DRAFT FINAL TECHNICAL REPORT ON EAST AFRICA SORGHUM & MILLET RESEARCH NETWORK (EARSAM)

(PHASE II - COVERING THE PERIOD 1986-1991)

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INTRODUCTION

1. Introduction

The region herein referred to as eastern Africa includes Burundi, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Tanzania, and Uganda. Almost all the major sorghum ecological zones found worldwide are represented in eastern Africa (1). The region is unique in that it contains areas of sorghum production in all the ecological niches in which the crop is normally cultivated; ranging from near sea level to 2500 m. Differences in physiography are reflected in the wide range of climates, soils, and crop requirements and constraints found within the region. Well over 75% of the region has an average annual rainfall between 400 to 1000mm. The bimodal rainfall generally falls for about 3 to 5 months and is highly variable. Temperatures in the different ecological zones are variable and can range from 6^0C (Highland) to 45^0 (Lowland), (2).

Although total sorghum and millet production in eastern Africa has increased in both hectarage, and, to some extent, yield per hectare, food production still is not keeping pace with population growth (>3.0%). There is, therefore, an urgent need to increase sorghum and millet production in order to help alleviate hunger and malnutrition (3).

Recognizing the need to improve productivity in this region, breeders have made efforts to increase yield through improved varieties. Despite their special efforts to develop improved varieties, the spread of these varieties is discouragingly slow compared to other cereal crops. The behavior of farmers as producers and consumers in a changing agriculture scenario is not well understood. However, the benefits of research investment in developing acceptable improved varieties are largely related to the market/utilization trends; which together with relative profitability are the motivating factors for adopting new varieties. The allocation of resources is relatively higher for sorghum improvement than for millets. The number of research projects within national agricultural research systems (NARSs), and the collaborative research projects on sorghum compared to the few on millets reflects the relative importance of these crops and this has been confirmed by members of the Eastern Africa Regional Sorghum and Millet (EARSAM) Steering Committee (4).

Sorghum

Of the total area cultivated to cereals in the region (Table 1), in each individual country, sorghum is either the first or second most important cereal. In the drier and drought-stressed zones of the region sorghum is the predominant crop. Since the region is recognized as the origin and center of diversity of the crop, it contains tremendous sorghum genetic variability especially in Ethiopia and the Sudan. Therefore, efficient collection and exploitation of this genetic variability has the potential to benefit not only the region, but also all other sorghum-growing countries. Globally, this is the single most important region for high-altitude and cold-tolerant sorghums in terms of both genetic diversity, and total tonnage produced. (Table 1). Most of the sorghums produced in the region are used for food and brewing local beer. Sorghum beverages (unfermented or fermented) are regarded as important food item in the rural areas. Average farmers grain yields range from 600 to 1000 kg ha^{-1} compared to experiment station yields of 2000 to 4000 kg ha^{-1}.

In the eastern African region, it is notable that efforts to initiate improvement on cereal crops, primarily maize, date back to the late 1930's and early 1940's (5). At that time, sorghum collections were being made in Kenya, Uganda, and Tanzania. Sorghum selection began at Ukiriguru, Tanzania, in 1948/49 and breeding at Serere Uganda, in 1954. Research in sorghum over the years included development of white and colored-seeded varieties, weevil resistance in stored grain, resistance to *Striga*, shootfly, and stem borers. A network of locations linked in a multilocational testing system assisted in identifying varieties with broad adaptation and reasonable levels of resistance to most of the diseases and pest problems of eastern Africa. Population breeding methods were developed that are still contributing to sorghum improvement.

Millets

The millets are a group of small-grained cereals that are grown on 15-20 million hectares, mainly in south Asia, China, USSR, and in several African countries. These crops have long been important components in traditional farming systems and in the diets of many millions of people in areas where stable food production is difficult due to uncertain rainfall, harsh soils, or topography. Millets are traditional crops of dryland regions in eastern Africa where agriculture is mainly rainfed. Most of the millets have a higher adaptability to drought and other environmental stresses and their cultivation minimizes the risks for dryland farmers.

Among the millets, finger millet *(Eleucine coracana)* is the predominant species grown in most eastern African countries with the exception of Sudan where pearl millet *(Pennisetum glaucum)* is predominant (Table 1). Finger millet is indigenous to eastern Africa and the region has tremendous genetic variability of the crop. Major finger millet producing countries in eastern Africa are Uganda, Ethiopia, Tanzania, Burundi and Kenya. In Uganda finger millet is largely grown in eastern, northern and western regions of the country where it forms a major staple food. In Ethiopia the major finger millet producing areas are located in northern, north western and western parts of the country. In Tanzania the most important finger millet producing areas are in the southern highlands particularly in Mbeya, Rukwa and Ruvuma regions. It is also grown in large quantities in Dodoma, Siginda, Arusha, Kilimanjaro and Mara regions. In Kenya Finger millet is largely grown in western Nyanza and Rift Valley Provinces.

In Uganda, Kenya and Burundi finger millet grains are ground in mixture with sorghum or cassava and used to make thin (uji) and stiff (Ugali) porridges. In Ethiopia it is used for bread (injera) alone or in mixture with teff (Eregrostis teff). In all the countries finger millet is most popular for making all types of local beers. In some countries as high as 75% of the total finger millet production is used for brewing.

Finger millet grain stores well and is free of major storage insect pests. Because of this it is used as an important famine food in some countries particularly in Uganda and stored for this purpose. Finger millet is largrely grown by peasant farmers and the predominant varieties used are their local landraces. Historically, millet breeding began at Serere, Uganda in 1950. Over the years research on finger and pearl millets has included the development of varieties and synthetics with resistance to abiotic and biotic stresses. Through multilocational testing and exchange of germplasm, varieties with broad adaptation have been identified.

Constraints to Production

Lack of improved cultivars: Low-yielding traditional landraces are predominantly grown; there is thus potential to improve the yield and stability of the existing varieties and landraces. Seed set, crop maturity, and plant height are important traits to be considered.

Drought and soil management: Many of the soils in the region whether heavy or light are of low fertility. Increases in production on such soils are only possible when improved varieties are grown with improvement in soil management. Drought, stand establishment, temperature, and nutrient stresses all significantly affect production. Intercropping and sole cropping are both practiced, and further work is required on the relationships of interplanted crops.

Diseases: Priority diseases for regional research include the pathogens that cause anthracnose, covered smut, grain mold, and ergot of sorghum. For finger millet, head blast and sorghum and pearl millet ergot are the most widespread diseases in the region and sometimes causes heavy damage to the crop. Downy mildew, rust, and smut are also common in the region; these diseases do not appear to do much damage to the local landraces, but the situation could change with the introduction of improved cultivars.

Insect pests: The predominant pests of sorghum are stem borers, shootfly, sorghum midge, and storage insects. Several of the insects found on sorghum also attack millets, but do not appear to significantly damage the crop.

Birds: *Quelea* and other species cause significant damage to both crops. The actual extent of damage has not been critically evaluated.

Striga: Several species of this parasitic weed attack sorghum and finger millet crops resulting in significant production losses.

On-farm trials: To translate research results to farmers, it is important to conduct verification trials on farmers' fields, coupled with economic analysis of on-farm trials to provide farmers feed-back to researchers.

Marketing and price control: Most countries have no official market or pricing policies for both crops; consequently the crop does not enter into official trading system and this is a disincentive to growers. Proper and cost-effective distribution of grain with adequate price control is essential to absorb excess production.

Postharvest handling and utilization: Eastern African countries are increasingly expressing concern about the postharvest handling, storage insects, and utilization aspects of both crops. It is important that for rapid acceptance, improved cultivars should be of acceptable quality for food products, brewing, and as livestock and poultry feed. Most countries have no official markets or pricing policies for these crops; consequently they do not enter into official trading systems, and this is a disincentive to growers.

Seed production: One of the bottlenecks to rapid movement of improved varieties and hybrids in the region is the lack of effective seed industry. Kenya is the only country with a good and well-established seed industry, but it alone cannot meet the need for seed production in the region. Varieties are produced but hybrid seed is only available in Sudan. It is, therefore essential to strengthen the seed industry in each of the regions' countries.

Historical Perspective

Since 1982 the United States Agency for International Development (USAID) and the International Crop Research Institute for the Semi Arid Tropics (ICRISAT) have provided funds to implement sorghum and millet improvement in eastern Africa through the Semi-Arid Food Grain Research And Development (SAFGRAD) Project.

Through the Organization of African Unity (OAU), SAFGRAD mobilizes the efforts and strengths of national agricultural research systems (NARSs) through networking, and by facilitating the mobility of scientists and research materials. ICRISAT has the capability to improve the research base of NARS through research support, training, and other activities.

Phase I (1982-86)

ICRISAT/SAFGRAD made remarkable progress in training scientists from national programs in the region. It brought together various national programs through scientist-to-scientist interaction during regional workshops and field tours. As a result of these interactions, scientists shared their research results, exchanged germplasm, and evaluated their elite sorghum genotypes on a regional basis. Thus, Phase I activities established the groundwork for Phase II.

Phase II (1986-91)

In 1986, further effort was needed to expand and strengthen sorghum and millets research in eastern Africa. This was achieved by developing a strong and efficient networking model. This model was designed to further strengthen the ties among the NARSs of the region, not only to interchange scientific results, experiences and germplasm, but also to share responsibilities for common problems in the region, and thus avoid duplication of efforts.

In 1986, during the 5th Regional Workshop in Bujumbura, Burundi, a Steering Committee (SC) comprising one NARS scientist from each country of the region was formed to provide overall guidance for networking activities. The SC members met again in Ethiopia in November 1986 and developed a regional network model, the Eastern Africa Regional Sorghum And Millet (EARSAM) network. The EARSAM network SC includes a Chairman, a Secretary, 6 scientists from NARS, and the EARSAM Coordinator. Representatives from donor agencies and international organizations attend its meetings as observers.

The SC members serve for 2 consecutive years and during each regional workshop (held every other year), 50% of the SC members are elected. The Chairman of the previous SC overlaps with the newly elected members in order to maintain continuity.

Steering Committe

- Prepares short- and long-term network action plans based on prioritized problems of regional significance.

- Monitors the implementation of workshop recommendations and SC decisions.

- Facilitates the implementation of the research network activities in their respective countries in particular, and in the region in general.

- Determines themes for future workshops and regional short-course training programs.

The Regional Coordinator

- o Contributes ideas to SC members.
- o Executes the decisions taken by NARSs.
- o Links ICRISAT scientists to NARS researchers in EARSAM network activities.

EARSAM Network Objectives

- o To assist NARS, in the development of improved varieties and hybrids that together with agronomic and soil management and conservation practices will result in higher and more stable economic yields in the region.
- o To assist NARS, to develop or adapt screening techniques to identify broad-based genetic resistances/tolerances to abiotic and biotic stresses, to incorporate them in elite breeding material, and to identify materials adapted to the various ecological zones in eastern Africa.

  To organize and promote systematic regional cooperative testing of available elite cultivars.

  To develop collaborative research projects on productionconstraints of major significance in the region with strong (lead) NARS, and provide critical inputs to enable them to carry out research adequately and satisfactorily.
- o Assist NARS, in training and manpower development.
- o Organize regional workshops, monitoring tours, and field days in order to report research findings, interchange ideas and breeding materials and to foster closer national program cooperation.

Collaboration with National Agricultural Research Systems (NARS)

In 1986, the major and common constraints to sorghum and millet production were identified by NARS SC members, research priorities were formulated, and lead research centers identified to carry out research projects in the region with the help of ICRISAT experts. As a follow up, ICRISAT developed collaborative research projects with NARS and transferred specific technologies developed at ICRISAT Center to lead-center scientists. In addition, needed research supplies were provided by ICRISAT to NARS for the proper execution of each project. The purpose of this collaboration, that utilizes scientific skills and research facilities available in the NARSs, is to develop research leadership of NARS scientists, to strengthen their ability to carry out effective research, and to generate appropriate and affordable research technology that can be used by farmers.

ACCOMPLISHMENTS

Accomplishments

Striga resistance screening with the Institute of Agricultural Research (IAR) Ethiopia

- Several hundred breeding and germplasm lines have been screened for resistance to *Striga* in field "sick" plots, and 27 resistant lines identified.

- In pot experiments at Holeta Research Station, 5 sorghum lines (SAR 24, Gambella 1107, N 13, ICSV 1006, and ICSV 1007) have been identified as resistant to both *S. hermonthica* and *S. asiatica*.

- All the identified *Striga*-resistant lines have been distributed to NARSs in the region for further testing and use in their programs.

Long smut (*Tolyposporium ehrenbigii*), with the Kenya Agricultural Research Institute (KARI), Kenya

- During surveys conducted in eastern Kenya in 1987 and 1988 sorghum long smut infestation was observed in farmers fields in Meru and Embu districts. At Marimanti Experiment Station in Meru, the disease incidence varied from 29% on susceptible genotypes to 0% in the local variety IS 8595. 18 lines that showed resistance to long smut at Marimanti have been selected.

- A long smut screening technique has been developed in the greenhouse at the KARI Research Station, Muguga using artificial inoculation. Sporidia were found to be a more effective source of inoculum when inoculation occurred at the boot stage.

- The resistance of IS 8595 was formerly attributed to its long glumes that completely cover the grain. Recent results indicate that complete glume coverage may not be directly linked with long smut resistance since other long-glumed genotypes have been found highly susceptible.

- It has been confirmed that seed treatment with systemic fungicides available in Kenya (Rocol (R) and Bayleton (R)) is ineffective in the control of long smut.

Covered smut (<u>*Sphacelotheca*</u> <u>*sorghi*</u>) with KARI, Kenya

- A simple and reliable screening technique to screen sorghum germplasm and breeding lines for resistance to covered smut has been developed and is being used to screen a large number of breeding and germplasm lines from NARSs, ICRISAT Center, and other sources. Maximum infection resulted when 10 g of seed was mixed with 50 mg of dry teliospores.

Ergot (*Sphacella sorghii*) with IAR, Ethiopia and l'Institut des sciences agronomique Rwanda (ISAR), Rwanda

- An artificial inoculation technique developed at ICRISAT Center has been transferred to scientists working at IAR, and ISAR.

- Over 300 sorghum lines have been screened for ergot resistance at Arsi Negele, Ethiopia, 48 lines have been identified that show less than 10% ergot-infected florets. After further screening of the 48 selected lines at Arsi Negele, 6 lines (ETS numbers 1446, 2448, 2465, 3155, 4457, and 4927) were confirmed as having resistance to ergot.

- The same technique was used at Rubona and Karama, Rwanda to identify 8 resistant lines (IS numbers 25531, 25485, 25489, 25527, 255530, 25533, 25537, and 25542).

- The relationship between pollination and ergot infection has been studied, ergot incidence has been found to increase with the time interval between inoculation and anthesis.

- The common grasses (*Panicum maximum* and *Cenchrus diliaris*) have been identified as alternate/collateral hosts of the sorghum ergot pathogen in Rwanda. These grasses may serve as primary sources of ergot inoculum.

Anthracnose (*Colletotrichum graminicola*) with IAR, Ethiopia

- An anthracnose artificial screening technique has been transferred from ICRISAT Center to IAR scientists working at Nazreth, and used to screen 111 sorghum germplasm and breeding lines; 67 anthracnose-resistant lines have been identified.

- The technique is being used to screen more lines from NARSs for resistance to anthracnose.

- An anthracnose resistance nursery is being organized, to be evaluated at anthracnose "hot spot" locations in eastern Africa to confirm stability of resistance.

Finger millet head blast (*Pyricularia setariae*) resistance screening, with KARI Kenya

- Nine hundred and sixty finger millet germplasm lines have been screened for resistance to finger millet head blast disease at Kiboko, and lines with variable levels of resistance selected. The 201 selected lines are being screened again for resistance at "hot spot" locations in eastern Africa to identify lines with stable resistance.

- A large number of finger millet germplasm accessions from ICRISAT Center, SADCC/ICRISAT Zimbabwe, and Uganda have been introduced and will be screened for head blast resistance at Kiboko in 1991.

Sorghum stem borer *(Chilo partellus)* with the Research Division, Ministry of Agriculture, Somalia

- Facilities for insect rearing on artificial diets have been established and successful rearing of *Chilo partellus* initiated at Bonka Research Station. The growth, development, and reproduction of *C. partellus* on the artificial diet were similar to those on its natural host, sorghum.

- An insect-pest survey has been conducted in the Bay Region. *Chilo partellus* was the only pest recorded in all the four districts surveyed, with infestations ranging between 6 to 60% deadhearts.

- It was found that carry-over of stem borers was mainly through the diapausing population in sorghum stalks and stubbles. About 74% of the stalks from the previous qu season contained diapausing larvae and each stalk had an average of 2 larvae, with a maximum of 15 larvae per stalk.

- It was found that stem borer infestation on sorghum crops at Bonka Research Station was half that on ratoon sorghum at Bonka in farmers' fields. Larvae, were in much advanced stage of development in the traditionally ratooned crop, indicating the increase in number of generations (at least 0.5 to 1) per season.

Evaluation of nutritional and food qualities of sorghum in eastern Africa with IAR Ethiopia; University of Nairobi, Kenya; and Food Research Centre, Sudan)

- In a study of the physicochemical characteristics and dehulling quality of 16 selected sorghum cultivars, representing the varieties that are commonly cultivated in Ethiopia, Kenya, and Sudan wide variation in quality was found among the cultivars.

- The organoleptic qualities of such traditional foods as *injera* and *nifro* (Ethiopia), *ugali* (Kenya) and *kisra* (Sudan) have beenevaluated and variation found in the quality of foods madefrom each cultivar. Grains of SPV 475 (India), Dabar (Sudan),and IS 24129 (Tanzania) had comparatively higher ratings for overall food quality.

- Significant associations have been observed between starch characteristics and *injera* quality, and protein content with *injera* and *kisra* quality.

- The tangential abrasive dehulling device (TADD) has been used to dehull large numbers of sorghum samples, and it can also be used to screen for grain hardness.

- If dehulled sorghum grain is used to prepare *injera*, the quality is significantly improved.

Studies on agroclimatic analysis of EARSAM network sites with ICRISAT Center and NARSs

The 22 EARSAM testing locations have been grouped into three classes:

High risk, short-, or medium-duration locations: (60-70 days growing season) where sorghum production can only be stabilized only with supplementary irrigation: Wad Medani (Sudan), Bonka and Afgoi (Somalia), Abu Naam (Sudan), Melkawerer (Ethiopia), Ilonga (Tanzania), and Karama (Rwanda).

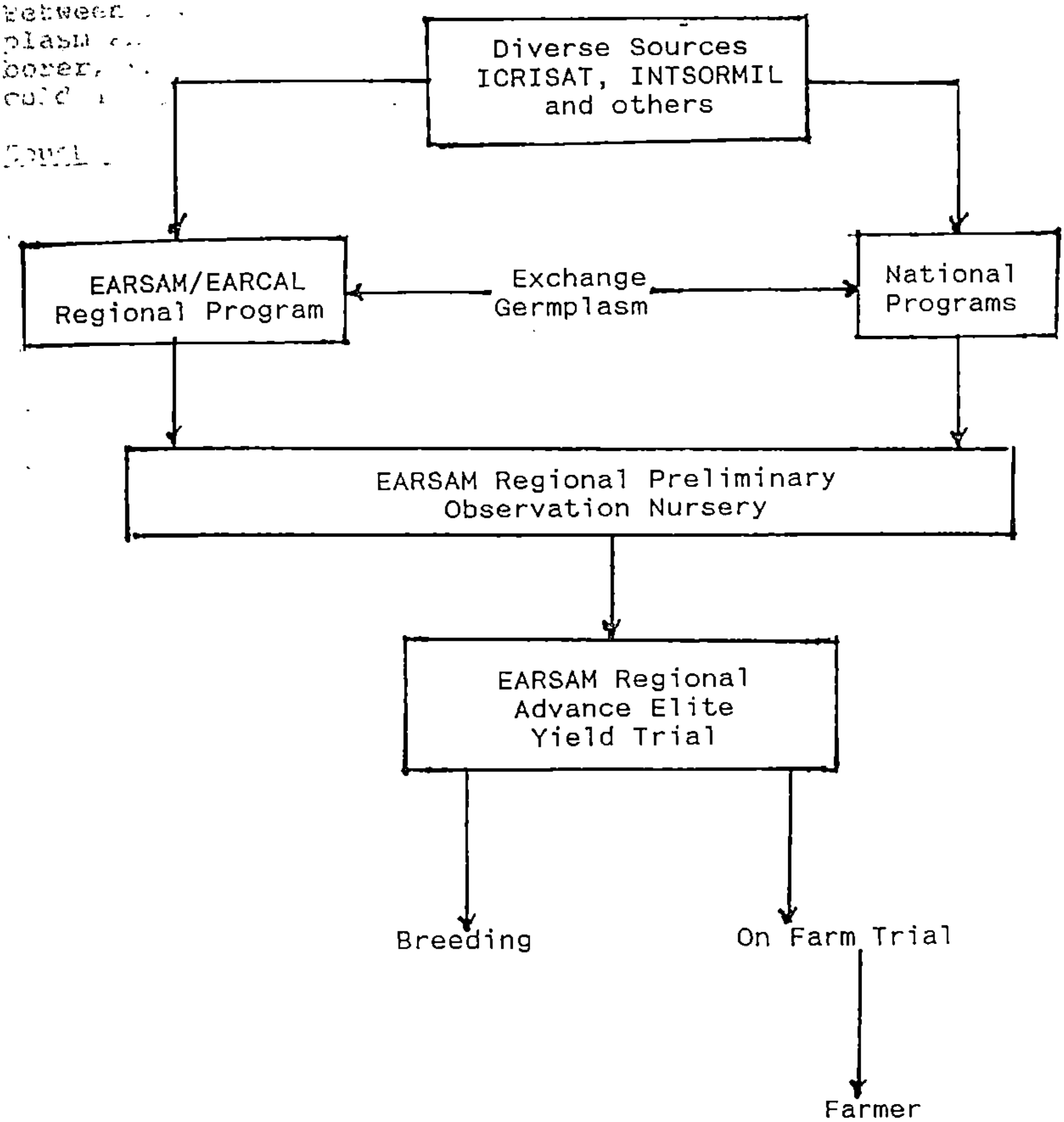
Low risk, medium-duration locations: (80-100 days growing season) where good soil and water management allow stable and increased sorghum yields: Nazret (Ethiopia), Abu Rein (Somalia), Makindu (Kenya), and Malindi (Kenya).

Low risk, long-duration locations (over 120 days growing season) where provision of drainage and fertilizers are necessary to maintain high sorghum yields: Rubona (Rwanda), Bako (Ethiopia), Alupe (Kenya), Mosso (Burundi), Lanet (Kenya), Katumani (Kenya), Kakamega (Kenya), Munanira (Burundi), Alemaya (Ethiopia), Rwerere (Rwanda) and Jimma (Ethiopia).

Regional Sorghum and Millet Germplasm Movement and Evaluation

Germplasm movement and evaluation in the region is an important and integral activity of EARSAM. Germplasm movement in the region from ICRISAT Center to NARS, NARS to NARS, and NARS to ICRISAT Center is extremely important to the sorghum and millet improvement program. This topic was thoroughly discussed and minuted by the SC members in Somalia on 25 July, 1988. A model (Figure 1) for germplasm movement and evaluation was developed and endorsed. In the 1989/90 sowing season, the EARSAM Regional Advanced Elite Yield Trial (EEYT) was organized , evaluated, and analyzed. (EEYT). As a follow-up, under the proposed model, EARSAM regional preliminary observation nurseries have been organized for evaluation in different agro-ecological zones in 1991.

Figure 1. Regional germplasm movement and evaluation.



As a result of germplasm movement, evaluation, and improvement by NARSs, several cultivars of sorghum and millet have been released by NARSs in the region since 1986 (Table 2).

Seed Distribution

Between 1986 and 1990 seed material of sorghum and millet germplasm and breeding lines, resistant or tolerant to *Striga*, stem borer, shootfly, downy mildew, midge, leaf diseases, ergot, and cold has been provided to NARS in the region.

Country	Number of samples
Burundi	731
Ethiopia	1052
Kenya	3451
Rwanda	615
Somalia	583
Sudan	534
Tanzania	525
Uganda	825

Several international nurseries and adaptation trials from ICRISAT Center and USA have been provided. These have been evaluated by regional NARSs who provided useful data, and selected productive and adapted cultivars for further testing or use in their own programs.

Testing Elite Germplasm

Sorghum scientists from NARSs who participated in the EARSAM Network's Sixth Regional Workshop held in 1988 in Somalia recommended that regional sorghum yield trials should be initiated, and requested ICRISAT to organize and coordinate these trials. In 1989 we organized and distributed to NARSs in eastern Africa two sorghum regional trials; the EARSAM Elite Sorghum Yield Trial (EESYT) for intermediate and lowland elevations, and one finger millet regional yield trial; the EARSAM Elite Finger Millet Yield Trial (EEFMYT).

EARSAM Elite Sorghum Yield Trial (EESYT-89)

Lowland:

This trial consisted of 25 entries and was evaluated at 14 locations. The location mean grain yields were highly variable across locations and ranged from 0.76 t ha^{-1} at Gadambalia, Sudan to 5.39 t ha^{-1} at Mombasa, Kenya.

We classified the 12 locations from which data were received into three broad ecological groups:

Group 1: Five locations; Baidoa (Somalia), Gadambalia (Sudan), Ilonga (Tanzania), Kiboko long rains, (Kenya), and Hombolo (Tanzania) in the hot, dry zone with short rainy season. (Table 3)

Group 2: Four locations; Mombasa (Kenya), Kiboko short rains, (Kenya), Wad Medani (Sudan), and Imbo (Burundi) with a comparatively reliable short/medium rainy season. (Table 4)

Group 3: Three locations; Melkassa (Ethiopia), Karama (Rwanda), and Katumani short rains, (Kenya) in cool areas with a medium/long rainy season. (Table 5)

In Group 1 ICSV 335 (2.52 t ha^{-1}, SE ±0.28) was the highest-yielding entry. In Group 2 ICSV 112 (4.60 t ha^{-1}, SE ± 0.50), was the highest-yielding entry and Kigufi (3.90 t ha^{-1}, SE ± 0.63) was the highest yielding entry in Group 3. ICSV 335, ICSV 112, CR:35:5 and Kat 83487 were among the highest-yielding entries in both Groups 1 and 2.

The EESYT-89 Lowland trial was severely affected by drought at Gadambalia, Sudan and Baidoa, Somalia in Group 1. However, Gadam Hamam produced acceptable yields at both these locations.

Intermediate:

The location mean grain yields were highly variable across the seven locations where this trial (consisting of 16 entries) was evaluated. Mean grain yields ranged from 1.02 t ha^{-1} at Murongwe, Burundi to 3.86 t ha^{-1} at Katumani (short rains), Kenya. We observed significant differences among entries for mean grain yield, plant height, and time to 50% flowering.

We classified the seven locations at which this trial was evaluated into two broad ecological groups:

Group 1: Four locations; Katumani short rains, (Kenya), Murongwe (Burundi), Arsi Negele (Ethiopia), and Robona (Rwanda) in areas with cool climate and medium to long rainy seaons. (Table 6)

Group 2: Three locations; Ukiriguru (Tanzania), Kiboko long rains (Kenya), and Kiboko short rains, (Kenya) in areas with slightly warmer climate and short/medium rainy seasons. (Table 7)

IS 9302 (3.60 t ha^{-1}, SE ± 0.53) was the highest-yielding entry in Group 1. While the control, Seredo 2 (3.50 t ha^{-1}, SE ± 0.38), was the highest-yielding entry in Group 2. In general, the entries that yielded well in Group 1 were the cold-tolerant entries contributed by NARSs from Rwanda and Ethiopia, while the entries that yielded well in Group 2 were the lowland adapted entries contributed by NARSs from Tanzania and Uganda. At Arsi Negele, and Murongwe the trial was severely attacked by ergot and some entries not adapted to cool climates failed to produce grain. Cold-tolerant IS 9302, Nyirakabuye, and Amasugi produced high yields at these locations.

EARSAM Elite Finger Millet Yield Trial (EEFMYT-89)

Location mean grain yields (Table 8) ranged from 0.56 t h^{-1} at Serere, Uganda to 3.08 t ha^{-1} at Alupe, Kenya. We observed significant differences among the 16 entries at all locations for grain yield, plant height, and time to 50% flowering, and for head blast resistance at Serère and Alupe. Gulu E (2.08 t ha^{-1}, SE ± 0.13) contributed by the Uganda NARS was the highest-yielding entry across the five locations The other high-yielding entries were P224 (1.98 t ha^{-1}, SE ± 0.13) and Serere 1 (1.97 t ha^{-1}, SE ± 0.13) all contributed by Uganda NARS but their yields were not significantly different from Gulu E. Entries U 10, P 227, and Engeny appeared to be resistant to head blast. KAT/FM 1 contributed by Kenya NARS and Accession numbers 100008 and 100057 both contributed by Ethiopia NARS were the earliest to flower at all locations, but these entries had high levels of head blast infection at Serere and Alupe.

Observation Nurseries

NARS scientists who participated in the EARSAM Network Steering Committee Meeting held at Nairobi in October 1990 recommended that preliminary regional cooperative sorghum and finger millet observation nurseries should be conducted, and requested ICRISAT to organize and coordinate these nurseries. We have organized and distributed to our cooperators in eastern Africa the following unreplicated preliminary observation nurseries for evaluation in the 1991 rainy season.

EARSAM Preliminary Sorghum Observation Nursery (EPSON) for dry and hot environments; 144 entries - 15 locations.

EARSAM Preliminary Sorghum Observation Nursery (EPSON) for humid environments; 184 entries - 11 locations.

EARSAM Preliminary Sorghum Observation Nursery (EPSON) for cool highland environments; 95 entries - 12 locations.

EARSAM Preliminary Finger Millet Head Blast Disease Resistance Nursery (EPFMBRN); 286 entries - 10 locations.

Entries in the above nurseries were selected from a nursery of several hundred introductions of sorghum and millet breeding lines and germplasm from NARS, ICRISAT Center, SADCC/ICRISAT, Zimbabwe, and USA. These introductions were evaluated at appropriate locations in Kenya in 1989 and 1990.

Research Support to NARSs

In general the national sorghum improvement programs in the region are relatively young and lack the expertise and funds needed to introduce and evaluate large numbers of breeding lines and germplasm accession. Most national programs also lack the technical skills to generate and handle large segregating populations. SAFGRAD/ICRISAT therefore provides support to NARSs in various ways.

Introductions: We introduce a large number of breeding and germplasm lines from ICRISAT Center, ICRISAT regional programs, USA Universities, and NARSs, and evaluate the material at; Kiboko for adaptation to hot and dry environments, Alupe for humid environments, and Lanet for cool highland environments.

These three locations in Kenya represent the sorghum-growing environments in eastern Africa. Selected material is then made available to NARS for further testing in appropriate environments. This has reduced the research load of NARS thereby allowing their limited resources to be spent on evaluating and screening specific and smaller amounts of material.

Regional crossing block: We plan to manage and handle a regional crossing block where we will make specific crosses based on NARSs' needs and requests. The NARSs will be provided with segregating material at early or advanced stages depending on their requirements and expertise. We will provide advanced lines to weaker NARSs for testing and early segregating material to stronger NARSs for continued selection and generation advancement.

Long-term research: We undertake long-term strategic research on priority problems identified by NARSs, that are time- consuming and require expertise, manpower, and research facilities that most NARS do not have at this stage; e.g., hybrid parental lines and hybrid development, genetic populations, mechanisms of resistances to major yield reducers, etc.

Facilities: KARI has provided research land at the Kiboko substation of the National Dryland Research Centre, Katumani to EARCAL to assist and support KARI and other NARSs in the region in long-term research that will eventually contribute to increased productivity. EARCAL has developed research facilities at Kiboko and built a crop-work area with research equipment, and a guest house for scientists and technicians from KARI and other NARSs to stay overnight while visiting the station or attending courses.

Training

Training of NARS scientists and technicians in eastern Africa is an important and integral part of EARSAM/EARCAL. During the period 1986-90, the following short courses were offered to NARS, and organized at their request:

Seed Production: Nairobi, Kenya, 1987 attended by 35 NARS scientists and 8 scientists from private companies. Eight ICRISAT scientists served as resource persons.

Entomology: Nairobi, Kenya, 1989 attended by 16 technicians from NARSs. Five ICRISAT scientists served as resource persons.

Pathology: ICRISAT Center, India 1989 attended by 16 technicians from NARSs. Eight ICRISAT scientists, and one NARS scientist from Kenya served as resource persons.

BreedingTechniques: Scheduled for June 1991 Kiboko, Kenya, will be attended by 16 technicians from NARS.

Workshops

One facet of EARSAM network activity that has grown markedly in size and quality has been the bi-annual regional workshops. These workshops are well attended by NARS scientists who present the results obtained from collaborative research projects and other studies. Scientists from ICRISAT, other international organizations, and universities attend these workshops, to share their knowledge, expertise, and experiences with NARS scientists, and to assist in the development of short- and long-term research strategies and work plans for the following years. These workshops are jointly organized with the NARS of the country where the workshop is held. The following workshops have been held since 1986:

Fifth EARSAM Regional Workshop: Bujumbura, Burundi, July 1986 attended by 50 scientists.

Sixth EARSAM Regional Workshop: Mogadishu, Somalia, September 1988, attended by 55 scientists.

Seventh EARSAM Regional Workshop: Nairobi, Kenya, June 1990, attended by 67 scientists.

We have published the proceedings of the Fifth and Sixth Regional Workshops, the proceedings of the Seventh Regional Workshop will be published in early 1991.

Monitoring Research Tours/Field Days

We organize monitoring research tours and field days for NARS scientists in the region. This enables them to visit and evaluate each others' research programs, to evaluate the entries in regional trials and nurseries, and to appreciate the interaction between genotypes and locations. The scientists are also given the opportunity to select or request genetic material for utilization by their national programs.

We have organized monitoring research tours or field days in Burundi 1986, Somalia 1988, Sudan 1989, Ethiopia 1990, and Kenya 1990.

Travel and Consultancy

ICRISAT staff in the regional program travel regularly in eastern Africa countries on request to monitor network activities, to interact with NARS scientists, and to transfer practical technologies and skills in order to strengthen NARS scientists' ability to carry out effective research in the development of technology readily usable by farmers.

Emphasis of ICRISAT is transfer instead developing or enhancing endogenous capability.

LESSONS LEARNED

3. Lessons Learned

Training: Well trained scientists and support staff are assets to a good national program. EARSAM network has trained field technicians as requested by NARS in different disciplines. However, there is a need to train BSc and MSc scientists in addition to field technicians. In addition, degree-level training (PhD and MSc) in all discipline is a high NARS priority. Funds were not available in Phase II to train scientists at post graduate level to adequately carry out collaborative research. The EARSAM Steering Committee members updated the list of manpower requirements for EARSAM countries for the period of 1992 to 1996 as follows: 24 PhDs and 29 MSc are required for eight countries in eastern Africa.

Millets: Allocation of resources by NARS is relatively higher for sorghum than millets. Also EARSAM network did not emphasize millets as much as it should have. However, we have learned that millets play an important role and have a higher adaptability to drought and other environmental stresses and their cultivation minimizes the risks for dryland farmers.

Among the millets, finger millet (*Eleucine coracana*) is the predominant species grown in most eastern Africa countries. However, pearl millet is important in the Sudan, eastern Kenya and central Tanzania only. Finger millet is indigenous to eastern Africa and the region has tremendous genetic variability of the crop. Most of the millets produced in the region is used for food and beverages. In addition, finger millet grain stores well and is free of major storage insect pests. Therefore, EARSAM network should assist NARS (Kenya, Uganda, Ethiopia, Tanzania and Burundi) to develop varieties with resistance to abiotic and biotic stresses and promote their utilization by producing acceptable good quality grain for food products, brewing and feed for poultry. Thus, funds should be made available in Phase III to strengthen the millets network activities.

Networking: No country in the region has all the necessary finance, trained manpower, germplasm and trechnologies to enable it to stand alone and solve all its sorghum and millets improvement problems. Therefore, we learned quickly that networking should continue and strengthened. Limited budgets for research within NARS coupled with inefficient bureaucratic procedures are often cited as limiting factors in sorghum and millets improvement. NARS scientists are often confronted with insufficient and/or untimely support to adequately conduct experiments. Therefore, the network in Phase III should have enough funds to provide research supplies and facilities as and when these are needed to adequately conduct and monitor (by NARS scientists) regional research activities.

Hybrid: Multilocation testing of varieties and hybrids clearly indicated that ICRISAT hybrids out-yielded varieties by 20-30%. Except for Sudan and Ethiopia, hybrid development is not very much emphasized in other countries in the region and at this stage ICRISAT regional program (EARCAL) in Kenya has taken full responsibility to develop good hybrids but eventually in Phase III, funds should be made available to encourage hybrid improvement and production in each country in the region. As a result, this will require strengthening seed industries in each country.

Striga: *Striga* is a serious parasitic weed on sorghum and finger millet crops resulting in significant production losses (40 to 80%) in farmers field. In Phase II, EARSAM network emphasized research on *Striga* with NARS and uniform trials were conducted in *Striga* sick plots for evaluation. The incidence of *Striga* was erratic at several locations and therefore, difficult to confirm resistance. In Phase III, more funds should be allocated to generate technologies with reliable and effective screening techniques in order to make useful progress.

RECOMMENDATIONS FOR PHASE III

4. Recommendations

Sorghum and millet improvement in eastern Africa will confront new challenges in the 1990s. The main objective of EARSAM and the NARSs is to facilitate the attainment of food sufficiency in eastern Africa, and we must therefore continue to adapt to environmental, social, and political changes to meet these challenges.

If present trends of underproduction and population growth continue, the net food production shortfall in eastern Africa will be quite substantial by the year 2000 (6). Therefore, SAFGRAD/ICRISAT and NARS combined efforts in the EARSAM network will better equip the NARS to deal with future challenges. We all realize and appreciate the comparative advantages of working together.

For the 1990s to contribute to increasing sustainable food production in eastern African countries, so as to improve the nutritional level and general economic well-being of low-income people the following can be considered as challenges:

Strengthening networking: No country in the region has all the necessary finance, trained manpower, germplasm, and technologies to enable it to stand alone and solve all its sorghum and millet improvement problems. Therefore, networking should be continued and further strengthened in order to exploit the existing strengths in each country and to optimize ICRISAT's input.

Strengthening the sorghum and millet research and training linkages between and among the different national programs, universities, private, public, and international institutions (ICIPE, ICRAF, etc.) is expected to promote and facilitate easy transfer of germplasm and technologies generated within the region, and thus contribute significantly to strengthening each of the national programs.

In addition to germplasm movement and evaluation through cooperative testing it is recommended that service activities are developed. At regional level these include; a crossing block, an off-season nursery, regional screening for resistance to yield limiting factors, and screening for food quality. To facilitate these services the regional program will need to continue.

Limited budgets for research within NARSs coupled with inefficient bureaucratic procedures are often cited as limiting factors in sorghum and millet improvement (7). NARS scientists are often confronted with insufficient and/or untimely support to adequately conduct experiments. The regional network cannot afford to be left at the mercy of such vagaries, and therefore must be in a position to help overcome constraints as they arise. The network should have enough funds during the 1990s to provide research supplies and facilities as and when these are needed to adequately conduct regional research activities.

Manpower development: Well-trained scientists and support staff are assets to a good national program. NARSs appreciate and recognize the training opportunities offered by EARSAM in the region, at ICRISAT Center, and elsewhere. However, the establishment of practical applied training opportunities for technicians in the region in a well-organized training center with adequate facilites is needed to meet expanding manpower requirements.

For specific types of training, appropriate national program centers should also be identified and strengthened so that they can implement training activities. Scientists from NARS and other international institutions will play leading roles in providing knowledge and experience for such activities.

Degree-level training (Ph.D, MSc) in all disciplines is a high NARS priority. Funds should be made available so that this training can continue to be provided.

Research station improvement and management: One of the limitations to good quality research within NARS is the paucity of effective research station management. Every year a substantial percentage of the data collected is inaccurate because it has been collected in poor experimental fields that lack proper management. It will therefore, be necessary in the 1990s for NARSs, in cooperation with other institutes involved in research station improvement and management, to train young scientists in station management in order to improve the research plots.

Major constraints to productivity: Research should be focused on the following priority targets, that have been described earlier in this paper.

grain molds (sorghum) and ergot (pearl millet)

Strategies to combat all these will need to be formulated and put into operation.

Germplasm Collection and conservation: ICRISAT experts from the genetic resource unit collect germplasm materials for all ICRISAT mandate crops from different sources in the world. All the collections are classified and stored properly at ICRISAT Center for evaluation with the purpose of making them available to NARS when the need arises.

Finger millet is known to have its origin in eastern Africa. Of the 3220 finger millet germplasm accessions conserved at ICRISAT, 2015 (63%) are from Africa (8). Though the number of accessions are small, they show considerable diversity for heads, finger and seed size, shape and colour. In general, African types produce larger and late maturing heads compared with those collected from India. In addition, larger germplasm collections of finger millet are also maintained at SADCC/ICRISAT, Bulawayo, Zimbabwe, Ethiopia, Kenya and All India Co-ordinated Small Millets Improvement Project (AICSMIP), Bangalore, India. All these collections should be adequately exploited, classified and eliminate duplications.

In view of the importance of this crop mainly in eastern, central and southern Africa, more effort should be made to collect and conserve germplasm before it is too late.

On-farm research: On-farm testing of released cultivars coupled with appropriate technolgies is an important activity, and should be strengthened. Such research should include on-farm verification and demonstration trials so that good feedback on the performance of improved cultivars in farmers' fields is obtained. One way to achieve this may be through cooperative links with appropriate Global 2000 programs in the region.

Strengthening seed industries: The shortage of good quality seed that is available to farmers is a major cause for the poor adoption and spread of released cultivars. It is therefore essential to strengthen private and public seed multiplication and distribution agencies, in each of the countries in the region. Once research has identified, evaluated, tested in farmers' fields, and NARS have released good hybrids adapted to regional requirements, agencies should be encouraged to produce quality hybrid seed.

Agroecological Zoning: The eastern Africa region is unique inthat it contains areas of traditional sorghum and millet production in diverse ecological zones; ranging from near sea level to 2500m with a wide range of climates, soils, and crop requirements.

Currently, there is no standardized method that can be used to characterize the different environments encountered in eastern Africa by sorghum and millet producers. The addition of environmental parameters should allow scientists to tailor the improvement and adaptation of germplasm to specific ecological zones. Therefore, there is a need for clear definition of; environments, their variations between and within seasons, and the yield-limiting factors in each agroecological zone of the region. It is also important to identify the relative probabilities of occurence of different types of stress. This is a long-outstanding requirement that was noted at least 10 years ago (8). The time has come to do something about it.

Effective marketing systems: Most farmers in eastern Africa are poorly capitalized, have little or no access to credit, a shortage of labor, and limited scope for marketing. As matters now stand, farmers have few opportunities or incentives to increase productivity. Therefore, effective marketing systems and infrastructures are needed to provide timely, low-cost inputs, such as fertilizers, chemicals, and seed in support of increased farm productivity (9).

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Table 1. Sorghum, millet, and total cereals; area harvested ('000 ha), production '000 t), and yield (kg ha-1) for eight countries in eastern Africa compared to total Africa.

Crop	Burundi	Ethiopia	Kenya	Rwanda	Somalia	Sudan	Tanzania	Uganda	Africa Total
Sorghum									
Area	58	900	146	173	550	3682	514	180	16963
Production	88	964	143	164	291	1924	503	260	13995
Yield	1514	1071	979	948	529	523	979	1444	825
Millet									
Area	13	200	96	2	0	1550	300	270	14263
Production	10	180	60	2	0	167	300	380	9302
Yield	769	900	625	833	0	108	1000	1407	652
Total Cereals									
Area	215	5017	1982	263	848	5448	3168	773	73957
Production	321	5925	3460	268	608	2369	4634	970	90845
Yield	1489	1181	1746	1019	716	435	1463	1255	1228

1. Source: FAO Production Yearbook 1989, Food and Agriculture Organization of the United Nations, Rome. Italy: FAO.

Table 2. Sorghum and millet cultivars released in eight eastern African countries

Country	Crop: Sorghum	Pearl Millet	Finger millet
Burundi	5 Dx 160 Gambella 1107		
Ethiopia	Melkamash Gambella 1107 Dinkmash Seredo		
Kenya	Serena Seredo IS 76 2 Kx 17		
Rwanda	Amasugi 5 DX 160		
Somalia	PP 290		
Sudan	White Dwarf Milo Hageen Durra 1 Gadam Hamam	Ugandi	
Tanzania	Serena Lulu Tegemeo	Serere 1 Serere Composite	
Uganda	Serena Seredo	Serere 1 Serere Composite	Engeny P 224

e 3. Mean grain yields (t ha⁻¹) of the highest-yielding sorghum entries at five stern African locations in Lowland Group 1 of the EARSAM Elite Sorghum Yield Trial FSYT-89) rainy season 1989/90.

try	Source	Location: Baidoa	Gadambalia	Ilonga	Kiboko (long rains)	Hombolo	Mean
SV 335	ICRISAT Center	2.84 (1)[1]	0.63(17)	2.66 (2)	3.90 (5)	2.31(20)	2.52 (1)
160	NARS, Burundi	1.23(25)	0.67(14)	2.67 (1)	3.11(16)	4.58 (1)	2.50 (2)
112	ICRISAT Center	1.89(11)	0.47(20)	2.16 (7)	3.87 (6)	4.04 (3)	2.46 (4)
5:5	NARS, Sudan	1.99(10)	1.08 (3)	1.49(17)	4.33 (1)	3.11 (9)	2.42 (5)
t 83487	NARS, Kenya	1.78(16)	1.08 (3)	2.00 (9)	3.55(10)	3.47 (5)	2.40 (6)
t 83369	NARS, Kenya	1.84(14)	0.86(10)	1.61(14)	4.10 (2)	3.33 (7)	2.34 (7)
m mam	NARS, Sudan	2.31 (4)	1.69 (1)	1.34(19)	3.69 (9)	2.78(17)	2.32 (8)
[illegible]	NARS, Rwanda	1.88(12)	0.42(22)	2.43 (5)	2.26(24)	4.22 (2)	2.23(11)
290	NARS, Somalia	2.52 (2)	0.78(11)	2.05 (8)	3.95 (4)	1.47(25)	2.11(13)
S 2284	NARS, Ethiopia	1.02(24)	1.61 (2)	0.63(25)	1.83(25)	1.98(23)	1.47(24)
ontrols							
Seredo	NARS Uganda	2.23 (6)	0.61(18)	1.82(11)	4.06 (3)	3.82 (4)	2.48 (3)
Hageen Durra 1 Durra 1	NARS Sudan	2.25 (5)	0.94 (6)	1.55(16)	3.23(13)	2.89(18)	2.16(12)
E		±0.15	±0.20	±0.20	±0.34	±0.32	±0.28
Trial mean (24 entries)		1.87	0.76	1.70	3.28	2.97	2.12
V(%)		14	45	20	18	19	

. Numbers in parentheses indicate ranking in trial

Table 4. Mean grain yields (t ha^{-1}) of the highest-yielding sorghum entries at one or more eastern African locations in Lowland Group 2 of the EARSAM Elite Sorghum Yield Trial (EESYT-89), rainy season 1989/90.

Entry	Source	Location: Mombasa	Kiboko (short rains)	Wad Medani (irrigated)	Imbo	Mean
ICSV 112	ICRISAT Center	6.31 (3)[1]	5.22 (3)	5.06 (2)	1.82 (2)	4.60 (1)
ICSV 401	ICRISAT Center	6.12 (6)	5.03 (4)	5.03 (4)	1.21(12)	4.32 (2)
KAT 88487	NARS, Kenya	5.50(13)	5.41 (1)	4.44 (7)	1.64 (2)	4.24 (3)
Dinkmash	NARS, Ethiopia	6.43 (1)	3.86(16)	4.85 (4)	1.18(15)	4.08 (4)
I36121	NARS, Ethiopia	5.80(10)	5.23 (2)	3.56(12)	1.18(16)	3.94 (7)
AT 83369	NARS, Kenya	6.34 (2)	5.02 (5)	1.80(22)	1.88 (1)	3.76(12)
ontrols						
Hageen Durra 1	NARS Sudan	4.84(24)	4.05(14)	5.27 (1)	0.97(20)	3.78(11)
eredo	NARS Uganda	5.50(21)	4.12(13)	2.82(16)	1.24(10)	3.42(14)
SE		±0.37	±0.46	±0.41	±0.10	±0.50
Trial mean (24 entries)		5.39	3.99	3.27	1.20	3.46
CV(%)		12	20	22	27	

Numbers in parentheses indicate ranking in trial

Table 5. Mean grain yields (t ha^{-1}) of the highest-yielding sorghum entries at one or more eatern African locations in Lowland Group 3 of the EARSAM Elite Sorghum Yield Trial (EESYT-89), rainy season 1989/90.

Entry	Source	Location: Melkassa	Location: Karama	Location: Katumani (short rains)	Mean
Kigufi	NARS, Rwanda	5.19 (2)[1]	3.74 (2)	2.78(23)	3.90 (2)
Framida	NARS, Ethiopia	4.08 (3)	1.61 (8)	5.26 (2)	3.89 (3)
Gadam Hamam	NARS, Sudan	4.39 (5)	1.45(11)	5.35 (1)	3.73 (4)
1804	NARS, Rwanda	2.99(10)	3.09 (3)	4.59 (4)	3.56 (5)
5 Dx 160	NARS, Burundi	3.11 (8)	3.82 (1)	3.19(20)	3.38 (6)
KAT 83369	NARS, Kenya	3.29 (6)	1.06(18)	4.64 (3)	3.00 (8)
Controls					
Seredo	NARS, Uganda	3.42 (1)	2.35 (4)	4.58 (5)	4.12 (1)
Hageen Durra 1	NARS, Sudan	2.15(14)	1.48(10)	4.52 (6)	2.72(12)
SE		±0.59	±0.32	±0.65	±0.63
Trial mean (24 entries)		2.68	1.52	3.86	2.69
CV(%)		38	37	29	

1. Numbers in parentheses indicate ranking in trial

Table 6. Mean grain yields (t ha^{-1}) of the highest-yielding entries at one or more eastern Africa locations in Intermediate Group 1 of the EARSAM Elite Sorghum Yield Trial (EESYT-89), rainy season 1989/90.

	Source	Locations				MEAN
		Katumani - (short rains)	Murongwe	Arsi Negele	Rubona	
IS 9302	NARS, Ethiopia	5.99 (1)	2.29 (2)	5.02 (1)	1.10 (5)	3.60 (1)
Nyirakabuye	NARS, Rwanda	4.41 (8)	2.57 (1)	3.33 (3)	1.14 (4)	2.86 (2)
Amasugi	NARS, Rwanda	2.51(14)	2.05 (3)	4.52 (2)	1.96 (1)	2.76 (3)
85MW 5340	NARS, Ethiopia	2.99(12)	1.61 (5)	1.54 (7)	1.78 (2)	1.98 (5)
Control Seredo	NARS, Uganda	4.52 (2)	1.55 (6)	0.66(11)	0.85 (9)	1.93 (6)
SE		±0.44	±0.23	±0.45	±0.28	±0.53
Trial Mean (14 entries)		3.69	1.45	1.99	1.02	2.04
CV(%)		21	28	39	48	

1. Numbers in parentheses indicate ranking in trial

Table 7. Mean grain yields (t ha^{-1}) of the highest-yielding sorghum entries at one or more eastern African locations in Intermediate Group 2 of the EARSAM Elite Sorghum Yield Trial (EESYT-89), rainy season 1989/90.

Entry	Source	Location: Ukiriguru	Location: Kiboko (long rains)	Location: Kiboko (short rains)	Mean
Serena	NARS, Uganda	2.04 (2)[1]	3.28 (4)	4.22 (2)	3.18 (2)
4MX 11/9/2	NARS, Uganda	1.90 (3)	3.13 (7)	3.74 (3)	2.92 (3)
TSX 183/2 2/2/1	NARS, Tanzania	1.59 (8)	3.34 (3)	2.13(12)	2.35 (8)
Controls					
Seredo	NARS, Uganda	2.39 (1)	3.78 (1)	4.34 (1)	3.50 (1)
ICSH 153	ICRISAT Center	1.88 (4)	3.52 (2)	2.49(10)	2.63 (5)
SE		±0.19	±0.35	±0.40	±0.38
Trial mean (14 entries)		1.64	2.98	2.86	2.49
CV(%)		20	21	24	

1. Numbers in parentheses indicate ranking in trial

Table 8. Mean grain yields (t ha⁻¹) of the highest-yielding entries at one or more eastern African locations of the EARSAM Elite Finger Millet Yield Trial (EEFMYT-89), rainy season 1989/90.

	Source	Locations					
		Alupe	Katumani (short rains)	Kabanyolo	Serere	Melkasa	MEAN
Gulu E	NARS, Uganda	3.62 (8)	3.10 (2)	0.83 (5)	0.79 (3)	2.05 (4)	2.08 (1)
P 224	NARS, Uganda	4.11 (1)	2.89 (3)	0.61(10)	0.70 (5)	1.56 (6)	1.98 (2)
Serere 1	NARS, Uganda	3.97 (3)	2.57 (7)	0.88 (3)	0.88 (1)	1.54 (7)	1.97 (3)
Engeny	NARS, Uganda	3.99 (2)	2.82 (4)	0.48(12)	0.62 (7)	1.33(10)	1.85 (4)
Ending	NARS, Uganda	3.18(10)	2.78 (5)	0.91 (2)	0.64 (6)	1.47 (8)	1.80 (6)
KAT/FM 1	NARS, Kenya	2.00(13)	3.21 (1)	1.00 (1)	0.37(12)	2.08 (2)	1.73 (7)
Acc# 100008	NARS, Ethiopia	1.24(16)	2.47 (9)	0.85 (4)	0.23(15)	2.27 (1)	1.41(13)
Control Ikhulule	NARS, Kenya	3.00(11)	1.43(16)	0.42(14)	0.42(11)	0.60(14)	1.18(16)
SE		±0.41	±0.41	±0.08	±0.08	±0.28	±0.13
Trial mean (16 entries)		3.08	2.51	0.65	0.56	1.38	1.64
CV(%)		23	28	22	24	35	

1. Numbers in parentheses indicate ranking in trial

1991-07

FINAL TECHNICAL REPORT ON EAST AFRICA SORGHUM & MILLET RESEARCH NETWORK (EARSAM)

OUA/CSTR-SAFGRAD

ICRISAT