterility (ms_3) identified from introduced sorghums was used in 1978 to start a population possessing male sterility and adapted to lowland areas. This past season the program was suspended. It will be continued this coming season.

Pedigree breeding to develop high-yielding acceptable and adapted sorghum

The objective is to make crosses among selected parents and to select locally acceptable cultivars of sorghum for the various sorghum growing zones of the country. This program has been underway since 1976.

Several hundred populations of F_2, F_3 and F_4 segregating progeny have been planted and evaluated at the various major stations (Table 2). Seed from selected plants, in each generation, from various stations representing each ecological zone will be pooled to form the planting material for next season.

Table 2. Total number of progeny planted at various locations and the numbers advanced, 1983

Generation	Location (elevation)	Total planted	No. of crosses selected	Plants selected
F_2	AL(H)	103	-	-
	AN(H)	5	5	11
	BK(I)	103	18	23
	MK(L)	263	113	198
	MI(L)	165	113	320
	KB(L)	165	-	-*
F_3	AL(H)	189	50	124
	AN(H)	448	241	583
	BK(I)	500	107	181
	DS(I)	500	32	50
	JM(I)	492	19	26
	MK(L)	131	74	130
	MI(L)	155	21	127
	KB(L)	509	-	-*
F_4	AL(H)	285	56	156
	AN(H)	77	4	4
	BK(I)	114	28	38
	DS(I)	114	15	23
	MK(L)	99	27	28
	MI(L)	40	14	64
	KB(L)	176	-	-*

*Total loss due to moisture shortage

The regular testing sites in this program have been Alemaya (AL) and Arsi Negele (AN) representing high elevation (H) locations; Bako (BK), Dedessa (DS) and Jimma (JM) serving as intermediate elevation (I) testing sites; and Kobo (KB), Melkassa (MK) and Mieso (MI) as low elevation (L) locations.

Other activities

Seed multiplication and maintenance

Elite varieties and breeding stocks and A & B lines were increased at each of the major sorghum stations. Such seed is normally used for organizing various trials and for providing samples to various national and international research centres.

Collection, evaluation, and utilization of indigenous sorghums

Every effort is made to collect, classify, and utilize the indigenous Ethiopian sorghums. There was no major activity in this regard this past season, but the exercise will continue in co-operation with the Plant Genetic Resource Centre/Ethiopia.

Off-season sorghum activity

This operation serves for advancing generations, seed multiplication as well as hybrid crossing purposes.

F_1s, selections from various generations, B-line conversion materials, pollinator lines, female parents, etc. are normally planted in the off-season.

Most of the material was harvested in time for planting in the regular season.

AGRONOMY

Sorghum plant density trials

The 1983 data (Table 3) are very similar to those of 1982. In both years Alemaya 70 gave better yields at a higher density (160,000pph) compared to ETS 4946 which is a relatively tall and late variety. ETS 4946 which had similar mean yields to that of Alemaya 70 showed a distinctly higher yield at 100,000 plants per hectare than at any other planting density. No consistent trend was evident for ETS 2752.

Table 3. Variety and plant population effect on grain yield of high altitude sorghums planted at Arsi Negele, 1983

Expected no. of plants/ha	Varieties			
	ETS 2752	ETS 4946	Alemaya 70	Mean
40,000	31.9	48.2	51.1	43.7
70,000	37.0	45.9	50.4	44.5
100,000	35.6	63.0	52.6	50.4
130,000	28.9	49.6	51.1	43.2
160,000	35.6	57.8	58.5	50.6
Mean	33.8	52.9	52.7	46.5

In such trials, the major problem appears to be the difficulty of establishing the desired plant population level for any meaningful comparison. At the low elevation locations no results were obtained due to moisture shortage.

Intercropping trials

Sorghum/maize

A sorghum/maize intercropping experiment was carried out at Arsi Negele and Alemaya. ETS 2752 and Alemaya 70 sorghum varieties along with Katumani maize were used. Besides sole crop planting for each sorghum variety and maize, the other treatment combinations were intercropping in alternate rows of 75cm distance, intercropping within the row, and broadcasting of a mixture of maize and sorghum.

Results obtained at Arsi Negele confirmed previous years' findings that yield levels from the intercrop combinations were higher than the sole crop of either maize or sorghum except in the broadcasting treatment (Table 4). Sorghum appeared to suffer most from intercropping, especially when intercropping was either within the row or broadcast. In the intercrop combination the lowest maize yield was 39 q/ha, equal to a 38 per cent reduction compared to single crop, while in sorghum (ETS 2752) the lowest yield of 9 q/ha represented a 78 per cent reduction relative to sole sorghum.

Table 4. Grain yield from the sorghum/maize intercropping trials at Arsi Negele, 1983

Treatment	Sorghum	Maize	Total
ETS 2752	49.0		49.0
Alemaya 70	41.8		41.8
Katumani	-	53.3	53.3
ETS 2752 with Katumani (alt. rows)	37.1	n.a.	-
Alemaya 70 with Katumani (alt. rows)	48.1	43.3.	91.4
ETS 2752 with Katumani (within row)	14.6	45.7	60.3
Alemaya 70 with Katumani (within row)	14.1	56.8	70.9
ETS 2752 with Katumani (broadcast)	8.9	36.7	45.6
Alemaya 70 with Katumani (broadcast)	17.6	33.3	50.9

n.a. = not available

Sorghum/haricot bean

There was no significant difference in sorghum yield whether planted alone or intercropped with haricot beans. This was also true in the 1981 and 1982 trials. The yield of haricot beans was high when planted alone but declined when intercropped. There was a highly significant difference for haricot bean yields.

The results of this trial indicate that an increased yield of haricot beans could be obtained by intercropping with sorghum without affecting sorghum yields, but the extra yield of haricot beans is too low to justify intercropping. In addition, harvesting and storage of haricot beans poses a problem since the haricot beans mature before the rainy season is over. As a result, optimum grain moisture level cannot be attained unless the harvest is hung in a shed to dry for some months.

Sorghum/legume

Compared to a single crop of sorghum, 15,37, and 42 per cent yield reductions were recorded when sorghum was intercropped with mung-bean, haricot bean and cowpea, respectively.

Fertilizer trials

N and P rate trial at Bako

A fertilizer trial on sorghum variety Bakomash 80 was started in 1980 to determine the optimum levels of N and P. After last season's (1983) result this trial was considered as having been completed. The recommendation is to fertilize with 50 kg/ha N and 75 kg/ha P_2O_5 for optimum yield.

Sorghum N and P rate trial at Alemaya

Six levels of N and P_2O_5 were used (0 to 250 kg/ha at 50 kg/ha intervals) on Alemaya soil series (sandy clay loam residual soils) and Damota alluvial soil series. The sorghum variety used was ETS 2752.

The results of this trial in 1983 have shown that on the Alemaya soil series 150 kg/ha N and the same amount of P_2O_5 gave significantly higher grain yields while on the alluvial soil 100 kg/ha N and 69 kg/ha P_2O_5 gave the best yield.

Time of N application

The different times of application were: all at planting, all at 30-40 days after planting (d.a.p.), all at flowering, half at planting and half at 30-40 d.a.p., half at planting and half at flowering, half at 30-40 d.a.p., and half at flowering and a control with no fertilizer. The sorghum variety used was ETS 2752 and the experiment was conducted on Alemaya soil series as well as on Alemaya black soil (vertisol).

On Alemaya soil series (sandy clay loam residual soil), the 1983 results indicated that the best time of application depends on the rate of N applied. A rate of 69 kg/ha N all applied at planting, gave the highest yield (80 q/ha) while at 150 kg/ha N half at planting and half 30-40 days after planting was the best method of N application.

On the black soil (vertisol) there were no differences in yield (60 q/ha) when N was applied either half at planting and half at flowering or half at 30-40 days after planting and half at flowering, regardless of the rates used (46 and 92 kg/ha N).

These results show that response to time of N application is dependent on the amount of nitrogen applied as well as on soil type.

Method of phosphorus application

Using the same variety (ETS 2752) and on different soil types (Alemaya series, black soil, Damota series) different rates and methods of phosphorus application were studied. The methods of phosphorus application studied were 5cm under the seed, two-side dressing, one-side dressing, broadcast and mix, and broadcast without mixing in the plough layer.

The results of the past season showed broadcasting and mixing in the plough layer was by far the best method of application.

Effect of soil type on response to fertilizer

The performance of five released high altitude sorghum varieties (ETS 2752, Muyra, ETS 3235, Alemaya 70, ETS 4946) was studied on two soil types (Alemaya series, black soils (vertisols)) under unfertilized and fertilized (150 kg/ha N, 115 kg/ha P_2O_5) conditions.

The overall mean grain yields (q/ha) of the five varieties are given in Table 5. The results from this trial showed that differences in soil type had a great influence in determining response to fertilizer application.

Table 5. Mean grain yields of five varieties,q/ha

Alemaya series		Black soil (vertisols)	
Fertilized	Unfertilized	Fertilized	Unfertilized
65.5	32.8	31.0	27.7

On the Alemaya series the fertilized plots yielded twice as much as those of the unfertilized plots while in the black soil yield differences between fertilized and unfertilized plots were not very high.

Other agronomic trials

Mean grain yield of Melkamash 79, Gambella 1107, and 76 T1 No. 23 significantly decreased with a delay in planting. The highest yield (35 q/ha) was obtained from the first date of sowing (June 2) while the last date of sowing (July 25) produced the lowest grain yield (10 q/ha) at Nazreth. This trial was intended to study the effect of planting date based on the number of rainy days between dates rather than using the conventional calendar dates.

The effect of planting depth (2, 4, 6 and 8cm) was also studied at Nazreth using the same three cultivars. There was no significant variety or variety x depth interaction, but the 4cm depth of planting gave a significantly higher yield than any of the other treatments.

Effect of tillage (no tillage, oxen ploughed, tractor ploughed) was studied. Despite low yields, preliminary data showed that tractor ploughing gave the best yields followed by the oxen ploughed treatment.

CROP PROTECTION

Entomology

One hundred and thirty entries received from the Plant Genetic Resources Centre/Ethiopia (PGRC/E) were evaluated for resistance/tolerance to stem borer (*Chilo partellus*). A replicated trial will be carried out with these tolerant entries to further confirm their reaction.

A half hectare observation trial was carried out with three trap crops, namely lupin, maize and sorghum, to control African bollworm on sorghum. Even though the incidence of the pest last season was low, the number of eggs counted on lupin was relatively higher compared to the other trap crops.

A few other trials on shootfly and stalk borer control using pesticides were not successful due to the low level of pest infestation during the past season.

Pathology

Of the 67 lines of sorghum evaluated for anthracnose (*Colletotrichum graminicola*) resistance, 13 showed less than 10 per cent leaf infection under field conditions. These lines will serve as useful sources for introducing resistance to susceptible varieties.

Investigations into factors leading to post-harvest damage of sorghum revealed the presence of more than 68 different types of fungi on sorghum seeds stored in underground pits. Among these fungi, the genera *Aspergillus*, *Penicillium* and yeast were predominant.

Weed control

Crop loss assessment due to weed competition

From trials at Bako, it has been established that weeds can cause 42 per cent yield loss in sorghum. The most critical competition period is during early crop establishment (3 to 4 weeks after seeding).

Chemical control of weeds in sorghum

This chemical control trial was intended to evaluate

herbicides for use in sorghum. Various herbicides at different levels, along with a hand-weeded and untreated weedy control, were included (see Table 6).

Table 6. The effect of different weed control treatments on grain yield of sorghum at Bako, 1983

Treatement (a.i./ha)	Grain yield (q/ha)
Primagram 2 kg	18.7
Primagram 2.5 kg	22.9
Primextra 2.5 kg	19.5
Gesaprim 2.0 kg	21.5
Terbutryne 2.0 kg	20.5
Terbutryne 3.5 kg	20.2
Hand weeded (twice)	15.2
Weedy check	8.1

All chemical treatments resulted in better control as reflected in the yield levels compared to the hand-weeded and untreated weedy controls. Among the chemical treatments Primagram and Gesaprim applied at the rate of 2.5 and 2 kg a.i./ha respectively gave slightly better yields at Bako.

The predominant weed species on the trial site were *Commelina benghalensis*, *Eleusine* spp., *Cyperus rotundus*, *Guizotia scabra* and *Galinsoga parviflora*.

YIELD TRIALS

During the 1983 crop season six groups of sorghum varieties and one hybrid were planted at various locations to evaluate the performance of elite varieties, lines and hybrids in the different ecological zones of the country.

The variety trials were three Lowland National Yield Trials with a total of 68 entries, Lowland Preliminary Yield Trial (25 entries), Lowland Sorghum Trial (15 entries), and two Lowland Sorghum Observation Trials with a total of 62 entries. In addition, an Intermediate Altitude Variety Trial (15 entries) and Intermediate Altitude Observation Trial (32 entries) were conducted at the appropriate locations. There were no high altitude yield trials this past season.

The major findings are discussed below.

Sorghum variety trials

In the three lowland trials planted at Mieso, there were a total of ten entries which gave better or comparable grain yields to the controls (Melkamash 79 or Gambella 1107). Yield levels ranged from 18 to 52 q/ha. Mean days to flowering varied from 65 to 74 days, while the range of plant height was 150 to 210 cm (Table 7).

Table 7. Mean grain yield, days to flowering and plant height of high yielding entries and two controls in the 1983 Lowland National Yield Trials, Mieso

Identification	Grain yield (q/ha)	Flowering (days)	Plant height (cm)
81 ESIP 4*	50.0	74	170
81 ESIP 17*	45.1	72	155
81 ESIP 40	42.9	67	150
81 ESIP 43	43.6	68	200
81 ESIP 45	46.5	68	170
80K 6085*	44.5	73	205
80K 6088*	43.6	71	163
82 LPYT-1 No.3	52.1	69	203
82 LPYT-2 No.3	51.0	70	300
82 LPYT-2 No.5	51.9	65	210
Melkamash 79 (control)	45.2	68	213
Gambella 1107 (control	47.3	75	211

*Advanced generation lines tracing back to the Ethiopian Sorghum Improvement Program crossing blocks. The rest are introductions from ICRISAT.

Table 8. Mean grain yield, flowering days and plant height of ten entries in the 1983 elite sorghum hybrids yield trial planted at Mieso

Identification	Grain yield (q/ha)	% of the best check (Melkamash)	Flower-ing (days	Plant height (cm)
IS 10360A X Tx 430	58.8	146.8	58	143
IS 10360A X Bulk Y-3	48.3	120.6	59	175
IS 10360A X YE-90	46.0	115.1	58	128
IS 10360A X YE-96	55.5	138.6	54	140
IS 10360A X 79 T_2 No.26	63.3	159.5	58	185
IS 10360A X 79 T_2 No.13	52.4	130.8	62	155
ATx 622 X 79T_2 No.13	50.3	125.7	62	173
ATx 624 X (FLR101 X CS 3541-1-1-2)	56.8	142.8	58	160
Gambella 1107	39.9	99.8	76	213
Melkamash 79	40.0	100.0	67	173
Mean	51.2		61	164
L.S.D. (0.05)	13.9		5	17
C.V. (%)	19		6	7

Bako, Jimma and Birr, IS9302 (ESIP 11), and IS9323 (ESIP 12) as an alternate, have been approved for release by the National Variety Release Committee for production around Bako, Didessa, Birr and Jimma areas which are intermediate in altitude (1,600-1,900m) and receive high rainfall (over 900mm).

These varieties need about 100 days to flower and grow to a height of less than 2 metres.

EASTERN AFRICA CO-OPERATIVE SORGHUM REGIONAL TRIALS (EACSRT), 1983

We had grown the 1983 Eastern Africa Co-operative Sorghum Regional Trials. Because of quarantine restrictions, all the ecologically grouped trials were planted in one location under irrigation. Days to flowering were recorded for all entries. Some entries, especially the white-seed types, were damaged by birds and some of the very late entries failed to set seed so no meaningful yield data could be obtained. We intend to replant the better entries in the appropriate locations this coming season and use some entries as parents in our 1984 crossing block. Future plans regarding the harvested seeds are indicated under remarks in Table 9.

We are interested in receiving elite materials from the region and would like to fully co-operate in future regional trials both by contributing the requested elite entries as well as by growing the trials.

We would also like to get more expertise and materials from the region in specialized areas such as Striga and Quelea control as well as on good grain quality and drought-tolerant type sorghums.

PLANS FOR 1984/85 SEASON

Breeding

Since moisture is the most limiting factor in most sorghum growing lowlands, breeding work will concentrate on identifying lowland types (including hybrids) which are short and early. In the wetter areas emphasis will be on reducing height and excessive vegetative growth while maintaining and increasing grain yield. Emphasis will also be placed on bird tolerant types.

Table 9. Results of the 1983 EACSRT planting at Melkassa, Ethiopia

Entry no.	Identification	Days to flowering	Remarks
	High elevation		
1.	Kadasi	74	Adv. for HE locations
2.	Hamra Hujariya	73	Adv. for HE locations
3.	Al-Ganad	73	Adv. for HE locations
4.	SVR 157	80	Discard
5.	ETS 2752	84	Ethiopian elite
6.	Alemaya 70	97	Ethiopian elite
7.	BM 10	73	Adv. for NZ area
8.	BM 27	70	Adv. for NZ area
9.	E 1291	68	Adv. for NZ area
10.	BJ 28 x BG 19	67	Discard
11.	Local (Gambella 1107)	73	Ethiopian elite
	Intermediate elevation		
12.	Buraihi	69	Adv. for NZ area
13.	SVR 8	77	Adv. for NZ area
14.	ESIP-12	74	Ethiopian elite
15.	Bakomash 80	74	Ethiopian elite
16.	SVR 157	69	Adv. for NZ area
17.	Ikinyaruka	68	Adv. for NZ area
18.	Susa	69	Adv. for NZ area
19.	2KX 17	75	No seed harvested
20.	Local (Gambella 1107)	72	Ethiopian elite
	Low elevation		
21.	Tajarib	70	For 1984 CP
22.	Sepon 80-1	67	Adv. for LE locations
23.	5 DX-160	73	Adv. for NZ area
24.	Serena	68	Adv. for NZ area
25.	Seredo	70	Adv. for NZ area
26.	F525 HT	69	Adv. for NZ area
27.	2KX 17/P/1	72	Adv. for NZ area
28.	Tegemeo	72	Adv. for NZ area
29.	2KX 17/6	75	Adv. for NZ area
30.	Gambella 1107	72	Ethiopian elite
31.	Melkamash 79	74	Ethiopian elite
32.	Badege	92	Adv. for LE locations
33.	Urumimbi	77	Adv. for LE locations
34.	76 T1 No.23	65	Ethiopian elite
35.	IS 8595	70	Adv. for LE locations
36.	Local (Gambella 1107)	73	Ethiopian elite
	Dry lowlands		
37.	Gharib red	64	Discard
38.	Gharib white	68	Discard
39.	3KX 72/1	66	For NZ area
40.	3KX 71/1	65	Discard
41.	3KX 73/4	67	For 1984 CP
42.	3KX 76/5	64	Discard
43.	5DX 135/13/13/1	71	For NZ area
44.	76T1 No.23	67	Ethiopian elite
45.	Mukueni	75	Discard
46.	DF 822	74	For 1984 CP
47.	Local (Gambella 1107)	74	Ethiopian elite

Note: LE = Low elevation   HE = High elevation
CP = Crossing pack   NZ = Nazreth

Note: Table 9.

Those designated as 'for NZ area' are to be included in our new brown and red seed sorghum yield trials at various locations in 1984 keremt for evaluation against bird damage.

Agronomy

Reliable information on optimum planting times is available for most production areas. Dry planting has also been investigated, particularly where planting of large areas is involved, so that the crop can benefit from the first rains. Plant population is routinely determined as and when new varieties become available, as well as for different moisture zones.

Moisture conservation

Despite the availability of suitable varieties the lack of proper moisture conservation practices has limited their use. In co-operation with the Agronomy/Physiology section at Nazreth, investigations into some aspects of moisture conservation to optimize yields in areas where rainfall is limiting and erratic will continue.

Intercropping

This is an important practice in Kefa, Sidamo and Hararge regions, mainly on peasant farms. Investigations into the appropriate crop and varietal combinations need to be done. Trials on intercropping of sorghum and legumes, as well as maize, are being done at Nazreth, Kobo, Bako and Arsi Negele.

Entomology

Stalk borers (Chilo in the lowlands and Busseola in higher areas) are the leading sorghum pests. Studies covering

infestation patterns, biology, varietal differences to infestation and practical and effective control measures will be made. Other pests of importance are African bollworm, shootfly, lygus bug and termites.

Pathology

Leaf diseases are the most serious problem in high-altitude and high-rainfall areas with anthracnose being the most prevalent disease. Other important diseases are smuts, honeydew, downy mildew and various grain moulds. Screening for resistance against most of these diseases is done in the breeding nurseries in collaboration with the pathologists.

Striga

A program covering screening of varieties for tolerance/ resistance to this parasitic weed in the laboratory and field and the possibility for cultural control is planned.

Other weeds

Sorghum is a slow starter and thus poor competitor with weeds in its early stages of growth. A comprehensive loss assessment due to major weeds in sorghum areas is being made, and control investigations using herbicides are to be continued.

Soil fertility

Trials to determine the optimal rates for N and P fertilizers will be undertaken for the wetter regions of Bako and Alemaya and for the drier eastern areas at Nazreth, Mieso and Kobo as new genotypes become available.

Utilization

Investigations regarding various aspects of sorghum food preparation and evaluation will continue.

Annex 1

The major sites where sorghum research was undertaken were:

Location	Rainfall (mm)	Altitude (m)
Alemaya (AL)	986 (900)	1,980
Ambo (AM)	1,000 (1,250)*	2,250
Arsi Negele (AN)	1,077 (1,150)**	1,960
Bako (BK)	796 (1,217)	1,650
Dedessa (DS)	1,401 (1,340)	1,450
Jimma (JM)	1,604 (1,533)	1,750
Kobo (KB)	413 (650)	1,500
Mieso (MI)	- (700)***	1,470
Melkassa (MK)	790 (808)	1,550
Melka-Werer (MW)	584 (647)	750

*The rainfall figures in brackets are long-term averages.
**Information is from the nearest town.
***The figure is only approximate.

In addition, several other supporting stations and farms run by the State, development agencies, Ministry of Agriculture, Relief and Rehabilitation Commission, peasant associations and other relevant organizations, have been used for field testing.

Annex 2

Contributing personnel, Sorghum Research, 1983/84:

Name	Station	Discipline
Biru Abebe (Dr)	Nazreth	Agronomy/Breeding
Kidane Giorgis	Kobo	Agronomy
Benti Tolessa (Dr)	Bako	Agronomy/Breeding
Gebreegziabher Amde	Jimma	Agronomy
Kebede Mulatu	Bako	Agronomy
D.C. Adjei-Twum (Dr)	Nazreth	Agronomy/Physiology
Asgelil Dibabe	Bako	Soil Fertility
Tamirie Hawando (Dr)	Alemaya (AAU)*	Soil Fertility
Assefa G. Amlak	Awassa (AAU)	Entomology
Abraham Tadesse	Bako	Entomology
Mengistu Huluka (Dr)	Alemaya (AAU)	Pathology
Teodros Mesfin	Alemaya (AAU)	Pathology
Mesfin Tessera	Bako	Pathology
Awgichew Kidane	Holetta	Pathology
Rezene Fessahaie	Holetta	Weed Control
Etagegnehu G. Mariam	Nazreth	Weed Control
Aberra Deressa	Nazreth	Agronomy
Yilma Kebede (Dr)	Nazreth	Breeding
Abebe Menkir	Nazreth	Breeding
Gossa Assefa	Nazreth	Technical Asst.
Nigusse Alemu	Nazreth	Technical Asst.
Tessema Woldu	Nazreth	Technical Asst.
Million Teshome	Mieso	Technical Asst.
Wondimu Abebe	Alemaya	Technical Asst.
Worku Konchie	Arsi Negele	Technical Asst.

* AAU = Addis Ababa University

REVIEW OF SORGHUM AND MILLET RESEARCH CONDUCTED IN WESTERN KENYA DURING 1983

N.W. Ochanda*

INTRODUCTION

The Western Kenya component of the Sorghum and Millet Improvement Program is centred at two locations - Kakamega and Alupe. These areas are within the Lake Basin Zone which is traditionally the most important sorghum and finger millet growing area in Kenya.

Research activities on the two crops during the 1983 season covered experimental work on breeding and agronomy both in and off the main stations. Sorghum staff were also involved in the National Extension Program activities which provide a regular forum for research and extension personnel to interact and exchange views on the problems farmers face in the field and which may help form the basis for research in breeding and agronomy.

The growing conditions in Western Kenya were generally favourable. A short dry spell in Kakamega from January to March was followed by heavy rains throughout the rest of the season. At Alupe, conditions were equally wet between April and November except for a short dry spell in July.

The total rainfall recorded at Western Agricultural Research Station (Kakamega) was 2,033.9mm, which was about 8.3 per cent above normal. At Alupe Agricultural Research Station, the total rainfall recorded was 1,720.2mm.

The major research activities carried out at each of the two stations can be summarized as follows:

<u>Kakamega</u>

(i) Regional Finger Millet Variety Trial;
(ii) Finger millet agronomy;

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*Alupe Agricultural Research Station, P.O. Box 278, Busia, Kenya

(iii) Eastern Africa Co-operative Sorghum Regional Trial (SR);
(iv) Bulking finger millet elite varieties.

Alupe

(i) *Striga* preliminary screening;
(ii) Sorghum agronomy trials on weed management and plant population;
(iii) Research outreach activities.

REVIEW OF RESEARCH ACTIVITIES

Some of the research activities carried out at the two centres are described in the following pages. A review of the Eastern Africa Co-operative Sorghum Regional Trial at Lanet (high altitude) is also included, together with on-going sorghum agronomy and breeding programs at Alupe.

Lake Basin Medium Altitude (Kakamega)

The following are the finger millet trials conducted in W.A.R.S. Kakamega (Kenya) during the year 1983. Some of the results are included. All trials were in RCBD with four replications. One sorghum trial is also included.

Regional Finger Millet Variety Trial

Some early and mid-maturing varieties earlier selected from a world collection nursery and a Kenyan collection nursery, laid down in W.A.R.S. Kakamega during the 1981 and 1982 seasons respectively, were evaluated over six sites. The yield data for five sites are given in Table 1.

The combined data analysis of varieties showed that significant interaction between the sites and the varieties existed. Most of the varieties yielded more than the local

Table 1. Early duration finger millet variety trial yield (kg/ha)

Variety	Site				
	Kakamega	Kericho	Busia	Kilifi	S. Nyanza
EK-KR-227	2145(8)	1355(6)	2145(1)	1056(7)	2597(2)
FAOH.49534-027	2592(1)	1271(8)	1679(10)	1178(6)	1649(7)
E-KR-228	2188(5)	1091(10)	1846(6)	990(8)	1094(11)
Ekalakala-1	1873(11)	1001(11)	966(12)	775(11)	2531(3)
E-KR-215	2214(4)	996(12)	1941(3)	563(12)	1098(10)
IE-934	2346(3)	1660(1)	2005(2)	920(9)	2282(4)
IE-1023	2137(7)	1409(4)	1917(4)	1326(4)	1017(12)
IE-933	2154(6)	1371(5)	1600(11)	1500(1)	3105(1)
IE-1010	2503(2)	1134(9)	1821(7)	1451(3)	1367(8)
P-283	2079(10)	1424(3)	1813(8)	1469(2)	1898(6)
IE-1022	1522(12)	1319(7)	1717(9)	685(10)	2029(5)
Local check	2142(9)	1501(2)	1847(5)	1257(5)	1228(9)
CV%	33.7	31.08	20.95	29.51	45.03
SE, kg	364	201	186	164	418

*No mean because checks are different
The numbers in brackets denote rank numbers

plant in most sites except at Kericho where the local check gave the second highest yield after IE-934. Generally, the performance at Kakamega was better than at other sites due to more favourable conditions prevailing at the site.

Agronomy research

Trials on the time of planting and transplanting, spacing/plant population, weed control and a trial on finger millet/beans intercropping were carried out. A trial on fertilizer

Table 2. Mid-duration finger millet variety trial - yield (kg/ha

Variety	Site			
	Kakamega	Kericho	Busia	Kilifi
BU-3	1376(11)	1644(7)	1292(9)	951(10)
SN-7	1718(7)	1772(5)	835(12)	1166(4)
Gulu-E	2254(2)	1311(11)	1900(2)	1188(3)
KA-1	1787(6)	1479(9)	1546(4)	1021(7)
Serere-1	2117(3)	1576(8)	2139(1)	1215(2)
KA-2	1608(8)	2624(1)	1217(8)	1062(6)
KA-4	2367(1)	1966(3)	1270(11)	537(12)
P-221	1837(5)	1355(10)	156(6)	819(11)
BU-6	1424(10)	1806(4)	179(3)	963(9)
B-1(a)	1548(9)	1689(6)	1524(5)	1104(5)
KA-5	977(12)	2444(2)	1351(7)	965(8)
Local check	1862(4)	1278(12)	1288(10)	1361(1)
CV%	40.50	30.56	30.79	40.30
SE, kg	352	267	227	207

*No mean because the checks are different.
The numbers in brackets denote the rank numbers. Different varieties showed superiority over different sites. The results of the combined data analysis show a similar trend to the early duration varieties.

response was laid down but due to heavy rains a wash-out was caused. Briefly some of the results are mentioned below.

Time of planting/transplanting Two varieties were used for the trial. These are Serere-1 and a local check (Ikhulule). Two methods of planting, i.e. direct seed sowing and transplanting (from pre-sown nursery), were followed. Planting/transplanting was done at three times as follows: onset of rains, two weeks after onset and

six weeks after onset of rains.

From the results, transplanting and/or planting at onset of rains showed superiority. Delaying transplanting for up to two weeks did not result in much loss in yield. The local check out-yielded Serere-1. Maximum mean yield was 4,644 kg/ha.

Spacing/population trial A local check (Ikhulule) and an early maturing variety (Ekalakala-1) were grown at inter-row spacing of 20, 30, 40 and 50 cm with intra-row spacing of 15 and 25 cm. This was to find out the best spacing and thus population density in plants/ha for finger millet. The trial was carried out in Kakamega only and thus the results are for Kakamega conditions.

A spacing of 40 cm x 25 cm for a population of 100,000 plants/ha gave the highest yield. This does not agree with previous years when a spacing of 50cm x 15cm (133,333 plants/ha) gave the highest yield.

The early maturing variety gave the highest mean yield of 5,735 kg/ha with the spacing of 40 x 25cm. The local check with the same spacing gave 4,305 kg/ha.

Weed Control Trial Two chemicals, Gesaprim and 2-4D amine, at the rates of 0.25 and 0.5 kg/ha, were to be compared with weed control by hand weeding (once and twice). Unweeded plots were left as controls.

Results showed that Gesaprim (0.5 kg/ha) and hand weeding twice are effective ways of controlling weeds. No significant difference was noted between these two practices (1,264 and 1,211 kg/ha respectively).

Fertilizer response trial This was designed to determine the optimal rates of N, P and K for finger millet. The rates

tried were:

Nitrogen 0, 20 and 40 kg/ha
Phosphorus 0 and 20 kg/ha

As mentioned earlier, the heavy rains interfered with the trial and so it was written-off. However, it is being carried out this year (1984).

Eastern Africa Co-operative Sorghum Regional Trial (1983 SR)

This was a trial co-ordinated by the SAFGRAD - ICRISAT Program, Kenya. Ten high-elevation varieties from several countries in Africa, together with a local check (E525 HR), were planted in W.A.R.S. Kakamega and several characters, e.g. time to 50 per cent flowering, plant height, disease score, grain weight, yield and other parameters were recorded.

The varieties are:

1. Kadasi from Yemen AR
2. Hamra Hujariya from Yemen AR
3. Al Ganad from Yemen AR
4. SVR 157 from Burundi
5. ETS 2752 from Ethiopia
6. Alemaya 70 from Ethiopia
7. BM 10 from Rwanda
8. BM 27 from Rwanda
9. E.1291 from Kenya
10. BJ 23 x BJ 19 from Kenya

As with the finger millet trials this was in RCBD but with three replications. The results show that BM 27 gave the highest yield, followed by E-1291, SVR 157 and E 525 HR (local check) respectively. However, BJ 23 x BG 19, followed by E 525 HR, was the earliest in flowering. Alemaya 70 and BM 10 showed some tolerance to disease.

Table 3. Eastern Africa Co-operative Sorghum Regional Trials Data conducted at W.A.R.S. Kakamega - December 1983

Entry no.	Entry identification	Plants harvested	Yield (kg/ha)	Days to 50% flowering	Plant height (cm)	Disease score (0-5)	Grain colour	Bird damage %
1.	Kadasi	52	233	92	197	2	white	25
2.	Hamra Hujariya	33	243	97	293	2.7	brown	17
3.	Al Ganad	51	884	81	184	1	white	30
4.	SVR 157	88	3,531	90	219	1	brown	0
5.	ETS 2752	61	157	127	224	1	white	10
6.	Alemaya 70	62	181	122	236	0	brown	7
7.	BM 10	90	3,411	89	240	0	brick red	5
8.	BM 27	91	4,052	84	206	1	brick red	4
9.	E 1291	55	3,534	81	150	0	brown	7
10.	BJ 28 x BG 19	60	1,100	73	189	3	brick red	7
11.	E525 (local check)	82	3,501	77	135	1.7	brown	12

Bulking

Bulking of some elite varieties of finger millet (P-221, P-283, Serere-1 and Gulu-E) and one sorghum variety (E 525 HR) was done.

For weeding on the finger millet bulking field, 2-4D amine was used.

The wet lowlands (Alupe)

Alupe Agricultural Research Station has been an important centre for work on sorghum breeding and agronomy. Sorghum breeding work at Alupe stagnated with the departure of Dr Rana in 1981 but agronomical investigations and some basic bulking operations continued even after the end of the F.A.O. supported sorghum improvement work.

Striga preliminary screening test

Genetic resistance in sorghum is recognized as the most economic way to combat Striga which is an important pest of cereals in the Lake Basin area of Kenya. Some initial work in this area had identified a few sorghum lines with good resistance or tolerance to Striga. In 1983 thirteen (13) sorghum lines were included in a Preliminary Screening Trial at Alupe in 3 row plots replicated four times. The lines were:

1. IS 3925
2. 12610C
3. N-13
4. 1219B
5. 3501
6. E 954063
7. IS 9985
8. IS 76

9. NES 7360
10. 2KX 17
11. Serena
12. Seredo
13. E 525

2219B was used as a standard check and true to form showed a high Striga count in all the replicates. Other lines with a high Striga count included NES 7360 and IS 76. N-13, Serena, E 525 and 2KX 17 showed comparatively less Striga infestation.

On-going Sorghum Breeding Programs

Rejuvenation and maintenance/Striga screening

The fairly large sorghum seed stock accumulated at Alupe during the period of the F.A.O. supported Sorghum Improvement Program was not properly maintained. There was a need for a rejuvenation and maintenance program to help maintain seed viability and to produce information on maturity, reaction to pests and diseases and reaction to Striga. Towards this end we have grouped the entire Alupe seed stock and newly introduced seeds and grew them out in a Striga-sick plot, as follows:

(i) A sorghum yield trial comprising 16 entries of sorghum germplasm from several eastern African countries;

(ii) A sorghum yield trial consisting of 11 entries identified as promising lines at various ICRISAT centres in Africa;

(iii) A sorghum nursery comprising 59 entries drawn from several ICRISAT centres in Africa and Mexico;

(iv) A sorghum midge trial comprising 33 lines of midge-resistant stock from Texas Agricultural Experiment Station, Lubbock;

(v) Multiplication of our six elite sorghum varieties - MY 146, Serena, Dobbs Bora, Seredo, E 525 and 3DX57/1/11/1. All these have yielded comparatively well in previous regional yield trials;

(vi) Sorghum breeding nursery made up of F_2, F_3, and F_4 populations from the Ethiopian Sorghum Improvement Program. The number of plots in the nursery is over 1,600.

ON-GOING SORGHUM AGRONOMY PROGRAMS

As pointed out during last year's Regional Workshop, a series of experiments on plant density and weed management were on-going in 1983. The objectives of these experiments were to establish the optimum number of plants that can be left per planting hole and the number of times that a sorghum crop needs to be weeded to give maximum yields.

In this regard two plant densities were investigated, i.e. 83,000 pl/ha and 110,000 pl/ha at a fixed row-to-row spacing of 75cm and incorporating one, two, and three plants per hole. For the weed management trials the same range of number of plants/hole was tried but the plant density was fixed at 110,000 pl/ha with row-to-row spacing of 60cm and 75cm. Results from these trials are in the process of compilation.

The widespread Striga infestation and resulting crop losses have been brought forward by farmers of this region as a matter of great concern. Currently we are involved in the initial screening of sorghum and finger millet cultivars

that have shown promising tolerance to Striga parasitism, including others from our elite lines whose reaction to Striga is unknown. These cultivars are being tested at various nitrogen levels to determine their reaction to Striga relative to nitrogen. In addition, a trap crop experiment is being conducted using various dicotyledons to determine which ones could be used as trap crops (false hosts). The specific objectives of this experiment are to determine:

(a) The extent or degree of suicidal germination induced in Striga by selected hosts;
(b) The possible mechanism for this kind of resistance to Striga.

This trial has a two-factor design involving the main factor (host) and the sub-factor (nitrogen) which will be applied to the true host at the recommended standard rate. The false hosts will be planted during the long and short rains of 1984, to be followed by the true hosts during the long and short rainy seasons. Only one susceptible sorghum variety will be used for the true host.

RESEARCH OUTREACH ACTIVITIES

Last year the Kenya Government, in a bid to develop and maintain a strong and efficient agricultural sector, launched the National Extension Program -'Training and Visits System'. This aims at ensuring a proper flow of research information to farmers by establishing a strong research-extension-farmer linkage and ensuring that information passed from the research stations is imparted to farmers through intensive supervision of frontline extension staff and regular visits to farmers.

Under this system, regular forums for both research and extension personnel are organized during which all aspects of crop production are discussed. New findings are also

discussed by researchers and feedback on the actual problems farmers are facing brought back by the extension personnel. This feedback is a vital input towards the formulation of programs that are appropriate and hence are of direct benefit to farmers. We have participated actively in this program since its inception.

One of the things that has come out of these discussions is the fact that some of the recommendations in use today are too broad based and therefore inapplicable to certain environments and varying management situations. There is therefore a need to make recommendations that are specific to specific areas. It has been pointed out, for example, that whereas many farmers have adopted row planting in favour of the traditional broadcasting method for sorghum, they find it very cumbersome to thin and weed, especially between plants spaced less than 20cm apart. We have mounted a series of on-farm experiments all over Busia District (the district in which we are based) in which we are investigating the maximum number of plants that could be left in one hole and the related spacings which would facilitate easy weeding using the conventional (14cm wide) jembe, and still give a good grain yield.

These experiments are farmer managed, save for the planting time when help from research and extension staff was given. We expect that we will carry the farmers along with what is being investigated and that this will offer them an opportunity to participate in evaluating the treatment that suits them most in their own farming conditions.

FUTURE PROGRAMS

Even though previous work on sorghum has led to several improved varieties which have yielded comparatively well relative to the traditional cultivars grown in western Kenya, there is a need to continue with a screening and testing program for varieties from within and outside Kenya. This will enable us

to broaden our genetic base in the light of some of the persistent problems limiting production in the area, including the menace of shootfly, sorghum midge, moulds and Striga. The pedigree populations from Ethiopia grown at Alupe this season will enrich our genetic base greatly.

SUMMARY

The sorghum and finger millet improvement programs in Western Kenya involve work on agronomy, breeding and research outreach activities. The weather conditions in 1983 were generally favourable thus allowing for both long rains and short rains crops.

Research activities were centred on finger millet varietal trials, agronomic investigations on time of planting, spacing, fertilizer response and weed control reaction to Striga tests and agronomic investigations on sorghum. Research personnel at Alupe were also involved in outreach programs in the form of monthly workshops with extension personnel which provide a regular forum for discussions on different aspects of the culture and use of sorghum.

Combating the menace of Striga is an important priority of the sorghum improvement program in western Kenya. Along with varietal screening we are also interested in finding out how nitrogen mediates tolerance to Striga. Other problems limiting sorghum production in the Lake basin area, including midge and shootfly attack, will be tackled by expanding the genetic base of our germplasm - thus the emphasis being placed on co-operative involvement with other countries and agencies involved in sorghum research.

LIST OF SORGHUM AND MILLET WORKERS WHO HAVE TAKEN PART IN THE WORK REPORTED

Lanet-Based Highland Program

Geoffrey Njehia - Certificate of Agriculture
- ICRISAT Trained on Crop Improvement

Alupe-Based Wet Lowlands Program

N.W. Ochanda - B.Sc.
- M.Sc. in Plant Breeding

G.O. Abayo - B.Sc.

E.S. Njeru - Diploma in Agriculture
- Sorghum Agronomy

Kakamega-Based Medium-Altitude Program

J.K. Rutto - Agronomy
- B.Sc. in Agriculture
- M.Sc. in Agronomy

C. Mburu - B.Sc.
- ICRISAT Trained on Crop Improvement

THE SORGHUM AND MILLET PROGRAM IN EASTERN KENYA

L.R. M'Ragwa and B. Kanyenji*

INTRODUCTION

Research at the National Dryland Farming Research Station at Katumani has furnished the necessary technology to enhance productivity of sorghum and millet in arid and semi-arid Kenya. However, very little has been achieved in 1983 because the area received very low rainfall (Table 1), but the little achieved is briefly reported below.

SORGHUM IMPROVEMENT

Research which was initiated in 1978 at Katumani developed four experimental varieties (2K x 17, 76T No 23, NES 7360, IS 8595) which are pre-released for production in Machakos and Kitui Districts. These varieties have the desired food and processing qualities but work on their adaptation is still on-going. The major activitity in 1983 was planning a sound varietal improvement program whose implementation has been delayed due to persistent drought.

Sorghum yield and the SAFGRAD regional trial

In 1983, LR materials flowering in under 65 days at Kampi-ya-Mawe (altitude 1,125 m) and 72 days at Katumani (1,575 m) were planted in sorghum adaptation trials. Each trial consisted of 20 entries in three replications. However, the low rainfall, with very poor distribution during this year, caused very poor germination and crop growth in all the trials. The trials were replanted in the 1983 short rains and they also failed due to drought. It was planned to replant but the 1984 long rains are also poor and poor results are anticipated.

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*National Dryland Farming Research Station, Katumani, P.O. Box 340, Machakos, Kenya

Table 1. 1983 Rainfall (mm) and pan-evaporation rate (mm) data

	Season											
Month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Rainfall	12.9	120.3	4.4	115.8	7.2	10.3	4.2	7.4	1.2	4.0	43.2	158.6
No. of days	3	6	1	9	3	2	1	2	1	1	5	14
Pan-evaporation mm	161.9	144.3	186.7	153.5	119.2	101.8	106.5	135.9	147.2	185.9	180.2	147.8

Most of the lines failed to germinate but over a thousand lines germinated and were visually evaluated. Visual selection for desired plant types was done and the selected lines were advanced into three trials. The lines were assigned into three groups on the basis of desired plant types (plant height, head types, seed setting and size abilities, etc.)

Group 1: 13 lines with a performance score of 1.5 were rated as the most desired plant types.

Group 2: 42 lines with a performance score of 2 were rated as the second best group.

Group 3: 108 lines with a performance score of 3 were rated as the third best group and the lines would be evaluated further so as to select good plant types.

Each group was advanced into a yield trial in three replications and were also planted under irrigation as advanced nurseries so as to monitor the yield potential of each selected line.

MILLET IMPROVEMENT

Pearl millet

The breeding objective is to select for high yield, seedling vigour, reduced height of local collections and the incorporation of rust and smut resistance in adapted selections.

Development of pearl millet composite

A bulk (B_O) of 12 lines which were selected from the height reduction project was constituted in 1983. This was grown under irrigation as a random mating population. The desired plant types were mass selected, harvested and threshed to constitute bulk, B_1. B_1 will be grown in an off-season nursery. This procedure of mass selection will continue until each individual line looses its charac-

teristics. When the new random mating population appears uniform, the derived material will be used to make a composite C_o. This will be improved using the S_2 scheme of the recurrent selection method.

Intra-population improvement in SC2 composite

Comparisons of the original SC2 (C_o) and improved SC2 (Cl) indicate that there was 34.6% gain in grain yield from 16 q/ha to 25 q/ha (Table 2). Calculations suggested that response to selection on grain yield in SC2 could be expected to be maintained in future cycles of recurrent selection as the material appears to have retained a high level of genetic variability.

Table 2. Comparison of original SC2 (C_o) and improved SC2 (Cl)

	Grain yield (q/ha)	Percent change	Days to 50% bloom	Percent change	Plant height (cm)	Percent change
C_1	16		53.3		199	
C_2	25	34.6	52	-2.4	203	2.0

Extraction of drought-tolerant plants from SC2 variety

The plants which survived drought and reached maturity from SC2 (families) planted in 1983 short rains were harvested and the material is being multiplied to provide enough seed for testing its drought tolerance.

Systematic descriptions and relationships between lines and between traits and some consequences for pearl millet breeding

Two hundred and fifty two pearl millet accessions grown in unreplicated plots were described and their worth as future sources of valuable genes was determined. The material was also classified into three groups according to plant height: group 1, less than 100 cm tall; group 2, between 101 cm and 160 cm tall; and group 3, above 161 cm tall. The magnitude of variation within the groups was estimated and the comparisons of the group means for various traits was done. The estimation indicated that there was high variability within all groups for plant height, days to 50% bloom, spike length, bristle length, productive tillers and 1,000 grain weight, which ranged between 5 g and 20 g with a trait mean value of 8 g. All the accessions selected and advanced into a yield trial had above average 1,000 grain weight (8 g), long spike (17 cm), days to 50% bloom ranging between 49 and 60 and productive tillers per plant were between 3 and 6. Correlation coefficients between traits with 1,000 grain weight were low ($<$ 0.5). However, there was good positive correlation ($>$0.5) between productive tillers per plant, and spike length with 1,000 grain weight. This correlation suggested that selecting plants with 3 to 6 productive tillers per plant and a spike which is more than 17 cm long could be effective in selecting materials with a high 1,000 grain weight subject to further investigation.

Regional Millet SAFGRAD Trial

This was not planted because the season had low rainfall but it will be planted in 1984 SR (October).

Trials which will may in 1984 LR will be repeated in 1984 SR, because poor results are anticipated due to low rainfall.

PROPOSED NURSERIES FOR NEXT SEASON

Sorghum

1. Evaluation and maintenance;
2. National Variety Performance trial;
3. Sorghum adaptation variety trials;
4. Three other preliminary trials;
5. Sorghum production project;
6. Multiplication of elite lines (2K x 17, 76T No 23, NES 7360, IS 8595);
7. SAFGRAD trial.

Millets

1. Multiplication of elite lines
   - Finger millet - EK-1
   - Proso millet - N-40101
   - Pearl millet - SC-2;
2. Evaluation nursery;
3. Preliminary yield trial;
4. SAFGRAD trial.

SORGHUM AND MILLET RESEARCH IN RWANDA IN 1983

Célestin Sehene*

INTRODUCTION

The 1983 program has been established as planned. In each of our three stations we planted the existing collection and a trial on population density and frequency of weeding and ridging. In Karama and Rubona one varietal yield trial was conducted.

In general, the season has not been very good especially in Rwerere where we had a severe drought in the months of December 1982 and January 1983. In Karama the drought arrived late in the season.

All the varieties collected throughout the country in July 1982 were sowed in Rubona. We had some hundred types identified as belonging to durra or durra-caudatum. After these first observations we selected some varieties to use in our crossing program. Those collected from the highlands have been planted in Rwerere in 1984 while all the types collected from below 1,500m altitude have been taken to Karama.

During 1983 we did not obtain any exotic material for Karama (dryland area). The only increases in the collection came from Mutara (N.E. of the country) but they have not been of particular interest. Some of them are very late and in such a zone we obtained a very low average yield (1,135 kg/ha).

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*Sorghum Improvement Program Leader in ISAR, Rwerere, BP 73, Ruhengeri, Republique Rwandaise.

COLLECTION

Rubona

In order to maintain and evaluate the existing material all the types have been sowed in three height groups (tall, medium and short). We did not get very good expression of our collection because of unfavourable climatic conditions, but some varieties produced at least 5 tonnes/ha, as indicated in Table 1.

According to the data, there are only three local varieties in the list with the check Kebo (SVR 157) not indicated but having an average yield over 5 tonnes. So the exotic material will always be of great interest in our program especially for pedigree breeding. The problem is that all those introductions have the same origin, i.e. ALAD Program (Lebanon). We will try to diversify the sources, mainly for the highland area where we have not yet got any useful exotic variety. In general only tall types give good yields.

Karama

We sowed the collection on 20 January 1983. In the beginning rain was scarce and growth delayed. At dough stage it was dry and we got much lodging and poor production. Only some varieties reached 4 tonnes/ha as follows:

SVR 1 = 5,026 kg/ha
1002 = 5,000 kg/ha
SVR 10 = 4,542 kg/ha
SVR 25/2 = 4,385 kg/ha
17851 L = 4,391 kg/ha
1804 = 4,052 kg/ha
SRV 157 = 4,026 kg/ha

Table 1. Some results of selected Rwandaise collections at Rubona in 1983

Variety	Yield kg/ha	% of expected check	Days to 50% flowering	Plant height (cm)
Ndamoga	5,039	87	103	264
1693-3 L	5,041	74	103	261
1790 L	5,000	72	101	277
1687	5,625	79	101	255
2037/78	5,164	62	103	301
1034	7,113	117	107	331
SVR 82	6,557	107	107	333
2026	6,496	101	107	324
1011	8,129	121	107	327
SVR 72/1	7,143	93	96	283
1761-3	6,198	95	85	218
1776	6,000	76	124	223
1785-1	7,172	104	86	246
H Jack/K60Ax5B	5,000	77	85	277
1804	6,889	107	91	271
1761-4	6,097	89	101	278
18-1	6,945	97	94	273
1686/78	7,172	92	93	256
1503-3n	6,000	78	123	177
1686	5,021	73	94	286
2043	5,252	84	82	148
ETS 0060-1	5,253	85	103	135
ETS 2045	6,198	110	88	152
ETS 1041	5,252	103	84	144
ETS 2036	5,164	97	84	121

In general, the exotic varieties have been more susceptible to diseases than locals. In the future, more Ethiopian material should be of great interest for Rwanda:

81 ESIP 3 = 3,151 kg/ha
81 ESIP 8 = 3,859 kg/ha
81 ESIP 52 = 3,297 kg/ha
81 ESIP 61 = 3,198 kg/ha
81 ESIP 95 = 3,687 kg/ha
81 ESIP 105 = 3,208 kg/ha
81 ESIP 121 = 3,245 kg/ha

Rwerere

The collection was planted at the end of December 1982. We did not get rain until February 1983. Plant establishment was very poor and some varieties died after germination. We tried to replant but as it was late the yield was very low and it was difficult to get seed for the next year for some varieties. Areas planted initially with sorghum have been recovered and planted with peas in March 1983.

The multiplications of the best varieties we had planted on farmers' fields did not give meaningful results and they are to be repeated this season (1984).

YIELD TRIALS

Only one advanced varietal yield trial was conducted at Karama and Rubona.

In Karama there were two places: one was on a plateau near Kilimbi Lake and a second under supplemental irrigation

where water was provided when necessary. The results are given in Table 2.

Table 2. Results of a sorghum variety yield trial in Karama, 1983

Variety	Rainfed		Irrigation	
	Yield kg/ha	Rank	Yield kg/ha	Rank
Tura	5,436	1	3,448	5
No. Gitendeli I	5,234	2	4,104	4
Ngirumpatse	5,149	3	4,717	1
Urumimbi	5,138	4	4,417	2
SVR 141	4,742	5	2,917	9
SVR 1	4,449	6	4,260	3
SVR 66	4,503	7	3,156	8
SVR 69	4,373	8	2,854	10
SVR 142	4,093	9	2,687	11
Badege	3,827	10	3,271	6
SVR 39	3,479	11	3,177	7

There were significant differences at the .01 level for treatments and blocks. The CV for the rainfed and irrigated trial was 8.5 and 21 per cent respectively.

The same varieties were sowed in Rubona during the same season. The results are given in Table 3.

Table 3. Some results of a sorghum varietal yield trial in Rubona, 1983

Variety	Yield (kg/ha)	% of expected check	Days to 50% flowering	Plant height (cm)
Tura	3,461	123	100	269
SVR 142	3,044	108	97	285
Ngirumpatse	3,940	105	108	290
SVR 1	2,809	100	100	317
Urumimbi	2,767	98	108	270
SVR 141	2,763	98	108	317
SVR 66	2,752	98	97	308
Badege	2,128	76	109	300
SVR 69	2,106	75	97	302
SVR 39	2,000	76	96	262

Yield data analysis showed significant differences between treatments and blocks at the 1 per cent level of probability. The CV for the trial was 16.3 per cent. The results should have been better but the population density was too high (around 300,000 plants/ha) and caused much lodging. Tura and Ngirumpatse varieties showed good performance as in Karama.

AGRONOMIC TRIALS

One trial on population density combined with the frequency of

weeding and ridging was repeated for the second time in the three stations. Densities ranged from 83,300 to 250,000 plants/ha (5, 9, 11 and 15 plants/m length within the row and 60cm between rows). Weeding was done after 1 month, 2 months, 1 and 2 months, and the last one after flowering, as necessary. Ridging was done 2 and 3 months after sowing.

The varieties used were: SVR 157 and SVR 1 in Karama, SVR 157 and Ikinyaruka in Rubona; BM 10 and BM 27 in Rwerere.

Karama

SVR 157 has been susceptible to drought which occurred at dough stage and also caused much lodging.

SVR 1 gave the highest yield at around 180,000 plants/ha. There was great variation in yield of SVR 157 such that it is difficult to identify which density is better (Table 4).

Rubona

As indicated before, we used SVR 157 and Ikinyaruka. We obtained about the same results for both varieties although they differed with time of weeding and ridging. The two varieties were similar at lower plant populations. At high population densities weeding after 1 and 2 months plus ridging at 3 months gave better results for both. Weeding after flowering was not done (Table 4).

Rwerere

The drought killed the plants from the first sowing done in December and when we tried to replant at the end of January it was too late for this location. The yield was low and it has been impossible to reach the desired density.

Table 4. Grain yield of a trial on population density X frequency of weeding and ridging at Karama and Rubona

Weeding after (months)	Ridging after (months)	Density (plants/ ha)	Karama		Rubona	
			SVR 157 (kg/ha)	SVR 1 (kg/ha)	Ikinyaruka (kg/ha)	SVR 157 (kg/ha)
1	2	83,300	4,198	3,464	2,176	3,318
1	3	83,300	4,273	4,578	2,817	2,971
2	2	83,300	4,620	3,234	1,121	2,254
2	3	83,300	3,940	3,508	2,035	3,320
1 and 2	3	83,300	3,122	4,170	2,753	2,950
1, 2 and AF	3	83,300	3,352	4,557	2,924	3,743
1	2	150,000	4,415	4,932	3,750	3,672
1	3	150,000	3,646	4,545	3,486	2,608
2	2	150,000	4,670	4,732	2,742	3,133
2	3	150,000	4,206	4,516	2,318	2,901
1 and 2	3	150,000	3,720	5,200	4,166	3,779
1, 2 and AF	3	150,000	3,383	3,802	4,524	2,976
1	2	183,300	3,904	4,940	4,035	2,899
1	3	183,300	3,958	4,492	4,385	4,926
2	2	183,300	4,236	4,800	3,318	2,869
2	3	183,300	3,805	5,165	3,125	2,232
1 and 2	3	183,300	4,062	4,247	3,757	4,532
1, 2 and AF	3	183,300	3,085	3,800	3,478	4,557
1	2	250,000	3,523	4,618	4,189	3,819
1	3	250,000	3,784	4,295	5,254	3,174
2	2	250,000	3,524	4,299	3,490	2,365
2	3	250,000	4,081	4,476	2,500	4,108
1 and 2	3	250,000	4,315	4,219	5,212	3,576
1, 2 and AF	3	250,000	4,899	4,505	3,982	3,968

Key: AF = after flowering

PEDIGREE BREEDING

This season a pedigree breeding program has been initiated at Karama. We sowed all the selected parents from our three stations (Rwerere, Rubona and Karama). We crossed in April 1983. The sowing dates have been staggered to try to synchoronize flowering time. We had 27 parents from Rubona, 15 from Karama and 17 from Rwerere. The crosses were planned for different characters in order to get a better combination of desirable traits. Out of 238 planned crosses we successfully completed 207. We had planned to sow F_1 seeds in July under irrigation to try to get two crops per year. However, we did not plant before September, so we sowed the F_2 seed only for Karama zone. Those for Rubona and Rwerere will wait for 1985.

Seed multiplication

The following varieties have been multiplied:

Rwerere	: BM 1, BM 10 and BM 27
Rubona	: WS 1297, SVR 157 and Ikinyaruka
Karama	: SVR 1 and SVR 157
Kinigi	: BM 1, BM 3 and N 10

MILLET

We sowed a collection of 93 varieties of different origins. Yields were very low due to drought.

ACKNOWLEDGEMENTS

I should like to thank everybody involved in the execution of this program, particularly IDRC and SAFGRAD, for financial assistance in organizing the last regional workshop held in Rwanda in June 1983 and printing the proceedings of that workshop.

THE SOMALI SORGHUM IMPROVEMENT PROJECT

E.K. Alahaydoian and Ali Nur Duale*

INTRODUCTION

The Sorghum Improvement Project, financed by IDRC Canada, is in its second phase. The objective is to develop a variety or varieties which could replace the local variety and produce higher yields to insure food security in the country. Although the project covers the whole of Somalia, most of the work is done for rainfed areas. Maize is predominant in the regions where irrigation is possible, but there are farmers who prefer sorghum. The dryland areas are divided into two distinct ecological zones. The low altitude region, with Bay region as its centre, is around 300m in altitude. The north-west region is around 1,500m in altitude. The local lowland varieties are 100-110 day varieties with rather small heads - very compact durra - and coloured seed. The plant is 150-175 cm in height. The varieties in the north-west are 6-month varieties with plants nearly as tall, but with larger heads and are also compact durra.

There are two rainy seasons. The Gu (April-September) is wetter than the Deyr (October-March). A 20-year average for the Gu season is 325-350 mm of rain and for the Deyr 200-225 mm. There seems to be a cycle of 6-7 years with 3-4 years of wet Gu seasons and 3-4 years of drier Gu seasons. The probability of rain failure for the Gu season is 45 per cent and for the Deyr season 65 per cent. The Gu season is the main planting and growing season. The Deyr is used for ratooning. The years 1980, 1981 and 1982 were wet ones. The

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* Agricultural Research Institute, Ministry of Agriculture, Mogadishu, Somalia.

precipitation for Gu in 1981 and 1982 totalled 700 and 650 mm respectively, and the totals for 1981 and 1982 were 950 and 1,100 mm respectively, but the 1983 Gu was an average one with 537 mm of rain, whereas the Deyr precipitation was only 87 mm. The total for 1983 was only 480 mm. We think that we are within the dry period of the cycle.

CROP IMPROVEMENT

The work carried out within the program is divided into agronomy, entomology, pathology and breeding.

Agronomy

The agronomy work includes yield trials as well as cultural practices and intercropping.

Yield trials

A good number of varieties were collected from Uganda, Kenya, Sudan and Egypt, in addition to those received from ICRISAT.

We grouped this material into 10 nurseries, including an adaptation trial. Some of these varieties are good yielders compared to the local ones. The local farmer gets around 300 kg/ha. The sorghum is broadcasted and not fertilized.

The entries CSH-6 (India), 72B18 red (Kenya), P954063 (USA), 2KX 17/8/1/2, Serena, 4MX 11/9/1/1/ (Uganda), IS 22790, IS 2872 (Egypt), 32-1, IS 8272 (Upper Volta), M 60263 (ICRISAT) and 3KX73/4 (Uganda/SAFGRAD) have produced

yields up to 300 per cent more than the local ones. We are confident that these same lines would perform even better if they were fertilized. We shall repeat these lines to check on the stability of the yield. One big problem that we have at the research station is the great variability in soils. The station has been used since 1953 (known history) and no attention has been paid to the maintenance of the fertility of the soil. Thus in all our experiments the coefficient of variability is unacceptably high. Measures have already been devised and are in the process of application to remedy this problem. If we are satisfied with performance upon repetition of these lines, we shall increase the seed and start larger-scale field testing, and at the same time cross with local varieties to improve the local stock.

The local germplasm, collected by IBPGR/ICRISAT, was divided into four nurseries to make the size of the experiment more manageable. It was sown in 1981 but in one replication. We tried to sow it in 1983, but could not do so because of the rains. The system of using two seasons is causing a heavy strain on the team, especially since the team is very small and the operations are manual. It was repeated in the 1984 Gu.

Cultural practices

The plant population At the station the spacing used is 75 cm x 50 cm with two plants per hill. This gives a plant population of 53,300 plants/ha. The plant population in farmers' fields is estimated to be between 20,000 and 30,000 plants/ha with several plants per hill. Our experiment concerning different populations during the 1983 Gu failed because we had to resow due to low germination and there was not sufficient rain after resowing. We think

that increasing the plant population and re-arranging the pattern would result in higher yields.

Date of sowing The farmer sows after the ground is softened by some rain. At times the first rains amount to 150 mm. We are initiating experiments to test the optimal time for the farmer to sow.

Fertilizer trials One nitrogen fertilizer trial was conducted by Mr Farrah, where nitrogen was applied at 0, 23, and 46 kg/ha. The varieties used were the local one and Dabar. He could not find any significant difference in yields. We think that nitrogen is not the only limiting factor. Another trial with nitrogen and phosphorus was set up during last *Deyr* season, but the paucity of the rains caused the experiment to fail.

Entomology

Sorghum has many pests in Somalia. The most important ones are stem borer (*Chilo* spp. and others), shoot fly (*Atherigona soccata*), midge (*Contarinia sorghicola*) in the humid areas, and different species of aphids and spider mites. The damage caused by army worms two weeks after germination and bollworms (*Heliothis armigera*) can be serious. Among birds the most important pest is *Quelea quelea*. The damage it causes varies with the seasons and with the rains. In 1983 the damage was very serious.

We requested and received lines resistant to stem borer, shoot fly and midge. In addition in 1982 we received from Texas A & M a set of 39 lines under the name of International Disease and Insect Nursery. In 1983 we screened all four nurseries for stem borer and shoot fly resistance under natural conditions. The lines from Texas were already screened once in 1982 and the number was reduced to 11.

The method followed for evaluation of stem-borer resistance is that used by ICRISAT. A few lines seem to be promising, but we need to repeat the trials in order to be able to proceed with some certainty. Some of these lines are not very desirable agronomically therefore we foresee a crossing block for entomology in the near future.

Shoot fly is the second most important pest. The seriousness of its attack varies from season to season, and like stem borer, is more important in the Gu season. The method used was computation of the percentage of plants dead at 14 and 28 days of age. The entries IS 4755, PB 8281, CSH-1, IS 4663, IS 5470, IS 18378, IS 18551 and PB 21217 seem to be promising. Unfortunately, the coefficients of variability are very high being between 112 and 192 per cent.

Seed supply did not permit us to establish a nursery in the irrigated area at CARS, Afgoi, to test the resistance to midge. This was done this season.

In order to give a healthy start to the plants we tried to treat the seed with Basudin-10. Only the granular form was available. The experiment failed due to very bad germination. We are not sure if the chemical is linked in any way with this problem. We intend to repeat the experiment with Basudin in powder form and hope to give the plants protection from shoot fly.

The fight against Quelea is being conducted by FAO. During 1983 the damage caused was evaluated at between 25 per cent and 100 per cent. The farmers around the station lost their entire crop to drought and Quelea. It is known that the birds dislike coloured seed. Our farmers' crops included plants with seeds ranging from white to brown, yet everything was eaten. If the rains are average and the whole region is

irrigated, then *Quelea* damage will be low and the coloured seeds will be spared. The settlement project tried to introduce the hybrid NK 006 - supposedly bird resistant - but they abandoned it. Certain varieties were noticed to be less desirable to the birds. At this stage we are doing very little to control damage by *Quelea*.

Pathology

Among the different diseases attacking the sorghum plant, covered smut is the most important. Mr Hirabe, pathologist at CARS, Afgoi, is trying to select resistant varieties. As soon as sources of resistance are identified we shall transfer the resistance to other lines as well. Mr Hirabe has concluded his experiments on seed treatments. At the beginning of the *Gu* 1984 season a campaign to treat the seed with Fernasan D was mounted by the Ministry of Agriculture in co-operation with FAO.

Plant breeding

In 1982 we started our breeding program by crossing 75 lines received from ICRISAT with two local varieties. Those crosses are in the F2 stage.

In 1982 we crossed 15 local lines, in two groups in diallel, to try to generate variability without altering the genetic background very much. The hybrids from these crosses will be selected, hopefully during the 1985 *Gu*. During 1984 we shall back-cross the 1982 hybrids as well as initiate new crosses between local lines and varieties found promising in the yield trials.

We are also initiating a crossing block to produce hybrids for the irrigated areas using cytoplasmic sterility. Certain hybrids that we received from ICRISAT gave encouraging results under dryland conditions. We shall try these hybrids to explore the possibility of using hybrids in the irrigated regions.

On the basis of the 1981 trials of the local germplasm, we have chosen the top six yielders and are trying to improve them by mass selection. We have received advanced breeding lines which we are currently evaluating.

THE SAFGRAD TRIALS

In the 1983 Eastern Africa Co-operative Program we have received seeds for two trials: one for low altitude and the other for medium altitude.

We have sown the low-altitude trial, comprising 10 varieties, at Bonka seed multiplication farm. The experiment was laid in a randomized complete block design replicated six times with a plot size of 5m x 3m at a spacing of 75cm x 50cm with two plants/hill. Due to problems with germination we are repeating the performance of six varieties only (see Table 1).

Table 1. Yield of six varieties from the SAFGRAD nursery at Bonka in Gu 1983

Identification	Yield (kg/ha)
3KX 73/4	615
3KZ 76/5	568
Gharib red	438
3KX 72/1	408
Local	275
Makueni	163

C.V. = 99.4%

The variety 3KX 73/4 seems to be promising. Moreover, the varieties Gharib white and Gharib red are desirable for their bold seed.

The medium altitude nursery was sent to the north-west region to be tested at the Abu-Rein station. The results are not in yet.

FUTURE PLANS

During 1984 our plan of work includes the following:

- Different trials;
- Local germplasm: yield and other observations;
- Cultural practices: population, intercropping;
- Entomology: ISSBN-82, ISSBN-83, ISSFN-82, ISSFN-83 ISMN-82 at Bonka and Afgoi.
- Survey of local germplasm for stem borer resistance;
- Breeding as previously mentioned.

THE SORGHUM IMPROVEMENT PROGRAM IN THE SUDAN

Abd Ellatif M. Nour*

INTRODUCTION

Sorghum bicolor is one of the most important grain crops in the Sudan, making up more than 90% of the Sudanese diet. It ranks first both in total area cultivated and total tonnage of grains produced. The total area suitable for cropping is estimated to be about 120 million acres, out of which 32.5 million acres are under actual cultivation. Currently, the area under sorghum is over 3 million hectares, and over 2.5 million metric tons of sorghum grains are produced.

In the Sudan, as in any semi-tropical country, the whole sorghum plant is utilized. The grain is used for making *kisra* (unleavened bread from fermented dough); a great amount is also used as porridge, as a popular soft drink (*abreih*), and as local beer (*marisa*). The stalks are used for building material, as animal feed and as fuel.

Sorghum is grown in all parts of the country where it is possible to raise a crop. It is produced from the arid region of the north to the equatorial areas of the southern region. However, the major areas of sorghum production are the central clay plains - known as the sorghum belt. This area includes the provinces of Kassala, Gezira, Blue Nile, White Nile and Southern Kordofan.

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*Plant Breeder, Gezira Research Station, Plant Breeding Section, P.O. Box 126, Wad Medani, Sudan.

SORGHUM RESEARCH

Modern agricultural research in the Sudan began in 1903 when some agricultural investigations were started by the Welcome Tropical Laboratories at Khartoum. In 1918 the first agricultural research farm was initiated at Wad Medani (now the Gezira Agricultural Research Station). This section was fully devoted to cotton research. Very little effort was put into sorghum research owing to its role in the rotation of the Gezira Schem Most of the sorghum research activities in those early days involved selection and evaluation of local and introduced sorghum germplasm.

Work on sorghum improvement in the Sudan was not started until 1952 when a full-fledged sorghum research program was initiated at Tozi Research Station and later moved to Abu Naama in 1963. This station was established as a result of difficulties and failures experienced by the Mechanized Crop Production Scheme in the Gedarif area. One of the main causes of failure was the fact that the varieties used were tall, late, and non-combinable. The second reason was that the introduced combinable varieties were not well adapted to Sudan conditions and thus gave very poor yields.

The main objectives set for sorghum improvement were high yields, uniform height and maturity, and the possibility of fully mechanized production. In the late fifties a series of selection efforts on local sorghum resulted in the identification of several varieties such as Tozi Umbenins, Fetarita Maaluk, Mugbash, Bahana, dwarf and tall Milo, Gadam el Hamam, Dabar, and Karkatib. These selections yielded more than 2.5 tons per hectare under rainfed experimental conditions without any use of fertilizer. Nevertheless, they were not accepted by local farmers and considered of low quality because they have brown testa and soft grains.

In an attempt to improve grain quality breeders resorted to hybridization. During the period 1958-1960, 12 crosses were made between good popular grain types such as Gassabi and Zerezira, and high yielding combinable types such as T.U.B.7 and Tozi Wad Akar 51/3. No good selections came out of these crosses.

The year 1968 witnessed a very extensive breeding program in which 55 crosses and reciprocal crosses were made between 13 parents, most of them from good local varieties. The F_1 was grown in 1969, but the F_2s were not planted until 1972. Selection in Sudanese stocks continued together with the hybridization work. The bulk of the breeder's work was mainly multilocation variety trials. As a result of all these investigations, two sorghum varieties, namely Dabar-1 and Gadam el Hamam - 47 were officially released to farmers.

In 1973 sorghum breeding work was transferred to Wad Medani, and since then selections continued in these crosses. After three years of selections, yield tests were started on the F_4 strains. More than 200 uniform strains were evaluated in generation trials conducted at five different locations. The results of these trials showed that 109 strains equalled or outyielded the two local controls (T.U.B.7 & Karkatib). They ranged in yield between 783 and 1,439 kg/fed while the best control ranged in yield between 781 and 1,006 kg/fed where one feddan is equal to 0.42 ha.

In 1976 the most promising strains from the previous year were entered in 9 pilot variety trials (PVT), mainly to evaluate F_5 progenies. Data from the trials showed that only 16 strains gave yields equal to or higher than the local check (Dabar). In the 1977 season the most elite selections were put in to a National Standard Variety Trial (SNSVT). Other promising lines were evaluated in four

preliminary yield trials.

During the period 1978-82 the SNSVT continued at five locations. Table 1 summarizes the average grain yield (kg/feddan) of the best 10 selections for the last four years. Sister lines Cr.35:5, Cr.35:39/26 and Cr.35:20 gave the highest yields in all seasons with the exception of 1980. Cr.35:5 has a wide range of adaptation, medium maturity, and acceptable height (140 cm). For all these reasons the strain Cr.35:5 will be submitted for release approval very soon.

INTERNATIONAL ORGANIZATIONS

Sorghum breeders in the Sudan are in close contact with their colleagues in the U.S.A., India, FAO, IDRC, INTSORMIL, and other international organizations. In 1972 the Ford Foundation's Arid Lands Agricultural Development (ALAD) Program started co-operative work with ARC at Wad Medani. This was our first experience of an international co-operative program. In this project thousands of varieties and hybrids were evaluated under Sudan conditions. Very promising lines were identified and incorporated into the National Program.

In 1977 ICRISAT started a sorghum and millet improvement project in the Sudan. ICRISAT provided two plant breeders, laboratory and office buildings, materials, equipment and funds. This program had a continuous introduction of exotic types and utilized them in crosses with the traditional and improved Sudanese types for seed quality and yield.

The ICRISAT Program accomplished excellent work by the synthesis of thousands of experimental hybrids during the 1979, 1980, and 1981 seasons. As a result of these efforts three elite experimental hybrids were identified and one of them

Table 1. Average grain yield (kg/feddan) of the best 10 selections over all locations, 1979-1983

Period	Strain	Medani	Samsam	Agadi	Tozi	Mean
1979/80	Cr.35:5	1,145	393	1,327	1,094	992
	Cr.35:30/26	1,614	631	1,219	1,265	1,182
	Cr.35:20	1,534	546	1,259	1,391	1,182
	Cr.34:6	920	255	957	1,532	916
	Cr.54:45	985	184	1,037	1,333	885
	Cr.32:1	825	161	882	1,156	849
	Cr.35:6	-	-	-	-	-
	Cr.60:4	924	355	938	1,300	879
	Cr.60:6	1,396	671	1,017	1,260	1,086
	Cr.60:9	1,124	517	1,289	1,132	1,016
	Mean	1,162	414	1,103	1,277	990
1980/81	Cr.35:5	310	216	790	1,099	604
	Cr.35:30/26	296	361	820	1,097	643
	Cr.35:20	420	234	886	1,033	671
	Cr.34:6	470	495	515	931	603
	Cr.54:45	621	566	366	954	626
	Cr.32:1	608	457	453	883	600
	Cr.35:6	456	345	560	802	608
	Cr.60:4	191	196	835	1,181	601
	Cr.60:6	265	378	909	1,133	671
	Cr.60:9	334	255	844	1,376	702
	Mean	407	351	698	1,049	626
1981/82	Cr.35:5	1,378	777	697	1,475	1,082
	Cr.35:30/26	1,323	818	960	1,529	1,160
	Cr.35:20	1,253	788	875	1,595	1,128
	Cr.34:6	1,233	955	891	1,678	1,139
	Cr.54:45	1,218	700	823	1,542	1,073
	Cr.32:1	1,218	707	1,103	1,572	1,143
	Cr.35:6	973	943	902	1,786	1,151
	Cr.60:4	1,173	952	616	1,160	978
	Cr.60:6	1,107	946	913	1,347	1,083
	Cr.60:9	1,115	905	807	1,251	1,020
	Mean	1,199	825	772	1,494	1,072
1982/83	Cr.35:5	2,123	768			1,446
	Cr.35:30/26	2,152	691	-	-	1,422
	Cr.35:20	1,950	774	-	-	1,362
	Cr.34:6	2,288	791	-	-	1,540
	Cr.54:45	2,545	569	-	-	1,557
	Cr.32:1	2,410	778	-	-	1,594
	Cr.35:6	1,850	785	-	-	1,318
	Cr.60:4	2,100	662	-	-	1,381
	Cr.60:6	2,252	800	-	-	1,526
	Cr.60:9	1,680	822	-	-	1,251

was officially released under the name of Hageen Durra-1.

Striga Research

Striga hermonthica is one of the major problems of sorghum production in many African countries. In the Sudan *S. hermonthica* is a problem wherever sorghum is grown and losses in grain yield can be very serious. In fact there can be 100% loss in some parts of the country. This problem is becoming more serious year after year, not only at the national level but also internationally. In an attempt to control this parasite, a National *Striga* Project funded by IDRC was initiated in 1978. The project is multidisciplinary with the breeding objectives of identifying the source of resistance and of transferring this resistance to good and adapted agronomic backgrounds. The program uses two types of screening methodology:

(a) Laboratory screening for low stimulant production;
(b) Field screening for *Striga*-tolerant lines by growing them in *Striga*-sick plots

The latter method was handicapped by several problems:

1. Uneven infestation of *Striga* in any particular season;
2. Lack of consistency in the reaction of the varieties from season to season or from location to location, i.e. one variety may react differently in different seasons in the same location or in different locations in the same season.
3. The germination of *Striga* seeds in the soil seems to be governed by unknown factors in addition to the stimulant. This is shown by the fact that at a given location a plot which is badly infested in one season may turn out to be free of *Striga* plants in the next season.

4) The great variations in flower colour, flower shape, petal arrangements and branching pattern in S. hermonthica, reported by Dr. M.J. Basudeva Rao in 1981, indicated that it is not a single parasite but a polymorphic complex.

In spite of all these difficulties, our screening efforts over more than four years resulted in the identification of several tolerant strains such as SRN-39, IS-9830, Tetron, N-13, Framida, Serena, and IS-7349.

Eastern Africa Sorghum Regional Trial

The 1983 Eastern Africa Regional Trials were organized by the SAFGRAD Co-ordinator and cover several African countries. The Sudan trial was planted on 13 July 1983 under supplementary irrigation and fertilization (36 kg of urea/feddan). Plot size of 4 rows x 5m x 75cm was used. Local variety used as a check was Dabar-1. All trial plans and data recording were done according to instructions provided by the Co-ordinator. Results of this trial are presented in Table 2.

SORGHUM RESEARCH

In 1979 INTSORMIL started a co-operative sorghum and millet research program which covers the following area:

(a) Breeding;
(b) Physiology;
(c) Pathology;
(d) Entomology;
(e) Training.

Table 2. Agronomic data of 16 sorghum varieties in the 1983 Eastern Africa Regional Trial, Wad Medani, Sudan

Variety	Days to 50% flowering	Plant Height (cm)	Agronomic score
Tajarib	92	197	4.7
Sepon 80-1	95	153	2.8
5DX-160	100	180	4.0
Serena	94	170	4.0
Seredo	96	170	3.3
E 525HT	94	180	4.0
2KX 17/B/1	97	188	3.0
Tegemeo	97	183	3.0
2KX 17/6	91	147	4.0
Gambella 1107	95	203	2.5
Melkamash	77	137	2.7
Badege	104	280	5.0
Urumimbi	106	-	5.0
76T1-23	77	143	2.7
IS 8595	103	163	5.0
Dabar-1	97	137	3.0
Mean excluding Dabar	94	180	3.8

SORGHUM IN EASTERN EQUATORIA OF THE SOUTHERN SUDAN

Trygve Berg*

INTRODUCTION

Eastern Equatoria is the southernmost province of the Sudan, bordering Ethiopia, Kenya, Uganda and Zaire.

In the South there are a number of mountain ridges with the Imatong/Acholi group rising to 3,167 m near the Uganda border. Further north, at an altitude of about 600 m, the landscape changes to plains which mark the southern extremity of the extensive areas of vertisols which occupy central Sudan.

The rainfall pattern is bimodal with the first rains in April and May and the second rains from July to October. Annual precipitation ranges from 3,000 mm in the mountains to 700 mm on the plains. However, the rainfall is extremely irregular and severe dry spells during the growing season are common in the drier areas.

The people of the area are divided into a number of ethnic groups culturally ranging from semi-nomadic cattle keepers to pure agriculturalists.

In the area to the east of the Nile, Norwegian Church Aid (NCA) is the main development agency, being responsible for a rural development program including both engineering (road and building), water drilling, health, education, co-operatives and agriculture.

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*Research Supervisor, Agriculture Project, Norwegian Church Aid/ Sudan Program, Torit, Eastern Equatoria, Sudan. Postal address P.O. Box 52802, Nairobi, Kenya

The agricultural activity is based on six rural development centres covering the main tribal areas. Activities are concentrated on animal power, agronomy and agroforestry. The agricultural project also has a veterinary service and workshops producing ox-power equipment as necessary back-up facilities for the animal power program.

Since 1982 there has also been a research section as a back-up for the agronomy program. Previously the agronomy research for the area had been the responsibility of the ODA/ World Bank funded Project Development Unit (PDU) which in 1981 restricted its area of operation to the land to the west of the Nile with a research base in Yei.

The agricultural project is working closely with the cooperative movement which provides the market outlet for surplus production.

SORGHUM IN EASTERN EQUATORIA

Wild sorghums, including both the subspecies arundinaceum and parasorghums, are common all over the area. Wild types are often found in stands of cultivated landraces. Introgressive hybridization probably occurs commonly.

On the clay plains sorghum is the only cereal. On lighter soils near the hills sorghum is commonly in a mixture with bulrush millet. In the hills and along the rivers, maize growing is also common, but all over the area sorghum is the main staple.

A collection of local varieties from the area was carried out in October 1983 by an expedition which was lead by Dr Melak Mengesha, leader of the Genetic Resources Unit of ICRISAT. The objectives of the trip were to explore genetic diversity, to

observe the extent of germplasm erosion and to collect samples. The trip was planned in consultation with the Sudanese program, INTSORMIL, and Norwegian Church Aid which had the pleasure of being host to the team.

A number of local varieties and wild sorghums were collected. However, the team was not able to cover more than a part of the area and most of the sorghum germplasm of the province is still unexplored. Severe germplasm erosion has not yet occurred and there is still time to carry out further studies.

Improved varieties

After the end of the civil disturbances in 1972 some people of the area returned from exile in Uganda bringing seeds of Serena with them. Later on PDU established that Serena is high yielding and reliable and it has been the recommended variety for a number of years now. Another Serere variety, Seredo, has done well in more recent trials and is a possible replacement for Serena.

The main merit of Serena is its short maturity period. The variety has contributed significantly to the filling of the hunger gap which usually occurs every year in June-July. But because of poor palatability and storeability the main production of sorghum for the rest of the year is still based on the old local varieties.

It is clearly necessary to follow up the variety testing with evaluation of the farmers' acceptance of the new varieties. In our project this will be done by on-farm observation trials with varieties which do well in on-station experiments.

REPORT ON SORGHUM AND MILLET IMPROVEMENT IN UGANDA

Vincent Makumbi Zake and John Peter E. Esele*

The first rains in 1983 provided a successful season for sorghum. Sorghum and millet seed was distributed in time to all sites, including the Eastern Africa Co-operative Regional Sorghum Trials. Besides the country trials, other trials grown included ICRISAT's International Sorghum Variety Adaptation Trials, the International Sorghum Hybrid Adaptation Trials, the International Pearl Millet Adaptation Trials and the International Disease Resistance Testing Programs.

The project had to face the problem of supplying sufficient seed to farmers in the face of the still weak Uganda Seed Project. The experience of 1982 indicated that the project could not handle the bulk production of 45 hectares required to meet national needs as the project was hit by labour shortages, especially at harvest time. Various areas were used to assist in the multiplication exercise, namely Prison Services at Serere and Soroti, the Arapai Agricultural College, Labori Farm, Church of Uganda Karamoja Seeds Scheme and Kidetok Catholic Mission.

Farmers' sorghum requirements are on the increase, especially this year which has been unpredictable as the rains started very late and, indeed, in some places like West Nile and Kitgum they have not started yet. The demand for P224 finger millet variety which has been released to restricted areas has also increased substantially.

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*Principal Research Officer-in-Charge and Plant Pathologist, respectively, U.A.F.R.O., Sorghum and Millets, Serere Research Station, P.O. Soroti, Uganda.

RESEARCH RESULTS

Sorghum breeding

The sorghum improvement program has continued to concentrate on the development of varieties and hybrids suitable for the Uganda population. The hot water emasculation technique was used to improve on yield, grain quality, agronomic excellence, and resistance to weathering, disease, pests and lodging. Emphasis has also been put on the development of drought escaping or tolerant sorghum varieties that could benefit Karamoja farmers.

Population breeding methods continue to be used to improve on sorghum grain yield and quality. These include mass selection, selfing and recombination. In 1979, a random selection of short fertile plants was done in the population: 118 selections were planted during the first rains in 1980. A number of crosses with the 4MX derivatives and world collection white and red flinty grain entries were made to produce the OZXs. During the first rains of 1983 a total of 342 OZX selections were planted. In addition, 358 OZX and 307 selections based on high yield and mid-term maturity were planted during the same period.

The 1ZXs were in their F_2 generation in the first rains of 1983. From the 1ZX F_2 generation, 184 selections were made based on yield, tillering capacity, height, compactness; 52 selections based on early maturity (50-57 days to flowering), yield and tillering; and 197 selections based on mid-term maturity (58-68 days to flowering), yield, tillering, good agronomic traits and resistance to diseases.

Development of Drought Escaping and Tolerant Varieties

Drought escaping or tolerant varieties and hybrids are very useful in areas prone to drought. Short maturity period varieties and hybrids have a high potential in such areas since they are capable of efficiently utilizing the scanty and unreliable rainfall to produce a reasonable crop. Valuable sources of early maturing and drought tolerant lines have been identified from the Turkana collections. 3KX and 7ZX derivatives developed at Serere are all early maturing and drought tolerant derivatives.

Last year 7ZXs were crossed to the 3KXs using hot water emasculation. A total of 76 crosses were made. The F_1s will be planted in the first rains of 1984. Thirty-six crosses were made between Hijack and eighteen 3KX early maturing derivatives. Ten crosses were also made between Hijack and 4MX derivatives. In addition all the above were crossed with CK 60A. Selection was based on earliness and high yield.

Sorghum germplasm

Due to poor storage facilities, a large number of sorghum accessions were lost. Existing germplasm consists of 32 entries from the U.S.A., 944 entries from ICRISAT (India) and 375 entries from Uganda, all of which are being maintained and utilized at Serere. Ethiopian accessions consisting of 1,078 entries are at Kitale National Research Station, Kenya. With the improvement of the storage facilities after the rehabilitation of the cold storage equipment, more accessions will be collected, especially from areas which were not covered intensively previously.

District Sorghum Variety Trials

Testing of experimental lines and hybrids from the breeding programs over a wide range of environments was done in order to evaluate performance and adaptability with the objective of identifying suitable varieties for release to farmers. The district variety trials for 1983 consisted of 24 varieties and hybrids. They were tested at 25 different centres covering a wide range of ecological zones. The performance of the varieties grown at six sites during the first rains of 1983 is presented in Table 1. The results indicate the consistent good performance of E 525HT and Seredo varieties and Hibred and Kafirnum x Simila hybrids. 4MX 11/10 performed comparably to Serena at most of the sites except at Serere variety trial centre and ranked fifth with 4MX 11/8.

Sorghum Screening Trials

Six screening trials were carried out during the year and consisted of the high quality grain materials, hybrids, grain-mould resistance trials and high lysine derivatives.

Sorghum Agronomy

One trial in 1983 was carried out on the effect and time of weed competition on sorghum yield. Weed competition is known to cause yield reduction greater than those caused by pests and diseases combined. It has been suggested that the first one third of a crop's life is the most critical for weed competition.

Results of this trial indicated that for good yield two weedings at two and four weeks after crop emergence are desirable. There was no significant difference between this

Table 1. Grain yields (q/ha) of sorghum variety trials grown at six sites - first rains, 1983

Entries	Serere D.V.T.	Serere V.T.C.	Tororo	Kamaido	Katakwi	Kuju	Mean	Rank
9DX 5/F5/34	20.6	12.4	27.0	10.6	15.0	7.2	15.5	20
9DX 8/F5/31	31.2	19.3	35.6	6.7	19.7	7.6	17.0	16
9DX 7/F3/11	27.6	9.4	27.1	6.0	14.2	6.0	14.9	21
9DX 5/F5/38/1	15.4	16.6	30.8	9.5	21.2	6.0	16.6	18
2KX 17/97-103	27.7	15.5	26.4	4.2	22.0	5.4	16.9	17
2KX 17/B/1	14.5	10.4	25.1	6.9	8.7	6.0	11.9	24
4MX 35/41	14.7	13.3	38.7	11.4	21.2	3.8	17.2	15
4MX 35/30	16.8	16.2	22.7	4.6	9.4	3.4	12.2	23
4MX 37/101	37.9	19.3	21.8	6.7	13.4	6.6	17.6	13
4MX 11/9/1	50.6	25.1	26.2	7.8	12.6	6.0	21.4	12
4MX 11/10	56.8	28.9	31.5	8.6	14.2	5.4	24.2	5
4MX 11/9/2	50.1	24.3	27.5	11.6	17.3	6.0	22.8	11
4MX 37/100	48.3	30.6	31.8	11.4	10.2	6.7	23.2	10
4MX 11/8	48.3	26.4	29.5	13.3	23.6	4.2	24.2	5
4MX 37/97	35.8	16.7	24.4	10.1	14.2	4.2	17.6	13
4MX 11/9/3	48.4	22.8	32.6	12.4	22.0	5.5	24.0	8
4MX 35/40	18.7	13.3	28.1	5.0	7.9	3.7	12.8	22
KXS*	55.0	21.1	32.2	14.3	21.2	6.3	25.0	4
Hibred	48.8	27.4	40.5	14.4	15.7	8.0	25.8	2
KXLD**	20.8	10.4	26.1	13.7	17.3	8.4	16.1	19
Serena	56.3	18.2	37.7	8.6	16.5	4.6	23.7	9
Seredo	54.9	21.4	35.3	14.4	20.5	7.1	25.6	3
E525 HT red	52.7	30.3	32.4	13.2	22.8	7.1	26.4	1
Simila	50.2	24.6	35.1	13.4	17.3	3.9	24.1	7
Mean	36.8	19.7	30.3	9.7	16.6	5.8		
LSD (P=0.05)	5.9	6.3	NS	9.1	12.9	NS		
CV%	15	37	-	6	16	-		

*KXS = Kafirnum x Simila

**KXLD = Kafirnum x Lulu D

weeding and weeding throughout the season, i.e. a completely weed-free condition. No weeding resulted in lower grain weight, lower plant stand counts at harvest and ultimately lowered grain yield. Weed competition, however, did not affect plant stand at thinning and the number of days to flowering. Starting weeding four weeks or later after emergence or season-long inter-row weeding gave moderately low yields.

Labour requirements for the various weeding regimes was not measured and could not therefore be used for comparative purposes. Considering the importance of this aspect a repeat of this trial will be planted in the first rains of 1984.

Finger Millet

Finger millet is an important cereal crop in Uganda. It has several considerable advantages over the other cereals. The grains store very well over long periods of time and the crop is almost free from storage seed pests. It is very rich in calcium and iron and, because of its low phenolic acid level, the calcium and iron are nutritionally available.

Since the initiation of the millet improvement program in 1965 the Unit has concentrated on the development of finger millet varieties that are high yielding, with better grain quality, white seed and resistance to the important blast disease and lodging. Breeding work so far conducted has resulted in the development of improved millet varieties for the Uganda environment. Consistently promising lines have also been identified. These consist of lines resistant to to neck and head-blast and lodging, white grain finger millet and genetic male-sterile conversions. Male sterility in finger millet has to a great degree enhanced outcrossing programs and widened the gene pool.

Finger millet population improvement

In order to establish a genetically broad based finger millet population, population breeding methods are being utilized. Four populations have been established:

Pop.1 C_1-C_6 consisting of introductions of A and B lines;
Pop.2 C_1-C_6 consisting of S_1 testing materials;
Pop.3 C_4-C_5 consisting of disease resistant materials; and
Pop.4 C_3-C_5 consisting of selections for earliness and lodging resistance.

All the populations were planted for further recycling.

In addition, another population, fertile disease resistant, Pop. C_2, was also planted for further recycling. Sibs and S_1 plants of all these populations were planted for seed maintenance.

Also 245 crosses were made between populations in their different cycles with known testers. The F_1s of these crosses will be planted in 1984.

One hundred and ten crosses, made from steriles of Pop.3 with world collection and disease resistant lines and the testers were planted in their F_1. F_2 selections were made and will be planted in the first rains of 1984.

Development of high yielding white-seeded varieties resistant to blast and lodging. The white-seeded finger millet varieties are very attractive for food. In addition, they are generally high yielding. The few white-seeded finger millet varieties introduced from Ethiopia and India are

not adapted and are extremely susceptible to blast and virus diseases. The Indian collections are shorter and hence are resistant to lodging. Crosses have been carried out since 1973. Selection has been based on white-seeded segregants resistant to lodging, blast and virus diseases and with a high capacity for tillering. Forty-three F_3s from crosses between white-seeded varieties with Indian collections, populations and selections from the world collection were planted for further selection. Twenty F_2 white-seeded back-crosses were planted together with their parents for further back-crossing. A third back-cross will be made in 1984.

Development of early maturing finger millet. Finger millet varieties with short maturity periods usually have high potential in areas of low and uncertain rainfall regimes. Attempts are therefore being made to develop finger millet varieties with short maturity periods and high tillering capacities. In 1983 361 F_3 selections from crosses between steriles and selected world collection early maturing entries were planted for further selection. Forty F_3 selections from crosses between Indian collections and testers were also planted for further selection. Selected F_4s are growing during this season.

District finger millet variety trials. Like sorghum, finger millet variety trials are of importance in assessing their performance and adaptability over a wide range of environments in order to identify appropriate and suitable varieties for recommending to farmers in the area. Thirty-six entries grown in a 6 x 6 triple lattice design were grown in 20 and 24 sites in 1982 and 1983, respectively. The performance of various entries grown at seven sites during the first rains of 1982 is shown in Table 2. Table

Table 2. Grain yield (q/ha) of finger millet variety trial grown at nine sites, first rains, 1982

Entry	UAFRO Serere	D.V.T. Serere	Ngetta	Labora	K'Maido	Masafu	Tororo	Aduku	Patongo	Mean	Rank
Eding	40.2	34.6	30.6	24.0	21.0	6.3	24.5	18.7	19.9	24.4	13
Engeny	34.1	24.0	38.6	17.4	22.5	9.8	19.9	16.4	17.9	22.3	23
Gulu E	30.3	31.8	41.4	21.5	26.3	10.4	24.7	16.7	18.4	24.6	12
Okiring	32.6	31.3	46.2	16.7	22.7	9.8	26.8	16.4	21.7	24.9	10
Serere 1	34.3	30.1	35.0	24.5	23.7	7.8	26.8	14.6	16.7	23.7	18
U 10	36.9	35.1	36.4	26.5	36.9	13.1	32.8	19.7	21.5	28.8	1
U 12	33.4	35.6	47.5	15.7	26.0	8.8	28.0	19.2	15.2	25.5	6
U 15	34.8	22.7	27.8	21.5	16.9	5.6	17.2	15.2	15.7	19.7	27
U 16	29.8	31.8	36.6	22.2	22.2	9.1	28.0	15.9	22.5	24.2	14
U 30	31.6	29.5	33.8	27.0	22.2	8.1	22.7	17.4	18.4	23.4	19
U 43	34.3	26.5	22.5	18.4	18.7	7.1	18.4	6.6	13.6	18.5	29
U 47	31.9	28.0	40.2	23.7	19.9	10.1	28.0	15.4	20.2	24.0	15
P 211	37.6	31.3	34.6	23.0	23.3	10.4	27.5	14.6	16.9	24.4	13
P 224	31.3	29.5	46.7	21.0	20.4	10.4	27.5	12.1	24.2	24.8	11
P 231	40.9	23.7	36.6	19.4	22.7	10.8	28.5	14.4	18.4	23.9	16
P 248	36.6	24.5	39.3	26.5	29.3	10.8	29.0	15.2	19.2	25.6	5
P 249	38.6	33.6	43.9	23.2	23.7	13.1	29.0	15.7	18.7	26.6	3
P 251	38.1	34.3	35.1	26.8	24.5	13.1	29.8	18.2	19.9	26.6	3
P 258	27.5	24.0	32.8	17.7	24.0	12.4	29.3	18.2	20.7	23.0	20
P 277	39.6	26.8	38.4	19.4	25.0	11.9	27.3	21.2	25.0	26.1	4
P 278	32.1	28.3	39.6	21.9	24.7	10.4	25.0	17.9	21.5	24.6	12
P 283	29.3	31.3	28.5	15.6	22.5	7.3	28.3	12.6	16.4	21.3	26
P 318	40.9	29.8	41.7	18.4	29.3	12.6	25.8	18.9	23.7	26.8	2
P 665	34.3	26.0	32.3	22.2	24.5	7.8	27.0	12.3	19.9	22.9	21
P 669	32.8	28.3	39.4	21.7	26.0	12.9	27.3	15.9	19.9	24.9	10
P 671	32.8	31.1	40.2	17.9	28.3	7.6	21.5	13.9	20.7	23.8	17
S X 3	32.0	28.3	42.4	22.2	19.7	8.6	29.8	14.6	19.9	24.2	14
S X 4	29.0	24.2	23.0	15.2	17.2	8.3	21.7	15.4	15.4	18.8	28
S X 5	31.1	28.8	32.8	21.7	19.4	8.1	20.2	17.7	15.9	21.7	25
S X 6	31.1	30.3	37.1	24.2	16.9	6.8	26.0	17.9	14.9	22.8	22
S X 7	34.8	31.3	27.8	23.0	20.2	8.8	22.2	13.4	17.2	22.1	24
S X 8	38.6	25.0	38.6	18.7	27.0	13.1	30.1	15.7	21.7	25.4	7
S X 9	28.3	37.1	42.4	21.5	27.0	9.1	24.0	17.2	18.4	25.0	9
S X 10	36.9	35.1	36.4	26.5	36.9	13.1	32.6	19.7	21.5	28.8	1
S X 11	32.6	22.7	30.8	21.5	17.4	8.8	21.2	11.1	14.9	20.1	27
Pop. 4 C3	40.9	37.4	33.8	23.5	25.8	9.3	26.3	11.1	19.9	25.3	8
Mean	29.5	34.1	23.5	9.6	26.0	36.6	15.7	21.5			
L.S.D. (P=0.05)	NS	NS	4	1	12	20	NS	2	2	15	
CV%	-	-	35	30	38	25	-	22	21	2	

3 shows the results of variety trials at nine sites during the first rains of 1983. Although crosses had an advantage over the local varieties with regard to yield, the differences were not significant. Nonetheless, S x 10 ranked first in both years.

Finger millet screening trials

Sixty-nine white seeded back-crosses were tested against 12 testers using 8 x 8 quadruple lattice design. The results are presented in Table 4. Eighteen crosses of testers with their parents were tested using a 10 x 10 simple lattice design with two sets. The performances in grain yield, days to flowering and plant height are shown in Tables 5 and 6.

Finger millet germplasm

The existing 1,200 entries consist of collections of Ethiopia, Bangalore, ICRISAT (India), Sri Lanka and Uganda. Increased attention to collection in Africa and India is intended for widening the genetic variability in order to increase yield and agronomic performance.

Bulrush millet

Bulrush millet is a drought-resistant cereal crop. It has a high nutritive value. The crop is suitable in areas where soils are sandy and rainfall sporadic and unreliable.

Bulrush millet population improvement

The improvement program at Serere has concentrated on forming an all purpose and early maturing bulrush

Table 3. Grain yields (q/ha) of finger millet variety trials at seven sites, first rains, 1982

Entry	UAFRO Serere	V.T.C. Serere	Ngetta	Labora	Kuju	Tororo	Aduku	Mean	Rank
Eding	32.8	29.0	37.3	25.4	15.2	24.5	19.7	26.3	18
Engeny	30.1	29.0	29.7	24.1	12.3	20.0	18.1	23.3	36
Gulu	33.5	30.9	30.9	25.9	16.3	24.8	19.4	26.0	22
Okiring	36.9	31.4	31.4	23.3	14.4	26.8	23.0	26.7	16
Serere 1	31.4	34.7	34.1	24.1	15.2	26.8	22.2	26.9	14
U 10	32.6	36.9	32.8	24.6	14.0	32.8	24.1	28.3	6
U 12	41.9	36.7	30.3	21.8	12.9	28.0	25.5	28.2	7
U 15	28.6	31.8	29.0	22.9	16.3	17.2	22.2	23.8	35
U 16	30.7	31.4	32.0	23.9	12.9	28.0	19.4	25.5	25
U 30	32.0	25.0	29.7	22.0	13.5	22.7	18.6	24.8	29
U 43	33.7	29.5	31.4	22.9	16.1	18.4	17.9	24.3	32
U 47	39.2	33.5	36.7	26.7	11.7	28.0	24.7	28.6	5
P 211	38.1	33.0	34.7	22.9	13.5	27.5	24.1	27.7	10
P 224	36.9	32.6	32.8	24.1	13.8	27.5	19.5	26.7	16
P 231	32.8	40.2	39.0	22.5	16.3	28.5	25.8	29.3	2
P 248	31.1	35.4	31.3	22.4	12.7	29.0	21.9	26.3	18
P 249	29.2	33.7	30.7	22.9	14.8	29.0	21.0	25.9	23
P 251	39.4	34.7	27.8	23.5	17.4	29.8	23.6	28.0	8
P 258	34.7	35.2	33.9	22.7	13.5	29.3	21.2	27.2	13
P 277	35.0	36.9	31.8	30.3	19.7	27.3	22.8	29.1	3
P 278	36.3	36.7	32.4	22.4	11.4	25.0	23.7	26.9	14
P 283	28.9	31.4	30.1	18.0	12.9	28.3	23.4	24.7	31
P 318	33.9	32.0	32.4	23.5	13.8	25.8	22.8	26.3	18
P 665	36.9	33.3	35.8	21.8	14.6	27.0	23.0	27.5	12
P 669	34.1	38.1	32.8	24.6	14.6	27.3	22.6	27.7	10
P 671	34.3	40.3	27.7	19.7	13.1	21.5	17.8	24.9	28
S X 3	30.9	39.6	38.6	27.8	15.2	29.8	20.9	29.0	4
S X 4	31.8	31.8	29.4	20.1	14.8	21.7	17.5	23.9	34
S X 5	30.9	34.1	41.9	24.1	07.8	20.2	21.6	25.8	24
S X 6	29.4	29.0	29.0	23.9	14.0	26.0	17.0	24.0	33
S X 7	36.9	31.4	29.9	18.0	15.5	22.2	19.8	24.8	29
S X 8	36.0	36.2	33.9	23.7	15.5	30.0	20.2	27.9	9
S X 9	38.6	37.1	27.7	24.6	13.1	24.0	17.3	26.1	21
S X 10	40.3	36.9	36.7	22.4	16.9	32.8	24.1	29.6	1
S X 11	36.6	30.1	27.0	24.4	17.8	21.2	20.3	25.3	26
Pop. 4 C3	33.0	29.0	27.0	23.5	14.8	26.3	21.3	25.0	27
Mean	34.1	33.7	32.2	23.4	14.2	26.0	21.2		
L.S.D. (P = 0.05)	NS	19.9	20.5	NS	NS	6.8	NS	15.9	
CV %	-	13	15	-	-	24	-	34	

Table 4. Grain yield, days to flowering and plant height of Ethiopia finger millet derivatives grown at Serere first rains, 1982

Entry	Grain yield (q/ha)	Days to flowering	Plant height (cm)
W.C. 65 x ENG P1/175 x Gulu E-51	11.1	59	90
W.C. 717 x ENG P1/14 x Gulu E-88	16.4	60	105
W.C. 717 x ENG P1/14 x Gulu E-58	14.3	61	110
S X 2	13.1	61	100
Serere 1	16.4	61	100
W.C. 717 x ENG P1/14 x Gulu E-2	13.1	59	100
W.C. 65 x ENG P1/14 x Gulu E-53	12.9	61	100
S X 12	16.5	59	90
W.C. 65 x ENG P1/175 x Gulu E-9	12.4	59	90
Okiring	15.2	65	90
W.C. 65 x ENG P1/175 x Gulu E-21	8.7	57	100
W.C. 65 x ENG P1/175 x Gulu E-59	8.4	58	95
W.C. 65 x ENG P1/175 x Gulu E-43	14.8	62	100
W.C. 717 x ENG P1/14 x Gulu E-39	12.9	57	90
Engeny	14.1	59	100
W.C. 65 x ENG P1/175 x Gulu E-44	12.1	54	90
W.C. 717 x ENG P1/14 x Gulu E-18	15.6	60	95
W.C. 65 x ENG P1/175 x Gulu E-37	13.4	58	90
W.C. 717 x ENG P1/14 x Gulu E-29	12.2	61	100
Gulu E	14.5	60	105
U 21	44.4	60	100
W.C. 65 x ENG P1/175 x Gulu E-22	9.1	51	85
P 226	13.3	62	95
S X 13	16.3	61	100
Eding	17.0	62	105
W.C. 65 x ENG P1/175 x Gulu E-36	12.5	55	75
P 283	15.6	61	100
W.C. 717 x ENG P1/14 x Gulu E-55	13.6	67	105
W.C. 717 x ENG P1/14 x Gulu E-64	12.4	54	90
W.C. 717 x ENG P1/14 x Gulu E-70	9.2	66	90
W.C. 717 x ENG P1/14 x Gulu E-74	14.3	61	90
W.C. 30	12.6	58	100
W.C. 717 x SER 1 P1/39 x Gulu E-42	11.0	54	90
W.C. 717 x SER 1 P1/39 x Gulu E-1	14.4	57	90
S X 1	14.4	64	95
W.C. 65 x ENG P1/175 x Gulu E-45	14.4	56	85
W.C. 65 x ENG P1/175 x Gulu E-3	14.6	59	95
W.C. 717 x ENG P1/14 x Gulu E-16	13.3	61	100
W.C. 717 x SER 1 P1/39 x Gulu E-48	14.6	60	95
W.C. 717 x ENG P1/14 x Gulu E-6	13.2	60	95
P 224	12.8	60	100
W.C. 65 x ENG P1/175 x Gulu E-4	9.4	53	100

Table 4. (contd)

Entry	Grain yield (q/ha)	Days to flowering	Plant height (cm)
5E x 32 x Serere 21/1	15.0	67	100
5E x 42 x Serere 26/6	14.1	63	105
5E x 22 x P102/1	15.1	63	105
W.C. 717 x ENG P1/4	14.9	61	110
W.C. 65 x ENG P1/5	16.1	68	100
W.C. 65 x ENG P1/175 x Gulu E-23	8.3	57	80
W.C. 65 x ENG P1/175 x Gulu E-41	12.1	57	90
W.C. 65 x ENG P1/175 x Gulu E-39	12.6	53	85
W.C. 65 x ENG P1/175 x Gulu E-17	7.2	54	110
W.C. 65 x ENG P1/175 x Gulu E-13	14.0	61	100
W.C. 65 x ENG P1/175 x Gulu E-60	14.1	56	95
W.C. 717 x SER 1/1/50	16.4	61	105
W.C. 65 x ENG P1/50	13.9	61	110
P 178 x P 577 x P 204 x P 495	12.4	60	100
W.C. 65 x ENG P1/175	14.6	60	100
W.C. 65 x ENG P1/175 x Gulu-8	14.7	58	95
W.C. 717 x ENG P1/14 x Gulu E-1	12.2	59	85
POP 1 C4	14.7	59	100
W.C. 717 x ENG P1/14 x Gulu E-101	14.7	59	95
W.C. 717 x SER I P1/39 x Gulu E-19	9.9	57	100
W.C. 717 x ENG P1/14 x Gulu E-23	13.9	65	95
U 15	14.1	64	105
Mean	13.4	60	96
L.S.D. (P = 0.05)	13	4	548
CV %	22	21	64

Table 5. Grain yield, days to flowering and plant height of first set of finger millet crosses grown at Serere first rains, 1982

Entry	Weight (q/ha)	Days to flowering	Plant height (cm)
W.C. 717 ENG P1/14 x Gulu E-92	29.8	60	100
W.C. 65 x ENG P1/175 x Gulu E-8	43.8	61	100
W.C. 717 x ENG P1/14 x Gulu E-33	35.8	61	95
W.C. 65 x ENG P1/175 x Gulu E-9	34.7	68	95
W.C. 717 x ENG P1/14 x Gulu E-37	41.3	57	105
W.C. 65 x ENG P1/175 x Gulu E-7	37.9	57	95
W.C. 65 x ENG P1/175 x Gulu E-5	33.4	57	100
W.C. 717 x ENG P1/14 x Gulu E-32	22.9	60	95
W.C. 65 x ENG P1/175 x Gulu E-62	26.9	58	80
W.C. 65 x ENG P1/175 x Gulu E-28	34.1	56	95
W.C. 717 x ENG P1/14 x Gulu E-49	36.2	66	100
W.C. 717 x ENG P1/14 x Gulu E-10	14.2	64	95
W.C. 717 x ENG P1/14 x Gulu E-7	32.4	64	95
W.C. 717 x ENG P1/14 x Gulu E-50	38.3	67	90
W.C. 717 x ENG P1/14 x Gulu E-32	30.3	60	85
W.C. 30	39.8	60	95
W.C. 717 x ENG P1/14 x Gulu E-60	39.6	60	105
W.C. 717 x ENG P1/14 x Gulu E-10	27.9	58	90
W.C. 65 x ENG P1/175 x Gulu E-59	44.0	58	95
W.C. 65 x ENG P1/175 x Gulu E-44	31.3	58	100
W.C. 717 x ENG P1/14 x Gulu E-3	31.8	65	110
W.C. 717 x ENG P1/14 x Gulu E-22	37.3	57	110
W.C. 717 x ENG P1/14 x Gulu E-97	36.0	62	95
W.C. 65 x ENG P1/175 x Gulu E-10	36.4	56	90
W.C. 717 x ENG P1/14 x Gulu E-13	41.5	61	90
W.C. 65 x ENG P1/175 x Gulu E-1	29.8	57	90
P 249	42.6	65	110
W.C. 717 x ENG P1/14 x Gulu E-13	30.0	66	75
W.C. 65 x ENG P1/175 x Gulu E-42	30.1	58	90
W.C. 717 x ENG P1/14 x Gulu E-6	37.3	60	100
W.C. 717 x ENG P1/14 x Gulu E-93	29.8	60	90
U 16	42.6	68	100
W.C. 65 x ENG P1/175 x Gulu E-21	32.2	56	90
W.C. 717 x ENG P1/14 x Gulu E-47	34.9	59	90
W.C. 717 x ENG P1/14 x Gulu E-33	33.0	60	95
5E x 22 x P 102	40.0	63	95
W.C. 717 x ENG P1/14 x Gulu E-28	27.3	63	95
W.C. 717 x ENG P1/14 x Gulu E-88	48.1	66	80
W.C. 717 x ENG P1/14 x Gulu E-19	20.3	61	90
W.C. 717 x ENG P1/14 x Gulu E-35	36.0	60	85
W.C. 65 x ENG P1/175 x Gulu E-11	30.0	58	95
W.C. 717 x ENG P1/14 x Gulu E-31	35.4	64	95
W.C. 717 x ENG P1/14 x Gulu E-1	24.8	55	100
MUT SEL 1	32.6	63	95
W.C. 717 x ENG P1/14 x Gulu E-35	39.2	64	80
W.C. 717 x ENG P1/14 x Gulu E-24	28.2	61	85
W.C. 65 x ENG P1/175 x Gulu E-5	39.6	57	90
W.C. 65 x ENG P1/175 x Gulu E-48	26.2	64	85
W.C. 717 x ENG P1/14 x Gulu E-44	45.9	63	85
W.C. 65 x ENG P1/175 x Gulu E-13	23.1	58	90
W.C. 717 x ENG P1/14 x Gulu E-41	30.0	63	100

Table 5. (contd)

Entry	Weight (q/ha)	Days to flowering	Plant height (cm)
W.C. 717 x ENG Pl/14 x Gulu E-14	22.9	60	90
W.C. 65 x ENG Pl/175 x Gulu E-10	38.1	59	90
W.C. 65 x ENG Pl/175 x Gulu E-7	20.7	56	100
W.C. 717 x ENG Pl/14 x Gulu E-48	35.6	60	95
W.C. 717 x ENG Pl/14 x Gulu E-47	36.8	71	100
W.C. 717 x ENG Pl/14 x Gulu E-36	27.5	57	115
W.C. 65 x ENG Pl/175 x Gulu E-2	25.2	57	90
W.C. 717 x ENG Pl/14 x Gulu E-40	34.5	62	100
W.C. 65 x ENG Pl/175 x Gulu E-12	12.5	55	90
W.C. 65 x ENG Pl/175 x Gulu E-1	24.1	56	90
W.C. 65 x ENG Pl/175 x Gulu E-6	22.2	54	85
W.C. 65 x ENG Pl/175 x Gulu E-12	26.0	60	105
W.C. 717 x ENG Pl/14 x Gulu E-40	26.9	61	95
W.C. 65 x ENG Pl/175 x Gulu E-47	33.0	60	95
W.C. 65 x ENG Pl/175 x Gulu E-11	23.7	57	95
W.C. 65 x ENG Pl/175 x Gulu E-8	24.5	54	95
W.C. 717 x ENG Pl/14 x Gulu E-12	31.8	61	95
W.C. 65 x ENG Pl/175 x Gulu E-3	22.6	64	100
W.C. 717 x ENG Pl/14 x Gulu E-9	28.2	61	100
W.C. 717 x ENG Pl/14 x Gulu E-23	32.6	66	100
W.C. 717 x ENG Pl/14 x Gulu E-9	29.6	62	105
W.C. 717 x ENG Pl/14 x Gulu E-38	36.0	65	100
W.C. 717 x ENG Pl/14 x Gulu E-17	42.3	61	85
W.C. 717 x ENG Pl/14 x Gulu E-12	34.5	62	110
W.C. 65 x ENG Pl/175 x Gulu E-1	19.9	56	90
W.C. 65 x ENG Pl/175 x Gulu E-9	27.9	55	85
W.C. 717 x ENG Pl/14 x Gulu E-67	39.8	65	85
W.C. 65 x ENG Pl/175 x Gulu E-3	36.4	55	90
W.C. 717 x ENG Pl/14 x Gulu E-20	34.3	65	90
W.C. 717 x ENG Pl/14 x Gulu E-59	37.9	60	90
W.C. 65 x ENG Pl/175 x Gulu E-4	48.9	60	105
W.C. 717 x ENG Pl/14 x Gulu E-27	32.4	58	90
W.C. 717 x ENG Pl/14 x Gulu E-26	26.9	56	90
W.C. 717 x ENG Pl/14 x Gulu E-42	37.0	67	95
W.C. 717 x ENG Pl/14 x Gulu E-45	48.9	65	100
W.C. 717 x ENG Pl/14 x Gulu E-34	34.9	62	85
P 224	49.8	61	110
U 15	31.5	55	90
W.C. 717 x ENG Pl/14 x Gulu E-51	31.7	67	105
W.C. 717 x ENG Pl/14 x Gulu E-4	38.7	66	90
W.C. 717 x ENG Pl/14 x Gulu E-46	35.8	62	95
P 318	44.1	63	110
W.C. 717 x ENG Pl/14 x Gulu E-11	33.0	59	100
W.C. 717 x ENG Pl/14 x Gulu E-23	42.1	63	85
W.C. 65 x ENG Pl/175 x Gulu E-8	23.3	57	95
W.C. 65 x ENG Pl/175 x Gulu E-12	26.7	57	90
W.C. 65 x ENG Pl/175 x Gulu E-52	32.0	57	90
W.C. 65 x ENG Pl/175 x Gulu E-3	39.6	58	90
W.C. 717 x ENG Pl/14 x Gulu E-6	33.4	56	90
Mean	33.0	60	95
L.S.D.	NS	11	10
CV %		13	23

Table 6. Grain yield, days to flowering and plant height of second set of finger millet crosses, grown at Serere, first rains, 1982

Entry	Weight (q/ha)	Days to flowering	Plant height (cm)
W.C. 717 x ENG P1/14 x Gulu E-34	29.5	62	95
W.C. 717 x ENG P1/14 x Gulu E-38	37.5	60	110
W.C. 717 x ENG P1/14 x Gulu E-87	33.7	65	110
W.C. 65 x ENG P1/175 x Gulu E-55	32.1	54	100
W.C. 65 x ENG P1/175 x Gulu E-40	35.2	58	105
W.C. 717 x SER 1 P1/39 x Gulu E-52	29.2	58	90
W.C. 717 x ENG P1/14 x Gulu E-67	32.6	66	115
W.C. 717 x SER 1 P1/39 x Gulu E-27	26.1	59	90
W.C. 717 x ENG P1/14 x Gulu E-67	32.6	66	115
W.C. 717 x SER P1/39 x Gulu E-27	26.1	59	90
W.C. 717 x ENG P1/14 x Gulu E-97	40.2	63	100
W.C. 717 x ENG P1/14 x Gulu E-98	31.4	63	100
W.C. 65 x ENG P1/175 x Gulu E-47	31.4	60	100
W.C. 717 x ENG P1/14 x Gulu E-78	28.4	63	105
W.C. 65 x ENG P1/175 x Gulu E-18	28.0	50	105
W.C. 717 x ENG P1/14 x Gulu E-79	41.7	66	100
Serere x 6	50.0	67	115
W.C. 65 x ENG P1/175 x Gulu E-28	35.2	59	100
W.C. 65 x ENG P1/175 x Gulu E-25	29.9	55	100
W.C. 65 x ENG P1/175 x Gulu E-54	28.0	54	95
W.C. 717 x ENG P1/14 x Gulu E-82	37.5	64	90
W.C. 717 x ENG P1/14 x Gulu E-54	37.5	64	85
W.C. 65 x ENG P1/175 x Gulu E-39	33.0	66	105
W.C. 65 x ENG P1/175 x Gulu E-34	28.4	58	95
W.C. 65 x ENG P1/175 x Gulu E-25	29.2	60	90
Eding	42.8	59	100
W.C. 717 x ENG P1/14 x Gulu E-100	29.2	63	95
W.C. 65 x ENG P1/175 x Gulu E-60	26.1	58	110
W.C. 65 x ENG P1/175 x Gulu E-16	16.7	53	85
W.C. 717 x ENG P1/14 x Gulu E-80	37.9	65	125
W.C. 717 x SER 1 P1/39 x Gulu E-33	37.9	61	110
W.C. 717 x ENG P1/14 x Gulu E-38	23.5	58	105
W.C. 717 x SER 1 P1/39 x Gulu E-46	30.3	59	100
W.C. 65 x ENG P1/175 x Gulu E-45	20.8	56	100
W.C. 65 x ENG P1/175 x Gulu E-37	37.1	62	110
W.C. 717 x ENG P1/14 x Gulu E-43	42.8	66	105
W.C. 65 x ENG P1/175 x Gulu E-19	10.2	57	95
W.C. 717 x ENG P1/14 x Gulu E-30	31.1	65	110
W.C. 717 x ENG P1/14 x Gulu E-73	29.2	63	100
W.C. 65 x ENG P1/175 x Gulu E-58	39.4	65	100
W.C. 65 x ENG P1/175 x Gulu E-45	36.4	60	90
W.C. 717 x ENG P1/14 x Gulu E-63	40.5	63	115
W.C. 65 x ENG P1/175 x Gulu E-32	29.5	61	105
W.C. 717 x ENG P1/14 x Gulu E-69	43.6	65	105
W.C. 717 x ENG P1/14 x Gulu E-85	21.2	56	100
Serere x 5	33.0	59	105
W.C. 717 x ENG P1/14 x Gulu E-11	42.0	63	90
Okiring	33.3	65	100
W.C. 717 x ENG P1/14 x Gulu E-95	35.2	62	100
W.C. 717 x ENG P1/14 x Gulu E-77	31.4	66	100
W.C. 717 x ENG P1/14 x Gulu E-72	37.1	65	110

Table 7. Grain yield, height and days to flowering of bulrush millet varieties and composite growth at two sites, second rains, 1983

Entry	Yield (q/ha)		Plant height (cm)		Days to flowering	
	Serere	Katakwi	Serere	Katakwi	Serere	Katakwi
Serere 50	3.3	3.1	169	174	52	57
Serere composite 13	1.9	2.8	163	175	53	58
Serere 17	1.6	2.0	160	143	51	55
Serere composite 4M	2.0	2.8	166	167	53	60
Serere composite 2	3.3	3.1	158	163	51	52
Serere 46	2.6	2.8	164	169	52	59
Serere composite 10	1.3	2.4	163	167	51	59
Serere 45	2.8	2.2	154	166	54	61
Serere composite 14	2.8	2.6	169	159	52	60
Serere 30	1.9	2.4	156	144	51	57
Serere composite 3M	2.2	2.6	166	169	54	58
Serere 33	1.7	2.8	156	164	52	54
Serere 38	1.5	2.9	156	189	55	69
Serere 40	2.8	2.7	164	172	54	61
Serere 34	1.9	2.6	161	175	52	61
Serere 6A	3.2	2.2	156	162	51	57
Mean	2.3	2.6	161	166	52	58
L.S.D. (P = 0.05)	0.74	1.2	6.6	8.52	2.39	8.79
CV %	5	8	80	214	4	35

Altitude	Location
Low	Serere
	Ngetta
Intermediate	Labora
	Kigumba
Very dry lowlands	Iri-Iri
	Kotido
High	Buginyanya

The Kotido and Iri-Iri trials were mismanaged and therefore no data are expected. Files have been received from Ngetta, Labora and Serere. Data for harvest at Ngetta and Labora sites were lacking on a number of entries and this was attributed to failure of setting grain. Though not proved it appears that covered smut (*Sphacelotheca sorghi*) might have been the cause of failure to set seed at Ngetta.

Sorghum pathology

For the last two years, the sorghum pathology program at Serere has been evaluating the disease occurrence on the improved cultivars and world collection entries in order to identify the economically important and potentially important diseases.

The results of this evaluation showed that both foliar and inflorescence diseases do occur. Among the foliar diseases, anthracnose (*Colletotrichum graminicola*) was the most important. It was the most frequent and most intensive on most sorghum varieties.

Sorghum downy mildew (*Peronosclerospora sorghi*) was another important foliar disease. Early infections led to complete leaf shedding. In such cases, the plants did not head at all. They remained stunted and dried up prematurely.

Also, grey leaf spot (Cercospera sorghi), leaf blight (Exserohilum turcicum) and leaf rust (Puccinia purpurea), were fairly important. However, since they set in after flowering, they did not seem to affect grain development very much, so may not be economically important at the moment. However, the developed cultivar Lulu is highly susceptible to leaf blight while Seredo is susceptible to grey leaf spot. Therefore anthracnose and downy mildew deserve immediate attention. In 1984, all the available sorghum germplasm will be planted in a preliminary anthracnose and downy mildew screening nursery in order to identify and develop effective and stable broad-spectrum resistance.

Grain molds are important on the heads. The disease was caused by several genera of fungi but the most important were Fusarium, Curvularia, Phoma, Colletotrichum, Helmenthosporium, Aspergillus and Penicillium.

Grain moulds have of late become one of the major disease and research problems in the improvement of the grain sorghum crop. Heavy selection pressure has to be exerted on much of our working material because most of the improved cultivars are susceptible. In 1984, therefore, a preliminary grain moulds screening nursery will be planted consisting of all the improved cultivars, breeding progenies and world collection entries.

Sorghum entomology

The sorghum entomology program has to date concentrated on determining the level of resistance of improved grain quality sorghum cultivars to storage pests. A large number of seed pests attack sorghum in store, notably the rice weevil Sitophilus oryzae and the grain moth Sitotroga cerealella.

All the cultivars so far tested have shown varying levels of resistance to these insect pests. No cultivars have been found to possess complete resistance. However, it appeared that certain grain characters, such as seed hardness, grain endosperm corneousness and seed size, seem to confer resistance.

Generally, however, the less corneous the grain, the more susceptible it was to the grain weevil but the less susceptible it was to the grain moth. The reverse is also true. Again, the rice weevil was found to be more important on threshed grain than the grain moth. On the other hand, the grain moth infests unthreshed heads more than the threshed grain.

Other insect pests found destroying sorghum in store include cockroaches, Tribolium sp., Rhizopertha sp., Carpophillus sp., saw-toothed beetles and mites.

In the field, the central sorghum shootfly, Atherigona sp., and the lowland stem borer, Chilo partellus, are extremely important. As from 1984 programs will be directed to screening for resistance to these field pests.

Finger millet pathology

Screening for blast disease resistance in finger millet

Following from the results of the disease evaluation trials in 1982, blast (Piricularia grisea) disease was rated as the most important. It was therefore decided that further research programs in finger millet pathology be directed towards screening for blast resistance.

The disease affects the plant at all stages of growth. The seedlings, leaves, nodes, internodes, neck and head

are all attacked by the fungus. However, the neck and head infections are the most important.

In 1983 several hundred varieties and pedigrees of crosses of finger millet at Serere were screened for resistance to Piricularia grisea under conditions of natural infection in the field. This was the preliminary blast resistance screening nursery. The nursery was planted out in 5 metre row plots in a two replicate randomized block experiment. It was designed to have a system of infector rows and test rows. The infector rows consisted of the most highly susceptible entries identified from the world collection in the 1982 evaluation trial. The infector rows were planted every fifth row. The intermediate four rows were the test rows. A susceptible check was planted every eleventh row. The results were taken at 50% anthesis and also at maturity. For neck blast, the incidence of infection was taken as a mean of the number of plants infected as a percentage of the total number of plants in the row. For head blast, severity of infection was taken as a mean of the number of spikelets infected per head. In either case, 10 plants per row were randomly selected for disease score. (A 0-10 rating scale was used where 0 = disease absent and 10 = total or nearly total destruction of susceptible plant parts.)

Generally, the white-seeded varieties are highly susceptible. Also, most Indian and some Ethiopian entries are susceptible. Local Uganda collections and most Serere crosses seemed to show resistance. Shorter lines are more susceptible although they mature earliest. Genetic lines with compact heads seem to show more resistance to head infections, but seem to be susceptible to leaf blast. The experiment will be planted in an advanced screening nursery in 1984.

SORGHUM IMPROVEMENT IN YEMEN PDR

Abdul Aziz Ahemed Bawazir*

INTRODUCTION

Sorghum is considered to be one of the most important cereal crops grown in this country. It is the prime food for humans and for livestock in the rural areas. According to the First Five-Year National Plan (1975/76-1979/80) sorghum occupied 45,900 acres out of a total of 70,300 acres under cereals and produced 14,800 metric tonnes out of the total cereals production of 27,500 metric tonnes. In the Second Five-Year National Plan (1980/81-1984/85) sorghum occupies 48,470 acres out of a total of 72,000 acres and gives an average production of 19,680 metric tonnes out of the total cereal production of 37,160 metric tonnes.

In 1983 the area under sorghum was recorded as 48,540 acres with an average production of 18,980 metric tonnes (Table 1). This indicates an increase of about 470 metric tonnes over 1982 production. Thus the area under sorghum and total production are increasing gradually every year.

Sorghum research in the country during 1983 was concentrated on a wide survey and collection of the local germplasm from different ecological zones in both parts of Yemen (North and South Yemen). Sixty-one local cultivars were collected from Tihana region of North Yemen (YAR) and from other different ecological zones of South Yemen (Yemen PDR). These collections were grown in March 1984 at El-Kod for morphological studies.

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*Plant Breeder and Head, Agronomy and Plant Breeding Section, El-Kod Agricultural Research Centre, Ministry of Agriculture and Agrarian Reform, Aden, Yemen PDR.

Table 1. Areas under sorghum and production during the Second Five-Year National Plan 1981-85

Year	Area in 000 acres	Production in 000 tonnes
1981	48.20	16.39
1982	48.51	17.46
1983	48.54	18.93
1984	48.55	21.36
1985	48.56	24.28
Overall average	48.47	19.68

Source: Department of Statistics and Planning, Ministry of Agriculture and Agrarian Reform, Aden, Yemen PDR.

Selection will be on the basis of their general adaptability.

Large amounts of material introduced from ICRISAT, ACSAD and SAFGRAD were grown during July 1983 at El-Kod Agricultural Research Centre and Seiyum Regional Research Centre (mid-altitude) for evaluation and selection. Selections from these materials were made on the basis of plant height (tall to medium tall) with chalky white grain colour according to the preference of the Yemeni farmers.

The weather of the region was generally dry. Average rainfall was 17.7 mm (Table 2). Almost all the country was more or less dry with slight rainfall at higher altitudes.

Table 2. Meteorological Report, 1983

Month	Average air temperature	Mean R.H. %	Rainfall (mm)	No. of rainy days
January	24.8	82.3	3.4	3
February	24.9	89.4	138.0	9
March	26.6	83.9	Nil	Nil
April	29.5	85.4	7.0	1
May	30.2	83.0	50.2	4
June	31.4	84.0	3.4	1
July	31.9	80.6	Nil	Nil
August	31.5	84.1	8.6	6
September	30.7	81.8	Nil	Nil
October	27.6	73.3	Nil	Nil
November	24.3	78.7	Nil	Nil
December	25	82.1	1.5	3
Total	338.4	998.6	212.1	27
Average	28.2	82.4	17.70	2

Source: El-Kod Meteorological Station, El-Kod Agricultural Research Centre, Ministry of Agriculture and Agrarian Reform, Yemen PDR

CROP IMPROVEMENT

Local cultivars

At the beginning more emphasis was directed to introduction, but in view of the good quality of the local types and their adaptation to local conditions, our strategy at present is to give more attention to the local types without, however, completely neglecting elite exotic materials.

Keeping farmers' preferences in mind more emphasis was put on improving the local cultivars. The improvement was based on selection for pearly grain colour with reasonable grain yield and acceptable fodder quality.

Periodical sorghum collection missions have been undertaken in Yemen PDR from 1969 until November 1978. In total 96 sites were sampled and about 24 local cultivars were identified. A selection program was initiated in 1977 in the coastal region of the country as a first step towards improving the existing local cultivar, Beini. But due to limited genetic variation, the intrapopulation selection carried out for three years did not lead to any substantial improvement in yield.

To provide a wide genetic stock for selection, a study tour to the northern part of Yemen AR was organized during November 1983 to collect some local germplasm from Tihama region for evaluation and selection under conditions in Yemen PDR. Seven YAR Tihama varieties were collected. It was observed that the Tihama cultivars of sorghum are more or less similar to those in Yemen PDR.

Another 54 local collections representing the different ecological zones of Yemen PDR were collected during February-March 1984. These 61 local germplasm samples collected from the two parts of Yemen were sown in the second week of March 1984 at El-Kod Agricultural Centre.

A selection program on the 61 cultivars will be carried out to improve the existing cultivars belonging to the different climatic regions of the two parts of Yemen.

Screening and selection of varieties

Local cultivars, partially collected between 1969 and 1978, were combined with varieties/entries introduced from ICRISAT (India), ACSAD (Syria) and SAFGRAD (Kenya) for evaluation on yield and quality of grain-cum-forage under Yemen PDR conditions.

The major criteria for selection are:

- Higher grain-cum-forage yield;
- Early maturity to escape or to minimize bird damage and to cope with drought conditions in the country;
- Resistance to pests, mainly shoot fly and stem borer;
- Consumer acceptability of the grain and forage quality.

A number of important varietal trials were carried out during 1983. The main trials can be summarized as follows:

Preliminary evaluation of ACSAD materials

Three evaluation trials introduced from ACSAD (Syria) as follows:

(a) Evaluation of 7 varieties/lines;
(b) Evaluation of 19 varieties/lines;
(c) Evaluation of 24 varieties/lines.

Three trials, along with the local check (Beini), were sown in an observation plot and separately in a randomized complete block with four replications each at El-Kod Agricultural Research Centre for preliminary evaluation and screening to study their adaptability to our conditions. Four plant characteristics (days to 50% flowering, plant height, head weight, and grain yield) were studied. Insect pests and plant diseases were also recorded.

As is indicated in Table 3, the varieties Dem.B-76-70, Dem.B-76-11 and Dem.76B-66 were significantly earlier than the local cultivars. This leads us to consider these three varieties as early maturing ones.

Table 3. Agronomic data of ACSAD varieties

Variety/line	Days to 50% flowering	Plant height (cm)	Grain yield (tonnes/ha)
Dem.B-76-104	48	78	0.6
Dem.B-76-59	50	236	0.4
Dem.B-76-70	47	110	0.6
Dem.B-76-11	47	69	0.8
Dem.B-76-72B	51	66	0.8
Dem.B-76-69	53	80	0.7
Dem.B-76-66	47	74	0.6
Beini (Local check)	52	83	0.5
S.E.	± 0.9	-	-
LSD 5%	2	-	-

Table 4 and 5 show that the varieties differed in days to 50% flowering, plant height, and grain yield. Very slight attack by shoot fly and stem borer was recorded. No evidence of aphid presence was observed.

These varieties/lines will be screened again for further studies and selection for earliness, plant height and grain yield in the coming seasons.

ICRISAT trials

(a) Seventy-eight lines introduced from ICRISAT (India) during the 1980/81 season were sown for general screening and evaluation. The selections were made throughout the last three seasons 1980/81, 1981/82 and 1982/83. The best performing 20 lines were selected to be sown in the 1983/84 season in agronomy trials involving different sowing dates and fertilizer levels. Three sowing dates, namely July-August, March-April and May-June, and three levels of fertilizer, 0, 50, and 100 kg/feddan urea (46%N) are under study.

(b) Thirty-four drought resistant lines introduced from ICRISAT during the 1983/84 season were sown in March 1984 for drought evaluation.

Effects of chemical weedicide application on sorghum yield (var. Beini)

The effects of two chemical weedicides, propachlor and atrazine, separately and in the ratio of 3:0.5 and 3:1 respectively, along with the no-weeding check, on the grain yield of local sorghum variety (Beini) were studied for the last three seasons 1980/81, 1981/82 and 1982/83. It was generally observed that grain yields under the two chemical weedicide treatments were

Table 4. Performance of ACSAD varieties

Variety/line	Days to 50% flowering	Plant height (cm)	Grain yield (tonnes/ha)
Dem. B78-224	57	54	1.3
Dem. B78-350	52	53	2.9
Dem. B78-III	65	61	2.5
Dem. B78-182	56	69	3.3
Dem. B78-29	64	80	2.3
Dem. B78-249	39	110	2.4
Dem. B78-397	54	66	2.8
Dem. B78-284	64	72	3.3
Dem. B78-305	54	79	3.2
Dem. B78-331	54	82	3.7
Dem. B78-72	60	87	2.4
Dem. B78-412	52	71	3.1
Dem. B78-321	61	88	5.5
Dem. B78-414	62	82	2.5
Dem. B78-317	62	86	3.2
Dem. B78-143	61	71	2.9
Dem. B78-197	61	108	1.9
Dem. B78-570	52	127	1.5
Dem. B50-77	51	210	2.1
Beini (local check)	55	275	0.6
S.E.	±0.3	-	-
L.S.D. 5%	1	-	-

Table 5. Performance of ACSAD varieties

Variety/line	Days to 50% flowering	Plant height (cm)	Grain yield (tonnes/ha)
Dem.B77-330	63	200	3.9
Dem.B77-470	53	63	0.9
Dem.B77-521	54	80	3.3
Dem.B77-570	57	127	2.5
Dem.B77-761	59	75	4.4
Dem.B77-764	56	175	3.2
Dem.B77-774	59	102	2.0
Dem.B77-950	54	132	3.7
Dem.B77-876	56	223	1.8
Dem.B77-57	54	60	2.5
Dem.B77-62	56	84	2.9
Dem.B77-66	55	81	3.5
Dem.B77-70	55	84	2.2
Dem.B77-75	52	65	3.2
Dem.B77-82	59	75	3.2
Dem.B77-85	51	63	3.5
Dem.B77-91	57	207	3.1
Dem.B77-98	55	119	2.2
Dem.B77-99	58	61	3.1
Dem.B77-56	52	58	2.0
Dem.B77-104	51	69	2.1
Dem.B77-121	60	74	3.5
Dem.B77-D92	54	86	3.5
Beini (local check)	52	192	0.5
S.E.	±1.1	-	-
L.S.D. 5%	4	-	-

significantly higher than the control. It was also concluded that propachlor + atrazine in the ratio of 3:0.5 gave better yields than all other treatments. This result will be verified with a large-scale trial at El-Kod Demonstration Farm and other extension farms in the country during July 1984.

The 1983 Eastern Africa Co-operative Sorghum Regional Trials

Two trials, namely low elevation and high elevation 1983 Eastern Africa Co-operative Sorghum Regional Trials, were sown in their respective regions during the 1983 season. The results of these trials can be summarized as follows:

Low Elevation Trial

Fifteen varieties introduced from the Eastern Africa Co-operative Sorghum Program (SAFGRAD, Kenya), along with the local variety (Beini), were sown during the second week of July 1983 at El-Kod Agricultural Research Farm. The trial was laid in a randomized complete block design with three replications. The seedlings were thinned to 20 cm apart in the row. The rows were 70 cm apart. The row length was 6 metres. The blocks were separated by two non-experimental lines on each side. All the heads were covered by netted bags at the flowering stage to prevent bird attack. All cultural practices had been carried out according to the standard procedures followed at El-Kod Research Farm.

The data on the different plant characteristics were recorded in Table 6. Analysis of variance was run on the data and C.V. and S.E. were also calculated. Significant differences among the varieties were recorded on plant height, head weight and 1,000 seed weight. Though there

Table 6. 1983 Eastern Africa Co-operative Sorghum Regional Trials, agronomic data for Low Elevation

Variety	Days to 50% flowering	Plant height (cm)	Insect score	Bird damage	Agro-nomic desira-bility	Grain yield tonnes/ ha)	1,000 seed weight
Tajarib	80	352	2	4	2	2.9	73
Sepon 80-1	79	174	1	4	1	3.5	55
5DX 160	63	164	3	5	4	2.8	62
Serena	64	165	3	5	5	1.7	64
Seredo	63	160	3	5	5	1.4	64
E525 HT	62	152	3	5	5	2.9	62
2KX 17/E/1	63	162	3	5	5	2.6	59
Tegemeo	62	196	3	5	5	1.4	56
2KX 17/6	61	183	3	5	5	1.3	55
Gambella 1107	65	217	2	4	2	2.7	61
Melkamash 79	64	190	3	5	3	3.0	65
Badege	65	105	3	5	5	1.7	53
Urumimbi	64	112	4	5	5	1.4	51
76T1-23	67	118	4	5	5	1.3	51
IS 8595	64	118	3	5	5	1.9	49
Beini (local check)	63	251	3	4	1	1.7	59
S.E.	N.S.	±14.9	-	-	-	N.S.	±2.4
L.S.D. 5%	-	44.1	-	-	-	-	7.2
C.V. %	-	10	-	-	-	-	5.1

were no significant differences on grain yield some varieties out-yielded the local Beini. The grain yield (tonnes/ha) was as high as 3.8 tonnes/ha (Melkamash 79) followed by Sepon 80-1 (3.5 tonnes/ha) and Tajarib (2.9 tonnes/ha) and as low as 1.3 tonnes/ha (2KX 17/16 and 76T1-23). The range in plant height was from 352 cm (Tajarib) to 105 cm (Badege).

In agronomic desirability score, the best four varieties were Tajarib, Sepon 80-1, Gambella 1107 and Melkamash 79. This was mainly due to their pearly grain colour which is desired by the farmers in Yemen PDR. These four varieties also recorded reasonable resistance to shoot-fly and aphids.

These results indicate the superiority of the Yemen AR and Ethiopia varieties over all other varieties due to their adaptability to our climatic conditions and farmers' preferences. Further concentration on selection in the Yemen AR and Ethiopian sorghum materials will be continued.

High Elevation Trial

Ten varieties of high elevation origin introduced from the Eastern Africa Co-operative Sorghum Program (SAFGRAD, Kenya), along with the local check (Kori) were sown during June 1983 at Mukairas Farm (high altitude region). The trial was laid on a randomized complete block design with three replications. The plant-to-plant distance was 20 cm whereas the row-to-row distance was 70 cm. The row length was 6 metres. The block was separated by two non-experimental lines on each side. Heads were protected by netted bags against bird damage at the flowering stage. Other cultural practices were carried out when and where necessary. Data on plant characteristics are given Table 7.

Table 7. 1983 Eastern Africa Co-operative Sorghum Regional Trials, performance of High Elevation Varieties

Variety	Days to 50% flowering	Plant height (cm)	Insect score	Bird damage	Agro-nomic desira-bility	Grain yield (tonnes/ ha)	1,000 seed weight (gm)
Kadasi	115	350	2	4	1	4.5	74
Hamra Hujariya	103	362	2	4	1	4.2	74
Al-Ganad	111	350	2	4	1	5.1	78
SVR 157	122	369	2	4	1	2.2	60
ETS 2752	122	358	3	5	1	3.3	67
Alemaya 70	127	363	4	5	1	3.3	66
BM 10	130	366	4	5	5	2.1	58
BM 27	129	375	4	5	5	2.1	57
E-1291	125	375	4	5	5	2.3	60
BJ28 X BG19	132	373	4	5	5	2.6	65
Kori	119	344	3	4	1	2.4	63
S.E.	NS	±4.7	-	-	-	±0.16	
L.S.D. 5%	-	14.9	-	-	-	0.51	
C.V. %	-	1.6	-	-	-	6.5	4.3

The Yemen AR variety Al-Ganad recorded the highest grain yield (5.1 tonnes/ha) and highest 1,000 grain weight (78 g), followed by Kadasi and Hamra Hujariya (YAR varieties) which gave grain yields of 4.5 and 4.2 tonnes/ha with 1,000 seed weight of 74 g and 73 g respectively.

The Ethiopian varieties ETS 2752 and Alemaya 70 showed some superiority in grain yield (3.3 tons/ha) and seed weight (66-67 gm) over the other varieties, including the local check (Kori).

The YAR varieties and the Ethiopian varieties showed good agronomic desirability, especially in grain colour (white-creamy), along with reasonable resistance to shoot fly and aphids.

Based on these observations it could be concluded that the YAR and Ethiopian varieties are more adaptable to the climatic conditions and local consumption patterns. Greater efforts will be directed towards selection in similar materials.

Plans for the next season

L. Selection on varieties from the Yemen Arab Republic and the Ethiopian program which suit local conditions and tastes will be carried out.

2. Hybridization of promising sorghum varieties to improve the local cultivars will be started. But due to a shortage of trained staff steps will be taken to seek the co-operation of the Ethiopian National Program in order to develop the F_1 crosses.

3. Identification and classification of the local germplasm

will be carried out with the assistance of the Genetic Resources Unit of ICRISAT.

4. Evaluation and selection of promising ACSAD materials will be carried out.

5. Screening and selection on the ICRISAT drought resistant lines will be continued.

6. Screening and evaluation of the Eastern Africa Co-operative Sorghum Regional Trials will be continued.

7, Verification trials on the use of the chemical weedicides, propachlor and the atrazine, will be carried out on the extension farms.

8. Agronomy trials on sowing dates, fertilizer levels, etc. on the promising selected varieties from the ICRISAT/SAFGRAD sorghum programs will be carried out.

9. Intercropping of sorghum with legumes will be investigated.

10. There is evidence of Striga invasion of the sorghum growing areas at Wadi Hedramout (mid-altitude region). A general survey of such areas will be carried as a first step towards a co-ordinated research program with the ICRISAT Striga programs.

11. A research program on millets will be initiated through co-ordination with the eastern Africa millet growing countries involved in the SAFGRAD program.

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THE SORGHUM AND PEARL MILLET IMPROVEMENT PROGRAM IN ZIMBABWE, 1983

J.N. Mushonga and V.E.E. Gwarazimba*

INTRODUCTION

Breeding and yield trials were the major activities of the 1983/84 National Sorghum and Pearl Millet Improvement Program. Much of the breeding work involved developing and advancing inbreds and crossing adapted lines to generate segregating populations. Pedigree selection and advancement of elite lines were also carried out as part of the breeding program. Several sorghum hybrids were developed with emphasis being placed on both pearly white edible types and red types for making opaque beer.

Yield trials were planted as a series of preliminary, intermediate and advanced tests. At the preliminary level four sorghum and three pearl millet yield trials were planted to assess the yield potential of newly developed and introduced varieties. Intermediate yield trials were planted in several localities in different agro-ecological zones to test and assess the adaptability and yield performance of promising varieties. Advanced yield trials were a new introduction to the trial series. Fifteen varieties of each crop with high yielding potential and good adaptability were planted at four sites. These were evaluated for yield stability against current commercial improved varieties. In addition to this series, on-farm trials were conducted at several communal area sites and research stations in marginal rainfall areas to

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*Department of Research and Special Services, Crop Breeding Institute, Causeway, Harare, Zimbabwe

evaluate the yield performance of ten elite varieties under the management and cultural practices of the farmers. Although no data have been analysed, valuable information was collected from these trials.

Two sorghum disease nurseries from ICRISAT were planted at Gwebi Variety Testing Centre. Two types of East Africa Co-operative Sorghum Regional Trials were also planted. These were high and low altitude trials planted at Harare Research Station, with an altitude of 1,506 m, and Panmure Experimental Station which is 881 m.

WEATHER

The 1983/84 season is best described as a continuation of the drought that has crippled Zimbabwe's food production for the last three successive years. Characterized by late, erratic and scattered showers, the season did not show any significant difference from the 1982/83 season. However, the drought was more severe in the marginal rainfall areas where high soil temperatures and low soil moisture reserves at planting resulted in very poor germination and crop establishment. Although crop failure (maize for example) was widespread, farmers who had planted sorghum and pearl millet had significant harvests. Most of our research centres experienced acute water shortages and as a result several trials were a complete failure. Although the season was good for screening drought tolerant sorghum and pearl millet varieties, more reliable and meaningful results could have been obtained with a good season.

CROP IMPROVEMENT

Efforts to widen the genetic base of the breeding program for both sorghum and pearl millet continued with further introduction of new sources of genetic variability. More material was received from ICRISAT which was responsible for generating elite lines and the available hybrids which are currently being tested under Zimbabwean conditions.

Selection work also continued with the development and advancement of lines and inbreds from both local and introduced germplasm materials. Crosses between locally adapted and exotic lines have been on the increase to generate more segregating populations in both sorghum and pearl millet. In fact the pedigree breeding method originated from such crosses.

Population development and advancement was continued from the previous season. Four random mating populations of pearl millet were advanced into further cycles of development. Yield grains have been assessed at every cycle. Two populations, a tall plain local (TPL) and an exotic Gass $(MS)_5$ C_4, have reached stages where they could be released as open pollinated varieties for use by the communal farmer. Four segregating sorghum populations have been received from Dr Ross of Nebraska State University, U.S.A. These have been planted in isolation for observation as well as selecting individual plants with good agronomic characters to be developed into elite lines.

Observation nurseries planted in the major arid zones of the country served as gene pools for the selection of high yielding varieties as well as drought tolerant lines. Several promising lines were selected and these will be

developed into restorer lines and drought tolerant inbreds.

Two hundred sorghum and 63 pearl millet test crosses were made from adapted inbreds to develop experimental hybrids. Efforts were made to select for and/or develop pearly white edible sorghum varieties. Selections were also carried out to improve the brewing qualities of both red and white sorghums.

AGRONOMY AND CROP PROTECTION

Agronomy work on sorghum and pearl millet was done by the Agronomy Institute. Population x variety and moisture conservation trials were planted at several sites in the communal areas of marginal rainfall. In the former trial series the major objective was to establish an optimum population that would give better yields under the farmers' cultural practices. Moisture conservation trials were aimed at assessing and establishing tillage practices that would maximize yields at particular moisture levels.

Work on pests and diseases was done by the Plant Protection Research Institute. Although we selected for disease resistance in our observation nurseries, the Plant Protection Research Institute monitored the stem borer (*Sesamia* spp.) and shootfly (*Antherigona* spp.). They also established damage thresholds and determined control measures for our trials. However, additional assessment of pests and diseases is yet to be done on farmers' fields and to record their threshold in these areas.

YIELD TRIALS

A variety yield trial is one of the major activities in the National Crop Improvement Program. It includes preliminary, intermediate and advanced variety trials. These are normally conducted in a series of four in the case of preliminary trials. The intermediate trial is only one type with 60 entries but planted at nine locations. The advanced variety trial is composed of 15 varieties but planted on four sites which were considered to have adverse growing conditions. Although drought has been severe for the last three seasons, sorghum gave reasonable yields at most of the locations. Some varieties gave yields as high as 7.5 tonnes/ha at Rattray Arnold Research Station.

However, pearl millet yields were quite low, as shown in Table 1. The 1983/84 yield results are still to be processed and therefore are not shown in this paper.

OTHER RESEARCH AND OUTREACH ACTIVITIES

More than 400 accessions of both sorghum and pearl millet germplasm were evaluated and characterized to identify useful and heritable agronomic characters for utilization in the National Breeding Program. Selections made will be incorporated into the 1984/85 season inbred development program.

Table 1. Pearl Millet Intermediate Variety Trial, 1982/83 grain yield in t/ha

Entry no.	Variety	Chibero	Chisumbanje	Kadoma	Makoholi	Matopos	Panmure	Mean over six sites	
1.	5054A X B282	1.52	0.25	2.24	1.95	0.72	1.99	1.45	16
2.	X 700516-R	0.92	0.31	2.34	1.60	0.60	1.68	1.24	25
3.	X 2287-3	0.97	0.24	1.81	1.44	0.67	2.62	1.29	24
4.	X J1188	2.55	0.27	2.56	1.28	0.82	1.89	1.56	9
5.	X J104	0.80	0.28	2.66	1.43	0.61	2.29	1.35	23
6.	X SC-2R	1.07	0.33	2.30	1.72	0.64	2.23	1.38	21
7.	X 700516-C	1.51	0.34	3.19	1.36	0.80	2.39	1.60	6
8.	X 700452-29	0.98	0.36	3.05	1.59	0.59	1.84	1.40	19
9.	X 700112	3.18	0.30	2.43	1.49	0.84	1.75	1.67	4
10.	X PIB 228	1.34	0.44	2.04	1.77	0.72	2.05	1.39	20
11.	X SC-2C	1.61	0.28	1.90	1.01	0.69	1.56	1.17	27
12.	X 15RMP 61	1.19	0.21	1.79	0.99	0.66	2.07	1.15	29
13.	T18DA$_1$X 700516-R	1.83	0.35	2.71	1.10	0.64	2.39	1.50	13
14.	X B282	2.98	0.26	3.01	1.41	0.71	1.87	1.71	3
15.	X SC-2C	0.75	0.31	2.44	1.36	0.49	1.68	1.17	27
16.	X J1188	3.42	0.29	1.62	1.57	0.49	2.09	1.58	8
17.	X 332 RMP51	1.01	0.62	1.94	1.29	0.76	2.12	1.29	24
18.	X SC-2R	1.96	0.37	2.55	1.19	0.86	2.35	1.55	10
19.	X 700112	1.57	0.28	2.72	1.60	0.63	2.47	1.54	11
20.	X 7LC 51	1.84	0.24	1.89	1.66	0.60	2.30	1.42	17
21.	X 15RMP 62	1.11	0.31	2.21	1.07	0.55	1.62	1.14	30
22.	T23DA$_1$X B282	2.61	0.22	2.91	1.70	1.69	1.35	1.58	8
23.	X T383	0.96	0.28	2.77	1.07	0.75	2.40	1.37	22
24.	X J104	0.87	0.27	2.89	1.37	1.16	2.51	1.51	12
25.	X B282	0.89	0.28	3.36	1.59	1.19	2.37	1.61	5
26.	X 7LC 51	1.27	0.27	2.22	1.53	0.65	2.42	1.39	20
27.	X 20LC 51	3.01	0.28	3.13	0.89	0.89	3.42	1.94	1
28.	X J1188	1.31	0.35	2.44	1.61	0.71	2.46	1.48	14
29.	T239A$_2$X B282	2.42	0.24	3.12	1.07	0.72	1.99	1.59	7
30.	X J1188	1.67	0.21	1.17	1.50	0.46	2.13	1.19	26
31.	X J104	2.02	0.20	1.15	1.20	0.60	1.76	1.16	28
32.	ALC (MS)$_2$	1.90	0.20	2.78	1.03	0.70	2.22	1.47	15
33.	PLC (MS)$_2$	1.34	0.12	1.73	0.72	0.47	2.40	1.13	31
34.	GAM 73-K77	1.66	0.14	2.26	0.81	0.74	1.10	1.12	32
35.	111A X 700516-R	2.11	0.35	2.20	0.76	0.93	2.09	1.41	18
36.	5141A X J104	1.84	0.32	3.53	1.56	0.91	2.86	1.83	2
	Mean	1.67	0.29	2.42	1.34	0.71	2.13		
	SE of mean	0.009	0.008	0.299	0.219	0.132	0.361		
	CV %	9.80	-	21.40	28.40	-	29.3		

1983/84 EASTERN AFRICA CO-OPERATIVE SORGHUM REGIONAL TRIALS

Zimbabwe conducted two sorghum regional trials for the low and intermediate altitude zones. Panmure, 881 m, was chosen for low altitude and Harare, 1,506 m, for the intermediate altitude trial. The majority of the varieties did reasonably well, except Badege and Urumimbi from Rwanda and IS 8595 from Kenya. These three varieties became photosensitive at Panmure, therefore no seeds were set. The analysis in Table 2 reflects the performance of 13 varieties instead of 16. Although the yields were reasonable, the season has been described as another drought year. The total rainfall for the season was 459.7 mm while average annual rainfall for Panmure is about 750 mm.

At Harare the yields were much higher than at Panmure with a grand mean of 7 t/ha (Table 3). In this case Ethiopian varieties Bakomash 80 and ESIP 12 yielded much better than the rest. The early maturing varieties did better than the later ones. Although some signs of photosensitivity were noticed on some varieties such as SVR 8 and Susa they still set some seeds. Good yields were noticed on both of these varieties.

A total of 571.3 mm of rain was received during the season. In a normal year Harare receives 800 mm of rain. The yields obtained from these are better than those which will be obtained from some sites in the National Program.

FUTURE REGIONAL TRIALS

More extensive regional trials (with more varieties) incor-

Table 2. Summary of yield and variate means of Eastern Africa Co-operative Sorghum Regional Trials planted at Panmure, Zimbabwe (altitude 881 m)

Entry no.	Variety	Days to 50% flowering	Plant height (cm)	Wt/1,000 seeds (g)	Plant population (000/ha)	Head wt (t/ha)	Yield (t/ha)	Range
25	Seredo	97	182	18	165	6.3	4.7	1
27	2 KX 17/6/1	99	188	22	148	5.9	4.5	2
34	76 T1-23	80	144	23	142	6.10	4.3	3
30	Gambella 1107	93	186	25	176	5.7	4.2	4
24	Serena	94	190	20	184	6.7	4.1	5
26	E 525HT	98	189	20	191	5.7	3.9	6
23	5DX 160	103	200	25	216	5.6	3.8	7
28	Tegemeo	97	191	27	145	5.3	3.8	8
22	Sepon 80-1	92	166	25	149	5.3	3.8	9
31	Melkamash	80	180	25	154	5.7	3.6	10
36	Chisumbanje	101	210	20	155	5.2	3.5	11
29	2KX 17/6	101	140	25	123	3.7	2.5	12
21	Tajarib	88	207	40	83	3.2	2.2	13
	Mean	94	182	24	156	5.4	3.8	
	S.E.	1.09	6.58	2.80	14.65	0.74	0.60	
	C.V.	2.0	6.2	20.2	16.2	24.4	27.7	
	LSD.05	1.59	9.5	4.08	21.34	NS		

Table 3. Summary of yield and variate means of Eastern Africa Co-operative Sorghum Regional Trials planted at Harare, Zimbabwe (altitude 1,506m)

Entry no.	Variety	Days to 50% flowering	Plant height (cm)	Weight of 1,000 seeds (g)	Plant population	Head weight (t/ha)	Yield (t/ha)	Rank
15	Bakomash 80	80	211	40	169	12.9	10.5	1
14	ESIP 12	84	205	38	144	11.5	9.6	2
17	Ikinyaruka	106	289	28	152	12.5	7.6	3
20	Chisumbanje	92	244	28	164	12.6	7.2	4
16	SVR 157	115	376	23	134	11.7	7.0	5
19	2KX 17	85	116	31	92	12.6	6.9	6
13	SVR 8	114	314	26	135	11.7	6.3	7
12	Buraihi	104	358	48	148	11.6	5.2	8
18	Susa	117	332	25	127	7.2	2.9	9
	Mean	100	272	32	140	11.5	7.0	
	SE	-	5.55	2.92	7.04	0.816	0.88	
	CV	-	3.5	15.5	8.7	12.2	21.6	
	$LSD_{.05}$	-	10.19	5.35	19.39	1.50	1.67	

porating yield trials, pest and disease management trials and also population trials will provide a better chance of extracting more reliable and meaningful information. An expanded regional exchange of local genetic material will enhance further co-operation.

There has been more emphasis on sorghum regional trials than on pearl millet, therefore, an intensified pearl millet co-operative program will certainly help expansion of a national program.

PLANS FOR NEXT SEASON

The National Sorghum and Pearl Millet Improvement Program is still small, therefore our efforts are still aimed at expanding it and increasing co-operation with local farmers. The gene pools will be increased by further introduction of new genetic material. Inbred development will be intensified to increase the number of adapted inbreds for the test cross program. Expanded international co-operation is envisaged.

Agronomy and crop protection trials on sorghum and pearl millet were carried out to reinforce the breeding program co-operative research work done for the East Africa Sorghum Regional trials, the purpose of this being to broaden the genetic pool of the program.

RESULTS OF THE EASTERN AFRICA CO-OPERATIVE SORGHUM REGIONAL TRIALS OF 1983/84

Brhane Gebrekidan*

BACKGROUND

Sorghum workers of the eastern Africa region, in their meetings of 17-20 October 1982 in Ethiopia, recommended: 'In order to initiate a regional program the meeting agrees that the SAFGRAD Co-ordinator will organize a regional sorghum variety trial for each of the four major agro-ecological zones. Trials will be based on entries contributed by national programs in the region'.

The main reasons for these regional trials were to evaluate the elite varieties available in each national program across the entire region and to find out the range of acceptance, in the region, of a given variety. Outstanding varieties from these trials may be identified by each national program and used for further testing and production and/or as parents in their breeding programs. The four adaptation zones identified for the regional trials were High Elevation, Intermediate Elevation, Low Elevation, and Very Dry Lowlands.

The regional trials, along with the annual workshops, are expected to contribute to strong linkages among the national programs of eastern Africa. By the time of this Third Regional Workshop, most of the sorghum and millet researchers of the region have come to know each other in person. This workshop will be the first opportunity for the participants to discuss the results of regional trials they have set up and run. The regional trials provide a good avenue for inter-country co-operation leading to free and rapid movement of germplasm,

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*SAFGRAD Co-ordinator for Sorghum and Millets, Eastern and Southern Africa, ICRISAT/SAFGRAD Program, P.O. Box 30786, Nairobi, Kenya

technical information, and research techniques. These trials also form a good basis for regional co-ordination of sorghum research. The visits to these trials by the Regional Co-ordinator provide an opportunity for the Co-ordinator and the Co-operator in each national program to jointly evaluate the trials.

MATERIALS AND METHODS

On the basis of the recommendations of the First Regional Sorghum Workshop in Ethiopia, seven countries in the region contributed 43 varieties for the four sets of regional trials. The list of entries, classified by contributing country and ecological zone, is given in Table 1. The numbers in the body of the table are the entry numbers as used in the four trials. Those contributing seeds sent 2-3 kg of each entry to the Co-ordinator in Nairobi. The trials were organized and seeds as well as trial handling guidelines and data forms were prepared and dispatched by the ICRISAT/SAFGRAD program in Kenya to 50 locations in eastern and southern Africa and the Yemens. The distribution list of the trials is given in Table 2.

All four trials were in randomized complete block design with three replications. It was recommended that the plot size used for all trials be 5m x 75cm x 5 rows with data taken from the centre three rows only. In some cases this was not followed. Cultural, crop protection, and fertilization practices were those normally used at each of the participating stations. The planting dates used at each station were also the normal planting times. In most situations, the seeds were drilled and seedlings thinned to the optimum spacing at each location. Data sheets, in duplicate, one to be returned to the Co-ordinator and the other to be retained by the Co-operator, were sent out. Data requested and recorded in full or partially were stand

Table 1. Entries contributed for the 1983 Eastern Africa Co-operative Regional Sorghum Trials

Contributing country	High elevation, >1,800m	Intermediate elevation, 1,500-1,800m	Low elevation, <1,500m	Very dry lowlands, rainfall < 500mm; elevation <1,500m	Total
Yemen AR	1. Kadasi	12. Buraihi	21. Tajarib	37. Gharib-red	8
	2. Hamra Hujaria		22. Sepon 80-1	38. Gharib-white	
	3. Al-Ganad				
Burundi	4. SVR 157	13. SVR 8	23. 5DX 160		3
Uganda			24. Serena	39. 3KX 72/1	8
			25. Seredo	40. 3KX 71/1	
			26. E525 HT	41. 3KX 73/4	
			27. 2KX 17/B/1	42. 3KX 76/5	
Tanzania			28. Tegemeo	43. 5DX 135/13/1/3/1	3
			29. 2KX 17/6		
Ethiopia	5. ETS 2752	14. ESIP-12	30. Gambella 1107	44. 76T1-23	7
	6. Alemaya 70	15. Bakomash 80	31. Melkamash 79		
Rwanda	7. BM 10	16. SVR 157	32. Badege		7
	8. BM 27	17. Ikinyaruka	33. Urumimbi		
		18. Susa			
Kenya	9. E-1291	19. 2KX 17	34. 76T1-23	45. Mukueni	7
	10. BJ 28X BG19		35. IS 8595	46. DB 822	
Total no. of entries	10	8	15	10	43

Table 2. Distribution list of the 1983 Eastern Africa Co-operative Sorghum Regional Trials

Country	High elevation > 1,800m	Intermediate elevation 1,500-1,800m	Low elevation < 1,500m	Very dry lowlands, < 1,500m and < 500mm	Total
Yemen AR	1	1	2	2	6
Burundi	1	1	1	-	3
Uganda	1	1	3	2	7
Tanzania	-	2	1	1	4
Ethiopia	2	2	3	2	9
Rwanda	1	1	1	-	3
Kenya	1	1	2	2	6
Yemen PDR	1	1	1	1	4
Somalia	-	1	-	2	3
Zimbabwe	-	1	1	-	2
Sudan	-	-	1	2	3
Total no. of entries	8	12	16	14	50

count, date and days to 50% flowering, plant height, disease score, insect score, bird damage, agronomic desirability, head weight, head number, grain yield, 1,000 seed weight, and remarks.

The uniform guideline for recording data as given to all co-operators contained the following information:

Stand count

Number of plants in the centre three rows of the plot.

Days to 50% flowering

Number of days from first effective rainfall date to the date when 50% of the plants in the plot started flowering.

Plant height

The mean height of the plants in the centre three rows of the plot, in cm.

Disease score

Visually score each plot for each major disease from 1 to 5 where 1 indicates little damage and 5 very severe damage.

Bird damage

Score each plot just before harvest from 1 to 5 where 1 indicates no bird damage and 5 represents very severe damage.

Overall agronomic desirability

Visually score each plot for overall agronomic desirability and adaptability from 1 to 5 where 1 represents excellent and 5 indicates very poor.

Head weight

The weight, in gm, of the dry ($<$15% moisture) sorghum heads harvested from the centre rows of each plot.

Head number

Count the number of grain-bearing harvested heads from the centre three rows of the plot.

1,000 seed weight

The weight, in gm, of a random sample of 100 seeds X 10 for each plot.

In this paper grain yield for those stations which have given weight of threshed grain per plot in gm has been converted to kg/ha. For those stations which have only reported yields as head weight in gm per plot, 70% of that weight was assumed to be the grain weight per plot and conversion to kg/ha was done and reported in the yield tables.

RESULTS AND DISCUSSION

Out of the 11 countries in Table 2 to which the four groups of trials were distributed, four are located in the southern hemisphere and the trials planted in these countries have not been completed yet. Therefore, no data had been received from any of these countries, except Zimbabwe, at the time this report was written. Data from one or more locations have been received from all countries of the northern hemisphere. Table 3 gives a classification of the traits evaluated by country and type of trial. In some stations, some traits were evaluated in one replication only. Only data on days to flowering, plant height, agronomic desirability, and grain yield

Table 3. List of locations and traits evaluated in the 1983 Eastern Africa Co-operative Sorghum Regional Trials

	1	2	3	4	5	6	7	8	9	10	11	12
High Elevation Trial												
Kakamega, Kenya	X	X	X	X		X	X	X	X	X	X	X
Lanet, Kenya	X	X	X	X		X	X					
Ibb, YAR		X	X			X		X	X	X	X	
Mukairas, YPDR	X	X	X		X	X	X	X		X	X	
Nazreth, Ethiopia		X										X
Intermediate Elevation Trial												
Ibb, YAR		X	X			X		X	X	X	X	
Katumani, Kenya		X	X				X	X				X
Nazreth, Ethiopia		X										X
Labora, Uganda	X	X	X									
Harare, Zimbabwe	X	X	X					X		X	X	
Low Elevation Trial												
Nazreth, Ethiopia			X									X
Taiz, YAR		X	X			X	X	X	X	X	X	
Zabid, YAR		X	X	X		X	X	X	X	X	X	
El-Kod, YPDR	X	X	X	X	X	X	X	X	X	X	X	
Ngetta, Uganda	X		X	X	X	X	X					X
Serere, Uganda	X	X	X	X		X	X	X	X	X	X	X
Wad Medani, Sudan		X	X			X						
Katumani, Kenya		X	X			X	X					X
Panmure, Zimbabwe	X	X	X					X		X	X	
Very Dry Lowlands												
Taiz, YAR		X	X	X		X	X	X	X	X	X	
Nazreth, Ethiopia		X										X
Katumani, Kenya		X	X				X	X				X
Bonka, Somalia										X		

1. Stand count
2. Days to 50% flowering
3. Plant height, cm
4. Disease score
5. Insect score
6. Bird damage score
7. Agronomic desirability
8. Head weight, gm
9. Head number
10. Grain yield, gm
11. 1,000 seed weight, gm
12. Remarks

appeared good enough to be summarized across countries and reported here.

High Elevation Trials

Data from five locations for number of days to flowering, plant height, grain yield and agronomic desirability for the High Elevation Trials are given in Tables 4, 5 and 6, respectively. The overall mean number of days to flowering across the five locations was 121 days, with Nazreth, Ethiopia reporting the lowest mean figure and Lanet, Kenya the highest. The first effective rain at Lanet was reportedly received a month after planting and the reported flowering days are apparently from the date of planting. Some entries took as long as 5 months to flower at Lanet. If 30 days are subtracted from each reported figure because of the delay in the rains the resulting numbers will be approximately as expected for the varieties in the high elevation set. The entries were also generally late at the two Yemen locations reporting data.

Table 5 shows that the entries were tallest (3m or more) at the two Yemen stations, also perhaps reflecting the photo-period sensitivity of most of the entries. The entries were generally shortest at Katumani, Kenya. The varieties contributed by Ethiopia and YAR were the tallest across most locations. The overall mean plant height for all varieties across the five stations was 264 cm. The data on flowering days and plant height taken together emphasize the point that in the high altitude areas of eastern Africa the most dominant varieties are late and tall. These are currently the most preferred plant types by local farmers of the region. The entries in this set are apparently the best available highland sorghums in each of the national programs of the region.

Table 4. Number of days to flowering of the High Elevation Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no.	Identi-fication	Seed source	Katu-mani, Kenya	Kaka-mega, Kenya	Lanet, Kenya	Nazreth, Ethiopia	Ibb, YAR	Muka-iras, PDRY	Mean
1.	Kadasi	YAR	88	92	152	74	108	115	105
2.	Hamra Hujariya	YAR	82	98	153	73	111	103	103
3.	Al-Ganad	YAR	73	81	152	73	106	111	99
4.	SVR 157	Burundi	92	90	151	80	102	122	106
5.	ETS 27	Ethiopia	112	125	138	84	141	122	120
6.	Alemaya	Ethiopia	100	122	151	97	119	127	119
7.	BM 10	Rwanda	79	89	124	73	105	129	100
8.	BM 27	Rwanda	77	84	124	70	99	127	97
9.	E-1291	Kenya	72	81	97	68	93	125	89
10.	BJ28 x BG19	Kenya	70	73	90	67	74	132	84
11.	Local check	Local	-	77	128	73	115	119	102
	Mean		84	92	133	76	107	121	102
	Local check		E-1291	E-525 HR	E-1291/ VA 206/ 26	Gambella 1107	Safari	Kori	

Table 5. Plant height, in cm, of the High Elevation Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no.	Identification	Seed source	Katumani, Kenya	Kakamega, Kenya	Lanet, Kenya	Ibb, YAR	Mukairas, PDRY	Mean
1	Kadasi	YAR	180	197	263	320	350	262
2.	Hamra Hujariya	YAR	205	294	325	362	367	311
3.	Al-Ganad	YAR	143	181	280	320	350	255
4.	SVR-157	Burundi	188	220	293	287	367	271
5.	ETS 2752	Ethiopia	225	296	252	367	359	300
6.	Alemaya 70	Ethiopia	228	303	288	330	363	302
7.	BM 10	Rwanda	220	273	312	313	366	297
8.	BM 27	Rwanda	195	206	240	240	375	251
9.	E-1291	Kenya	153	150	173	165	376	203
10.	BJ28 x BG19	Kenya	135	189	155	160	373	202
11.	Local check	Local	-	135	157	387	344	256
	Mean		187	222	249	295	363	264
	Local check		E-1291	E-525 HR	E-1291/ VA 201/ 26	Safari	Kori	

Table 6. Grain yield, in kg/ha, and agronomic desirability score, of the High Elevation Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no.	Identification	Seed Source	Katumani, Kenya	Katumani, Kenya A.D.*	Kakamega, Kenya	Lanet, Kenya A.D.*	Ibb, YAR	Mukairas, PDRY	Mean
1.	Kadasi	YAR	840	2.8	-	5.0	3,644	4,500	2,995
2.	Hamra Hujariya	YAR	1,501	2.5	-	5.0	3,393	4,200	3,031
3.	Al-Ganad	YAR	2,007	2.5	-	5.0	3,985	5,100	3,697
4.	SVR 157	Burundi	1,657	3.3	2,511	4.0	2,844	2,200	2,303
5.	ETS 2752	Ethiopia	267	4.5	-	5.0	3,585	3,300	2,384
6.	Alemaya 70	Ethiopia	-	4.8	-	5.0	3,126	3,300	3,213
7.	BM 10	Rwanda	1,867	3.3	2,481	4.0	889	2,100	1,834
8.	BM 27	Rwanda	2,135	3.3	2,980	3.7	1,733	2,000	2,212
9.	E-1291	Kenya	1,932	3.3	3,200	2.7	1,958	2,300	2,347
10.	BJ28 x BG19	Kenya	650	3.8	-	2.0	771	2,600	1,340
11.	Local check	Local	-	-	2,321	2.0	2,993	2,300	2,538
	Mean		1,428	3.4	2,699	3.9	2,629	3,082	2,459
	Local check		E-1291		E-525 HR	E-1291/ VA 201/ 26	Safari	Kori	

*Agronomic desirability, 1 most desirable, 5 least desirable

The yield data given in Table 6 are generally low. The two Yemens reported the highest mean yields with about 3 tons/ha each. Yields of over 4 tons/ha for the three entries from YAR were reported from Mukairas, YPDR. At Ibb, YAR the same three entries, Kadasi, Hamra Hujariya, and Al-Ganad, gave the highest yields of about 3.5 tons/ha each. Al-Ganad was the overall highest yielder across all locations. In agronomic desirability score at Katumani, Kenya, Al-Ganad and Hamra Hujariya were the best entries. However, at Lanet, Kenya, these Yemeni entries were scored as agronomically undesirable compared to the local check. A very special and prominent feature of the Yemeni entries was their extra large seed size. The high-altitude Rwanda sorghums with deep brown seeds were found undesirable under the high-altitude situations of Yemen and they did not seem to be very well adapted to the Yemen sorghum environment.

Intermediate Elevation Trials

Tables 7-9 give the agronomic data for the Intermediate Elevation Trials grown at four locations. The mean number of days to flowering for this group was 85 days. The varieties were latest at Ibb, YAR and Harare, Zimbabwe and earliest at Nazreth, Ethiopia. Plant height in this group was also much less than in the High Elevation Group. The only entry which was as tall as 3m was the local entry at Ibb. The Rwandaise and the Yemeni varieties were distinctly the tallest ($>$3m) at Harare, Zimbabwe. All entries were under 2m in height at Katumani, Kenya and Labora, Uganda.

The mean yield for this trial for the three yield-reporting stations, Katumani, Ibb, and Harare was about 3.8 tons/ha. At Katumani the best varieties, considering agronomic appearance and grain yield, were SVR 8 and ESIP-12. Bakomash

Table 7. Number of days to flowering of the Intermediate Elevation Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no.	Identi- fication	Seed source	Katu- mani, Kenya	Labora, Uganda	Ibb, YAR	Nazreth, Ethiopia	Harare, Zimbabwe	Mean
12.	Buraihi	YAR	71	89	89	69	104	81
13.	SVR 8	Burundi	77	70	108	77	114	89
14.	ESIP-12	Ethiopia	79	70	106	74	84	82
15.	Bakomash 80	Ethiopia	78	79	109	74	80	84
16.	SVR 157	Rwanda	72	75	95	69	115	85
17.	Ikinyaruka	Rwanda	71	77	94	68	106	84
18.	Susa	Rwanda	78	79	109	69	117	91
19.	2K X 17	Kenya	-	70	103	75	85	83
20.	Local check	Local	-	70	95	72	92	82
	Mean		75	75	101	72	100	85
	Local check		-	?	Juraa	Gambella 1107	Chisum- banje	

Table 8. Plant height, in cm, of the Intermediate Elevation Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no.	Identi-fication	Seed source	Katu-mani, Kenya	Labora, Uganda	Ibb, YAR	Harare, Zimbabwe	Mean
12.	Buraihi	YAR	135	190	252	358	233
13.	SVR 8	Burundi	160	181	192	314	212
14.	ESIP-12	Ethiopia	178	143	192	205	180
15.	Bakomash 80	Ethiopia	160	193	227	211	198
16.	SVR 157	Rwanda	192	121	278	376	242
17.	Ikinyaruka	Rwanda	168	166	217	289	210
18.	Susa	Rwanda	182	212	277	332	251
19.	2K X 17	Kenya	-	167	88	116	123
20.	Local check	Local	-	187	318	244	249
	Mean		168	173	227	272	217
	Local check		-	?	Juraa	Chisum-banje	

Table 9. Grain yield, in kg/ha, and agronomic desirability score of the Intermediate Elevation Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no	Identification	Seed source	Katumani, Kenya, AD*	Katumani, Kenya	Ibb, YAR	Harare, Zimbabwe	Mean
12.	Buraihi	YAR	3.3	2,035	1,656	5,200	2,963
13.	SVR 8	Burundi	2.5	2,502	2,182	6,300	3,661
14.	ESIP-12	Ethiopia	1.5	2,434	2,780	9,600	4,938
15.	Bakomash 80	Ethiopia	2.3	1,542	3,464	10,500	5,169
16.	SVR 157	Rwanda	3.0	2,194	3,367	7,000	4,187
17.	Ikinyaruka	Rwanda	3.5	1,658	2,074	7,600	3,777
18.	Susa	Rwanda	3.0	2,063	2,027	2,900	2,330
19.	2KX 17	Kenya	-	-	566	6,900	3,733
20.	Local check	Local	-	-	2,406	7,200	4,803
	Mean		2.7	2,061	2,280	7,000	3,780
	Local		-	-	Juraa	Chisumbanje	

*Agronomic desirability score, 1 most desirable, 5 least desirable

80 and SVR 157 were the best yielding entries for Ibb although the latter was not desired there because of apparent high tannin and brown seeds. At Katumani ESIP-12 has been selected for further trials and, similarly, Bakomash 80 has been advanced for further testing in the YAR. The highest yielding entries at Harare were Bakomash 80 and ESIP-12 with 10 tons grain/ha. Both of these varieties have been released by the Ethiopian program for the intermediate altitudes. The Harare station has reported a mean yield of about 7 tons/ha for the trial which was a very good yield by almost any standard. The local check variety, Chisumbanje, gave about 7 tons/ha of grain yield.

Low Elevation Trials

The Low Elevation Trials had the highest number of entries (16) and were grown by the largest number of locations compared to the other three trials. This group appeared to be of most interest in the region both from the point of view of entry contributions and request for grow-out of the trial. Taking eastern Africa as a whole, the crop in this ecological zone, below 1,500 m altitude, accounts for the bulk of the sorghum grain produced in the region.

The agronomic data reported by eight locations in seven countries are given in Tables 10-12. Data for days to flowering are given in Table 10. Compared to the high and intermediate altitude sorghums, this group was much earlier across all locations, with an overall mean of 76 days to flowering. Wad Medani, Sudan and Panmure, Zimbabwe with 95 and 94 days, respectively, reported the longest time to flowering. Since the trial at Wad Medani was irrigated, the high figure appears to be a reflection of delayed irrigation. Serere, Uganda and El-Kod, YPDR, with 62 and 65,

Table 10. Number of days to flowering of the Low Elevation Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no.	Identi- fication	Seed source	Katu- mani, Kenya	Naz- reth, Ethi- opia	Serere, Uganda	Taiz YAR	Zabid YAR	El- Kod, YPDR	Wad Medani, Sudan	Pan- mure, Zimba- bwe	Mean
21.	Tajarib	YAR	70	70	54	72	66	80	89	88	73
22.	Sepon	YAR	70	67	57	82	71	79	95	92	76
23.	5DX 160	Burundi	72	73	64	96	74	63	100	103	80
24.	Serena	Uganda	71	68	62	86	67	64	94	94	77
25.	Seredo	Uganda	74	70	67	87	67	63	93	97	77
26.	E525 HT	Uganda	74	69	60	88	67	62	94	98	76
27.	2KX 17/13/1	Uganda	74	72	65	89	76	63	97	99	79
28.	Tegemeo	Tanzania	76	72	65	89	75	62	97	97	77
29.	2KX 17/6	Tanzania	76	75	66	93	74	61	98	101	80
30.	Gambella 1107	Ethiopia	68	72	63	81	72	65	95	93	79
31.	Melkamash 79	Ethiopia	73	74	60	60	66	64	77	80	69
32.	Badege	Rwanda	90	92	69	-	63	65	104	*	80
33.	Urimimbi	Rwanda	89	77	67	-	66	64	106	*	78
34.	76T1-23	Kenya	70	65	59	61	61	67	77	80	68
35.	IS 8595	Kenya	76	70	58	96	61	64	102	*	75
36.	Local check	Local	-	73	59	89	67	63	97	101	78
	Mean		75	72	62	83	68	65	95	94	76
	Local check		76T1-23	Gambe- lla 1107	E1937	?	Gaira- ia	Be- ini	Dabar	Chisum- banje	

*Vegetative only, no seed set

respectively, had the earliest flowering days. Two varieties 76T1-23 and Melkamash 79, took under 70 days to flower across all locations. The latest entries were the two Rwandaise varieties, Badege and Urumimbi. Further, since the two stations with about 15½° N (Wad Medani) and 17½° S (Harare) latitude have the longest days during the crop season, the late flowering days may also be a reflection of the photosensitivity of most of the entries in this trial.

Table 11 gives the data on plant height in cm. Compared to the high and intermediate elevation sorghums the Low Elevation group were shorter with an overall mean of 174 cm. Katumani, Kenya and Taiz, YAR, respectively, reported mean heights of 132 and 147 cm. These were the shortest reported, whereas Serere, Uganda and Taiz, YAR reported the tallest mean heights, about 2 m, for the trial. The three varieties which were tallest across all locations, Badege, Urumimbi, and Tajarib, show some very interesting interactions, if the data are not in error. Tajarib with 352 cm at El-Kod was the tallest entry at that location and yet at Katumani with 110 cm height it was one of the shortest entries. The two Rwandaise entries, Badege and Urumimbi, measured about 3 m each at Serere, Uganda and Zabid, YAR and yet the same varieties were reported as the shortest entries at El-Kod, YPDR, with about 1 m height only. These data need further checking and confirmation before any conclusion can be drawn on this apparent variety x location interaction.

For the Low Elevation Trial, data on grain yield and agronomic desirability scores are given in Tables 12 and 13, respectively. The yields were generally low with an overall mean of just over 20 q/ha. The trial at El-Kod was irrigated and those at Katumani and Taiz received supplementary irrigations as well. Seven varieties produced about 3 tons/ha or over at El-Kod out of which Sepon 80-1, Gambella 1107 and Melkamash 79 were considered most desirable for the Yemeni

Table 11. Plant height, in cm, of the Low Elevation Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no.	Identi- fication	Seed source	Katu- mani, Kenya	Serere, Uganda	Taiz YAR	Zabid, YAR	El- Kod, YPDR	Wad Medani, Sudan	Pan- mure, Zimba- bwe	Mean
21.	Tajarib	YAR	710	196	170	228	352	197	207	209
22.	Sepon 80-1	YAR	128	177	120	170	208	153	166	160
23.	5DX 160	Burundi	130	209	153	187	164	180	200	174
24.	Serena	Uganda	122	175	157	168	165	170	190	163
25.	Seredo	Uganda	122	178	160	162	160	170	182	162
26.	E525 HT	Uganda	115	178	158	164	152	180	189	162
27.	2KX 17/13/1	Uganda	110	172	167	191	162	188	188	168
28.	Tegemeo	Tanzania	120	182	145	191	196	183	191	173
29.	2KX 17/6	Tanzania	108	162	143	158	183	147	140	149
30.	Gambella 1107	Ethiopia	132	196	163	218	217	203	186	188
31.	Melkamash	Ethiopia	147	185	123	155	190	137	180	159
32.	Badege	Rwanda	208	322	-	306	105	280	*	244
33.	Urimimbi	Rwanda	185	294	-	287	112	230	*	222
34.	76T1-23	Kenya	108	130	103	149	118	143	144	128
35.	IS 8595	Kenya	-	193	170	195	118	163	*	168
36.	Local check	Local	-	189	125	360	251	137	210	212
	Mean		132	196	147	206	178	179	182	174
	Local check		76T1-23	E-1937	?	Gairaia	Beini	Dabar	Chisum- banje	

*Vegetative only, no seed set

Table 12. Grain yield, in kg/ha, of the Low Elevation Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no.	Identi-fication	Seed source	Katu-mani, Kenya	Sere-re, Uganda	Taiz, YAR	Zabid, YAR	El-Kod, YPDR	Pan-mure, Zimbabwe	Mean
21.	Tajarib	YAR	1,119	1,182	2,177	643	2,400	2,200	1,620
22.	Sepon 80-1	YAR	910	952	3,423	1,389	3,800	3,800	2,379
23.	5DX 160	Burundi	2,207	2,588	1,343	1,493	2,800	3,800	2,372
24.	Serena	Uganda	1,559	2,862	2,583	1,514	3,100	4,100	2,620
25.	Seredo	Uganda	1,626	2,613	3,303	1,493	2,900	4,700	2,772
26.	E525HT	Uganda	1,966	1,898	2,644	1,493	3,000	3,900	2,483
27.	2KX 17/13/1	Uganda	313	604	3,080	1,058	2,100	4,500	1,942
28.	Tegemeo	Tanzania	525	460	1,813	1,244	1,400	3,800	1,540
29.	2KX 17/6	Tanzania	1,186	479	1,680	1,182	1,300	2,500	1,387
30.	Gambella 1107	Ethiopia	1,311	1,070	2,769	1,082	2,800	4,200	2,205
31.	Melkamash 79	Ethiopia	1,142	1,935	2,303	1,224	2,900	3,600	2,184
32.	Badege	Rwanda	2,593	1,898	-	124	2,100	*	1,679
33.	Urumimbi	Rwanda	2,121	2,626	-	124	1,300	*	1,543
34.	T6T1-23	Kenya	381	2,103	1,431	1,411	1,300	4,300	1,821
35.	IS 8595	Kenya	-	1,157	840	291	1,400	*	825
36.	Local check	Local		1,842	2,924	352	1,700	3,500	2,063
	Mean		1,293	1,642	2,308	1,007	2,269	3,800	2,053
	Local check		T6T1-23	E-1937	?	Gairaia	Beini	Chisum-banje	

Table 13. Agronomic desirability score* of the Low Elevation Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no.	Identi-cation	Seed source	Katumani, Kenya	Serere, Uganda	Taiz, YAR	Wad Medani, Sudan	Mean
21.	Tajarib	YAR	3.5	2.3	2.7	4.7	3.3
22.	Sepon 80-1	YAR	3.0	3.0	2.0	2.8	2.7
23.	5DX 160	Burundi	2.3	1.7	4.3	4.0	3.1
24.	Serena	Uganda	3.0	1.0	4.0	4.0	2.8
25.	Seredo	Uganda	2.8	1.0	2.0	3.3	2.3
26.	E525 HT	Uganda	3.0	1.7	2.7	4.0	2.8
27.	2KX 17/13/1	Uganda	2.5	2.3	2.0	3.0	2.4
28.	Tegemeo	Tanzania	2.5	1.7	2.3	3.3	2.4
29.	2KX 17/6	Tanzania	2.5	1.7	3.0	4.0	2.8
30.	Gambella 1107	Ethiopia	2.0	2.0	2.0	2.5	2.1
31.	Melkamash 79	Ethiopia	2.3	2.0	3.0	2.7	2.5
32.	Badege	Rwanda	3.0	1.3	5.0	5.0	3.6
33.	Urumimbi	Rwanda	3.0	1.3	5.0	5.0	3.6
34.	76T1-23	Kenya	3.3	1.7	4.0	2.7	2.9
35.	IS 8595	Kenya	3.5	3.0	3.3	5.0	3.7
36.	Local check	Local	-	2.0	2.3	3.0	2.4
	Mean		2.8	1.8	3.0	3.6	2.8
	Local check		T6T1-23	E-1937	?	Dabar	

*Most desirable, 5 least desirable

situation. Sepon 80-1 was the highest yielding entry at Taiz and El-Kod. This variety has recently been released in YAR. Although varieties like Seredo have yielded well in Yemen, their grain quality is not considered good enough for acceptance by Yemeni farmers. Based on the overall agronomic desirability score, the best entries for Katumani were Gambella 1107, Melkamash 79 and 5DX 160. At Serere the best varieties were the Serere bred varieties Serena and Seredo, but these varieties did not have good scores in Wad Medani, Sudan, mainly because of their poor grain quality. In Taiz the best agronomic desirability scores were given to Sepon 80-1, Seredo, 2KX 17/13/1 and Gambella 1107. At Panmure, Zimbabwe, five varieties, Seredo, Serena, 2KX 17/13/1, Gambella 1107, and 76T1-23 gave over 40 q/ha. The first three varieties are from Serere whereas the last two are from the Ethiopian program.

Very Dry Lowlands Trials

Sorghum production under very dry lowland situations in eastern Africa has a high probability of failure. In this region there are areas below 1,500 m in altitude having less than 500mm annual rainfall. Since such conditions make sorghum production very difficult, most countries in the region have indicated a strong interest in the trial designed for this ecological zone. All countries in the region, except Burundi and Rwanda, requested this trial for testing in their very dry lowlands. In all of the countries that have grown this set in very dry lowland rainfed stituations the trials have reportedly failed. The data for this set reported in Tables 14 and 15 are from areas with more reliable rainfall and supplemental irrigation conditions. All the three stations reporting some results on this set, Katumani, Taiz, and Nazreth, have reported giving supplemental irrigation.

As expected, this group contained some of the earliest entries of the four trials discussed in this report. The

overall mean number of days to flowering for the three reporting stations was 73 days, with Katumani and Nazreth reporting 62 and 69 days, respectively, as location mean. Gharib red and Gharib white were by far the earliest entries (53 days) at Katumani. They were, however, too grass-like with very low seed number on the panicle and were rated lowest in agronomic desirability at that location. At Taiz, some of the entries, such as Mukueni, DB 822, and 5DX 135/13/1/3/1 were relatively late, taking 100 days or more to flower.

Grain yield (Table 15) for this group, both at Katumani and Taiz, was very low. The very low yields at Katumani are mostly due to very poor stand establishment. At Katumani, the most desirable entries in the lot were the two local entries, Makueni and DB 822. The varieties available from the national programs for this zone would need a lot of improvement so that better and more stable yields could be realized from this difficult sorghum production zone of the region.

CROP PROTECTION AND OTHER COMMENTS FOR ALL SETS

For all of the four sets, the data recorded on stand count, disease and insect score, bird damage, and 1,000 seed weight appeared erratic in some of the locations and did not lend themselves to analysis across locations. Some varieties, such as 2KX 17, entry No. 19 in the Intermediate Elevation Set, had very poor stands across all locations. This was apparently due to weevil damage on the seed that was sent out. Many of the entries with white and pearly grains were severely damaged by birds at several locations. In general, however, diseases

Table 14. Number of days to flowering and plant height (cm) for the Very Dry Lowlands of the Eastern Africa Co-operative Sorghum Regional Trials

Entry no.	Identification	Seed source	Katumani, Kenya		Days to flowering		Mean days to flowering
			Days to flowering	Plant height cm	Taiz, YAR	Nazreth Ethiopia	
37.	Gharib Red	YAR	53	135	75	64	64
38.	Gharib White	YAR	53	140	67	68	63
39.	3KX 72/1	Uganda	70	93	90	66	75
40.	3KX 71/1	Uganda	72	110	94	65	77
41.	3KX 73/4	Uganda	67	128	88	67	74
42.	3KX 76/5	Uganda	62	115	88	64	71
43.	5DX 135/13/1/3/1	Tanzania	70	115	103	71	81
44.	76T1-23	Ethiopia	72	118	67	67	69
45.	Makueni	Kenya	76	188	102	75	84
46.	DB 822	Kenya	81	180	99	74	85
47.	Local check	Local	-	-	85	74	80
	Mean		62.3	132	87	69	73
	Local check		DB 822		SPV 386	Gambella 1107	

Table 15. Grain yield, in kg/ha, and agronomic desirability* score of the Very Dry Lowlands Set of the Eastern Africa Co-operative Sorghum Regional Trials, 1983

Entry no.	Identi-fication	Seed source	Katumani, Kenya*	Katumani, Kenya	Taiz, YAR	Mean grain Yield
37.	Gharib Red	YAR	5.0	461	1,365	913
38.	Gharib White	YAR	5.0	393	1,423	908
39.	3KX 72/1	Uganda	3.0	321	1,345	833
40.	3KX 71/1	Uganda	3.0	437	733	585
41.	3KX 73/4	Uganda	3.5	552	1,039	795
42.	3KX 76/5	Uganda	4.0	880	773	826
43.	5DX135/13/1/3/1	Tanzania	2.8	1,847	1,071	1,459
44.	76T1-23	Ethiopia	3.0	635	983	809
45.	Mukumi	Kenya	2.3	1,143	1,481	1,312
46.	DB 822	Kenya	2.5	356	1,308	832
47.	Local check	Local	-	-	1,308	1,308
	Mean		3.4	702	1,166	934
	Local check		DB 822		SPV 386	

*Agronomic desirability score, 1 most desirable, 5 least desirable

and insects were reported not serious at most locations. High insect scores were indicated at the YPDR locations without designation of the insect causing the problem. Aphids and shoot-fly were reportedly seen on the trials. Zabid, YAR, reported significant leaf blight with the YAR variety Tajarib being the most susceptible and 2KX 17/6 from Tanzania the most tolerant entries. The Yemeni high altitude sorghums did not set seed at the high altitude location in Kenya (Lanet). At Lanet, high disease scores were recorded without designation of the disease.

SUMMARY OF ENTRIES ADVANCED FOR FURTHER TESTING AND/OR UTILIZATION

For the seven countries from which results of one or more of the four trials were expected, the advanced entries are given below by country:

Yemen Arab Republic

In general, the local Yemeni varieties were considered superior to all of the introduced varieties, primarily based on grain size and colour. Two entries from Ethiopia, Bakomash 80 and Melkamash 79, have been selected for further testing.

Yemen People's Democratic Republic

The preference for extra large seed without testa seems to hold here just as in YAR. The entries from YAR and Ethiopia were considered best for YPDR conditions. Promising entries selected for further testing were Al-Ganad, Kadasi, Hamra

Hujariya, Tajarib and Sepon 80-1 from YAR and ETS 2752, Alemaya 70, Gambella 1107 and Melkamash 79 from Ethiopia.

Sudan

No information on entries advanced from these trials has been given. However, based on agronomic appearance score, the entries which were better than Dabar-1, the standard local check, were Gambella 1107, Melkamash 79, 76T1-23, and Sepon 80-1.

Ethiopia

Since the Ethiopian quarantine regulations have not allowed the growing of the four trials in the appropriate ecological zones, all observations for the four sets of trials were made at the central co-ordinating station, Nazreth, only. Therefore, tight selection pressure was not applied on those materials which should have been grown in stations ecologically different from Nazreth. Accordingly, Kadasi, Hamra Hujariya, Al-Ganad and Badege were selected for future high elevation trials. Some 12 entries with brown seeds were selected for a special brown seeded sorghums trial for the Nazreth area. Some of the 2KX entries and Sepon 80-1 were also selected for further testing. Entries selected as parents for the Ethiopian crossing program were Tajarib, DB 822, and 3KX 73/4.

Kenya

The results presented of trials planted at Kakamega and Lanet did not indicate entries to be advanced. At Katumani, the selections made for further testing were ESIP-12, Bakomash 80, 5DX 160, Gambella 1107 and Melkamash 79. These selections were made in the 1983 short rains and they have already been

planted in this 1984 long rainy season.

Uganda

No comment has been made about advancing any of the entries from the trials. In general, the Serere bred varieties such as Serena, Seredo and 5DX 160 (from Burundi) had the best rating for agronomic desirability.

Somalia

Incomplete results received from the Bonka station indicate that in the Very Dry Lowlands Trial the 3KX series, from Uganda, gave a mean yield of about 5 q/ha and reportedly appeared promising.

Zimbabwe

The best performing varieties in the Intermediate set in Harare were Bakomash 80 and ESIP-12. Both of these varieties have been released by the ESIP. For the Panmure area the best varieties were Seredo, Serena, and 2KX 17/13/1 from Uganda and Gambella 1107 and 76T1-23.

Burundi, Rwanda and Tanzania

Results have not been received yet.

In general, looking at the performance of several varieties it can be said that the transferability of varieties within the same ecological zone, i.e. between countries in Eastern Africa, is quite good. The implication of this good transferability of varieties between countries is that a regional breeding program, based on distinct ecological zones, can develop varieties suitable for a number of countries of the region.

ACKNOWLEDGEMENTS

The co-operation of the sorghum researchers in the national programs of eastern and southern Africa and the Yemens in contributing seeds and growing out the trials is gratefully acknowledged. A list of Co-operators is given at the end of this paper.

LIST OF CO-OPERATORS IN THE 1983/1984 EASTERN AFRICA CO-OPERATIVE SORGHUM REGIONAL TRIALS

Burundi

Mr Zenon Kabiro

Ethiopia

Dr Biru Abebe
Dr Yilma Kebede

Kenya

Mr J.K. Rutto
Mr G.K. Njehia
Mr C.M. Adamson
Mr Ben M. Kanyenji
Dr Abdul Shakoor

Rwanda

Mr Celestin Sehene

Somalia

Mr A.N. Alio
Dr E.K. Alahaydoian
Mr Ali Nur Duale

Sudan

Dr Abd Ellatif M. Nour
Dr Gebisa Ejeta
Dr Trygve Berg

Tanzania

Mr Clemence S. Mushi
Mr H.M. Saadan

Uganda

Mr Vincent Makumbi Zake
Mr J.P.E. Esele

Yemen Arab Republic

Dr Ali Kambal

Yemen Peoples Democratic Republic

Mr Abdul Aziz Bawazir

Zimbabwe

Mr Joseph N. Mushonga

THE ROLE OF INTSORMIL IN SORGHUM AND MILLET IMPROVEMENT IN EASTERN AFRICA

John A. Mann*

INTRODUCTION

INTSORMIL is a consortium of eight U.S. universities with expertise in sorghum and millet improvement, agronomy, entomology, pathology and utilization, and a commitment to using this expertise to help improve these crops in the developing world. INTSORMIL's fundamental commitment is to increase the productivity of small farmers worldwide who depend on sorghum and millets for their families' food, and at the same time to help provide a more nutritious diet for those families.

INTSORMIL is one of several such groups funded by the United States Agency for International Development (USAID). The money is channeled through INTSORMIL to participating universities, with the intent of Congress being that this money be used to strengthen research in the U.S. in areas relevant to LDC problems and to develop collaborative ties between U.S. scientists and their colleagues in the developing world. This involves scientific exchanges as well as the collection and development of germplasm suitable for direct use by LDC scientists. In addition, INTSORMIL institutions are expected to take the lead in the training of scientists from countries where sorghum and millets are produced and consumed. It was (and is) the hope of Congress that such ties would help develop the internal infrastructure of agriculture in the LDCs by providing strong research back-up and technical assistance to those newly trained scientists and their colleagues from a cadre of U.S. scientists having interest and expertise in similar areas of endeavour.

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*INTSORMIL/OSU-FSR, Sorghum/Millet Improvement, Ilonga, Tanzania

INTSORMIL is now ending its fifth year: in this audience are a number of scientists trained by INTSORMIL institutions, and I'm sure a number of others who soon will be going to those institutions for advanced degrees. In the past when scientists such as yourselves returned home from training to begin work, you left the expertise of your professors behind, other than perhaps an encouraging letter now and again. INTSORMIL funding for those participating institutions means, however, that expertise can still be available. A large part of INTSORMIL money in every Principal Investigator's budget goes to travel, and thus those scientists are available to visit and consult with you at your station. It also means that those U.S. scientists with larger budgets than yours can take on the task of doing basic research important to you, and let you apply the results in your program.

As INTSORMIL expands its role in the sorghum/millet growing areas of the world, two additional types of assistance are being developed. One of these is the long-term assignment of INTSORMIL scientists to developing countries to give assistance not directly tied to the usually short-term USAID projects. This should allow for the identification and training of staff, and then allow the newly trained staff members to work with the INTSORMIL employee for a period of time to gain experience and insure a smooth transition. INTSORMIL has such employees in Honduras and Tanzania at present, as well as one Principal Investigator seconded to CIAT in Columbia. A second type of assistance being tried is to identify LDC scientists with superior programs but limited internal budget support and supplement their research programs with INTSORMIL funds. This would allow them more flexibility in their purchase of needed supplies, and strengthen their overall ability to do their job without aid projects.

INTSORMIL IN TANZANIA

INTSORMIL and the Tanzania Agricultural Research Organization signed a Memorandum of Understanding in 1982 whereby INTSORMIL agreed to supply to TARO a sorghum/millet improvement specialist, to be included in a proposed (and now functional) Farming Systems Research Project. In the summer of 1982 materials were selected and a large number of crosses made in College Station, Texas, for eventual inclusion in the TARO sorghum program at Ilonga. Because most of the Texas material is directly derived from the Sorghum Conversion Program and is thus of rather recent African origin, much of the introduced material has proven well adapted if not perfectly suited to Tanzania conditions. Previous experience had also shown that many of the Texas lines were very well adapted to Tanzania as well as other east African countries.

From INTSORMIL germplasm stocks, a total of 932 F2 bulks, over 650 F3 lines and 350 'genetic resource' lines are in the TARO nurseries at Ilonga. In addition, there are two populations in the sixth breeding cycle (one a tan plant, white-seeded food type), S1-S3 selections from those populations, and over 500 lines of BC1 Ms3 genetic male sterile material being developed for eventual inclusion in synthetic varieties. In all, over 8,000 5m rows have been planted this year. By the beginning of next season these materials will have been incorporated into the on-going program at Ilonga, and will have become a part of the necessary expansion of the program and its germplasm base. These materials will also be available to any public sector breeder in eastern Africa, upon request.

INTSORMIL IN EASTERN AFRICA

It is the mandate of the U.S. Congress, and the intent of the

management and scientific personnel within INTSORMIL, that INTSORMIL play an active role in sorghum/millet development here in Africa, in Asia and Central America where these crops are primary foods for human consumption. I will try to describe in brief how INTSORMIL becomes involved in such development programs, what kind of services they can offer, who is involved, and what their areas of expertise are. Typically INTSORMIL becomes involved in sorghum/millet work in a country when a request for assistance is received via the USAID mission in that country. The request originates from the appropriate government body and might, for example, request technical assistance in solving a particular pathological or entomological problem. Such a request might also ask for a broad spectrum of assistance. In any case, the Management of INTSORMIL would ask for assistance from their scientists in the appropriate field(s), and a visit to the country making the request would ensue. During that visit, the INTSORMIL scientists would assess the problem and suggest some kind of arrangement whereby INTSORMIL could become involved on a formal basis with the research organization responsible for the problem in the host country. After satisfactory negotiations, some kind of Memorandum of Agreement might be signed detailing the problem and the commitments of each party to solve the problem. This might involve scientific exchanges, consultancies on a regular basis in either or both directions, solving of a basic research problem at a U.S. university, training of host country scientists, or any other satisfactory arrangement. INTSORMIL and the host country scientific research organization would then establish and maintain a collaborative relationship until that problem was solved, or until the host organization was strengthened to the point of self sufficiency. At all times, continued INTSORMIL assistance would be at the discretion of the host government.

For further information about INTSORMIL please contact Dr Glen Vollmar, Director, 241 Keim Hall, University of Nebraska, Lincoln, NE 68538-0723, U.S.A.

CONCLUSION

Now that you have some idea of how and why INTSORMIL functions and how we can help you in your sorghum/millet program, I would invite any and all of you to spend some time with me during the remainder of this conference to discuss how we at INTSORMIL can be of assistance to you. Like all organizations, INTSORMIL runs on a limited budget, and cannot do everything for everyone. We would, however, like to establish at least informal ties with each of you, and thus be aware of your interests and problems. In this way we can serve you, and thus speed progress in the development of sorghum and millets as food for the world's hungry. I thank you for your time and attention.

SUMMARY OF DISCUSSIONS

TANZANIA

Alahaydoian

In the case of brown sorghums, supposedly unpalatable to the birds and which are grown on large scale, has anybody been able to evaluate the loss of crop due to birds ? Is it true that the birds will not eat the brown sorghums ?

Doggett

It all depends on the amount of bitterness at the stage which coincides with the arrival of the birds. I have seen a white palatable variety which stood untouched whereas a bitter brown variety was completely eaten at dough stage. I have seen 4,000 acres of Dobbs wiped out by birds.

Alahaydoian

In your trials for Striga resistance, have you been able to isolate any lines with resistance ?

Saadan

We are at the stage of increasing the seed we have received from ICRISAT, and we shall carry out trials and identify resistant varieties in the very near future.

TANZANIA (contd)

Doggett

ICRISAT and IDRC are supporting a program of *Striga* resistance in West Africa, and already one variety which is brown seeded has been selected as resistant.

Brhane

How is the co-ordination between the sorghum improvement activities of TARO and the University of Dar es Salaam done ?

Saadan

Scientists from the University of Dar es Salaam are invited to attend and participate in the TARO Co-ordinating Committee meetings. There are also some research projects handled jointly by TARO and the University. However, we need to improve the co-ordination between the two institutions.

Esele

In your presentation of an overview on the Tanzania National Sorghum Improvement Program, it was mentioned that the variety 5D x 135/13/1/13/1, which in Uganda is named 'Seredo' is not liked by Tanzania farmers. Could there be any other reasons, other than colour, that make farmers not to prefer this variety ? In Uganda, this variety has a high preference by farmers.

TANZANIA (contd)

Saadan

Serena, which has the same colour as 5D x 135/13/1/13/1, is being eaten in Tanzania. The Tanzania seed release committee did not see the need to release this variety because it is very similar to Serena in many respects.

Doto

More discussions on the Quelea problem are needed. This will enlighten us further as to which cultivars should be used in the breeding programs either brown, yellow or white. Methods should be designed on how to go around this problem. We would like to get ideas on what is happening in other countries of the region on this serious problem.

Brhane

We discussed this issue during our workshop in Rwanda last year. We have made arrangements for a specialist, Dr Michael Jaeger, to give a special paper on this topic on Friday.

Doggett

After working so long on bird resistant sorghums, I do not believe we can solve the problem through breeding alone.

Alahaydoian

Does the Tanzania farmer practice intercropping

TANZANIA (contd)

usually and are the legume plant populations used in your experiment typical of what farmers use ?

Mbowe

Intercropping is very popular in Tanzania. The populations used by the farmers for the main as well as for the intercrop are much lower, perhaps 50% lower than the population used in our experiment.

Kirkby

Mr Mbowe's paper appeared to comprise an excellent example of the sensible application of a farming systems perspective on the research station. Rather than relying upon evaluation by calculating LER (Land Equivalent Ratio) alone, or by calculating total economic value of the two associated crops, he has tried to anticipate farmers' likely adoption of each treatment by giving consideration to their preferences, needs for production of legumes and of cereal crop. My question, then, is how Mr Mbowe established these assumptions are correct, i.e. what further work will be done before issuing a recommendation to farmers ?

Mbowe

Farmers' preferences for increasing sorghum vs. legume were established during discussions with farmers involved in Village Trials. The next step will be to conduct on-farm trials with the more promising treatments, to verify their acceptability.

TANZANIA (contd)

Nour

You have commented that groundnut controls *Striga* by increasing soil fertility. Is the control not due to the suicidal germination of *Striga* plants induced by the groundnuts rather than increased fertility ?

Mushi

Intercropping is practised widely thus there are intercrops which increase soil fertility.

ETHIOPIA

Brhane

In trials involving both high tannin brown sorghums and white palatable ones, birds normally wipe out the palatable sorghums and do little damage on others since they have been provided with a choice.

Unless the sorghums are palatable, birds usually avoid high tannin sorghums as they have other

ETHIOPIA (contd)

alternatives such as seeds of wild grasses.

Schmidt

Are Melkamash 79, Gambella 1107 and ETS 2752 widely grown varieties in Ethiopia ?

Yilma

They are released varieties for the high altitude areas (ETS 2752) and low elevation regions (Melkamash 79 and Gambella 1107). However, there are no good statistics bearing on their distribution.

Zake

Why don't you include locally grown sorghums as checks in your breeding nurseries ?

Yilma

The local sorghums are included as checks in our various yield trials.

Mushi

In the fertilizer trials conducted, you have used a nitrogen dose of 150 kg/ha which has resulted in significantly higher grain yield. Have you looked at the economic feasibility of applying such a high dose ?

ETHIOPIA (contd)

Yilma

No, we have not but the socio-economic section of the IAR has a program that deals with this issue.

KENYA

Mushi

In your studies on the possible mechanism of resistance/tolerance to Striga infestation, what method and equipment are used ?

Ochanda

Striga sick plots are normally used to screen sorghum germplasm for resistance/tolerance. Counts of Striga plants are made and susceptible sorghum checks are used.

Doggett

Is the Kenyan program engaged in co-operative

KENYA (contd)

activities with Serere and/or with Dr Ramaiah's <u>Striga</u> program in Upper Volta ?

Ochanda

Efforts have been made to get Dr Ramaiah's input into our program. Some materials have already been received from him but we have yet to receive his <u>Striga</u> nursery. We do not have major co-operative activities with Serere but I believe we should.

Kirkby

You report that increased contact with farmers by means of the T & V extension system has led to a realization that recommendations need to be more site-specific. How has this affected your program planning and the likely future development of your research program ?

Ochanda

We have initiated on-farm trials on farmers' fields in the areas of plant densities for sorghum and maize and time of planting trials for cotton. This is in all the division of Busia District where I am located. We thus hope to involve the farmers in what is being investigated and that their early participation will provide an opportunity for them to evaluate the treatments that suit them most in their own conditions.

KENYA (contd)

Esele

I am particularly interested in your program because I know that most of the materials handled at Serere are also handled in Kenya. One problem is blast on finger millet. We look at this disease as a major constraint in the production of finger millet in Uganda. At Serere, we have programs on screening and breeding for blast resistance. I notice no mention of this important disease is made in the Kenya report. May I know whether the disease is of no eonomic importance in Kenya ?

My second question is on charcoal rot in eastern Kenya. Some time in 1980/81, most of the sorghum lines at Machakos had succumbed to this disease and there was a more or less total loss of the crop. What is the situation now ? Is anything being done on this disease in eastern Kenya ?

Ochanda

Blast is an important disease in Kenya. We screen for this disease but our main concern is to classify the materials into either early or late maturity for our two maturity group programs: early for eastern and late for Western Kenya.

M'Ragwa

Charcoal rot is still one of the diseases we are screening for. It continues to be the major disease

KENYA (contd)

under severe moisture situations in eastern Kenya.

RWANDA

Alahaydoian

The trials reported from experimental stations are very high. How do these compare with farmers' yield levels ?

Sehene

Sorghum yields of farmers are about half those obtained in trials, mainly due to later planting, poor weeding and broadcast sowing.

SOMALIA

Kirkby

While I am sure we all sympathize with the serious

SOMALIA (contd)

problems of research station management faced by the Somali sorghum program, these may not be entirely unique to that country. Are there ways of improvising and overcoming the limitations, at least until station management improves. For example, CV's used to be very high on trials conducted at Ilonga, Tanzania. One strategy followed was to rent more representative and uniform land from a farmer and fence it for trials.

Alahaydoian

Yes, this could be done, although it would require additional funds for rent and for employing guards. Fencing may have to be improvised using thorny branches since fencing wire is unavailable.

Yilma

A different set of problems which are in a way controllable e.g. land preparation, weeding, and fertility were mentioned. These are basic to a research program and unless these pre-conditions are met how can one operate ?

Alahaydoian

Yes, these are basic problems that contribute to a great deal of variability in our research results. We are trying to alleviate these problems but they still exist.

Yilma

Does a backcross program involving drought resistant

SOMALIA (contd)

and local materials help in producing drought resistant cultivars ?

Alahaydoian

There are no specific major genes for drought resistance and we are not relying on a backcross program only but we are also carrying our material through a pedigree breeding scheme.

Yilma

The variety Gharib did not appear impressive under our Ethiopian conditions. It did not carry very much seed. Can you comment further about it ?

Alahaydoian

Since it is early and has bold seeds it appeared adapted to lowland conditions of Somalia.

SUDAN

Mushi

Rainfall distribution rather than annual amount seems

SUDAN (contd)

to be a problem in the Sudan. Have you tried soil moisture conservation practices such as fallowing which which are said to store moisture for the following season ?

Nour

We have not, but we have our agricultural engineers who look into this issue in detail.

Menkir

While screening for Striga tolerance, is there a close relationship between laboratory screening and field evaluation ?

Nour

No, there is not. The low correlation observed could be ascribed to differences in the mechanisms of resistance.

Menkir

Varietal resistance to Striga seems to vary from location to location. Have you encountered the same problem in the Sudan ?

Nour

Yes, we have. We have observed variations not only due to locations but also due to seasons in the same locations.

SUDAN (contd)

Sehene

What are you using as agronomic practices against Striga which have been effective ?

Nour

We have used mulching, fertilizer and intercropping sorghum with groundnuts. The combination gave good Striga control. We have also used mulch alone as well as mulch plus nitrogen fertilizer. Mulch plus nitrogen fertilization gave the best control of Striga.

Doggett

The variety Framida shows 'low stimulant' resistance and may also have 'mechanical' resistance to Striga. N-13 has shown resistance in most places. There may be different strains or races of Striga. Abu naama may have a virulent race. Soil conditions greatly affect Striga development, especially on the black vertisols. The same patch may have no Striga if it was wet at the wrong time, but may be heavily infested the following season. It would be good to see the combination of some nitrogen fertilizer plus resistant variety (Framida) tested more widely. It seems effective in West Africa.

Stand establishment is an important component of yield per ha. It is possible to make progress by selection and to improve establishment. In the early

SUDAN (contd)

days at ICRISAT, we started breeding for improved stand establishment using Naga white from Ghana as a parent. This cultivar has large seedlings with excellent seedling vigour.

UGANDA

Alahaydoian

Please make further comments about the unthreshed sorghum heads and storage pest infestation ?

Esele

In our laboratory experiments on testing for tolerance/ susceptibility of our elite sorghums to storage pests, we work on threshed grain. We felt that this is not quite representative of the average farmer's situation. The average farmer in Uganda stores his grain unthreshed. So we tested and found that the unthreshed heads are more susceptible to the grain moth than to the grain weevil. I suspect that this is due to field infestation, because the moth is more likely to start its infestation on the sorghum grain even before harvest.

UGANDA (contd)

Alahaydoian

I agree with you. We have observed the same situation in Somalia. I feel that this is because the grain is intact on the unthreshed head. Since the glumes partially cover the grain this could be a factor contributing to the reduced ability of the weevil to infest the grain on the unthreshed heads.

Yilma

How did you arrive at the hot-water emasculation technique for finger millet crossings ?

Zake

There are a number of techniques used and these have been published. At Serere, the hot-water emasculation technique on finger millet was adopted because, after all, the technique was already being used on sorghum. The only difference is that whereas in sorghum a temperature of $46^{O}C$ for 10 minutes is used, in finger millet, we use a temperature of $52^{O}C$ for 2½ minutes.

RECOMMENDATIONS OF THE THIRD REGIONAL WORKSHOP ON SORGHUM AND MILLET IMPROVEMENT IN EASTERN AFRICA HELD IN MOROGORO, TANZANIA, 5-8 JUNE 1984

1. The workshop recognizes with appreciation and thanks the Tanzania Agricultural Research Organization (TARO), the Morogoro campus of the University of Dar es Salaam, the International Development Research Centre (IDRC), the Semi-Arid Food Grains Research and Development (SAFGRAD) JP 31 of the Organization of African Unity, and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) for sponsoring, organizing and hosting the workshop.

2. Since the recommendations given by the 1983 workshop are still valid further effort should be made to follow up and implement more of the recommendations.

3. Appreciating the usefulness of having invited speakers address the workshop on selected topics of interest to the participants, the workshop recommends that further effort be made to invite speakers on such topics as millet improvement, Quelea, sorghum and millet grain quality, and breeding for drought resistance.

4. It is recommended that the Eastern Africa Co-operative Sorghum Regional Trials be continued with contributions from the national programs of the region and the ICRISAT/SAFGRAD regional program.

5. It is recommended that a regional sorghum screening nursery composed of the most promising and advanced breeding lines from Ethiopia, Tanzania, Uganda, and ICRISAT plus selected disease and insect nurseries be organized for initial grow-out and evaluation in Ethiopia, Tanzania, and Uganda. It is further recommended that after evaluation the best entries from this screening nursery be made available to the other national programs of the region.

6. Recognizing the importance of current scientific literature, highlighting the unavailability of such literature service to the national researchers in sorghums and millets in Eastern Africa, it is strongly recommended that ICRISAT be requested to provide more expanded literature service to the national programs of the region.

7. Since crop loss assessment, quarantine, and other crop protection issues have repeatedly come up in the workshop it would be desirable to have more crop protection researchers participate in the future sorghum and millet regional workshops.

8. As in the past, this workshop was appreciated and commended by all those who took part. As in 1983 it is again strongly recommended that the workshop continue to be held in an annual basis with the same format and style. It is further recommended that the 4th Annual Regional Workshop on Sorghum and Millet Improvement in Eastern Africa be held in Uganda in 1985.

LIST OF PARTICIPANTS

Ethiopia

Yilma Kebede	Team Leader Sorghum Research Institute of Agricultural Research Nazreth Research Station P.O. Box 103 Nazreth, Ethiopia
Abebe Menkir	Research Officer I Institute of Agricultural Research Nazreth Research Station P.O. Box 103 Nazreth, Ethiopia

Kenya

Lawrence Riungu M'Ragwa	Agricultural Officer National Dryland Farming Research Station Katumani P.O. Box 340 Machakos, Kenya
Newton Ochanda	Sorghum Breeder Alupe Agricultural Research Station P.O. Box 278 Busia, Kenya

Rwanda

Célestin Sehene	Research Officer I.S.A.R. Rwerere B.P. 73 Ruhengeri, Rwanda

Somalia

Eugene-Kevork Alahaydoian	Advisor Somali Government Sorghum Improvement c/o Bay Region Agricultural Development Project P.O. Box 2971 Mogadishu, Somalia

Sudan

Abd Ellatif M. Nour	Plant Breeder Gezira Research Station Plant Breeding Section P.O. Box 126 Wad Medani, Sudan

Tanzania

Andrew Doto	Breeder P.O. Box 3000 Morogoro, Tanzania
N.R. Kasembe	Director General Tanzania Agricultural Research Organization P.O. Box 9761 Dar es Salaam, Tanzania
Mariam Mujie Keregero	Lecturer Department of Food Science and Technology University of Dar es Salaam P.O. Box 3006 Chuo Kikuu Morogoro, Tanzania
C.L. Keswani	Professor Department of Crop Science University of Dar es Salaam Faculty of Agriculture, Forestry and Veterinary Science Chuo Kikuu Morogoro, Tanzania
Charles D. Kitundu	A.F.O. III TARO, Hombolo P.O. Box 279 Dodoma, Tanzania
Boniface W. Kolla	A.F.O. III TARO, Tumbi P.O. Box 306 Tabora, Tanzania
John A. Mann	INTSORMIL Sorghum and Millet Improvement TARO, Ilonga Private Bag Kilosa, Tanzania

Tanzania (contd)

F.F. Augustino Mbowe	Scientific Officer Tanzania Agricultural Research Organization Ilonga Private Bag Kilosa, Tanzania
Samuel I. Mndolwa	Field Officer TARO, Ilonga Private Bag Kilosa, Tanzania
Deogratias D.R. Mpesi	Technical Officer Sorghum Dehulling and Milling Project S.I.D.O. P.O. Box 2476 Dar es Salaam, Tanzania
A.N. Mphuru	Associate Professor Faculty of Agriculture, Forestry and Veterinary Science P.O. Box 3001 Morogoro, Tanzania
Clemence S. Mushi	Agronomist TARO, Ilonga Private Bag Kilosa, Tanzania
Bruno J. Ndunguru	Associate Professor and Head Department of Crop Science P.O. Box 3005 Chuo Kikuu Morogoro, Tanzania
Hamis M. Saadan	Scientific Officer TARO, Ilonga Private Bag Kilosa, Tanzania
M. Seenappa	Senior Lecturer in Food Science Department of Food Science P.O. Box 3006 Chuo Kikuu Morogoro, Tanzania
Martha E. Quentin	Assistant Lecturer Entomology University of Dar es Salaam Crop Science Department P.O. Box 3005 Chuo Kikuu Morogoro, Tanzania

Uganda

Peter Esele	Pathologist U.A.F.R.O. Sorghum and Millet Unit Serere Research Station P.O. Soroti Uganda
Vincent Makumbi Zake	Principal Research Officer-in-Charge U.A.F.R.O. Sorghum and Millet Unit Serere Research Station P.O. Soroti Uganda

Yemen PDR

Abdul Aziz Ahmed Bawazir	Head Agronomy and Plant Breeding Section El-Kod Agricultural Research Centre c/o FAO P.O. Box 1188 Aden, Yemen PDR

Others

Trygve Berg	Research Supervisor Norwegian Church Aid P.O. Box 52802 Nairobi, Kenya
Brhane Gebrekidan	SAFGRAD Co-ordinator SAFGRAD/ICRISAT Program OAU/STRC JP 31 SAFGRAD P.O. Box 30786 Nairobi, Kenya
Hugh Doggett	Special Advisor International Development Research Centre 15 Bandon Rd Girton Cambridge CB3 OLU United Kingdom
Taye Bezuneh	Director of Research OAU/STRC - SAFGRAD P.O. Box 1783 Ouagadougou, Upper Volta

Others (contd)

Earl F. Ellington	Associate Dean College of Agriculture University of Nebraska 010 Ag. Hall Lincoln Nebraska 68583 U.S.A.
Roger A. Kirkby	Program Officer Crop and Cropping Systems International Development Research Centre P.O. Box 62084 Nairobi, Kenya
Ozzie Schmidt	Program Officer International Development Research Centre P.O. Box 62084 Nairobi, Kenya

THE THIRD REGIONAL WORKSHOP ON SORGHUM AND MILLET IMPROVEMENT IN EASTERN AFRICA, MOROGORO, TANZANIA

5-8 June 1984

PROGRAM

Monday 4 June

	-	Arrival of participants in Morogoro
1700	-	Registration of participants

Tuesday 5 June

	-	Chairman: H.M. Saadan
0800	-	Welcome address - H.M. Saadan
	-	Opening address - J.N.R. Kasembe, Director General of TARO
	-	Background and purpose of the workshop - Brhane Gebrekidan
	-	Coffee Break
	-	Chairman: Hugh Doggett
	-	Rapporteur: F.F.A. Mbowe
1000	-	Overview of the Tanzania sorghum and millet improvement program - H.M. Saadan
	-	The history of sorghum improvement in Tanzania - A.L. Doto
	-	Present status of sorghum breeding in Tanzania - H.M. Saadan
1230	-	Lunch Break
	-	Chairman: Taye Bezuneh
	-	Rapporteur: C.S. Mushi
1400	-	Sorghum agronomy in Tanzania - C.S. Mushi

- Sorghum based intercropping - F.F.A. Mbowe
- Diseases of sorghum in Tanzania - F.M. Shao
- Sorghum processing and utilization in Tanzania - M. Seenappa and N.T.A. Bangu

Wednesday 6 June

- Chairman: Brhane Gebrekidan
- Rapporteurs: Abebe Menkir
  Newton Ochanda
  Roger Kirkby
  Yilma Kebede
  Peter Esele

0800 - Country Papers: Ethiopia
Kenya
Rwanda
Somalia
Sudan
Uganda
Yemen PDR

Thursday 7 June

- Trip to Ilonga Experimental station (spend whole day on the trip and return to Morogoro in the evening)

Friday 8 June

0800 - Results of the 1983 E.A. Sorghum regional trials - Brhane Gebrekidan

- Final discussions and recommendations
- Closing remarks - Roger Kirkby

1400 - Field and laboratory visits, Morogoro Faculty of Agriculture

- Workshop dinner

Saturday 9 June

- Participants leave for home.

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1984-06

Sorghum and millet improvement in Eastern Africa

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