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THE SADCC/ICRISAT SORGHUM AND MILLETS IMPROVEMENT PROGRAM

The First Five Years

INTRODUCTION

Program Initiation

At their Lusaka meeting in March, 1980, the Heads of SADCC States requested ICRISAT to establish a research institute in Botswana. Botswana has the responsibility for agricultural research for SADCC. ICRISAT responded with a mission in November 1980 and they recommended the establishment of research teams to be based at appropriate locations in the Region. The mission report was accepted by the Council of Ministers in March of 1982. Looking back, it may have been better to have established a Regional Research Institute (possibly in a less severe environment than that of Botswana) and to have the teams as units or departments of this institute. Such a structure would have provided a rational base for such activities as agroclimatology, germplasm resources, documentation, training, contribution to experiment station development, contribution to seed production, to crop utilization; etc., i.e. of activities important to all teams but difficult to fully support within a crop improvement or activity specific team. There may be value to still consider such an approach.

SADCC Interaction

The program is viewed as a SADCC Sorghum and Millets Improvement Program managed by ICRISAT. There is a close working relationship between SACCAR and the program. The SACCAR Director chairs the annual meeting of the Technical Advisory Panel and the Project Manager presents an annual report to the SACCAR Board. There are numerous informal interactions. There is an exploratory/searching element in the relationship of mutual concern and contribution.

Objectives and Orientation

The first five years of the program have been directed to program establishment. Staff for the program are essentially in place, facilities to support research are completed or nearing completion, program priorities have been implemented. The primary objective of the program is to strengthen National capability to improve sorghum and millets. To address this objective, three areas of activity have been identified, research, education and training, and service (primarily improvement of research facilities). To accomplish the objective a time horizon of 25 years has been estimated. The program has enjoyed support from USAID, CIDA, and GTZ at a level of 17.8 million US dollars for the 5 year period (approximately 1984-1988). This level of funding has permitted the program to establish and to respond to opportunities not adequately visualized when the project document was first written.

Staffing

Research, to identify higher yielding cultivars of sorghum and millets, particularly for the poorer farmers of the Region working in drier, low productive situations, was no doubt the intent of the Heads of States in their request to ICRISAT. When dealing with agricultural improvement one is working with a dynamic system where cultivar change should be accompanied with management change, and both these factors can result in changes in pest populations. A critical team of scientific talent was considered important and that stabilization of research within nation programs was critical to sustained crop improvement. A research team of sorghum breeder, millet breeder, agronomist, pathologist and entomologist with support from an experiment station manager, administrative officer, and project leader was identified. An economist was to join later to help foster input in intercropping and farming systems once improved cultivars were available.

This team was employed in a programmed sequence during the first 5 years. Employment was undertaken by ICRISAT and was international in scope. That it was international in scope, I feel was valuable at the beginning to get program objectives and priorities in place while national scientists availed educational opportunities. It also reduced competition with National programs for their qualified staff. Direction is now changing to increasingly employ regionally which is essential during the 25 year life of the program.

Program Changes

As the program began problems of development of the regional station and of experimental error generally in the Region encouraged a greater input into improvement of conditions of research. This has been visualized as actual improvement of physical facilities and by use of appropriate experimental design. Approval was given to continue the principal position of station development and operations officer from the first 3 years, as originally visualized, to the full five years. In fact, the position is continued through the second 5 years, and additionally, a regional staff position for the second 5 years is now filled. While this team is not adequate to solve all problems in the region, it is capable of supporting station development and stimulating greater contribution. Hopefully, this can become an important project area of SACCAR for the improvement of national research stations.

It became apparent that to improve the opportunity for use of sorghum and millet they should be convenient to utilize. From a food point of view this essentially means to be as convenient as maize to prepare into locally desired foods and beverages. The capability, particularly of Zimbabwe, to over produce, indicated a need to improve market opportunity. Approval was given to add a food technologist to the program and to modify the roll of the economist to marketing and policy. International and regional meetings have taken place and the program is beginning to focus on cultivars selected with several end uses in mind and to look at multiple crop uses. A laboratory with modest pilot plant is under construction to support this activity. Research is getting underway. Interest in this area of utilization is high within the SADCC countries.

The original concept was for the Regional Program to focus on improvement of sorghum and pearl millet. At the first workshop a request was made to add finger millet and this was subsequently approved. There was also an expressed interest in the utilization of sorghum and millets as animal feeds. This use is widely visualized as expanding in the future. The principal millet breeder now devotes about half of his time to feeds, and increasing proportion of his time to finger millet. It is planned that a regional breeder will be employed in 1990 to continue the input into pearl millet improvement.

During the first 5 years there were 2 short courses for scientific technicians and 2 for station managers. The program has expanded in scope for the second 5 year period. To support this expanding activity approval was given to employ a Regional Training Officer and to construct a dormitory. This, and an expanding array of training material has placed the program in a strong position to carry out this important aspect of the project.

These 5 activities/changes in station development and management, crop utilization, training, addition of finger millet and forages represent important changes that occurred during the first 5 years and are now an integral part of the program. That it was possible to include these changes/additions makes the program more relevant to the Region.

Input into farming systems is included in the original project proposal and experiments on intercropping have just begun. The idea was to focus on crop improvement first to pave the way for input/collaboration in this area of activity.

NATURE OF INTERACTION WITH NATIONAL RESEARCH SYSTEMS

As indicated, the focus of the Regional Program is strengthening National research capability. The existing capability varies with each country. For example, in Zambia, the sorghum and millet breeders are experienced and contribute to regional activities; while in Lesotho, they are in the process of creating a sorghum improvement program. There are also environmental/problem differences. For example, long season varieties are required in Tanzania but not in the rest of the region. The disease, leaf blight, is important in central-northern Zimbabwe, but not in the south. The Regional Program, then must tailor its interactions pretty much with each national program. There are Regional nurseries and trials that are relevant across most SADCC countries. This need to interact with each country has been part of the strategy of each regional scientist.

CROP IMPROVEMENT

We have divided the crop improvement process into two major categories - the generation of genetic variability, and the exploitation of this variability. Generation of variability includes activities of germplasm acquisition and evaluation, crossing and early generation evaluation, screening for resistance and quality traits. In this activity large numbers

of entries are involved and discard rates are high. We have felt this to be a primary responsibility of the Regional Program to avoid overloading the National Programs. These activities need to be undertaken in different environments so the Regional Program has identified a number of National Stations representing these environments and contributes technical staff and full support to the conduct of these evaluation activities. While these activities are undertaken on National Stations under the direct supervision of the scientist on that station, the results are for the Region. This has worked reasonably well, but has contributed to more of a "them and us" attitude than we expected which we now want to rectify. Ultimately, these activities will need to be part of National Programs and the Regional Program should encourage this. A few National Programs already undertaken activities leading to the generation of variability.

Exploitation of variability leads, via a logical sequence of nursery selection and yield trial evaluation, to new varieties and hybrids for different end uses. Coupled with this aspect are crop management considerations, demonstration, national release, and concern for seed production, particularly maintenance of pure seed (breeders seed). The contribution of the Regional Program in these activities varies with country from very little to substantial. A measure of achievement will be the stabilization of these activities within National Programs and some progress can be identified.

Recently, and particularly in relation to returning students, we have explored ways of interacting with them to encourage, support, and expand the total research input. Initially, for the second 5 year period, we anticipated post doctoral programs, secondment of national staff to the Regional Program for as much as a year, and for scientists returning from degree programs to spend 1-3 months with the Regional Program. These activities were visualized as steps to increase local input into regional activities. It has become apparent, that there is a high demand in home country programs for them hence a reluctance to release them to the Regional Program.

The problem was reappraised so that Regional Scientists would interact with returning (or existing) National Scientists to develop joint work plans. This idea was first explored in Tanzania and was well received. They suggested that their scientists be principal scientists, present the project to their annual workshop, and that both Tanzania and the Regional Program would support the project. This is felt to be ideal. It is essential that both parties are held technically and fiscally accountable and the work plan provides one good mechanism for the Regional Program to support/strengthen infrastructure required for good research.

INTERACTIONS WITH OTHER AGENCIES

The ICRISAT Center

As might be expected the Regional Program has benefitted substantially from interaction with the ICRISAT Center. Benefit has not only been breeding stocks and techniques, but also staff. Their station manager spent 2 years with us, the administrative officer about the same and then joined the program. The millet breeder, entomologist and project manager came to the Regional Program from ICRISAT (the millet breeder from an ICRISAT program in Senegal). All training activities, have been organized and implemented by staff from the ICRISAT training unit (this year Regional Staff participated and will take future leadership). We have had an ICRISAT pathologist for 6 months at the Regional Center and another for the same amount of time in Zambia. An ICRISAT millet breeder worked with the Zambia program for 6 months and ended up with a job as Zambia National Millet Breeder. There have been shorter term visits of ICRISAT staff on particular aspects of the program and ICRISAT Center staff have participated in all Regional Workshops and monitoring tours. Regional staff also gain from periodic visit to the Center.

Interactions, primarily with breeding stock, have increased with ICRISAT programs in East and West Africa. There has been participation of Regional Staff in functions in Eastern Africa and visa versa.

Interactions with the International Sorghum and Millet Collaborative Research Support Program (INTSORMIL)

INTSORMIL is a program within 5 universities in the USA to use USAID funds to undertake research relevant to and within 3rd world countries. In southern Africa, they are particularly involved in Botswana. They have consulted for us on problems of acid toxic soils and sooty stripe (a fungal disease). We have had useful interactions on disease and insect problems and breeding.

Additional Interactions

We have benefitted from research on downy mildew and smut in pearl millet and ergot on sorghum by scientists working with us from the Wye College, University of Reading, and the Imperial College, London, and on aspects of crop utilization with the Carlsberg Research Laboratory in Copenhagen.

Collaboration with the International Livestock Center for Africa (ILCA) has begun.

These consultancies, exchanges have broadened our research and training opportunities and helped us increase our efficiency.

RESEARCH ACTIVITIES

Scientists in the Regional Program have a component of their activities in development research and a component in evaluation and adaptation of research accomplishments. Roughly 30% of each scientists time is spent with scientists in National Programs. The Annual Workshop is a reporting and planning meeting. Its effectiveness has increased greatly over the years and is now highly interactive and useful. Annual monitoring tours are also organized where scientists from National, Regional and International Programs can visit several experiment stations in the Region. This activity has been another forum of discussion, exchange of ideas and materials, and to build esprit de corps among workers in the Region. National scientists have been supported for meetings and study tours. Visits of Regional Scientists to National Programs provides an opportunity for close interaction. The Program leader makes an annual report to the SACCAR Board and the Director of SACCAR chairs the annual meeting of the Technical Advisory Panel. All of these activities contribute to the research activities on sorghum and millets in the region and help ensure its relevance.

Breeding

Breeding activities take place with sorghum, pearl, and finger millets, and sorghum - millet forages. In each case the activities were initiated by introducing breeding stocks, collections from around the world and evaluating them at 4-7 locations in the region. These activities began at different times, sorghum in 1983, pearl millet in 1984, finger millet in 1985, and forage in 1987. Introduction and evaluation has occurred every year and is a continuing activity. Introductions include good breeding stock and sources of resistance on utilization/quality traits. Introductions are evaluated, the best going to National Programs and into Regional Program nurseries and crossing blocks. Selections from these eventually are included in preliminary trials and then Regional Trials.

The sorghum and pearl millet breeding programs have developed breeding populations, and recently these are being developed for the forage program. These populations are developed for different maturity zones and/or special traits (bristles (awns) in pearl millet). Generally, these populations are being random mated, in some, cycles of selection has begun to develop new varieties and parents of hybrids.

Varieties and hybrids of sorghum and pearl millet and finger millet varieties have gone through various stages of testing and some have been released. The forage program is in a more preliminary test evaluation phase. Selections have been made collaboratively with the pathologist and entomologist and the gain in resistance, particularly to several leaf diseases is apparent.

Specific efforts are being made, jointly with the Tanzanian National Program to select long season types suitable to their environment.

Efforts will increasingly be made to select varieties and hybrids with traits useful to food, feed and non food industrial uses. We are waiting for the completion of our Food Tech/Crop Utilization lab to become fully involved with these activities.

Agronomy

The agronomy program recognizes major problems of drought and production technology. Research approach involves problems of stand establishment, growth variability, plant density and spacial arrangement with nitrogen and weed control, and problems of moisture capture and availability to plants. Interactions with national scientists have led to site specific research. Information has been gained on increased uniformity of growth with use of nematocides, contribution to improved stand, interaction of sowing date on yield, quantification of weeds on yield of different stand densities, moisture availability with different soil configurations (tied ridges for example), and techniques to enhance moisture stress for research. There is also interest in crop management to contribute to reduce error variance in experimental plots.

Pathology

The pathology program has endeavoured to confirm disease priorities, to locate "hot spots" for screening, and to look for racial variability. With weather fluctuations this has not been as easy as it might seem. Seven diseases have been identified of major concern, ergot and downy mildew in pearl millet, downy mildew, leaf blight, sooty stripe, anthracnose and ergot in sorghum. Techniques have been adapted to screen for several of these diseases, an effort is being made to develop techniques for sooty stripe, and a much greater input to look for resistance and/or escape from ergot in sorghum is planned. Resistance has been found for ergot and downy mildew in pearl millet, downy mildew and leaf blight in sorghum. Though not of the same priority, resistance has also been found for downy mildew, false mildew, and rust in pearl millet. Multiple resistance has been found in a few lines of pearl millet and sorghum.

Progress has been made in predicting severity of downy mildew and leaf blight in sorghum from climatic parameters (primarily temperature).

Progress has been made in the Region on disease identification, scoring, and screening for resistance.

Entomology

The entomology program has gained information relevant to insect pests in the region - what pests, where in the region they are important, and when they are important. A number of pest nurseries from the Regional Program and the ICRISAT Center have been evaluated in the Region both to learn about insect pests and to evaluate plant response (look for resistance). These efforts have been focussed into Zimbabwe, Zambia, Malawi and Tanzania.

Most studies have included a strong training component. A study on stemborer yield loss is underway as part of the PhD thesis research of a Zimbabwean entomologist. A vacation period student from the University of Zimbabwe has assisted in evaluating the impact of leaf feeding on yield loss. Reduction in yield has been found to be higher when plants are infested with first instar larvae from 12 to 24 days after emergence than later in the plants life.

A PhD student from Botswana is conducting research on the Sugarcane aphid at the Regional Center. A leaf sheath cage technique is being developed for rapid screening. Varieties are being identified with a good level of resistance. There is also indication that there may be some differences between the aphids found in Botswana with those being tested at Matopos.

Studies on resistance to storage insects, involving Sitophilus and Sitotroga have been initiated.

At the request of the Department of Agriculture, Zambia, research has begun in close cooperation with the Zambian sorghum entomologist to learn about the armoured cricket. This insect has increased in importance over the past few years in drier portions of the country (as well as in several other countries). Results to date show that cricket nymphs depend on their development on immature grass seed and adults only migrate to sorghum and millet when the grass seed is no longer available. It has been found that the migration of these flightless insects can be blocked by cutting a steep sided small ditch around the field. The ditch can be more effective if an insecticide is placed in the bottom. This study is on going.

The entomologist, with the pathologist, form a team with the breeders to evaluate breeding lines.

Food Technology/Crop Utilization

The area of food technology/crop utilization is recent in the program but already gaining recognition in the Region. The lab and lab equipment are in process of development - accumulation but it will be the best part of a year before we are fully operational. However, activities have begun with standardization of procedures for pearling index, milling yield, endosperm hardness score, floatation test, gelatinization temperature, size grading and size fractionation. Tests for micro malting and determination of diastatic power, particularly in support of the PhD thesis for the Zimbabwe sorghum breeder, are in daily use. The sugar level in a large number of introduced sweet stemmed sorghums has been determined at several growth stage in plants growing with and without irrigation. There has been collaborative work with the Carlsberg Lab, Copenhagen, on malting and diastatic power, and on the use of internode chips to make construction boards.

An international and a Regional meeting have taken place to explore expanded uses of sorghum and millets. These meetings have been valuable in helping focus research activities.

The food technologist is currently involved in consulting on interests in Zambia and Botswana blending sorghum flour into that of wheat and soyabeans respectively. There is a need to develop grain standards to serve existing interests in sorghum utilization.

Economics

The Principal Economist, seconded to the Regional Program from the International Food Policy Research Institute (IFPRI) has recently completed his first year with the program. The focus of research as three major objectives:

- a) research on marketing constraints affecting sorghum and millet
- b) research on options and constraints for expanding utilization of sorghum and millets and
- c) research on factors influencing the substitution in production and consumption across the coarse grains - sorghum, millets, and maize.

A number of important observations have been made:

- a) Sorghum and millet are generally produced in more remote areas increasing market costs and reducing competitiveness as compared to maize.
- b) Marketable surpluses of sorghum and millet tend to be highly variable over years reducing willingness to depend on these crops for industrial inputs.
- c) Localized, informal market prices tend to be higher than those for maize reflecting their value in local brewing. This limits competitiveness for industrial output.
- d) Sorghum and millets are most frequently produced in food deficit areas where food security is of concern.
- e) There is need for high yielding varieties and hybrids of sorghum and millets to effectively compete with maize. Currently, maize yields are often higher than those for sorghum and millet in agroecology zones most suited to smaller grains.

Research is conducted by the Principal Economist, generally including a training component. The economist, along with the food technologist have participated in studies requested by the Government in Botswana and Zambia. Research is conducted cooperatively with Departments of Agriculture and Universities. Research includes aspects of production, marketing, and utilization by small scale farmers in Zimbabwe; a survey study to ascertain the sorghum and millet situation in Tanzania; the possibilities for substituting sorghum, millet and cassava for maize in the wheat milling, baking, brewing and stock feed industries in Zambia; and the roll of dehullers

and marketing constraints in Lesotho.

Education and Training

The Programs input into manpower development has two important components: degree education and training of several types. The education component has been sub contracted by ICRISAT to INTSORMIL. This is a program involving universities in the USA.

The object of the education program is to have qualified scientists as required in the sorghum and millets improvement programs of the SADCC countries. It was visualized that this objective would be achieved over a ten year period.

A strategy for education was initially organized by two INTSORMIL scientists. This strategy was approved by the Coordination Technical Committee (CTC preceding SACCAR) with minor modification. The strategy varied with country and was multidisciplinary.

As of March 1, 1989, INTSORMIL had processed a total of 41 SADCC students encompassing all nine SADCC countries as indicated in the following table.

Current Status of SADCC Education by Country and Degree as of March 1989

Country	B.S.	M.S.	Ph.D.	E.T.'	Total
Angola	0	2	0	0	2
Botswana	1	1	1	0	3
Lesotho	2	3	0	1	6
Malawi	0	3	6	0	9
Mozambique	0	1	0	0	1
Swaziland	0	1	1	0	2
Tanzania	2	3	1	1	7
Zambia	2	4	0	1	7
Zimbabwe	0	3	1	0	4
Total	7	21	10	3	41

'ET - early termination

An indication of distribution across disciplines is as follows:

SADCC Education by Discipline

Discipline	B.S.	M.S.	Ph.D	Total
Agricultural Economics	0	1	0	1
Agronomy/Physiology	7	6	1	14
Entomology	0	1	2	3
Food Quality	0	1	0	1
Plant Breeding	0	6	4	10
Plant Pathology	0	4	3	7
Seed Technology	0	0	1	1
Soil Fertility	0	1	0	1
Total	7	20	11	38

'Does not include early terminations.

The number of students represents a relatively high level of success considering the number of sorghum and millet scientists in the region but represents about two thirds of the proposed number. The distribution across disciplines is reasonably close to the initial objective. Some deviation represents altered country interests, an opportunity wanted by the CTC in the beginning.

Based on experience of the first five years it has been suggested by SACCAR that the scope of education be broadened to include more disciplines. The number anticipated for education in the second phase is about 60 and the proportion going for the Ph.D will be higher. A strategy for phase II education is currently being organized for SACCAR approval.

The training component of the manpower development program included the six month In-Service Training Program at the ICRISAT Center (22 trainees); two six week training programs (15 trainees) for scientific technicians at the Regional Center; three six week training programs (46 trainees) for station superintendents at the Regional Center; and periodic individual training activities for one or two scientists/technicians at the Regional Center. This training has generally gone well leading to a broader training activity in phase II, the employment of a training officer, and the construction of a dormitory (now completed). One problem faced has been competition for technicians at the time of crop maturity. This is an ideal time for training but the technicians are needed at their home station at this time, particularly with so many scientists away for education. It is anticipated to expand facilities at our off-season location (Mzarabani) to enable training when home pressure is low.

The annual monitoring tours have also provided an opportunity for training. The rather frequent visits of Regional scientists to National Programs has enabled useful interactions.

The education, training activities are an integral and important component of the Regional Program.

Assistance to National Programs

The major assistance has been the improvement in facilities to improve research. The major contribution to date has been in Zambia, but assistance to other countries has taken place (except Angola). Assistance has included land survey and earth moving, provision of farming equipment, assisting with tractor repair, purchase of a vehicle and of motor cycles, construction of houses, assistance with seed stores, provision of laboratory equipment and computer equipment. This assistance has been provided based on need and is not an uniform package. It is anticipated in the future, as possible, to associate development of facilities with research activities.

The improvement in conditions of research is given high priority by agricultural leaders in the Region. The Programs contribution has been modest, helpful, and has given some impetus to this activity. It has been possible to strengthen our input in this area, hopefully, it can become an important SADCC program.

Technicians have been provided by the Regional Program at selected national stations for the evaluation of early generation lines and to screen for resistance traits. In a few cases, technicians have also been provided at a countries request to strengthen their program while several of their scientists are away at universities.

Several of the SADCC countries have benefitted from the off season nursery managed by the Regional Program. This facility has been used, in part, to make crosses and to increase seed for National Programs.

Development of the Regional Center

It has been necessary for the Regional Program to create its research base. The Program is hosted by the Government of Zimbabwe situated on the Matopos Research Station, a station of the Department of Research and Specialists Services.

Some 45 hectares of land have been developed at Matopos and another 18 on sandveld at Lucydale some 12 km away. The Program has enjoyed assistance from Aisleby, the Bulawayo Sewage Farm, where irrigation water is assured. Farm equipment to manage the land has been obtained.

An offseason station has been developed at Mzarabani in the Zambezi River Valley in northern Zimbabwe. The offseason activity began with 0.25 hectare, expanded to 6.5 and is now approximately 35 hectares in size. Land has been developed, irrigation installed on a portion of the land, a guest house constructed, as well as a technicians house and 3 houses for general hands. This is a valuable facility to enhance the rate of crop improvement.

Construction has been substantial and nears completion. An office lab building, a crop processing building and a farm service center were first constructed. There are now field buildings (3 at Matopos, one at Lucydale and one at Mzarabani) to process harvested crops. Fifty houses were constructed for general hand and drivers; and 15 houses were built for technicians, secretaries and accounts people. Recent construction includes a food technology/crop processing lab and pilot plant, four greenhouses and head house, a dormitory and 6 simplex units for single staff. There is still need for some additional housing. Laboratory equipment has been obtained to support an expanding research program. There is still need for equipment.

It is significant that the first two Regional staff on location were a station development and operations officer and a sorghum breeder. It has been possible to timely generate the facilities required to support the research program. This has, been a significant factor to the success that the program has had.

Conclusions

The first five year phase was one of organization. A staff was brought together, research facilities created. Large numbers of breeding stocks and germplasm collections were regionally evaluated and selected. Improved varieties and hybrids are beginning to emerge. Pest problems have been prioritized and locations identified to work on them. The importance of crop utilization and market opportunities has become part of the research strategy. Research priorities and objectives have been identified and implemented. Scientists of the Regional Program work well as a team.

The education - training component has moved well and will contribute to the human resources vital to the long term stability of improvement of sorghum and millets. The input into improvement of research facilities should enable well trained scientists to be more effective in their research.

The Regional Program has developed numerous channels to interact with scientists in National Programs. This is important to the establishment of research activities and monitoring them over time. These interactions have gone reasonably well and we feel that the Regional Program is viewed as contributing to the SADCC Program.

LRH/cd
27 July 1989