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Manuscript Report 183e

National Workshop on Sorghum

Proceedings of the First Biennial Sorghum Workshop held in Baidoa, Somalia, 16–19 June 1986

April 1988

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La présente série est réservée aux documents issus de colloques, aux rapports internes et aux documents techniques susceptibles d'être publiés plus tard dans une série de publications plus soignées. D'un tirage restreint, le rapport manuscrit est destiné à un public très spécialisé.

Esta serie incluye ponencias de reuniones, informes internos y documentos técnicos que pueden posteriormente conformar la base de una publicación formal. El informe recibe distribución limitada entre una audiencia altamente especializada.

IDRC-MR183e

NATIONAL WORKSHOP ON SORGHUM

Proceedings of the First Biennial Sorghum Workshop, held at the Bonka Research Station, Baidoa, Somalia, 16-19 June 1986

Sponsored by
Agricultural Research Institute,
International Development Research Centre, and
Bay Region Agricultural Development Project

Workshop organizer
Hussein Mao Haji

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Foreword

Sorghum is the most important crop in Somalia. It is used for human food and animal feed. The fact that sorghum is widely grown in Somalia reflects its adaptation to our environment which is described as an arid to semi-arid zone.

Sorghum is the most important mandate crop for Bonka Research Station and is also an important crop for the Agricultural Research Institute whose joint Sorghum Improvement Program is aimed at producing high-yielding and stable varieties. To achieve this, research efforts are focused on yield-limting factors such as drought, insect and disease damage. An end-product of such research will be the development of lines that are acceptable to the farmers.

There has been a need to review past and present knowledge of sorghum in Somalia. The aim of the workshop whose papers are being presented here is to review our research results. The discussion on the papers has led to the formulation of recommendations for future action. We hope that the workshop has stimulated more intensive and wider ranging research on sorghum in the country, and that these proceedings will serve as a useful reference for sorghum scientists.

This First Biennial Sorghum Workshop was sponsored by the International Development Research Centre (IDRC), Bay Region Agricultural Development Project (BRADP) and Agricultural Research Institute (ARI).

I would like to express my sincere appreciation to all the individuals who donated their valuable time to make the workshop a success. Particular appreciation is due to Abdi Ahmed Mohamed (Baffo), Ahmed Sheikh Hassan, R.J. Buker, R. Lavigne, J. Lavigne and P. Porter for their tireless efforts.

Hussein Mao Haji
Workshop Coordinator

CHAPTER ONE

INAUGURATION

WELCOME ADDRESS

Mohamed Warsame Duale
General Manager
Bay Region Agricultural Development Project

It is a great pleasure for me to welcome you, on behalf of the organizers of this Biennial Sorghum Workshop, to the city of Baidoa and to the Bonka Research Station. You have come to Baidoa at certainly one of the best times of the year weatherwise, and I hope you will enjoy it.

This national sorghum workshop is the first of its kind. National and expatriate scientists working on sorghum are here to discuss on different aspects of research related to this crop. It is something to be proud of to see so many scientists that belong to different institutions of the country all ready to contribute and share their ideas.

All of you assembled here are experts in one aspect of sorghum improvement or another and all of you are aware of the needs and challenges that relate to this important food and feed crop.

I trust that the harmony which discussions generate from this workshop will greatly assist us in overcoming the challenges lying ahead.

I wish all a pleasant stay and a fruitful workshop. I would like now to welcome the Vice-Minister of Agriculture Dr. Noor for the opening of the workshop.

OPENING REMARKS

Dr. Mohamoud Abdi Noor
Vice Minister of Agriculture

Ladies and Gentlemen,

Good morning to all of you. I am very pleased to have the opportunity to give the opening remarks. As you are aware crop agriculture supplies a means of livelihood to about 22% of Somalia's people, who cultivate about 1.0 million ha. The cropped area includes some 70,000 ha under controlled irrigation, about 100,000 ha receiving flood irrigation and 830,000 ha under rainfed conditions. The major crops grown in Somalia are sorghum, maize and sesame. Sorghum is the major staple food for Somalis. It occupies an area of around 520,000 ha under rainfed conditions[1].

According to the current five year plan, top priority is accorded to increased cereal production. In order to achieve this objective, one must first recognize the major production constraints. I believe that this gathering for the first Sorghum workshop and with the presence of the scientists who are actively involved in sorghum research will allow a better understanding of the production constraints of the sorghum crop. It will also give an opportunity to understand each others' programs, discuss on the future strategies and give priorities for our research in the different research areas of the sorghum crop.

It is wonderful to see such an interest on this crop, and I sincerely hope that we all gain new knowledge and ideas from the workshop, to carry on appropriate research in the future.

I am sure that this workshop will develop much useful information and contribute a great deal to the attention needed by sorghum improvement.

Again I hope that our deliberation will go well and that useful results will emerge from this workshop.

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[1] Somalia: Ag. Sector Survey, April 1987.

OBJECTIVES OF THE WORKSHOP

Hussein Mao Haji

It is a great pleasure to welcome you all to the First National Sorghum Workshop to be held in Somalia. This workshop has been made possible through the generous support of the International Development Research Centre, Agricultural Research Institute, and the Bay Region Agricultural Development Project. We are most grateful to all three institutions.

Sorghum is the major staple food for the Somalis. It occupies an area of about 520,000 ha under rainfed conditions, of the Bay Region, Northwest, Lower Shabelle, Middle Shabelle, Hiran, Bakol and Gedo. Sorghum will, however, continue to be the most important crop in Somalia because it is the most promising crop in the semi-arid and arid climates where the little rain received is highly variable and generally unreliable. Being well adapted to the semi-arid areas on account of its drought tolerance, there is more scope for expanded sorghum production in Somalia.

Sorghum yield in Somalia is low (300-500 kg/ha) when compared to the sorghum yield in Africa and Asia (500-800 kg/ha). The reasons for this are:

1 - Drought, which normally occurs at the final stage of crop growth (after flowering).
2 - insects of different types:
  a) soil insects
  b) insects at the seedling stage
  c) grain eating insects
3 - Diseases

We will be having time to discuss the reasons for low yield and how to improve the sorghum production in Somalia. Several research works on sorghum -- breeding, agronomy, entomology, pathology, etc. -- have been carried out in Somalia. It was thus felt necessary to bring together researchers concerned with sorghum to discuss their work and exchange views to evolve future research strategies and possible collaborations.

Therefore, the objectives of the workshop are to look into the production system of sorghum in Somalia, to identify the major problems to start working with; and to identify problem areas where more research or collaboration is needed.

Let us clearly remember that our client is the farmer and he is not prepared to accept any kind of improvement that will involve high risks. Therefore, his situation and approach should be taken into consideration when we discuss future research strategies.

I hope we will have a most fruitful time here together, exchanging our ideas and views freely, and carefully considering the comments of others. Hopefully, this workshop will lead to more collaborative research between scientists from different places in the country.

C H A P T E R   T W O

I N T R O D U C T I O N

SORGHUM RESEARCH HIGHLIGHTS IN SOMALIA

Abdullahi Nur Alio
Director ARI

1. INTRODUCTION

1.1. Climate

The rains in the regions of Somalia where sorghum is grown total around 600mm per year and have a bimodal distribution: 350mm for the Gu season (April - July) and 250mm for the Dayr (October - February). The rains fall during the first 40-50 days at the beginning of each growing season. The rains fall in showers and it is not rare to have 150mm in a few hours (in Dinsore - Bay Region, 191mm in 4 hours during Dayr 85). At Bonka Research Station the air temperature range registered was 20-43°C throughout the year; the soil temperature was never below 28°C.

1.2. Sorghum

Sorghum, a dryland crop, is the traditional food-crop in Somalia. Both rural and urban populations use it. With the advent of irrigation, the areas close to the rivers are being sown to maize which yield more than sorghum, and is less susceptible to Quelea damage. In those regions where irrigation facilities are available, sorghum has virtually disappeared and what is more important, food habits have changed. Moreover Quelea quelea and other birds make sorghum cultivation, at present, uneconomical.

The rainfed areas, where sorghum is sown, is estimated to be around 500,000 ha. Starting from 1984, with the liberalization of the sorghum price, there was an increase in the area under sorghum. The main regions where sorghum is grown are Bay, Bakol, Gedo, part of Middle and Lower Jubba, part of Hiran and the Northwest.

The Bay region and the Northwest are the most important sorghum producing areas. The Bay region alone accounts for more than half of the area under sorghum. This is why the sorghum improvement project is centered in Baidoa. The Northwest which has a different agroclimatological zone should have its own center for research. The sorghum variety as well as its environmental requirements for its production differ completely from those of the Bay, and other southern regions as a whole.

Animal production is another important facet of the Somali economy. Camel, cattle and ovines are produced for the local market as well as for export. Sorghum is an important element in the feed composition. The stover, stalk and leaves, are consumed in the field after the heads are harvested. Sorghum could play a more important role as forage.

2. Research Highlights

2.1. Varieties

The local varieties can be grouped into two: the Baidoa local and Elmi-Jamma of Northwest. Both varieties are tall (may reach 2-2.5m) are very compact and goose-necked. Elmi-Jamma has larger heads than

Baidoa local and requires around 150-160 days to mature whereas Baidoa local requires around 115-120 days. It has a differently coloured pericarp, but the endosperm is hard flinty and stores well. The crop in the field is a mixture of lines from yellowish-pinkish to dark red and brown. As the risk of bird damage increases in intensity, the darker lines increase in the population. New varieties are desirable. They should be earlier and higher yielding. The height of the plant and number of leaves have also their importance. These characteristics are desirable for the plant to be used for forage.

Recognizing the importance of forage sorghum and anticipating the requirements in the near future, we have already started research in view of developing and releasing forage sorghum lines. 238 lines of forage sorghum are now under trial.

In carrying out research in forage sorghum we are hopeful that forage sorghum will give acceptable results in drylands. But at the same time it is difficult to visualize forage as sole crop in dryland regions, for the basis of the economy is subsistance. Therefore the most desirable combination will be for drylands dual type: sorghum for food and for feed.

2.2. The soil

The soil in the Bay region is the clay loam type known as cotton black soil. It is the moderately expandable type. The pH is 7.5 to 8.0. The fertility of the soil is rather limited and certain elements, such as iron, copper and zinc are not readily available due to the pH. The nitrogen and phosphorus are in short supply. The fertility can be maintained and even improved by use of organic manure and fertilizer. For the time being the chemical fertilizers are out of reach of small holders due to high prices and low availability. As for the manure the movement of the cattle make its collection, storage and re-use difficult. Thus the soils are being depleted creating instability in production. Experiments are current to demonstrate the effect of chemical fertilizers and evaluate their economics. The barnyard manure is also under testing. Experiments with manure carried out in late 1960s showed a doubling in the yield in addition to other benefits. Stability of yield is of high importance to the farmer. The majority of the farmers in the sorghum producing areas are subsistent farmers, thus consuming the major part of their production. The varieties to be developed should maintain their yields or else they will be refused by the farmers.

2.3. Diseases and Pests

2.3.1. Diseases

Sorghum, being grown in dryland conditions, is not affected by many diseases. We have noticed anthracnose leaf blight and downy mildew but they were of no economical importance.

The most important disease is the smut, mainly covered kernel smut. Low incidence of loose smut and even lower incidence of head smut are also observed. The occurence of this disease is more prominent in some regions than in others. In the Bay region, the Baidoa district is virtually clean. Experiments with inoculated seed gave 50% as highest incidence. The district of Qansadhere is known for this affliction and the incidence varies between 25%-40%. The occurence of smut is even higher in the Northwest, and an average of 50% of the sorghum is affected.

In view of the importance of this disease it would be desirable that the new varieties have genetic resistance to it. But experiments carried out by the department of pathology at CARS, Afgoi demonstrate that the loss due to smut can be reduced very much by seed treatment. Vitavax and Fernesan-D at 3 g/kg of seed have reduced the losses tremendously. Therefore, we consider that work on incorporation of the genetic resistance in the local and future varieties should have lower priority.

2.3.2. Pest

2.3.2.1. Insects

Sorghum is attacked from its emergence, successively by grasshoppers, mole crickets, shoot fly, armyworm, aphids, red spider mites, earworm and in humid areas by the midge at flowering time. Damage by grasshoppers/mole crickets can be serious at times. Baits made of bran and stomach poisons have given good results. The stemborers, mainly Chilo partellus, are the only ones that can affect the plant throughout its life cycle. We have seen up to 4 generations in very bad years in Bonka. But Basudin 10G is used against the borers. The new varieties need to have genetic resistance against borers. But no absolute resistance is known, at least in the cultivated species, and that is why scientists use the 'less susceptible' terminology.

Around fifty lines, from ICRISAT, are under trial for this character. Most of them are being considered as germplasm. We do not expect to have fast results as this characters is multigenic.

Whereas the local variety of sorghum is tolerant to the stemborers, maize varieties are not and a high percentage of loss has been reported. Interspecific hybridization is not easy and far exceeds the capabilities of ARI. We believe that some other way of saving the crop can be found. We asked ICIPE to help us and they agreed. After several meetings the project is ready and will start as soon as the funds are available. This problem is affecting a very large sorghum producing area and we believe that the solutions developed by ARI/ICIPE can be applicable elsewhere.

2.3.2.2. Birds

This second notable pest, Quelea quelea, is the most detrimental. It starts its damage when the grain is in the milk or soft dough stage and in certain years can cause very high damage as in 1983. To combat this pest ornithologists are using "Queleatox" spray, even though it is debatable if one could cause reduction in the population. Reports from South Africa, cited by Dr. Doggett, show great increase in the population, after 25 years of efforts, instead of the anticipated decrease.

The Quelea control project, an FAO regional project, has had to overcome very many obstacles and consequently the efficiency was low. The quelea control program of Somalia benefits nowadays from the assistance of the German Technical Assistance (GTZ) which has donated an aircraft, spray chemicals and funds.

It is thought that earlier maturing varieties might escape the damage. This theory has been proven untenable. The Australian project at Kurtunwarey and Sablaleh used water injection to start the sorghum ahead of the rains and thus assure an earlier crop. The birds caught up with it.

We do not believe that there are resistant varieties. Scientists have come to agree that some biochemical and morphological traits are helpful if feeding pressure is low.

3. Cooperation

The Somali sorghum improvement program is a cooperative project between ARI and IDRC. The comprehensive program that was established initiated work on the crop and started a training program at the same time. To date two graduates have received or about to receive their M.Sc. degrees in plant breeding. The entomologist is expected in April 87 and the agronomist in July 87. the pathologist starts his studies in August 86.

The program put up in cooperation with IDRC is a multidisciplinary program. In addition to the agricultural disciplines, food quality will be tackled at a later stage.

Although the present IDRC support is for a limited period the program was designed and developed to have far reaching effects. With the third phase the technical assistance will cease and the Somali researchers, trained at different universities and on the job, will take full responsibility.

Already, the sorghum team, under the advisorship of Dr. Alahaydoian has selected four varieties which are under testing in 16 locations within and outside the Bay region. Already these four varieties are under agronomic testing. These will be intensified starting next season, Dayr 1986. This is the second season for such testing and we are contemplating the release of at least 2 varieties. A germplasm base has been developed with more than 1500 lines, in addition to the partial collection done by ICRISAT. Plans are being developed for another and larger collection, all over Somalia to complement that done by ICRISAT in 1979.

A hybridization program has already been started and this season it was enlarged. Desirable varieties, selected among many, are to be crossed to local and to A lines. Next season we shall start the crosses for entomological purposes.

Interspecific, shattercane x sorghum, hybridization, is envisaged for the smut problem. We shall ask ICRISAT to give us a hand with it.

As soon as the varieties are selected, storage and quality research will start. A forage program has also been started. During the past five years many problems had to be solved. We received much assistance. The Bay region agricultural development project gave tremendous assistance putting at our disposal land, office space, workers and services. In fact our counterparts from BRADP are an inherent part of the sorghum team. We have much esteem for their contribution. Special thanks go to its general manager Mr. Mohamed Warsame for his unfailing moral and material support. Good cooperation with the extension and faculty of agricultural sciences has been established.

ICRISAT with all its branches participated in our program and built up our germplasm base.

Thanks are due to Research Institutes of Kenya, Uganda, Ethiopia, Egypt, Sudan, Uppervolta and Mali for their contribution in seed.

SAFGRAD with its contribution of seed, organization of workshops and initiation of information services contributed and is still contributing to our program.

We are thankful to USAID, FAO and ACSAD for their support to our program.

Special thanks go to Dr. Roger Kirkby (IDRC) for his unselfish personal efforts, and to Dr. Hugh Doggett (IDRC) for his advices. Many thanks to all those who contributed and are still contributing to our efforts.

Finally we thank Dr. Mohamoud Abdi Nur - Vice Minister for Agriculture, for his initiation and moral support of this inter and intra-national collaborative work.

A RESEARCH OVERVIEW

R. J. Buker
Research Director

The agricultural research program of the Bay Region Agricultural Development Project, headquartered at the Bonka Research Station, is funded by several sources. USAID, through a contract with the University of Wyoming, plus the World Bank/IFAD, IDRC/ARI, African Development Fund, and the Somali Government all contribute support.

Sorghum may be produced on 95% of the cultivated land in the Bay Region; therefore, our research effort is centered on sorghum and its production problems. In the past Deyr season, the stalkborer appeared to be the first limiting factor in production, where this season soil fertility is seen as a major limiting factor. As production improves, moisture undoubtedly will control yield.

Our largest program is sorghum improvement, where the effort is centered on testing lines developed from other programs, primarily from international breeding centers throughout the world.

Since sorghum is a monoculture in the Bay Region, we wish to reduce the population's dependence on a single species. Therefore, we have a grain legume and oil seed section whose objective is to provide the Region with high protein legumes and reduce the Region's dependence upon imported vegetable oils. This effort is primarily a variety testing and introduction program. Oil crops that are also legumes, such as peanuts and soybeans, could fill both roles. Cowpea is second to sorghum in production. We have located an early mungbean based on 7 seasons' data, which we plan to introduce from Taiwan. We just started testing early pigeon peas. Sunflower and safflower are the highest yielding oil crop species under test. Safflower has salt and drought tolerance and produces a high quality oil which we hope can be extracted by a simple press.

The soils of the Bay Region are slowly declining in productivity, for we note that recently cleared land produces higher yields. We hope that Leucaena will restore the productivity of old fields and at the same time produce forage at the end of each dry season.

The Agronomy Section is attempting to document present practices and at the same time evaluate population, spacing and other cultural practices used in the Region to produce sorghum.

The Dryland Agronomy Section works on fallow systems and moisture relationships related to species and methods of cultivation. They work closely with our farming operations team, who prepare land by cropping it so that the land will be ready for future research work. Chemical weed control during the fallow is encouraging. Commercial farming with imported diesal may be a questional use of foreign exchange and therefore, we are working on animal traction systems.

The Agricultural District Offices come under our control. They register land holdings, and provide information and materials to farmers. We also coordinate our efforts with the Extension Service, which is a vital link in the distribution of research findings to farmers.

Where the stalkborer and other insects cause major losses in the Region, we do research on insect control and provide chemicals and train people to work in the plant protection area.

The most exciting recent discovery is the marked response to phosphorus fertilizer jointly demonstrated by our Soil Fertility Section and our Farming Operations team. Placing triple super phosphate under the seed at planting time has produced a fourfold improvement in seedling height. At the same time, it has reduced variability in plant height. In the past, this plant growth variability has slowed the progress of all research efforts at this station, but this season, for the first time, we appear to have located the major cause of variable plant growth at Bonka. Next we will have to fine tune this discovery to see how it fits with other fertilizer elements and how chemical and local natural sources of P fit into the economics of crop production throughout the Region.

And finally, education is an ongoing formalized and informal process at Bonka. In the past nine months we have sent one staff member to the U.S. for a special program, three to India, one to Nigeria, plus four to Afgoi. Also, Utah State University taught a two-week class here on extension-research interaction. We have our own English education program and nearly 20 took the TOEFL exam. Investing in educating your most productive staff guarantees future progress.

THE EXPANDING ROLE OF INTSORMIL

Jerry W. Maranville*

The International Sorghum and Millet Collaborative Research Support Program (INTSORMIL) was activated July 1, 1979. Its objective was to improve human nutrition through research and technology development. During the first years, over 80 scientists from eight Land Grant universities were active in collaborating with scientists from several countries from around the world solving a variety of problems in sorghum and millet production and utilization for human food or animal feed. These crops were chosen as highest priority since they are of major importance for the least developed and most marginal areas of the world. The program functions under Title XII legislation and is funded by USAID.

INTSORMIL has several well defined goals. These are:

1. Sponsor and support workshops in various areas of sorghum production, utilization and socio-economics.
2. Support publication of sorghum and millet proceedings, publications and newsletters.
3. Cooperate with building the international sorghum/millet germplasm bank at ICRISAT.
4. Support a program of scientist exchanges.
5. Help build research institutes in host countries.
6. Promote communication among sorghum/millet researchers worldwide.
7. Train host country scientists through graduate degree programs.

The latter of these goals has probably been the most effective input INTSORMIL has made and continues to make. There have been several dozen students obtaining M.S. and Ph.D degrees at the universities involved in the several discipline areas in which INTSORMIL is active. Other goals are being reached as well. For example, a relatively recent workshop at ICRISAT was co-sponsored by INTSORMIL and the proceeding, "Sorghum in the Eighties," has been widely acclaimed as one of the best comprehensive treatments of recent research accomplishments to appear for some time.

Before proceeding further, mention should be made of the universities and other organizations involved. Collaboration and training support initially was occurring at the University of Arizona, Florida A&M University, Kansas State University, University of Kentucky, Mississippi State University, University of Nebraska, Purdue University, and Texas A&M University. There were also several international centers involved, including CIAT (International Center for Tropical Agriculture), CIMMYT (International Maize and Wheat Improvement Center), ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), and IRRI (International Rice Research Institute). Additionally, cooperative relationships have been established with SAFGRAD (Semi-Arid Food Grain Research and Development) and FAO (Food and Agriculture Organization).

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* Crop physiologist, Department of Agronomy, University of Nebraska - Lincoln, U.S.A.

Several discipline areas were designated in which collaboration in research, development and training should occur. Projects in the following areas have been initiated:

1. Breeding, genetics and varietal improvement
2. Agronomy, cultural practices
3. Plant pathology
4. Entomology
5. Physiology, especially plant stress research
6. Storage, utilization and nutrition
7. Socio-economic considerations

In many cases because of the particular training of scientists involved and university program objectives, certain universities are more active in some discipline areas than others. Texas A&M, for example, having more of a tropical climate in some locations, is a more suitable place to study the plant pathology and entomology problems. It is also known for its extensive sorghum breeding activities in many areas, although a sorghum breeding component is found at several other universities. Kansas State University is doing most of the pearl millet agronomy and has a pearl millet breeder. Recently, the University of Nebraska has joined the efforts in pearl millet breeding, agronomy, and utilization for food. Purdue University is widely known for its cereal utilization program, and the University of Nebraska for its crop physiology. Mississippi State University has been taking the lead in acid soil research in cooperation with CIAT.

Mention was not made of all the universities since during the past six years of INTSORMIL's existence, several things have changed. One of these has been budget constraints which, just last year, necessitated the removal of the socio-economic component from the program. The University of Kentucky was most responsible for that component and is now no longer part of INTSORMIL. Two other universities, the University of Arizona and Florida A&M University, have also dropped out of INTSORMIL, leaving only five universities to carry out the program. Activity in the area of storage has also been sharply curtailed, but again may be reactivated.

INTSORMIL operates by stressing "collaborative research" among researchers working in host countries in a joint venture approach which includes sharing knowledge, research techniques and plant materials. INTSORMIL is <u>not</u> a funding agency where host country scientists can apply for and receive grants to conduct research. Resources are made available through the collaboration that is occurring, and may be direct money expenditures agreed upon by both sides. For example, if the collaborating scientists decided that sample analysis was necessary to reach objectives and facilities were not available in host countries, then analyses would usually be made and paid for at the Land Grant university(ies) involved. A certain piece of necessary equipment may be purchased at the U.S. and sent to host countries for use. There are instances where direct dollars have been made available for operative expenses involved in the host country research. The INTSORMIL management entity overseas expenditures, and the headquarters is located at the University of Nebraska, Lincoln, Nebraska (USA). The management entity includes the program director, Dr. Glen Vollmar, assistant program director, Dr. John Yohe, and two office staff.

Not every country in the world producing and consuming sorghum is necessarily involved in INTSORMIL activities. The program has limited resources and these impose certain constraints on how many countries can be involved. A technical committee representing the various discipline areas receives proposals and activates and makes recommendations to a five-member Board of Directors who represent the Land Grant universities involved. In addition, a committee representing certain ecogeographic zones was established to make recommendations regarding targeted areas to the same board. Initially, major activities were ongoing in Sudan, Botswana, Honduras, Philippines, Mexico, Columbia, Niger and Brazil. More recently, the focus has been toward Africa, where a majority of INTSORMIL resources are to be directed. The countries of Mali and Senegal were added, and strengthening of the Niger program is underway. INTSORMIL activities in the Sudan have been terminated for the time being.

USAID staff participate in technical committees, ecogeographic zone committees and Board of Directors' meetings. AID mission support in host countries contributes to INTSORMIL's activities. These activities are reviewed by an external review panel of scientists who are recognized internationally for their research achievements, and make recommendations periodically to INTSORMIL participants.

To be involved, the AID mission within the host country generally initiates the procedure. Representatives of the host country, however, must be in agreement that INTSORMIL can provide useful assistance and that a request be made. In the end, it is actually the host country which will sign a Memorandum of Agreement with INTSORMIL outlining the general objectives of the collaboration, and what each entity can provide. A host country representative may actually initiate some action by informing the AID mission that they desire INTSORMIL assistance. The AID mission can then contact USAID in Washington or INTSORMIL directly requesting discussions for collaborative involvement. Every request cannot always be acceptable to INTSORMIL if the entire complement of resources available and scientific manpower have been committed to other country programs. If INTSORMIL should decide that collaboration is desirable and would be potentially possible, a team is usually sent over to formulate approaches and get the necessary signatures of the Memorandum of Agreement. Sometimes this is a Memorandum of Understanding. For example, the memorandum may state that INTSORMIL will train scientists, do chemical analyses, and provide germplasm and some research funds for research projects. The host country may agree to provide transportation and lodging for the INTSORMIL scientist(s) involved in the research whenever they travel there for planning, reviews, etc. This ensures the continuity necessary for these programs to work.

Each scientist within the Land Grant universities who is involved with INTSORMIL generally has or is involved with a very specific project. These scientists are known as "PI's" or project investigators. For example, at the University of Nebraska, there is a project entitled "Sorghum Drought Resistance," which is run by two PI's and is involved in at least two or three host countries. Another is entitled "Sorghum/Millet Mineral Efficiency," and has two PI's, (Dr. J. W. Maranville and Dr. R. B. Clark) and is involved in three host countries. This project has concentrated on nitrogen and phosphorus research, and acid soil/aluminum toxicity problems as well as making contributions to minor element research. Each targeted country also has a specific research budget, and this is separate fro that of the individual projects. The targeted country budgets are partially controlled by the management entity of INTSORMIL at the recommendation of a "country coordinator." This coordinator is also usually a project PI, but familiar with a specific country's problems or may be involved in a project directly related to a major country constraint. The coordinator oversees the activities within the country and coordinates all of the individual projects which may be involved. The coordinator also identifies in collaboration with host country scientists those problems which need attention and pairs them with appropriate INTSORMIL projects and PI's.

INTSORMIL has been relatively successful in meeting its objectives. Projects in the Philippines and Dominican Republic have been strikingly successful. The formation of a hybrid seed productio program in the Sudan and release of a new hybrid DH-1 attest to achievements. Successful collaborative conduct of workshops and publications of their proceedings have aided considerably in our ques to solve problems in sorghum and pearl millet growing nations. Now that the mandate is for increased inputs to African nations where these crops are consumed, it may open up new chances for other Africa countries to be involved in addition to the ones already targeted.

CHAPTER THREE

SORGHUM IMPROVEMENT AND PRODUCTION

REVIEW OF SORGHUM RESEARCH IN SOMALIA

A.H. Shirwa(*) and M.A. Noor(**)

1. Introduction

In Somalia sorghum is the most important cereal from the point of view of extensive cultivation, the use for human and animal consumption, and was until recently the highest in total production, being slightly surpassed by maize. It is mainly cultivated in rainfed areas and is estimated to cover a seasonal area of over 388,000 ha (Ministero dell'Agricoltura, 1975).

The annual rainfall in the sorghum cultivated areas range between 250 to 700mm,with an average of 450-600mm per annum (Maneghimi, 1960; Tozzi, 1961b). Approximately 60% of the rain falls in the "Gu" season (April-June), and the rest in the "Dayr" season (October-December)

According to various sources the production of sorghum fluctuated with the amount of annual rainfall e.g. bad years were 1955, 1956, 1974, 1983 and good years were 1954, 1957, 1975, 1982,1985 (Rocchetti, 1960; FAO, 1982; Food Early Warning Project, 1985). Table 1 shows the average production of sorghum for various periods since 1954 and there is a general trend towards an increase in production resulting from expansion of area despite the fluctuation due to climate.

Table 1. Sorghum Production in Mt ('000)

Years	1954	1955	1956	1957	1958	1959	1970	1971	1972	1973	1974
Prod.	100	57	50	100	65	63	126	119,6	175,5	102,7	94,6
Years	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Prod.	129,9	165,2	219,3	169,3	150	136,4	172,1	235	120	221	226

As the yield of sorghum is also determined by the amount of rainfall, in good years the yield per hectare ranges between 6-7 $q.ha^{-1}$, in average years it is 3-5 $q.ha^{-1}$, in low rainfall year 1-2 $q.ha^{-1}$ and complete failure in extremely bad years (Tozzi, 1961a; Tozzi, 1961b).

In the last 30 years various programmes of research, studies and developmental efforts were carried out with minimal impact on the production per hectare. This is mainly due to the discontinuous nature of these efforts, the fact that it was often carried out by expatriate staff with limited spans of time, and that the results were aften lost or remained unavailable to subsequent research workers.

This review is an attempt to put into perspective the findings of the previous studies on sorghum and to extract recommendations for the application of already generated technology.

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2. Results

The following National and International Organizations were involved in sorghum research in Somalia:

1. Italian colonial administration in Genale (1911-1912) and Bonka (1953-1954 and early 1960's).
2. USAID in 1954 at Bonka.
3. University of Wyoming 1964-1969 at Afgoi and Bonka.
4. Agricultural Research Institute, 1970 till present.
5. IDRC, 1981 till present.
6. UNDP/FAO, 1976 till present.
7. Bay Region Agricultural development Project with technical assistance from University of Wyoming, 1981 till present.
8. Faculty of Agriculture, assisted by University of Florence, 1974 till present.
9. Settlement Development Agency and IDA supported semi-mechanized rainfed, 1981 to present.

The majority of the work done constituted of:

1. Screening of numerous varieties both local and introduced, mainly for yields, but at times also for agronomic characters such as earliness, disease and insect resistance, bird resistance, drought resistance, etc.
2. Agronomic studies involving fertilizer application both organic and inorganic, land preparation methods, fallowing, insect control, plant population, weed control, etc.
3. Selection and breeding of both local and introduced lines.

2.1 Variety Trials

The most predominant type of studies were varietal trials. Four of these trials are presented in this review from various periods of research activity. Table 2 summarizes the work done by University of Wyoming team in 1966-1967, which resulted in the identification, multiplication and release of the varieties Wadaker and Martin (Univ. of Wyoming, 1967; 1968; 1969). These varieties were eventually lost.

Tables 3 and 4 show the results of varietal comparisons of F.A.O. Sorghum Observation Nursery in "Gu" 1971 and "Dayr" 1971 at Afgoi, which resulted in the identification of lines with high potential yields. However, no further studies were carried out on these lines (CARS, 1971).

In 1981 trials were conducted on materials introduced from Sudan and a local variety as shown in Table 5. Although yields were generally low, both Gadam el Hamam and Dabar out-yielded the local variety (BRADP, 1981a).

Considerable further work is under way in the IDRC and BRADP supported research, however, no variety has been released so far.

Table 2. Varietal trials at Bonka from 1966 to 1967. Yields in $q.ha^{-1}$.

Entries	Gu 1966	Dayr 1966	Gu 1967	Average Estimated Production
1. S.B. 79	19.68	8.97	1.9	10.2
2. Wadaker	-	7.99	17.3	23.7
3. Martin	-	6.97	5.7	11.9
4. E-44	26.96	-	8.2	16.6
5. HX451	24.39	-	6.4	14.5
6. HX58	35.95	-	7.2	20.0
7. S.B. 65	14.98	8.60	-	8.2
8. HX57	22.25	12.85	-	12.5
9. Serena	-	9.01	-	10.2
10. Dobbs	10.69	-	-	5.5
11. Franida	14.55	-	-	7.4
12. HW105	26.48	-	-	13.4
13. HW61	12.48	-	-	6.3
14. S.B. 77	12.41	-	-	6.3

(1) For Dayr 1966
(2) For Gu 1967

Table 3. Varietal trial at Afgoi in Gu 1971.

Entries	$q.ha^{-1}$	Entries	$q.ha^{-1}$
1. 5 DX 61/62	24.29	28. B.64L-3755	9.88
2. MS2219 AX 153691	22.91	29. TX 2528 68-L-7874	9.78
3, 5 DX 142/4	20.60	30. BATAN 69-939 P_2	9.64
4. CSH-2	19.87	31. IS 3796	9.35
5. 83521	19.49	32. RT X 7078	9.20
6. CSH-1	18.18	33. TX 2512 68L-7842	8.70
7. 3DX 57/1/C	17.23	34. TSS 3-4	8.66
8. RT X 7000	16.68	35. Local	8.53
9. 159301	15.66	36. 85596	8.46
10. SWARNA	15.59	37. TX 2523 68-L-7865	8.37
11. TX 2519 68-6-7856	15.38	38. 25522-2B	8.25
12. BT X 3197C K 60F568	14.76	39. TSS 13-7	7.97
13. VAR 65-814	14.03	40. I 564 18C	6.66
14. 83609	13,29	41. TX 2521 68-L-7861	6.48
15. IS 511	12.81	42. TX 2529 68-L-7876	6.28
16. RT X 414 F569	12.56	43. TX 2525 68-L-7868	6.22
17. 78447	12.27	44. TSS 3-1	6.03
18. local	12.19	45. 1879	5.65
19. 159344	12.12	46. TSS 17-1	5.28
20. BIXAL	11.98	47. TX 2532 68-L-7883	5.14
21. B. 65L-5432	11.90	48. TSS 1-12	5.10
22. RT X 415-F569	11.78	49. TSS 1-9	4.91
23. TX 2518 68L-7854	11.37	50. TSS 11-1	4.72
24. 5 DX 36/1/2	11.30	51. TSS 2-1	4.67
25. TX 2536 L-64K-241	11.26	52. TSS 11-3	4.44
26. E3 X A3	10.97	53. TSS 10-1	2.06
27. ROK Y 34	9.99	54. 5912	1.54

Table 4. Varietal trial at Afgoi in Dayr 1971.

Entries	Prod. q.ha^{-1}	Entries	Prod. q.ha^{-1}
1. 5 DX 61/62	70.25	25. ROK 34	33.06
2. Swarna	55.56	26. 3dw. Kafir b	31.81
3. 4 dw. Kafir	55.50	27. F 65	30.90
4. 83521	53.06	28. F 64	30.90
5. C 48 A	53.06	29. 7078	30.87
6. Caprock	49.31	30. Kafir Milo 4dw.B	30.87
7. 5 DX 61/62	46.18	31. BR 44	29.65
8. BR 64	44.93	32. 7078	29.65
9. 3 dw. X 57/1/E	44.31	33. 85596	28.06
10. E 57	43.68	34. 3 dw. YE R	27.43
11. IS 511	43.40	35. F 61	27.15
12. IS 3796	42.43	36. BL X AI	26.53
13. 7078 deriv.	42.15	37. ROK 35	25.90
14. 65-814	41.82	38. e dw. Kafir R	24.65
15. 83609	40.90	39. CK 60	24.65
16. F 56418 C	40.87	40. 4dw. YE Hegar	24.65
17. 78447	40.50	41. 7078 deriv.	20.90
18. IS 3944	38.40	42. 3dw. Smut Resist.	20.90
19. 7078 deriv.	37.15	43. 2522-2B	18.40
20. 4 dw. Vasey YE Fet.	36.81	44. E3 X A3	18.40
21. Mildew Resist. R	34.65	45. 1879	18.40
22. IS 9344	34.31	46. B 32 A	14.96
23. C X 60 deriv.	33.40	47. A 25	12.16
24. C 42 Y	33.40	48. Batan 69-939	12.15

Table 5. Varietal trial at Bonka in Gu 1981.

Entries	Production q.ha^{-1}
1. Gadam el Hamam	8.04
2. Dabar	7.70
3. White Nilo	5.79
4. Local Fududuq	5.23
5. Abo Saben	4.80

2.2 Cultural Practices

Observation of plant population of sorghum in farmers' fields is around 15,000-20,000 p.ha^{-1}; however, studies carried out indicate invariably an increase in yield resulting from increase in plant population as shown in Table 6. Although the yields are generally low from the above mentioned experiment, there is almost a doubling of yield from 10,000 p.ha^{-1} to 48,000 p.ha^{-1} (BRADP, 1981a).

Table 6. The influence of plant population on sorghum yield in an experiment conducted at Bonka in Gu 1981.

Treatments	Distance between Lines in cm	Distance within Lines in cm	Population p.ha^{-1}	Production q/ha^{-1}
1	70	30	48,000	5.85
2	75	40	33,000	5.48
3	60	30	65,000	5.46
4	100	50	20,000	4.48
5	100	100	10,000	2.87

The Wyoming team in the 1960's made several studies on the response of sorghum to animal manure (Univ. of Wyoming, 1967; 1968; 1969) and presented adequate data, including visual presentation, indicating positive response to the application of manure. Table 7 is an example of such results. In addition, organic matter application in the form of animal manure was compared with the application of inorganic NPK fertilizers as shown in Table 8. There is clear indication of response to both phosphorus and organic matter. Nitrogen alone was inferior to phosphorus and manure application. There was no control in the experiment. These results seem to be similar to results found in the Gu 1986 season in Bonka after 18 years.

Table 7. Response of sorghum yield to application of animal manure.

Season	Production q.ha^{-1} Manure	Control
Gu 1967	28.4	12.7
Dayr 1967	11.8	4.4
Dayr 1968	24.2	8.7

Table 8. Response of sorghum yield to manure and NPK fertilizer.

Treatments	Production q.ha^{-1}
1. 40 - 40 - 0	21.5
2. 40 - 40 - 60	20.7
3. Manure 25t/ha (dry weight)	19.4
4. 40 - 0 - 60	17.5
5. 40 - 0 - 0	16.1

Similarly there was positive response of the yield of sorghum to green manure application in the form of cowpea and mungbean as shown in Table 9.

Table 9. Response of sorghum yield to green manure with cowpea and mungbean.

Season	Treatment	Production manure	q.ha^{-1} control
Gu 1967	Green manure after harvest of grain	-	-
Dayr 1967	-	7.1	5.3
Gu 1968	Green manure in flowering stage	-	-
Dayr 1968	-	6.8	4.8

Extensive and relatively long study was carried out on the effect of fallow on sorghum (Univ. of Wyoming, 1965; 1967; 1968; 1969); however, there was no significant response to fallow in both "Gu" and "Dayr" seasons. Summary data are presented in Table 10.

Table 10. Response of sorghum to fallow in q.ha^{-1}.

Year	Production in Gu				Production in Dayr			
	After fallow		Control		After fallow		Control	
	No.Repl.	Mean	No.Repl.	Mean	No.Repl.	Mean	No.Repl.	Mean
1966	-	-	-	-	3	17.3	2	15.5
1967	3	11.3	2	13.9	3	7.7	2	6.6
1968	3	15.9	2	13.4	3	9.2	2	10.6

Farmers in Somalia know well the significance of weeding, and the results obtained have supported this belief as shown in Table 11.

Table 11. Response of sorghum yield to time of weeding.

Treatment	Time of weeding	Production q.ha^{-1}
1	one week after emergence	4.21
2	two weeks after emergence	3.85
3	three weeks after emergence	3.7
4	control	2.65

Stalkborer is a major insect pest on sorghum and results from experiments show that its damage causes decline in yield and delay in maturity while exposing plants to drought. Invariably application of insecticides resulted in increased yield as shown in Table 12.

Table 12. Response of sorghum yield to stalkborer control at Bonka in Dayr 1981.

Entries	Production $q.ha^{-1}$ Treated	Control
1. Dabar	6.47	1.36
2. 71403	4.65	0.54
3. 71464	4.65	0.79
4. 71506	4.22	2.43
5. Local Fududuq	3.10	1.17
6. GPR 148	3.05	1.17
7. 71258	2.27	1.04
8. 71341	1.68	0.73
9. 71261	1.43	1.75
10. LGP 23	1.35	0.55

2.3 Selection

Selection of both local and introduced material were carried out for various objectives including earliness, insect and disease resistance, bird resistance, and productivity. Table 13 shows that improvement can be achieved by selection within local germplasm.

Table 13. Selection of local sorghum materials for yield in $q.ha^{-1}$.

Lines	Production Bonka	Afgoi
Selected by visual observation:		
Highest yielding line	25.8	20.6
Lowest yielding line	10.7	7.0
Average of selected lines	12.9	12.4
Selected by weight for further testing:		
Highest yielding line	25.8	20.6
Lowest yielding line	14.4	12.0
Average of selected lines	21.5	15.4

3. Recommendations

1. There is need for continuity in research, in order to obtain and utilize generated technology and experience.

2. There is dire need for trained Somalis to take over the responsibility for research and technology development, so that experience gained is not lost.
3. Ways must be found to conserve and diseminate research results on a wider basis.
4. A system of conservation and maintenance of germplasm, both local and introduced that prove useful under our environment, must be introduced.
5. Population higher than the present farming practices must be encouraged; approximate recommendation may be 30,000-40,000 plants per ha.
6. Early planting to use full advantage of a short rainy season must be encouraged.
7. There was definite response of sorghum to organic matter application in various forms e.g. manure and green manure. Therefore, the application of animal manure must be encouraged.
8. Phosphorus application with seed seem to be beneficial, and should be extended.
9. Fallowing has not proven useful and further verification is necessary; however, its extension should not be carried out.
10. Early and timely weeding should be encouraged and more labour saving devices introduced.
11. Stalkborer control by cultural practices and chemicals should be encouraged.
12. Although data are not presented here, Smut control through seed treatment must be popularized.
13. Tannin containing varieties, although bird tolerant, should not be encouraged because of their negative effect on protein quality.
14. In selection of grain sorghum the role of sorghum as fodder must be kept in mind, and forage types must also be studied.

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HIGHLIGHTS OF THE SORGHUM IMPROVEMENT PROGRAM

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Abstract

Sorghum is the most important crop in the Bay Region. Therefore, it was given the first priority for research. During phase I (1981-1983), the program started slowly and one of the major constraints in achieving progress was the high (50-170%) Coefficient of Variation (C.V.) encountered.

One of the biggest achievements in stage II was the reduction of the Coefficient of Variation to a more manageable level. This has contributed to the qualitative improvement of the results and increased its acceptability. The program is dealing with a big amount of germplasm (mainly introduced). The results obtained from ACSAD and some other introduced lines were very encouraging. In phased II (1984-1986), a group of enthusiastic national staff, who received their post-graduate training overseas, has taken over the Sorghum Improvement Program leadership.

1. Introduction

Sorghum is the major crop for food and fodder in Somalia. It occupies an area of around 400,000 hectares under rainfed conditions, in Baidoa, Hiran and Bakol regions in the south, and Hargeisa in the Northwest. In Bay region alone it occupies an area of 95% of the total cultivated area.

The sorghum crop is grown entirely under rainfed conditions. Maize cultivation has greatly increased in popularity in the last two decades replacing irrigated sorghum production almost completely. However, sorghum is and will continue to be the most important crop in Somalia; being well adapted to semi-arid areas on account of its drought tolerance, there is more scope for expanding its production in the country.

The average rainfall in the sorghum cultivated area ranges between 500-600 mm per year in a bimodal distribution: 300-350mmm for the Gu season (April-July), and 200-250 mm for the Deyr season (October-February).

The yield of the local sorghum is around 3-5 $q.ha^{-1}$ in the Gu season and 1-3 $q.ha^{-1}$ in the Deyr season.

Since Bay region is the centre of sorghum production, a joint effort between BRADP and IDRC/ARI supported program was initiated in 1981 with the following objectives.

I) The general objective of the research program is the improvement of sorghum for food under rainfed conditions in different agroecological zones of Somalia.

II) The specific objectives are the development of sorghum with the following characteristics:

a) Higher yield potential

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b) Drought tolerance and early maturity
c) Tolerance to insects, mainly stemborer and to diseases like grain mold and smuts
d) Adaptability to environmental conditions prevailing in different zones of the region
e) Acceptability to Somali consumers.

To achieve these objectives screening program and selections of the local sorghum cultivars and introduced germplasm was initiated in 1981. The introduced materials were received from the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) and from other sorghum improvement projects and institutions in Africa, USA and Asia. A cooperation with ICRISAT in carrying out the international trials for yield as well as for disease and pest resistance was established.

2. Progress in phase I

I) Sixty-nine local sorghum varieties were collected from farmers' fields mainly in the Bay region area. Evaluation in field plots showed that the local varieties:
a) have high tillering ability
b) are very tall and medium to early in maturity
c) are tolerant to drought when the rainy season ends earlier than usual
d) are comparatively more tolerant to stemborer than introduced lines
e) are low in yield

II) Five hundred sorghum lines were introduced from ICRISAT (India), East Africa and Texas, U.S.A. Evaluation of the introduced lines in field plots showed that:-
a) they are comparatively more susceptible to stemborer than the local
b) many exotic types were poorly adapted to the dry, infertile conditions
c) they are unstable in yield over the seasons
d) some of them yielded 3 fold of the local varieties provided protection from mainly stemborer was ensured
e) many exotic lines were late in maturity compared to the local
f) they were shorter than the local sorghum and were open headed types

One of the main constraints during the experimentation in stage I and part of stage II was the high C.V. A range of 50-170% was calculated in the seasons until 1985. This high C.V. was mainly due to the heterogeneity of the soil. The variation of the soil in fertility delayed any progress for at least two years and thus selection for improved cultivars over the seasons was almost impossible.

Phase I started slowly and the program was run by an expatriate advisor with a very limited number of staff. In phase II a small cadre of enthusiastic national staff have returned from overseas to the project.

3. Progress in phase II

In phase II the general and the specific objectives remained the same as in stage I.

During stage II, there was tremendous reduction in the coefficient of variation which was one of the major constraints. A range of 21-57% C.V. was calculated while a range of 50-170% C.V. was reported in stage I. This added to the qualititive improvement of the results and increased its reliability. This reduction in C.V. was primarily due to the application of fertilizers, for the soil was deficient of several elements, and to the use of a machine plot planter and to the reduction of the number of rows per plot (2 rows per plot).

Twelve lines were identified from ISDRON-80, ASCAD and other sources with: 1) high yield potential, 2) early to medium in maturity, 3) less susceptibility to stemborer and 4) tolerance to drought.

These lines were tested in five locations within the Bay region during Deyr 1985 and the results were encouraging.

New germplasm amounting to 900 lines were introduced from ICRISAT, Mali, Uganda and ASCAD (Damascus-Syria) to study their adaptation under Bay Region conditions.

Selection of desirable characters (high yield potential, early maturity, drought tolerance and tolerance to stemborer) was made from F2 generations of the cross between the local and the exotic materials.

4. Research Activities in phase I and II

4.1 Yield Trials

a) Local Germplasm:

Sixty-four entries out of 96 were available in 1981. A complete set of the material was requested from ICRISAT and the seed was increased for extensive data collection. Many lines were eliminated over the seasons. The results obtained showed that there was narrow genetic variability among the local sorghum. This may not be true since the collection was made in Bay region and its surroundings only. The entries were reduced over the seasons and came down to 11 in 1986 of which the best entries are selection numbers 57, 40 and 48.

b) ISDRON-80:

ISDRON-80 nursery has been tested for seven seasons. Originally the lines consisted of 80 entries. The performance was very variable over the seasons. The lines were reduced to 13 during Gu 1986 of which 71260, 71684, 71249-1 and 71240 were found to have been promising over the seasons. Three of the above mentioned lines namely 71260, 71684 and 71240 were included in the 12 lines which were tested in the offstation nurseries at five locations within the Bay region.

c) The Drought Resistant Nursery:

The performance of the lines constituting this nursery was highly variable. The number of the lines were reduced from 35 to

12 lines. In Gu 85, the best five lines were: IS 12611, TOWAKAL, ET 12-5, SPV 105 and SL 1502.

d) International Sorghum Preliminary Yield Trial (ISPYT):
This set has been tested for several seasons. The entries were reduced to 5 lines. M 35-1 X RS/R-195-3-2-1, M 35-1 X RS/R-195-3-2-2 and the Indian Synthetic 323-1-3 have shown promise.

e) The Kenyan Nursery:
Out of the 23 entries, 9 lines were promising and tested in the Gu season of 1985. Few lines have been doing consistently well: PI 954063-1, IS 8595 and IS 76T No.23.

f) International Disease and Insect Nursery (IDIN):
This nursery, from Texas A&M, originally had 30 entries. The number was reduced to 5 by Gu 85. The agronomic characteristics were not outstanding, and insect resistance was not satisfactory. Two line GPR 148 and QL3 Texas were good yielders and early in maturity, therefore were included in the entomology nursery of Gu 1986.

g) The Ugandan Nursery:
During the past 3 years the Serere scientists supplied us with nearly forty lines. 5 DX 135/13/1/3/1 (Sereno), Seredo, 4 M X 11/9/1/3 and Himidi have shown promise.
In Gu 1985 Seredo was tried in one replication with a plot of around 2500m^2 and yielded 1207 kg.ha^{-1}. The same variety in experimental plots produced 630 kg.ha^{-1}. Seredo was included in the offstation trial of Deyr 1985.

h) OAU/SAFGRAD Nursery:
This nursery was tried for 2 years and only the Ugandan line 5DX135/13/1/3/1 has been the promising one.

i) Upper Volta Nursery:
From the early maturing lines of the Upper Volta nursery varieties SC108/4/8XCS3541 and 32-1 have been promising in yield and early maturity.

j) International Sorghum Variety Adaptation Trial (ISVAT):
The nursery was reduced and some of entries such as SPV 138, ICSV 147 and ICS 154 were worth considering, but still one more testing is required for final selections.

k) F5 Lines:
Deyr 1986 was the second season of test for the F5 lines. In the next Gu season of 1987 the nursery will be reduced.

l) Sorghum Breeding Advance Lines:
These lines were received from Sudan by the courtesy of Dr. Gabesa Ejeta. A total of 35 advanced breeding lines were tested in two nurseries. The results obtained were variable therefore one more season of testing is required. GSA 5538, 5575, 5574 and GSA 5561 were the best yielders in both Gu 1985 and Gu 1986 seasons.

m) Elite Pollinators:
This collection of 76 lines were divided into 5 nurseries for the ease of handling. The coefficient of variation for these nurseries were higher than the rest ranging between 40 and 62%. The materials were tested for 2 seasons and the results were very variable. Many lines were promising though. However, one more season of testing is required.

The intention for these nurseries were to consider them as breeding materials for the breeding program as well as for release as varieties.

n) The ACSAD Nursery:

This nursery was received from the Arab Centre for Studies in Arid and Dry lands in Damascus, Syria. The seeds were received after the sowing date of Gu 1985. Therefore delayed sowing was made and only 11 mm of rain was received after sowing them. Surprisingly, the performancee was exceptionally good and some of the lines such as 81-990-1298, 1435, 1565 and 1194 even outyielded the local with significant difference at the 1% level. The Gu season of 1986 was the third season of testing these materials and the above mentioned four lines were included in the offstation trials.

o) Dabar Purification Trial:

Dabar along with another sorghum variety (QADAM=-AL-HAMAM) was introduced into the country as food and seed aid to the entire nation in general and as seed aid to the farmers in particular. The seeds were imported in 1980 from Sudan by FAO after a severe drought occurred. However, farmers found that all the introduced sorghum varieties were not good and suitable for the underground storage system they use.

In Deyr 1985, 72 heads of Dabar variety were selected from a population of Dabar that was growing in the 100-ha farm. The selection was based on sizable head grain, early maturity, no tillering, good exertion and medium height. To avoid contamination from stray pollen, all the 72 entries were planted in Gu 1986 in an area fairly distant from other sorghum.

Only 7 entries were selected from the 72 entries. These 7 entries were high yielding ones that were average to slightly earlier than average in maturity. None of the 7 entries were tall or had poor exertion or were segregating for height genes.

4.2 Entomology Trials

Different sets of entomology experiments were received from ICRISAT for evaluation against stemborer, shootfly and midge. The damage due to shootfly and midge are almost negligible in the Bay region. Stemborer is considered as the major yield limiting pest of sorghum which can attack the sorghum plant at any stage of its growth. Chilo partellus is the predominant species of stemborers in the Bay region.

(a) International Sorghum Stemborer Nursery:

The promising lines were IS 18667, IS 5538, PB 8254, PB 8311 and PB 21119. IS 18662 was included in the offstation trial of Deyr 1985 and has persistently been the best in 3 locations due to its tolerance to stemborer. IS 5538 and PB 21119 have shown more tolerance to stemborer in both Gu 1984 and Gu 1985 seasons.

(b) International Sorghum Shootfly Nursery:

Since the infestation due to shootfly is very low, the nurseries were screened for stemborer resistance and for yield potential. The results were variable in Gu 1986. However, the promising lines for the past seasons were IS 4664, IS 55470, IS 18584 and IS 5585.

(c) International Sorghum Midge Nursery:

These sets were sent for midge screening in the limited areas like Afgoi where it can be found. Testing was made for yield and stemborer tolerance as well. The results of Gu 1986 were variable like the shootfly nursery. However, IS 3461, IS 9807, IS 19476 and AF 28 were promising in the past seasons.

(d) Crossing Program:

A certain number of crosses between the high yielders of the exotic materials and the local sorghum were made. Selections were also made from the segregating materials. A certain number of the crosses previously made between exotic and local were backcrossed to their local parent.

An ISHAT (International Sorghum Hybrid Adaptation Trial) set was sown in 1983 to study its production capacity. Later the hybrids were subjected to selections and the selected lines were sown during Deyr 1985.

Forty A&B lines received from ICRISAT were tested in the field under observation prior to the crossing program. The results were not encouraging.

5. Future Strategies:

i) As fodder is an important component for animal food, simultaneous evaluation for quantity of dry matter, juiciness and sweetness of stover of promising materials will be quite useful.

ii) Stemborer problem is very serious and needs top priority. Screening for stemborer through artificial infestation is not feasible because of lack of facilities for such work. Therefore, a search for 'hot-spot' where heavy infestation is available naturally in every season will be carried out.

iii) Considering that drought is a common feature because of poor amount of total rainfall plus the erratic distribution of it, a priority and more emphasis should be and will be given to finding drought tolerant lines.

iv) Earliness is another important factor which will be included in the top list of priorities.

v) In collaboration with ICRISAT germplasm unit, a systematic program of local germplasm collection nationwide will be organised in order to increase the genetic stock.

vi) Storageability of different exotic materials will be studied for the purpose of discovering consequences for the future release of variety/ies.

vii) Evaluation of the varieties that can be released to the farmers will be ensured.

viii) Future introduction of new genetic soures to contribute to the accomplishment of the specific objectives (drought tolerance, stemborer resistance, earliness, yield response to improved management, disease resistance and good storegeability) will be assured.

ix) Studying the factors influencing the utilization of sorghum in the urban areas will be conducted. A mini dehuller was recently installed at Bonka Research Station which can be used for that purpose.

x) Strengthen and expand the current relationship with other institutions that conduct sorghum research programs nationally and internationally.

LOCAL AND DABAR SORGHUM AT THE BONKA RESEARCH STATION

Abdullahi H. Wardere (Siiruu)*

1. Introduction

The Bay Region, situated between the rivers of Shabeelle and Juba, constitutes the main rainfed area where rainfall ranges from 400-600 mm per year.

There are two cropping seasons, namely Gu (March-July) and Deyr (September-December), which coincide with the main rainfall periods. The environmental conditions of the region are conducive for sorghum production.

Sorghum was and still is the main staple food and rainfed crop grown in the region for generations. It is a source of cash money for the farmers of the region and also a means of trade for other things needed. There is virtually no farm in the region where sorghum is not grown.

The farmers apply traditional practices which contribute to the low sorghum yields. On the average farmers obtain a yield which varies from 300 to 500 $kg.ha^{-1}$. Most of them grow sorghum after sorghum with no rotation. However, some farmers do sometimes intercrop the sorghum with some pulses - primarily cowpea.

Usually the farmers put 3-5 seeds per hill, hoping that at least one plant will emerge, since they don't use seed treatments. Based on their own experience, the farmers ratoon their crop should they foresee a bad rainy season.

Sorghum is used in the following ways:

a) The stover is used for livestock grazing and feed.
b) The stalks are used for hut roofs.
c) The seeds are eaten after fixing them in boiling water (this is called "cambuulo").
d) The seeds are milled and then the coarse particles are put in boiling water; after a short while the fine particles are added and the whole mixture is stirred until it gets thick and thus served (this is known as "soor").
e) Another way is by making porridge ("mushaari" or "shurbad").
f) Sometimes the seeds are roasted or fried and eaten that way ("dango").

The importance of the crop prompted the joint efforts of collaboration between the Bay Region Agricultural Development Project and ARI/IDRC in carrying out a Sorghum Improvement Program. In this Program an effort is made to select within what is in the region mainly on local and Dabar sorghums.

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2. Research on Local and Dabar Sorghum

In 1979, local sorghum germplasm samples were collected from the regions of Gedo, Bakool and Bay. There was not much genetic variation observed in the local germplasm (Bonka Reserch Station, 1983).

To get more insight about the local germplasm, a selection of eighty heads was made from the 100 hectare farm near Bonka Research Station in Gu 1984. The criteria for selection were head size, head type, plant height, stalk strength and insect-disease-free characteristics.

These eighty heads of local sorghum were selected primarily for yield and were tested in Deyr 1984.

In each season, selected lines from the previous season were retested. The selection operation was planned to continue for four seasons - 2 Deyr seasons and 2 Gu seasons.

There was found a considerable difference in yield of the local sorghum over the past 3 seasons while in any particular season the difference in yield was narrow (table 1). The table contains yield data of seven local sorghum entries grown during Deyr 1984, Gu 1985 and Deyr 1985. The data from Deyr 1985 are arranged in decreasing order with respect to yield. These seven entries have been selected for further testing in Gu 1986.

Table 1. Yield ($kg.ha^{-1}$) of seven local sorghum entries over the three seasons of Deyr 1984, Gu 1985 and Deyr 1985.

Entry	Deyr 1984	Gu 1985	Deyr 1985
67	662	497	213
31	1447	563	191
32	1417	440	155
34	1083	363	133
50	837	512	130
09	532	351	109
51	687	441	101

This selection operation will terminate in this Gu season of 1986 and the resulting material will be multiplied and used for both breeding crosses and production.

In addition to the eighty heads of local sorghum, a Dabar selection of eighty heads was made from the 100 hectare farm. This selection was handled the same way as the local selection.

The seasonal differences in yield over the 3 seasons were smaller than that of the local selection while the differences in yield in the same season were similar to the local selection (table 2). In the table, the data of Deyr 1985 were arranged in decreasing order with

COMPARISON BETWEEN STABILITY PROCEDURES FOR SELECTION PURPOSES IN SORGHUM BREEDING

E. K. Alahaydoian*

1. Introduction

Genotype-environment interaction has always played a very important role in the performance of varieties at different sites. The multilocational yield tests, analysed in the conventional way, give information on this interaction but not on the reaction of the individual line or variety to that environment. Several procedures were developed to evaluate these individual reactions.

Finlay and Wilkinson (1963) regressed the individual yield on the mean yield of all varieties for each site in each season. To achieve a high degree of linearity in the computed regressions, they used the logarithmic scale.

Eberhart and Russell (1966) rejected the use of the logarithmic scale, and regressed the individual observation on the environmental index which is the mean of all varieties at a certain location minus the grand mean. They consider the regression coefficient as well as the deviation from the regression line as parameters for stability.

Anderson (1974) found good correlation between ranking, using the site average as a common denominator, and the results of the Eberhart and Russell regression procedure.

These procedures and others were compared to select varieties in view of release and to choose the easiest.

2. Materials and Methods

A set of seventy sorghum lines, under the name of ISDRON-80, was sent to the Agricultural Research Institute of Somalia in 1981. Beween Gu 81 and Gu 84 the varieties were tested six times at the Bonka Research Station, Baidoa. In 1982 a certain number of lines were selected and grouped in a separate set which was tested alone. High coefficients of variability compelled us to increase the number of replications so that the eleven lines to be discussed were tested over the six seasons at replications ranging from one to eight.

The populaion used was 53,300 plants per hectare at the spacing of 75 x 50cm (2 plants/hill). The randomised complete block design was always adopted. No fertilizer was spread due to the lack of this commodity. Basudin 10G was the standard treatment against the stem-borer.

The stability analysis was performed according to procedures described by Finlay and Wilkinson (1963) and by Eberhart and Russell (1966). We also regressed the individual yield of a variety on the yield of the local in the corresponding season (procedure 3). Two ranking procedures: the Anderson method and as percentage to the local were also tried as procedures 4 and 5, respectively.

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respect to yield. The 13 Dabar sorghum entries in the table have been selected for further testing in Gu 1986.

Table 2. Yield (kg.ha^{-1}) of 13 selected Dabar sorghum entries over the three seasons of Deyr 1984, Gu 1985 and Deyr 1985.

Entry	Deyr 1984	Gu 1985	Deyr 1985
58	783	645	243
70	580	701	241
24	629	847	223
10	710	794	210
73	1445	742	191
39	716	683	150
14	1011	902	148
20	659	658	140
33	864	753	140
63	882	683	116
31	554	710	104
27	502	973	102
57	807	668	101

This Dabar selection is also going to terminate in this Gu season of 1986 and the resulting material will be handled like the local sorghum selection.

The yield data of Deyr 1984 in both tables are unusually high because the season had exceeded the normal Deyr rainfall by 130% (Bonka Research Station, 1984).

On the 100 hectare farm where Dabar material was grown, we observed many off-type plants as well as highly tillered plants. This tillering was presumably due to stalkborer damage. Another characteristic of this material was its poor exersion. Therefore, another Dabar selection was initiated in Deyr 1985. Seventy-two heads of Dabar were selected on the basis of their head size, good exersion, medium height and non-tillering habit. Each head was planted in a two-row plot in an area away from contamination of pollen from other sorghum. The objective of the selection was to get a pure Dabar that is early maturing, comparatively better yielding, with no tillering and good exersion.

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3. Results

The analysis of variance for stability (Table 1) gave highly significant results for the seasons, but neither the varieties nor the variety-season interaction was significant. The stability parameters are presented in Table 2.

The analysis according to Finlay and Wilkinson method produced the following series in increasing order of stability: Local, 71509, 71425, 71680, 71406, 71091, 71684 and 71205, whereas 71499, 71255 and 71244 prefer more fertile conditions increasingly. The lines 71684, 71091, 71406, 71680 and 71509 in the former group and 71255 and 71244 in the latter have outyielded the local. The lines 71091, 71680 and 71406 would be recommendable for moderately fertile soils in addition to the local whereas 71255 and 71244 would be suitable for more fertile areas. The line 71684 having strong opposition to changes should be tried in land more impoverished than Bonka.

The coefficient of regression and the deviation from the regression line are used concurrently by Eberhart and Russell. The following would be a series with increasing stability: Local, 71499, 71244, 71255, 71205, 71680, 71425, 71091, 71509, 71406 and 71684. The first five have very large deviations and their stability is considered to be less even if the coefficient of regression is lower than the unit such as that of 71205. The lines 71091, 71680 and 71406 would be recommended for areas of low fertility and 71684 for poor areas. The lines 71244 and 71255, the former having large b-value and the latter large deviation, may perform well in the fertile areas of Qansadhere.

Table 1. Analysis of variance of yield of eleven varieties of sorghum of ISDRON-80 at Bonka.

Source of variation	D.F.	Sum of Squares	Mean Square	F-value
TOTAL	65	6845263		
SEASONS (S)	5	3787922	757584	14.928
VARIETY (V)	10	519965	51997	N.S.
SEASON X VARIETY	50	2537376	50748	
SEASON (Lin.)	1	0.806	0.806	
S X V (Lin.)	9	4043723	449303	<1.0
Pooled Deviations	40	90475261	2261882	

Table 2. Stability parameters for yield in eleven lines of sorghum in ISDRON-80 at Bonka.

Line	Mean Yield	F & W	E & R		Regressed on Local		Anderson	Relative Local
	kg/ha		b	d^2	b	d^2	%	%
71091	824	0.635	0.669	141525	0.294	304699	141	186
71680	773	0.761	0.806	81218	0.548	197077	130	160
71684	746	0.333	0.450	128488	0.184	206240	134	182
71244	704	1.510	1,526	113699	0.521	1087555	106	149
71255	665	1.341	1.014	393440	0.095	898376	105	155
71406	638	0.727	0.597	111933	0,062	286567	109	149
71509	588	0.863	0.694	101923	0.163	322857	98	138
LOCAL	585	0.919	0.714	432395	1.0	000000	99	100
71205	580	0.203	0.479	361528	0.157	459036	103	140
71425	580	0.847	0.740	24611	0.385	194850	96	123
71499	544	1.126	1.175	374869	0.651	769935	85	112

The striking features of the results by procedure 3 are the greatly reduced coefficients of regression and the greatly increased, at times ten times, of the deviations as compared to those by procedure 2. Three lines had coefficients larger than the unit by procedure 2 but we do not encounter any line in column 6 which has a b-value larger than that of the local. The following would be a series to consider: Local, 71244, 71255, 71499, 71205, 71509, 71680, 71091, 71425, 71684 and 71406. The last five lines would be the more stable ones and all but 71425 have outyielded the local. Selections for poor lands will include 71684 and 71406 with small and very small b-values respectively and moderate deviations, while for moderately fertile areas 71091 and 71680 with medium and larger b-values and moderate deviations would be suitable. The line 71244 would be more suitable for fertile areas with 71255 a possible companion.

The ranking procedures will permit us to select 71091, 71684 71680 and 71406 by Anderson's method and 71091, 71684, 71680, 71255, 71244 and 71406 by the last procedure. There is better agreement between results by Anderson's method and that by Eberhart and Russell than between the latter and those by procedure 5. In this last analysis 71244 and 71255 would be selected but not by procedure 4. It is true that ranking does not specify the adequate environment for the selected line.

The results of our selections are summarized in Table 3.

Table 3. Selection results by different stability procedures in ISDRON-80 sorghum lines.

PRECEDURE	F & W	E & R	Reg./Local	Anderson's	Rel.Local[a]
FERTILITY					
POOR	71684	71684	71684	71684	71684
				71406	71406
			71406	71091	71091
				71680	71680
					71244
					71255
MODERATE	71091	71091	71091		Local
	71680	71680	71680		
	71406	71406			
	Local				
HIGH	71244	71244	71244		
	71255	71255	71255??		
			Local		

a In the last two procedures (ranking) the lines are grouped because they are simply selected without designation of the environment.

4. Discussion

The results of the analyses agree very well with each other. One can detect only minor differences between the selections by the three regression methods.

The deviations from the regression line are rather large, much larger than what are being reported by other breeders, which denote a violent reaction of some of these lines to the growing medium at Bonka.

In the semi arid tropics, perhaps the most variable factor of the environment is the available moisture. The fertility of the soil changes over time but quite slowly. The land around the station is covered with brush and trees where Mimosoideae are represented abundantly. The soil in such regions is not very fertile initially. We have seen areas of newly cleared bushland where the production had started to decline after a few years of cultivation. Addition of fertilizers, organic or inorganic, helps to maintain the fertility and the uniformity of the soil, but if this practice is ignored for a long time the soil will be exhausted, very variable and the genotype-environment interaction will be very high. Therefore it is not surprising the large fluctuations evidenced by the deviations.

At this stage a question of practical importance rises: What should be the weight accorded to the deviation in any decision of selecton? The question becomes more important if environments like ours are encountered. Finlay and Wilkinson have conveniently side-stepped the issue by using the logarithmic scale. Eberhart and

Russell do not address it. The few papers that we have seen, dealing with stability, do not go far enough to announce the selections performed, if any, and do not discuss the bases of such selection. The problem is a complex one and no easy answer is expected.

In a conventional analysis of variance new varieties are always compared to the standard, be that standard the local variety or that in current use. The local is the check, the reference, the yardstick, the variety intimately known to the farmer. Although the Western farmer is much better informed and his operation is more of a commercial nature, the standard variety is always included in the demonstration. Don't Plaisted and Peterson (1959) insist on it? The farmers of the Third World, more subsistence farmers than commercial, are even more conservative. Any variety presented to the farmer has to be compared to his local variety or else it is doomed to failure.

The third procedure - regression on the local variety - has been proven to yield results very highly correlated with the two other procedures. Moreover it has the advantage to give information in relation to the local or the standard, a known and widely used variety. Thus the breeder's selection has more real foundations. It could be argued that this variety varies in performance and at times, our case, rather widely. But these variations are already known to the farmer and accepted by him. The site average and the environmental index also vary and being an abstract concept are not easily grasped by neither the Western nor the Third World farmers.

When variety release is the purpose of the national programs, we recommend the use of the third procedure. However, in any other case, especially for screening purposes, any of the three methods could be used since they are nearly equivalent in their requirements of time and effort.

In opposition to the regression methods, the last two procedures are very simple mathematically. The calculations are very easy and the time needed is very short.

The ranking has always been used by breeders: either the absolute yield or relative to the local. Anderson's concern is the risk incurred by the farmer adopting a new variety. But to minimize the risk, the variety should yield high and maintain its performance. In other words high and stable yield should be the characters of this new variety.

Ranking seems to have a good correlation with the regression methods. At least 4 varieties selected by ranking are also possible to be recommended using the regression methods. Yet, these four lines are good for moderately fertile and poorer areas. Ranking relative to the local permitted to select two more lines that are good for more fertile conditions. But ranking does not deal with the environment where the selected line can be used advantageously. That is left to the regression methods.

The breeder could select the top yielders by ranking them relative to the standard variety, then apply regression, to delimit the adequate environments, to a reduced number of lines saving time and effort but securing most of the information needed to base his selection decision on concrete bases.

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STUDIES ON SOME SORGHUM AGRONOMIC PRACTICES

Habiba Ali Nuur*

1. Introduction

Sorghum is a major food crop in Somalia, especially in the Bay Region. Agronomic information pertaining to a crop is specific to a region. Such information is necessary not only to the agronomist, but also to the farmer, breeder and a host of other scientists. There is a scarcity of such information concerning sorghum in the Bay Region of Somalia.

To remedy this situation, we undertook a series of experiments to supply information on plant population, plant density, time of sowing, time of thinning, and time of weeding of sorghum. These experiments were started during the Dayr season 1984 at Bonka Research Station.

2. Time of Sowing Trial

a) Objective: To determine the effect of planting dates on yield of local sorghum.

b) Materials and Methods: Local sorghum was planted on four dates and in eight replications in a randomized complete block design. The dates of planting were; before the rain, soon after the first rain, one week after the first rain and 2 weeks after the first rain. The plots were 2-row plots, rows 75cm apart, 5m long, thinned to a population of 40,000 plants per hectare.

c) Results: The results on grain yield of sorghum planted at four different dates during the last three seasons on the Bonka Research Station were as follows: The treatment soon after the first big rain gave the highest yield in both Dayr 85 and Gu 85 seasons. But in Dayr 85, results were unreliable because the growth of sorghum was very poor and in consequence the yield was generally very low. Severe damage by stalkborer and shortage of rainfall were the major contributors to this poor yield.

3. Time off Weeding Trial

a) Objective: To determine the effect of time of weeding on the grain yield of sorghum.

b) Materials and Methods: Local sorghum was planted in a randomized complete block design replicated eight times. The plots were two-rows, 75cm apart, 5m long and the plants were thinned to 40,000 plants per hectare. The weed population in the plots ranged from a low of 10% to a high of 50% ground cover. Weed cover in the plot area was not uniform and the calculated coefficient of variation was 31.2%. The first weeding was done when weeds were 3cm high. The remaining three treatments followed the first at one-week intervals.

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c) Results. In 1984 Dayr season, the treatment where weeding was done the earliest, that is, weeds 3cm high, resulted in the highest yield of 970 kg ha^{-1}. As the date of the first weeding was delayed, yield decreased from the high of 9.70 q/ha to 766, 592 and 578 kg ha^{-1}, respectively. Similar results were also acquired in Gu 85 season, where the first treament resulted in the highest yield.

4. Time of Thinning Trial

a) Objective: To determine if time of thinning has an effect on sorghum yields. Some growers in the Bay Region delay thinning so that they rough out small diseased or insect infested plants.
b) Materials and Methods: The plots were thinned to a population of 40,000 plants per hectare when the sorghum plants were 10, 20, 30, 40cm above the ground. The plots were 2-rows, 75cm apart, 5m long. The design used was a randomized complete block design replicated eight times.
c) Results: The dates for Dayr 84 and Gu 85 season showed that the treatment where thinning was done when plants were 30cm tall gave the highest yields. The treatment where thinning was done when plants were 40cm tall gave the second highest, but in both seasons the differences were statistically non-significant for all treatment means.

5. Plant Per Hill Trial

a) Objective: To determine if the number of plants per hill had any effect on sorghum grain yield.
b) Materials and Methods: Local sorghum was planted in a randomized complete block design replicated eight times. The treatments consisted of hills spaced 33, 66, 100 and 133cm apart within the row. The rows were 75cm apart and 5m long. The plots were thinned to 40,000 plants/hectare. This resulted in 1, 2, 3, 4 plants per hill.
c) Results: The two seasons of Der 84 and Gu 85 were not consistent. In the Dayr 84, 3 plants per hill gave the highest yield of 800 kg ha^{-1}, while in Gu 85 the 2 plants per hill gave the highest yield 3 kg ha^{-1}.

6. Plant Population Trial

a) Objective: To determine which sorghum plant population results in the highest grain yields and most stable production.
b) Materials and Methods: Local sorghum was thinned to a population of 30, 40, 50, and 60 thousand plants per hectare. The plots were two-row plots 5m long, 75cm between rows.
c) Results: In both seasons, the results were consistent in that the treatment of 50,000 plants/hectare gave the highest yield, 990 kg ha^{-1} and 200 kg ha^{-1}, respectively, for Dayr 84 and Gu 85 seasons. As could be seen from the two seasons, the 84 Dayr seasons always outyielded the Gu 85 season. The sorghum

in the Gu 85 season had insect problems. Those included infestation by stalkborer as well as heavy infestation by *Heliothis armigera* (American bollworms).

SORGHUM PRODUCTION ON BAIDOA SOILS

P.M. Porter*

Abstract

The Baidoa soils are largely cropped to sorghum. They can be classified as Typic Chromusterts, which indicates they are dark colored soils with a large amount of clay that swells on wetting and shrinks on drying. These soils are calcareous and alkaline, with a pH of about 8. While the surface soil does not have a salt problem, below 25 cm some profiles are saline, others sodic, and still others saline-sodic. They are low in available nitrogen and phosphorus, and a growth response has been observed with the addition of these nutrients. The iron and zinc levels are also very low and the potential exists that these nutrients may limit plant growth in certain areas. The soil moisture holding capacity of these soils is very high. However, a large portion of the moisture in the soil is not available to the plant.

1. Vertisols

The Baidoa soils were formed in situ on the limestone plateau and occupy over 100,000 hectares in the Bay Region (Figure 1). They are among the most fertile soils in the Bay Region and are predominately cropped in sorghum (Hunting Technical Services, 1982, p.173).

The Baidoa soils could be classified as Typic Chromusterts, meaning they are a fairly typical dark colored Vertisol with a ustic (between aridic and udic) soil moisture regime. Conditions that give rise to the development of Vertisols are parent materials high in, or that weather to form, large amounts of montmorillonitic (expanding) clay and a climate with wet and dry seasons. One of the most conspicuous characteristics of the Vertisols is their capacity to shrink and swell enormously upon change in the moisture content. Vertisols crack widely in dry seasons. After the cracks develop,surface material sloughs off into cracks. On wetting the clays, the soil expands again and the cracks close. This churning or inverting action causes pedoturbation, a gilgai microrelief, and the formation of slickensides, which are characteristics of Vertisols. (Detailed information on these processes are found in Mohr et al, 1972; Ahemd, 1983; Thompson and Beckmann, 1982; and Transactions, 1982.)

2. Soil Texture

Soil texture refers to the relative proportions of the various size groups of individual soil grains in a mass of soil. It is an

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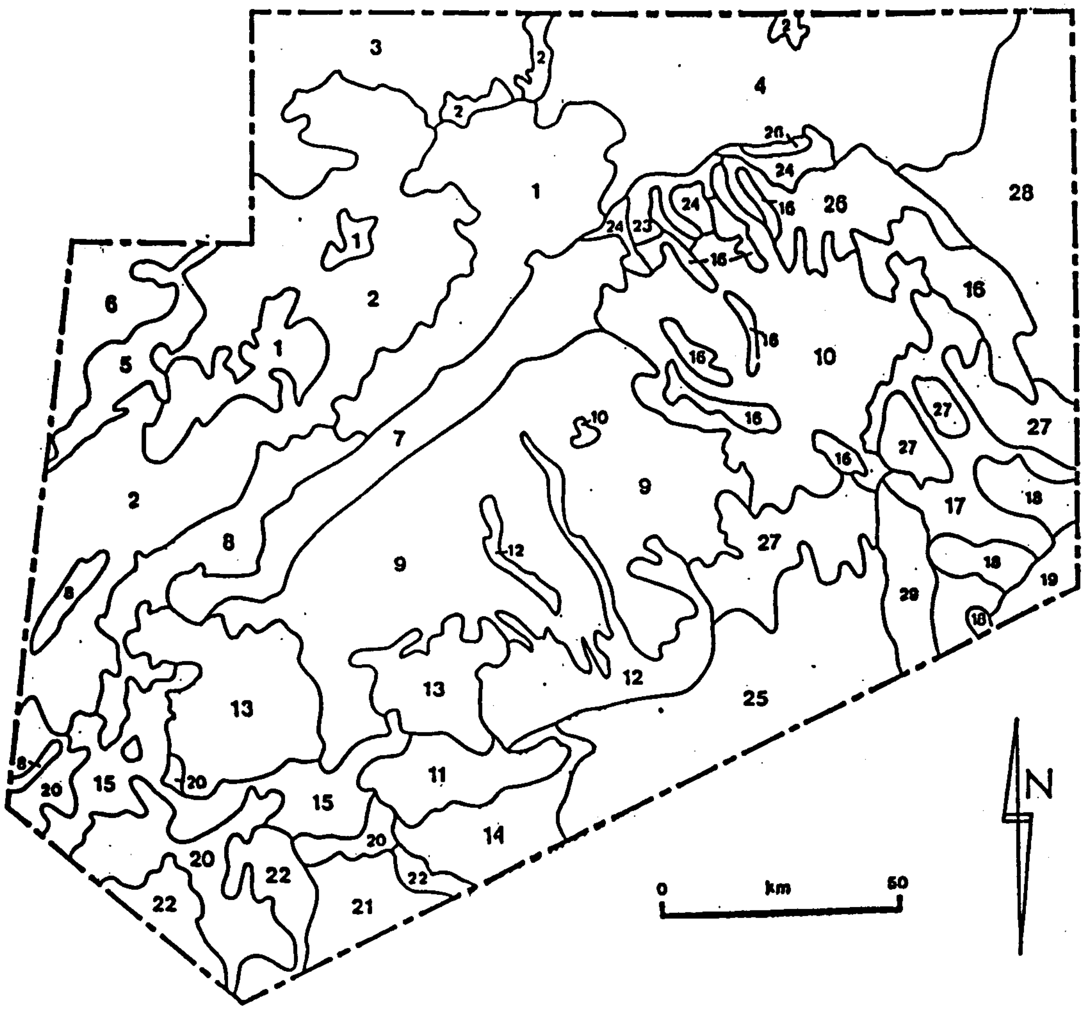

Figure 1.. The Baidoa soils in the Bay Region of Somalia (HTS, 1982, p.26). (Baidoa soils = #1)

important soil characteristic because it affects infiltration rates, total water storage as well as plant available water storage in the profile, and the fertility of the soil. The rate and extent of many physical and chemical reactions important in plant growth are governed by texture because it determines the amount of surface on which the reactions can occur. Clay may have thousands of times more surface area per gram than silt and nearly a million times more surface area than sand (Foth, 1978, p.28).

The Baidoa soils are composed of a relatively large proportion of clays, and are thus considered fine textured soils. Their organic matter content is relatively low, but it is fairly uniformly distributed in the first meter of the profile (Table 1). The dark coloration of these soils is due to organic matter particularily associated with the very fine clay. The dark colored Baidoa soils have developed on nearly flat topography. On areas of greater relief red soils have developed. Their coloration is due to the increased weathering that has occurred on those sites. This association between the dark brown soils and red soils is also found in Austrialia and India (Ahmed, 1983, p.98 & 101).

Table 1. The soil texture and organic matter content of Baidoa soils.

Source	Depth cm	Sand %	Silt %	Clay %	O.M. %
Univ. of Sydney, 1985 (average of 3 sites)					
	0-10	16	17	67	0.9
Lockwood, 1968, app.2 (average of 5 sites)					
	0-30	18	13	69	1.4
	30-90	20	10	70	1.4
	90-150	26	10	64	1.3
	150-190	24	8	68	0.7
HTSb, 1982, p.47 (1 site)					
	0-10	20	32	48	ND*
	10-20	11	30	58	ND
	20-52	11	30	58	ND
	52-97	20	25	55	ND
	97-140	20	25	55	ND
CARS, 1986 (average of 2 sites)					
	0-25	42	15	43	ND
	25-50	28	11	61	ND
	50-75	26	10	64	ND

*ND = not determined

3. Saline, Sodic and Salin-Sodic Soils

Saline soils contain sufficient soluble salts to impair plant growth. The main effect of soluble salts on plants is osmotic, since high salt levels make it difficult for the plant to obtain water for growth. The plant root contains a semi-permeable membrane permitting water to pass but rejecting most of the salt. Thus, water is osmotically more difficult to extract from increasingly saline solutions.

The relative growth of plants in the presence of salinity has been termed their salt tolerance. Sorghum is said to have a 'moderate' salt tolerance (USDA, 1969, p.67). Grain yields were shown to be reduced by 10, 25, and 50 percent when the electrical conductivity (EC) of the soil was 6, 9, and 12 $mmhos.cm^{-1}$, respectively (Bohn, 1979, p.233). To determine the EC, the solution (most commonly a saturation extract, but often a 1:2 or 1:5 soil:water extract) is placed beetween two electrodes. When an electrical potential is imposed, the amount of current varies directly with the total concentration of dissolved salts. At constant potential the current is inversely proportional to the solution's resistance and can be measured with a resistance bridge. Conductance is the reciprocal of resistance and has the units of reciprocal ohms, or mhos. (The SI units for conductivity is $siemens.m^{-1}$· where 1 siemens (S) is equal to 1 mho. Thus 6 $mmho.cm^{-1}$ is equal to 0.6 $S.m^{-1}$.) Since some salt-sensitive plants are adversely affected in soils whose saturation extracts are as low as 2 $mmho.cm^{-1}$, the boundary between saline and nonsaline soils is 2 $mmho.cm^{-1}$ in the saturation extract.

Soil particles absorb and retain cations on their surfaces. While absorbed cations are combined chemically with the soil particles, they may be replaced by other cations that occur in the soil solution. 'Cation exchange' is the reaction whereby a cation in the soil solution replaces an absorbed cation. Certain cations, like those of sodium, calcium, and magnesium, are readily exchangeable. Other cations, like those of phosphorus and ammonium, may be held on the soil particles and only are only exchanged with great difficulty. They are said to be 'fixed'. The sum total of the exchangeable cations that a soil can adsorb is the cation exchange capacity (CEC). The exchangeable-sodium percentage (ESP) is the percentage of the cation-exchange capacity of a soil occuppied by sodium. If sodium accounts for over 15 percent of the exchangeable cations (thus having a ESP of greater than 15) the soil is termed a sodic (formerly 'alkali') soil.

If a soil contains both a high concentration of soluble salts (EC greater than 2 $mmho.cm^{-1}$) and a large amount of soluble sodium (ESP greater and 15) it is termed a saline-sodic (formerly 'saline-alkali') soil.

Data indicate the surface 25 cm of the Baidoa soils are neither saline, sodic, nor saline-sodic (Table 2). However, roughly a quarter of the 29 soils sampled at a depth of 25-75 cm were saline, an additional quarter were sodic, and a seventh were saline-sodic. Below 75 cm the proportion of samples that were saline, sodic, and saline-sodic was approximately a quarter, a sixth, and a half, respectively. Thus for the majority of profiles studied there is a high concentration of salts below a depth of 25 cm. The quantity of soluble salts alone does not appear to be high enough to cause a reduction in sorghum grain yield (since an EC of 6 $mmho.cm^{-1}$ would cause only a 10 percent reduction in grain yield). However, the effect on sorghum growth and yield of the presence of high sodium concentrations in the subsoil has not been studied in depth (ICRISAT, 1982, p.164).

The presence of high quantities of sodium causes organic matter and clays to disperse, thus making the soils slowly permeable to water and impeding plant root development (Foth, 1978, p.221). On non-salt affected soils the root system of sorghum occrurs mainly in the top 25 to 30 cm. Reports indicate that while sorghum roots can extend to a depth in excess of 1.5 m, over 75 percent are in the top 30 cm (Peacock and Wilson, 1984, p.261).

Although there is no available data concerning the distribution of the root system of sorghum growing on Baidoa soils, it is felt that the roots do not extend very deeply into the profile. This may be due in part to the elevated salt and sodium concentrations which occur in the subsoil.

Table 2. Electrical conductivities (EC) and exchangeable sodium percentages (ESP) of Baidoa soils.

Source	Depth cm	Average EC $mmho.cm^{-1}$	Number Saline	Average ESP %	Number Sodic	Number Saline-sodic
Lockwood, 1968, p.12 of app. 2 (5 profiles analyzed)						
	0-25	1.0	0 of 5	7.4	0 of 5	0 of 5
	25-100	6.4	3 of 5	9.4	0 of 5	1 of 5
	100+	8.0	1 of 5	17.4	0 of 5	4 of 5
HTS, 1982a, p.63 of vol. 2 (24 profiles analyzed)						
	0-25	0.5	0 of 24	4.5	0 of 24	0 of 24
	25-75	1.7	4 of 24	15.0	8 of 24	3 of 24
	75+	4.1	6 of 24	17.5	5 of 24	11 of 24

4. Soil pH

The aqueous liquid phase of the soil and its solutes is termed the soil solution. If the soil solution contains more hydrogen ions (H+) than hydroxyl ions (OH-) the soil is said to be an acid soil. In alkaline soils the soil solution contains more OH- than H+. Alkaline soils are sometimes referred to as basic soils. The degree of 'acidity' (or 'alkalinity') of a soil at a specified moisture content or soil-water ratio is expressed in terms of the pH scale. An acid soil has a pH of less than 7 and an alkaline soil has a pH of greater than 7.

A calcareous soil contains calcium carbonate (CaCO3) and, when treated with hydrochloric acid (HCl), a bubbling can be observed representing the evolution of carbon dioxide. The Baidoa soils are calcareous since they react when treated with HCl (Lockwood, 1968, app. 1, profile 29). The pH of calcareous soils is controlled by the hydrolysis of calcium carbonate as follows:

$$CaCO_3 + 2H_2O \longrightarrow Ca(OH)_2 + H_2CO_3$$

The greater dissociation of the calcium hydroxide ($Ca(OH)_2$) and production of OH^-, as compared to the production of H^+ from the weak carbonic acid (H_2CO_3), creates an alkaline effect. As a result the pH of calcareous soils ususally ranges from about 7 to a maximum of 8.3. A soil pH of greater than 8.5 generally indicates appreciable exchangeable sodium ions.

Soil pH is used as a method for diagnosing possible nutrient problems just as a doctor measures your body temperature to determine the presence of a possible infection. Perhaps the greatest general influence of pH on plant growth is the effect of pH on the availability (i.e. solubility) of nutrients. The general relationship between pH and availability of several plant nutrients are shown in Figure 2. Note that for calcareous soils phosphorus, iron, zinc, copper, and boron may be too insoluble to meet plant needs.

The pH of saturated soil pastes from various depths with profiles of Baidoa soils indicate that the pH varies only slightly with depth and is approximately 7.8 (Table 3). The optium soil pH for sorghum growth is 5.5 to 7.5 (Foth, 1978, p.210). However, grain sorghum can be produced on soils that have a pH ranging from 5.0 to 8.5 (Chapman and Carter, 1976, p.264).

To lower the pH of the Baidoa soils appreciably, the calcium carbonate must be leached out, and this is impractical. Since the pH of calcareous soils cannot be practically altered, crop selection and fertilization with deficient nutrients are commonly the only practical solutions for growing crops on calcareous soils (Foth, 1978, p.219).

Table 3. pH of Baidoa soils.

DEPTH	Lockwood, 1968 5 samples	HTS, 1982 1 sample	CARS 2 samples
0-30	8.0	7.5	7.8
30-90	7.8	7.6	7.8
90-150	7.9	7.6	-
150+	7.7	-	-

5. Nutrient Status

There is only a limited amount of information concerning the fertility level of the Baidoa soils. Work conducted at Afgoi in the mid-1960's showed that levels of available phosphate in the surface horizons were very low, while the levels of potassium were high (HTS, 1983, p.8). More recent analyses (Univ. of Sydney, 1985 and Soil Test Ltd, 1985) produced similar results for phosphate and potassium. It was stated that available phosphate "is extremely low and would not be

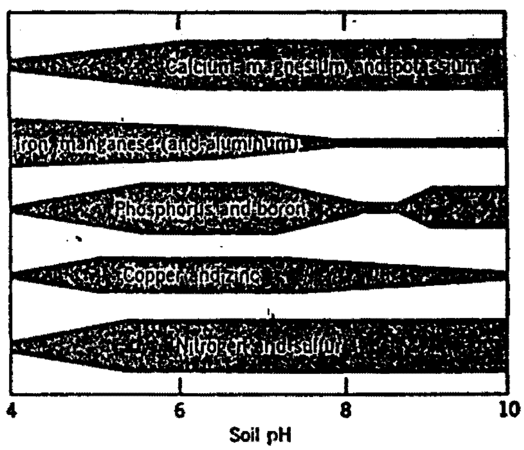

Figure 2. General relationship between soil pH and availability of plant nutrients: the wider the bar, the more available the nutrient (from Foth, 1978, p.207).

expected to support satisfactory yields in grain crops." University of Sydney analysts state, "Both the organic matter and nitrogen contents were also quite low, and it is very likely that improved yields would not be sustained without application of nitrogen. As the soil pH suggested, the trace elements zinc, iron, and copper are also very low (<2.0, <20, and <0.5 ppm, respectively)." Sorghum growth is known to be very susceptible to zinc and iron deficiencies but less susceptible to copper deficiencies (ICRISAT, 1982, p.181-183). Based on the soil analyses and the requirements of sorghum, one would not expect the other essential elements (especially potassium, magnesium, suflur, and calcium) to be limiting sorghum growth on the Baidoa soils.

For sorghum it is estimated that grain yields of 800 kg per hectare remove 24 kg nitrogen, 2 kg phosphorus, and 24 kg potassium (Agricultural Compendium, 1985, p.477). The fixation of nitrogen from the air by bacteria amounts to between 20 and 50 kg nitrogen per hectare per year (Agricultural Compendium, 1985, p.536; Transactions, 1982, p.67). Thus the nitrogen level in the Baidoa soils which are continually cropped to sorghum may be at or near a steady state. The already small amount of available phosphorus would be further depleted over time. These soils contain vast amounts of potassium reserve, so that element would not be expected to be depleted.

Initial results from fertilizer research currently* being conducted at the Bonka Research Station show that the plant height of the local sorghum variety is significantly increased by the addition of both phosphorus and nitrogen but not affected by the addition of just nitrogen (Figure 3). It should be stressed that the positive effect of the phosphorus and nitrogen fertilizer on sorghum growth would not be expected if there had not been adequate rainfall or if the fertilizer was not applied properly (Transactions, 1982, p.69).

6. Soil Moisture

The Baidoa soils have a relatively high water storage capacity in the root zone because of their high content of clay. However, the so-called 'plant available water' determined instrumentally is not necessarily related to easily available water for crops growing on this type of soil. The moisture content at the 'wilting point' (15 bar tension) of this type of soil can range from 20 to over 30 percent on a gram per gram basis (Ahmed, 1983, p.103). Thus although the soil appears wet and actually contains moisture, this moisture may not be available to the plant because it is so tightly held by the clay.

In an effort to better understand the movement of water in the Baidoa soils, soil moisture determinations are being conducted over the course of time. The gravimetric soil moisture content at four different depths in a field of sorghum is shown in Figure 4. At the end of the 'jillaal' dry season the soil moisture content at depths of 25-50, 50-75, and 75-100 cm was approximately 28, 30 and 32 percent, respectively. It took over 130 mm of cumulative rainfall before the soil moisture content at depths of 25-50 and 50-75 cm began to increase substantially. Likewise, over 220 mm of rainfall had fallen

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Gu 1986 (April - August)

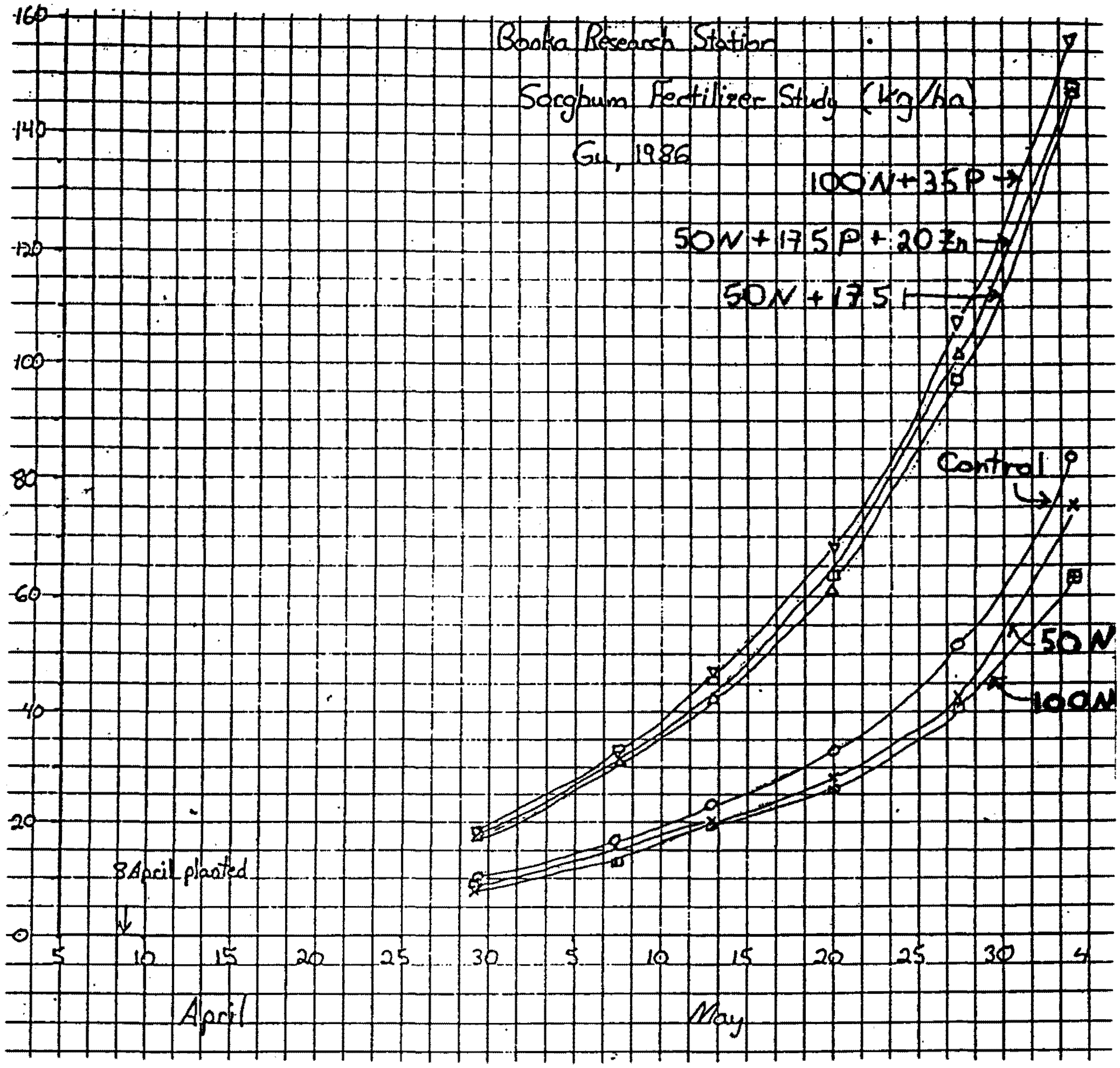

Figure 3. Plant heights for local sorghum grown at the Bonka Research Station in Gu, 1986.

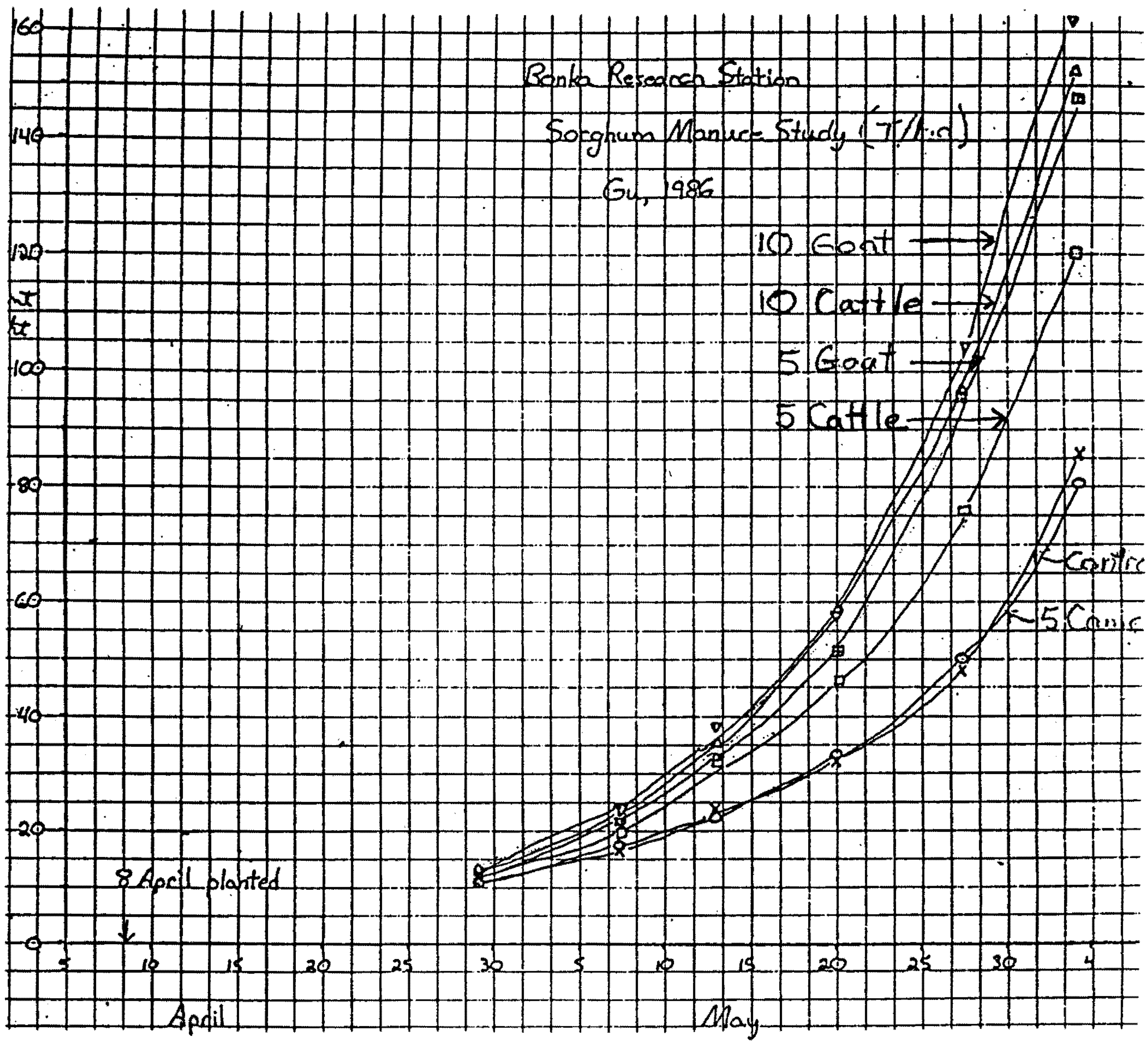

Figure 3a. Plant heights for local sorghum grown at the Bonka Research Station in Gu, 1986.

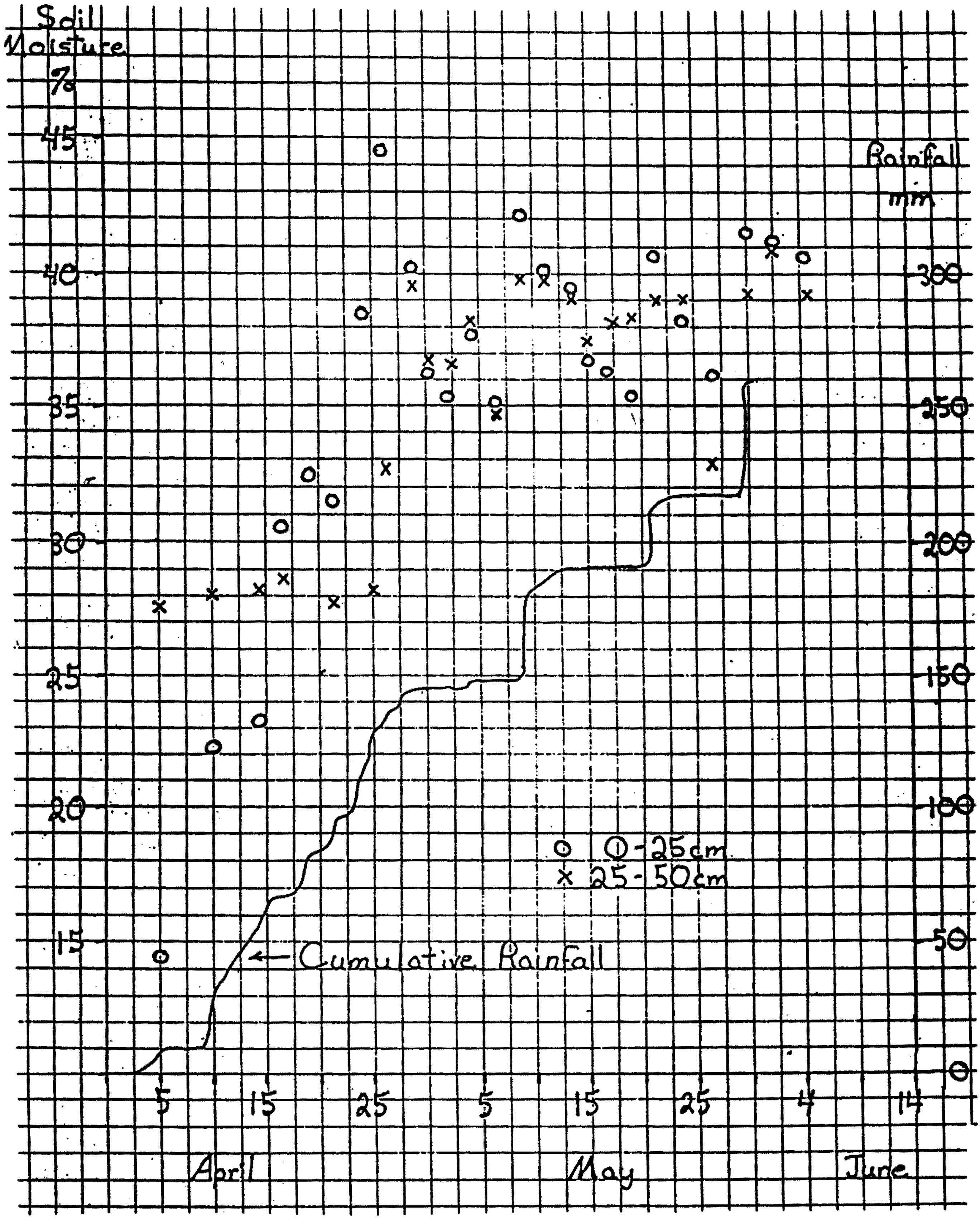

Figure 4. Soil moisture contents and cumulative rainfall over the course of time. (Each point represents the average of 3 replications.)

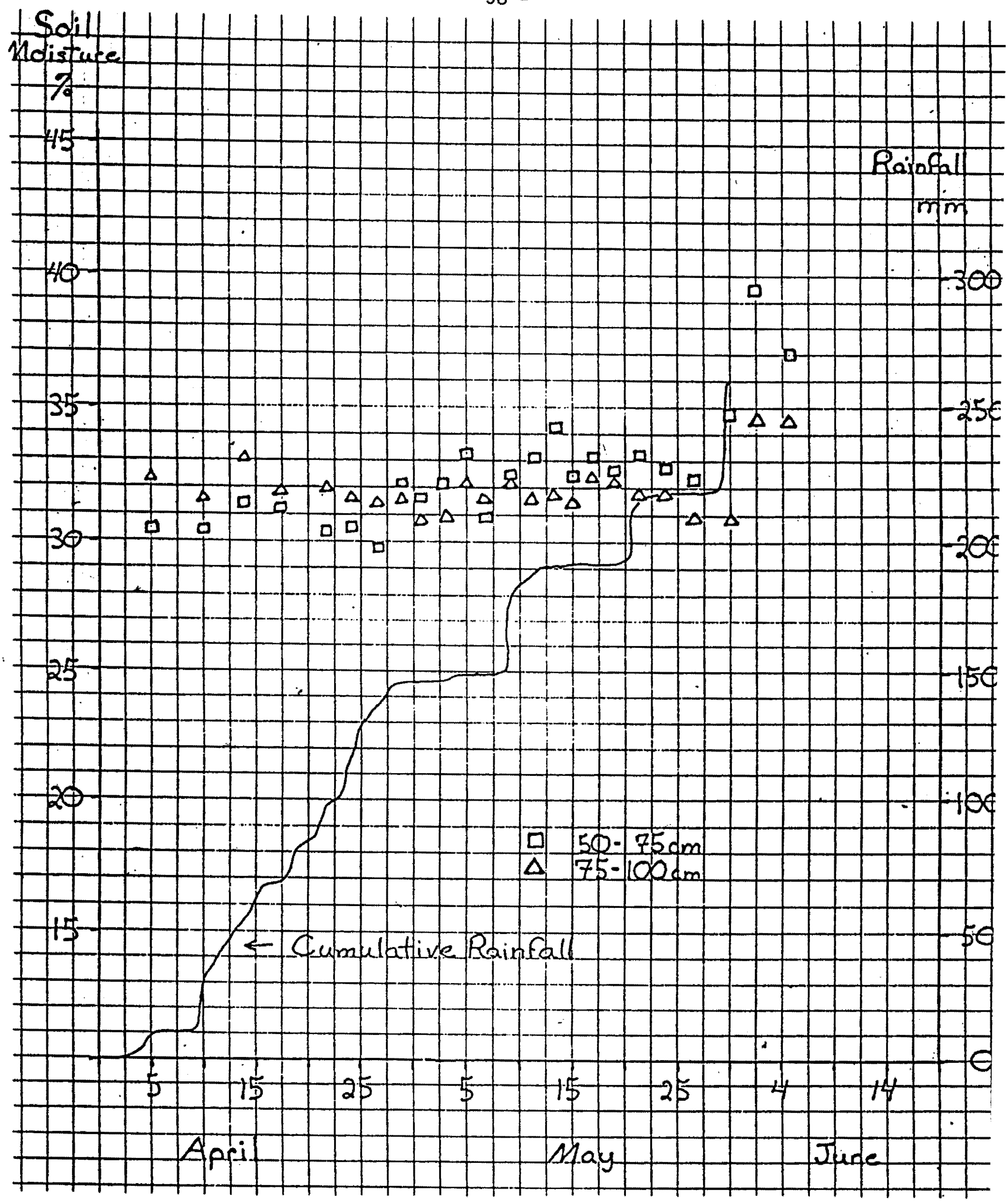

Figure 4a. Soil moisture contents and cumulative rainfall over the course of time. (Each point represents the average of 3 replications.)

before the soil moisture of the soil at a depth of 75-100 cm began to increase. This data indicate that the infiltration of moisture through the soil profile is relatively slow. Further interpretations of these results will be possible as the season* progresses and additional data are recorded.

7. Conclusions

The Baidoa soils are calcareous Vertisols that are extensively cropped with sorghum. The surface 25 cm of these soils has neither a salt nor sodium problem, but below that depth higher levels of salt and or sodium do occur in certain locations. It is unlikely that the salts or sodium reduce sorghum grain yields or dry matter production. Soil analyses indicate that the phosphorus and nitrogen levels in these soils are extremely low, and a marked response in sorghum growth has been observed due to the addition of phosphorus and nitrogen fertilizers. Further studies involving phosphorus placement and rates as well as the interaction between various phosphorus and nitrogen rates are needed in order to predict both grain and dry matter response. Although certain other essential elements are found to be quite low in Baidoa soils it is unlikely that they are currently affecting sorghum growth.

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* Gu 1986

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THE EFFECT OF VARIOUS AGRONOMIC PRACTICES ON THE YIELD AND WATER USE OF VARIOUS CROPS GROWN IN THE BAY REGION

M. A. Smith*

1. Introduction

If inputs , such as agricultural chemicals, machinery and improved varieties were available, there would be a large number of different agronomic practices available to Bay Region farmers. Without these inputs, the range of options is greatly reduced and even the better farmers are probably exploiting the present agro-pastoral system at a rate which is degrading the environment and reducing future yield prospects.

Improvements in agricultural production in most other countries have come from the adoption of a package of new technology rather than the introduction of one or two improvements. Therefore, this paper will deal with a range of practices which have proven successful in off-station demonstrations in the region, elsewhere in Somalia and in other countries. No apology is made for the fact that the present farmers are unable to use these practices due to deficiencies in the agricultural sector's infrastructure. This must be improved at the same time as new technology is introduced if yields are to be increased.

2. Current Sorghum Yield Levels and Water Use in the Bay Region

There is very little reliable data available on grain yields of durra type sorghum, the major crop in the region. The commonly quoted figure is a mean yield over both seasons of 300 $kg.ha^{-1}$ per crop. The Agricultural Research Component (ARC) of BRADP is now undertaking an intensive survey to measure yields and rainfall throughout the major cropping areas of the four districts. Results of a preliminary survey in Gu 85 among 22 samples contained yields ranging from 111 to 1130 $kg.ha^{-1}$ with a mean of 519 $kg.ha^{-1}$ in what was considered to be a good season. In Dayr 85 there were crop failures in most areas but on small areas which received favourable rains a mean yield of 450 $kg.ha^{-1}$ was recorded.

In Gu 85, local durra type sorghum in a long term fallowing trial (LFT) produced a mean yield of 469 $kg.ha^{-1}$ on a seasonal rainfall of 336mm. In Deyr 85 with some additions of fertilizer on the same trial site the yield was 325 $kg.ha^{-1}$ on a seasonal rainfall of 173.3mm. Based on observations on both seasons the total amount and more importantly the distribution throughout the season of rainfall must be the major factor setting yield limits in a marginal rainfed semi-arid tropical environment, such as that in the Bay Region.

However, these yields are below those recorded in similar environments elsewhere in the world and reasons for this need to be investigated. Wylie (1986) has reviewed the literature and made some

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generalizations regarding expected yields and water use efficiency in similar environments in Queensland, Australia. These are incorporated in Table 1, col. 4.

Table 1. Baidoa rainfall and probability of exceedance (from HTS 1982) for each season and estimated maximum crop yield limits for sorghum.

Rainfall Gu season (mm)	Probability of exceedance (%)	Crop	Yield per mm of rainfall ($kg.ha^{-1}$)	Yield limit ($q.ha^{-1}$)
139	90	sorghum tops	10-20	14-28
		sorghum grain*	3- 7	4-10
181	75	sorghum tops	10-20	18-36
		sorghum grain	3- 7	5-13
240	50	sorghum tops	10-20	24-48
		sorghum grain	3- 7	7-17
344	20	sorghum tops	10-20	34-68
		sorghum grain	3- 7	10-24

* This assumes a harvest index of 30% grain and 70% fodder for durra tops. Commercial hybrids are usually 50% grain (Wade, 1986). Data on harvest index of durra sorghum will be collected in the coming harvest to determine an actual value.

In both the Gu and Dayr 1985 seasons, soil moisture measurements were made in sorghum crops at the LFT. Effective rainfall ceased within 40 days of emergence in both seasons. Leaf area of the plants at this point in time was very low in contrast to that at the end of the seasons so it is possible to assume that most crop growth was made on stored soil moisture. In Gu 85 sorghum crops removed an average of 40mm of available soil moisture from the top 100 cm between the end of the rains and harvest. At a yield of 469 $kg.ha^{-1}$ this equates to 11.7 $kg.ha^{-1}.mm^{-1}$, which is in the realm of possibility considering the assumptions made in derivation. In the Dayr 76mm was removed with a water use efficiency of 4.3 $kg.ha^{-1}.mm^{-1}$.This crop suffered severe stalkborer damage.

The climatic factor of most importance to grain production is not the lack of rainfall each season, but its short duration, especially in the Dayr season which lasts for an average of only 33 days in Baidoa (HTS, 1982). Even a short season sorghum variety must therefore complete the last 60-70 days on stored soil moisture. The high cracking clay content vertisol soils of the Region are ideally suited to dryland farming under this rainfall regime. Total soil moisture storage at the LFT site in the top 100 cm is approximately 430mm. Wilting point soil moisture content and therefore plant available water content (PAWC) has not yet been measured on this soil and it is necessary to use the assumption that half of the total water is available. If this is the case, and there are some doubts due to

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* Gu 1986

marginal salinity levels being recorded lower in the profile (Smith, unpublished data), then the sorghum plants are using only 1/3 to 1/5 of this resource with corresponding loss of grain production.

Observations of the current* heavily fertilized crop suggest that phosphorus, zinc and other nutrient deficiencies may have been limiting root growth in past seasons to such an extent that the plants could not exploit all the available stored soil moisture. Additionally soil fertility appears to affect the phenological development of the crop ensuring that the plant will produce more growth on stored soil moisture under more fertile conditions. A great deal more work is required before this hypothesis is fully tested.

In summary it would seem that local sorghums are quite efficient in converting the water they use into dry matter. Where improvement in plant strategies could be made is in extracting more moisture from the soil, to allow more plant growth before the rains cease, and in converting more of the above-ground dry matter to grain. This assumes that grain is more valuable than forage.

3. Agronomic Practices with Development Potential in the Bay Region

1) Bare fallowing

In areas with low and variable rainfall and high water holding capacity soils, i.e., Bay Region, farmers for many years have kept land free from weeds for one or more seasons to allow rainfall from that season to partially fill the profile. This stored moisture in combination with the cropping seasons' rainfall assures a larger and more reliable crop than could be expected if crops were grown each season. Generally storage efficiency is approximately 25%, i.e., 25% of the fallow seasons' rainfall remains in the soil until the following season. In addition to moisture storage, bare fallowing increases available nutrients due to organic matter breakdown and gives some control of weeds, plant pests and diseases.

The LFT was set up to measure, under controlled conditions, the effect of 1 and 2 season duration bare fallows. The failure of crops to exploit the soil moisture store has prevented the demonstration of the probable bare fallow yield advantages to date.

As can be seen in Table 1, in 1 out of 2 Gu seasons rainfall exceeds the total assumed PAWC of 215mm. As the Gu has an average length of 38 days in Baidoa (Hunting Technical Services, 1982), it is doubtful whether having available water in the profile at the beginning of one of these seasons would be of any advantage. Bare fallowing is likely to be far more beneficial in the drier, more erratic Dayr seasons.

One small experiment where some treatments were fallowed in Gu 85 did show a significant increase in Dayr 85 yield from 229 $kg.ha^{-1}$ where sorghum was grown in the Gu to 437 $kg.ha^{-1}$ where a bare fallow was maintained by herbicide. Lack of soil moisture data makes it difficult to attribute this response to a particular cause, but as the plots which were mechanically fallowed yielded only 237 $kg.ha^{-1}$, improved weed control due to the residual effects of the herbicide on the dominant perennial weedss seems to be an obvious possibility.

Although bare fallowing is of little advantage to the existing genetically, nutritionally and entomologically debilitated sorghum crops, a program of computer simulations is planned, in addition to the continuation of the LFT, to evaluate the probabilities of yield improvement across seasons if and when crop growth can be improved to take advantage of all PAWC.

2) Crop rotations and crop selection

If sorghum yields are increased over all the existing farmland, overproduction is highly likely as sorghum will never be a preferred cereal in the more sophisticated urban markets. Farmers will have to diversify and oilseeds are ideally suited to the region with very little current production to satisfy local demand.

Safflower and sunflower are far more tolerant of saline soil conditions than sorghum.

Electroconductivities of saturated soil extracts at which 10% yield reductions are recorded are 8,8 and 6mmhos/cm respectively. Some 48% of all samples taken by HTS (1982) from depths below 10cm on agricultural soil types had levels above 8mmhos.cm^{-1}. Yields of sunflower and safflower have exceeded yields of sorghum in both seasons completed to date at the LFT (Table 2).

Table 2. Yield of various crops at LFT - Gu and Dayr 85.

Season	Crop	Yield (kg.ha^{-1})
Gu	sorghum	469
	peanut	414
	sunflower	1193
Dayr	sorghum	325
	cowpea	271
	safflower	340

Crops are not obviously deficient in nitrogen at present, but if yields are increased by adding other inputs, nitrogen deficiency will again reduce yields to low levels without fertilizer in a sorghum monoculture. Grain and possibly forage legumes in a rotation are the economically viable way to attack this potential problem.

3) Fertilization

This subject will be dealt with by another author (see Porter), but first observations of crops grown this season suggest that fertilizers are necessary to gain maximum benefit from a whole range of other crop management options. In mechanised farming it s also very important to have equipment capable of applying this fertilizer in the most economic manner, e.g., braodcasting of triple superphosphate is obviously most inefficient in a high calcium soil.

4) Weed control

The suite of weeds found on the old farmlands of the Bay Region are exceedingly well adapted to avoiding damage by mechanical weed control methods. However, these deep-rooted perennial weeds can be controlled economically in fallows using small amounts of water, simple controlled droplet application sprayers and glyphosate. The hormone weedkiller, 2,4,D, has given good control of dicots in sorghum under ideal growing conditions.

5) Plant population and arrangement

Population and spacing trials with local durra sorghum, at Bonka Research Station, have given low yields under unfavourable growing conditions and failed to give a clear indication of response to these manipulations. Reasons for this are obvious. In Dayr 85 sorghum was sown in the LFT at 40,000 plants.ha^{-1}; after stalkborer attack there were 128,000 tillers at harvest with only 30,000 viable heads.ha^{-1}.

With poor root growth it is likely that practices, such as skip-row planting, which have been tried at the farm this season will reduce yields. Conversely, Thomas et al. (1981) and Blum and Naveh (1976) found that sorghum grown on stored soil moisture with yield expectations of less than 900 kg.ha^{-1} would benefit from an asymetric plant arrangement. Row spacings up to 2m failed to reduce yield at the same low plant populations suited to this rainfed crop. The improvement in yield was due to the plants using water they could not reach early in their growth at the more important grain filling stage. The reduction in row length per hectare with increasing row width makes the application of other inputs attractive. Machine planting, hand or machine insecticide or fertilizer applications and within the row hand weeding after mechanical interrow cultivation will all be much faster at wide row spacings. Additionally, the same amount of fertilizer per hectare is much more concentrated and therefore available at wide row spacings.

4. Conclusion

Hopefully the first section demonstrated that sorghum yields in the region have not reached the rather low ceiling imposed by the low and erratic bimodal rainfall of the region. There are many agronomic practices which could be used to increase production and a few of these are outlined in section B. To be effective these practices will need to be combined with advances from other research groups - breeders, entomologists and plant nutritionists.

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EVALUATION OF DIFFERENT CROPPING SYSTEMS ON SHALLOW BLACK SOILS IN SEMI-ARID INDIA*

A. M. Abikar**

1. Introduction

Insufficient and erratic rainfall is the general characteristic of the semi-arid tropics. Rainfall is confined only to a limited period of 3 to 4 months, leaving the rest of the year relatively dry. More than 70% of the cultivated area of India is lying in the semi-arid tropics.

Vertisols with different depth (deep, medium and shallow) and Alfisols (red soils) are the predominant soil groups. Cereals such as sorghum, pearl millet and setaria, and legumes such as pigeonpea, mung bean and chickpea are the major food crops; groundnut is the major cash crop. Intercropping involving these crops is widely practised.

Shallow black soils (inceptisols) constitute nearly one third of the Vertisol group (27.1 million ha) in India. Because of light texture and shallow depth (15 to 30 cm), they hold less available moisture (50 to 100 mm) in the profile. They are cropped only in the rainy season, and whenever there are long dry spells during the rainy season, crop are subjected to moisture stress. The rainfall is generally more than sufficient for a single crop but may not be sufficient for planting another crop in sequence. There was a need to explore alternative cropping systems to effectively utilize the seasonal water. Intercropping based on long season crops such as pigeon pea or ratoon cropping that extend cropping beyond the rainy season may be more important for these soils. Double cropping with two full season crops may not be possible but sequential planting with very early maturing crops such as mung bean and setaria may be possible.

The experiment was conducted with the following objectives:

1) to explore the possibility of increasing the cropping intensity on shallow black soils by intercropping, sequential and ratoon cropping systems,

2) to identify promising cropping systems for shallow black soils, and

3) to identify operational problems associated with the practice of different cropping systems.

Various terms of cropping systems used in this paper are defined to avoid confusion in understanding them. These definitions are based on the most widely accepted opinions (Andrews and Kassam, 1976; Willey, 1979).

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* This study was conducted at ICRISAT, India, as partial fulfilment for MSc degree.

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1. Sole cropping

It is defined as growing of one crop variety in a pure stand in a given season at the recommended rate of plant population.

2. Multiple cropping

Growing of two or more crops on the same field in a given year in time or space. It extends cropping beyond one season and allows to harvest more than one crop.

a) Intercropping: Intercropping is growing of two crops or more crops simultaneously on the same area of land. The crops are not necessarily sown and harvested at the same time, but usually involves a substantial period of overlap in their growing periods. Crop intensification is both in time and space dimensions. Intercropping would have a distinct reproducible spatial arrangement which is not the case in mixed cropping.

b) Sequential cropping: This refers to a sequence of two sole crops grown one after the other, where the second crop is sown immediately after harvest of the first crop with minimum turn around. Crop intensification in this system is the time dimension.

c) Ratoon cropping: The practice of removing the apical bud of crop plants and activating their lateral buds to produce a new crop is known as ratoon cropping (Plucknett et al, 1970). The ratoon growth can be managed for grain or for fodder.

3. Methods of evaluating cropping systems

Since crops differ in different cropping systems, indices used to evaluate them should be such that they enable to combine the yields of the component species in the systems (Rao and Willey, 1979). Several methods have been developed to assess intercropping systems. The Competition Index developed by Donald (1963), The Relative Yield Total suggested by DeWit and Van Den Bergh (1965), and The Competitive Ratio by Willey and Rao (1980) help to assess the competition between species in intercropping. The Land Equivalent Ratio (LER) suggested by IRRI (1974) helps to quantify whether or not an intercropping system is advantageous over sole cropping, and if so, by how much. LER is defined as sum of the relative land areas required as sole crops to achieve the same yields as from 1 ha of intercropping (Willey, 1979). It is calculated as follows:

$$LER = L_a + L_b = \frac{Y_a}{S_a} + \frac{Y_b}{S_b}$$

where L_a and L_b are LERs of the individual crops. Y_a and Y_b are the individual crop yields in intercropping, and S_a and S_b are the respective sole crop yields. A ratio greater than 1 indicates an advantage for intercropping, and a ratio less than 1 indicates a disadvantage for intercropping. LER indicates the biological efficiency of growing two or more crops together in intercropping in a given environment. LER is a ratio and large values could be obtained simply because of low yields of sole crops, so sole crops should be managed very well to obtain the potential yields. Some doubts have been expressed on whether LER follow normal distribution and they can be analysed. However, Oyejola and Mead (1982) observed that LERs tended to be normally distributed if sole crop yields averaged over all replications are used for calculation of individual plot LERs. They suggested that LERs calculated on that basis can be subjected to analysis of variance. Willey (1985) reviewed the merits and demerits of LER and other methods of evaluating intercropping systems.

Yields of crops in intercropping can be combined on the basis of nutritive value of component crops such as calorie, fat, crude protein, lysine and methionine (Beets, 1977) or on monetary basis.

Monetary return is the most practical method of evaulation when different types of systems are to be compared (Perrin et al, 1979). One limitation of this method is that since prices vary frequently over time and space, relative ranking of systems may not remain the same. However, to avoid this problem cropping systems may be compared at different price ratios of crops so that inferences can be drawn quickly for any price situation (Perrin et al, 1979); Reddy et al, 1982). While comparing cropping systems the practical difficulties encountered in the field should also be taken into account. Other criteria worth considering are labour demand and operational expenses.

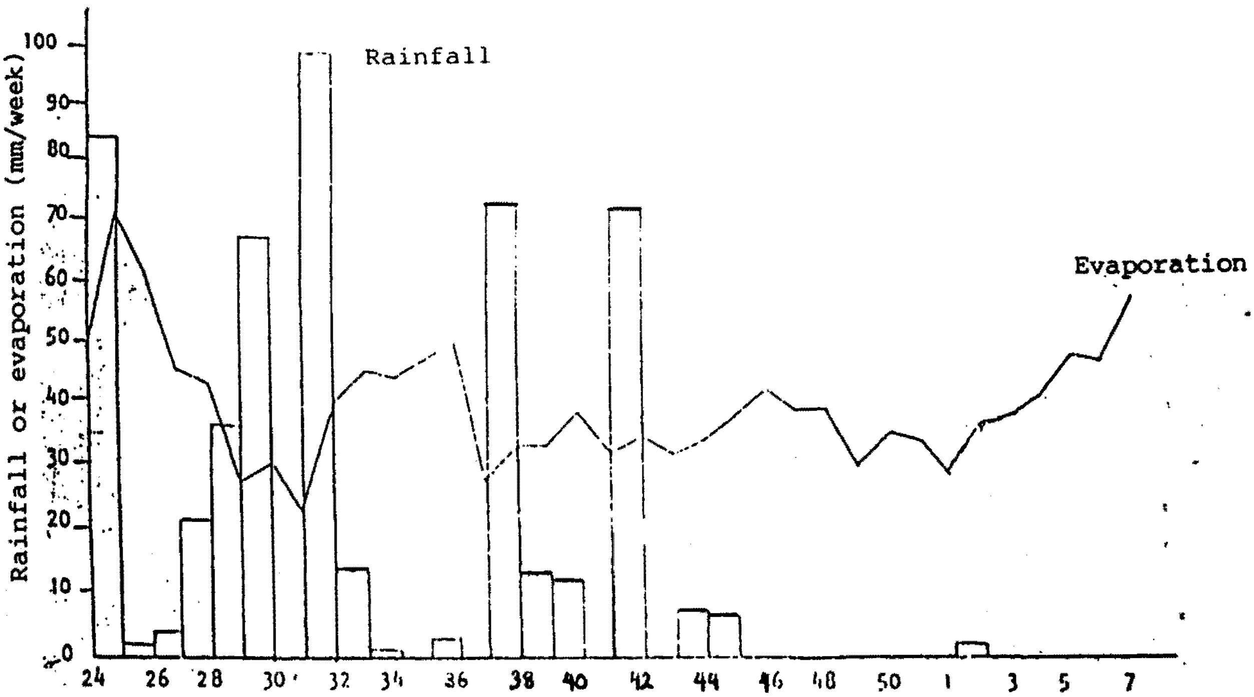
2. Materials and Methods

The experiment was conducted at ICRISAT Center about 25 km northwest of Hyderabad (17°N, 500 m elevation) during the rainy (Kharif) and postrainy (Rabi) seasons of 1984-85 (from June 1984 to February 1985).

The experimental plot was of a shallow black soil that has low water holding capacity (about 75 mm of available water), and hence subjected to rapid moisture depletion. The soil was classified as sandy clay loam. The nutrient status of the soil was low, particularly in respect of nitrogen and phosphorous. It was medium in available potassium. Therefore, crop yields would be extremely low if nutrients are not supplemented through fertilizers. The soil was alkaline in reaction.

The total rainfall received during the period of experimentation from June 1984 to February 1985 was 600 mm; 511 mm of that rain was received from June to September and 88.6 mm from October to February (Fig. 1). Mean maximum and minimum temperatures were 30.4 and 17.2°C, respectively. The average daily pan evaporation was 5.2 mm/day from July to December 1984. Twelve different cropping systems were evaluated for their biological and economic performance on shallow black soils. These twelve treatments were examined in a Randomized Block Design having three replications. The plot size was 120 m^2

a) Rainfall and evaporation



b) Relative humidity

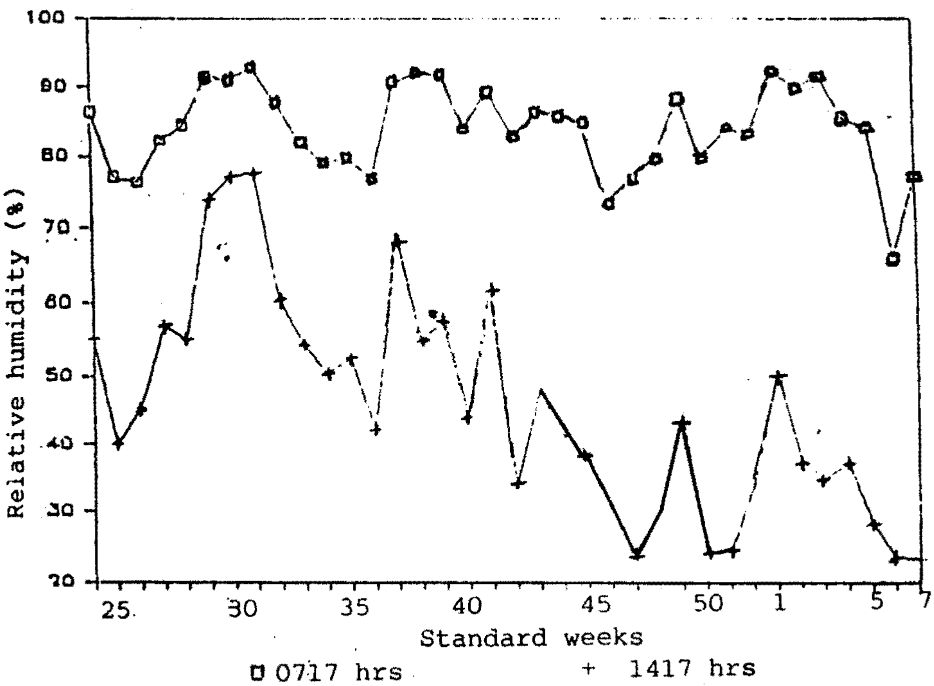


Fig. 1: Meteorological data collected at ICRISAT Center from June 1984 to February 1985.

consisting of four broadbed-and-furrows, each of which was 1.5 m width and 20 m long.

Plowing, levelling and sowing of crops were carried out with the help of animal-drawn wheeled tool carrier (tropicultor). One hundred kg ha^{-1} of diammonium phospshate (18-46-0) was applied at planting time using a fertilizer drill mounted onto the tropicultor. Top dressing was done only to cereals with 42 kg N ha^{-1} afer weeding.

3. Results and Discussion

Given the unfavourable climatic conditions, sorghum yielded reasonably well at 2.46 t ha^{-1} in sole cropping. Pearl millet produced only one third of the sorghum yield because of delayed establishment and also partly due to the suppression of the crop by weeds in the early stage. Sorghum suffered a yield loss of 22% in intercropping with pigeonpea. Pearl millet also suffered a yield loss of 30% in intercropping with pigeonpea. Earlier studies indicated that cereals intercropped with pigeonpea would, under normal circumstances, yield similarly as the sole crop if the intercrop was planted same as at the sole crop density (Natarajan and Willey, 1980; Rao and Willey, 1983; Shelke, 1977). However, in a below normal rainfall year, sorghum yield was significantly reduced in intercropping (ICRISAT, 1980). This was attributed to moisture stress and increased competition between pigeonpea and sorghum under such limited moisture conditions. The sizeable reduction in yield of intercropped sorghum and pearl millet in this study could be attributed to moisture stress that the crops had experienced during the dry spell. The dry spell coincided with flowering and grain formation stages of the cereals, when drought effects are generally more pronounced (Seetharama et al., 1983). Under limited moisture conditions the cereal/pigeonpea intercropping may experience the stress effect more than the sole crops because of having additive populations.

Except the sole crops of pigeonpea and groundnut which gave above one tonne per ha, all others produced very low yields. Mung bean produced only 332 kg.ha^{-1} because of the dry spell during pod formation stage. The yields of postrainy season crops were also low because of the small amount of stored moisture left in the profile at the end of the rainy season. In fact the postrainy season crops in sequential systems could not have been established without the 73 mm of rain received during September. For the same reason although mung bean was harvested on 20 August 1984, setaria and safflower were not sown until 21st September. The performance of postrainy season pigeonpea was poor partly because of the limitation of moisture and the general reduction in growth of pigeonpea due to low temperature and short days (Narayanan and Sheldrake, 1979). There was very little moisture left in the profile after harvest of early pigeonpeas, hence the ratoon growth was poor.

Table 1. Grain or pod yield of crops in different cropping systems

Cropping systems	Sorghum	Pearl millet	Medium Pigeon pea	Early Pigeon pea	Ground nut	Saffl.	Setaria	Mung
<u>Sole Crop Systems</u>								
Sorghum	2457							
Pearl millet		791						
Pigeonpea			1112					
Groundnut					1225 (812)a			
Intercrop Systems								
Sorgh/Pigeonpea	1924		401					
Pearl millet/ pigeonpea		556	730					
Pearl millet/ groundnut		513			825 (486)			
Groundnut/pigeonpea			715		718 (486)			
<u>Sequential Systems</u>								
Mung-early pigeonpea				327				334
Mung-safflower						416		335
Mung-setaria							836	327
<u>Ratoon System</u>								
Early pigeonpea/ ratoon				1035				
SE(+)	238.6	132.0	105.2	89.9	68.5 (50.1)			42.5
LSD			363.9	547.3	269 (198)			
CV%	18.9	36.9	24	22.9	12.9 (14.0)			22.2

a Numbers in parentheses are kernel yield of groundnut ha-1

The yield advantage of cereal/pigeonpea intercrops was much lower (14% and 36%) than was generally reported in previous studies (Natarajan and Willey, 1980a; Rao and Willey, 1983; Shelke, 1977). This was because of the reduced cereal yield in intercropping and relatively less contribution of pigeonpea than in normal circumstances. Pigeonpea yield as a proportion of its sole crop was only 36% in intercropping with sorghum and 66% in intercropping with pearl millet. Since the residual soil moisture in the postrainy season was very low, intercropped pigeonpea did not compensate for the loss of growth due to the competition of cereals in the rainy season. This was evident from the significantly reduced growth of intercropped pigeonpea compared to the sole cropped pigeonpea. Between the two cereals, sorghum was much more competitive to pigeonpea than pearl millet, probably because of its height and longer maturity. Rao and Willey (1983) observed that these two plant characters mostly determined the competitiveness of cereals to pigeonpea. Hence, intercropping advantage was less with sorghum/pigeonpea compared to that with pearl millet/pigeonpea.

Table 2. Land Equivalent Ratio (LER) of different intercropping systems calculated on the basis of grain yield

Intercrop Systems	Land Equivalent Ratio Rainy season crop	 Postrainy season crop	Total LER
Sorghum/Pigeonpea	0.78	0.36	1.14
Pearl millet/Pigeonpea	0.70	0.66	1.36
Pearl millet/Groundnut	0.65	0.67	1.32
Groundnut/Pigeonpea	0.59	0.64	1.23
SE (+)			0.1
CV%			14.6

Pearl millet inntercropped with groundnut, despite having only one fourth of the population, yielded same as the pearl millet intercropped with pigeonpea. This shows that the lower population of pearl millet was advantageous in a drought year. For the given pearl millet population in this system, the expected yield was only 25% (1 row millet : 3 rows groundnut) of the sole crop, but more than twice the expected yield in this experiment indicated that the inter-species competition between millet and groundnut was lower than the intra-species competition. The increased millet yield was due to increased yield per plant as a result of increased tillering (Reddy and Willey, 1981). While the above could be the major reasons, however, it must be pointed out that the higher relative yield of millet in this system could be partly due to low yield of sole millet which was replanted a week later. Intercropped groundnut gave 67% of the sole crop yield, only slightly lower than the expected 75%. The overall yield advantage of this intercrop system was 32% which was within the range of that reported by other workers (Reddy and Willey, 1981; Lima, 1983). The higher productivity of intercropping was due to the efficient use of the growth resources (Reddy and Willey, 1981). The relative yields of the component crops in groundnut/pigeonpea intercrop were nearly equal, 59% in the case of groundnut and 64% in the case of pigeonpea. Although this pattern closely resembled that observed in previous studies (ICRISAT, 1980), the relative yields themselves were low, probably because of the detrimental effect of moisture stress. Thus the overall advantage of 23% for this system was much lower than the 50% to 70% observed in normal years (ICRISAT, 1980). This intercrop system was also planted in additive populations as the cereal/pigeon pea systems and groundnut matured around the same time as sorghum. Lower relative yield of groundnut compared to sorghum or millet indicates that groundnut had experienced greater competition from pigeonpea than the cereal intercrops.

Considering the limitations of the environment, it appears that sole cropping with full season crops such as groundnut, sorghum or pigeonopea and intercropping with pigeonpea are the appropriate cropping systems for shallow black soils.

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CHAPTER FOUR

SORGHUM PESTS AND DISEASES

DISTRIBUTION AND BIOLOGY OF STALKBORER IN THE BAY REGION

Robert Lavigne*

1. Introduction

Stalkborers are by all reports the most important pests of sorghum in Somalia. Unfortunately, this appraisal is based largely on casual observation and there is little quantitative data available. Certainly this is true for the Bay Region.

The first extensive description of the behaviour of stalkborers in Somalia was prepared by Lazarevic (1976) in a report to the Government of Somalia. He identified *Chilo partellus* as the most destructive species on sorghum and maize, but did not have data to back up his statement. Characteristics, biology and life cycle of this stalkborer on maize were studied by Nur (1978) at Afgoi. Van Gent (1985) summarized the published information on stalkborers in Somalia noting that in the period covered by the review (1961-1983), "research findings were often either inconclusive, or the wrong conclusions were drawn" from the data collected. He noted specifically that no data on fluctuations in stalkborer incidence (within-season, season-to-season, or year-to-year) have ever been collected. Reported data to date according to his review dealt only with the incidence of stalkborers in the lower Shebelli region.

2. Incidence of stalkborer in the Bay Region

First systematic surveys to determine the incidence of stalkborers in the Bay Region were conducted by the author in 1985. It has now been established, by random sampling of fields in all districts, that stalkborers occur in 100% of the fields.

Two species of stalkborers have been found in the Bay Region: *Chilo partellus* (Swinhoe), the spotted stalkborer, and *Sesamia cretica* Led., the pink stalkborer. These identifications were made by personnel at the Smithsonian Institution in Washington, D.C., U.S.A.. *Sesamia cretica* is apparently a long time resident of Somalia, if not a native insect. However, *C. partellus* is of Asiatic origin and first appeared in East Africa in the early 1950s (Ingram 1983). Despite its late arrival, it has spread rapidly and now is found in Kenya, Uganda, Tanzania, Malawi, Sudan and Somalia. Like all invaders, its successful establishment can be attributed to the fact that it arrived without its complement of parasites and predators.

In the Bay Region *C. partellus* has become the dominant species suggesting that either *S. cretica* has never been very abundant or the former species has outcompeted for the available resource, i.e., the sorghum plant. Despite its reduced abundance, larvae of the pink stalkborer have been collected in most fields surveyed. Within fields in the Bay Region, 80-100% (mean 96.4%) of the stalks were infested with the spotted stalkborer in the Gu 1985 season, but only 39-53% of the stalks were infested with this species

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in the Deyr 1985 season. Similarly in the Gu season 0-90% (mean 36.7%) of the stalks in any given field were infested with the pink stalkborer, whereas in the Deyr season only 6-26% of the stalks were infested.

3. Damage

Damage caused by the larvae can be of considerable consequence. The early instar larvae damage the tender leaves of sorghum while the older caterpillars bore into the heart, stem and inflorescences. When unrolled the damaged leaves attacked by early instars show characteristic transverse rows of holes resembling each other in size and appearance. The larvae tunnelling in the stalks fill them with frass and excreta, while severly weakening them.

Young plants sometimes exhibit 'dead hearts' after destruction of the growing point by developing stalkborer larvae. Plants adapt to this interference with normal growth by tillering. It is suspected, though not documented, that the resulting yield from tillers is less than what would be produced by the original stalk. Certainly, we have observed that many plants which exhibit 'dead heart' never produce heads on tillers. Consequently, we conducted surveys in both the Gu and Deyr seasons to obtain some idea of the potential loss to the farmer as a result of dead heart. This data, collected in all four districts in the Bay Region, is presented in Table 1. The mean potential loss (percentage) to farmers in Deyr 1985 was 19.5 and in Gu 1986 was 14.6.

Table 1. Comparison of incidence of dead heart between the Deyr 1985 and the Gu 1986 season.

District	Percent infestation	
	Deyr 1985	Gu 1986
Baidoa	17.6%	-
Bur Hakaba	15.9%	15.3%
Dinsoor	19.8%	14.9%
Qansa Dhere	24.9%	13.7%

Fungi and bacteria can easily penetrate into sorghum stalks through the bore holes of the pest, and ultimately weaken the plant. Many infested plants fall to the ground during heavy winds prior to harvest and the heads are then consumed by animals, such as porcupines.

Additionally, the growth of attacked sorghum can be severely stunted and the yield can be considerably reduced. Yield loss due to feeding of larvae in sorghum stalks throughout the season is as yet undetermined for the Bay Region, although in Kenya it can reach 45% (Reddy, personal communication). When C. partellus was controlled 100% in maize, the yield per hectare reach 40 quintals at the Afgoi Research Station in 1976, whereas in untreated plots the yield was 13.9 quintals.ha^{-1}, almost a three fold increase (Nur 1976). At

Bonka Research Station in Deyr 1985, a single application of insecticide served to increase sorghum yields by an average of 3.2 quintals.ha^{-1} (30,000 plants/ha; Table 2), which is approximately double the average current yield of ca. 3.4 q.ha^{-1}.

Table 2. Yield gain resulting from a single application of insecticide at 5 weeks following emergence at 4 potential plant populations.

Variety Chemical	Yield Increase per plant	per hectare at potential plant pop/ha 30,000	40,000	50,000	60,000
Dabar Basudin	12.5g	3.8q	5.0q	6.3q	7.5q
Dabar Carbaryl	14.8g	4.4q	5.9q	7.4q	8.9q
Dabar Endosulfan	4.7g	1.4q	1.9q	2.4q	2.8q
Seredo Endosulfan	12.3g	3.7q	4.9q	6.2q	7.4q
White Charger Endosulfan	8.6g	2.6q	3.4q	4.4q	5.2q
Mean	10.6g	3.2q	4.2q	5.3q	6.4q

4. Life history and bionomics

A brief synopsis of the life history of the spotted stalkborer on maize, based in part on observations by Nur (1976) is as follows. The eggs are laid at night in clusters of 25-100 arranged in two or three rows on the underside of young leaves. Eggs are usually laid the night following emergence and one female may produce more than 300 eggs. The eggs hatch after 4-8 days and larvae start to emerge in the early morning hours. The larvae feed, after hatching, on the tender folded leaves and bore, as soon as their size increases, into the midrib and later into the heart or the stem. When the substrate proves to be unsuitable for some reason, later instar larvae migrate to other locations on the developing stalk and reenter it. Larvae also feed on the peduncle. The larval period lasts 18-21 days under laboratory conditions. Pupations takes place in the stem after the fully-grown larva has gnawed an exit hole for the adult in the stem wall. The adult emerges after 5-7 days. This continuous cycle is observed during the rainy season. Where a conspicuous dry season occurs, the pest enters into larval diapause (resting stage) sometime after the rains. The diapausing larvae remain in the dry stalks or stubble where they await the next rainy season. They pupate after the first rain showers and the moths emerge some days afterwards.

In the Bay Region the life history of C. partellus on sorghum is essentially as that described above. Weekly surveys have been made during the Gu 1986 season on the Agricultural Research Complex 100 ha farm. With the exception of the variety, Seredo (planted over a three week period following the rains), all varieties were planted prior to the rains and plants emerged 13-14 April. First instar larvae were observed three weeks later on 4 May. Larvae presumably went through the normal five instars and the first pupae were collected in 21 days, i.e., 25 May. Adults have emerged from live pupae collected from stalks after 1-7 days.

According to Nur (1976) Chilo partellus has six generations a year in maize at Afgoi, since each generation lasts about 30 days in the laboratory (other than generations which go into diapause). While the potential for multiple generations exists, it is highly unlikely that more than two generations occur in a sorghum crop in a single season in the Bay Region. First, eggs are deposited by females over several weeks following the first rains and first instar larvae are most prevalent around the 4th to 6th week of plant growth. In Kenya at the Mbita Point Field Station maximum oviposition by females of C. partellus occurred on plants aged 7.21 weeks (Alghali 1985). Secondly, at Bonka the appearance of pupae (Table 3) coincides with head development stage of the sorghum crop suggesting that there is insufficient time left for a new generation of stalkborer to complete its development.

Table 3. Incidence of stalkborer pupae in sorghum on the 100 ha farm, ARC, Baidoa, Somalia (50 stalks/sample).

Date	Variety of sorghum				
	Durra	Seredo	Dabar	White Charger	HD1
04/5	0	0	0	0	0
11/5	0	0	0	0	0
18/5	0	0	0	0	0
25/5	2	0	1	3	0
01/6	0	1	1	6	3
08/6	5 (1E)	0	8	0	4 (1E)
15/6	2 (2E)	0	2 (2E)	3 (4E)	1 (4E)

Thirdly, the pattern of occurrence of apparent instars is what one would expect of a species that oviposits over an extended period of time (Table 4). The term apparent is used because measured larvae (by length) fell into five groups which seemed to simulate natural instars. While the accepted method of determining instars is to use Dyars law which involves measurement of head capsules, the method is impractical where laboratory facilities are not available. Additionally field sampling is facilitated where length of larvae can be readily measured by relatively untrained personnel. As can be seen in Table 4 what is presumed to be the second generation first instar larvae appear in the durra (local) sorghum on 22 June. Since at this date the sorghum is already headed out and can soon be expected to start drying out it is highly unlikely that it would serve as an attractive oviposition site in that condition.

Table 4. Distribution of instars of <u>Chilo partellus</u> based on measurements of lengths of larvae collected in durra (local) sorghum at Bonka ARC, Gu 1986 season.

Date	0.1-0.2	0.3-0.6	0.7-1.0	1.1-1.4	1.5-2.2	pupae
22/6		*	*	*	*	
15/6				*	*	*
8/6			*	*	*	*
1/6		*	*	*	*	*
25/5	*	*	*	*	*	*
18/5	*	*	*	*	*	
11/5	*	*	*	*		
4/5	*	*				

Length of larvae

In the Bay Region larvae which enter diapause may remain in standing dead stalks in fields for a considerable period of time. Data collected in the Hagar 1985 season show that some larvae that entered diapause in late August were still alive in standing dead stalks (in fields not planted in the Deyr season) on 23 December, 4 months later. With the same intent, i.e., to determine larval survival in diapause two 'stooks' (solid houses made from sorghum stalks) were constructed 29 September 1985 from green stalks harvested at the end of the Gu season. Bimonthly samples of 25 stalks were examined for presence of live larvae. Live larvae were still being found in the stalks 29 May 1986, 9 months later.

It should be noted at this point that <u>C. partellus</u> has several alternate hosts: maize, wheat, pearl millet, finger millet, foxtail millet, sugarcane, rice, eleusine, and a number of wild grasses of the genera <u>Sorghum</u>, <u>Panicum</u>, <u>Pennisetum</u>, <u>Echinochloa</u>, <u>Sporobolus</u>, <u>Cenchrus</u>, etc. (Schmutterer 1969, Seshu Reddy 1983).

This tremendous adaptability of the spotted stalkborer to survive adverse conditions has important implications for control techniques. Because of its ability to survive over long periods of time, adult females can be expected to emerge and lay eggs at any time during the year as long as a host plant is available. Because farmers in the Bay Region do not practice sanitation, volunteer sorghum plants can be found at all times of the year thus serving as a reservoir. Therefore, there is no possibility of eradicating the pest even if the stalkborer didn't use alternate hosts. It can be expected that chemicals will reduce the density of stalkborer attack, but it is doubtful if they will ever be economically feasible for the subsistence farmer.

The major hope portrayed for subsistence farmers has been the development of varieties 'resistant' to the stalkborer. Thus far, no 'resistant' varieties have been developed (Reddy, personal communication), but in the Bay Region Mao and Alahayodoyan (personal communication) have tested a number of lines which show tolerance to stalkborer attack in a nursery situation.

Along this line we have been interested in determining if stalkborers avoid any particular lines which we currently have in production. Periodic examinations of stalks dissected weekly during the current Gu season* show that there are definite differences between varieties in frequency of attack (Table 5).

Table 5. Comparison of Gu seasonal incidence of Chilo partellus in five varieties of sorghum grown on the 100 ha farm, ARC, Baidoa, Somalia, 1986 (no. larvae/50 stalks).

Date	Variety of sorghum				
	Durra	Seredo	Dabar	White Charger	HD1
04/5	36	0	1	25	7
11/5	31	8	9	42	74
18/5	42	9	8	67	58
25/5	20	6	8	28	56
01/6	9	5	30	29	9
08/6	0	0	3	8	5
15/6	7	2	5	4	6
Mean	20.7	4.3	9.1	29	30.7

Thus there seems to be hope for the subsistence farmer if the resistant varieties developed by Research are acceptable to the farmers, i.e., have good taste, acceptable appearance and good storage attributes.

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* Gu 1986

SORGHUM, ITS QUALITY AND STORAGE IN SOMALIA

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1.1 Introduction

Sorghum is one of the two staple crops which is grown mostly in Bay Region. The production of sorghum had declined in the past few years for various reasons. It has again gained momentum since 1985.

In the current five year Development Plan the Government envisaged attaining self-sufficiency in food grain through implementation of various development plans to encourage increased food production both in the irrigated and rain-fed areas. The most important step taken by the Government was the liberalised policy as regards to producers' price, open market and other incentives. The 1985 Gu season produced a bumper crop both for sorghum and maize. This was attributed to the pricing policy, though good rains and other incentives by the Ministry of Agriculture also contributed to it. This combination of factors necessitated ADC (Agricultural Development Cooperation) to come forward and enter into competition with local traders in grain. The Government quickly stepped in to arrange enough loan for ADC through the Somali Development Bank. ADC once again established its credibility and as a result purchased over 20,000 tonnes of sorghum during 1985 Gu season. Private traders neither had enough storage capacity nor did they have so much finance to compete with ADC as they did before.

Almost all the senior staff of ADC had been receiving continuous training since 1983 in ware-house management, grading and inspection, quality control and monitoring, pest control and pest monitoring, and grain book keeping and accounting under the auspices of FAO Project GCP/SOM/032 financed by the Netherland Government. Through this training ADC became fully aware of the importance of standards and maintainance of quality during long periods of storage. These facts resulted in the purchase of quality grain by ADC and thereafter maintaining the stocks in pest free and apparently mycotoxin free conditions.

Perhaps because of the good reputation which ADC has now established, the international agency like the World Food Programme in Somalia has entered into contract with ADC to purchase grain for distribution to the refugees and more of such agencies are likely to follow.

1.2 Storage of Sorghum

In Somalia farmers generally store sorghum in pits which are usually dug out in front of their houses. These pits are first lined with straws and such other materials for the prevention of the migration of moisture from the underground to the grain. These pits so prepared are filled with grain. After filling the grain the top is

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covered with straws or plastic sheet and finally compacted with earth in more or less dome shaped fashion to protect the grain from rain. The traders store their sorghum in whatever way they like. No specific methods are followed. Sorghum or any other type of grain may be stored mixed with any other crop the trader may be dealing with, making pest control operation a difficult task. To save on storage costs, the traders fill the store with bags of commodity lined up against the wall and from floor to the ceilings, leaving no space around for quality and pest monitoring.

1.3 Storage at Governmental Level

At Governmental level, storage facilities mostly exist with ADC for storage of locally produced sorghum and maize even though at times they are also used for imported commodities such as wheat and maize. ADC has about 103 grain ware-houses scattered all over the country. Most of these ware-houses are located close to the production areas. Most of the stores in sorghum producing areas are fair in condition for storage of sorghum. However, more storage facilities will be required in view of anticipated increase in production due to the availability of credit facilities and inputs. Further strengthening of extension services will encourage the farmers to increase production both through improved methods and seed and through extended coverage. In March 1985, FAO also approved a project to advise the Government of Somalia through the Ministry of Agriculture on the marketing of agricultural produce. This will further encourage the farmers to produce more sorghum and maize requiring additional storage facilities in the not-too-distant future. By then some of the old stores will have to be demolished requiring additional storage facilities for the sorghum.

1.4 Underground pits

There are a few old underground pits in sorghum producing areas located within ADC premises. Some new ones were constructed during 1985 bumper crop season to take the season's sorghum crop. Storage of sorghum in the pits, no doubt, limits the pest infestation to a certain extent but cannot keep it free from the possibility of creating hot spots and microbial activity. Based on my own judgement through general observation, underground storage of sorghum could only be safe for long term storage if the underground pits are rendered moisture proof all round and the sorghum is placed inside insect infestation free condition and with moisture contents not exceeding about 10 percent. If this is not followed insects migrate to the top of the bulk of grain and so does the moisture, creating congenial condition both for insect and microbial activity. Due to diurnal temperature, moist air migrates to the top of the grain bulk and having no escape from inside the underground pits remain arrested on the top space, causing excessive moisture on the top part of the grain. During the night when the temperature drops down, the moisture may sometimes condense affecting the grain. Sometimes the moisture remains arrested on the sides of the pits and affects grain on the periphery. In both cases continued process of this kind causes discolouration and caking of grain besides posing health hazards due to mycotoxins. No doubt grain storage in underground pits of various designs are being practised also in many parts of India, countries in North Africa and Latin America. All these countries claim that the grain could be stored for longer periods without deterioration. This is indicative that serious studies should be undertaken through a long term project under some technical assistance.

2. Study on sorghum quality in the Bay Region

To the best of my knowledge, no serious studies have been carried out on the quality of sorghum in Somalia, except that it is said to be tannin free. During 1985 season information on pest situation in stored sorghum indicated infestation by *Rhizopertha dominica* and *Tribolium* species but only at lower to medium level. Thereafter pest control operations were undertaken by FAO Project GCP/SOM/032/NET during December 1985 and January 1986 using PHOSPHINE fumigation followed by periodical residual structural spray using synthetic pyrethroids, malathion and dichlorvos. Store hygiene work was also carried out prior to storage of sorghum. During that period the stores were periodically inspected for sign of reinfestation but strict store hygiene kept the sorghum free of infestation. In order to determine whether the quality of sorghum in Somalia conforms to general internationally acceptable quality standards from the physical properties point of view, physical analyses were carried out at the ADC grain testing laboratory, by the author after collecting randomised samples from Baidoa, Qansadhere, Dinsor and Uffurow districts in June 1986.

2.1 Method of Analysis

For the purpose of bulk sampling, sorghum was scooped at random from every stack in the ADC stores at the locations mentioned above. Each bulk sample comprised of about 20-50 kg in weight. The bulk sample was then mixed and sub-divided into 4 samples each of about 1 kg. Each sample was analysed for the following factors:

1. Percent moisture content (dry weight basis) using moisture meter.
2. Percent extraneous matter including straws and twigs.
3. Percent half broken grain (weight basis).
4. Percent quarters and less (weight basis).
5. Percent mouldy grains (by count).
6. Percent shrivelled (immature) grain (by count).
7. Percent Insect damage (by count).
8. Number of dead insects worked out on 1 kg basis.
9. Number of live insects worked out on 1 kg basis.

2.2 Conclusions and recommendations

The results are summarised in table 1. From the results given in the table, it is evident that the quality of sorghum in Somalia is by no means inferior than the internationally acceptable standards though scope for further improvement is evident.

Table 1. Summary of the Analyses carried out for the Quality Standard of Sorghum produced in Somalia.

OVERALL PERCENTAGE	Area BAIDOA	QANSADHERE	UFFOROW	DINSOR	OVERALL AVERAGE
BY WIEGHT					
Moisture content	11.93	11.65	10.8	12.2	11.65
Extraneous matter	0.88	0.85	0.8	0.47	0.75
Half broken	2.3	3.05	0.9	2.43	2.17
Quarters and less	2.28	2.25	2.5	2.13	2.29
BY COUNT					
Mouldy grain	1.7	1.5	0.85	1.6	1.41
Shrivelled grain	2.63	1.5	1.43	2.5	2.0
Insect damage	2.0	5.0	2.43	2.25	2.92
Live insect	0	0	0	0	0
Dead insect	8.25	6.75	2.5	3.0	5.13

The following recommendations are made:

1. Long term study to be undertaken to determine quantitative and qualitative losses of sorghum in underground storage.
2. To work out suitable designs for underground pits if necessary.
3. To reduce broken percentage by introducing improved methods of threshing.
4. To work out losses due to harvesting and threshing. From the sample there was an indication that harvesting and threshing were not carried out properly.

THE LEAF* DISEASES OF SORGHUM IN SOMALIA

Ahmad Nur Jama**

1. Introduction

The importance of sorghum as a staple food for almost every Somali family is well documented in the literature and therefore needs no emphasis in this paper. Nevertheless, it should be kept in mind that our dependence on this crop will unquestionably continue to increase very rapidly. Partly because of the failure of other substitute crops to survive in the adverse environmental conditions that commonly prevail in the sorghum growing areas and partly because of the ever-increasing national demand for basic food.

The effects of moisture on germination, penetration, incubation period, sporulation and other subsequent steps of a disease cycle is a well known fact to the students of plant pathology. No plant pathogen will initiate infection without the presence of free moisture or, at least, high relative humidity. This, obviously indicates how the occurrence of almost all diseases in a particlar region is very closely related with the amount and distribution of the annual rainfall. Indeed, this was the situation we have very frequently witnessed during our field surveys carried out between 1979-1984, where a greater number of diseases with higher level of incidences have been observed in wetter seasons than in drier ones, even though favorable temperatures and availability of enough moisture concomitantly determine the duration and number of disease cycles. In sorghum areas of Somalia, moisture is the limiting factor, since almost all other climatic factors are favorable for initiation and development of many diseases and pests*** throughout the year.

Besides smuts and grain molds which are always considered as inflorescence and grain disease, eight other foliar diseases have been recorded by various researchers (Table 1). But, since these reports were all based on plant symptoms, very recently, further isolation or/and identifications have been carried in our laboratory where the exact entities of seven of these diseases have been determined either by direct microscopic examinations of their spores and spore-bearing structures found on collected plant materials or by growing diseased tissues on appropriate artificial media to promote sporulation.

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* Several criteria are used as a basis for classification of plant diseases. These include according to the <u>symptoms</u> they cause, the <u>type of plants</u> affected, the <u>pathogen</u> that causes the disease and finally according to the <u>plant organ</u> affected by those pathogens. In this context, therefore leaf disease means those diseases that prevalently but not exclusively attack leaves.

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*** The term pest is sometimes used to cover a wide range of biotic agencies damaging to plants. In the present context, we are restricting the definition to all invertebrates, with the exception of nematodes, which cause damage to plants or their products.

Table 1. Names of all diseases of sorghum in Somalia, their respective causal agents, their geographical distribution at present and the dates of record by different researchers.

Disease	Pathogens	Host	Distribution	Date/Author
Covered Smut	Sphacelotheca sorghi	sorghum	Widespread	Golato (1967)
Head Smut	S. relliana	sorghum	"	" "
Loose Smut	S. cruenta	sorghum	"	" "
Long Smut	Tolyposporium ehrenbergii	sorghum	"	Castellani, Jama, Issa (1979)
Grain Molds	Fusarium spp.	sorghum	"	Issa, Hirabe
	Curvularia spp.	sorghum	"	(1981)
Rust	Puccinia purpurea	sorghum	"	Ali (1979)
Downy Mildew	Sclerospora sorghi	maize sorghum	Afgoi Balad	Issa, Hirabe (1981)
Leaf Blight	Helminthosporium turcicum	sorghum	Widespread	Castellani, Jama, Issa (1979)
Sooty Stripe	Ramulispora sorghi	sorghum	Only southern regions	Gray (1984)
Sooty Moulds	Capnodia spp.	sorghum maize	Only southern regions	Hirabe, Jama (unpublished)
Rough Leaf Spot	Ascochyta sorghina	sorghum	Only southern regions	Jama, Issa (unpublished)
Anthracnoses	Collectrichum graminicola	sorghum	Widespread	Castellani (1979)
Maize dwarf Mosaic	Virus Virus	maize sorghum	Afgoi	Gray (1984)

2. Description of the Diseases and their Causal Organisms

2.1. Rough leaf spot

2.1.1. Symptoms; slight chlorosis appear on leaf blades at the first symptoms on or around which groups of round black pycnidia develop. The pycnidia protrude above the leaf surface so that, when rubbed off, give the leaf a characteristic roughened texture. Subsequently the infected tissues become necrotic and develop light-coloured circular to oval lesions with dark margins. The lesions are surrounded by chlorotic haloes and are covered with the black pycnidia. The lesions may coalesce and form longer necrotic areas and the whole leaf may be killed.

2.1.2. Pathogen: The fruiting bodies of Ascophyta sorghina are globose, depressed, papillate pycnidia with diameter varying from 140 to 300 micron. They contain numerous oblong ellipsoid two-celled hyaline pycnaspores which are much coarser than those of A. sorghi.

2.2. Sooty Stripe:

2.2.1. Symptoms; the first symptoms are elongated elliptic lesions which are regular in outline and which, at first, have straw colour at center and purplish to tan lesion margins. As these lesions age, the centers darken and become greyish because conidia are produced and then black or sooty coloured as the numerous black superficial loosely attached sclerotia develop (a clearly distinguished feature of this disease from the similar leaf blight).

2.2.2. Pathogen: the signs of this fungus consist of aggregates of mycelium which form more or less compact subepidermal stromata from each of which fasciculate conidiophores arise. These conidiophores make sporodochia which emerge through the stromata and produce abundant slender, filiform multiseptate conidia (3.8 -86.3 x 1.9-3 micron). Eventually the stromata and the conidiophores produce black, scattered, superficial, subglobose sclerotia (53 - 170 micron in diameter).

2.3. Leaf Blight

2.3.1. Symptoms: Leaf blight is symptomatologically very similar to the sooty mold. It initiates with small flecks which appear within 3 to 4 days after favorable infection period. Within two weeks, these small lesions turn into larger fusiform lesions which are tan to grey at centers and pigmented at edge. Localized wilting within the leaf as well as total wilting of the individual plants are not uncommon when favorable infection periods are prolonged.

2.3.2. Pathogen: From subepidermal stromata develop 2 to 6 septate olivaveous conidiophores which measures (7 - 9 by 150 - 250 microns). Later on, 2 to 6 conidiophores emerge from the stromata. On their tips, these conidiophores carry straight or slightly curved, pale olivaceous conidia which normally are widest in the middle but tapering towards both ends. The conidia have 3 to 8 septate and vary greatly in size and shape ranging from 45-132 by 15-25 microns. Usually, they have a protruding hilum and a polar germ tube.

2.4. Anthracnose

2.4.1. Symptoms: Colletitrichum graminicola could infect leaves, stems, pedicels, heads and the grain. However, leaf infections always prodominate over the others. The symptoms appear as small ovate to irregular zorate spots. The central area of the leaf spots is tan while borders are red to brown. Acervuli develop on the older portion of the spots.

2.4.2. Pathogen: the fruiting structures of the pathogen consist of dark, superficial, circular to oval acervuli, with dark mycelium forming the basal stroma - these acervuli are present in both surfaces of the leaf. Each acervulus has black to dark brown sepate setae or spines among the conidiophores. The conidia which are borne singly are terminal, spindle-shaped, slightly curved, hyaline and one-celled.

2.5. Downy Mildew

2.5.1. Symptoms: the characteristic leaf symptoms of this disease on sorghum, like other crops, are white to yellow streaking of the leaves and development of the downy mildew on the streaks, followed by necrosis and browning. Dwarfing or reduced elongation of the upper

2.5.2. Pathogen: the fruitifications of the pathogen consist of conidia which are borne on long sterigmata or the erect conidiophores which are knobbed and bulbosed at the bottom basal cell and a main axis (80-150 microns) which is usually dichotomously branched into primary, secondary and tertiary branches terminating in tapering sterigmata (13 microns long). The conidia vary in size but most frequently measure 21 to 24.2 x 19 to 22.9 microns. They are hyaline with thin wall, continuous at apex and unmodified and without papilla of dehiscense. The conidia germinate invariably by hyphae. Clearing the leaf with lactophenol or discolourizing it by overnighting in similar compounds, the oospores are easily seen under microscope from the old leaf lesions. They are very similar to those of S.graminicola and germinate by the formation of a germ tube.

2.6. Sooty Mould

2.6.1. Symptoms and Pathogens: Sugary deposits commonly known as "honey dew" from Aphids first appear on plant parts. As soon as the conditions favour, species of Capnodia and Limacinia fungi grow abundantly on these exudates giving the leaves superficial, black sooty appearance. These materials could be easily rubbed off with a moistened cloth.

3. Kinds of Damage Caused by the Sorghum Leaf Diseases

(a) Reduction in leaf growth.
(b) Reduction in actively photosynthesizing leaf tissues by necrosis or chlorosis.
(c) Considerable defoliation.
(d) Stress on translocatonal balance and wilting.
(e) Increase of evapotranspiration.
(f) Interference with the amount of light that reaches the plant.

4. Their world distribution and methods of control

The World distribution, seasonal overcarryng means, factors promoting plant disease development, their host range, their control methods of the above described diseases are shown on Tables 2 and 3.

Table 2. Some Pathogens, their World Distribution, Seasonal Overcarrying Means, and Factors Promoting Disease Development.

Pathogens	Distribution	Overcarrying Means	Factors Promoting
Ascohyta sorghina	Africa America Asia Europe	Pycnidia in/on crop residues	High temperature Wind Abundant nitrogen fertilizer
Ramulospora sorghi	Africa Asia America Australia	Sclerotia and/or sporodochia on/in crop residue or sclerotia in soil/seed	Higher temperature High humidity (700-1000mm isohyets) High nitrogen fertilizer
Helminthosporium turcicum	Africa Asia Oceania America Europe	Conidiophores in/on plant residues or seeds	16-32° temperatures High humidity
Puccinia purpurea	Africa Asia America	Teliospores in plant residues or alternate hosts or volunteers	Cooler humid environments
Collectotrichum graminicola	Asia Africa America Europe Oceania	Acervuli in plant residues or in/on seeds	Warm, humid weather and wind rains, presence of Downy mildew infection, abundant nitrogen fertilizers
Sclerospora sorghi	Asia Africa America	Oospores in/on plant, soils, seeds or glumes	Temperatures 32°C max, 21-23°C opt. and 10 min. Humidity 100%, big leaf canopy, wind light followed by darkness exudates

Table 3. Leaf Disease, their Respective Pathogens, their Host Range, Non Chemical and Chemical Control Measures.

Disease	Pathogen	Host Range	Control measures Non Chemical	Control measures Chemicals
Leaf blight	Helmintho-sporium turcicum	Sorghum spp. Maize, Teosinate, Paspalum.	Resistant varieties, sanitaton	Organomercurys* Thiram, Manels, Chloro Thatonil
Anthrac-nose	Collecto-trichum graminicola	Many cereals and grasses.	Resistant varieties, elimination of other hosts and volunteers, sanitation like ploughing, rotation, early harvesting.	Benomyl, Manels, Zineb, Captgol, Folpet and Chlorothalonil.
Downy mildew	Sclerospora sorghi	Sorghum spp. maize, Panicum, typheron, Heteropogon contortus, Euchlaena Mixicana.	Resistant varieties, destruction of other hosts, sanitation.	Matalaxyl, Phosetyl, Diothiocar-bamates
Rust	Puccinia purpurea	Sorghum spp.	Resistant varieties, sanitation, destruction of volunteers.	Thiram, Maneb, Mancozeb and Oxycarboxin.
Sooty stripe	Ramulospora sorghi	Sorghum spp.	Resistant varieties, destruction of crop residues, crop rotation.	Thiram, Zineb, Captan, Methythiophonate
Rough Leaf spot	Ascochyta sorghi	Sorghum spp.	Crop sani-tation, crop rotation, selection of seed from healthy plants.	Chloatheloril, Maneb, Zineb and Apatafol.

Table 3. (continued)

Disease	Pathogen	Host Range	Control measures Non Chemical	Chemicals
Sooty moulds	Capnodia spp.	Many plants	-	Insecticides.
Viruses	Maize Dwarf Mosaic Virus	Maize/ Sorghum, others	-	Insecticides.

* Seed dressings with organomercurials and other compounds have considerable advantage over foliage application. However, the use of mercuric compounds especially alkyl compounds has been decreasing in recent years. Probably because of human risk and environmental reasons. Therefore, to reduce the risk we need some expertise, staff and appropriate equipment.

5. Conclusions and Recommendations

To achieve substantial increases of food and feed production, it will definitely require the following parameters to be pursued: expansion of crop acreages, improved methods of cultivation, use of fertilizers, use of improved varieties, and use of irrigation, when possible. Nevertheless, realization of these parameters will be attained only through effective and appropriate research closely affiliated with well motivated national extension services. But a very interesting question is to what effect will these new agricultural technologies have on the kinds, severity of development, and rates of spread of the diseases that attack sorghum, a crop already plagued with serious pest, diseases and weed problems? Clearly, the answer to this question is the expansion and appearance of more devastating pathogens that will cause further huge losses unless otherwise effective and adequate plant protection measures are accomplished along with the other aforementioned parameters.

Although such work still remains to be done, in recent years, fortunately, some progress has been made on Smuts and Grain mold diseases, the most serious sorghum diseases at the present time. Hence, we believe that it is very justifiable to give this area of research higher priority than other sorghum diseases. However, this means neither to devote all our attention nor to place all available resources on the study of these two diseases.

It is true that yield loss from a particular leaf disease seems economically unimportant to a particular farm, but the total losses are, without doubt, very substantial when considering the number of various leaf diseases occuring on the plants of an individual field and the large hectarages planted to this crop. Not less important than that is also the complex relationship which most of these diseases have among each other as well as with other pests and diseases of sorghum. Vectors and Viruses or Aphids and sooty moulds serve as good examples of such associations. Therefore, surveys are urgently needed to study the geographical distributions of the leaf diseases, to assess the extent of their losses and to determine their interaction with other sorghum pathogens and pests. Meanwhile, particular attention must be paid to the discovery and identification of new pathogens.

Moreover, detailed research must be conducted to know more about the biology of the individual diseases, since such findings are the usual pre-requisite for designing and developing proper control methods to enrich yields and safeguard quality.

So far, cultural treatments are the only control methods available for most of these pathogens as well as for many other notorious pests and pathogens of sorghum.

Ploughing, removal of stalks and stubbles, burning or deep burial of plant debris immediately after harvest, destruction of alternates and alternative hosts, weeding and other sanitary measures should be vigorously practised as they have proved successful in many parts of the world on many crops by reducing pest and pathogen populations drastically. Similarly much benefit derives from avoidance of crop ratooning which is a common practice in Bay region as it harbours many of these pathogens, as well as others, which increase their severity in the subsequent crop.

Chemical applications other than seed treatments are not likely to be economically worthwhile. For this reason, centres with reliable and efficient machinery for treating seeds and testing their germinability should be established at various districts of sorghum growing areas. In fact this practice is a main requisite for the introduction of a Home-Saved Seed Policy. So that, in the long run, Somali farmers will get their seeds treated from seed suppliers aided and controlled by government seed certification scheme. For the moment some important chemicals recommended for use against sorghum diseases as other cereal diseases and their corresponding target organisms are listed in Table 3.

In cooperation with plant pathologists, plant breeders must include disease resistance as a major item in their programme in addition to their main aim of breeding for consistantly high yield and better quality. Concentrating efforts on finding sources of resistance which are reliable, that is, ones that are stable and durable, is strongly recommended. For this purpose, close collaboration with international institutes, such as ICRISAT will be profitable.

It will take us many years or even some decades to put together an efficient and absolutely magnificient plant quarantine service to delay as long as possible or better yet to prevent the introduction and spread of exotic, harmful organisms that would cause catastrophic epidemics. This is due to several limitations. First, the means are lacking and both skill and experience are lagging. Secondly, Somalia has very long borders with its neighbours and therefore it will not be an easy task, if not impossible, to regulate the movement of all leaving plants, living plant parts or plant products. Thirdly, as long as the existing food imbalance exists, restrictions on the badly needed millions of tons of donated foodstuffs are impossible. Nevertheless, to lay down a solid foundation for the future development of plant uarantine service priority should be given to the following areas:

1. To increase the number of the present personnel and improve their skills through relevant training.
2. To provide the minimum required equipments and station 2 to 3 staff members at each of the main inland entries, international airports and major harbours to regulate the movement of all living plants, and living plant parts.
3. To import the safest type of planting materials from the safest areas.
4. To establish more properly equipped post-entry quarantine stations, like the one recently installed at Afgooye, in various regions of the country.

Hopefully, if these initiatives are fostered, numerous plant pathogens including foliar diseases of sorghum as well as many other pests will certainly be intercepted.

Finally, experience has taught us that diseases which are considered minor today may in time become major and therefore overstressing the importance of today's problems could easily divert our attention from understanding the nature of our tomorrow's headache and what exact precautionary measures to be taken. It must be thereby realized that disease such as Damping off, Mycotoxin, ergot, etc. are not unimportant and by no means should be neglected. We believe future research on these areas would be especially fruitful.

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PRELIMINARY STUDY OF GRAIN MOLD ON DEVELOPING SORGHUM GRAINS UNDER IRRIGATED AREAS

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1. Introduction

Sorghum is the principal staple crop in Somalia. The bulk of the crop is grown in the inter-riverine areas both in irrigated and rainfed conditions. Observations made in irrigated areas have shown the presence of large number of barren panicles, with no grains developed.

A combination of complex factors such as grain mold, insect attack, bird damage or environmental conditions were attributed to be responsible for that barreness. Therefore, it is the objective of this work to screen these overlapping factors and at least find out the primary cause of this barreness.

Because of its effect on grain development, grain mold was selected as the first factor to study while others were tentatively excluded.

2. Materials and Methods

The site of the experiment was at the Central Agricultural Research Station (CARS), Afgoi. The material under experimentation was a sorghum variety named Dabar.

The experiment included two treatments; treatment A and treatment B each of which contained two plots; treated plot and control plot. The plot size was 4m x 5m, and the entire area of the experiment was $100m^2$.

Before planting the germination viability of the seeds was tested, and the result was optimum. After the land was prepared planting of treatment A was done on 5 May 1984.

Furadan was planted with the seeds of the treated plot to protect the young seedling from the attack of insects, especially stalkborers and nematodes, while the control plots were planted without Furadan.

Three seeds were planted in every hill. Two days after planting, the first irrigation was done. Combined operations of weeding, thinning and second irrigation were done 25 days after germination.

Forty-five days after germination, first application of Basudin was done to the treated plot of treatment A, while the control plot was left untreated. After two weeks from the first application, the second application was done to the treated plot in treatment A.

On 7th of July, 50% flowering was recorded in treatment A, and on 8th of July, a net was covered on the treated plot of treatment A to

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protect it from bird damage, while the other plot (control plot) was left uncovered. On the same date, 10 heads of 10 plants were selected randomly from each of the two plots. They were marked with numbers so that samples can be collected for laboratory analysis at 4 day intervals.

The collected materials were surface-sterilized by soaking them in mercuric chloride solution (0.1%) for two minutes. The materials were then washed twice in sterile water and placed on autoclaved potato dextrose agar (PDA) medium in petri-dishes. After 48-72 hours of incubation at room temperature of 24-27°C, microscopic examination was done.

The hyphal tip purification method was followed in order to obtain cultures for the identification of each isolated fungus. Identification was performed according to the cultural characteristics of the growing colonies on PDA, as well as their morphological properties.

When the plants of both treatments were in half-bloom[1], 50 heads from 50 plants were selected randomly from each treatment. These 50 plants were marked with numbers for the purpose of disease rating.

The following scale was adopted to measure the intensity of attack.

0 = No visual symptoms of grain mold.
1 = Few caryopsis were attacked by grain mold.
2 = 1/3 of the panicle was attacked and no grains developed.
3 = 2/3 of the panicle was attacked and no grains developed.
4 = Complete attack of the panicle by grain mold and no grains developed.

The second treatment of the experiment (Treatment B) was planted on 30 May 1984. Furadan was planted with the seeds of the treated plot, while the control plot was planted without Furadan. The same agronomic practices were performed as in treatment A. Basudin was applied 3 times between germination and flowering stage. 50% flowering was recorded on 28 July.

3. Results and Discussion

The climatic conditions under which the experiment was conducted is shown in appendix 1.1. The half-blooms, soft-dough and the hard-dough stages of the first treatment A coincided with no rains. But because the atmospheric condition was conducive to the development of grain mold, visual symptoms of grain molds were observed. During physiological maturity, many rains occured and the symptoms observed earlier became clearer and developed seed discolorations were evidenced.

The half-bloom stage and the soft-dough stage of the second treatment B concided with many rainy occasions. These rains were in a condition to increase the relative humidity of the heads which were

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[1] classification based on the growth stages of sorghum by Vanderlip and Reeves (1972).

under development. No rains occured during the last 2 stages of the growth cycle, but the atmospheric humidity promoted the incidence initiated by the early rains.

Conidial forms of fungal species of Cladosporium, Alternaria, Helminthosporium, Pennicilium, Aspergillus, Fusarium, Nigrospora, Curvularia and Colletotricum were found on the surface scrappings made on 20 head samples, collected from the treated and untreated plots of treatment A (see appendices 1.2-1.4). While the surface sterilized materials of treatment A were dominantly encountered by the conidial forms of the fungal species of Curvularia, Fusarium, Helminthosporium and Alternaria (see appendices 1.3-1.5).

Conidial forms of the fungal species of Cladosporium, Alternaria, Fusarium, Helminthosporium., Aspergillus, Pennicilium, Colletotricum, Stenphyllium and Nigrospora were common on the surface scrappings of both treated and untreated plots of treatment B (appendices 1.6, 1.8), while the species of Fusarium, Curvularia, Helminthosporium and Alternaria were isolated from the surface sterilization made on treated and untreated plots of treatment B (see appendices 1.7, 1.9).

Along the samplings, a rating method was done on the barrenness caused by grain mold at grain development stage in all treatments. The rating started at the half-bloom stage.

In the treated treatment A grain mold symptoms were not visually observable, but few barren heads which did not produce grains were present, as the means of the ratings indicate (appendix 1.10). The slight increase of the mean of the ratings during the soft-dough stage indicates that slight traces of grain mold symptoms were present on the grain development stage.

The grain mold symptoms observed in soft-dough stage made no considerable change during the hard-dough stage. The mean of the ratings made during that stage showed a very small increase. Similarly, the mean of the ratings of the physiological maturity stage made no significant increase compared to the other stages.

Mean of the half-bloom stages of the 50 heads in the control plot of treatment A exceeded the mean of the first two classes of the disease rating scale which signifies that the caryopsis of the panicles were attacked by grain mold. The presence of the disease symptoms were visually observable, and a number of barren heads which did not produce grains were also observed (see appendix 1.11).

A significant increase of rating means was encountered at the soft-dough stage, which is the stage next to the half-bloom. This was almost equivalent to the third class of the disease rating scale. Symptoms of grain mold were visually observed on the heads, and the attacked parts showed barrenness. Similarly, the rating means of the hard-dough stage showed a considerable increase compared to its antecedent stage (the soft-dough). Its rating coincided with the 4th class of the disease rating scale.

At physiological maturity, which is the last stage of grain development, the rating means indicated a score which is equal to the 5th class of the disease rating scale.

In the treated plot of treatment B the ratings made during the half-bloom stage showed no presence of grain mold which could be visually observable (see appendix 1.12) even though there were a number of barren plants. During the soft-dough stage, no significant increase of the rating means occurred. Only few traces of grain mold symptoms were observed on some plants.

The hard-dough stage which is the stage next to the soft-dough stage showed no significant change of the rating means. A slight development of the previous symptoms were observed.

The rating means showed a significant increase at the physiological maturity stage. Slight discolorations of the grain was also witnessed.

At the half-bloom stage, there was the presence of a good number of barren heads which did not produce grains. Only slight symptoms of grain mold was observed, which signifies that few caryopsis were attacked by grain mold as the rating means indicate (see appendix 1.13).

In the soft-dough stage, slight discolorations were observed, and an increase of the rating means indicated that change. During the hard-dough stage, a significant increase of the rating means was observed.

Well developed grain mold symptoms were observed on the physiological maturity stage. The rating means indicated that almost the entire panicle was attacked by grain mold and no grains developed in that attacked part.

4. Summary and Conclusions

As was mentioned in the objectives of this experiment considerable number of barren heads were frequently observed in the sorghum grown under the irrigated areas.

Many factors including the grain mold were attributed to be responsible for the barrenness. Grain mold was selected to be the first factor under study.

The climatological data recorded during the duration of the experiment indicated that the climatic condition under which the experiment was conducted was favourable for the incidence of grain mold.

The fungal forms isolated from the surface scrappings and surface sterilizations made on the samples collected from both treatments of the experiment showed that the growth of the majority of the fungal species were superficial. While the species of Curvularia, Fusarium, Helminthosporium and Alternaria were isolated in high numbers from the surface sterilizations, the first two only can be considered as the principle pathogens that cause grain mold.

The results from the disease rating made during the grain formation stages indicated that grain mold was present and its symptoms were usually observable. Also very high frequency of barren heads were observed in the control plots of both treatments.

Moreover serious infestations of stalk-borers on the vegatative stages and heavy bird attacks during the grain formation stages on the control plots of both treatments were observed.

From the results obtained, it can be concluded that grain mold cannot be attributed as the primary factor of barrenness observed in sorghum heads grown in irrigated areas. If the problem has to be minimized, good control measure against insects primarily stalk-borers and grain eating birds should be formulated.

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GERMINATION RESPONSES OF SORGHUM VARIETIES (SORGHUM BICOLOR L. MOENCH) TO FUNGICIDE SEED TREATMENTS*

Ahmed Sheikh Hassan**

1. Introduction

The discovery of seed treatment for the control of plant diseases dates back to the seventeenth century when some farmers in Bristol, England, saved wheat seeds from a sunken ship. One of the area farmers was reported to have planted some of the salty wheat seeds and found that his plants were protected from the grain smut which was a great problem at that time. The farmer succeeded in convincing other area farmers that salty seeds, when planted, did not contract the disease. This technique was probably discontinued when Schulthuss of Germany recommended blue Vitriol instead of salt as a seed treatment. Later the use of chemical fungicides and insecticides as seed treatments became a common practice.

Fungicide seed treatments are used to prevent or reduce plant losses from diseases caused by fungal organisms at different stages of plant growth particularly during seed germination and seedling development. Certain chemicals kill the organisms on the surface of the seed, while others destroy the organisms within the seed, and still other chemicals kill or retard the activity of soil organisms near the planted seed (Agrios, 1978). In treating seeds with chemicals, precaution should be taken regarding the dosage used so that the viability of the seed is not lowered or destroyed. It is also important that enough chemical should be retained on the seed for its protection against soil pathogens and soil organisms which have an adverse effect on the germinating seed or developing seedling.

The objectives of this fungicide seed treatment study were:

- To determine the chemicals' effects on the sorghum seed germination.
- To determine if higher chemical rates than those recommended cause phytotoxicity in sorghum seeds.
- To determine germination reactions of different cultivars to the different seed treatments.

2. Materials and Methods

Nine different cultivars of sorghum seeds obtained from the same season's harvest and four fungicide seed treatments, Benlate (50% Benomyl), Captan, Vitavax-34 and Vitavax-200FF (Vitavax + thiram) were

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* This study was conducted at the seed laboratory of Arizona Crop Improvement Association in Tucson, Arizona, USA, as partial fulfilment for MSc degree.

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used in this experiment. The chemicals were applied at different rates: below recommended rates, recommended rates, and above recommended rates.

Each chemical and its rates were analyzed separately. A 95% confidence interval of the rates and cultivars for each chemical was calculated using the mean square error of the control tests and was compared with the increments that the treatments provided. If the rate increment yielded higher than the upper confidence interval, then it was conlcuded that at a 95% confidence level, the rate gave a higher germination percemtage than the controls. If the rate increment was less than the lower confidence interval, it was concluded that the rate gave a germination percentage lower than the control germination at a 95% confidence interval.

3. Results and Discussion

(i) Benlate treatments: The analysis of variance of the germination increments that Benlate (systemic fungicide) provided suggest that there were both rate and cultivar differences at the .05 level of significance. The first three rates used (0.25, 0.5, 1.0 $g.kg^{-1}$ of seed) gave significantly higher increments of germination to the cultivars at the .05 level, but when the fifth rate (2.0 $g.kg^{-1}$ of seed) was applied, there was no significant increment (Table 1). This can be attributed to the phytotoxicity at the level of chemical used, even though it did not indicate a lower increment than the upper confidence interval.

Table 1. Germination increments relative to the control mean germinations of nine cultivars of sorghum provided by the application of 5 different concentrations of Benlate (chemical 1).

Cultivar	X % Germination of Controls	Rates of Benlate 1	2	3	4	5	X (.96-1.04)[2]
6	59.50	1.23	1.11	1.03	1.10	0.99	1.09a
8	62.20	1.19	1.03	1.24	0.99	1.04	1.10a
1	63.28	1.27	1.27	1.19	1.21	1.03	1.19b
2	68.89	1.08	1.12	1.07	1.01	1.01	1.06a
4	73.34	0.96	1.08	1.11	1.13	1.07	1.05a
5	74.60	1.03	1.03	1.04	1.09	1.07	1.05a
9	79.64	1.09	1.07	1.08	1.11	1.01	1.07a
7	81.03	1.04	1.03	1.06	1.04	1.07	1.05a
3	82.64	1.04	1.06	1.02	1.06	1,05	1.05a
(.97-1.03)[1]	X	1.10a	1.09a	1.09a	1.07ab	1.04b	

Means of rates or cultivars followed by the same letter do not differ significantly from each other at the .05 level (LSD).

1. 95% confidence interval for rates.
2. 95% confidence interval for cultivars.

The cultivars that had control mean germinations lower than 70% indicated the highest increments in germination when Benlate was used. Also, the cultivars with control mean germination lower than 70% provided little or no increments at all when the fifth rate was used. It can be concluded that these cultivars showed more reduction in germination increment than the cultivars with control mean germinations of above 80% at the 5th rate. Similar results were concluded from the work done by Ellis, et al (1975) and Mengistu, et al (1974) on soybean seeds.

(ii) Captan treatments: The analysis of variance of the germination increments that Captan (seed protectant fungicide) provided indicate that rates were not different at the .05 level of significance, but there was a cultivar difference at that same level. Rate 3 (2.6 g A.I./kg of seed) was the only rate that provided a higher mean increment than the upper confidence interval, but it was not statistically significant (Table 2). When the fourth (3.25 g A.I./kg of seed) and fifth (3.90 g A.I./kg of seed) rates were used, there was a substantial reduction of the increments that rate 3 provided, which can be attributed to the phytotoxicity of the chemical at the level used.

Table 2. Germination increments relative to the control mean germinations of nine cultivars of sorghum provided by the application of 6 different concentrations of Captan (chemical 2).

Cultivar	X % Germination of Controls	Rates of Benlate 1	2	3	4	5	6	X (.96-1.04)[2]
6	59.50	1.01	1.03	1.00	0.94	1.04	1.02	1.01cd
8	62.20	0.95	0.75	1.15	0.91	0.87	0.95	0.93a
1	63.28	0.90	1.03	1.13	1.07	1.03	1.04	1.04de
2	68.89	0.94	1.05	1.05	0.40	0.87	0.94	0.96ab
4	73.34	1.04	1.12	0.95	1.11	1.07	1.10	1.07e
5	74.60	1.08	1.10	1.07	1.06	1.04	1.03	1.06e
9	79.64	1.01	0.92	1.02	0.95	0.98	1.05	0.99bc
7	81.03	1.07	1.06	1.06	1.05	1.04	1.05	1.06e
3	82.64	1.04	1.08	1.05	1.10	1.04	1.08	1.07e
(.97-1.03)[1] X		1.00	1.02	1.06	1.01	1.00	1.03	

Means of rates or cultivars followed by the same letter do not differ significantly from each other at the .05 level (LSD).

1. 95% confidence interval for rates.
2. 95% confidence interval for cultivars.

On the other hand, like Benlate, Captan was more phytotoxic to the cultivars that had low control mean germinations. Unlike Benlate, Captan applied to those cultivars did not result in large increments of germination.

(iii) Vitavax-34 treatments: The analysis of variance on the increment data of vitavax-34 (systemic fungicide) revealed that there was both a rate and cultivar difference at the .001 level of significance. The third rate used (2.6 $g.kg^{-1}$ of seed) indicated a significantly higher increment than both the upper confidence interval and the other rates (Table 3). There was a decrease in increment when the fourth (3.25 $g.kg^{-1}$ of seed) and fifth (3.90 $g.kg^{-1}$ of seed) rates were used, suggesting that the higher rates were phytotoxic. The sixth rate (4.5 $g.kg^{-1}$ of seed) gave a slightly higher increment than the prior two rates for which an explanation is not available at the present time.

Table 3. Germination increments relative to the control mean germinations of nine cultivars of sorghum provided by the application of 7 different concentrations of Vitavax-34 (chemical 3).

Cultivar	X % Germination of Controls	Rates of Vitavax-34 1	2	3	4	5	6	7	X (.96-1.04)[2]
6	59.50	1.03	0.74	1.13	0.94	1.03	1.15	0.93	0.98ab
8	62.20	1.12	0.97	1.06	0.97	0.98	1.10	1.04	1.03cd
1	63.28	0.96	0.93	1.18	1.08	0.96	1.01	0.96	1.01bc
2	68.89	0.96	0.95	1.08	0.99	0.85	0.98	0.81	0.95a
4	73.34	1.12	1.03	1.08	1.13	0.95	1.01	1.07	1.06d
5	74.60	0.99	0.98	1.02	1.01	0.97	1.03	1.05	1.01bc
9	79.64	1.00	0.97	1.11	1.03	0.97	1.07	1.07	1.03cd
7	81.03	1.04	1.03	1.01	1.04	1.01	1.03	1.05	1.03c
3	82.64	1.02	1.07	1.10	1.04	1.03	1.06	1.06	1.05cd
	(.97-1.03)[1] X	1.03 b	0.96 a	1.09 c	1.03 b	0.97 a	1.04 b	1.00 ab	

Means of rates or cultivars followed by the same letter do not differ significantly from each other at the .05 level (LSD).

1. 95% confidence interval for rates.
2. 95% confidence interval for cultivars.

The cultivars with control mean germinations of above 70% performed better than those with lower control mean germinations. There were indications of decrease in increment in these cultivars with control mean germinations of less than 70% when high rates of vitavax-34 were used. Only cultivar 8 gave an increment in germination when the sixth and seventh rates were used, while it indicated a decrease with the fourth and fifth rates. The specific reaction which is different from the other cultivars with low control mean germinations could not be explained. This chemical was more phytotoxic to poor quality seeds than to good quality seeds, which agrees with the previous chemicals.

(iv) Vitavax-200FF (Vitavax + Thiram): The analysis of variance on the increment data implied that there were both rate and cultivar differences at the .05 and .001 level of significance, respectively. All seven rates of the chemical used gave higher increments compared to the upper confidence interval for rates (Table 4). The second (2.34 $g.kg^{-1}$ of seed), third (3.12 $g.kg^{-1}$ of seed), fourth (3.9 $g.kg^{-1}$ of seed) and fifth (4.9 $g.kg^{-1}$ of seed) rates used gave good increments to the mean rate value of the nine cultivars. The fourth rate of the chemical gave the highest increment even though it was not statistically different from rates 2, 3 and 5.

Table 4. Germination increments relative to the control mean germinations of nine cultivars of sorghum provided by the application of 7 different concentrations of Vitavax-200FF (chemical 4).

Cultivar	X % Germination of Controls	Rates of Vitavax-200FF 1	2	3	4	5	6	7	X (.96-1.04)[2]
6	59.50	1.18	1.26	1.21	1.31	1.29	1.18	1.14	1.22e
8	62.20	1.14	1.19	1.12	1.24	1.19	1.18	1.08	1.16cd
1	63.28	1.11	1.12	1.15	1.14	1.12	1.15	1.11	1.13bc
2	68.89	1.08	1.08	1.08	1.12	1.07	1.08	0.92	1.06a
4	73.34	0.96	1.10	-	-	-	-	-	1.03a
5	74.60	1.04	1.09	1.03	1.08	1.08	1.06	1.09	1.06a
9	79.64	1.06	1.11	1.10	1.13	1.11	1.09	1.03	1.09ab
7	81.03	1.08	1.02	1.11	1.07	1.09	0.99	1.02	1.05a
3	82.64	1.06	1.08	1.07	1.11	1.09	1.01	0.99	1.06a
(.97-1.03)[1] X		1.08 ab	1.12 bcd	1.11 bcd	1.14 d	1.13 cd	1.09 abc	1.05 a	

Means of rates or cultivars followed by the same letter do not differ significantly from each other at the .05 level (LSD).

1. 95% confidence interval for rates.
2. 95% confidence interval for cultivars.

Mean cultivar increments provided by the seven rates indicate that all the cultivars yielded higher increments than the upper confidence interval for the cultivars except cultivar 4, which was treated only with rates 1 and 2 due to a shortage of seeds available. The cultivars with low control mean germinations (6, 8, 1), gave higher increments than the rest when each rate of the chemical was used. This agrees with the study done by Ellis et al (1975) on soybean seeds and also with Benlate treatments in this experiment. Contrary to the results of Benlate, though, vitavax-200FF produced more phytotoxicity to good quality seeds rather than to poor quality seeds.

4. Summary and Conclusions

Four seed treatment fungicides (Benlate, Captan, Vitavax-34 and Vitavax-200FF), in varying concentrations, were applied to nine sorghum cultivars. Benlate and Vitavax-200FF improved the germination of the sorghum cultivars better than Captan and Vitavax-34. Benlate and Vitavax-200FF also showed a lesser phytotoxicity to sorghum cultivars than Captan and Vitavax-34 when high concentrations of the chemicals were used. All four chemicals increased the germination of the cultivars that had control mean germinations less than 70% to a greater degree than the cultivars with mean control germinations higher than 70%. Also, the cultivars with mean control germinations less than 70% showed more phytotoxicity than the others when high rates of Benlate, Captan and Vitavax-34 were used. On the contrary, Vitavax-200FF did not cause lower germinations in the cultivars with control mean germinations less than 70% but in those with control mean germinations above 80%. Vitavax-200FF at the concentration of 3.9 $g.kg^{-1}$ of seed gave the highest increment in germination.

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THE DRIFT SPRAYER WITH ROTARY ATOMIZER FOR BIRD CONTROL

Gerhard Redwanz*

1. Introduction

The need for economical methods to prevent bird damages was the reason to develop the "Ground Drift Sprayer". As experience in Northeast Nigeria and Niger demonstrated, the Ground Drift Sprayer can replace aerial treatments which require much higher inputs in know-how and money. It should be pointed out that the positive experiences made with the Sprayer in the Sahel countries are not necessarily applicable to other regions or bird pests other than the red-billed weaver bird.

Frequently the control by aircrafts and sometimes by the ground sprayers are not very economical to solve bird problems. And even the total figures of bird damages are sometimes negligible in connection with the whole economic system of a nation. But for the regional policy it makes sense to use even relatively expensive bird controlling methods to prevent the migration of concerned farmers.

2. The Ground Drift Sprayer

The main component units are:

1. one generator
2. one compressor (air)
3. one spray tank
4. one telescopic mast
5. one atomizer head

The operating principle of this unit is as follows:

The generator produces the electricity on a very high frequency, more than 120 Hz, compared to normal electricity which has only 50 Hz. This high frequency is necessary to produce the extremely high speed of the atomizer head.

The compressor has to condense the air which is pressed in a tube to the spray tank. The compressed air has the function to transfer the avicide "fenthion' ($C_{10}\ H_{15}O_3\ PS_2$) from the spray tank into the atomizer head. Inside the atomizer is a perforated aluminium tube and the chemical can penetrate through this perforation with its high pressure. From there it clashes on the outer perforation with high speed rotating the atomizer head and the avicide is expelled from there into the surrounding air.

The high speed rotation in connection with the high pressure is able to pulverize the oily chemical into small droplets (35 um). This super fine droplet is needed to ensure that the spray stays air-borne, like a fog bank for a sufficiently long time. Thermic and inversion layers lengthen the period in which the spray floats in the air.

Wind or non-wind conditions endanger the success of the treatment because with zero wind speed the products' cloud will fall straight

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down on the ground. High wind speeds have also fatal results because there are not sufficient chemical particles per cubic meter floating in the air, thus making sure that the birds have enough contact with the avicide.

3. The exact survey of a roosting site or breeding colony of Quelea birds

In the detailed survey information must be collected on the following points:

3.1. Time of inflight is bird specific. But it is also influenced by the number of birds at the site, the concentrations over a specific unit area, the distances between the feeding grounds, the drinking places and the roosting sites. Also the diversity of feed available and the prevailing weather and daylight conditions influence the inflight time.

3.2. The inflight direction is influenced from the above mentioned points and here particularly from scarce feeding grounds, which is forcing the birds to search over widely scattered areas. In this case, the swarms will return less dense and from varied directions to the site.

3.3. The height of inflight is primarily species-specific. The topography and the height of the vegetation in the vicinity of the area are influencing factors.

3.4. The number and species of birds in a roosting site is calculated by using both a "count-estimate method" and an exact observation method of the incoming species in a roosting site.

3.5. The prevailing wind direction during the time of spraying has to be observed with a compass several days before treatment. It is also important to check the wind direction immediately before treatment.

3.6. The vegetation height is closely related to the inflight height of the birds in the site. The density and composition of the vegetation are also important factors to the inflight behavior of the red-billed Quelea. Birds usually have a high inflight height when descending to a roosting site with dense and heavy vegetation. In lighter stands of vegetation they also fly in from the sides or below the crown tops.

3.7. Main bird concentrations in the site: Observing the inflight in the evening does not usually suffice to localise places where birds concentrate in the roost. Furthermore, movements within the site take place for longer periods afer inflight, before the birds take up their final resting space. A better indication of the main locations where birds concentrate can be the observation of the fly-out in the morning which is more direct, over a shorter period and with denser swarms. If ground conditions allow, the site should be thoroughly surveyed on foot.

3.8. <u>Size and shape of the site</u>: The site can be measured exactly using a prismatic amplitude compass, a directing pole and a topofil. The measures obtained are transferred onto graph paper and an outline sketch is obtained.

If the main inflight directions of the birds, the prevailing wind direction at the time of the treatment and the specific bird concentrations on the site are all entered into the sketch it becomes a major decision making aid for the control operation.

4. Environmental aspects

It has to be noted that the environmental effects of the ground drift sprayer are not negligible. Sometimes useful birds, small mammals and some reptiles feed on treated and dying birds and they can die too. Even domestic animals which graze in the area could be affected by the falling particles of the chemical.

However, the total consumption of 2 drift sprayers are between 10 and 20 l of Fenthion. Treatments by aircrafts often use 10 times higher amounts compared to the drift sprayers. Therefore, the ground drift sprayer is a good alternative to reduce unwelcomed environmental effects.

CHAPTER FIVE

SOCIO-ECONOMIC CONSIDERATIONS

RESEARCH AND DEVELOPMENT: THE CASE OF THE BAY REGION

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1. Introduction

The Bay Region is the most important dryland agriculture area in the inter-riverine zone of Somalia. It covers an area of approximately 40,000 sq. km. The economic importance of the region for the country is reflected by the priority it is given in the national development planning. The ongoing Bay Region Agricultural Development Project (BRADP) was established in 1980 with the major objectives of creating the physical infrastructure necessary for increased agricultural output as well as conducting research on crop production to enhance productivity.

This paper examines the role of agricultural research in the overall development process, and discusses accordingly the problems of and prospects for agricultural research under the specific conditions of the Bay Region.

2. The instrumental role of agricultural research in the overall development process.

2.1 Small farmer economics and the efficiency of traditional agriculture

The majority of the farmers in developing countries are small farmers. They are in essence subsistence farmers whose main concern is to secure adequate food for household consumption, and they are only secondarily attracted to markets (Ruthenberg, 1980). This does not mean that small farmers are completely self-sufficient and have no connections with the market. Their requirements for industrial items and agricultural commodities not produced on the farm are met either through either selling part of their food production or by producing also a cash crop. On the other hand, many small farmers are trapped in a chronic underproduction situation where the basic food requirements are barely met.

The resources at the disposal of the small farmer are the two components of the physical environment, land and water -- i.e. rainfall and/or irrigation --, and family labour (Holenberg, 1978). Although the production systems resulting from the use of these resources are characterized by low productivity it is nevertheless well recognised that the small farmer is an efficient producer in allocating resources between enterprises and activities so that the maximum benefits are derived from the farm as a whole (Mellor, 1967).

However, the economic efficiency gained by the small farmer does not negate further improvement of the system; it simply indicates that given the resources available in a traditional agriculture the small farmer is operating in the most rational manner utilizing each input

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at its optimum level with the best combination of resources. In other words, given the low level of the technology they employ, farmers are confronted with limited options, and by trial and error experience accumulated through generations they have developed production systems which have low productivity but are stable and efficient.

In this sense, then, the small farmer is already doing a good job and would need very little advice. But any changes in the economic environment or level of technology affect the established efficiency and create a need for adjustment. Indeed, the image of a traditional agriculture that is static, both in economical and ecological terms, is undergoing a change: involvement in market production is increasing while population pressure is undermining the bases of some ecologically sound systems. At present, traditional agriculture faces the difficult tasks of feeding an increasing rural population and of accomodating the changing consumption habits of a fast growing urban population. To meet these demands, the efficiency of traditional agriculture has to be improved.

Efficiency is a term that denotes a relationship between input and output in a given system and varies with different systems (Spedding, 1979). Thus, despite the foregoing discourse on the efficient management of the small farmer it is evident that the traditional agriculture of the developing countries is much less productive than the modern agriculture of developed countries (Todaro, 1981). Comparing the two systems, Todaro (1981) reported that in 1980 only 75 million people were engaged in the agricultural sector of the developed countries and had produced commodities worth US$125 million, whereas a total agricultural population of 1,230 million in the developing countries had generated a value of only US$77 million. From the biological point of view, although the conversion of the photosynthetically active solar radiation into plant dry matter in the tropics is potentially two to three times greater than the potential in a temperate environment, the actual transformation shows a performance value of just one tenth of that obtained in a temperate climate; furthermore, the proportions of dry matter converted into edible parts are 30-56 per cent and 5-35 per cent for the advanced agriculture in the temperate zones and traditional agriculture in the tropics, respectively (Ruthenberg, 1980). Evidently, the low production associated with traditional agriculture emanates from its inability to realize what is potentially feasible with the application of technological innovations, rather than from the use it makes of its presently available resources (Mellor, 1970).

2.2 Transfer of technology

Most of the agricultural advances realized in the developed countries have resulted from the application of science and technology to farm problems. The use of fertilizers and pesticides, the development of high-yielding varieties, and the provision of improved irrigation techniques and efficient farm mechanization systems have created the basis for a highly productive agricultural system. The total production of 17 major crops in the USA, for example, increased from 252 million tons in the period 1938-40 to 610 million tons in 1978-80. The 242 per cent increase was achieved with an increase of just three per cent in the cropped area (Borlaug, 1983).

The need for the transfer of technology from the developed countries is very obvious. The process is, however, complex and requires critical evaluation and adaptation of the introduced technology (Matlock, 1984). A vivid example of a technologically successful transfer is the so called 'Green Revolution' in which the yield/hectare and total production of cereal crops in some developing countries have been dramatically increased through the application of technological innovations. In India, the production of wheat at the time of the introduction of the high yielding varieties was 11 million metric tons with a national average yield of under one ton per hectare. By 1981, almost 15 years later, wheat production had increased to 36.5 million metric tons, largely due to a 100 percent increase in the national average yield (Borlaug, 1983).

2.3 The social dimensions of technological changes

Although Green Revolution packages have dramatically increased the yields of several food crops, the technological improvements have been adopted mainly by large rather than small farmers(Adams, 1982). The differential rates of adoption of the proposed technology among the two groups of farmers were determined by differences in their socio-economic conditions (Andrew and Alvarez, 1982). Although the high yielding varieties were scale-neutral in nature and could be used in both large and small farms, the supplementary inputs required to realize their potential yields were not. The additional costs imposed by the new technology for acquiring fertilizers, pesticides and farm machinary and for implementing proper irrigation systems required financial commitments the small farmer could not afford. Furthermore, the small farmer did not have access to credit nor could he bear the risk associated with the new technologies.

The reason why small farmers do not usually benefit from agricultural development programmes can be explained by the development strategy underlying the programmes themselves. The diffusion approach which is widely used in agricultural extension programmes is a progressive-farmers strategy that gives priority to the large farmers because of their responsiveness to innovations. Although diffusion theory assumes that the benefits of a new technology will ultimately trickle down to the least responsive ones, i.e. the small farmers, there are several imperfections in the diffusion model that undermine the validity of this proposition (Roling et al, 1976; Adams 1982). In fact, the technologies developed for divulgation suit well the needs and conditions of the large farmers rather than the small ones. Even in the case of scale-neutral technologies the messages that indirectly reach the small farmers are distorted in the process of interpersonal communication. Also, due to the policy of the extension bodies favouring the perpetuation of their established links with the progressive farmers, technologies are often channelled successively almost through the same network, hence preventing the small farmers to ever catching up.

The diffusion approach, therefore, reinforces the autonomous diffusion occurring within the existing socio-economic setup and aims at promoting the efficiency of the most competitive producers operating under the economic forces of the market. This development objective was adopted by the now developed countries when they were undergoing the transitional phase of economic transformation to become industrialized nations. Under those circumstances farmers who failed to adapt themselves to the rapidly changing technological innovations were doomed to bankruptcy and were forced to leave the rural areas to join the growing industrial workforce. The uncritical application of the diffusion approach to the conditions of the contemporary developing nations is certainly ahistorical. In the developing countries, the industrial sector is either almost non-existent or has a limited capacity for growth to be able to absorb a considerable number of farmers driven away from their land. In the absence of these industrial opportunities, technological innovations that discriminate against the majority of the farmers - i.e. the small subsistence farmers - in favour of the few better-off ones simply distort the development that is needed in the developing countries by further aggravating the conditions of the rural poor and widening the gap between the rich and the poor. The problem with the progressive-farmer strategy is that it emphasizes the need for economic growth and pays little or no consideration to the questions of equity in income distribution and social justice. Naturally this is not an acceptable development strategy.

2.4 Appropriate technology from relevant research

After having experienced failures in the wrong direction of rapid industrialization strategy, Third World countries have ultimately recognized the fundamental role of agriculture in their overall national development. Also, since the 1970s, the agricultural reserch policies in those countries have undergone changes shifting their priorities from export crop problems to the more pressing ones of food production.

The Green Revolution has demonstrated that impressive results in yield and output of food crops can be obtained in Third World countries by exploiting the world scientific and technological stocks. However, the high social and economic costs that were involved - i.e. greater dependence on expensive imported inputs and increased social disparity - have warned against the indiscriminate use of technology and have underlined the need to search for alternatives (George, 1977). The most important lesson that agricultural scientists can draw from the Green Revolution is that "improved seeds cannot solve the problems of unimproved farmers" (Owens and Shaw, 1974). The improvement of the farming community as a whole is, thus, today the dominant issue in the development thinking.

The general consent among researchers is that to be effective in raising the productive capacity of the small farmers as well as improving their living standards, proposed technologies should be appropriate to the conditions of these small-scale producers. Matlock (1984) gives perhaps the most comprehensive definition of an appropriate technology as "one which meets the perceived needs or desires; makes fullest possible use of locally available resources for construction, operation and maintenance; minimizes secondary problems of environmental degradation (pollution and depletion of resouces); and is compatible with the social, political and economic constraints of both men and women users and their community".

According to Greenland (1975) the problem of appropriate technology is mostly one of creating new technologies rather than just a transfer of existing ones from the advanced agriculture of the developed countries. For the small farmer in the humid tropics, where soil erosion is also a problem, he proposes a mixture of modern and improved traditional technologies: (1) zero tillage; (2) improved varieties for mixed crops; (3) phosphorus fertilizer; (4) legumes of high nitrogen fixing capacity; and (5) ash or mulch of deep-rooted species to control acidity, where lime application is not feasible.

On the other hand the development of the semi-arid tropics requires not only careful management of technology, but also social and cultural adjustments to meet future needs of populations living in the area (Bowden, 1979). On the development of the semi-arid regions of Africa, for instance, Jones (1985) concluded that "Any 'green revolution' .... will come, not as a result of a wonder package of new seed and list of infallible instructions but, slowly, by gradual improvements on a broad front". The major challenge to research in semi-arid environments is to find methods of soil and water conservation that increase the presently low rainfall-use-efficiency obtained in most of the existing farming systems (Thorne and Thorne, 1979; Jones, 1985).

Given the meagre amount of resources allocated to agricultural research in the developing countries, the question of efficient utilization of these resources in the search for appropriate technology is of considerable importance. The judgement on the appropriateness of a technology lies ultimately with the farmers, and they express this through adoption or non-adoption of the proposed innovations. One important factor, other than suitability to the physical environment, that determines the adoption of a research developed technology by small farmers is its ability to match with needs, objectives and resources.

The importance of the involvement of the small farmers in the research process, from early stages of problem diagnosis up to the final stages of technology evaluation, is nowadays being increasingly appreciated by the scientific community (Matlon et al, 1984). The classical approach to technology generation which has been adopted by most agricultural research institutions is that researchers identify farmers' problems and undertake studies to find solutions, while the extension people are left with the task of persuading farmers to apply research recommendations. The shortcoming of this approach is that it ignores the value of the participation of the potential users in the process of technology creation.

Lundgren and Raintree (1983) expose the irrationality implied by the top-down research model:

"The answer of many researchers, that they 'already know what the problems are' without having to bother with the complications of a formal diagnostic procedure, is analogous to a doctor's making either the patently absurd assumption that all patients are the same, or his claiming arrogantly that a well-trained practitioner is able to treat patients without recourse to examination."

2.5 The 'ideal' research model for developing countries

Several alternative methods, aimed at ensuring more active involvement of the farmers in the research process, have been employed as alternative to the conventional top down model. However, some of them, too, suffer from the same major defect as the top-down approach: lack of research attention specifically directed to the solution of the problems of the resource-poor subsistence farmers (Chambers, 1985).

The ideal model for agricultural research in developing countries would, probably, be the one termed by Chambers (1985) as 'Farmer-First-and-Last' (FFL). The following discussion is based on the ideas expressed by the author in his article "Agricultural Research for Resource-Poor Farmers: The Farmer-First-and-Last Model".

The FFL model is in a developmental phase, but the application of its prototypes under various circumstances in several countries have shown promise. The distinguishing characteristics of the FFL model, grouped according to the stage of research process they belong to, are as follows:

(i) Appraisal stage:
- rapid and cost-effective appraisal
- holistic view of the farming systems (including household and its needs)
- learning from farmers
- multi-disciplinary approach and genuine dialogue

(ii) Research and development (R&D) stage:
- on-farm and with-farm R&D
- experiment-station-based research and scientists as a supporting system providing consultancy

(iii) Technology evaluation stage:
- adoption by the farmers as criteria for evaluation

The comparisons between the conventional research model, denominated by Chambers (1985) as Transfer of Technology (TOT), and the new approach, FFL, (Tables 1 and 2) show how research, in the context of the latter model, is viewed as means for the development of the majority really in need, rather than for just a small group. The FFL model links research to the real world of the small-scale producers and avoids research that is undertaken in isolation from the farming system.

The cornerstone of the FFL model is its commitment to assuring that researchers are not engaged in answering wrong questions. To avoid that undesirable situation it proposes to consider small farmers not just as a 'target group', but as valuable research partners who have also the right to actively participate in their own development.

Table 1: Constrasts in learning and Location

	TOT	FFL
Research priorities and conduct determined mainly by	Needs, problems, perceptions and environment of scientists	Needs, problems, perceptions and environment of farmers
Crucial learning is that of	Farmers from scientists	Scientists from farmers
Role of farmer	'Beneficiary'	Client and professional colleague
Role of scientist	Generator of technology	Consultant and collaborator
Main R and D location	Experiment station, laboratory, glass-house	Farmers' fields and conditions
Physical features of R and D mainly determined by	Scientists' needs and preferences, including statistics and experimental design; Research station resources	Farmers' needs and preferences
Non-adoption of innovations explained by	Failure of farmer to learn from scientist; Farm-level constraints	Failure of scientist to learn from farmer; Research station constraints
Evaluation	By publications; By scientists' peers	By adoption; By farmers

Source: Chambers (1985)

Table 2: Process of Activities and Their Location

TOT		FFL	
Resource-rich conditions	Resource-poor conditions	Resource-rich conditions	Resource-poor conditions
Scientists define problems and opportunities		Transfer of ---------------- scientists	Scientists learn about farm families' needs, resources and priorities
1 1			1 1
On-station research			Joint definition of problems and opportunities
1 1			1 1
New high-yielding technology		On-station referral of problems --------	On-farm with farmer R and D
1 1			1 1
Demonstrations and testing on-farm			Farmers test and evaluate
1 1			1
Other resource-rich farmers	Resource-poor farmers	Resource-rich farmers	Other resource-poor farmers

Source: Chambers (1985)

3. Case Study: The Bay Region

3.1 Introduction to the region's agriculture

Dryland farming, defined as the growing of crops and/or rearing livestock under limited availability of rainfall (Bowden, 1979; Arnon, 1975)a, is the exclusive form of agriculture in the Bay Region, except for Baidoa district where an area of 100 ha is under irrigation (Hunting Technical Services, 1982). The dominant feature of the economy is semi-nomadism characterized by mixed farming systems with distinct enterprises of crop and livestock production. Most of the rural population pursue both activities concomitantly, while only a few households can be classified as pure farmers or pure nomads. The Bay Region is heavily rural in character: the rural population makes up 93 per cent of the estimated 440,000 inhabitants of the region (Hunting Technical Services, 1982).

Of the region's total area of 4 million hectares, only about 15 per centis suitable for dryland crop production whereas the rest is utilized for natural grazing (Hunting Technical Services, 1982). Given the estimated total cropped area of about 134,000 hectares (Ministero dell'Agricoltura, 1975), it would appear that approximately 75 percent of the potentially cultivable land is still unexploited for crop production. However, the realistic potential for expansion of the currently cropped land is considered by some people to be just half of the above stated value (Hunting Technical Services, 1982). The limitations on the utilization of these areas for cropping purposes are generally imposed by low rainfall regimes, but more importantly by constraints on permanent settlement - i.e. lack of water supply for domestic and animal use.

The total number of livestock has been estimated to be about 1.02 million animals consisting of 31 per cent camels, 30 per cent cattle and 34 per cent goats (Hunting Technical Services, 1982).

3.2 Thirty-four years of research and extension

The region's Bonka Research Station was founded in 1952 (Worzella and Musson, 1954). The fragmentary nature of the available information on its activities since then makes it difficult to undertake a thorough critical research review. From the few available documents, however, it is possible to draw a historical sketch of the agricultural development efforts in the region. The periodization of the history of research and extension projects in the Bay Region (Table 3), based on the operational periods of the implementing bodies, helps to reveal several important points.

First, no systematically organized research activities were conducted before Bonka Research Station was rehabilitated under BRADP management in 1981. The period prior to 1981 can be subdivided into two categories: (1) periods (1952-60 and 1976-80) in which research existed as a separate institution and (2) periods (1960-62 and 1963-70) in which research activities constituted a secondary task of an extension scheme. The information on the initial activities of the Bonka Research Station during 1952-60 is scarce, while the 1976-80 period, when the research station next regained its autonomy, can be considered a very unproductive one.

Table 3: Research and Extention Projects during 1952-1981 and Their Main Activities.

Period	Implementing bodies: Research	Implementing bodies: Extension
1952-1960	AFIS - Establishment of Bonka Research Station - varietal adaptation of sorghum and millet - crop rotation and fallow systems - new crops: cotton, peanuts, soybean and agava fibre plant	
1954-1960		AFIS - Foundation of Bonka Farmers' Training Center - oxen training for plowing and row-planting
1960-1963	MOA - No available information	MOA - oxen training - distribution of oxen drawn implements (plows and cultivators) and seeds
1963-1970	University of Wyoming - Research and extension institutions merged together to form Farmers' Training and Demonstration Center - demonstration trials on the effect of animal manure, green manure, commercial fertilizers and fallowing. - observation trials on cultural practices and yields of sorghum - distribution of improved seeds of sorghum, peanuts, cowpeas and mungbeans - distribution of eggs for hatching of improved poultry breeds (Rhode Island Red)	
1970-1975	MOA - No trials or extension activities were carried out	

Continuation of Table 3.

1976-1980	ARI - Center rehabilitated through FAO/UNDP Project - very little research work accomplished	MOA - No extension work
1979-till present		AFMET - animal training - on-farm and centre-based demonstration and trials (row-planting, inter-cropping, use of animal power) - distribution of improved seeds
1981-till present	BRADP: Experiments on: - sorghum improvement - fertilizers - entomology - fallowing - oil and legume crops - intercropping - forage - animal traction	

Sources: Worzella and Musson (1954); Hoffarth (1964); Ali Hussen et al (1964);
University of Wyoming (1968); Hunting Technical Services (1982)

Notes: AFIS (Amministrazione Fiduciaria Italienne delle Somalia)
MOA (Ministry of Agriculture)
ARI (Agricultural Research Institute)

Most of the trials carried out before 1981 were set up for demonstration purposes rather than for experimentation and hence are of limited scientific value. For instance in the Dayr of 1963 (Hoffarth, 1964) only one out of almost ten trials conducted had replications at all. Similarly, only one in nine trials during the Deyr 1968 season had a replicated design (University of Wyoming, 1968). This would mean that only ten per cent of the trials in these periods were designed to produce useful information on the problems under study.

Second, the emphasis on extension activities rather than on research reflects the tendency that prevailed in the agricultural development thinking in the 1950s and 1960s. The major issue at the time was to demonstrate to the farmers the beneficial effects of some agricultural techniques assumed to be undisputedly superior to the traditional ones. Thus, rigorous experimental works seem to have been considered avoidable if not unjustifiable during those early stages of technology transfer.

Third, the establishment of successive unrelated projects, financed and implemented through foreign technical assistance, have diverted attention from the need to build up the institutional foundations of the Bonka Research Station in terms of cadre preparation and formulation of long-term research plans.

3.3 Reasons for lack of success

Despite the large investment in extension activities and the formerly limited and presently intensified research efforts, traditional sorghum production techniques and the cropping systems in the Bay Region remain unaffected. The proper identification of the factors that have obstructed the adoption and diffusion of the proposed innovations - i.e. row-planting, legume-sorghum rotation, ox cultivation, and introduced sorghum lines - is very essential for the formulation of correct research and extension policies in the future.

Generally, the lack of acceptance of a proposed technology by the farming community may be attributed to any of three possible causes or combinations of them: (1) farmers' reluctance to change, (2) a weak extension system, or (3) the inappropriateness of the technology itself. It is my contention that the lack of research and extension impacts on the farmers' production in the region is mainly due to the absence of convincing improved techniques produced by research, rather than to either poor extension work in reaching the farmers or to the farmers' resistance to change.

Although the process of change is usually marked by reluctance in the early stages, farmers, in the end, tend to adopt those technologies that fit their needs and production objectives well. The activities of the Bonka Farmers' Training center over the past thirty years indicate that a considerable number of the region's farmers have been exposed to the thinking and technical messages endorsed by the extension institution. Therefore, if the farmers have not absorbed the recommended techniques this might well be interpreted as their conscious response towards technologies that have not appealed to their needs.

A close examination of the comparisons between expected reasons for the adoption of the proposed technologies and probable explanations for farmers' reluctance to accept them (Table 4) suggest that the 'innovations' already presented to the farmers are unfinished products of research which require further refinements. And this, perhaps, explains why technologies that are apparently 'appropriate' - i.e. simple and affordable - have failed to attract the interest of the small farmers in the region.

The brief historical analysis of past research projects in the Bay Region shows that due to the short span of life of each individual project, the studies undertaken apperently were not properly designed to produce conclusive data. In fact, the existence of these projects and separate unrelated entities have hindered the institutional development of the Bonka Research Station, leading to inadequate research plans within each project and lack of follow-up across projects. The other important factor that has contributed to lack of meaningful results from past research and extension efforts is the

Table 4: Comparisons between claimed advantages of promoted technologies and probable reasons for farmers' dissatifaction with them.

Technologies	Reasons for promotion	Probable reasons for lack of adoption (Farmers' questions)
(1) Introduced sorghum lines (Dabar and GBR-148)	- Yield superiority compared to local varieties	- Always? - Storage characteristics?
(2) Row-planting	- Allows better weed control and use of agro-chemicals	- Labour requirements at sowing? - Ease compared to random planting? - If no agro-chemicals are used and farm is salaax[1]?
(3) Ox cultivation	- Labour saving, ease drudgery work, better weed control and increased food production	- Economics? - salaax farms?
(4) Legume/Sorghum rotation	- Improve soil fertility as well as human diet	- Compatibility of the legume sole cropping with the farming system? - Grain legumes' storage characteristics?
(5) Legume/Sorghum intercropping	- same as above	- Sorghum yield in intercropping compared to yield in traditional mixtures? - Optimum sorghum: legume proportions?

[1] Weed-free condition

choice of the top-down model adopted for both activities. This approach opts for dictating improvements to farmers regarding their production techniques and hence their own livelihood, rather than learning from them in order to develop together techniques that they can really afford to adopt.

3.4 Looking ahead

Agricultural research plays an important role in fostering the rate of agricultural development in developing countries. It is, however, unreasonable to expect that 'faith in science' alone would be sufficient to justify research undertakings. Planning and programming of agricultural research is indispensable to achieving an efficient utilization of the limited resources allocated for research (Arnon, 1975)b.

In consideration of past shortcomings of the Bonka Research Station, the following proposals can be made to improve the resource-use efficiency at the research station:

(1) Formulate a clearly stated and officially documented research policy of the institution. This requires a defination of the organization's research goals and the research areas required (Arnon, 1975)b.

(2) Establish a well-defined plan with proper articulation between its component programmes. Here a balance between short-term programmes, reflecting the immediate needs of the farmers, and the long-term ones, that respond to the national requirements, is essential. In this regard, the improvement of the traditional techniques should be given a top priority; the objective should be small, incremental and sustainable changes rather than great technological leaps away from the present farming system.

(3) Adopt a Farming Systems Research approach. Much more emphasis needs to be placed on the identification of farmers' felt needs and the development of appropriate technologies with the collaboration of farmers.

(4) BRADP should improve the Bonka Research Station not only as a research organization that has to serve the project during its short life span, but also as a station that has to develop into an indipendent dryland research institution in the future.

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PLANNING ON-FARM RESEARCH WITH FARMING SYSTEMS PERSPECTIVE

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1. Introduction

Somalia Agricultural Extension Training and Farm Management Project is one of the several projects which turned to On-Farm Research with Farming Systems Perspective (FSP) towards the end of its life. The project had 2 years to go when it was rewritten to have FS flavor/component. It should be mentioned that at the beginning the project was Extension and Training and had no FS element in it. A Farming Systems Economist was added to the team just about 18 months before the project was to expire. With a very cooperative chief of party and a very progressive agronomist, the Farming Systems economist was able to function effectively towards the recommended goal.

Understanding Farming Systems prevailing in a particular environment may be necessary but not sufficient condition to design an effective intervention for addressing small farmers' problems. Designing an appropriate intervention and suggesting alternatives need technical experience and ingenuity. There are several approaches to addressing the same problem but determining which of the approaches can best address a problem is an art.

In order to understand the Farming System prevailing at the target area, the FS specialist, with the help of the other team members, first, conducted an exploratory survey. The analysis revealed several pertinent farmers' problems and farming systems in the survey area. The target area was classified into three recommendation domains - traditional, transitional, and improved stages (Appendix 2.1). There were unique practices associated with each domain. For example, the traditional stage used local seeds and practised intercropping and random planting. The transitional stage used some improved seeds and practised some row planting. The improved stage practised row planting, used some improved seeds and applied some chemicals such as fertilizer and insecticides (Appendix 1).

Farmers' problems were ranked and classified into endogenous and exogenous. The endogenous problems were those within the control of the researcher, such as labour at weeding time, pest problems, etc., and the exogenous ones were those outside the control of the researcher, for example lack of fuel, lack of rainfall, etc. The agronomist developed simple interventions based on the survey results at the Extension Training Centers to address some of the problems. Such trials as irrigation, weeding, stalkborer control and fertilizer were established at the Extension Training Centers (ETCs). These trials served three purposes:

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1. As interventions to farmers' problems.
2. As practical training grounds for the training of the Field Extension Agents (FEAs).
3. As training for the Subject Matter Specialists (SMSs) in experimental design.

There has always been a Seasonal Training designed for Regional Extension Officers (REOs), Subject Matter Specialists (SMSs) and the District Extension Officers (DEOs), at the beginning of every season. Since the project was rewritten two seasons ago, the emphasis has been problem solving with systems approach. At the training of Dayr 1985 farming systems approach to problem solving was the focus. The procedure adopted during this training constitutes the main theme for this paper. The first part considers Systems Approach to Problem Solving. It is followed by group presentation of different approaches to the same problems and, then the plan of work.

2. Systems Approach to Problem Solving

The field officers were informed of the date of the training and were told to prepare reports on progress and problems of the previous season as well as general problems. The training was scheduled for two weeks. After the opening ceremony, the REOs were given time to read their reports. The REO and his subordinates formed a panel during the presentation. Contributions were given and questions asked. A summary of the problems was outlined on the chalkboard and recorded by the participants. The reading and discussion of the reports took about two days for six regions.

The Technical Assistants (TAs) listed all the problems reported by the regions. Common problems were put together and non-common ones reserved for individualized attention. The next stage was to classify the problems into exogenous and endogenous. The exogenous ones were listed to be referred to the Project Management Unit (PMU), which has mandate with the Ministry of Agriculture. The common endogenous problems were written on the chalkboard for attention. These problems were associated with three main crops: maize (corn), sorghum, and sesame. Participants were divided into groups by regions. To each regional group was assigned the crop(s) produced in its region, and was asked to:

1. State the problem(s) in simple sentence(s).
2. State probable causes (here to the participants were explained the difference between symptom and cause).
3. Suggest possible interventions (this took one day).

3. Group Presentation

Group/regional presentations took two days. Each group presented its work and very interesting discussions ensued on relevance and applicability of points raised. A summary for each discussions was put down and suggestions offered by the TAs. The most common problem identified by all the regions was "Labour at Weeding Time". Five main interventions were suggested by the group, namely: row planting and plant population, intercropping, timely weeding, use of herbicide, and use of fertilizer.

Explanations given to each suggested intervention were as follows:

(i) Row planting and plant population: By planting in rows it would be possible to ascertain the number of plants per field area and thus an optimum plant density. It will also afford faster weeding and application of chemicals. This suggested intervention was mostly for Transitional Stage domain as well as for some Traditional Stage farmers. It also applied to maize and sorghum.

(ii) Intercropping: The idea here was that farmers would be taught how to intercrop in rows at different patterns, for example, one row of maize one row of legume, two rows of maize one row of legumes, or the reverse, and two rows of maize two rows of legumes. The same patterns were suggested for sorghum and sesame. The rationale for this practice is that by intercropping, some space would be filled and the legumes might spread and thus might require only one or fewer weeding(s). Also, the legumes might replenish some nitrogen lost to the grains. This practice was geared towards the Traditional Stage.

(iii) Timeliness of Weeding: A season's trial at the ETCs showed that the first weeding was critical and that two weedings were requisite for a season's production. The question was, "When should the first weeding take place and thus the second weeding?". Different times were suggested for the first and second weedings. This practice was suggested for Transitional Stage and perhaps the Traditional Stage domains.

(iv) Use of Herbicides: This intervention was not emphasized very much because there has been very little or no study on the use of herbicides in Somalia. Consequently it was suggested that farmers who monocropped and especially used fertilizer could be a good target for such trials. This intervention was definitely meant for the Improved Stage domain.

(v) Use of fertilizer: The idea is not to reduce labour costs or costs for weeding. The suggestion by one group was that if the farmer could increase his/her yield by, say, a third, then he/she would increase his/her income - all things being equal - and thus would be in a position to afford labour or any weeding costs. This trial was also geared towards the Improved domain.

4. Plan of Work

After all corrections, contributions, and suggestions had been made, each regional group was asked to use its work to prepare a plan of work for the Season. Examples of the developed plan of work for one region is appended (Appendix 2.2). A common data collection proformat was developed for collecting agronomic and economic data in the course of the trials (Appendix 2.3). All trials, intended for farmer's fields, were also to be established at the Extension Training Centers (ETCs), to serve the three purposes mentioned earlier, and to enable the SMSs to exercise closer control over them.

Since the rewritten AFMET project concentrates mostly on two regions, the above plan would receive emphasis in those two regions. The arrangement was that due to fewer TAs in the new project, the Agronomist would be fully responsible for the trials at the ETCs with the SMSs as his contact/delegate persons, and the Farming Systems Economist be in charge of trials on the farmers' fields with the DEOs as his contact persons. It is intended that by the end of the project, September 1986, the national staff should be able to identify problems, develop possible causes, and suggest practical intervention to the problems.

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AN INSTITUTIONAL BUILDING ADAPTIVE RESEARCH PROTOTYPE: A CASE STUDY OF FARMING SYSTEMS RESEARCH/EXTENSION TRAINING FOR THE BAY REGION, SOMALIA

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1. Introduction

A continuing debate centers on which research-dissemination model should be used in Third World countries. Should we export our very successful experiment station generation of technology that is disseminated through extension, or is the farming system research (FSR) perspective a better model? Those that prefer a model that involves the farmer in defining the research and in testing and trial verification prefer the FSR model. The jointly sponsored USAID, World Bank and African Development Fund Agricultural Farm Management Extension Training has been short of research and supervisory support for the mandated Training and Visit System (T & V).**

There is increasing support for participatory involvement in efforts to maximize farm-family livelihood and quality of life in Third World countries. Top-down dissemination of technology often fails for many reasons. For example, sustainability of practices, after the inputs of donor intervention, requires commitment based upon participation. Needs assessment of farm families are usually lacking. Technology being transferred is generally not individualized to specific needs of farm families, thus only accepted by the more progressive farmers. As usual then the subsistence farmers continue to be forgotten. The application of the maximum participatory involvement concept is vital for implementing effective agricultural programs in developing countries. Adaptive Research is developed and utilized to the degree of Research/Extension/Farm Family correlation. If any one of these groupings is slighted, breakdown of technology transfer results.

It is most important to understand that this maximum participating involvement is not automatic but rather happens in logical sequence. The normal and very natural procedure is identified in the following diagram:

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** T & V methodology implemented in Somalia was very narrowly defined as Top-down technology transfer, with no transition for Agent/Farm Family input involvement.

Model for Acceptance

Tell	Sell	Involvement
Hearing		Seeing & doing

This illustration shows that some acceptance is generated by both telling and selling but that a much greater amount of acceptance takes place when people are involved. This implies that involvement should be at all stages of program development -- from needs assessment through adoption of technology. It also implies that, for most people, introduction of an idea or a particular technology might logically begin with telling or selling. Any extension methodology, when utilizing this approach to Adaptive Research development and Technology Transfer, should be most effective. T & V, as implemented in Somalia, employed the first two stages but has never included the third stage, thus creating a very stagnant programming environment. For this reason the AFMET Project has generally accepted the programming concepts included in Farming Systems Research/Extension Perspective (FSR/EP) to reinforce the mandated T & V system.

The preliminary efforts by the AFMET staff members for conducting FSR/EP was most encouraging. For example, extension staff response at the Region, District and Village levels was most positive. Conducted in selected villages, farm families responded quite enthusiastically to surveys. District Extension Officers (DEO), Specialists and Field Extension Agents (FEA) and Farmers in selected villages, collaborated in conducting both verification trials (on-farm comparison trials) and recommended demonstrations to be used for Farmer's Field Days. Excellent agronomic data was collected by FEA's, DEO's and Specialists. The AFMET staff analyzed and evaluated the data, providing most meaningful information for Extension staff to share with farm families.

From the beginning, it was recognized that a link was missing in this process. Extension rather than Research was providing technical packages for delivery. Even though it was recognized from the beginning of the Project that this missing link was greatly needed, response from the Central Agricultural Research Station (CARS) has been minimal. However, more recently the staff of the Bay Region Research Station at Bonka have worked closely with the Extension staff in both plot work and training. They responded to our invitation for Institution Building development to establish a FSR/EP programming prototype that could be generalized to other areas of Somalia and, with appropriate modification, transfer the prototype to other Developing Countries. A research farm, adjacent to the Extension Training Center (ETC) in Baidoa, provides the setting for Research and Extension staff to cooperate.

In order to expedite this Institutional Building/Adaptive Research team effort between Extension and Bay Region Research, the two Projects contracted with Utah State University (USU) for two temporary duty personnel (Agricultural Educator and Extension Specialist) to provide, with the assistance of the USU Project staff, a training workshop for the combined Research and Extension staff of the Bay Region.

2. Rationale for Training

Farming Systems Research/Extension Perspective looks at technology development and technology transfer, from the perspective of the farm family. Identified felt needs are considered as problems and/or opportunities for program resolvement. Some of the needs become research problems. Farming Systems Research studies the context within which farm families live and work. Therefore, Extension liaison members of the team need to be trained to study not just the cropping and animal production systems, but more specifically, the interrelationships between cropping and animal systems and socio-economic factors.

Extension is expected to generate farm-family perceived opportunities that suggest research either at the Research Station, at the Educational Training Center (ETC), or on farm. Research designs and conducts the on-station trials, assists in designing and installing the trials at the ETC and assists Extension in designing the on-farm trials that are conducted by the farmer with close FEA supervision. A particular problem might logically require testing at any of the three levels. A trust relationship between the farm family and FEA will insure farm family commitment to the Research/Problem Solving team.

It was hoped that this training might overcome impediments present in Somalia between Research and Extension. This was seen to be an institutional building process to promote teamwork and trust through productive experience.

An even more encompassing desired outcome of this training was to stimulate an interest within the Central Agricultural Research Station Administration to become involved in this cooperative Institutional Building mode. If this were accomplished it was felt that the bureacratic impediments between Research and Extension would be overcome. This experimental involvement, supported by sound Farming Systems Research/Extension Perspective theory, resulted in excellent Research/Extension team building. Even before the two-week workshop was completed, interest was expressed by the CARS Administrator to conduct a similar workshop in the Lower Shebelle Region to develop similar Research/Extension Institutional Building between CARS and Extension. Not only are Extension and Research "ready" for this relationship but private entities as well as other governmental organizations/ institutions will be included as the "perspective" mode evolves.

Prior to this training, programming emphasis has been directed toward agronomic production. It was decided that farm family members' involvement with inter-disciplinary interactions should be taught. It was also agreed that FSR/EP training should include group process theory and practice that builds social skills and probem solving critical thinking skills. Participants need instruction to gain an appreciation for integrative decision making to include clearly stated goals, positive use of confrontation, de-emphasis of negotiation and majority-minority impact on decision making and the generation of the best solutions that logic and reasoning can derive through wide participation of the total group. The training was also designed to have FSR/EP support and reinforce the mandated T & V methodology -- that FEA's would become more effective in technology transfer through effective adaptive research development and dissemination.

3. The Training Program

The training program began with a presentation to the Research and Extension participants by Dr. R. Buker, Director of the Bonka (Bay Region) Research Station. He explained agronomic research and small plot design and analysis. His presentation provided introduction to assignment of Extension participants to assist in harvesting research plots. Research and Extension teams harvested plots from 8:00 a.m. to 11:00 a.m. on 6 of the 10 days of the Workshop. Participants were sensitized to the need for accuracy of experimentation, sound plot design, and procedures for data collection, analysis and subsequent recommendations for on-farm application.

The remainder of the schedule for each day, 11:30 a.m. to 1:00 p.m. and 3:30 to 6:00 p.m., was devoted to the following topics:

1. Explanation of research (explained above)
2. Explanation of Extension Services in Somalia
3. Explanation of Farming Systems Research -- linking Extension to Research
4. Explanation of why FSR/E
5. The approaches for FSR/E -- Interdisciplinary program development
6. Practicing Sondeo surveying with Role Playing for effective Agent-Farm Family interaction
7. Developing practical Sondeo using interdisciplinary approach
8. Conducting actual Sondeo. The Sondeo or rapid rural reconnaissance was seen to be of major importance for this workshop. Role playing and practice resulted in participants gaining skill and confidence in doing surveys and an initial appreciation for systematic study to combat potential erroneous assumptions and biases in interpreting farm problems.
   Small group problem solving was used to generate topics for the survey instrument and to analyze survey results. Instructors observed group interaction and reinforced the stages of group development that represent the individual member movement from commitment to personal goals to a commitment to group goals.
9. Identifying direction for a detailed survey using interdisciplinary approach
10. Preparing questionnaire using interdisciplinary approach
11. Practicing questionnaire administration using role playing
12. Actual administration of the questionnaire
13. Questionnaire analysis/Group problem solving process
14. Creating awareness of use of the survey results by both Research and Extension in developing appropriate technology with the farmer--the "down-stream" approach

15. Recounting the process and suggesting possible constraints
16. Planning and conducting exploratory survey (Sondeo) as a portion of the 2-day Monthly Training of FEA's

This 10-day Workshop directly preceeded the 2-day Monthly Training for FEA's. In anticipation for using these local FEA s to survey the villages within their responsibility, the Regional and District Extension Officers, supported by the Research staff, planned for teaching Sondeo the first 5-hour day and supervised survey of a nearby village the second and final day of the Monthly Training. The FEA's enjoyed the experience and gained a better perspective of farmers' problems from the survey experience. Analysis of the data collected was shared with all REO's, Subject Matter Specialists and DEO's at the Annual Extension Training at AFMET.

4. Evaluation

The Research and Extension participants gave a most positive response in their evaluation of the Workshop. They were asked to rate the Workshop on a 10-point scale from -5 to +5 for interest, take-home value, and general effectiveness. They rated the Workshop from 3.9 to 4.4 with a mean of 4.0. Participants received a high rating for this progress toward a working understanding of FSR/EP.

5. Summary

Sufficient models exist to impact positively on research technology transfer in developing countries. There are many limitations to the application of these appropriate models, often beginning with turf protection of various groups, organizations and institutions. The difficulty found in obtaining cooperation among these different entities often limits progress toward effective technoloy development and transfer.

The effort to institutionalize cooperative relationships between Research and Extension in Somalia represents an attempt to foster teamwork at the grass roots level. The Annual Training was conducted sequentially for the Bay Region Bonka Research Station (Rainfed), and the AFMET Project, proceeding on the assumption that Research and Extension needed to establish a close working relationship. Conditions were "right" for this development to succeed. For the past 18 months Research and Extension were seeking ways to support each other to maximize the use of facilities and program staff. Through opportunistically using harvest time and training schedule conflict to work as a Research-Extension team, a positive first step was taken to build a sustainable cooperative environment. While all purposes of exploratory surveys for FSR/E were not reached in this 10-day training, real progress was made. Both Research and Extension staffs gained a working understanding of FSR/EP program development. Specifically they gained practice in developing survey skills and a beginning understanding of the farm-family problem identification. Categorization into domains, useful for designing intervention strategies, was internalized during plan of work preparation.

A very significant application of this annual training for District Extension Officers and Subject Matter Specialists was their subsequent two-day monthly training for FEA's. This was accomplished by preparing them to teach Sondeo techniques to FEA's. The FEA's did conduct Sondeos on the second day of their program. Preliminary evaluation indicates that this transfer was most successful.

It is expected that this training, with appropriate follow-up, will provide Research and Extension a means to maximize participatory involvement of a total team effort in providing intervention for resolvement of farm-family problems. Heretofore, the T & V Extension methodology has been top-down--research to farmer approach, with little concern for farmer-specific orientation and subsequent participation in problem solving.

This instructional program was planned and conducted as a step towards development of a prototype that would also serve in the development projects in other Third World countries.

SEASONAL PRICE TRENDS AND MARKETING OF SORGHUM IN THE BAY REGION

Orhan Saygideger*

1. Introduction

As the main agricultural policy of Somalia is to become self sufficient in food grain production, certainly sorghum will play an important role in achieving this goal. Among the measures instituted in the current plan which are expected to stimulate sorghum production are an upward revision of producer prices and devaluation of the Somali shilling.

However, in the Bay Region it is equally important to stabilize the seasonal variation of prices received by farmers in order to reduce the risk they are facing. Better pricing mechanism and stabilization of prices would, of course, be achieved through the improvement of the marketing structure of the region. This paper attempts to find out whether the recent government policies have made any impact on price level, price stabilization and eventually on the production level of sorghum.

2. Main Marketing Institutions in the Bay Region

In 1971, ADC was given a monopoly power over all trade in sorghum and maize. ADC has established agents throughout the Bay Region for the collection of grain and payment to the farmer. The principal objective of the ADC is to secure a fair price to farmers and protect them from seasonal fluctuation of prices. Total storage capacity of ADC exceeds 400,000 tons and they are located in the major producing areas of the region[1]. The law enacted in 1971 gives ADC a monopoly power over the trade of sorghum and maize in Somalia. But after 1980, ADC began to allow private traders to resume buying and selling activities. The Presidential circular of 9 August 1982 changed the 1971 law, allowing farmers to store grain and stating that farmers are not obligated to sell grain to ADC.

Today ADC plays a reduced role in buying and selling sorghum and maize in the region. Farmers and private traders are selling grain mostly at the local markets in the region. There are two types of sorghum sellers on the market: wholesalers who sell in the shops and retailers who sell it in the outside market. The second type are mostly women. The private markets operate seven days a week and are mostly located at the centre of the cities.

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[1] ADC has above and underground storage facilities totalling to 430,000 tons in Baidoa, Dinsor, Kansa Dhere/Ufuru and Buur Akaba.

3. Some Basic Information on Sorghum Marketing

Source of Supply and Marketing Distance

According to a survey[2] which was carried out on the private markets in Baidoa, Kansa Dhere and Buur Akaba, average marketing distance for farmers selling their product on these markets is around 25 km. This distance varies from one market to another. Farmers are coming to Baidoa market from an average distance of 30 km since this market plays an important central role. These distances reduce to 15 km and 29 km for Buur Akaba and Kansa Dhere markets repectively. However, the survey result reveals a fact that farmers are coming as far as 100 km and more to sell sorghum on the market to meet his cash requirements. The marketing distance especially tends to increase after Gu season harvest as farmers need more cash since they keep more animals for breeding.

Table 1 shows the major sorghum producing areas and their distances from the centre markets. The survey result suggests that Awdinle which is about 30 km from Baidoa is a major supply area for sorghum in the Baidoa district as this centre supplies almost one-fourth of sorghum to the Baidoa market. Overall, Baidoa market serves some 100 "Tuulos" around a 100 km perimeter. Some 13 percent of farmers retailing sorghum at Buur Akaba market are reported to be coming from Buur Haybe which is 30 km from the distrit market. Though smaller than Baidoa market, Buur Akaba serves more than 120 different sorghum producing "Tuulos" in the district. The main sorghum supplying centres in the Kansa Dhere district are Duuray, Ufurow and Ismaciil which are some 15 km perimeter around the market.

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[2] Marketing Study in the Bay Region: NMEF Working Paper No.3.

Table 1: Percentage Share of Sorghum Producing Centres and Their Distance from the Local Markets.

From	To	Percentage	Distance (km)
Awdinle	Baidoa	22	30
K. Dhere		12	85
Bardaale		8	30
Bonday		6	12
Sarmandere		3	55
Others		49	-
B/Haybe	B/Akaba	13	30
Masaaro		7	36
B/Akaba		6	-
K. Dhere		5	12
Duuray		5	8
Others		64	-
Ufurow	K. Dhere	19	16
Duuray		17	12
Ismaciil		13	6
Qasaalay		8	17
K. Dhere		6	-
Others		37	-

Source: NMEF Files.

4. Seasonal Price Trend of Sorghum

The price data presented are based on the survey conducted in the Bay Region during 1984-1985 period and represent the average of the three major district markets[1].

It was observed that farmers are mostly selling sorghum in one litre tin cans. They are locally called "shood" and the amount of sorghum they contain varies from one type and seller to another. Thus the amount of sorghum in the "shood" was weighed many times and then the prices were converted to standard one kilogram units.

Table 2 shows the average prices received by farmers on the three markets of the Bay Region during the period of June 1984 to May 1985. Looking at the Table, one can see that the impact of the seasons on sorghum prices is very pronounced. Prices progressively rise as farmers exhaust their harvest of the previous year. A peak is reached around May-June for sorghum. During and after harvesting season, however, price falls. This sharp decline is caused by the combined effect of markets being flooded with large quantities of newly harvested crops and the availability of substitute for each of the

[1] Baidoa, Buur Akaba and Kansa Dhere markets.

crops. Prices are at their lowest around September-November after which it begins gradually to rise as the quantities of surplus produce brought to the market decreases.

Table 2: Average Monthly Sorghum Prices Received by Farmers (1984-1985) (So. sh./kg).

Months	J	J	A	S	O	N	D	J	F	M	A	M	Aver-age
White	19.8	17.0	16.0	11.6	11.6	12.5	14.6	14.5	13.7	14.4	18.3	19.5	15.4
Red	19.1	16.7	15.8	11.0	12.2	11.3	13.3	12.0	12.4	15.4	16.5	17.6	14.5
Aver-age	19.4	16.9	16.2	11.3	11.4	11.9	13.9	13.5	13.0	14.7	17.5	18.6	15.0

Source: NMEF Files.

The prices of white sorghum are consistently higher than the prices of red sorghum. On the average this difference revolves around 5 to 6 percent which reflects the premium paid by the buyer for white sorghum over the red one. However, this percentage in the free market is lower than the percentage difference of 12 percent offered by ADC (See Table 4 on page).

Table 3 compares farmer's prices with the market retail price obtained from the Mogadishu CPI calculations during the same period.

Table 3: Comparison Between prices on Baidoa and Mogadishu markets (So.Sh./kg)

Months	J	J	A	S	O	N	D	JA	F	M	A	M
Mogadishu (P_M)	38.7	38.9	35.5	31.9	29.4	29.1	30.4	34.0	33.1	32.8	32.1	33.7
Baidoa (P_B)	19.4	16.2	16.2	11.3	11.4	11.9	13.9	13.5	13.1	14.7	17.5	18.6
P_M/P_B	2.0	2.4	2.2	2.2	2.8	2.6	2.4	2.3	2.5	2.3	1.8	1.8

The difference of prices between producing and consuming centres becomes dramatic especially after the harvest season where the rural prices drop drastically. It is difficult to impute this difference of more than 100 percent to the transportation costs, handling charges, shop rents and middlemen margins. However, it is obvious that overhead costs are higher in Somalia since the amounts involved are small and the profit margin demanded by wholesaler and retailer in Mogadishu are considerably higher.

5. Comparison of Rural Prices with ADC Prices

Table 4 shows the buying prices of ADC over the period of 1981 to 1985 which was a fixed price throughout the country. ADC in recent years has been adjusting the prices upward as a result of high rate of inflation in the economy. But, ADC buying prices are still lower than the local market prices in those markets surveyed. Table 5 shows comparison of the mean local prices with those of ADC's during the period of 1984-1985. Despite the recent dramatic increase in the ADC prices, the average ADC prices during the period of 1984-1985 are 50 percent less than the free market prices in the Bay Region. Even comparing market prices in May with ADC's announced price in July, the ADC prices are still lagging some 40 percent behind the free market prices.

Table 4: ADC Buying Prices (So.Sh./100 kg).

					Percentages changes (%)		
	1981/2	1983	1984[1]	1985[2]	1983/82	1984/83	1985/84
Red Sorghum	150	160	320 400	1185	7	150	196
White Sorghum	160	180	370 450	1300	13	150	189

Note: ADC Prices are effective from September to September.
[1] As of December 1984 prices were adjusted again.
[2] As of July 1985.

Table 5: Comparison of Prices (1984/85)

	Mean Local Market Price[1]	Mean ADC Buying Price[2]	ADC Price compared with Market price
Red Sorghum	14.5	6.4	Less by 50.1
White Sorghum	15.4	7.1	Less by 51.1

[1] Table 2.
[2] Average of 1984 and 1985 ADC buying prices, Table 4.

6. Conclusion

Policy-makers are usually setting policies and targets without any relevant information available to them. Prices that farmers receive and other related marketing information are extremely important parameters for any regional development program or for setting future policies and targets. Seasonality of sorghum price suggests that ADC has been playing a reduced role in stabilizing sorghum prices. Private traders are more active and efficient in collecting sorghum from the farmer in the region only to sell at a big profit margin at the big consumer centres. Certainly, this does not help the Government policy of keeping food prices down at the reasonable level. Once again, the new policies of privatization seems to be working at the expense of farmers. ADC should play a more active role in shaping up new grain pricing policy which would transfer some of the excess profit back to the farmers.

The survey results also point out some sorghum surplus areas within the region. These areas should be given more attention by the research component of the Bay Region Agricultural Development Project (BRADP) in the future as the farmers of these areas may be the early followers of the new technologies recommended.

The average marketing distances for sorghum indicate that the farmers in the region are not subsistance farmers. They are indeed commercially oriented. They are producing a certain amount of surplus sorghum and are travelling on the average, 25 to 30 km to the market to sell their products and buy other things.

Finally, the sorghum prices over a year period are observed to be at the same level despite the high inflation rate of the economy during the same period. This observation implies that the production level is indeed going up in the Bay Region partly due to the joint effort of BRADP and AFMET and mainly due to the favorable weather conditions in that particular year.

Monitoring prices and other marketing parameters is important for the project management unit and the policy makers at large.

A P P E N D I C E S

Appendix 1.1. Weather data in 1984.

Date	Min.Temp.	Temperature Max.Temp.	Mean Temp.	RH %	Precipitation
1/7- 7/7/84	20.0	28.5	24.3	77.4	6.4
8/7-14/7/84	20.6	28.8	24.7	81.8	8.1
15/7-21/7/84	28.2	28.2	24.2	78.0	6.2
22/7-28/7/84	19.7	24.9	22.3	60.0	-
29/7- 4/8/84	21.3	28.9	25.1	80.0	-
5/8-11/8/84	20.7	29.0	24.9	71.1	-
12/8-18/8/84	20.9	29.5	25.2	69.2	-
19/8-25/8/84	17.7	25.0	21.4	60.0	-
26/8- 1/9/84	21.1	30.0	25.6	70.7	-
2/9- 8/9/84	20.2	29.4	24.8	68.6	-
16/9-22/9/84	21.7	30.7	26.2	71.6	-
23/9-29/9/84	21.6	30.3	26.0	67.9	-
30/9-6/10/84	21.2	30.4	25.8	69.1	34.4
7/10-10/10/84	22.1	31.1	26.6	69.9	36.0

Appendix 1.2. Fungi Identified from Surface Scrapping Treated of Treatment A.

Species	Conidial Frequency
Cladosporium sp	+ + +
Alternaria sp	+ + +
Helminthosporium sp	+ + +
Penicillium sp	+ +
Aspergillus sp	+ +
Fusarium sp	+
Collectotrichum sp	+
Curvularia sp	+

\+ = Low Conidial Frequency
++ = Medium Conidial Frequency
+++ = High Conidial Frequency

Appendix 1.3. Fungi Isolated and Identified from Surface Sterilization Treated of Treatment A.

Species	Conidial Frequency
Curvularia sp	+ + +
Fusarium sp	+ + +
Helminthosporium sp	+ +
Alternaria sp	+

+ = Low Conidial Frequency
++ = Medium Conidial Frequency
+++ = High Conidial Frequency

Appendix 1.4. Fungi Identified from Surface Scrapping of Untreated Treatment A.

Species	Conidial Frequency
Cladosporium sp	+ + +
Alternaria sp	+ + +
Helminthosporium sp	+ +
Penicillium sp	+ +
Fusarium sp	+
Aspergillus sp	+
Nigrospora sp	+
Collectotrichum sp	+
Curvularia sp	+

+ = Low Conidial Frequency
++ = Medium Conidial Frequency
+++ = High Conidial Frequency

Appendix 1.5. Fungi Isolated and Identified from Surface Sterilization of Untreated Treatment A.

Species	Conidial Frequency
Curvularia sp	+ + +
Fusarium sp	+ + +
Helminthosporium sp	+ +
Alternaria sp	+ +

\+ = Low Conidial Frequency
++ = Medium Conidial Frequency
+++ = High Conidial Frequency

Appendix 1.6. Fungi Identified from Surface Scrapping of Treated Treatment B.

Species	Conidial Frequency
Cladosporium sp	+ + +
Alternaria sp	+ + +
Helminthosporium sp	+ +
Aspergillus sp	+ +
Fusarium sp	+
Penicillium sp	+
Collectotrichum sp	+
Stemphylium sp	+
Curvularia sp	+

\+ = Low Conidial Frequency
++ = Medium Conidial Frequency
+++ = High Conidial Frequency

Appendix 1.7. Fungi Isolated and Identified from Surface Sterilization of Treated Treatment B.

Species	Conidial Frequency
Curvularia sp	+ + +
Fusarium sp	+ + +
Helminthosporium sp	+ +
Alternaria sp	+

+ = Low Conidial Frequency
++ = Medium Conidial Frequency
+++ = High Conidial Frequency

Appendix 1.8. Fungi Identified from Surface Scrapping of Untreated Treatment B.

Species	Conidial Frequency
Cladosporium sp	+ + +
Alternaria sp	+ + +
Helminthosporium sp	+ +
Aspergillus sp	+ +
Penicillium sp	+ +
Stemphylum sp	+
Collectotrichum sp	+
Nigrospora sp	+
Fusarium sp	+
Curvularia sp	+

+ = Low Conidial Frequency
++ = Medium Conidial Frequency
+++ = High Conidial Frequency

Appendix 1.9. Fungi Isolated and Identified from Surface Sterilization of Untreated Treatment B.

Species	Conidial Frequency
Fusarium sp	+ + +
Curvularia sp	+ +
Helminthosporium sp	+ +
Alternaria sp	+

+ = Low Conidial Frequency
++ = Medium Conidial Frequency
+++ = High Conidial Frequency

Appendix 1.10. Ratings on Grain Development Against Grain Mold and Barrenness of Treated Treatment A.

NP	10/7	13/7	18/7	23/7	28/7	2/8	7/8	12/8
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	4	4	4	4	4	4	4	4
6	0	0	1	1	1	1	1	1
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	4	4	4	4	4	4	4	4
12	0	0	0	0	0	0	0	0
13	0	0	1	1	1	1	1	1
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0
18	0	0	1	1	1	1	1	1
19	4	4	4	4	4	4	4	4
20	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0
26	0	0	0	0	1	1	2	2
27	0	0	1	1	1	2	2	2
28	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0

Appendix 1.10 continued

30	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0
34	0	0	1	1	1	2	2	2
35	4	4	4	4	4	4	4	4
36	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0
40	0	0	1	1	1	2	2	2
41	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0
43	4	4	4	4	4	4	4	4
44	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0
49	0	0	1	1	1	2	2	2
50	0	0	0	0	0	0	0	0
Mean	0.4	0.4	0.54	0.54	0.56	0.64	0.66	0.66

Appendix 1.11. Rating on Grain Development Against Grain Mold and Barrenness of Untreated Treatment A.

NP	10/7	13/7	18/7	23/7	28/7	2/8	7/8	12/8
1	0	0	0	0	1	2	3	4
2	4	4	4	4	4	4	4	4
3	0	0	1	1	2	2	3	4
4	0	0	1	1	2	3	4	4
5	0	0	0	1	2	2	3	4
6	0	0	1	1	2	2	3	4
7	0	0	1	1	1	2	3	4
8	0	0	0	1	2	3	4	4
9	0	0	0	0	1	2	3	4
10	0	0	1	1	3	3	4	4
11	4	4	4	4	4	4	4	4
12	0	0	1	2	2	2	3	4
13	0	0	1	2	3	3	4	4
14	4	4	4	1	1	2	3	3
15	0	0	1	1	2	3	3	4
16	4	4	4	4	4	4	4	4
17	0	0	1	1	1	2	3	4

Appendix 1.11 continued

18	0	0	1	1	1	2	3	3
19	0	0	1	2	2	2	3	4
20	4	4	4	4	4	4	4	4
21	0	0	0	0	1	2	2	3
22	4	4	4	1	2	3	3	4
23	0	0	1	4	4	4	4	4
24	4	4	4	4	4	4	4	4
25	0	0	1	2	2	3	4	4
26	0	0	1	1	2	3	4	4
27	0	0	0	1	2	3	4	4
28	0	1	1	2	3	4	4	4
29	4	4	4	4	4	4	4	4
30	0	0	2	2	3	4	4	4
31	0	0	1	2	3	3	3	4
32	0	1	1	1	2	3	4	4
33	0	1	1	2	4	4	4	4
34	0	0	0	1	2	3	4	4
35	0	0	0	1	1	2	3	3
36	4	4	4	4	4	4	4	4
37	0	0	0	1	2	2	3	3
38	0	0	1	2	2	3	4	4
39	4	4	4	4	4	4	4	4
40	4	4	4	4	4	4	4	4
41	0	0	1	2	3	3	4	4
42	0	1	2	2	2	3	3	4
43	4	4	4	4	4	4	4	4
44	0	0	1	1	2	2	3	4
45	4	4	4	4	4	4	4	4
46	0	0	0	0	1	2	3	4
47	0	0	1	1	2	3	4	4
48	0	1	2	2	3	3	4	4
49	4	4	4	4	4	4	4	4
50	0	0	0	1	1	2	3	3
Mean	1.12	1.22	1.52	1.58	2.46	2.98	3.54	3.88

Appendix 1.12. Rating on Grain Development Against Grain Mold and Barrenness of Treated Treatment B

NP	28/7	2/8	7/8	12/8	17/8	23/8	25/8	3/9
1	0	0	0	0	1	1	2	2
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	4	4	4	4	4	4	4	4
5	0	0	0	0	0	0	0	0

Appendix 1.12 continued

6	0	0	0	0	0	0	0	0
7	4	4	4	4	4	4	4	4
8	4	4	4	4	4	4	4	4
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	4	4	4	4	4	4	4	4
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0
18	0	0	0	0	1	1	1	2
19	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	4	4	4	4	4	4	4	4
24	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
26	0	0	1	1	2	2	2	3
27	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0
32	4	4	4	4	4	4	4	4
33	0	0	0	0	0	0	0	0
34	0	0	1	1	1	2	2	2
35	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0
40	4	4	4	4	4	4	4	4
41	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0
44	0	0	1	1	2	2	3	3
45	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0
Mean	0.56	0.56	0.62	0.64	0.72	0.8	0.84	0.86

Appendix 1.13. Ratings on Grain Development Against Grain Mold and Barrenness of Untreated Treatment B.

NP	28/7	2/8	7/8	12/8	17/8	23/8	25/8	3/9
1	0	1	2	2	3	4	4	4
2	0	0	1	1	2	2	3	4
3	0	1	1	2	2	3	4	4
4	4	4	4	4	4	4	4	4
5	4	4	4	4	4	4	4	4
6	0	0	1	1	2	2	3	3
7	0	0	0	1	1	2	2	3
8	0	0	1	2	2	3	4	4
9	0	0	0	1	1	2	3	3
10	4	4	4	4	4	4	4	4
11	0	1	1	2	2	3	3	4
12	0	1	2	2	3	3	4	4
13	0	0	0	0	0	0	0	0
14	0	0	1	1	2	2	3	3
15	0	0	1	2	2	3	3	4
16	0	0	0	0	0	0	0	0
17	0	0	1	1	2	2	3	4
18	4	4	4	4	4	4	4	4
19	0	0	0	0	0	0	0	0
20	0	1	1	2	2	3	3	4
21	0	0	0	0	0	0	0	0
22	0	1	1	2	2	3	3	4
23	0	0	0	0	0	0	0	0
24	0	0	0	1	1	2	2	3
25	0	1	1	2	2	3	3	4
26	0	0	1	1	2	2	3	4
27	0	0	0	0	0	0	0	0
28	0	0	0	1	1	2	2	3
29	0	0	1	1	2	2	3	3
30	4	4	4	4	4	4	4	4
31	0	1	1	2	2	3	3	4
32	0	0	0	0	0	0	0	0
33	0	0	0	0	1	1	2	3
34	0	0	1	1	2	2	3	3
35	0	1	1	2	2	3	3	4
36	0	0	0	0	0	0	0	0
37	4	4	4	4	4	4	4	4
38	0	0	0	1	1	2	2	3
39	0	1	1	2	2	3	3	4
40	0	0	0	0	0	0	0	0
41	0	1	1	2	2	3	3	4
42	0	1	1	2	2	3	3	4
43	0	0	0	1	1	2	2	3
44	0	0	1	1	2	2	3	3
45	0	0	0	0	0	0	0	0
46	0	0	1	1	2	2	3	3

Appendix 1.13 continued

47	4	4	4	4	4	4	4	4
48	0	0	0	0	0	0	0	0
49	0	0	0	1	1	2	2	3
50	0	0	1	1	2	2	3	3
Mean	0.56	0.00	1.08	1.46	1.72	2.32	2.44	2.82

APPENDIX 2.1
RECOMMENDATION DOMAINS
GENERATED FROM THE SURVEY RESULTS

The results of the diagnostic survey conducted for planning on-farm research demonstrated some unique characteristics associated with the FEA (Field Extension Agent) units surveyed. The main indicators for this categorization are types and levels of input use, and farming practices. This approach was used because the whole area falls under one big domain - irrigated - and the farmers grow identical crops. Moreover, they all practice the same religion - Islam - and speak the same language - Somali. The main distinguishing factors are types, levels and use of inputs and ways of cultivating the identical crops. It was found legitimate therefore, to identify and categorize the farmers into some homogenous groups by using the above indicators.

Three main domains were identified, namely:

a. Traditional Stage or First Stage
b. Transitional Stage or Second Stage
c. Improved Stage or Third Stage (See Figure 1)

The name coined for the domains are just to show the level of development in production. The reader may be warned that the authors do not mean that the traditional stage produces less than, say, the transitional stage. It is most probable that a farmer in the traditional stage is proportionately more economical in total production than a farmer in the improved stage. Also, a FEA unit may not fit neatly into one domain. Table 1 shows the spread of the FEA units in the Recommendation domains. FEA units such as Sameisamei, Majabto and Mushani fit into the categories pretty well, while Farhane, B/Sheikh and Gebei are fairly spread through two or more stages. Classification of the surveyed area has been suggested below, based on input use and practices.

<u>Mushani</u> - Mushani farmers are mostly traditional in their use of inputs and practices. Most of the farmers do not use insecticides, fertilizers, and improved seeds. They also practice intercropping or relay cropping and plant at random. The suggested categorization is the Traditional Stage.

<u>Gebei</u> - This FEA unit has moved a little up above Mushani. At least, most of the farmers do row planting and only about 25% practise intercropping/relay cropping during the Dayr season. The common practice and use of inputs in this unit are: use of local seed, non-use of insecticides and fertilizers, and intercropping/relay cropping. Gebei may fit into Semi-Traditional Stage.

<u>B/Sheikh</u> - The farmers here are a little more advanced than the first two areas. However, there are traits of traditionalism. They still use local seeds and a sizeable number of them plant at random and practice intercropping and relay cropping. Few farmers use fertilizers. In fact, the use of fertilizers makes this unit different from the first two areas. This unit may be classified in the Transitional Stage.

Majabto - Majabto uses some fertilizer, improved seeds and does some row planting to some extent. This area is, therefore, the most advanced in the use of inputs, and practices of all the areas mentioned above. However, weeding is below the required number. Also, their use of insecticides is not effective because the rate reported is far below the minimum. This area is very small compared with the rest of the five areas. Majabto also is suggested to belong to the Transitional stage.

Sameisamei - This area is a neighbour to Majabto. It has similar characteristics to Majabto: it is comparatively a small area; the farmers use fertilizers and some (more) insecticides (than in Majabto); and weeding is below minimum. However, about 20% of the farmers do not plant in rows, and very few use local seeds. This unit is in the Improved Stage.

Farhane - This is the largest unit in the FEA units surveyed, in terms of farm family. It is as big as Majabto, Sameisamei, Gebei and B/Sheikh put together. Consequently, any traits shown by this unit in this survey mean a large number of farmers are involved. Farhane demonstrated almost a bit of all the characteristics found in all the areas. However, the most prominent of all are the use of fertilizer, use of local seeds, and planting at random. Farhane may be classified under the Semi-Improved Stage.

Figure 1. Recommendation Domains generated from the survey results.

Stage 1 Stage 2 Stage 3

Recommendation Domains source: Borrowed from a discussion with Dr. M.P. Collinson.

Table 1. Some suggested categorizations of FEA units into some Recommendation Domains for on-farm research/trials.

FEA unit	Traditional Stage (Stage 1)	Transitional Stage (Stage 2)	Improved Stage (Stage 3)
Sameisamei		X	XXXXX
Majabto		XXXXX	X
Gebei	XXXX	XX	
B/Sheikh	X	XXXX	X
Mushani	XXXXXX*		
Farhane	X	XX	XXX

* Totally in the Traditional Stage.

APPENDIX 2.2

Yasin M Essa
SMS for Agronomy

Guideline for Farming Systems Approach to Research Comparison Trials for Dayr season 1985 Middle Shabelli Region

It was discussed at the seasonal training that the Middle Shabelli region should have a number of comparison trials for the Dayr 1985 season. Thus, after lengthy discussion with the REO and DEOs in the Region, three main districts were selected for the trials. The arrangement is that each of the FEAs, in consultation with the DEOs and SMS, will establish four trials in his unit. The trials suggested are:

1. Intercropping
2. Weeding (Timing)
3. Fertilizer Application (plus or minus)
4. Plant Population and Thinning Practices

<u>Responsibilities</u>

The location of the trials at each FEA unit is to be decided by the DEOs and FEAs. The FEA is to select farmers who are cooperative, not necessarily his friends or relations. The REO is to see that each DEO has established the required number of trials. He is to organize periodic meetings with his DEOs to acquaint himself with the progress and problems respecting the trials.

The SMS is to help the DEO lay out plans for the trials (each FEA is supposed to draw the field plan of the trials he/she is conducting). Area supervision rests on the DEO. Field supervision rests on the FEA. He should know, follow up, and record what and when the farmer is doing in the field. He is to report the problems and progress as well as the suggestions to the DEO.

<u>Specific Trials</u>

All the trials in farmers' fields are also established at the ETC farm.

1. <u>Plant Population</u>: The FEA is to be present or instruct the farmer on how to sow the seeds according to the specification.

Example:

Two population levels - 80 cm between rows and 50 cm between hills. Thin to: (a) Two plants per hill for 50,000 plants/ha (b) One plant/hill for 25,000 plants/ha. For a 25 m row, there will be 100 plants to give 50,000 plants/ha. For 25 m, there will be 50 plants to give 25,000 plants/ha.

2. <u>Fertilizer</u>: This comparison will only be established where the farmer can obtain fertilizer, Thus we have two situations: (a) where the farmer is planning to use fertilizer, and (b) where the farmer is not planning to use fertilizer but can obtain enough to establish a trial.

<u>Note</u>: Three types of data are needed at harvest - yield on

a. 100 kg/ha
b. 200 kg/ha
c. 0 kg/ha fertilizer fields for comparison.

There are two suggested application periods:

a. Just after emergence, and
b. Before tasseling.

Even though the farmer is responsible for spacing, plant population, application of stalkborer control, row planting, etc., the FEA is to record all these data and, in fact, all the operations performed on the farmer's field, including irrigation, weeding, data of rainfall,etc.

3. Weeding Trials: The objective here is to consider or observe timing of weeding. The plan discussed during the seasonal training was to obtain two jibals after the farmer has planted and then record all field practices as the farmers carry them out.

1st weeding: 1st jibal - weed 15 days after emergence
2nd jibal - weed 20 days after emergence

2nd weeding: 35 days after emergence on both jibals

3rd or 4th weeding: record if the farmers weed.

Note: Weather can alter these fixed data but the intervals for weeding should be kept.

4. Intercropping: Crops to be considered -

   a. Maize intercropped with a legume
   b. Sesame intercropped with some vegetables.

Spacing 80 cm x 50 cm or 75 x 50 cm with 2 plants/hill or as farmers decide how it should be cropped.

Note that the FEA should measure or weigh before the farmer consumes any of the legumes.

Four yield data are expected at harvest, separately:

(1) Yield of intercropped maize
(2) Yield of intercropped legumes
(3) Yield of pure stand maize
(4) Yield of pure stand legume.

These comparison trials will serve as an integrated concept. Through the different management practices of the farmers and their economic acceptability, we can classify the specific and the common constraints facing the farmers during the season. The results of these trials and their interpretation will show the adoptability of extension philosophy and methodology in this region.

The record keeping (all the agronomic and economic data) that we considered, concerns not only the comparison trials but also the other contact and non-contact farmers in order to get further information about their improvement.

Comparison Trial Layout

1. Fertilizer application

Level 1	Farmer's Field
Level 2	

a. If the Farmer's Field is zero Urea/ha, then Level 1 would be 100 kg Urea/ha and Level 2 would be 200 kg Urea/ha.
b. If the Farmer's Field is 100 kg Urea/ha, then Level 1 would be zero Urea, and Level 2 would be 200 kg Urea/ha.
c. If the Farmer's Field is 200 kg Urea/ha, then Level 1 would be zero Urea and Level 2 would be 100 kg Urea/ha.

2. Weed Control

a. Early weeding	Farmer's Field
b. Late weeding	

a. Early weeding - first weeding 15 days after emergence and second weeding 35 days after emergence
b. Late weeding - first weeding 20 days after emergence and second weeding 35 days after emergence

Any additional weedings will be done if the farmer weeds his field.

3. Intercroppint

a. Pure Maize	
b. Intercrop Maize/Legume	Farmer's Field
c. Pure Legume	

a. Pure stand of maize as farmer plants.
b. Intercrop of maize and legume. Alternate rows of maize and legume on same row widths and spacing the farmer uses.
c. Pure stand of legume as farmer plants.

4. Population and thinning

a. 50,000 plants/ha	Farmer's Field
b. 25,000 plants/ha	

Row width = 80 cm, between plants = 50 cm. See accompanying sheets on Plant population and Spacing.

a. 50,000 plants/ha will have 2 plants per hill at thinning.
b. 25,000 plants/ha will have 1 plant per hill at thinning.

APPENDIX 2.3

Yasin M. Essa
SMS for Agronomy

Agricultural Extension Training and Farm Management Project
Johar Region
Record Keeping Data for Farming System Approach/Research
Cpmparison Trials for Dayr 1985.

Name of the FEA ______________________________
Name of the Village ___________________________________
Name of Contact/Non-Contact Farmer ___________________________________
Type of Trial ___________________________________

1. Field size a) Jibal ________________ b) Hectare __________
2. Land Preparation Data From _______________ To ________________
3. How many days she/he spent in land preparation __________________
4. Date of Planting From _____________ To _____________________
5. Mode of planting
    a) Yambo _________________ Cost/Man-day ___________________
    b) Tractor _______________ Cost/hour _____________________
    c) Animal Traction _______________ Cost/animal day ___________
6. Man-days he/she spends in planting ________ Cost/man-day__________
7. Date of Thinning From ________________ To ___________________
8. Man-days spent on first weeding and thinning ____ Cost/man-day ___
9. If it occurs, record first weeding date/thinning date
   From ____________ To ______________
10. Man-days spent on first weeding and thinning ____ Cost/man-day____
11. Second weeding date From ________ To ________ Cost/man-day ______
12. Third weeding date From ________ To ________ Cost/man-day_______
13. Canal Cleaning date From ________ To ________
    Man-days spent _________________ Cost/manday ___________________
14. Guarding - Number of persons_______ Cost/person/day ____________
    Number of days _________
15. Harvesting
    Date of cutting _______ man-days spent ______ Cost/man-day ______
    Date of collecting ____ man-days spent ______ Cost/man-day ______
    Date of husking________ man-days spent ______ Cost/man-day _______
    Date of threshing _____ man-days spent ______ Cost/man-day _______

16. The ways of measurement used
    a. Kilogram
    b. Sacks _____________ Weight/sack __________________
    c. Quintal
    d. Suus
17. Yield Obtained (to be recorded on separate sheet where possible)
18. Storage by:
a. Pit _______________ days _______________ Cost/man-day __________
b. Room ______________ ___________ Rent Equivalent __________
c. Drum ________ No. of Drums used ______ Cost/Drum _____________
19. Chemicals Used for Storage
    a. Date of application ____________________
    b. Rate of application ____________________
    c. Sort of chemicals ________________ Cost of chemical/kg _______
    d. Days spent __________________ Cost/manday _____________________

GLOSSARY

Dayr — A Somali word for the minor agricultural season (October-January)

Farming practices — The various operations required in farming, such as land preparation, sowing, weeding, irrigating, harvesting, controlling pests, etc.

Farming Systems — The system encompassing all farming operations, crops and animals.

Gu — A Somali word for the major agricultural season (April-July)

Inputs — Those items supplied by man to his farming system. These may be personal, such as his and/or his family's labour, or purchased such as tillage implements, irrigation, seed, water, fertilizers, chemicals, hired labour, etc.

Jibal — A Somali word meaning 1/16 of a hectare.

On Farm Research (OFR) — (Off- station Research) Conducted at the ETCs, and on farmers' fields. At the ETCs will be applied agronomic research trials as well as demonstration and comparison trials. On farmer's fields will be demonstration and comparison trials.

Quintal — 100 kilograms

Recommendation Domain — A grouping of farmers who will be given the same recommendations, usually grouped because of availability to various inputs, or agroecological differences.

Subsistence Farming — Farming enterprise in which over 50% of the produce is consumed at home.

Technology Development — The working together of the farmer and Subject Matter /Extension Specialists to develop a farming system that is suitable to the farmer.

Yambo — A Somali word meaning hoe.

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