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Final Report • 1983-1988

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UNIVERSITY OF WYOMING

University of Wyoming
Laramie, Wyoming

Published 1990
Printed in the United States of America
Library of Congress 90-071745
ISBN 0-941570-14-2

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Bay Region Dryland Agricultural Research
Final Report • 1983-1988

Bay Region Agricultural Development Project

USAID Project 649-0113

Submitted by

The University of Wyoming Team

The Bonka Dryland
Agricultural Research Station
Baidoa, Somalia
September 1988

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FOREWORD

THE BAY REGION Agricultural Development Project marks yet another step in the progress of Somalia, one of many developing nations in Africa, toward institutionalizing a program of agricultural research to acquire, test, and, where appropriate, adapt advanced technologies to the production process. This project evolved from an earlier U.S. Agency for International Development (USAID) effort wherein the Central Agricultural Research Station (CARS) was created in Afgoi in the 1960s. During the earlier activity, an agricultural extension training center was established with demonstration plots in Baidoa. CARS had a high level of activity directed toward irrigated crops; the expansion of a program into rainfed agriculture required a site representative of the production environment faced by area farmers.

The resulting Bay Project was a multidonor funded activity. Experience gained early in the Project highlighted the need for better multidonor coordination. Once that issue was resolved, host country and foreign expatriate scientists were able to devote serious efforts to addressing agronomic questions in a professional way. The initiation of farming systems research was another step toward enabling the researchers to concentrate on real issues considered production constraints by the farmers of the Bay Region. In addition, the farming systems research (FSR) activity provided an economic base line with the opportunity for periodic data collection to determine progress by crop season.

Cooperation among American resident researchers, officials of the Project Management Unit, and Ministry of Agriculture officials in Mogadishu resulted in selection of participants who were well-suited for advanced degree training in the United States. Coordination between the Somali and American staff in Somalia, and coordination with and follow up by the University of Wyoming training coordinator resulted in a relatively high number of Somalis returning from US training to the Project, thereby enhancing its success. The Bay Project was, in many respects, a showcase of a well-coordinated training activity that constructively contributed to building a Somali research capability for the Project and the future of Somalia.

While one can digress and comment on many factors contributing to the success of this project, the most important factors were the personnel on the Project involved in the day-to-day activities and a few key individuals involved in support of those activities.

For the Somali personnel, two key individuals active throughout the life of the project were the Project Director, Mohamed Warsame Duale, who was instrumental in acquiring critical commodities and resolving personnel and other issues; and Dr. Mohamood Abdi Noor, Vice Minister of Agriculture, without whose consistent support success would have been considerably lessened.

While there were a number of outstanding individuals provided by the University of Wyoming, Dr. Robert Lavigne stands out as a major figure who coordinated, with the Project Director, commodity and research personnel needs, as well as participant training. In carrying out the team leader tasks, Bob saw to the myriad of minutiae essential to the success of a project.

At the University of Wyoming, Colin Kaltenbach, associate dean of the College of Agriculture, represented UW leadership at the working level. His consistent and interested handling of a multitude of issues provided invaluable support to the Project. UW accountant Greg Field provided intensive research and reconciliation of accounts during the critical close-down period of the Project.

In some developing countries, USAID project officers are at times considered impediments to progress by both their host country counterparts and contractor personnel. However, having provided supervision to the two key Bay Project officers for USAID, Flynn Fuller and Rodger Garner, I can attest to the tense times during the life of the Project where both did their best to serve two masters, the interests of the Project and Somalia, and the sometimes cumbersome USAID regulations.

There are many others whose contributions were outstanding, but those mentioned above are individuals without whom the Project would not have been so successful.

Finally, recognition must be given to the donors: USAID, World Bank, International Development Research Centre, African Development Bank, and International Fund for Agricultural Development. The donor officers over the years exhibited the positive interest and concern that contributed to continuous financial support and the success of the Project.

This report attempts to provide a record of what transpired during the active years of the Project, as well as research results generated during the life of the Project. It provides an institutional foundation for continued rainfed research on the Bonka Dryland Agricultural Research Station by Somali researchers. We at the University of Wyoming feel here have been solid accomplishments in institution building as well as semi-arid rainfed research. We would hope to maintain constructive contact with the individuals and the Somali institutions we have been involved with.

J. Raymond Carpenter, Director
International Agricultural Programs
University of Wyoming

(Dr. Carpenter is on a reverse Joint Career Corps assignment to the University of Wyoming under an Intergovernmental Personnel Act (IPA) loan from USAID.)

ACKNOWLEDGMENTS

The success of this research project has been the result of the combined efforts of many people beyond the researchers and the consultants. The field work, supervised and conducted by both UW team members and Somali nationals and their staffs, could not have been possible without the involvement of the Bay Region Agricultural Development Project (BRADP) Project Management Unit (PMU).

The encouragement and support provided by Mohamed Warsame Duale, Project director of BRADP, has helped make this the successful enterprise it has become. His two assistant project managers, Omar Haji Duale and Hassan Abdo Munye, have been most helpful. The assistance of the staff of the Project Management Unit has been invaluable. The untiring support of Dr. Mohamood Abdi Noor, Somali Vice Minister of Agriculture, was greatly appreciated.

Outside the Project, support from USAID has been excellent. Consistent support from the U.S. Embassy, through ambassadors Robert Oakley, Peter Bridges, T. Frank Crigler, and their respective staffs, has been most appreciated. USAID Mission Director Louis Cohen has been an inspiration to all of us, and the entire Team wishes him well in his retirement. Appreciation goes as well to his successor, Lois Richards, whose special effort in individual situations was most appreciated. Special thanks go to agricultural development officers Jerry Neptune, Ray Carpenter, and Ralph Conley, and to Project officers Flynn Fuller and especially Rodger Garner for their help in facilitating the various activities in which the Team was engaged. USAID personnel were most helpful during our stay, particularly the office of the expeditors, which included Carie Yassin Kaire, Abdi Mohamed Issak, Abdi Abdullahi Yusuf, and secretary Faduma Sharif Hassan. Dan Vincent, in the engineer's office at USAID, was instrumental in obtaining for us our most excellent compound manager, Ali Haibeh Mohamed, without whom our living quarters would have been much less pleasant.

At the University of Wyoming, we wish to first express our appreciation to the personnel of the International Agricultural Programs office of the College of Agriculture, who under various leadership (William Smiley, Linda Shill, Robert Julian, Jerrold Dodd, and J. Raymond Carpenter) provided the Team with untiring support and encouragement. Thanks are also due to Harold Tuma, and to Lee Bulla, both former Deans of the College of Agriculture. The former

initiated the Somali Project and the latter provided the support and encouragement leading to its successful conclusion. Tom Dunn, acting dean (between Tuma and Bulla), gave the Project excellent support while in that role and has continued to do so as dean of the Graduate School.

When Ms. Shill, who had worked for Mr. Smiley, assumed the duties of the home office, only one part-time college student assisted her. Wyoming support actually improved, even though Ms. Shill was grossly overworked. Ms. Shill moved to California and Robert Julian, Ken Hoyt, and Sharon Johnson were hired. Dr. Julian's and Mr. Hoyt's expertise added to the program. The current home office team—Dr. Carpenter (and especially his predecessor, Dr. Jerrold Dodd), Elaine Rodgers, Alicia Espinoza, Cynthia Dunn, Margaret Toro, John Sapp, Ken Gavin, and Peter Guernsey—has provided invaluable assistance.

Appreciation and pride go to a Wyoming Team that truly performed as a team: Bernard J. Kolp, Jerry Costel, and Richard Rooney of the first team, 1983-85; Robert Buker, Paul Porter, Nels Andersen, Grant Richardson, Hedera Porter, Julie Howard, Rosemary Buker, Judy Lavigne, and Chai Nyet Fah of the "second wave," 1985-88. Thanks are also in order to Mike A. Smith, Australian dryland agronomist, not only for his expertise, but for "holding down the fort" for the three-month period between teams, then orienting the Chief of Party/entomologist and farm superintendent when they arrived. His successor, Graham Eagleton, provided innumerable examples of his expertise in a superior, professional manner.

We have been proud and pleased to work with the Somali research staff. The support of the current research director, Ahmed Sheikh Hassan, has been inestimable. His contributions to this Project should not go unrecognized, for he is a valuable asset in this position. We appreciate the assistance of deputy director Abdullahi Hussein Wardere, Sorghum Improvement Programme director Hussein Mao Haji, Forage Section leader Addo Adan Magan, Soils Section leader Abdullahi Hussein Abdi, Plant Protection Section leader Ali-nur Hussein Duale, Grain Legumes and Oil Crops Section leader Aden Ali Ossoble, Soil Moisture Section leader Abdi Ahmed Mohamed, Animal Traction Section leader Ali Obsiye Bon, and all their staff. A special thanks to the Farm Operations Section, without which the research sections could not function, and to the district agricultural officers, who were so active in data retrieval for the Farming Systems Section. The

Plant Protection Service Unit is especially recognized for its valuable contributions in the areas of survey, research, and insect control.

Finally, we are grateful to the people of the Bay Region. We could not have succeeded without their unselfish help and good will. We hope that the trust and support they gave us in completing this project will result in a better standard of living in their future.

Robert J. Lavigne
Chief of Party
Wyoming Team
September 1990

Special recognition for their hard work and dedication to publishing this report goes to: Robert Lavigne, senior editor chief of party/entomologist, BRADP; Nancy Nichols and Kim Gould, editors, UW Publications Service; Carol Stevens, designer, UW Graphic Arts; Allory Deiss, computer graphics, UW Graphic Arts; and Judy Lavigne, copy editor, UW International Agricultural Programs.

Chapter 1

USAID Project 649-0113: History and Implementation

by Robert Lavigne

The Bay Region Agricultural Development Project (BRADP)

BRADP is an integrated multidonor development project established by the government of Somalia with the specific aim of increasing agricultural and livestock production in the principal dryland sorghum region of the country. The concept of an integrated agricultural project for the Bay Region was first proposed in 1977 and was inaugurated in 1981 with the financial backing of the World Bank, International Fund for Agricultural Development (IFAD), United States Agency for International Development (USAID), African Development Fund (ADF), and the International Development Research Council (IDRC).

Overall direction of the Project is vested in the Project Management Unit (PMU), headed by the project manager, Mohamed Warsame Duale. The Project consists of four implementation components: the water component (responsible for *wars* and wells), the roads component (responsible for construction and maintenance of the Project road network), the veterinary component (responsible for livestock health), and the agricultural component (responsible for the District Agriculture Office network, the Plant Protection Service, and the Bonka Dryland Agricultural Research Station, or BDARS). It is with the agricultural component that the USAID Project 649-0113 is mainly concerned. Strengthening agricultural research in the Bay Region has been its principal focus.

Mohamed Warsame Duale, project manager of the Bay Region Agricultural Development Project.

Agricultural Research Goals of the Project

The University of Wyoming was brought in as a consultant to render technical assistance for the agricultural research program. The major objective of the agricultural research in the BRADP was to develop and make available production packages that farmers could use to increase production on a sustained and profitable basis. To that end, the contractor provided specialists in the areas of entomology, forage and crop production, agronomy, farming systems, agricultural economics, soil fertility and management, and farm and machinery management. These personnel, both short-term and long-term, have assisted, trained, advised, and, where appropriate, directed Somali Project staff in:

1. Improving and expanding field trials relative to improved methods of crop and soil management.
2. Determining grower production problems associated with rainfed crops commonly grown in the Bay Region and designing and conducting applied research to solve those problems.
3. Analyzing and interpreting research results and preparing appropriate papers, reports, and production bulletins
4. Conducting economic evaluations of available farm inputs and formulating recommendations to be disseminated by the extension service.
5. Establishing a cooperative on-farm research program involving research and extension.
6. Organizing and implementing a training program for the Somali technical and research staff involving in-country, U.S., and Third World country scientists.
7. Establishing and managing a seed farm, seed processing plant, and a central seed storage facility.
8. Establishing and maintaining cooperative relationships with international research centers, institutes, and programs worldwide.

Publications

The University of Wyoming Team and their Somali counterparts produced 21 research papers, 11 publications for local use, 14 work plans, and 51 quarterly, seasonal, annual, and final reports. Additionally, 19 reports were submitted by 14 consultants who visited BRADP and contributed to our understanding of problems facing Somali agriculturists. Copies of these papers and reports were filed in the office of the Chief of Party in the American Compound, and were left there in the charge of the Research Director at the end of the Project. In addition, duplicates of most of these reports and papers were sent to the BDARS library.

Climate

Raingauge stations were established at 11 sites in the Bay Region and personnel were trained in taking data. Gu and Deyr season rainfall data were compiled and analyzed for reliability of rainfall.

New Buildings

The construction of the new building complex was essentially completed in March 1986. This complex included offices for research staff, laboratories for conducting of research, housing for Farm Operations, storage for equipment and parts, and seed storage facilities.

In 1987, a chemical stores building was completed and all chemicals (pesticides and fertilizers) were placed there. These included pesticides formerly stored in the Plant Protection Service warehouse. A signout system was initiated and strictly enforced, with the building being kept locked at all times.

Farm Operations

During the 1983-1988 period, farm operations were consolidated and made more efficient. New farm equipment was purchased, as well as a large variety of tools and parts for both new and old equipment. Parts were obtained for the latter, and these were stored and maintained in one part of the new building complex. A person was hired and trained as stores manager. Other personnel were hired and trained to repair and maintain farm equipment. Safety training programs were initiated for all staff.

Soils

The soils of the Bonka Dryland Agricultural Research Station were characterized and the limitations to sorghum growth and yield were identified. Important elements in farmers' fields had been depleted through years (often 100) of continuous use. The application of commercial fertilizers was shown to substantially increase growth. Method of application of phosphorus, the primary limiting factor, was found to be as important as availability. Soil moisture storage was also found to be critical.

Dryland Agronomy

Efforts in agronomy were constantly expanded during the 1983-1988 period. The work gradually broadened from its focus on climatology, soil moisture, and measurement of fallowing efficiency to include experimentation on intercropping and crop rotations. New plants were introduced, such as safflower and leucaena, which better utilize available moisture. Optimum plant populations were established for sorghum (60,000/ha), cowpeas (75,000/ha), mungbeans (200,000/ha), safflower (150,000/ha), and peanuts (75,000/ha). The importance of weeding intensity, timing, and weeding technique was established and the effectiveness of certain herbicides was demonstrated. Additionally, under an alternate cropping regime, sorghum stubble mulching resulted in a 39 percent increase in mungbean seed yield and 37 percent increase in sorghum grain. An inductive model, the Sorg-f model, was successfully adapted to and tested on the Bonka station to predict the effects of moisture conservation through the practice of clean-fallowing.

Crops

Improved varieties of cowpeas, mungbeans, soybeans, and safflower were obtained from a variety of sources, and these were tested at BDARS. Extra-early maturing varieties of cowpeas and a superior variety of mungbean (Filsan) have been shown to provide increased yields. The latter variety was released to farmers in 1987 and was widely accepted. An increase in peanut production has occurred during the 1981-1988 period, but more research is needed to develop improved varieties that are drought and insect tolerant.

Plant Protection

A plant protection research team was established beginning in 1985. At the same time, the Plant Protection Service Unit was rejuvenated and provided with new direction, which included training in safe storage and safe application of pesticides and collection of biological and distributional data on important crop insects.

Diseases

The role of disease in crops planted in the Bay Region was recognized early. Surveys were conducted throughout the Bay Region; diseases encountered were characterized and methods for their control were developed. From the farmers' point of view, the most successful program initiated was the introduction and free distribution of FernasanD in 9 gm packets for the control of covered kernal smut as well as for the control of insects attacking emerging seedlings. A series of publications on diseases of crops in the Bay Region was produced, several of which were published in both Somali and English.

Insects

Research was initiated and successfully carried out on the role of insect pests attacking sorghum and means of controlling these pests. Insects attacking sorghum in underground storage pits were identified and chemicals for their control were tested. Seasonal history studies on sorghum insects were conducted with the cooperation of both researchers and the Plant Protection Service Unit. The results of multiple chemical trials have been produced in 1988 in a bulletin entitled, "Control of Insects on Bonka Dryland Agricultural Research Station."

Farming Systems

Relevant agricultural research begins and ends with the farmer. With the development of research capabilities by Somali research personnel, efforts were made to expand their influence throughout the Region. Increased emphasis was placed on trials conducted in farmers' fields by the establishment of an off-station section collaborating with the Agricultural Farm Mechanization and Extension Training Center (AFMET). Additionally, two substations were developed for experiments under different environmental conditions and using technology more closely resembling that of the farmers. A Farming Systems Section was established and it obtained a database of information that is to be used for setting research priorities, identifying potentially fruitful areas of research, and to act as a yardstick against which future progress in technology development and new crop adoption can be measured.

Computerization

Computers were introduced to university-trained personnel at Bonka in 1986. Personnel were trained both on the Apple IIc and on IBM compatibles, initially using word processing programs. An ongoing program of computer training was conducted. Research personnel were also trained in the use of statistical packages for analyzing research data and survey data.

Statistical Analyses

Training of Somali researchers in statistical analysis of data was initiated by the first Wyoming Team. More complex analysis of data was introduced by the second Team and further training was provided by a consultant from the U.S. Fish and Wildlife Service in the waning months of the Project.

Staff Development and Training

Approximately 100 research-oriented personnel were trained on research plot technique and subsequently conducted numerous trials over the five-year period. As a result of gaining expertise in field trial technique, Somali research personnel were trained in research paper presentation and presented 15 papers at international meetings. Additionally, personnel were trained in farm equipment use, farm equipment repair, maintenance of parts, storage and maintenance of pesticides, and fertilizer stores. Sixty-one Somali researchers were sent for further training during 1983-1988; 27 of them received university training.

Extension-Research Cooperation

An Extension-Research Cooperative Research Program was developed and initiated. This program continued throughout the 1984-1988 period. A six-member farming systems team was established to achieve a closer linkage between research and extension. Personnel were drawn from staff at BDARS, AFMET, and the BRADP veterinary component. They were charged with the responsibility of formulating objectives of the on-farm program and of coordinating the joint activities of research and extension. The farming systems team concept is a blueprint for a more effective link between research and extension and should pave the way for research to have a direct and relevant impact on farming in the Bay Region. This thrust was in its infancy at the completion of the Project.

JUDY LAVIGNE

Research Director, Ahmed Sheikh Hassan (right) and Deputy Research Director, Abdullahi Hussein Wardere (left).

Chapter 2

The Bay Region: Land, Soil, and Climate

by Graham Eagleton

THE BRADP IS A MULTIDONOR, integrated development project charged with increasing the agricultural production of the Bay Region. This region covers approximately 4 million hectares of the inter-riverine area of southern Somalia (fig. 1). Approximately 350,000 hectares of cracking clay (Vertisol) plains are planted each year with the principal crop, a local race (sorghum bicolor) of durra sorghum. The remaining soils have a lower water-holding capacity and, being less suited to cropping, are used primarily for livestock production. The interaction of soil type with the strong seasonal rainfall pattern results in a unique economic mode within the Region, termed *agropastoralism*. This is characterized by a lifestyle dependent on both cropping and livestock production, activities that are intricately interrelated.

Land

The Bay Region is located between latitude 1°30' and 3°30' N and longitude 42°30' and 44°35'E. It is composed of four administrative districts: Baidoa, Bur Hakaba, Dinsoor, and Qansa Dhere. The capital of the Region is the town of Baidoa located at 3.08°N, 43°38'E and at an elevation of 487 m asl on the escarpment at the edge of a limestone plateau that occupies the northern portion of the Region (fig. 2).

There are three major physiographic units: the limestone plateau in the north (400-650 m asl), the basement complex in the southeast (80-350 m asl), and the limestone depression between the plateau and the basement in the north central part of the Region (350-400 m asl). The

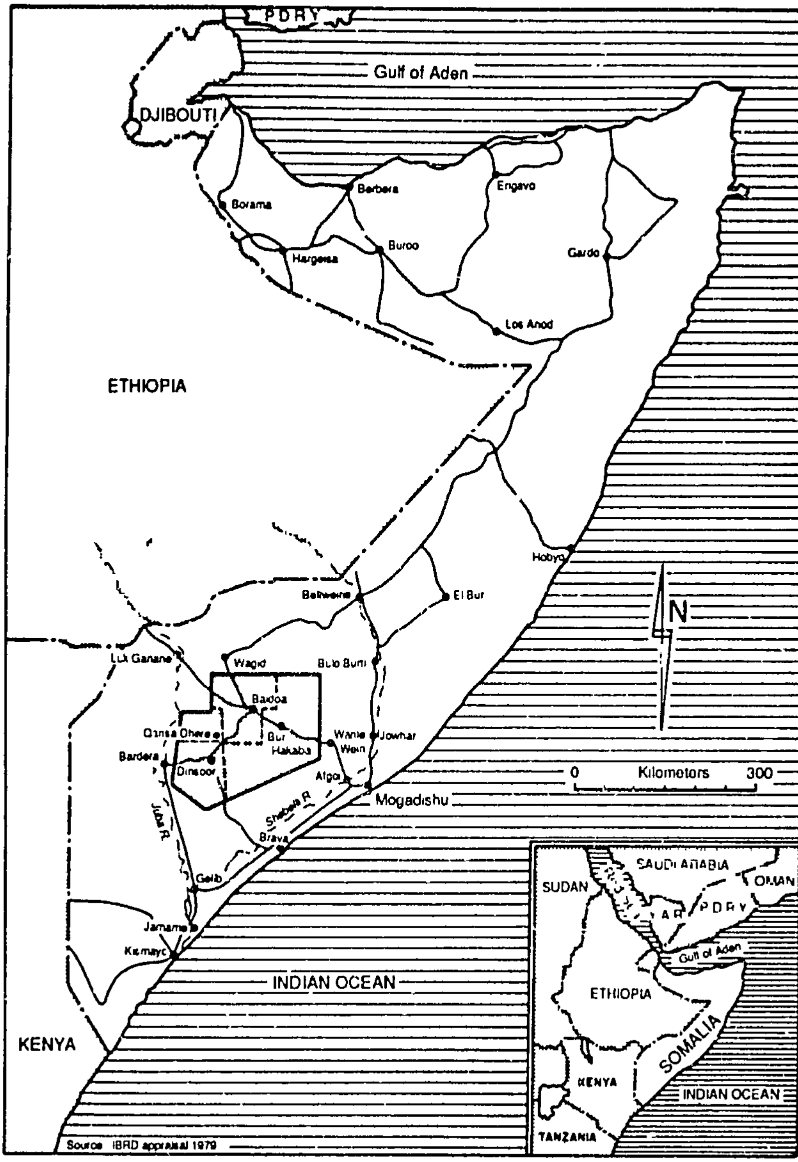


Fig. 1 Inter-riverine area of southern Somalia

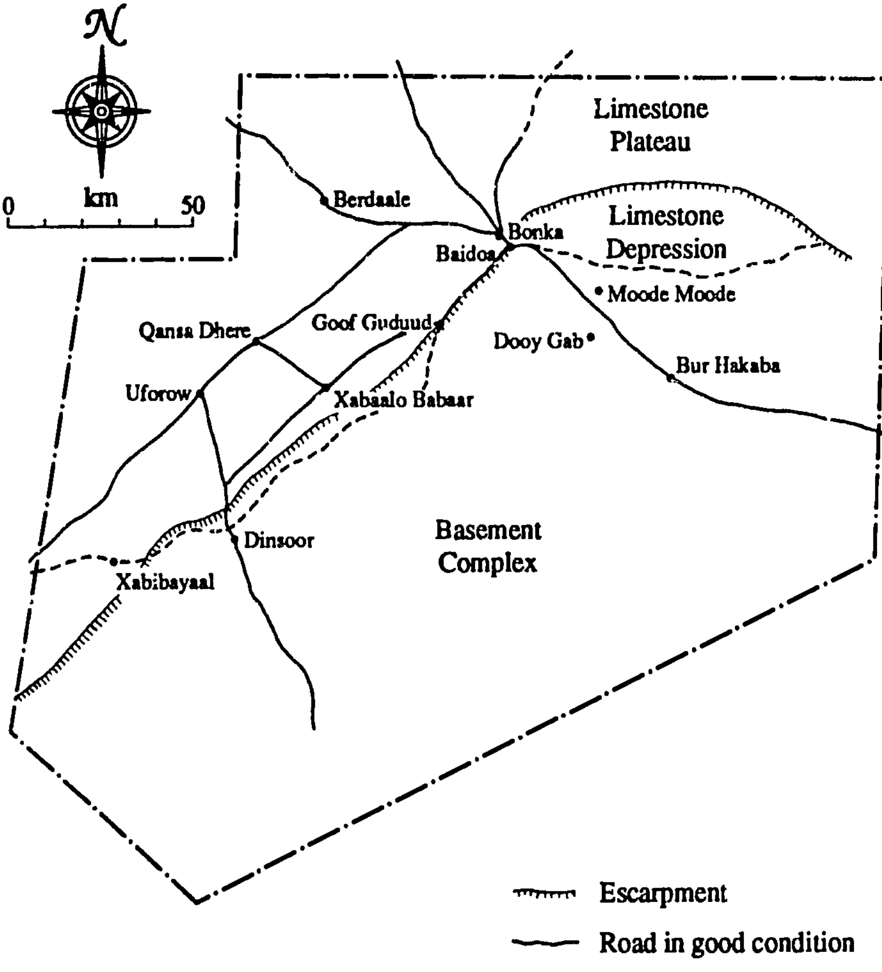


Fig. 2. Land of the Bay Region

limestone plateau has a gently rolling topography with few catchments of any size. The basement is flat, generally with a slight slope from northwest to southwest and drainage lines passing out of the Region to the south. In the basement area, scattered rock outcrops, known locally as *bur*, are a feature of the landscape.

Soils

The Bay Region accounts for less than 7 percent of the total land area of Somalia. Less than 15 percent of the land of the Region is cropped in any one season, yet in recent years it accounted for more than 60 percent of the total sorghum grain production in Somalia. Virtually all the crop production in the Region occurs on Vertisols, which occupy 18 percent of the land area.

Based on soils, vegetation, and geology, the Bay Region has been subdivided into five major geomorphological-ecological units: basement complex peneplain, limestone plateau, basement complex-limestone interface, coastal plain deposits, and clay plains (Lockwood/FAO, 1968; Hunting Technical Services, 1982). The basement complex peneplain, which occupies 29 percent of the Region, is primarily a sandy Ferralsol (Latosol). The calcaric Orthents (Regosols) of the limestone plateau overlay the basement peneplain and occupy 33 percent of the Region. The basement complex-limestone interface comprises a cuesta, which occupies 6 percent of the Region. The majority of the soils in the coastal plains, which occupies 14 percent of the Region, are Orthids (Solonetzic).

The Regosols are located on the periphery of, and spotted throughout, the cultivated Vertisols. The Regosols are better drained and less sticky when wet than the Vertisols. Because of these factors villages are frequently located on the Regosols, adjacent to the Vertisols. This allows the agropastoralists to have immediate access to both cultivated land and land for livestock to graze.

The Vertisols have been classified into five major mapping units: Baidoa, Amin, Mode Mode, Bur Hakaba, and Uiamo (Lockwood/FAO, 1968; Hunting Technical Services, 1982). They have a good water-holding capacity because of their high clay content, are calcareous, and have a relatively high cation exchange capacity. However, lack of plant available phosphorus limits crop growth and yield in many, perhaps most, locations.

ROBERT LAVIGNE

View of Bur Hakaba village and surrounding area from the top of Bur ("rock") Hakaba

Climate

The climate of the Region is described as semiarid tropical and is dominated by the annual movement of the Inter-Tropical Convergence Zone (ITCZ), which results in a distinctly bimodal seasonal pattern.

The weather of the Region is warm and dry (table 1). Baidoa has a mean annual temperature of 26°C, a rainfall of 580 mm, and an annual change of day length of half an hour. Dinsoor and Bur Hakaba are hotter and drier.

Temperatures vary little across the Region and over time. It is usually 2° or 3° C cooler on the escarpment than on the basement plain. June to August is up to 5° C cooler than February to March (fig. 3). If it were possible to irrigate, subtropical species such as maize, soybean, and sunflower would grow well in the Region. Night temperatures are a little too high for optimal cropping of temperate crops like wheat, lentils, and linseed.

Rainfall is bimodal and variable (fig. 4). On average, 45 percent of total annual rainfall in Baidoa falls in the months of April and May, known as the Gu season, and 39 percent in the months of October and November, known as the Deyr season (table 1). The intervening dry seasons, known as Hagar (July to August) and Jillal (January to March), are quite predictable in the low level of rainfall. In the years 1985-87 of this project, April-May was on average a little wetter (59 percent of the total rain) and October-November a little drier (29 percent) than normal (table 3). Crops in the Deyr season of 1986 failed altogether.

The Gu season usually begins to build up in the last dekad (ten-day interval) of March and declines in the first dekad of June (fig. 2). The first Deyr season showers are usually in late September and the last showers in the first dekad ot December. Over the fifty years of records for Baidoa, first emergent rains (>10 mm) of the Gu season occurred in the last dekad of March (M3) on 27 percent of occasions and in the first dekad of April (A1) on 31 percent of occasions. Forty-two percent of late March (M3) plant emergences would have risked failure due to lack of timely follow-up showers, whereas only 6 percent of early April (A1) emergences would have risked failure to establish. Eighteen percent of first Deyr season emergence rains occur in the last dekad of September (with a likely failure rate of 44 percent) and 35 percent in the first dekad of October (with a failure rate of 6 percent).

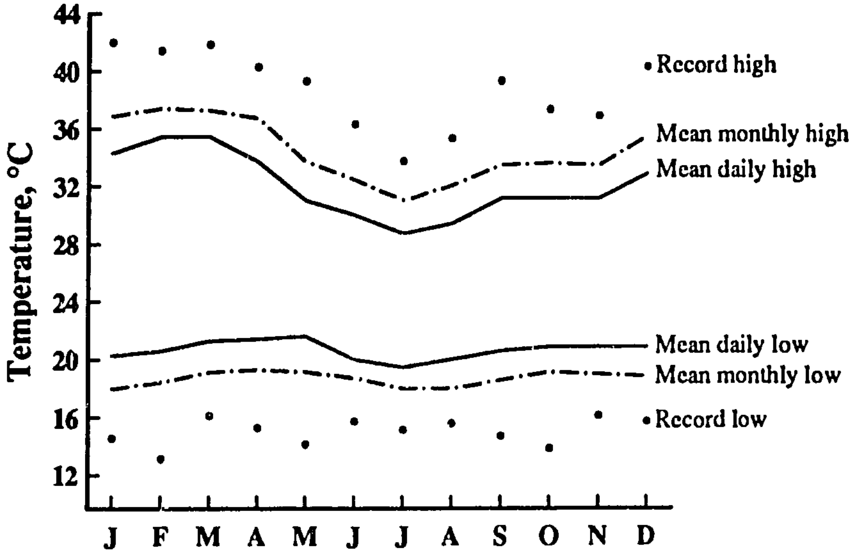
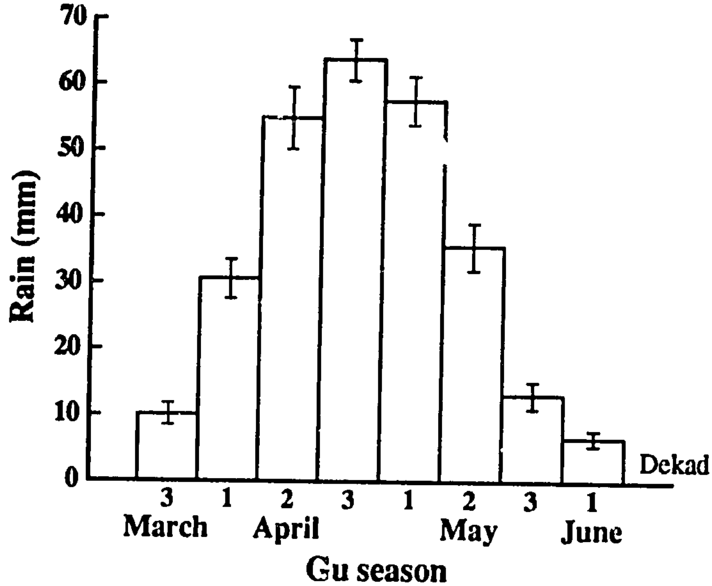


Fig. 3. Monthly temperature means and ranges for Baidoa based on 25 years of intermittent records between 1922 and 1988



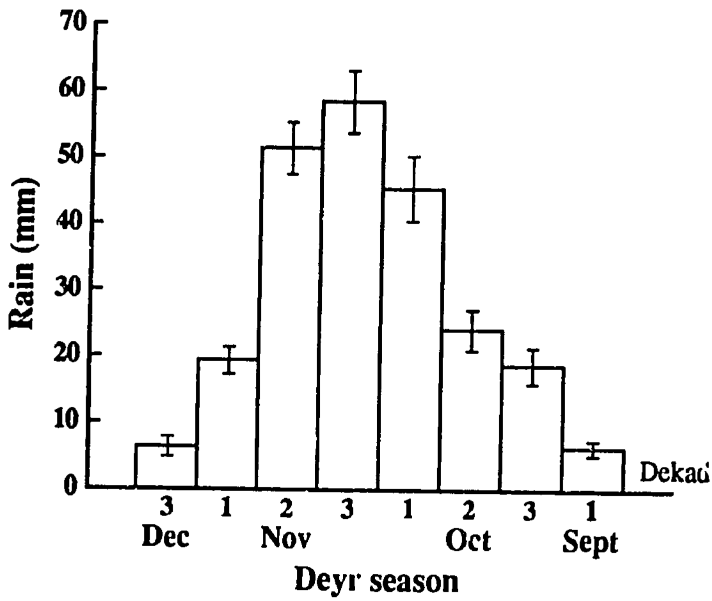


Fig. 4. Mean rainfall and standard deviation of the means, for 10-day intervals recorded across 50 years of Gu and Deyr seasons in Baidoa

In Baidoa the risk of a total Deyr season failure due to inadequate rainfall is twice as high as for the Gu season. Sixteen percent of Gu seasons and 35 percent of Deyr seasons over the fifty years of recording have received less than 175 mm (in eight dekads). Typically, the Deyr season rainfall is of shorter duration than the Gu season.

In many seasons it is usual for one part of the region to be experiencing above-average rainfall while another part is in severe drought (table 4). In 1986-87, Ufurow in Qansa Dhere district had three consecutive seasons without a sorghum crop, while Xabaalo Babaar had optimum yields. In Gu 1988, however, the picture was reversed, with rainfall in Ufurow exceeding that of Xabaalo Babaar by 31 percent. The mean annual rainfall is highest in the Baidoa district. The amount of rain and risk of crop failure becomes greater as distance from Baidoa increases. Dinsoor district has the least reliable rainfall (table 1).

The intensity of individual rainfall events shows similar variability. Between 1922 and 1960 in Baidoa, there was an average of only nine days per annum in which rainfall exceeded 20 mm. An average of three days per year received greater than 50 mm. In the most intense rainfall events measured in the period from Gu 1986 to Gu 1987 at Bonka, 1.4 mm/minute fell for seventy-five minutes (table 5). Rainfall of this intensity can cause significant runoff and erosion in susceptible localities. Fortunately, rainfall events of this intensity are of short duration, and farming areas of the Region are relatively flat.

The effectiveness for crop production of many of the low-intensity rainfall events is less than the total rainfall averages would imply, despite the high moisture-holding capacity of Bay Region soils. Annual average wind speed exceeds 3 m/sec, and preliminary data suggest an average pan evaporation of 240 mm per month (table 1). Evaporation from the wet soil surface is of the order of 3 mm/day and from the dry surface, 0.5 mm/day. Because 50 percent of days experiencing rainfall receive less than 5 mm, most rainfall events have negligible impact on crop growth.

As a result of the low variable rainfall per cropping season, and the high potential evapotranspiration, only the most drought-tolerant crop species are successfully grown in the Bay Region. Sorghum is grown in preference to maize, and cowpeas rather than soybeans. Sesame finds little place in the Region, but safflower appears well-adapted to the climate. While the Gu season can support adapted cultivars of maize, sunflower, dry beans, and peanuts, the Deyr is more suited to millet, mung beans, and cowpeas. For both seasons, sorghum is the staple and will remain so.

Effect of drought on the growth of local sorghum at BDARS

NELS ANDERSEN

Effect of an overabundance of Gu season precipitation at BDARS

The Bay Region is unfortunate in the low overall level of received rainfall per season. However, the excellent moisture properties of the soils, the uniformly equitable temperatures, and the bimodal distribution of rainfall allowing for two crops per year results in a potential annual crop productivity that would be the envy of many much wetter parts of the world. It is a vital resource for Somalia and one that must be developed to its fullest extent.

Table 1: Monthly climatic data for three sites within the Bay Region.

BAIDOA

	DATA YEARS	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
RAINFALL (mm)	52	2	5	23	150	113	16	16	8	13	140	86	11	582
NO. OF WET DAYS	50	1	2	10	7	4	4	2	2	10	7	2	51	
MEAN MAX TEMP °C	25	34.1	35.4	35.5	33.5	30.8	29.7	28.4	29.3	30.9	31.0	31.0	32.7	31.9
MEAN MIN TEMP °C	25	20.0	20.0	21.0	21.2	21.1	20.0	19.3	19.7	20.1	20.6	20.5	20.5	20.4
R.H.percent	19	61	60	63	71	76	72	72	68	66	72	75	67	69
WIND SPEED m/s	5	3.3	3.6	4.0	2.8	2.6	2.9	3.1	3.6	3.6	3.1	2.7	2.8	3.2
PAN EVAPORATION (mm)	2	278	292	346	271	232	149	148	216	236	193	262	260	240
DAILY SUNSHINE (hours)	4	9.0	10.0	8.8	6.6	6.9	6.2	5.3	7.3	6.7	6.1	8.8	8.3	7.5

BUR HAKABA

	DATA YEARS	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
RAINFALL (mm)	24	3	1	11	134	96	15	20	4	11	107	57	10	541
NO. OF WET DAYS	21	0	0	1	6	5	3	3	1	1	6	4	1	31
MEAN MAX TEMP °C	14	34.4	35.8	36.6	35.9	34.9	33.2	32.6	33.0	34.1	34.0	34.3	34.8	34.2
MEAN MIN TEMP °C	14	21.9	21.6	22.7	23.1	23.4	22.8	22.1	22.3	22.3	22.5	22.4	21.5	22.2
8 AM R.H.percent	4	51	51	56	63	68	65	66	61	59	62	62	58	60

DINSOOR	DATA YEARS	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
RAINFALL (mm)	2	2	0	27	132	73	19	12	11	10	80	97	10	473
NO. OF WET DAYS	12	0	0	2	7	5	4	2	1	1	5	5	1	32
MEAN MAX TEMP °C	3	34.9	36.5	37.5	35.0	32.2	30.3	30.1	30.9	32.0	33.1	32.4	33.9	33.2
MEAN MIN TEMP °C	3	20.6	20.8	21.9	21.5	21.9	19.8	19.1	18.4	20.7	21.5	21.0	20.5	20.6
WIND SPEED m/s	2	2.6	3.2	2.5	2.3	1.5	2.4	2.7	2.9	2.6	2.0	1.9	2.5	2.4

Table 2. Distribution of rainfall at Bonka in the Gu and Deyr seasons of 1984 to 1986. The distribution is divided into eight dekads (10-day intervals) for each season.

GU	M 3	A 1	A 2	A 3	M 1	M 2	M 3	J 1	TOTAL
1984	-	-	-	-	-	-	-	-	-
1985	15	25	110	69	43	67	13	-	(342)
1986	0	28	55	63	38	12	66	17	279
1987	0	0	16	27	51	107	35	1	237
1988	10	5	324	81	5	0	0	45	470

DEYR	S 3	O 1	O 2	O 3	N 1	N 2	N 3	D 1	TOTAL
1984	15	1	78	91	14	52	0	8	259
1985	0	1	108	20	32	3	8	0	172
1986	0	10	11	11	7	9	12	3	63
1987	0	0	4	80	70	17	0	0	171
1988	-	-	-	-	-	-	-	-	-

Table 3. Reliability of rainfall in the Gu and Deyr seasons in Baidoa based on 50 years of records.

	TOTAL (mm)		percent YEARS WHEN RAIN WAS LESS THAN				
	MEAN	SD	100	125	150	175	200 mm
GU SEASON	281	123	4	4	10	16	28
DEYR SEASON	241	147	17	19	25	35	46

Gu season is here defined as the period from and including the third dekad (10 day interval) of March to the third dekad of June. Deyr season is from third dekad of September to the first dekad of December.

Table 4. Gu and Deyr season rainfall at sites in the Bay Region between Deyr 1986 and Gu 1988.*

	DEYR '86	GU '87	DEYR '87	GU '88
DINSOOR	124	260	258	244
BUR HAKABA	87	409	261	222
QANSA DHERE	70	304	99	249
BONKA STATION	63	237	171	470
BONKA FARM	-	164	230	435
MODE MODE	-	229	203	190
TOOSWEYNE	-	181	174	359
BERDALE	-	245	141	182
MANAAS	-	262	208	207
XABAALO BABAAR	-	325	259	280
UFUROW	-	104	82	368

* Gu season = third dekad of March to first dekad of June.
Deyr season = third dekad of September to first dekad of December.

Table 5. Intensity of rainfall recorded in tipping bucket rain gauges at Bonka and Qansa Dhere between Gu '86 and Gu '88.

	GU'86	GU'87		DEYR'87	GU'88
	BO	Q'D	Q'D	Q'D	BO
NO. OF DAYS RECORDED	13	5	11	10	13
MEAN DURATION PER RAINY DAY (min)	74	357	283	393	295
MEAN RAINFALL PER RAINY DAY (mm)	11	21	20	8	29
MEAN INTENSITY PER RAINY DAY (mm/min)0.1	4 0.06	0.07	0.02	0.09	
INTENSITY OF MOST INTENSE RAIN EVENT*0.45 (mm/min)	0.75	0.40	0.42	1.39	
DURATION OF MOST INTENSE RAIN EVENT (MIN)	40	12	42	24	75
NO. OF DAYS INTENSITY >0.25 FOR DURATION >15	9	1	4	2	8

* Rain event = a single unbroken fall of rain
BO = Bonka
Q'D = Qansa Dhere

Chapter 3

The People and Culture of the Bay Region

by Garth Massey

The Bay Region and Its People

THE PEOPLE OF THE RURAL BAY REGION share many similarities with the Somali people of the northern and central regions of the country, yet have several unique characteristics. Among these are their dialect of *Afmay-may* and the preponderance of households engaged in both farming and animal-keeping.

The physical environment of the Bay Region is one of infrequent and scattered rains that allow for two growing seasons, though poor rains sometimes nullify efforts to obtain adequate food by farming activity alone. Inconsistency of soil types provides for cultivable areas broken up by sandy and rocky soils, or else stretches of land suitable only for grazing spotted with arable soils. Hand-excavated, rain-fed ponds and wells numbering several thousand are the major source of water for both humans and animals. These allow for village settlements and farming to exist alongside livestock-keeping, though the annual movement of animals, and sometimes whole families, to available water is common.

Excluding the populations of the four district capitals — Baidoa, Bur Hakaba, Dinsoor, and Qansa Dhere — there are about 432,000 people in the Bay Region, which covers an area of approximately 40,000 square kilometers. Most of the rural people live on scattered homesteads near their fields or in clustered villages containing, on average, 52 separate households. Because each household has an aver-

GARTH MASSEY

Nomad hut under construction. Material in foreground will cover frame. The entire house was carried by the camel in the background.

age population of 5.8 persons, the average village size is a little over 300 people. There are an estimated 1,494 villages in the Bay Region, with those families living on scattered homesteads identifying themselves as being attached to one of these villages. High cropping areas have a higher population density, though the villages are actually smaller than in areas where livestock-keeping is more important.

Salient facts about the population include:

1. The median age of males is 21.6 years while the median age of females is 18 years.
2. Median age at marriage for women is about 17 years.
3. A first child is born, on the average, in a woman's nineteenth year and each subsequent child is born about 2.3 years after the previous one.
4. Women who complete their childbearing years (about age 35-40) will have an average of 5.3 children, but because some women die prior to this age, the average number of children per woman giving birth is 4.9.
5. The fertility ratio in 1983 for women who had ever been married was 636, and the crude birth rate was 54.89, high figures compared to many countries of the world but not unusual for lesser developing countries (LDC's) such as Somalia.
6. The infant mortality rate is 156 per 1,000 births; about one in six children die in their first year. About three children in four survive to adulthood (age 15).
7. Adult women are most likely to die during their childbearing years, and the median age of death for females is 35 years. The median age of death for men is 50 years. (Note: Misreporting of ages makes these latter figures somewhat suspect.)

The household in the rural Bay Region is a semi-autonomous economic unit that usually extends to no more than two generations and only occasionally contains relatives beyond the nuclear family unit. Sixty-two percent of all households surveyed contain only parents and their children. In about a quarter of all households, persons reside who are related to the household but not immediate family (spouse or child). Seldom will two or more of a man's wives share the same household.

Though polygamous, only about 20 percent of all married men have more than one wife at any one time. If they marry a relative, people are most likely to marry (in about 20 percent of all cases) their father's brother's daughter or son. Sixty-eight percent of all marriages, however, are not between close relatives. Divorce is not uncommon, and most persons will have more than one spouse during their lifetime. Adult men seldom live without a wife, but women frequently will not remarry after they have completed their childbearing years.

Villages are governed by groups of elders who also occupy positions as village chairpersons and governing committee members authorized by the government of Somalia. Crossing family lines, these individuals mediate disputes and arrange village-wide activities through practices of consensus formation. Water disputes are handled separately by the individuals who control or are responsible for the water source, as well as those who, by payment or contributing labor, have access to the water.

Literacy in the Bay Region is very low, despite the Literacy Campaign of 1973-75. Twelve percent of all males over the age of four can read and write the Somali language; this figure is 2 percent for similar females, yielding an overall literacy figure of 6.5 percent for the Region. Fewer than 5 percent of all males and 1 percent of all females over the age of four have attended government school.

Illness and disease are most often treated by traditional healers, including sheiks. Though Western medicine is remotely available to most villagers, it is used within the framework of traditional disease causation and healing beliefs. Pharmacies are the most common source of Western medicine. The greatest health problem for most adults is bronchial pneumonia. Women often suffer from a combination of anemia, toxemia, and protein deficiency, which is most acute during pregnancy. Gonorrhea and syphilis are serious health problems for adults. For children, infectious diseases, including measles and whooping cough, compounded by protein and energy deficiencies are major causes of death.

Work and the Organization of Labor

The people of the rural Bay Region are accurately described as agropastoralists. They overwhelmingly are involved in both crop production and animal-keeping, revealed first in their identification with specific types of labor. Most men and women identify themselves or are identified by the head of household as being farmers: 53 percent of

GARTH MASSEY

Brahma cattle with herder at local watering place, or "war."

all men and 44 percent of all women. Twenty-two percent of all men and 10 percent of all women are identified as either herders or farmer-herders. Men are much more likely to identify themselves as being herders if they are under 25 years of age. Only children are most likely to be identified as herders, and young girls are often identified as "mother's helpers."

Work groups are formed to farm and to care for livestock away from the village. Those doing farm work vary from informal groups of neighbors who work for part of a day or a single day to groups that regularly work together over an entire season. The most permanent work group is composed of similarly aged young men who provide help to each other and those in need on their fields or with their animals; this group often forms a social club that is discouraged in more orthodox villages. Formal cooperatives are not readily found in the Bay Region, though notable exceptions include villages where a respected religious figure dominates village life. Government efforts to form and support cooperatives have met with little success.

In 30 percent of the cases, a family's animals are herded among those of another family, although they are seldom herded by a non-family member. People may be hired to do farm work, however, with 15 percent of all households having hired others to work for them in the past several years. Business and wage employment is very unusual for women; men are about five times as likely to do such work. This usually involves owning or working in a small shop but also includes work as a Koranic teacher, soldier, house builder, hauler, blacksmith, charcoal maker, driver, guard, or animal trader.

Farming and Crop Production

Crop production is strongly regulated by unpredictable weather, availability of labor, livestock production needs, a very rudimentary but well-adapted technology, and little control over pests and crop diseases. Still, most people of the rural Bay Region seek to maximize their production of grain and would prefer to increase their farming activities at the expense of livestock production if their efforts would safely assure an improved standard of living.

The major crop in the Region is sorghum, of which the local variety dominates. Several interconnected factors influence people's preference for one type over others, and these have played a role in the unwillingness to adopt introduced varieties of sorghum. The most common introduced sorghum variety, GBR, has been tried in 34 of the

ROBERT LAVIGNE

Local farm plot

83 villages surveyed, but is being grown now in only three villages. Other crops grown in the Region include cowpeas, maize, soybeans, mung beans, groundnuts, and irrigated crops in a few areas. The people are favorably disposed toward these and would like to increase their production if possible.

Nearly all crop production is performed by the *yambo* (hoe), which has several advantages but greatly limits the amount of cultivation one person can do as well as the quality of weeding — the most critical of agricultural tasks. Though previous land inventories have indicated that there is much land available for cultivation, this is (in almost all cases) land where there is little possibility of obtaining or storing permanent water, and where obtaining or storing such water is difficult.

Land is considered to be privately owned but is seldom acquired through purchase. It is more likely to be loaned to a family or person in need or with temporarily available household labor. Most commonly, land is acquired through inheritance, a traditional practice that usually transfers land to the son around the time of marriage.

Several previous studies of the size of family landholdings and the amount of land cultivated have provided strikingly contradictory findings. Based on 590 household reports, it was found that the average household farms about 1.93 hectares or about one-third hectare of land per person.

The production of sorghum was low during the year of this research (1983-84). Families with a harvest averaged 10.19 quintals of sorghum in the spring and 11.19 quintals of sorghum the previous fall. The distribution of production is skewed by a few farms producing far more than the average, and the median total amount produced for both seasons combined is 14.9 quintals.

In terms of family food needs, the United Nations Food and Agriculture Organization (FAO) estimates indicate that an individual needs about 1 to 1.5 quintals of sorghum per year to receive between 1,000 and 1,500 calories per day from sorghum. Reports by villagers about their food needs similarly indicated that the average household of five to six persons would need a minimum of 12 quintals of sorghum per year. These figures show that households are providing for their basic subsistence needs in grain, with little surplus production available for sale.

Obstacles to increased crop production include climatic factors, diseases and pests over which the farmer has little control, poor weeding practices, unsystematic seed selection procedures, poor transporta-

BERNARD KOLP

Drying local sorghum heads prior to underground storage in "bakars."

tion which limits the availability of inputs as well as marketing, and low producer prices set by the Somali Agricultural Development Corporation (ADC).

Herding and Livestock Production

Only 20 percent of all rural households in the Bay Region do not have some livestock holdings (camels, cattle, goats, or sheep). The number of animals a household owns is directly related to the size of the household, a fact true for both camel and cattle ownership. Age of the household head also explains livestock holdings, with households headed by a man aged 45 to 64 having the largest number of cattle. Households headed by males aged 55 to 70 are most likely to have the largest number of camels. For nearly all the people of the Bay Region, however, animals play a major economic role, providing both food and power while requiring significant labor inputs and major consideration in the decisions families make about the allocation of scarce resources. Women are less likely to own animals than are men, but female household heads are nearly as likely as men to own large livestock, though the number of animals is usually less.

The basic diet of the rural people is sorghum and milk. Milk is vitally important to the diet of children, and for those herding away from the village and in the dry season when stores of grain are depleted, the availability of milk will determine people's life or death. Ghee (clarified butter or fat), too, is an important part of the diet, and meat is occasionally consumed, providing an irregular but valuable source of protein.

Animals are valued and require different considerations based on several characteristics. Their ability to withstand drought and to travel long distances is critical, as is the forage they are able to consume, the reliability and amount of milk they provide, their market value, labor requirements, and utility in meeting obligations for religious rites and family observances. Each of these must be addressed in considering changes in herd management strategies.

Herd composition and reproduction rates based on Project data indicate that people seek to maximize the production of milk ahead of all other considerations. For camels the reproduction rate is one new birth every 5.4 years for mature females; for cows the reproduction rate is only one calf every 3.9 years. This is barely half the rate that could be achieved under more favorable circumstances and indicates an inefficient operation for the production of milk and the reproduction of the herd. Cattle herd management may be slightly more efficient among smaller than among larger herds, with 25 percent of smaller herds composed of lactating females, 39 percent composed of dry mature cows, 5 percent bulls, 16 percent immature females, and 15 percent immature males.

In understanding the determinants of animal husbandry practices, it is clear that the Region can be divided into groups of those who raise crops, those who raise animals, and those who have a mixed economy of crops and livestock. Livestock practices are tied to farming practices in many complex ways. This linkage is based on and helps to determine livestock movement within the Bay Region, patterns of herd growth and change, and the role of livestock in subsistence and commercial activities. Major constraints on livestock production include the seasonality and unpredictability of rains, the cycle of necessary farming activities, the significance of the location of farms in relation to grazing areas, and the cycle of family growth and the changing composition of family members.

Livestock movement is neither haphazard nor perfectly consistent from one year to the next. Watering needs and the availability of water, availability of grazing, insect infestations, market prices, level of sorghum stocks, utility of committing labor to farm work, and need to seasonally avoid some soil types make for a constant adjustment of movements. Most livestock are moved from one area to another in close proximity to the village. Longer distances are covered at the height of the dry seasons and usually follow a north-south path, with those herds in the northern part of the Bay Region often going into the Bakool Region and those near Baidoa and to the south going to the Lower Shebelle Region.

Both traditional practices and economic activities are applied to keep labor as well as livestock numbers and herd composition in balance. These include the inheritance of livestock at marriage and the transfer to relatives in need. Also observed are practices of infrequent hiring of herders, allowing more or less milk to go to calves, and the trading of livestock. For nearly all families in the Bay Region, the maintenance of herd and household viability rather than the intention to make a profit from livestock transactions is the reason behind people's actions.

Marketing and Commercial Activities

Most people in the rural Bay Region live outside the monetized economy, producing nearly everything they need and engaging in minimal market activities. This is likely to change in time, however, as opportunities are made available and demands for medical treatment, education, veterinary services, crop protection, and consumer goods increase.

In half of the surveyed villages sorghum had been marketed in the past year, but in only half of these was it sold in both Gu and Deyr seasons. In a quarter of the villages sorghum is either never marketed or rarely marketed. Marketing varies directly with the quality of the farming and the availability of markets relative to each village, as would be expected. In the spring season of 1983 only 6 percent of the households with a yield marketed any sorghum; this figure was 11 percent for the previous fall season. Those that did market usually sold only small amounts to meet daily needs. In some cases, during the dry season sorghum was sold to purchase water. More frequently, in times of great need animals were sold to purchase sorghum.

In addition to low levels of production, market prices greatly influence the amount of sorghum sold. In fact, production is probably less when market prices are low than when they are high. Production was especially low during 1983, when the ADC price was fixed at 150 Somali shillings per quintal. This study indicated that farmers could expect to profit by only 14 shillings per quintal at the fixed market price, a figure consistent with an earlier FAO report. The lifting of ADC price controls on grain in late 1983 resulted in hardship for those needing to buy sorghum, but producers said they intended to increase their production if the price remained above 300 to 500 shillings per quintal.

Groundnuts are an increasingly popular crop to produce, largely because of their selling price. Cowpeas are also popular but must be marketed immediately after harvesting due to a lack of available storage facilities. This drives the price down and inhibits increased cowpea production. The marketing of agricultural products is confined to the above, except for irrigated crops grown in a few villages near major towns.

It is more common for women than men to be involved in the sale of items, with the exceptions of large amounts of grain and the sale of animals. Women are the major marketers of animal products and other items such as mats, vessels, sorghum stalks, ropes, and hides. Lack of transportation is a major constraint on marketing, and apart from those villages near larger towns, trading and sales are confined to the local villages.

Animal products that are sold include eggs (over half of all households with sales had sold eggs), ghee (about a third had sold ghee), and milk. It is much more likely that a household will calculate its labor and livestock needs with an eye toward sales of livestock products than toward the sale of animals.

Commercial livestock production is limited to small producers who have only occasional needs for cash income and to large producers who are engaged in livestock buying and selling as a business. The former has no deliberate sales strategy, while the latter uses market fluctuations to his advantage. The former will be less likely to practice castration or preweaning slaughter than the larger producer, concentrating more on herd growth than on sales.

Of the 815 households surveyed, 50 had sold cattle in the previous year and 30 had purchased cattle, showing the general pattern of animal sales versus acquisitions. Using these and other figures on cattle and camel sales, it is estimated that approximately 59,000 households in the Bay Region have cattle, and among these nearly 8,000 cattle were sold and slightly less than 6,500 were purchased in 1983. In comparison, over 20,000 households have camels, nearly 3,500 camels were sold, and about 2,200 camels were purchased by households in 1983.

Livestock traders play an important role in the link between small producers and the market. Market rationality is seldom the rule by which traders are able to operate. Most producers sell according to their immediate needs rather than market fluctuations and seek to increase their female breeding stock, thus placing a higher value on them. Traders are prohibited from selling reproductive stock for export and so must purchase male slaughter animals of lower value. Consumer demand follows the Islamic cycle of holidays, which bears no relationship to the seasonal cycle of rains and drought that affect the quality of animals as well as herd movement and development. Efforts to increase animal production for marketing must take into account this complexity of factors in implementation plans.

Project Implementation Recommendations

Within the context of various obstacles to increased production, several areas of proposed activity can be suggested. These include vastly improved health provisions with special attention to maternal, infant, and early childhood health.

Women should be a more direct focus of implementation efforts. They serve as major producers and sources of labor in the Bay Region. Increasing their well-being, their time available to engage in more profitable economic activities, and their receptivity to innovations is fundamental to any positive change in the Region. The use of various appropriate technologies would be a useful first step in this direction.

Bay Region farmers utilize extensive rather than intensive production techniques. This is partly due to the existence of a surplus of resources vis-a-vis people to exploit them. However, as population increases in response to better health care, there will be a need to increase crop production. Grain storage will need to improve. This requires a greater understanding of the traditional storage system and efforts to enhance it by means of locally available materials. The use of manure and other means of enriching soils and preventing soil depletion (crop rotation, improved tillage, and so forth) should be considered. Help in reducing losses to birds and the eradication of noxious weeds and bushes is strongly desired by the subsistence farmers. A greater appreciation of the reasons people prefer or reject certain sorghum varieties is needed, as is research designed to enhance the local variety of sorghum. The use of draft animals can be found in many parts of the Region, but problems in providing adequate forage and water in the dry season as well as provision of appropriate knowledge and the means to till and cultivate fields present obstacles to this.

Government services are unavailable or underutilized throughout the Region. Past experience has led to some distrust on the farmers' part, which must be overcome with a more effective agricultural extension effort. Veterinary services are the most widely used, but there are immediate problems there, too.

The Bay Region is an agropastoral environment, and any proposed changes should recognize the many links between the production of crops and the production of animals and animal products. Agropastoralism is probably the healthiest and most resilient production system for this environment and should be maintained as efforts to increase production proceed.

Chapter 4

A Dryland Agricultural Research Station in the Making: The Early Years, 1983-1985

by B. J. Kolp

Mid-Term Review

A MID-TERM REVIEW WAS CONDUCTED by Hunting Technical Services Ltd. (HTSL) midway through the Project. At this time the building of roads in the Bay Region was a major concern of the Project management. Because the agricultural research phase involving the Wyoming Team was late in starting, the mid-term review occurred just a few months after three members of a proposed five-member Wyoming team arrived in country. No changes in the specialists' positions or equipment could be made until completion of the review. The contract was amended after the review, and suggested amendments were submitted on January 12, 1984.

Equipment and Buildings

Equipment and office space was limited and laboratory space was nonexistent in the first years. Construction of the BDARS began on February 22, 1985. Some of the delay in construction was due to building plan changes for the seed farm (seed processing and drying building and Baidoa workshop were routed to BDARS). Adjustments in the initial plans were instituted. Even though delays were frustrating at the time, they proved to be beneficial.

Soil Variability

Extreme variation in the soil at the BDARS caused many problems with field experiments. In the early years coefficients of variation (CVs) exceeding 120 percent were calculated. To have usable results, the CVs should be below 20 percent, preferably in the 10 to 14 percent range. Proper tillage equipment was unavailable at the station. Due to delays in ordering, the new equipment did not arrive until after the departure of the Director of Research in 1985. In order to improve the appearance, seed bed, rainfall distribution, and precision in planting, a land leveler was obtained from the Central Agriculture Research Station (CARS) at Afgoi.

Transportation and Fuel Shortages

Due to severe fuel shortages several times during the two-year period, farming operations had to be curtailed as well as travel to Mogadishu and within the Bay Region. Not all of the off-station trials or surveys were attempted because of lack of fuel. Harvesting sorghum, mung bean, cowpea, and peanut trials in a given area requires several trips, as they do not mature at the same time. The mung bean and cowpeas are indeterminate in flowering; to be properly harvested, they must be picked two to three times. In the Gu '84 season, these crops were not harvested on time or were stolen; therefore, research data was lost. More detailed information is furnished in Chapter 9, Grain Legumes and Oil Crops.

Student Training

A number of research personnel holding bachelor of science degrees from the Somali National University and some having secondary degrees were sent outside of Somalia for further training. Seventeen returned with M.Sc. degrees; one with a Ph.D; one with an associate of arts degree, and one has just obtained his B.S. degree. As a result of this program, several well-trained people have returned and are making valuable contributions to the BDARS program in research and leadership.

From the long-term aspect, sending the researchers abroad for further training greatly enhanced the total research program. From the short-term aspect, it depleted the experienced research staff. At the

WESLEY SEAMANDS

Original office building at BDARS, 1983 time of the arrival of the 1983-85 Wyoming Team, the Project was fortunate to have one experienced person with a bachelor of science degree in each research section. Fortunately, in Somalia a candidate for the bachelor of science degree must conduct research. Mohamed Mohamed Sheikh (Safat), a person with secondary training, was in charge of the Grain Legumes and Oil Crops Section. He was an outstanding individual who was sent to the United States for training.

Research Accomplishments, 1983-85

Before any progress could be made in research, several research constraints had to be dealt with. The research personnel at BDARS lost several of their trials during the 1983 Gu season that should not have been lost. Only 287 mm of rain fell during that season, but that is adequate for crop production. Yield results were obtained during the 1983 Deyr season with only 85 mm of rainfall.

Factors that resulted in loss of research data during the 1983 Gu season were (1) poor stand establishment resulting from poor seed, poor placement of seed, poor seedbeds, as well as insects, and soil-borne and seed-borne pathogens; (2) excessive soil variation; and (3) poor experimental plot technique.

1984 Gu Season

Total rainfall for the season was only 82 percent of normal, and 50 percent of it fell between April 18 and April 30. From April 18 until July 31, 235 mm of rain fell. Normal for this period is 281 mm.

Areas of research were broadened to include intercropping trials involving sorghum with cowpeas, mung beans, and peanuts. Plant population trials were initiated on sorghum, peanut, and sunflower cultivars. Successful planting date trials were conducted on mung bean and local sorghum varieties. Those data were lost due to birds, insects, diseases, soil variation, porcupines, and thievery.

An extension-research cooperative research program was developed and initiated. A sorghum plant population trial and sorghum, mung bean, and peanut planting date trials were established on the Extension Training Center.

Thanks to the assistance of Dr. Fred Gray (UW Plant Pathologist, consultant), it was possible to identify several diseases attacking the crop plants and take meaningful disease notes.

BERNARD KOLP

Cowpea variety trial at BDARS in 1984

1. Variety Trials
   a. Cowpeas
      Ashy stem blight caused by Macrophomina phaseolina, bacterial blight caused by Xanthomonas phaseoli, and powdery mildew attacked the cowpeas in the cowpea variety trial. The local blackeyed cowpea entry showed the most resistance to bacterial blight. Only 7 percent of the plants were diseased, compared to 37 percent for Tvr 1502-19. The blackeyed local produced 0.73 q/ha compared to Tvr 1502-19, which produced only 0.34 q/ha.
   b. Mung beans
      Large differences were noted in resistance to ashy stem blight. The Local Bonka entry and VC 2565 Sel A showed only 6.6 percent and 4.0 percent diseased plants, while some entries showed as high as 50 percent infected plants. The droughty, weakened condition of the plants enhanced the disease level of ashy stem blight.
   c. Safflower
      The highest yielding safflower cultivar was VC 152, which produced 3.23 q/ha. This was a good yield, considering the dry season.
   d. Soybeans
      The African armyworm and rabbits attacked the cultivars in the soybean variety trial. The rabbits ate the apical parts of the plants, seriously reducing growth. Even with extensive damage, Otootan produced 1.35 q/ha.
   e. Peanuts
      Rhizoctoria root and pod rot was found in the yield trials. In spite of the disease and drought, the cultivars averaged 3.53 q/ha. The highest-yielding, V31, produced 5.71 q/ha, compared to the local check, which produced only 2.97 q/ha. Peanuts are a good cash crop for the farmers in the Bay Region.
   f. Sunflowers
      The sunflowers were disease-free. The highest- yielding entries were Sorem 82 and RO 22, producing 4.07 q/ha and 3.83 q/ha of air dry seed, respectively. RO 22 was the highest yielding entry in the 1983 Deyr season sunflower yield trials. The local early entry produced 1.65 q/ha and the local late 1.43 q/ha. It was noted during the 1983 Deyr season that

early and late types existed in the local used as a check. Selections were made and tested as separate entries during the 1984 Gu season.

2. Plant Population Trials
   a. Peanuts
   The average peanut yields for 100,000, 130,000, 160,000, and 190,000 were 2.94, 3.08, 2.96, and 2.44 q/ha, respectively, at BDARS. These differences were not statistically significant; however, yields tended to decrease when population exceeded 160,000 plants per hectare.
   b. Sorghum
   Sorghum populations of 20,000, 30,000, 40,000, 50,000, 60,000, and 70,000 plants per hectare resulted in yields of 3.84, 6.25, 6.88, 7.03, 6.76, and 5.68 q/ha. The yields were not significantly different: however, yields did increase to a high of 7.03 q/ha at a population of 50,000 plants per hectare. The variety x plant population interaction was non-significant, indicating that GBR-148, Local, and Dabar responded the same to changing plant populations. As an average of all populations, Dabar, GBR-148, and Local produced yields of 7.22, 6.11, and 4.90 q/ha. Dabar yielded significantly more than the local.
   A sorghum plant population trial was established at the Extension Training Center by the extension-research coordinating committee. Grain yields could not be obtained because several heads were stolen prior to harvesting. Forage yields were collected. Air dry forage yields were 359, 387, 415, 442, and 470 kg/ha from plant populations of 20,000, 30,000, 40,000, 50,000, and 60,000 plants per hectare. Grain yields on the BDARS peaked at 50,000 plants per hectare, whereas forage yields tended to increase to 60,000 plants per hectare.
   c. Sunflowers
   Seed yields of sunflowers grown at 30, 40, 50, 60, and 70 thousand plants per hectare were 1.78, 1.94, 2.20, 1.97, and 1.88 q/ha. No significant differences were noted among populations; however, yields tended to peak at 50,000 plants per hectare.

3. Planting Date Trials
   a. Mung beans
      Mung bean planting date trials were planted at the BDARS and the Extension Training Center. Planting very soon after the first rain resulted in the highest yields at both locations. Planting two weeks after the first rain resulted in the lowest yields. Mung beans are early in maturity, and during the Gu season, which is longer than the Deyr season, it appears to be possible to wait until after the first rain to plant mung beans. At BDARS, the earlier the planting date the higher the percentage of plants attacked by charcoal rot. The heavily infected early planting, however, yielded more than the late planting. Mung bean plants resulting from planting before the rains were 78 percent infected by charcoal rot, whereas only 11 percent were infected when planted two weeks after the first rain.
   b. Sorghum
      Sorghum planted at the Extension Training Center before the first Gu season rains (April 2), just after the first rain (April 20), and two weeks later (May 4) resulted in air dry forage yields of 299, 229, and 161 kg/ha. Heads were stolen from the plots prior to harvest, making grain yield determinations inaccurate. The correlation between grain and forage yields in another trial was calculated to be 0.98, indicating that grain yields would be similar in magnitude to the above forage results.

4. Intercropping Trials
   a. Sorghum-cowpea trial
      Cash returns from sorghum and cowpea production were estimated. Assuming the price of cowpeas is 24 shillings per kilo and the price of sorghum is 12 shillings per kilo, pure sorghum gave the highest return of 5,394 shillings per hectare and pure cowpea stands the lowest with 1,080 shillings per hectare. Cowpeas in the intercropping trial were not seriously attacked by ashy stem blight and bacterial blight.
   b. Sorghum-mung bean trials
      In this trial the mung beans were given a value of 24 shillings per kilo and the sorghum 12 shillings per kilo. The mung beans only produced 5.37 kg/ha at a value of 126 shillings. The intercropping ratio of 2 mung beans to 4 sorghum plants produced an income of 1,812 shillings.

c. Sorghum-peanuts trial

In order to compare the different treatments, the sorghum was valued at 11.6 shillings per kilo and the peanuts at 32.6 shillings per kilo.

The pure sorghum yields in this plot were very low, with an average yield of only 1.95 q/ha with a value of 2,269 shillings. The highest treatment was the 3 sorghum to 2 peanut planting population with an income of 7,118 Somali Shillings.

5. Sorghum Fertilizer Trial

Urea fertilizer was applied to sorghum at the rates of 0, 45, 90, and 135 kg n/ha. The fertilizer was applied as a side dressing after sorghum emergence. The 45 kg produced forage yields of 525 kg/ha, which was significantly (P = 0.05) higher than the 0 and 135 kg rates. Grain yields were not statistically different; however, grain yields followed forage yields with a correlation of R = 0.98. By rank the grain yields of 3.87 q/ha were highest when 45 kg n/ha were applied.

6. Tillage Study

Five tillage methods—disc harrow, field cultivator, disc plow, chisel plow, and ripper - were utilized to prepare sorghum ground prior to the 1984 Gu season. The tillage depths were 150 mm, 150 mm, 200 mm, 250 mm, 350 mm, and yields were 3.22, 3.17, 3.54, 3.26, and 3.86 q/ha, respectively. The yield differences were not statistically significant.

B. 1984 Deyr Season

The average total rainfall for the Deyr season is 241 mm. During the 1984 Deyr season 258 mm was received, or 7 percent above normal. A visiting sorghum consultant recommended that the sorghum section plant only during the Gu season; as a result, they lost an excellent growing season.

The extension-research cooperative research program, which was initiated during the 1984 Gu season, was expanded during the 1984 Deyr season. Each of the twenty-two agricultural extension agents planted a sorghum yield trial. Four agents established planting date trials on sorghum, peanuts, cowpeas, and mung beans. Sorghum plant population, plants per hill, date of thinning, planting date, and sorghum weeding trials were established on BDARS.

1. Variety Trials
   a. Cowpeas
      Three varieties of cowpeas were tested from 1981 through 1984 and the results summarized. TvX3-59 from Nigeria ranked first in yield when grown during the Deyr season, second during the Gu season, and first when both seasons were averaged. Even though TvX3-59 produced good yields during the test period, it should not be released to growers. During the 1984 Deyr season 22 percent of the plants in the yield trial were infected with charcoal rot; only 10 percent of the Red Local was infected.
   b. Mung beans
      Several mung bean varieties received from the Asian Vegetable Research and Development Centre (AVRDC) in 1981 were grown in yield trials, utilizing a Bonka Local as a check. Varieties V1945, V1168 Sel B, V3476, and VC 1560 Sel D were among the yielding varieties when the 1981-84 Deyr seasons, Gu seasons, and combination of both seasons' yield data were summarized. The Deyr season average yield for all varieties was 3.23 q/ha as compared to the Gu season average yield of 1.74 q/ha. During the 1984 Gu season ashy stem blight was reported in the trials. The high-yielding entries V1945, V1168 Sel B, V3476, and VC 1560 Sel D received readings of 52, 23, 18 and 41, respectively. Only 6 percent of Local Bonka plants were infected by ashy stem blight. The introductions should not be released to growers.
   c. Safflower
      The safflower varieties continued to produce fair yields with few insects and little disease or damage from animal or fowl. VC-152, as in the 1984 Gu season, was one of the higher-yielding varieties in the Deyr season.
   d. Soybeans
      No data were collected from the soybeans planted before the rains, as rabbits destroyed the plants in the vegetative stage. Seed received from INTSOY (International Soybean Program) in the state of Illinois in the United States was planted after the rains started. Large differences were detected among varieties. INTSOY sent a range in types in order to determine which types would be best for Somalia. The higher-yielding entries produced 2.15 and 2.02 q/ha. Soy-

bean can be grown like cowpeas and mung beans in Somalia and could be used to produce cooking oil.

e. Sunflower

Sunflower yields well during the Gu and Deyr seasons. It is nearly as reliable as sorghum in productivity. With the proper processing equipment, sunflowers could become a valuable oil crop in Somalia.

RO-22 averaged 5.01 q/ha during the Deyr 82, Gu 83, Gu 84, and Deyr 84 seasons, and the Local Early only averaged 3.12 q/ha.

f. Peanuts

Peanuts continue to yield well in Somalia. In one trial over a five-season average, variety V-11 produced an average of 5.84 q/ha compared to the local with 4.83 q/ha. In another trial over five seasons, V-33 averaged 6.49 q/ha and the local 4.97 q/ha.

Roasted peanuts are a popular snack food in Somalia. They could also be utilized as a valuable source of cooking oil.

g. Sorghum

Twenty-two agricultural extension agents established sorghum yield trials in their respective areas. Three distinct sorghums were used—Local, Dabar, and GBR-148—so that they could be easily identified by researchers and local farmers. These three entry trials were utilized not only to collect data but also to train extension agents in establishing and caring for research plots.

Results were gathered from seven locations. Local, Dabar, and GBR-148 averaged 3.61, 2.67, and 2.01 q/ha, respectively.

2. Planting Date Trial

In the planting date trials there were four planting dates: prior to rains, soon after rains, one week after rains, and two weeks after rains.

a. Mung beans

The respective yields for the above dates were 1.69, 1.76, 1.58, and 1.17 q/ha. The quick emergence and early maturity of mung beans enables them to produce high yields even with late planting. Yields summarized from three 1984 Gu and Deyr season trials were 1.52, 1.86. 0.69, and 0.69 q/ha, respectively. A three-season average supports the Deyr season trials.

b. Cowpeas

The cowpea average yields for the above planting dates were 1.65, 1.78, 0.93, and 0.47, respectively. No significant difference in yield was noted between the first two dates.

c. Sorghum

Local sorghum yields for the above planting dates were 6.51, 8.76, 3.88, and 3.07 q/ha. No significant differences in yield were detected between the first two dates.

The planting date resulting in the highest yields for mung beans, cowpeas, and sorghum was as soon as possible after the first rain of the season. Planting before the rains started resulted in very small yield reductions, indicating that one could plant before the rains using machinery or in order to spread out hard-labor tasks. Yield reductions as high as 50 percent can result when planting is delayed 1 1/2 to 2 1/2 weeks after the seasonal rains start.

3. Intercropping Trials

Most farmers in the Bay Region do not practice intercropping as such. Where sorghum stands are poor, they plant mung beans or cowpeas, which is a good practice. Fewer diseases develop where mung beans and cowpeas are planted as an intercrop rather than a pure stand. When the legumes are planted at many locations in a field, harvesting is difficult. Indeterminate varieties of cowpeas and mung beans must be harvested at least three times; if not, yield is lost. Considering the way they are now utilized by Bay Region farmers, cowpeas and mung beans should be selected with determinate growth habits. It would reduce labor requirements.

a. Cowpea-sorghum intercropping

During the past three seasons and the 1984 Deyr season, the lowest-yielding treatment in shillings per hectare was the pure cowpea planting, and the highest was sorghum. The highest intercropping ratio was one row of cowpeas to one row of sorghum.

b. Mung bean-sorghum intercropping

During the 1984 Deyr mung beans cropped alone produced the highest income per hectare. This was partly due to the high value of mung beans at the end of the Deyr season.

4. Crop Management Trials
The trials in this section were conducted to determine methods of increasing crop yields through management. These trials were conducted on BDARS. Some of these trials were to be planted by the agricultural extension agents in future seasons as demonstration and research plots. Several of the trials in this section were part of the Cooperative Research-Extension Program.
   a. Sorghum—time of weeding trial
   The purpose of this trial was to show the importance of early weeding. During the 1984 Deyr sorghum emergence in the trial was October 19. The first weeding dates of the various treatments were October 28, November 6, November 20, and November 27. The second weeding dates were whenever needed. The respective sorghum yields were 9.70, 7.66, 5.92, and 5.7[illegible] q/ha, showing that early weeding is very important. The height of the sorghum at the first weeding was less than 10 cm.
   b. Sorghum—time of thinning trial
   Sorghum plants were thinned to 40,000 when they were 10, 20, 30, and 40 cm high. Early thinning reduced competition for moisture and there was less damage to the remaining plants. Plants thinned at the 30 and 40 cm plant height resulted in damage to the root systems of the remaining plants; however, plants not damaged by insects and disease could be saved. At the thinning heights of 10, 20, 30, and 40 cm, the respective grain yields were 8.14, 8.00, 7.28, and 9.76 q/ha.
   c. Sorghum—plant population trial
   The sorghum was thinned to plant populations of 30,000, 40,000, 50,000, and 60,000 per hectare. The resulting grain yields were 8.78, 8.48, 9.00, and 9.89 q/ha. No significant differences were detected among treatments; however, the trend tended to be upward even at 60,000 plants per hectare. Results from the 1984 Gu season indicated that the highest yields were at 50,000 plants per hectare. One population will not be best for all seasons. The higher plant populations will result in higher yields during seasons of high rainfall. By delaying thinning, farmers could thin to a population suited to rainfall received.
   d. Sorghum—plants per hill
   Sorghum was planted in rows 75 cm apart in hills within the

row 33, 66, 100, and 133 cm apart. The plants were thinned to 1, 2, 3, and 4 plants per hill for a plant population of 40,000 plants per hectare. It was not possible to obtain reliable grain yields because of thievery.

Large differences in lodging percentage was noted. With 1, 2, 3 and 4 plants per hill the lodging percentage was 21.2, 21.2, 17.5, and 6.2 percent, respectively. The higher the number of plants per hill, the lower the amount of lodging.

5. Sorghum Selection Trials

Large differences in plant types were noted among plants within the Local and Dabar cultivars growing in the Bay Region. During the 1984 Gu season, 80 selections were made from local sorghum and 87 selections were made from Dabar. These selections were planted on the BDARS on October 11, 1984. Emergence was on October 19. GBR-148 was used as a check, as it is genetically homogeneous. About 70 percent of the selections were discarded on the basis of visual selection.

a. Local selections

Yield data was collected on 28 selections from seven trials. The highest-yielding selections were L-25 and L-31, which yielded 14.47 and 14.17 q/ha, compared to GBR-148, which produced 4.30 q/ha. The earliest maturing selection was six days earlier than the latest maturing selection.

b. Dabar selections

About 90 percent of the Dabar selections were discarded on the basis of appearance.

The earliest-heading selection was D-47, which headed in 58.0 days, 19.3 days earlier than GBR-148, which headed in 77.3 days. The average heading date of all Dabar selections was 69.4 days.

The highest-yielding Dabar selection was D-80, which produced 15.80 q/ha compared to GBR-148, which produced 4.44 q/ha in this trial.

An early-maturing sorghum is needed for planting in the Deyr season. Because of storage problems in Somalia, it is important to produce sorghum crops during both the Deyr and Gu seasons. Early-maturing cultivars also tend to escape disease attacks. If not used as is, D-47 could be used as a valuable parent in producing local types with early maturity.

Chapter 5

A New Beginning: 1985-1988

by Robert Lavigne

ON MARCH 28, 1986, dedication ceremonies were conducted for the Bonka research complex and for the new PMU office complex. Visiting dignitaries who participated in the ceremonies included the first vice-president of Somalia (and minister of defense) Mohamed Samatar; the vice minister of agriculture, Mohamed Noor; the Chinese ambassador to Somalia, Shi Chen Xiun; the World Bank representative, Brian Falconer; and USAID representatives Ray Fox and Habad.

The construction of the new buildings, the return of Somali personnel from overseas training, and the arrival of the new University of Wyoming Team combined to provide a new impetus to research efforts at Bonka. A steering council, composed of all senior researchers, was initiated wherein research directions and problems were freely discussed. Planning sessions were conducted at the beginning of each season, and research results were jointly critiqued afterwards. Close cooperation was established with AFMET, the Agricultural Extension Service, and cooperative research was continued both on the AFMET farm and in conjunction with field extension agents.

The following chapters deal with the progress made by the second UW Team and its Somali counterparts. These chapters provide the current status of research at BDARS and suggest avenues of research for the future.

JUDY LAVIGNE

BDARS inauguration ceremonies. Vice minister Noor cuts the ribbon, as project manager Mohamed Warsame Duale, the Chinese ambassador to Somalia, and World Bank's Brian Falconer look on.

JUDY LAVIGNE

PMU inauguration ceremonies attended by Abdi Mohamed Noor, vice-minister of agriculture (second from right), then vice-president Samatar (far right, cutting the ribbon), and project manager Mohamed Warsame Duale (second from left), 1986.

View of BDARS buildings, 1987

JUDY LAVIGNE

Research staff and support personnel at Bonka Dryland Agricultural Research Station (BDARS), 1987

Chapter 6
Soils
by Paul Porter

Introduction

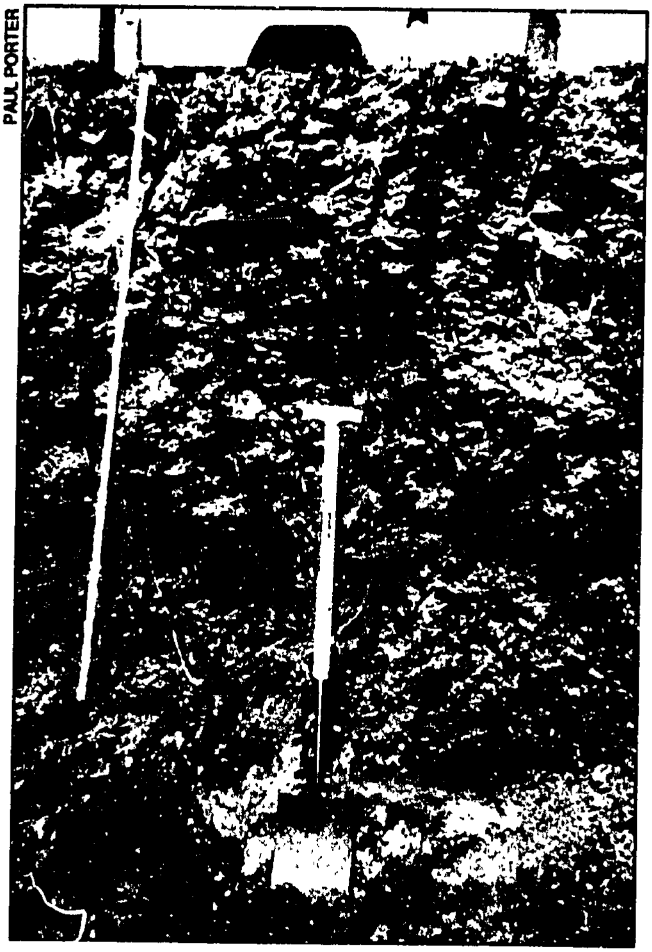
IN THE EARLY 1980s, effective research at the BDARS was severely hampered because of the irregular crop performance of the station. As stated in the BRADP mid-term review (Hunting Technical Services Limited [HTSL], 1983, 39) open grazing, poor plowing techniques, and variation in soil fertility levels contributed to this problem. In view of this, the Soil Fertility Section (now known as the Soils Section) was formed in January 1986. The first priority of the research conducted by the Soils Section was to investigate the reasons for the poor and variable crop growth at the BDARS and, if possible, to recommend corrective measures. The second priority was to assess the fertility status of the soils in the Bay Region and to recommend improved farming practices.

After a brief discussion of the cropped soils of the Bay Region, the remainder of this chapter summarizes reasons for poor and variable crop growth at BDARS in particular and in the Region in general. Improved research and farming practices, as well as important research findings from the Soils Section, are also discussed.

Vertisols

The majority of crop production in the Bay Region occurs on a soil type known as Vertisol. Vertisols occupy approximately 18 percent of the land area of the Region, and between 50 percent and 60 percent of the Vertisols in the Region are now, or have recently been, cropped.

The Vertisols in the Region have been classified into five major



Soil profile in farmer's field at Doy Nunnay, Baidoa district.

groups: Baidoa, Uiamo, Amin, Bur Hakaba, and Mode Mode (Lockwood/FAO 1968; and HTSL 1982). All are probably Typic Chromusterts and are similar to other Vertisols found in East Africa (Porter et al., in press). Their texture is commonly clay throughout the profile, with the clay minerals high in montmorillinite. Consequently, these soils develop deep, wide cracks during the dry season that close during the wet season. They tend to be calcareous with a pH of about 8.0. The cation exchange capacity ranges from 30 to 70 cmol kg^{-1} of soil. The predominant exchangeable cation, which accounts for up to 80 percent of the exchange complex, is calcium followed by magnesium. In general these Vertisols have nil to low salinity and sodium hazards in the surface 0.5 m, and low to moderate salinity and sodium hazards in the 0.5 to 1.0 m depth. Soil analysis has demonstrated these soils to be high in available potassium and very low in available phosphorus (Newton 1968; Strong 1986). The organic matter content is generally less than 1.5 percent in the top 0.2 m. There is some indication the organic matter content of the soils has declined after prolonged periods of cultivation (Strong 1986). Field capacity of the Baidoa soils at the BDARS is approximately 42 percent, and the permanent wilting point is approximately 28 percent on a gravimetric basis. The bulk density at field capacity is approximately 1.1 to 1.2 g cm^{-3}.

Soil Variability

In the past "soil variability" was a much-used phrase at the BDARS. Too often it has been misused. Soil variability has been used (sometimes as an excuse) to explain poor plant stands, variable plant heights, variable yields, high experiment coefficients of variation (CVs), and nonsignificant treatment differences. More often than not, factors other than soil variability were responsible.

In defense of the soils at the BDARS it should be pointed out that they are extremely uniform. There are no major structural or textural differences in the profile between locations on the research fields. Those differences that are apparent are normally explainable. The soils are deep and there is little chance salinity and sodium found at depth affect sorghum growth or yield. The land is generally gently sloping to the southeast, and there are no major topographical changes. It is accurate to say the fertility level of the soils at the BDARS was low prior to the large-scale application of commercial fertilizers beginning in Gu 1986.

Variable Plant Growth

Both in farmers' fields throughout the Bay Region and in research plots, variable plant growth has quite often been automatically attributed to "soil variability." The casual observer will see marked differences in sorghum plant growth, both within and between farmers' fields. If one questions the farmers as to why this area of the field has better plant growth than that area, almost without exception one gets a logical response. The two most common reasons given are (1) the areas were planted at different times; and (2) the areas were weeded at different times. These are probably the most important reasons for the observed differences. Other responses include differences in past land usage (time in cultivation, site of an animal holding pen) and differences in soil moisture due to water ponding in low spots or droughtiness in high spots.

Statistical analyses of many field experiments reported in seasonal reports produced by BDARS staff in the early to mid-1980s often showed nonsignificant treatment differences and high CVs. Variability in plant growth was believed to be the "major contributor to the large coefficients of variation recorded," and, implicitly, the variability in plant growth was due to "soil variability" (Work Program, Deyr 1985). Low soil fertility is only one of many factors that can contribute to variable plant growth. Other factors of equal or greater importance include improper planting, weeding, and thinning of research plots.

Improved Research

As stated earlier, the first priority of the Soils Section was to identify the reasons for the poor and variable crop growth at the BDARS and to recommend corrective measures. A major reason for poor and variable crop growth in many research trials was, and still is, due to a lack of diligence and concern on the part of the researcher. Experimental design and treatments are not always well planned. Trials are often planted in haste, with little regard for seed bed preparation, seeding rate, and depth of planting. Trials are weeded and thinned by casual laborers who want to finish the task quickly and have little reason to proceed with care. Often such laborers are supervised by junior staff members who know more about the plots in the research trials than the senior staff member responsible for the trial. Insufficient attention is paid to final plant stand density, diseases, and insect, bird, and animal damage. Weeds, especially shattercane, are allowed to set seed, which complicates future studies on the land. Probably the surest way to obtain better research results is for the senior researchers to become more directly involved in conducting their research trials. This means spending more time in the field.

After lambasting the research staff in the above paragraph for poor research habits, it must also be stated that much progress has been made in the last few years in improving the quality of research at the BDARS, and that some of the best, most productive researchers in Somalia now work at BDARS.

Improved Farming Practices

In order to survive, the farmers of the Bay Region have had to adopt appropriate farm production strategies consistent with their changing needs. Most farmers realize the importance of planting before the rains begin in order to take advantage of the entire growing season and to reduce the effects of post-flowering moisture stress. They are also aware of the importance of weeding. Unfortunately, these tasks are not always performed in a timely manner due to labor constraints.

There is noticeable plant growth variability between fields and between locations within one field. Normally that variability can be explained. Quite often, successful farmers—those with the most impressive fields—are those who:

1. Practice *salaax*, or weed-free farming
2. Control the *hobada* or shattercane
3. Treat their seeds with chemicals before storage
4. Plant in a timely fashion at the recommended seeding rate
5. Thin when the seedlings are still very small
6. Remove plants with smut or other diseases from their fields
7. Intercrop with legumes
8. Prohibit water runoff by constructing tied-ridged bunds where runoff is a problem and cost of bunds is economic

In the not-too-distant future the successful farmer will be one who:

1. Uses insecticides
2. Employs animal traction to aid in planting and weeding
3. Uses fertilizers
4. Uses identified improved varieties
5. Diversifies into other crops besides sorghum

Research Findings

Over the past five growing seasons the Soils Section has conducted a large number of fertility trials, and has closely monitored moisture content in the soil profile. Results from the research have been recorded in the seasonal reports, and the reader is referred to those reports for detailed discussion of the various research trials.

The results of the research trials conducted by the Soils Section since Gu 1986 demonstrate:

1. Inorganic Fertilizers
   a. Phosphorus (P) is the growth-limiting plant nutrient at the BDARS and in other areas of the Bay Region.
   b. Crop growth and yield can be increased substantially when Triple Superphosphate (TSP) or Diammonium Phosphate (DAP) are properly applied to these soils.
   c. Crop growth and yield are not affected by application of Nitrogen (N) alone.
   d. Of nine plant nutrients, only P was shown to limit plant growth.
   e. Method of P application is important if optimum yields are to be obtained. For sorghum, nesting and/or banding the fertilizer is more efficient than broadcasting the fertilizer.
   f. Residual effects of P-containing fertilizers were observed. Crop growth and yield were positively affected two growing seasons after the P fertilizers were applied.
   g. P fertilizers promote early seedling vigor and speed maturity of both sorghum and mung beans.
   h. Plant stands of sorghum are not affected when TSP is laced in the hole directly with the seed.
   i. Sorghum yields are increased when as little as 1.1 g TSP is placed in the hole directly with the seed (that corresponds to 20 kg TSP ha^{-1}). Better yields are obtained when 4.5 g is applied per hill. Similar results were obtained with DAP—but with DAP it may be necessary to separate the seed from the fertilizer at planting.

2. Organic Fertilizers
   a. Goat and cattle manures, broadcast at 5 T ha^{-1} and then incorporated, improved crop growth and yields.

b. Camel manure had no apparent effect on sorghum growth.
c. Crop growth was positively affected the second and third cropping season after the application of goat and cattle manure, but not after camel manure.
d. Tied-ridge bunds, 2 m by 2 m by 0.2 m high, reduce the problems of runoff and the manures being washed out of the field (plot).
e. When used properly, guano, from northern Somalia, increased plant growth and yield. Guano placed below the seed at 14 g $hill^{-1}$ significantly increased sorghum yield. High rates (100 g $hill^{-1}$) adversely affected seedling emergence and vigor, and yields decreased.

3. Soil Moisture
   a. In Gu 1986, there was over 300 mm of cumulative rainfall at BDARS, yet in part because of the distribution and intensity of the rain events, very little moisture percolated below 0.75 m. Very little, if any, soil moisture below a depth of 0.75 m was utilized by sorghum plants.
   b. In Deyr 1986, there was just over 80 mm of cumulative rainfall, but this was not enough to sustain sorghum growth. Rainfall did not infiltrate beyond the surface 0.25 m. In Jillal 1987, some soil moisture between 0.25 and 0.50 m was lost due to evaporation.
   c. In Gu 1987, there was approximately 250 mm of cumulative rainfall. Because of the manner in which the rainfall was distributed over time, percolation of soil moisture (the wetting front) was observed to depths below 1.0 m.
   d. In Deyr 1987, cumulative rainfall totaled about 175 mm. The wetting front never exceeded a depth of 0.5 m. Moisture stored in the soil from the previous Gu 1987 rains was crucial for the development of the Deyr 1987 sorghum crop at the BDARS (which was planted on land fallow in Gu 1987). Sorghum roots extracted moisture from between 0.75 and 1.0 m.
   e. In Gu 1988, there was over 500 mm of cumulative rainfall, and the wetting front exceeded 1.0 m. Sorghum roots were observed below 1.5 m.
   f. By monitoring the soil moisture over time, it was possible to estimate field capacity of the soil to be about 42 to 44 percent (gravimetric) and the permanent wilting point to be about 28

PAUL PORTER

Laboratory demonstration of the effect of adding various elements to BDARS soil on the growth of local sorghum to 30 percent (gravimetric). Bulk density at field capacity was determined to be between 1.1 and 1.2 g cm^{-3} in the surface meter of soil.

g. Runoff and erosion does occur and can be severe (as was observed in Gu 1988).

h. The salinity level and pH of the soil at depths up to 1.0 m does not change as the soil dries and rewets. It is unlikely that the current soil salinity level at the BDARS is adversely affecting sorghum growth and yield.

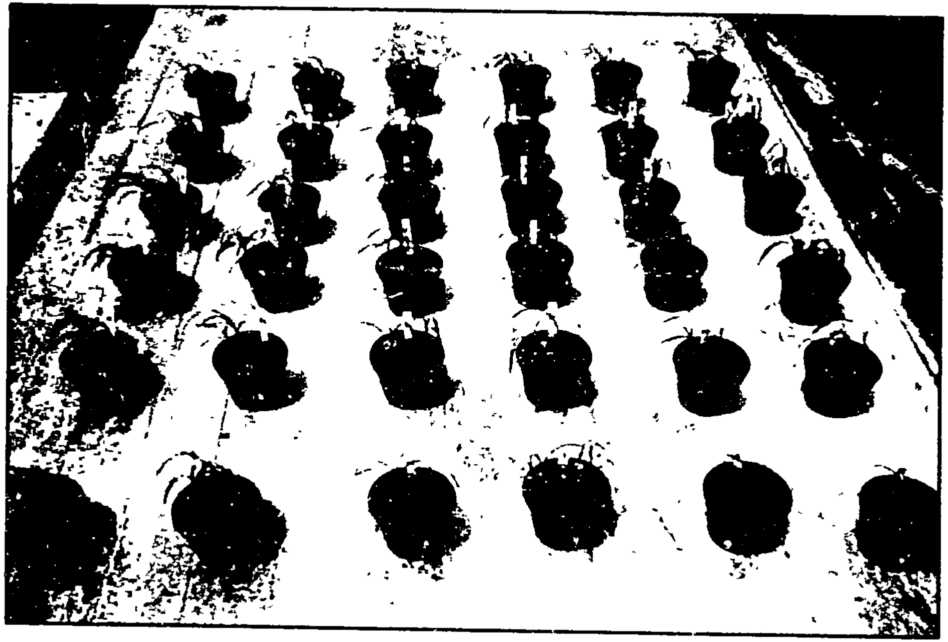
Staffing

The Soil Fertility Section was established with the arrival of Paul Porter in January 1986. The original team consisted of Porter as section leader, Abdullahi Hussein Abdi (Jenyo) as senior research officer, and Shamis Abdullahi Nuur and Abdirahman Mahmed Ali as research assistants. In June 1986 Abdirahman Mahmed Ali was transferred to another project. He was replaced by Aden Awil Ateye. In 1986 this team clearly demonstrated the effects of phosphorus fertilizer, accumulated much data on the movement of moisture into the profile, and studied the salinity level of the soils at the research station.

In February 1987 Abdirashid Dulane Rafle joined the Soil Fertility Section as senior research officer and in March 1987 Said Mohamed Jimale joined as junior research officer. In May 1987 Shamis Abdullahi Nuur transferred out of the section, and Hinda Saleban Jama and Adan Mohamed Nur joined the section as junior research officers. The name of the Soil Fertility Section was changed to Soils Section in October 1987. Adan Mohamed Nur left the section in October 1987, and in November 1987 Said Mohamed Jimale transferred out of the section. No staff changes were made in the first eight months of 1988.

Residual effects of both organic and inorganic fertilizers have been studied by the Soils Section since 1987. The team worked closely with the field extension agents both to train them on fertilizer use and to evaluate how extensive the phosphorus deficiency is in the Bay Region. Preliminary work on rainfall runoff was initiated in 1988.

Several Soils Section staff members have had the opportunity to receive training overseas—training that is crucial for their development as scientists. Abdirashid Dulane Rafle received his master's degree from the University of Arizona in 1986, visited with soil scientists at the International Crops Research Institute for the Semi-Arid Tropics



Laboratory pot trial demonstrating the effect of quano added to BDARS soil on the growth of local sorghum

(ICRISAT), Hyderabad, India, in March 1988, and also attended a USDA-sponsored soils course in mid-1988. Abdullahi Hussein Abdi spent six months working with soil scientists at ICRISAT in 1987. Aden Awil Ateye is currently receiving further training at ICRISAT.

Results from the Soils Section have been presented at a number of national and international meetings, including the First Biennial Sorghum Workshop in Somalia (1986), the American Society of Agronomy Annual Meetings (1986 and 1988), the Conference on Livestock and the Improved Management of Dark Clay Soil in Africa (1987), and the Sixth East African Regional Sorghum and Millet Workshop (1988).

Summary

In the relatively short time the Soils Section existed, it has identified some of the important constraints and limitations to improved research at the BDARS and crop production in the Bay Region. Important future work will involve fine-tuning extension recommendations concerning P fertilizer usage, setting up the soils laboratory to evaluate the P status of the soil, and conducting water balance studies.

Chapter 7

Dryland Agronomy

by Graham Eagleton and Grant Richardson

Objectives

CROP AND LIVESTOCK PRODUCTION in the Bay Region is limited by the low and variable level of received rainfall. In some seasons, low rainfall is the primary limitation on crop yields. In other seasons, rainfall is second only to phosphorus level in limiting crop yields. Phosphorus limitation can be overcome with fertilizer (see chapter 6). However, inputs of moisture by irrigation is possible on only a small fraction of the arable land area. In this sense, rainfall is the lowest common denominator of crop productivity in the Region.

Optimizing the use made of this finite resource has been the principal objective of those sections of the research station concerned with dryland agronomy. This work has consisted of:

1. Measuring the moisture limitations of the cropping system (especially climatic and soil moisture characteristics).
2. Experimenting with the agronomic components of moisture use in the cropping system (crop species, plant arrangement, weed control, and farming technology, mainly animal traction).
3. Modeling and testing (both on- and off-station) cropping systems and strategies thought to optimize moisture use (fallowing, intercropping, rotations, bunding, and crop residue management).

The focus of the endeavor in dryland agronomy has been broad. The methodology has been to set up omnibus trials (the long-term fallow trial is the best example) that could examine the key agronomic elements within a single system. By exploring these factors in interaction, they could be prioritized for more detailed research. What this approach has sometimes lacked in finesse it has made up for in the insights it has offered into the subtleties of the existing system and the challenging task that lies ahead for those who would seek to improve it.

Personnel and the Development of a Team

Dryland agronomy as a distinct discipline at BDARS began with the arrival of Bernie Kolp and the first Wyoming Team. In late 1984 Mike Smith (a consultant with John Bingle Proprietary Ltd.) was contracted as dryland crops agronomist and Abdi Ahmed Mohamed (Baffo) returned from post-graduate study at Reading in the United Kingdom. Along with Ali Obsiye Bon, Abdirisak Osman Said, Mohamed Ahmed Abdullahi Nur (Brigato), and others, they established the Soil Moisture Section, which later evolved into the Dryland Cropping Systems Section. At the same time, the Agronomy Section, which later became the Sorghum Agronomy Section, was formed under Ahmed Sheikh Hassan, the current research director.

During Mike Smith's time (October 1984-December 1986), the long-term fallow trial was set up, the importance of phosphorus was first recognized, the system of rotations and fallows within the research station was initiated, and off-station testing began. Two short-term consultancies by personnel from John Bingle Proprietary Ltd. contributed to this effort: Wayne Strong (October 1986) provided input into the Soil Fertility Section, and Stewart Barton (March-June 1986) set up the animal traction research activity.

With the departure of Mike Smith and his replacement by Graham Eagleton, and with the period of Barton's second consultancy (January—August 1987), the opportunity was taken to restructure the dryland agronomy effort. Abdi Ahmed Mohamed was upgraded to head of the Dryland Cropping Systems Section (previously Soil Moisture), with Eagleton as adviser, and Ahmed Aden Odowa as research officer. The work of this section had gradually broadened from its focus on climatology, soil moisture, and measurement of fallowing efficiency to include experimentation on intercropping and crop rotations. The emphasis on soil moisture as a unifying concept remained, however, and gained strength from a short consultancy (June 1988) by Mike Foale, an authority on soil-crop-water relations in sorghum.

Under Stewart Barton, an animal traction section developed. Omar Mohamed Ali was sent to Nairobi for training and returned to be in charge of animal harnessing. Ali Obsiye Bon was sent to ICRISAT for experience with animal traction implements and their evaluation. After Barton's departure, the section was retained as a unit and received valuable assistance from the conscientious field work of Ibrahim Abdi Kher and Rashid Mohamed Aden.

The off-station activity was formalized in a new section with Abdinur Mohamed Ismail as research officer responsible for on-farm trials carried out in cooperation with AFMET extension agents. When Abdinur departed for nine months' training in Australia, Hassan Ahmed Muse took charge of on-farm experimentation.

Overall leadership of the agronomy effort was with Grant Richardson in his capacity as adviser to the research director. At the time of the Wyoming Team's departure in late 1988, responsibility for dryland agronomy was in the hands of four sections: Sorghum Agronomy, Dryland Cropping Systems, Animal Traction, and Off-Station Testing.

Environmental Limits to Moisture Availability Climatology

The first task of the Wyoming Team was to establish a network of weather stations. In mid-1984 the location of the official meteorological site for Baidoa town changed to BDARS. The facilities were upgraded by the Food Early Warning Systems Department (FEWS) in 1987.

During 1984-88 Haji Sheikh Ahmed was in charge of meteorological records at BDARS. Rainfall, sunshine hours, pan evaporation, and maximum and minimum temperatures were recorded at 8 a.m. daily. Wet and dry bulb temperatures, wind speed, cloudiness, and soil temperature were recorded at 8 a.m. and 12 a.m. Similar records were taken in Dinsoor town. Rain gauges were installed at Bur Hakaba and ten other sites in the Region and were attended to by a range of personnel, including district agricultural officers and veterinary officers. At BDARS, Qansa Dhere, and Bur Hakaba, tilting siphon rain gauges were installed.

For Baidoa town, rainfall was recorded intermittently since 1922 (Fantoli 1965). For Bur Hakaba there is a broken record of 27 years of rainfall data and for Dinsoor, 14 years. These data were recently compiled by FEWS in 1988. At Bonka all weather data taken since 1984 was put on computer disk. The data compiled by Fantoli is also available on computer disk.

The quality of these data is patchy. This is particularly so for relative humidity (wet and dry bulb temperatures) and pan evaporation, which are crucial in determining crop-water budgets. Some rain gauges need to be relocated because of the presence of trees and other obstructions that have grown or been built since they were installed. There is also a need to install stand-alone solarimeters, at least at Bonka and Dinsoor, to measure total received radiation, an input into most crop growth models.

The climate of the Region is characterized by low, variable rainfall, moderate unvarying temperatures, and high advective conditions. On average, potential evapotranspiration is well in excess of rainfall in all months except April and October. Variability in rainfall is both temporal and geographical. There is considerable variability in intensity of individual falls. Rainfall events less than 4 mm can be regarded as having negligible impact on plant available soil moisture, because of the high evaporative demand. Even falls as high as 20 mm contribute little to growth unless immediately taken up by the crop. At the other extreme, rainfall events greater than 50 mm per day can result in significant losses as runoff. The features of climate result in a fallow efficiency of less than 25 percent of received rainfall, despite the favorable moisture characteristics of the soils.

Soil Characteristics

During the period of Mike Smith's consultancy, soil pits were dug to a depth of 2 m at six sites on the BDARS, two sites at Doy Gab, and two in the vicinity of Xabaalo Barbar. Soil profiles were described qualitatively. In the pits at Bonka, samples were taken to measure salinity levels, bulk density, moisture content at 15 bars (in a pressure membrane apparatus), and soil chemical composition. Infiltration rates (using a double-ring infiltrometer) and rooting depth (by visual assessment and from the moisture-extraction patterns) were recorded.

During 1988 some of these parameters were remeasured. Bulk density and infiltration rates need to be measured at field capacity because of the problems of cracking soil and lateral water movement when the ground is dry. The record rains of Gu 1988 enabled a reassessment of those values. The introduction of thin-walled coring tubes and the occasion of Mike Foale's consultancy enabled estimates of rooting depth to be refined.

Soil moisture has been monitored gravimetrically for several successive seasons by both the Dryland Cropping Systems Section and

Soils Section. In the case of the long-term fallow trial, soil moisture has been recorded to a depth of 1 m six times a year from Deyr 1986 to Gu 1988. It is unfortunate that the capacity for well-fertilized sorghum roots to extract moisture from below 1 m was not realized when this trial was initiated. Future assessments of moisture use will need to take account of the deeper soil layers.

The Vertisol soils of the Region have excellent moisture-storage characteristics (1.5 mm per cm of soil depth). The plant available water holding capacity (PAWC) may be as high as 300 mm, because sorghum roots have been shown to extend to a depth of at least 2 m. Infiltration rates are higher (49 mm/hr) and bulk density lower (1.2 g/cc) than in Vertisols in many other parts of the world. The typical hand cultivation methods of the Region have preserved the soil structure, minimizing runoff and erosion, making optimal use of the self-mulching characteristics of the surface and retaining soil cracks for the rapid uptake of rainfall.

Enhanced understanding of the role of soil cracks in the moisture cycle is important to correct soil management. In most of the world's soils, water enters the surface as a distinct wetting front that proceeds at a uniform rate down the profile in response to additional rainfall. In Vertisols, however, the wetting-up occurs as spikes with rapid penetration to depth down the soil cracks and slower diffusion by capillary action into the massive blocks. Evaporative loss from deep in the soil is not greatly increased by the presence of open cracks. Evaporation is driven by heat radiation that is greatest at the surface and least in the deep layers. The implication of this is that soil management should be such as to maintain its open, cracked structure. This will lead to most rapid penetration of rain into the deeper soil layers, where it is protected from evaporation. Future research will need to focus on the measurement of runoff and to assess the efficacy of alternative methods for minimizing and harnessing runoff. This area of research has received little attention in the first phase of the Project.

Agronomic Components of the Cropping System

Crop Species and Varieties

Because sorghum makes up 90 percent of the land area sown to crops, it has rightly been the subject of most of the dryland agronomy work. It is clear that the Local sorghum variety is extremely well-adapted to the Region and that little is to be expected from introduced varieties in terms of increased moisture use efficiency. The most profitable area for future breeding work will be in the genetic adjustment of harvest index.

Several other crop species are well-adapted to the prevailing moisture conditions. The cowpea has an ancient history in Northern Africa. The peanut and the mung bean are perhaps less venerable, but the cultivars are well-established. There has been some initial success with the mung bean in selecting a new improved cultivar, Filsan (VC1168B), that competes well with the Local variety under short, Deyr season conditions. Maize and sesame are grown in wet seasons, but not usually in the Deyr.

Of the more recent introductions, safflower is an exciting prospect because electricity is now available in Baidoa town, and could power an oil seed crushing plant. Safflower is efficient in utilizing available soil moisture because of its deep root system. It produces a high-quality cooking oil, with the seed containing 30-45 percent oil. Because Somalia imports almost two-thirds of the vegetable oil it consumes, safflower could be a crop that would reduce these imports significantly. It appears to be well-adapted to the soils and climate of the Bay Region, has very few insect pests or diseases, is drought-tolerant, and has produced satisfactory yields at BDARS. In preliminary plant density trials, production varied between 410 and 500 kg/ha on unfertilized soil. Although yields were not accurately measured, observations showed fertilized plants produced approximately 50 percent higher yields than unfertilized plots during the Gu 1988 season.

Safflower is so efficient in soil moisture removal that there is some concern about reduced soil moisture availability at lower depths for the following crop. Relatively large cracks appear in the soil, probably because of the depletion of soil moisture from the heavy clay, especially where tractor tires compact the soil after stand establishment. Harvesting by hand is somewhat difficult due to the spines on the stems and leaves, but can be accomplished with home-made gloves and with reasonable care in pulling the plants. Threshing and cleaning pose no serious problems.

Despite theoretical reservations about the adaptability of *Leucaena leucocephala* in this low rainfall environment, it has in practice proven remarkably robust on the deep, alkaline clays and may yet surprise the skeptics. Undoubtedly, with more research by the crop improvement sections, other crop species will be added to the repertoire from amongst the many that have been under experimentation—pigeon pea, sunflower, guar, buffelgrass, millet, French bean, soybean, *Stylosanthes*, alfalfa, blackgram, and *Lab lab*.

Plant Arrangement

The Sorghum Agronomy Section has been responsible for most of the work on plant density and arrangement in sorghum. Trials have shown that a plant population of 60,000 per hectare is optimal for Local sorghum in the Gu season. This corresponds closely with assessments of plant populations in farmers' fields in which sorghum is grown in hills—three plants to a hill and 19,000 hills/ha. It is probable that under conditions where phosphate fertilizer is liberally applied, plant densities could be raised. There is some suggestion that a lower population might be best suited to the Deyr (see chapter 4). Studies by the Dryland Cropping Systems Section in which nitrogen fertilizer was banded alongside sorghum rows indicated that grain yields are often reduced by close planting arrangements. In dryland cropping there has to be a trade-off between reducing surface evaporation by rapid ground cover and minimizing transpiration losses from the deeper soil layers early in the life of the crop.

An area of research that deserves close study in future programs is seedling establishment and the role of multiple planting and crop thinning in the optimization of plant density. Uncertain seed quality and vigor, uneven surface-soil conditions, and soil insects contribute to considerable variation in plant density. In practice, farmers adopt multiple planting and multiple thinning to adjust plant numbers to the opportunities presented by the unfolding seasonal conditions. This is a complex practice offering an important challenge to the agronomist. It is at the frontier of current research in agronomy.

The situation for oilseeds and legumes is less complex because establishment seems usually to be more reliable. Larger seed size and initial seedling vigor contribute to this. Because of an inherently slower growth rate, these crops always appear more uniform than sorghum and maize crops.

The Grain Legumes and Oil Crops Section, under the able leadership of Aden Ali Ossoble, has investigated plant density responses in the more important crops. To generalize, the plant populations that have been found optimal are cowpeas, 75,000 plants/ha; mung beans, 200,000 plants/ha; safflower, 150,000 plants/ha; and peanuts, 75,000 plants/ha. Because many of these crops are grown as intercrops with sorghum, there is need to determine plant population in interaction with other species. This is one of the objectives of the Dryland Cropping Systems Section.

Weed Control

In considering the optimization of moisture-use efficiency in a cropping system, it is easy to take for granted the fundamental role of weed control. Perhaps this is why there is no single research section devoted to this issue. For Bay Region farmers, weed control is the most important factor within their control; in it they invest the greatest portion of their effort for potentially the greatest reward.

Studies by the Farming Systems Section have revealed considerable diversity across the Region in the severity of the weed problem and in strategies adopted to handle it. In the Doy Gab area of Bur Hakaba district, where weed intensity is high and rainfall variable, opportunity-weeding is adopted. In areas of more consistent rainfall and lower weed intensity, such as Xabaalo Barbar in the Qansa Dhere district, a policy of maximal weed control known as *Salaax* is profitable.

The Dryland Cropping Systems Section has used much of its resources examining weeds and their control using a variety of approaches—weed species collection and identification, studies of weeding intensity and timing, and trials on weeding technique. In the four years available to it, the program has been necessarily sketchy but the conclusions important.

In a dry season, failure to weed will result in zero yield, but usually a single weeding after surface moisture has evaporated and the crop is beginning to draw on deeper stored moisture is as economical as multiple weedings. In a wet season when phosphorus and sometimes nitrogen are the most limiting factors, weeding up to three times beginning early in the life of the crop will increase yields due to reduced competition for nutrients, light, and moisture. The optimum number of weedings will be a function of soil fertility and the general hygiene of the field. Raising soil fertility increases the potential for weeds. Nitrogen fertilizers encourage grasses, and manure, particularly if uncured, is a notorious source of new weed seeds. In well-established *salaax* areas little weed control is necessary to maintain field hygiene, but if the weeding pressure is released the *salaax* quickly deteriorates.

There is an obvious succession in the ecology of weed control. In uncropped land or long neglected fields, *Acacia* scrub predominates. Allowing the land to revert to *Acacia* is one strategy used in regenerating the fertility of exhausted land. However, clearing the land of *Acacia* is a very costly exercise, requiring many hours of hand labor, heavy chemicals such as Tordon, or mechanized land clearing methods (bulldozer and tractor).

In cropped areas of high weed intensity or in recently neglected fields, grass weeds dominate. A particularly intractable grass is the species *Digitaria rivae*, known as *korto*. Fortunately, it is very easily controlled by low rates of Roundup. Roundup kills the underground parts, which are resistant to traditional hand-hoeing methods.

If weeding intensity is increased, the grasses diminish and the deeper-rooted annuals gain in importance. The most important species of these is the wild lettuce, kable (*Launea* sp.). This species utilizes deeper soil moisture. While hand-hoeing and animal traction can reduce this competition, it fails to destroy the root system, which is a continual source of new shoots. In sorghum, 2,4-D can be used to control kable, but in legumes its chemical control is difficult because the most promising herbicide, trifluralin, appears not to control it. In fallows, Roundup controls kable but is less effective against *wanshaqaaq* (another *Launea* sp.) and *beraajis* (*Ipomoea* sp.), and quite ineffective against *kabxan* (*Thespesia dana*). Atrazine or 2,4-D can be used as cheaper alternatives to Roundup in fallow weed control. Atrazine is not safe to use where legumes are to be planted after the fallow.

Animal Traction

Whereas herbicides are presently out of reach of the great majority of farmers in the Region, animal traction offers considerable potential to ease the cost and burden of weeding, which is the single most important operation in the cropping cycle.

Animal traction farming has an ancient history within northeast Africa, yet in the Bay Region it is almost nonexistent despite 30 years of extension efforts to promote it. In 1985-86 Michael Martin, a Wyoming graduate student, surveyed animal traction use in the Region and identified three main factors preventing widespread adoption: a lack of suitable implements, insufficient numbers of trained animals, and the ever-present risk of drought and feed shortages rendering working animals useless. A more radical assessment would suggest that animal traction is simply less profitable than hand labor in many instances, because the increased costs are not met by increases in crop production. It is a general observation that animal traction has taken a foothold in Africa, usually in environments where tillage is a necessary precursor to cropping.

In the Bay Region, primary tillage is not usually necessary, and so the main thrust of animal traction research since 1986 has been on weeding. Cognizant of Martin's findings, the animal traction work has emphasized

1. Single light-weight animals (cows and donkeys rather than oxen)
2. The development of a local capacity to manufacture implements (the traditional wooden plow, cheap metal frame cultivators, donkey and oxen collars)
3. Liaison with AFMET in the training of farmers to use the traditional wooden plow
4. Testing of implements for specialized purposes (rolling injection planters, fertilizer spreaders, and the Matlama planter-fertilizer unit)

Animal traction excites interest in farmers, yet it is apparent that the decision to adopt animal traction involves significant risk-taking. It is difficult to adopt animal traction in a piece-meal fashion, and those few farmers who have taken it up have been led to change their whole system of growing sorghum, e.g., furrow and ridge cultivation, row planting, and shallow between-row cultivation. Plowing on the contour to reduce runoff losses is one avenue of research that needs future work. Using animal power for bunding and bank formation is another way to improve moisture use. The traditional wooden plow from northern Somalia, which has only recently been introduced to local farmers, seems well-suited to these tasks. However, this implement is not as well-suited to weeding as are the metal-framed cultivators. Weeding must be shallow to minimize moisture loss through exposing deeper soil to evaporation.

The Modeling and Testing of Alternative Cropping Systems

The Sorg-f Model

A farming system is more than the sum of its components. While deductive analysis of its parts is essential to understanding the inner workings of the system, eventually these components must be brought together into a single working unit. Unfortunately, agronomic research into whole systems is usually expensive and long-term. Inductive models have evolved to reduce the need for elaborate empirical testing.

The Sorg-f model has been used to predict the response of Local sorghum to a range of environmental and management conditions. In particular, it has been used to predict the effects of moisture conservation through the practice of clean-fallowing. Data from the long-term fallow trial has provided the empirical test with its predictions.

GRAHAM EAGLETON

Cows pulling locally constructed wooden cultivator with "steel points" in animal traction tests.

Sorg-f works by synthesizing current knowledge of the components of a sorghum crop into a conceptual model of the whole crop. Model inputs include such factors as daily rainfall, temperature, and radiation; plant-available water-holding capacity and runoff characteristics of the soil; maturity class and leaf number of Local sorghum; planting date and density. Model outputs include estimations of emergence date, total dry matter production, grain yield, and number of days to maturity.

Some of the predictions that have come from applying the model to 40 years of rainfall records for Baidoa are:

1. On average, sorghum yields in the Deyr season will be half that recorded in the Gu.
2. Fifty mm of stored plant-available moisture at the beginning of a Gu season will, on average, double grain yields.
3. If a field is clean-fallowed during a Gu season, less than 25 percent of the rainfall received is stored in the soil profile for the subsequent Deyr season crop.
4. Clean-fallowing in the Deyr season will not increase sorghum yields in many Gu seasons, but Gu season fallows will usually increase Deyr season sorghum yields.
5. For neither the Gu nor Deyr season would the yield foregone in a clean fallow be compensated adequately by increased local sorghum yield in the subsequent season.

The Long-Term Fallow Trial

This trial was set up as an empirical test of the effects of maintaining a weed-free fallow for one or two seasons' duration on subsequent crop yields. It incorporated a complex rotational scheme that included sorghum, safflower, sunflower, cowpea, and peanuts. Soil moisture was monitored for the three and one half years that the trial was in progress. Most of this work has been carried out by Abdi Ahmed Mohamed.

As far as sorghum yield is concerned, this trial and other supplementary trials have confirmed the predictions of the Sorg-f model, that seed yield of local sorghum is not sufficiently increased after a clean fallow to compensate for the lost production in the fallowed season. If a farmer is going to spend money keeping a piece of land free of weeds, it is more profitable if that land grows a crop than if it is kept bare for a subsequent sorghum crop.

The picture is more promising for other crops. On average, fallows do store moisture, although inefficiently, for use next season. Fallows have benefits in pest control and in the mineralization of nitrogen. In two successive Gu seasons of the long-term fallow trial and in supplementary trials, peanut yields were substantially increased by a previous fallow season. Where inputs such as phosphate fertilizer are to be used in the commercial production of peanuts, it is probable that a Deyr season fallow would be profitable. Further research is needed to verify this and to identify the precise reasons for the response.

Intercropping

Preliminary trials conducted by Abdi Ahmed Mohamed in Gu 1986 indicated that leguminous species grown at low populations between sorghum rows did not significantly reduce sorghum yields nor result in greater use of soil moisture reserves. The total production of the intercropped areas was greater than if the same area had been sown to equivalent proportions of monocropped sorghum and legumes.

In Gu 1987, results suggested that a higher population of cowpeas (up to 15,000 plants/ha) than farmers currently use (about 4,000 plants/ha) could be sustained in intercrops without reduction in sorghum yield.

Subsequent trials in the short Deyr of 1987 and on farmers' fields in Gu 1988 have shown some reduction in sorghum yields with high cowpea densities, but a proper balance between sorghum and the cowpea can increase the overall productivity of the land.

Work with varietal mixtures in sorghum has also shown interesting increases in productivity due apparently to synergistic effects between varieties.

This is a profitable area of research, with relevance for the existing cropping system.

Stubble-Mulching and Nitrogen-Moisture Interactions

Sorghum stubble incorporated into the soil at the end of Gu 1987 resulted in a 39 percent increase in mung bean seed yield and 37 percent increase in sorghum grain in Deyr 1987. These yield increases could be explained by increased infiltration and reduction in moisture losses from runoff and surface evaporation.

When sorghum stubble was again incorporated without nitrogen fertilizer at the end of Deyr 1987, there was a reduction in sorghum growth in the subsequent wet season of Gu 1988. When nitrogen was

PAUL PORTER

Intercropping trial of local cowpeas and local sorghum conducted by Dryland Cropping Systems Section on BDARS included with the stubble, yields were restored to the same levels as plots that received nitrogen but no stubble. Mung bean stubble was less demanding of mineralized nitrogen reserves than sorghum stubble.

In low rainfall seasons, other trials with nitrogen fertilizers have resulted in marginal increases in seed yield where skip-row plant arrangements have been used, but reductions where plant populations have been high.

Such relationships between moisture and nitrogen in the cropping system will assume greater importance when farmers begin to satisfy the phosphorus demand of their crops.

Bunding

Runoff control has been a neglected area of research. The establishment of a bunding trial by Ahmed Aden Odowa in Gu 1988 and bunding trials by the Soils Section have set the scene for this important work. The use of vegetation banks to reduce runoff will also be the focus of future research.

Chapter 8

Sorghum Breeding

by Hedera Porter

Overview

THE SORGHUM IMPROVEMENT SECTION at BDARS was revitalized in 1981 through the assistance of Eugene Alahayodoyan (IDRC). With few assistants and little infrastructure, he began acquiring and testing exotic varieties for their yielding ability under local conditions. In addition, a collection of Local sorghum germ plasm (made by IBPGR in 1980) from Bay, Bakol, Gedo, Middle Shebelli, and Hiran regions was planted for evaluation. Data on days to 50 percent flowering, plant height, seed color, and maturity were recorded. It was concluded that the Local germ plasm base was rather narrow. Investigation of Local germ plasm is an important step in determining the basis of the material to be improved. Over the seasons, additional exotic materials were received from many countries. In Gu 1983, hybridization was incorporated into the sorghum program. This work involved crosses within the Local germ plasm, as well as crosses between Local and exotic material. In hindsight, crossing between local varieties that differ by only a few qualitative traits is futile. In order to generate new combinations, one must start with diverse materials.

Nineteen eighty-three marked the arrival of Bernard J. Kolp (chief of party, Wyoming Team, and research director and the first of the USAID-sponsored support staff members). In addition to personnel, equipment also began to arrive. Until Deyr 1984, all planting had been done by hand. This, along with an ever-increasing amount of germ plasm, lack of adequate storage facilities, no fertilizers, and a great reliance on casual labor had resulted in nearly meaningless research trials. CVs on trials carried out in the Sorghum Improvement Section ranged from 50 percent to 170 percent. Selection of high-yielding varieties is difficult under local conditions. Yield differences are harder to demonstrate statistically at low yield levels, because the effects of soil variability are accentuated by poor growing conditions. It takes an increase in the number of replications and better experimental techniques to show the yield advantage of new varieties in low-yield environments. Efforts to achieve statistically significant differences among varieties were attempted by increasing the number of replications to as many as six. With the advent of machine planting, appropriate cultivation tools, returning trained personnel, and fertilizer application, CVs began dropping. In Gu 1985 the highest experimental CV was 65 percent. While this is still unacceptable for yield purposes, it reflects a substantial decrease compared to previous seasons.

Because of the difficulties in carrying out definitive trials, selection of promising materials was hampered. Much more material was advanced from season to season than was desirable. Entomological trials initiated in Gu 1982 were continued by the section until 1987. This material has proven to be agronomically poor. The primary use of the material would be in a crossing program. However, research has shown that true stem borer resistance-tolerance is an elusive character.

In August 1986, Alahayodoyan completed his contract. This left Hussein Mao Haji (master of science degree, 1984) and Abdullahi Hussein Wardere (master of science degree, 1985) in charge of the section. In June of 1987, Hedera Porter was hired as a collaborative researcher in the section.

Even though sorghum is a self-pollinating crop, the amount of outcrossing can be substantial. This is important because it affects contamination of breeding stocks. Some method of control is important, because outcrossing is nearly always at least 5 percent and can reach as much as 50 percent depending on the environmental conditions. Progress has been hindered in the section due to the lack of controlled pollination. An example of this is the sorghum variety, Dabar. Dabar was received as part of the United States government-sponsored "Grain Aid" program during the 1982 drought and was tested for its performance at Bonka in subsequent years. Since 1984, three different expatriate scientists have commented on the heterogeneity of the Dabar grown at the 100-ha farm. They initiated head selections in an effort to develop high-yielding, uniform varieties. However, this material has not been maintained. Again in 1988 selections were recommended and collected. It remains to be seen if this material will make it further than its predecessors. Recent visitors familiar with Dabar stated that the material station personnel are calling Dabar only vaguely resembles the actual variety. Outcrossing has been a problem for other materials as well. It is difficult to make progress in selections when a proportion of the material is crossed to unknown parents. More effective use of remnant seed, as well as controlled pollinations using paper bags, must be made. Modest efforts have been made by the section this past season (Gu 1988), yet the procedure must be stepped up.

All hybridizations made in 1983 and 1984 have been lost. Renewed efforts of this important aspect of sorghum improvement were initiated in Deyr 1987. In Gu 1988, additional crosses were made between the Local and desirable exotic materials and among promising exotic materials themselves. This process will generate useful variability needed in an improvement program.

While an awareness is developing among the national staff with regard to proper experimental techniques, progress still needs to be made. This will only be accomplished with adequate role models. Supervision of experimental technique is still required.

Introduced Materials

Open-Pollinated Varieties

Most of the germ plasm received and tested by the Sorghum Improvement Section consisted of open-pollinated varieties. Materials have been received from India, Kenya, Uganda, Ethiopia, Upper Volta, Mali, Zimbabwe, Syria, and the United States. The advantage of such varieties is that the farmers can maintain their own seed supply.

Nearly all of the material tested has failed to perform consistently superior to the Local variety. This is not surprising, considering that the Local type has evolved under the environmental and biological pressures of the area for quite a number of years. However, two promising varieties, ICSV 193 and PP 290, have been recommended for off-station testing in Deyr 1988. ICSV 193, under fertilized conditions, has maintained a higher grain yield as well as an equivalent stover yield when compared to the Local sorghum. Additionally, it possesses grain characteristics similar to those of the Local. It is hoped that these two varieties may complement the farmers' grain and fodder production efforts.

ROBERT LAVIGNE

Comparison of growth from the Local durra sorghum (left) with that of one of the many new varieties.

Hybrids

Much discussion has been raised concerning the role of hybrid sorghum in Somalia. This controversy has surrounded the lack of a hybrid seed industry in the country. A relatively small number of hybrids have been tested on-station in recent years. Material from ICRISAT has been developed as dual-purpose sorghum, supplying good quantities of both grain and fodder. Commercial hybrids obtained from Pioneer and Dekalb appear to have been primarily developed as animal feed.

Yield trials to date have been encouraging. Under fertilized conditions, it appears that there is a greater yield advantage for hybrids in a drier season than in a wet season when compared to the Local. Several promising hybrids (ICSH 109, ICSH 110, ICSH 434, and ICSH 205) have been identified. These materials have been recommended for off-station testing under farmers' conditions.

Summary

Sorghum is the staple crop of the inhabitants of the Bay Region. Current production levels are at the subsistence level. The Sorghum Improvement Section of BDARS is actively involved in trying to increase yield levels in the Region. Research over the past seven years has involved testing of introduced varieties and hybrids. Recent advances in experimental technique have aided their efforts. Several promising introductions (open-pollinated varieties and hybrids) have been recommended for off-station testing, beginning in Deyr 1988.

Chapter 9

Plant Protection

by Robert Lavigne

Introduction

PRIOR TO THE CONSULTANCY in 1983 of Robert Lavigne as the expatriate entomologist, research on insect pests in the Bay Region was minimal, i e., confined to one chemical experiment per season or the gathering of data by sorghum plant breeders on stalkborer "resistant" varieties. No attempt had been made to look at pest biology, cultural control methods as they relate to stalkborers (the major pest of the Region), or obtaining additional chemicals to be tested for pest control. Additionally, no attempt had been made by personnel to acquire, summarize, or read any literature relating to control of insect pests other than *Crop Pests of Somalia* (Mitchell, et al., ca 1982). Seasonal reports prepared were so simplistic that no data of use to an entomologist were presented. Additionally, CVs were so high (or not calculated) that the collected data were essentially useless. A series of recommendations was made in late 1983, but due to the lack of trained plant protection personnel, none were carried out. This lack of action resulted in a request by BRADP for the services of an entomologist.

Plant Protection Research

Personnel

The expatriate entomologist, upon his arrival in July 1985, was given the task of initiating a research program with major emphasis on the control of stalkborers. Fifty percent of his time was to be directed to plant protection research and 50 percent to administrative duties as chief of party of the Wyoming Team. As did his predecessor, Dr. Kolp, the chief of party devoted a great deal of time to administration as well as research, resulting in 10-15 hour work days. The Plant Protection Section was established in late 1985 with formal job assignments being made at that time (Quarterly Report Oct-Dec 1985). The expatriate entomologist was made head of the section and remained in that position until Ali-nur Hussein Duale, who received his master of science degree in 1988 from the University of Tanzania, replaced him.

During the time the expatriate was leader, he was ably assisted by Mohamed Abdurahman Mohamed, senior research officer, July 1985-January 1988; Mohamed Hassan Mohamoud, senior research officer, May 1987-September 1988; Said Ali Abdullahi, junior research officer, September 1986-present; and Said Mohamoud Jumale, junior research officer, April-September 1988. Abdilatif Hamud Mohamed, junior research officer, was added to the staff in the area of plant pathology in late 1987.

Role of Plant Protection

According to the 1983 Hunting Technical Services Ltd (HTSL) report (vol. 2, 53), "The damage caused by insect pests is generally recognized as a major factor limiting crop production levels in Bay Region, a factor second only in importance to rainfall in determining yield levels."

The report provided a very specific set of recommendations on the direction that an entomological program should take:

1. Establish contact with other national research bodies and international agencies engaged in investigations into stalkborer control, and review published literature, extracting information relevant to the Bay Region situation.
2. Ascertain that the species *Chilo partellus* is the major species in the Bay Region, and, if so, study the biology of this species in the local environment.
3. Examine the role of ratoon sorghum and the sorghum stubble in the carryover of larvae and pupae of the stalkborer from one season to the next.
4. Carry out surveys to determine the within-season variation in stalkborer attack in the Bay Region, sampling sorghum stalks to determine stalkborer populations over as wide an area as possible.
5. Investigate the effectiveness of a range of insecticides for stalkborer control.

6. Establish whether opportunities exist for biological control of stalkborer through the identification of natural enemies — insect parasites, viruses, and so forth.
7. Investigate the effect of various other insect pests, such as crickets, *Heliothis*, and the Beve bug on sorghum production.
8. Improve the effectiveness of campaigns against crickets, armyworms, and so forth.
9. In addition, the entomologist determined that there was a need to assess the extent of grain losses from sorghum storage pits and to develop recommendations for the control of stored grain pests.

The strategies implemented to achieve these goals were as follows:

1. Initiate a literature search for articles dealing with the biology and control of stalkborers.
2. Conduct independent research involving the testing of hypotheses.
3. Conduct joint experiments with other members of the research group, particularly the Agronomy Section and sorghum breeding group.
4. Consult periodically with researchers at CARS and with members of the Faculty of Agriculture at the Somali National University to obtain their input into the program at BDARS.
5. Develop recommendations for specific pesticides for use against stalkborers and other pests affecting crops at BDARS and in the Bay Region.

Accomplishments of the Section

In the past three years, there has been an expansion of the role of plant protection research on the research station. Much effort has been expended in keeping a coherent program going through a succession of personnel.

Life history of stalkborer

Over the course of several seasons the life history of *Chilo partellus*, the major stalkborer pest in the Bay Region, was explored. It was established that two overlapping generations normally occur each season with larvae of the second generation diapausing. In Gu 1988 a

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Plant Protection Service crew making post-harvest counts of stalkborers.

partial third generation was observed for the first time with second and third instar larvae being found at the nodes under the leaf sheaths. The appearance of the third generation is attributed to the unusually extended period of high precipitation that occurred during this particular season.

The data for five seasons support those obtained in the deadheart surveys, which show heavier infestations are present in the Deyr season than in the Gu. Looking at regional means, plant heights are less in Deyr seasons than in the Gu, which may be due in part to reduced available moisture. As a direct result of the drought of Deyr 1986, there was a reduction by half of the mean number of larvae per stalk and mean number of infested nodes per stalk in the subsequent Gu 1987 season. Additionally, there was a reduction in percentage of attacked plants, supporting the argument that an area-wide six-month break in available food results in a significant reduction in stalkborer populations. In other words, diapausing larvae were stressed and unable to survive the long dry period. An increase in the number of fields infested by *Sesamia cretica*, the minor stalkborer pest of the Region, also was obtained. These data support the premise that back-to-back plantings (Gu and Deyr) of sorghum lead to population buildups of lepidopterous pests. It is necessary, therefore, to break the life cycle of the pest. This can best be done by having subsistence farmers cease the practice of back-to-back planting of sorghum and instead initiate a program of alternate cropping in tandem with a program of sanitation.

The explanation for these proposals is that there is greater survival of diapausing larvae in the short (one-month) period between the Gu and the Deyr seasons than between the Deyr and the Gu (Lavigne 1988). During this latter period (the Jilaal), the larvae are subjected to at least three months, and sometimes four, of intense sunshine and drought conditions that are detrimental to survival. Farmers also practice better sanitation at the beginning of the Gu season in anticipation of better harvests and destroy roots in which diapausing larvae survive. On the other hand, farmers practice ratooning during the Deyr seasons. Early rains stimulate early plant growth, which then serves as ideal substrate for ovipositing females.

Control of stalkborer

In past years, research has been restricted almost entirely to the testing of different insecticides. This resulted in recommendations for the use of Sevin and Basudin. However, no recommendations were developed for the proper application of these insecticides. Other possible control measures had been neglected completely.

Recently the Plant Protection Section has begun filling this gap by collecting the basic field data necessary to study the feasibility of control measures other than chemical control, and to improve on the chemical control itself.

For any realistic increase in grain legume production at the subsistence farming level, pest control is essential; hence, a major priority is the development of pest-resistant varieties. While resistant varieties are the ideal solution, there has been little practical progress to date. Even in the event that a more tolerant variety becomes available, it is unlikely to provide adequate control of the total pest spectrum. Consequently, other control methods need to be researched and combined with plant resistance to form an integrated pest management system.

1. Cultural

Cultural practices, such as tillage, sanitation, crop rotation, time of planting, density, fertilizer, and water management have been suggested as possibly affecting stalkborer populations by Seshu Reddy (1984). A start on testing this assumption was made at the end of the Gu 1985 season and research was continued through Gu 1988. Tests carried out on time of planting, plant density, and plant populations showed no differences for stalkborer numbers or attacks on plants.

In a continuous cropping trial that compared various fertilizer and fallow trials, there was an unmistakable trend paralleling data obtained from other experiments. Treatment 1 (unfertilized sorghum planted every season) provided the lowest yields. At the same time, this treatment had the shortest stalks, the least tunneling by stalkborer larvae, the least number of larvae and pupae, and the second to least number of entrance and exit holes. Conversely, treatment 5 (fertilized sorghum—mung bean—fertilized sorghum) had the highest yield, stalk heights nearly equal to that of treatment 2, the second least amount of tunneling, the second least number of entrance and exit holes, and the second least number of larvae and pupae. Obviously, stalkborer adults were attracted to healthier plants, but those plants that were fertilized were better able to withstand the insect attack. The difference in yield was an increase of 45.5 percent, despite an increase in the infestation rate of 15-40 percent. These data provide further support for the practice of crop rotation, which is the one control available to the subsistence farmer not requiring purchased inputs.

2. Chemical

The use of insecticides on sorghum and legumes in the tropics will inevitably increase, and a high research priority must be the preservation of natural levels of biological control of the existing pests. Selection of a pesticide is not enough; research is required on time of day, spatial distribution, and application methods in order to protect natural enemies. Certainly, maximum potential yield of a variety may not be the desirable goal if this requires a heavy insecticide blanket. Using a simple pest management package that relies heavily on the use of moderately resistant varieties will be enough to enable skilled farmers to control their pests.

Integrated farming systems studies are required to determine the conditions influencing the small farmer's choice of control measures.

Using matched-pair comparison tests, it was established that carbaryl was effective in controlling the first instar stalkborer larvae, which are responsible for deadheart. Subsequent tests using granules have provided variable results.

Other insect pests of sorghum

1. Mites (red feather)

   Preliminary information on the role of mites affecting sorghum in the Bay Region has been collected. The problem in farmers' fields is usually confined to the Deyr season, and a program of crop rotation would solve the problem. This solution would require no purchased inputs.

2. *Heliothis armigera*

   Data have been collected showing the problem could easily be solved if farmers would switch to open-panicle sorghums. Tests using chemicals such as endosulfan and polytrin will give adequate control, but these are too expensive.

3. Armyworm

Both Cymbush (ULV) and carbaryl (Vetox 85 wettable powder [WP]) were tested against the armyworm in a Deyr 1985 outbreak prior to initiation of control efforts and both provided 100 percent control. The controlling factors in choice of chemical, i.e., cypermethrin ULV, were ease of application and the elimination of the need to carry large quantities of water to the infestation site.

4. Brown field cricket

An outbreak of this cricket was brought under control in Deyr 1985 through the use of a carbaryl-corn bran bait. Subsequent tests showed that a malathion or BHC-based bait produces much better results.

5. Beve bug

This insect is not considered a pest of importance in the Bay Region at this time, because specimens of the Beve bug, Calidea sp., have only been collected infrequently by the expatriate entomologist and the Plant Protection Service Unit despite extensive surveys of sorghum in the head stage throughout the Bay Region.

6. Millipedes

Following the destruction of the off-station planting at Xabaalo Barbaar, the plots were examined to ascertain what might have caused the problem. Millipedes were determined to be responsible. The farmer reported millipedes had only been a problem on his farm the past three years and they were especially bad in the Deyr seasons. Thus far, attempts to control millipedes with dieldrin 18 percent EC, applied at the rate of 250 ml/10 liters of water; Dursban 5G granules, applied at the rate of 5 kg/ha; and heptachlor, applied at the rate of 25 ml/10 liters of water, have been unsuccessful.

Insect pests of alternate crops

In other insect control tests, cypermethrin was found to control *Heliothis armigera* larvae on safflower; endosulfan was found to control Nezara viridula, the green vegetable bug, on mung beans; and several chemicals were found to control stored grain pests in above-ground stored bags. Recommendations from multiple chemical trials have been produced in a bulletin titled *Control of Insects on Bonka Dryland Agricultural Research Station* (Lavigne 1988). More testing needs to be done with chemicals for the control of podborers and thrips on mung beans and cowpeas, for the control of mites responsible for the condition known as red feather, for the control of brown field crickets, and for the control of millipedes.

Additionally, the research section has investigated the incidence of stored grain pests in bakaars, including identification of those found in the Bay Region.

Grain storage

Tests were completed on (a) storage capabilities of five varieties of sorghum in bakaars in threshed and unthreshed conditions, (b) effect of storage of threshed grain in plastic bags, (c) use of chemicals to control stored grain pests in standard storage bags, and (d) use of chemicals for the control of stored grain pests in sorghum heads in standard storage bags.

Training

The expatriate entomologist and his counterpart, Ali-nur Hussein Duale, have conducted training of plant protection personnel in (a) insect identification, (b) handling of pesticides, (c) pesticide safety (a pesticide safety specialist was brought to Somalia in August of 1988 to provide instruction to plant protection personnel and to all BDARS researchers), and (d) insect control techniques.

Little progress has been made to date in training field extension agents (FEAs) and providing them with resources in the form of chemicals and sprayers. There has been little equipment and a limited amount of chemicals to distribute.

Pesticide storage

The cleanup campaign of the chemical storehouses in the Bay Region has been completed. The exercise was of great use in terms of both cleanup and training in the handling of pesticides. A new chemical stores building was constructed at BDARS and has solved many of the problems that previously existed.

When the expatriate entomologist arrived, only one motorized backpack sprayer was functional. The rest, about 24, were broken or had been cannibalized for spare parts. All broken sprayers were recalled from the agricultural district offices. Spare parts were ordered

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Plant Protection Research Section staff, Ali-nur Hussein Duale, section head (right), and Mohamed Hassan Mohamud emptying the contents of an armyworm trap.

from the manufacturing company. At the conclusion of the project, 16 have been repaired and are now operational. Unfortunately, the particular model used is no longer produced, and all of the remaining spare parts have been obtained. Consequently, it will be necessary to order new equipment if motorized sprayers are to be used extensively in the future.

Insect monitoring

Three insect species (*Spodoptera exempta, Heliothus armigera,* and *Atherigona* sp.) are being monitored through pheromone traps or attractants to determine their seasonal abundance. The collected data will have predictive value and, it is hoped, provide a clue as to the best time for chemical control.

Recommendations for Future Research

1. In the course of three years of experimentation at Bonka, several no-input farming activities have been evaluated for their effectiveness in controlling stalkborers: intercropping, trap crops, continuous cropping, genetic manipulation, and resistance. In all of these tests, no significant differences in stalkborer infestations have been found. Data collected on the life history of *Chilo partellus* indicate breaking the cycle of the pest in the diapausing state shows the most promise. Consequently, it is recommended that the farmers engage in an area-wide crop rotation and sanitation program. Surveys carried out by the Plant Protection Service Unit show insect problems are more severe in the Deyr season. These could be largely eliminated by crop rotation.

2. Sanitation should be practiced by all farmers, instead of by only 5 percent of the farmers (Howard 1988), because sanitation eliminates the source for diapausing pupae.

3. Farmers should be encouraged to build stooks (solid fodder stacks) every season as part of a pest control package. The advantages of stooks are twofold: (a) provision of fodder for animals during droughts or exceptionally short rainy seasons

and (b) confinement of diapausing larvae in the interior of stooks, which would cut down on the numbers of stalkborer adults escaping into the environment the following season.

4. Farmers should be encouraged to grow open-panicle sorghums because surveys have shown very few Heliothus larvae (another sorghum pest identified by farmers as being important) are present in open-panicle heads.
5. More work should be done with intercropping because experimental results from other countries indicate intercropping provides some reduction of pest insects.
6. Research should be continued on stalkborers with an emphasis on integrated control. To this end the Plant Protection Section should cooperate with the newly hired ICIPE entomologist who will be working on the stalkborer problem throughout Somalia during the next three years.
7. An artificial rearing program for stalkborer should be established. The Plant Protection Section leader, Ali-nur Hussein Duale, is already trained in this field, while Mohamed Hassan Mohamed is now being trained at ICIPE. A program of artificial infestation should be initiated to accurately assess resistance in cultivars being grown by the Sorghum Improvement Section.

Personnel in Section Sent for Training

Mohamed Abdurahman Mohamed, senior researcher for the Plant Protection Section, was sent to Queensland Agricultural College in Lawes, Australia, in January 1988, for one year of training leading to a graduate diploma in plant protection.

Mohamed Hassan Mohamud, junior researcher, was sent to the International Center for Insect Physiology and Ecology (ICIPE) at Mbita Point Research Station, Kenya, for six months of training in biocontrol of stalkborer procedures.

Abdilatif Hamud Mohamed, plant pathology technician, was sent to Queensland Agricultural College in January 1988 for one year of specialist technical studies in plant pathology and protection.

Plant Protection Service Unit

The Plant Protection Service Unit came under the wing of BRADP in late 1985 soon after the arrival of the expatriate entomologist, who was subsequently made section leader. At that time the unit was poorly motivated and lacked any clearly defined goals. Activities prior to mid-1985 were largely confined to (a) spraying chemicals on local farms in the area around Baidoa, (b) responding to insect outbreaks under the direction of the National Plant Protection Service in Mogadishu, (c) providing small amounts of chemicals to farmers in Baidoa district for insect control, and (d) storing pesticide chemicals in a dirt-floored warehouse in case of insect and bird outbreaks.

This unit has evolved from an untrained, underutilized, unskilled group of individuals into a reasonably well-trained and highly motivated unit that is able to perform surveys and respond to pest outbreaks in an efficient manner.

The service has functioned well under a series of regional heads: Abdirahim Abdullahi Ismail, 1982-January 1987; Abdulkadir Ali Samatar, 1987-January 1988; and Hersi Dini Hassan, acting head, January-September 1988. Much of the credit for the successes attained by the unit goes to the dedicated cadre of secondary school trained personnel: plant protection technicians Hassan Mukhtar Ahmed, Mutaf Nur Hassan, Abdirahman Ali Magan, Abdinur Yusuf Irad, Abdulkadir Sheikh Isak, and Omar Mohamed Ali; mechanic Mohamed Nur Mohamed Ker; and the driver, Mohamed Hassan Ibrahim (Midi).

As the Project concluded, the section was involved in surveys on a systematic schedule to obtain baseline data for use by the Plant Protection Section in formulation of research programs as follows:

1. Monthly surveys for life history studies of stalkborers.
2. Deadheart survey from the third to fifth week of each growing season.
3. Survey for covered kernal smut at the milky stage of sorghum
4. Stalkborer density survey following harvest.
5. Red feather survey for mites conducted at same time as smut survey.
6. Sorghum stalk cost survey following harvest.
7. Insect and rat damage surveys in bakaars, conducted intermittently.

Additionally, they are involved in applied research on farmers' fields in the area of insect control, as a result of which they are able to make chemical recommendations. They also work in cooperation with the Plant Protection Section in (a) collection of data, (b) conduct of experiments, (c) control of insects in research plots, and (d) control of stored grain pests.

Surveys over the past several seasons have revealed:

1. Many of the insect problems, such as stalkborer, are more severe in the Deyr season or, as in the case of red feather, are confined to that season.
2. Closed-panicle sorghums have more severe infestations of *Heliothus armigera* than do open-panicle sorghums.
3. Covered kernal smut in the Region is largely under control through the use of FernasanD.
4. The economic value of sorghum stalks is greater in the Deyr season.
5. By implication, surveys indicate that a program of crop rotation would solve many of the local farmers' insect problems.

The most successful program engaged in by the Plant Protection Service Unit, as far as farmer acceptance is concerned, has been the distribution of the seed dressing chemical FernasanD. The chemical has been shown to be effective for covered kernal smut and is reported by farmers to be excellent for the control of insects attacking emerging seedlings. The demand for the chemical has increased each season and is now distributed in 9-gram packets that are sufficient to treat 3 kilos of threshed sorghum grain.

The two pest outbreak control programs, cricket and armyworm, were handled in a professional manner. With regard to the cricket campaign, Plant Protection Service Unit technicians feel that the amount of assistance they were able to render was too little, due to lack of sufficient amounts of chemicals, and in many cases too late. The latter statement relates to the fact that much of the information received came as a result of casual visits by farmers to plant protection headquarters. There is a definite lack of a communication network to provide data on the extent of an infestation when it is just beginning so that control efforts can be initiated quickly. Once surveys were initiated by the Plant Protection Service Unit, the extent of the cricket problem became readily apparent, but by that time some of the farmers' crops had been wiped out.

Recommendations for Future Work

1. Continue surveys of pest insects.
2. Establish collection of identified pest insects according to crops.
3. Obtain a curator to maintain and add to the collection.
4. Maintain the chemical store in clean condition.
5. Obtain sufficient hand-operated backpack sprayer equipment to train FEAs and release some for their use in training farmers.
6. Improve distribution system for insecticides.
7. If a plant pathologist becomes part of the Plant Protection Section, order fungicides.
8. Train a mobile pest outbreak unit to be provided with a vehicle and camping equipment.
9. Expand seed treatment program for smut with the establishment of a distribution system.
10. Obtain better protective equipment for plant protection personnel.
11. Establish a small library at plant protection headquarters with information on chemicals, use and safety, application equipment, recommendations, and so forth.
12. Continue testing program for chemicals.
13. Initiate distribution and sale system for FernasanD to make it readily available to the farmers.

In-Service Training Given to Personnel

1. Insect identification, especially crop pests and stored grain pests
2. Calibration of equipment
3. Equipment repair (sprayers)
4. Pesticide safety
5. Determination of quantities of pesticides to apply
6. Course in basic entomology

Personnel Sent Abroad for Training

Abdulkadir Ali Samatar, Plant Protection Service Unit regional head, was sent to Queensland Agricultural College in Australia in January 1988 for one year's training leading to a graduate diploma in plant protection.

Abdirahim Abdullahi Ismail, former Plant Protection Service Unit regional head, was sent to Colorado State University in the United States for training in plant protection. He did not return; this was a great loss to the program.

Difficulties Encountered in Carrying Out the Plant Protection Program

All in all, only minor difficulties have been encountered in carrying out the plant protection research and service programs. The major problem has been and continues to be the intermittent shortage of petrol, which has in some cases forced a slowdown in research and service operations.

Chapter 10

Development of "Filsan": Grain Legumes and Oil Crops

by Grant Richardson

(NOTE: Dr. Richardson prepared this section with the assistance of information provided by former Research Director Dr. Robert Buker, who worked closely with Somali researchers in the development of "Filsan.")

Introduction

RESEARCH ON GRAIN LEGUMES and oil crops began early in the life of the Project. It was recognized that grain legumes are concentrated sources of protein and especially beneficial as fortifiers of cereal grains in the human diet, especially for the very young. Even though cowpeas, mung beans, and peanuts occupy less than 5 percent of the cultivated land in the Bay Region, they fit well into the cropping systems, either as a rotation crop or as an intercrop with sorghum, the leading crop in the Region. They supply their own nitrogen, are relatively drought-tolerant, mature earlier than sorghum or maize, and are popular crops for home consumption.

Peanuts have become more popular in recent years as a cash crop, as well as being consumed by the farmer family. Safflower, a relatively new oil crop, shows promise as a cash crop, especially if an oil-processing plant in the Region becomes a reality. Other crops that have been tested for adaptability to the soils and climate of the Region are sunflower, soybean, and pigeon pea. A very recent introduction to the area is the pinto bean, which may become an important crop if it is acceptable as a food on the family table.

Goals

The goals pursued by the Grain Legumes and Oil Crops Section have been three-fold:

1. To select or develop high-yielding, early-maturing varieties with attributes acceptable to the farmers.
2. To identify and study major pests and diseases, if any, and to develop suitable methods of control.
3. To develop agronomic practices for increasing yields and total production, such as correct planting dates, most desirable plant densities, proper thinning and weeding dates, and benefits from the application of fertilizers. (It was determined early in the research effort that Gu and Deyr seasons required different agronomic techniques if economic increases in production were to be attained.)

Constraints

Production of grain legumes and oil crops was found to be constrained by several important factors:

1. Plant populations were much below optimum.
2. There was a lack of varieties with potential for high yield, uniform seed maturity, and resistance to shattering losses under dryland conditions.
3. Little care was taken in protecting the crops from insects, diseases, and weeds.
4. Stored grain and seed were seriously damaged by insects, especially bruchids.

Strategy

Various sources were contacted to obtain improved varieties. Safflower and soybeans were obtained from the United States. Cowpea lines were received from the United States and Nigeria, while peanuts and pigeon peas were obtained from ICRISAT in India. Mung bean lines were obtained from the AVRDC in Taiwan. Testing these lines at BDARS with the available local varieties was the main approach for selecting superior-yielding varieties or lines. Promising varieties were included in multilocation trials to measure their performance in the four districts of the Bay Region.

Research Leadership

From 1981 to 1985 the section was divided into two groups: the Grain Legumes Section and the Oil Crops Section. During 1981, Sahra Ali Osman led the Grain Legume Section. Abdikarim Mohamed took over the leadership of the Grain Legume Section in 1982. In 1983, Ali Mohamed Abdi took over the leadership of the aforementioned section. During 1984 Ali Mohamed Abdi was the leader of the Grain Legumes Section, while Amina Ali Garad directed the work of the Oil Crops Section. During 1984-85, Aden Elmi Abdullahi served as section leader of grain legumes and Abas Mohamed Nasir supervised the research effort on oil crops. Subsequently, the two groups were combined into a single section. Research efforts are now being conducted under the able leadership of Adan Ali Ossoble.

Cowpeas

Research on the cowpea since 1981 has shown this crop to be well-adapted to and to fit well into the cropping systems on the farms of the Bay Region. Some very promising lines have been found to be higher-yielding than the local and are early-maturing and agronomically acceptable. Although an improved variety for widespread adoption by the farmers has not yet been released, that objective is very close to being reached. Top yields of 1,700 kg/ha were obtained from some extra-early-maturing varieties in 1986, with maturity periods of only 57 days, compared to 70 days for the local.

Mung bean

The outstanding success story of the Grain Legumes and Oil Crops Section was the release to the farmers in 1987 of a superior mung bean variety, Filsan. It is earlier than the local, has larger seeds, and usually produces more seed per hectare. The farmers have readily accepted it as the best available variety, and planting seed is in great demand. Filsan has consistently matured at least ten days earlier than the local, making it a better risk for the shorter Deyr season. More than 100 varieties or lines were tested in the search for Filsan, but the research effort was rewarding to the staff at BDARS and to the farmers of the Bay Region. Mung bean research has shown the crop to be well-adapted to both the Gu and Deyr seasons in the Bay Region. It responds well to added fertilizer phosphorus and fits well into a crop

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Adan Ali Osoble, Grain Legumes and Oil Crops Section head, prepares information for local farmers and extension workers on the merits of the new "Filsan" mung bean.

rotation with sorghum and cowpeas. It is an accepted source of protein in the Somali diet, and the hectares devoted to its production are increasing.

Pigeon Pea

The pigeon pea was tested for its adaptability to the climate and soils of the Bay Region from 1982 to 1986. Most of the varieties were obtained from ICRISAT, but some came from the University of Queensland in Australia. The yields have generally been disappointingly low and the required growing season too long for this environment. For these reasons, research on the pigeon pea was halted in 1986. Even though a few lines from Australia matured in 120 days, it was decided that other legume crops, such as the cowpea and mung bean, were better adapted than was the pigeon pea.

Pinto Bean

A new, high-protein food crop was introduced into Somalia for the Gu season of 1988 and planted in an observation trial at BDARS. The variety, NW 590, was brought from Lesotho, where it had been tested for four years and widely accepted by the farmers in that area of southern Africa.

The pinto bean is the most popular grain legume for human food in North and South America and many other countries of the world. It has several advantages over most other competing crops: (a) it is early-maturing (approximately 54 days), (b) it produces all of the flowers, and thus the pods, over a short period of time (requiring only one harvest), (c) it is non-shattering (harvest time is not very critical), (d) very few insects and diseases are damaging to it, and (e) it apparently will be an acceptable food in the Somali diet.

Sample plants were harvested from the observational planting to determine the potential yield in the Gu season. Based on a plant spacing of 16 cm and a row spacing of 50 cm, the pinto bean plants would have produced between 6,000 and 10,000 kg/ha of beans, a very good potential yield. About 200 kg/ha of diammonium phosphate (DAP) was applied in a concentrated band below and to the side of the seed at planting time. Adequate moisture was available during the season for normal growth and development of the plants. The pinto bean should be further tested in the Deyr and Gu seasons to adequately determine its adaptability as a new crop for the Bay Region.

Sunflower

Starting with the 1981 Deyr season, sunflower varieties were compared for the purpose of discovering a high-yielding variety that was well-adapted to the Region. Testing continued until the Deyr 1985 season, at which time the crop was dropped from the program (even though yields equivalent to safflower had been recorded), because of excessive bird damage and because the locally extracted oil had an unacceptable quality (a dark sediment).

Safflower

Safflower appears to be a potentially good oil crop for the Bay Region. Varieties were tested from 1981 to the present, and research results have shown at least two lines, VC152 and VC155, to be the best varieties compared. It was proved that safflower can be successfully planted with a grain drill in 10 cm rows, but that wider rows (36 to 54 cm) stimulate the plants to grow taller, for more efficient machine harvesting, and produce as much or more than narrower rows. It responds well to added fertilizer and has a deep tap-root system, making it possible to extract soil moisture from the lower soil depths. This feature makes safflower a drought-tolerant crop in this area.

The oil content of safflower seed is relatively high—30-40 percent—and is of excellent quality as a cooking oil. Research indicates it could become a major oil crop in the Bay Region and drastically reduce the amount of oil imported into Somalia. Further research to refine production techniques is needed. The most economic rate of fertilizer application needs to be determined, considering that preliminary results indicate a substantial response to applied DAP.

The deep-rooting habit of safflower, although highly desirable for the crop, may limit the kinds of crops that should follow a previous safflower crop. Soil moisture is so nearly depleted by the extensive deep-root system that a following crop may not have enough reserve water for adequate yields, especially in a subsequent Deyr season or if rainfall is less than normal. Evidence of this moisture depletion appears as wide, deep cracks in the clay-type soil, especially where tractor tires compact the soil between the rows of safflower. If early seasonal rainfall is adequate, the problem may not occur in the following crop.

Soybean

One of the world's leading oil crops, the soybean, was introduced into our research program in the 1983 Deyr season with the planting of ten entries from the state of Mississippi in the United States. The results of continuing research on possible high-yielding varieties have been variable and inconclusive. Rabbits have devastated some of the trials, termites have also been destructive, and seed inoculation, with the appropriate nitrogen-fixing bacteria, has been required. Nevertheless, a few varieties have produced over 2,000 kg/ha of seed when phosphate fertilizer was broadcast before planting.

More research on the soybean is needed before a decision on its adaptability and competitiveness with other oil crops is reached. The soybean plant has a relatively deep root system, making it somewhat drought-tolerant. It should not yet be discarded as a potentially suitable oil crop for the Region, even though test results have been somewhat inconsistent.

Peanut

The peanut began to become an important crop in several areas of the Bay Region in 1982. Since that time, the area planted to the peanut has been increasing, especially in areas of the Qansa Dhere district. It has been recognized not only as a nutritious food legume but also as a profitable cash crop. It has definitely begun to be an important source of protein in the diet of the people of the Bay Region. Because the peanut plant can supply its own nitrogen, it does not deplete the nitrogen content of the soil.

Peanut production requires a relatively high investment in seed and labor for successful yields. Therefore, it should probably be planted mostly in the Gu season. Although little research has been conducted on its potential as an intercrop, its requirements are different from those of the sorghum plant. Therefore, it should probably be limited to sole plantings. Yellowing of the plants in some soils and seasons has been widely observed. To date, research results have not determined conclusively the causes or the remedies. Lack of soil oxygen after substantial rainfall, especially in low areas of the field, is undoubtedly one of the causes. More research is needed to solve this problem, although yields are seldom severely reduced by the chlorosis.

Testing of the performance of the peanut at BDARS was initiated during the Deyr season of 1981. All the entries were obtained from

ICRISAT and the United States. The results from that season showed that the local variety had a greater potential yield than the introduced varieties. Trials since that time have shown that a few varieties may be somewhat better yielding than the local.

More research on the adaptability of the peanut and on its competitiveness with other oil-producing crops is needed to be done before a decision can be made on its potential as an important crop in the Bay Region. The peanut crop occupies less than 5 percent of the cultivated land in the Region. However, an increase in peanut production has been witnessed during the last few years as more farmers realize its importance as a cash crop. More research should be done to develop improved varieties and better techniques in producing and harvesting the crop.

Summary

Grain legumes and oil crops have been researched at BDARS during the life of the Project. Some well-qualified leadership has directed the research effort and meaningful research has been conducted. Promising lines of each crop tested have been identified and a superior mung bean variety, Filsan, has been released to the farmers. The place of these food legume and oil-producing crops has been established in the cropping systems of the dryland farms of the Bay Region. They are destined to become more important in the years ahead, as they are mostly drought-tolerant and can produce comparatively well in both the Gu and Deyr seasons. The need for more vegetable protein in the Somali diet must, and can, be met by these crops. Many of them show definite promise as good cash crops for the area. The research program should go forward under the capable leadership of Aden Ali Ossoble. New and better varieties will unfold, and improved production techniques will be developed and demonstrated.

Chapter 11
Farming Systems
by Julie Howard

Introduction

Relevant agricultural research begins and ends with the farmer. As senior BDARS staff members developed confidence in their ability to conduct meaningful research on-station, questions gradually arose about the relation of this research to farmer practices in the Bay Region and the lack of knowledge about them.

These concerns were addressed in several ways. Increased emphasis was placed on trials conducted on farmers' fields by the Off-Station Section in collaboration with the extension service. Two substations were developed, where experiments could be conducted under different environmental conditions and using technology more closely resembling the farmer's. Finally, the Farming Systems Section was established, with the initial directive of creating a database of information on Bay Region farming systems that would aid in setting research priorities, identifying potentially fruitful areas of intervention, and providing a yardstick against which future progress in technology development and adoption could be measured.

Data collection focused on five areas seeking to (a) estimate farmer sorghum yields, hill population, and head density through seasonal crop cuttings; (b) learn from farmers about production constraints and the major characteristics of existing crop and livestock systems during extensive semi-yearly interviews; (c) obtain specific input-output data on crop and livestock production for a small sample of farmers, interviewed weekly, to facilitate construction of enterprise budgets; (d) determine seasonal price patterns for a range of commodities through weekly monitoring at district market centers; and (e) measure a sample of farms to establish average size of total and cultivated landholdings.

Program Development and Staffing

The farming systems survey builds on the excellent study conducted by Garth Massey et al., *Socioeconomic Baseline Study of the Bay Region* [1984] (see chapter 3), which provides many insights into the unique society and culture of the Bay Region agropastoralists. The futility of development efforts that are not sensitive to local culture has been demonstrated time and again. The Massey study described the general characteristics of crop and livestock husbandry, framed in their relationships to family and village life, while the current farming systems survey focuses on providing a detailed quantitative picture of production in both areas.

Survey activities began in 1986. During short-term consultancies, agricultural economists Carl Olson and Julie Howard selected study villages using a multistage sampling technique and developed a preliminary questionnaire. District agricultural officers were trained in interviewing techniques and conducted the first sorghum yield survey following the Gu 1986 season. Howard returned in May 1987 as full-time farming systems economist, and the following month a Farming Systems Section was established at BDARS.

There has been close collaboration throughout between the Farming Systems Section and the Regional Coordination Section. Instead of fielding a separate staff of farming systems enumerators, the district agricultural officers implemented all survey activities in addition to their assigned land registration, meteorology, and plant protection duties.

Under the direction of Ali Yusuf Dirie and later Said Mohamud Abdi, the district agricultural officers—C/risaaq Jaamac Dugsiye, Hassan Mohamed H. Ibrahim, Ibrahim C/llahi Mohamed, Hassan Ahmed Muuse, and Abdi Mohamed Hassan—together with regional coordination assistant Shamis Abdullahi Nur and farming systems assistant Mohamed Nur Haydar, cheerfully and responsibly carried out yield surveys and weekly interviews on their own and accompanied Baidoa staff during semi-yearly interviews. These activities led them far afield on bad roads, long after normal working hours and sometimes overnight, and frequently challenged their abilities to improvise either vehicles or fuel supplies, or both.

JULIE HOWARD

Reebay (Bur Hakaba district) farmers being interviewed by BDARS personnel as part of the farming systems survey.

A major side benefit of the survey activities has been a strengthening of the Project field offices. Through frequent training and supervision, and, most importantly, through regular interactions with farmers in a number of villages, the district agricultural officers have become sensitive and capable representatives, facilitating a two-way flow of information and resources between farmers and the staffs of BRADP and other state agencies.

The addition of economist Maryan Abdulle Mohamed to the Farming Systems staff in January 1988 provided a much-needed professional boost to the section. Previous experience with the national census allowed her to make immediate contributions in the development of survey instruments and supervision of field personnel. After computer training, she took on much of the responsibility for data entry and analysis as well.

Bay Region Farming Systems

Bay Region farmers are agropastoralists. Protein-rich livestock products complement the sorghum diet. Agropastoralism is an important risk-spreading strategy, because high rainfall variability means that crops are often poor or fail completely, especially in the Deyr season. Farmers usually say crop production is more important to them but acknowledge that "animals can walk to water but the farm cannot." They are primarily subsistence-oriented, with less than half of farmers selling any sorghum, and little marketing of milk or ghee.

There is a lesson in this old and delicate balance between crops and livestock. New technology must be evaluated not only for yield increase but also for its impact on the whole crop and livestock system. Production increases are desirable and attainable, but the stability of the system, vital for subsistence farmers, should not be sacrificed.

The average livestock herd size is 14 animals; half of these are cattle, and the remainder usually goats and camels, and, less commonly, sheep. Bay Region farms are strikingly homogeneous; about 90 percent of cultivated land is planted in sorghum or a mixture of sorghum and cowpeas. Maize, groundnut, tomato, watermelon, and sesame are also grown in low-lying areas, and during seasons with especially good rainfall.

Farms are homogeneous, too, in the uniformly low level of technology used. Except for isolated religious communities that have adopted animal traction, tractors, and limited pump irrigation, the prevailing tool is the *yaambo*, or hoe, and sorghum varieties are local.

Fertilizer is unknown, manure is not used, and farmers are just now becoming aware of pesticides such as seed treatment and rat and cricket baits, although none of these are available in shops.

Sorghum yields in the Gu and Deyr reflect the disparity between the two seasons. Gu 1986 and Gu 1987 yields averaged over 800 kg/ha across the region (table 6), while crop failure was widespread in Deyr 1986 and only half of the villages had a crop in Deyr 1987. Those villages with sorghum yields averaged just 245 kg/ha.

Constraints on Production

The constraints on crop and livestock production identified by farmers constitute a research and action agenda for the future.

Insect and Disease Pests

Stalkborer is the most frequently cited constraint by farmers, along with the mite-spread disease, red feather, millipede, as well as heliothis, and wireworm. Major pests of the underground storage pits, or bakaars, are the weevil, cricket, rat, and grain moth.

The Plant Protection Section has already identified cultural or chemical controls for most of these pests. Cost-effectiveness and safety must be demonstrated before recommendations can be issued in some cases, but seed treatment and rat and cricket baits have already been distributed during several seasons and are widely accepted by farmers. Seed treatment is especially popular; half of farmers surveyed have tried it and would be willing to purchase it in shops if it were available. Currently there are no private sales of agricultural inputs in the Region. An important next step will be to encourage safe distribution of a few pesticides through private channels.

Ticks are the most important problem for livestock owners, followed by *bushakalool*, a vitamin-deficiency syndrome in cattle, and blackquarter in cattle. Acaracides are usually available for sale in the veterinary dispensaries and have been cleared for private distribution. Most owners who have visited a dispensary have done so in order to get acaracide. Veterinary teams are available to vaccinate animals against blackquarter and other diseases, but farmers seem less aware of this service or see no need to inject a healthy animal. Antibiotics are sold at dispensaries to treat afflicted livestock, but this is of course less effective than prevention. Education campaigns in the villages would help to overcome these problems.

Table 6. Gu 1987 sorghum crop cutting results

	Gu 1987	Gu 1986	% Change
Baidoa District			
Mean yield (kg/ha at 12%)	819	573	+43%~
Standard deviation	362	204	
Number of samples	20	11	
Bur Hakaba District			
Mean yield (kg/has at 12%)	1049	718	+46%~
Standard deviation	373	293	
Number of samples	20	15	
Qansa Dhere District~			
Mean yield (kg/ha at 12%)	622	921	-33%~
Standard deviation	322	213	
Number of samples	20	16	
Dinsoor District			
Mean yield (kg/ha at 12%)	840	1071	-22%~
Standard deviation	291	392	
Number of samples	18	19	
Region			
Mean yield (kg/has at 12%)	832	821	+1.3%~
Standard deviation	367		
Number of samples	78	61	

Note: The high standard deviations indicate that there are substantial variations in farmer yields within each district. During Gu 1987, crop cuttings were taken from two fields in each village. Further data show that the variation in yields between farms in the same village is often startling, frequently exceeding 100 percent.

Lack of Rain, Lack of Grazing

While it is not possible to control the amount of rain that falls, it may be possible to utilize what does fall more efficiently. Farmers have noted heavy runoff and some soil erosion during high-intensity rains, especially during the Gu season. Bunding is already practiced on sloping fields in the Region and where farmers plant more moisture-demanding crops such as maize. Further research may result in improved bunding methods and facilitate expansion of this conservation practice.

The short-season mung bean variety released by the Grain Legumes and Oil Crops Section, Filsan, is ready to harvest 15 to 20 days before the more commonly grown cowpea and is very well liked by farmers. Continued research may identify other varieties that perform well under low rainfall conditions.

Similarly, more research in the neglected field of animal nutrition may bring rewards in techniques for increasing stalk digestibility (e.g., through the addition of urea and molasses) and identify promising drought-resistant forage species. The potential for growing fodder crops in the Bay Region should also be investigated in the next phase.

Weeds and Labor Shortage

Weed control is a general problem in the Region, although severity of weed infestation is more acute in some districts than in others. The great majority of farmers identified two Launea species, *kable* and *warshaqaaq*, as their biggest weed problems, followed by *kuuley* grass.

Underlying the weed control issue is the shortage of labor at weeding time. This shortage is one of the most important bottlenecks constraining sorghum production in the Bay Region. Unlike operations such as planting and harvesting, which can be spread out over weeks if necessary, the first weeding must be completed within a very short span of time following germination to assure a good yield. The area of sorghum that can be cultivated by a family is limited to what can be successfully weeded by family members plus whatever outside labor can be afforded.

Weeding labor is expensive because extra hands are scarce and because of the arduous nature of the work. Nevertheless, over 80 percent of farmers use paid or work group labor for this important task, more than for any other operation, and two-thirds wish to hire more. But 10 percent of planted land in the Region is still left completely unweeded, and farmers often must leave part of their fields without a second or third weeding due to lack of labor.

Two methods of easing the weed burden are now under investigation, but cost-effectiveness is a problem for both. The Dryland Agronomy Section is screening herbicides, but equipment and product costs remain prohibitively high for small farmers. Animal-drawn cultivators have been promoted for 20 years, but only 3 percent of farmers use them regularly.

The potential for widespread adoption of animal traction in the Bay Region is influenced by several factors. First, if animal traction is promoted for cultivation only, chances of wide use are probably slight. Animal traction programs in other countries have been hard pressed to show that use of traction in only one operation generates significant economic benefits. The variability of rainfed agriculture increases risk and extends the length of time it will take for a farmer to recover the steep initial investment in equipment and animals. Additionally, the switch to animal traction for weeding requires the farmer to plant in rows rather than in the customary random hills. It can take several seasons or years for the farmer to become fully proficient and realize full benefits from using animals to plant and weed. Thus, if the real objective is to increase weeding efficiency, it may be wiser to focus on chemical control.

Prospects for both adoption of animal traction and increased economic benefits improve if the animals can be used for multiple operations. In the Bay Region, these might include plowing of newly cleared land, construction of bunds for water conservation, transportation of grain and other items, and food processing. There is potential to improve the efficiency of the whole farming system, but substantial investment and concerted effort would be required of agricultural authorities, in contrast to the piecemeal nature of current efforts. A credit program, manufacturing and training facilities for local blacksmiths, and training and technical support for extension agents would all have to be initiated and sustained for a minimum of eight to ten years.

Other Constraints

Farmers are less likely to identify the important intangible constraints on the farming system. Somalia's growing population and ailing economy will put more and more pressure on farmers to grow for the market, not just for subsistence. Improvements in sorghum varieties and soil fertility are extremely critical, especially because the possibility of a limited amount of arable land in the Bay Region means production increases will have to come largely from improvements in yield per hectare rather than area expansion.

Nutrition is a concern as families become more sedentary and have less access to livestock products. A sorghum-based diet is low in protein but can be improved by adding legumes such as cowpeas, mung beans, and groundnuts. Relatively small quantities of these crops are now grown and consumed, partly because long-term storage is difficult.

Finally, possibly the most neglected aspect of Bay Region agriculture is the role of women. Molly Longstreth (1986) found women on average spend an hour longer in the fields each day than men. In addition, they spend one-half hour gathering water and an astounding three and a half hours daily on food processing. Small wonder women can rarely be persuaded to sit for an interview or attend a farmer field day; they are just too busy. Sorghum processing techniques are very primitive, using mortar, pestle, and grinding stones, and research into labor-saving alternatives is urgently needed.

Future Directions

With the completion of the baseline survey, efforts are underway to integrate the farming systems activities being carried out by individual sections. Personnel from the Farming Systems, Dryland Agronomy and Off-Station sections are joining with extension and veterinary services representatives to form a multidisciplinary team that will conduct on-farm research and evaluate proposed technology in the context of the whole crop and livestock system. It is hoped the team will institutionalize the healthy three-way communication among researchers, extensionists, and farmers that has already helped make farming systems research more relevant to Bay Region needs.

Chapter 12

Computers

by Hedera Porter

Introduction

COMPUTERS WERE INTRODUCED TO BDARS in an effort to enable the researchers to become self-sufficient in timely data analysis and in the production of high-quality research reports. Record-keeping, report writing, and data analysis are integral parts of a successful research program. While the researcher must still formulate the reports, word processing has simplified the task of producing an acceptable product in a shorter period of time. To date the researchers have been fortunate to have Judy Lavigne (administrative secretary) to type their reports for them, using the Project's Apple computer. Computers are a relatively recent addition to the research station facilities. In total, the Project has purchased seven computers (one Osborne, two Apple IIc's, one IBM-XT, and three Zenith Z-159s). All but the Osborne are still functioning.

The first formal effort to teach computer use to Bonka researchers was in May 1985 by Mike Martin (consultant/UW graduate student). One of his primary tasks was to instruct the researchers in the analysis of trial data using the microcomputer program MSTAT. Unfortunately, the Osborne computer broke down shortly after instruction began and the class had to be canceled.

In early 1986 BRADP purchased two Apple IIc's—one for use by the expatriate staff and one for the controller at the Project Management Unit (PMU). During this time, several researchers and the PMU controller took advantage of informal training by Robert Lavigne on the IIc, and it was, and still is, used mostly for report writing and administrative work. Abdi Ahmed Mohamed was extensively trained on the IIc in both word processing and statistics.

In December 1986 an IBM-XT computer, ordered by the home

JUDY LAVIGNE (inCider Magazine, April 1987)

Chief of party, Robert Lavigne, introduces Abdi Ahmed Mohamed, section leader of Dryland Cropping Systems Section, to the complexities of an Apple IIc statistics program.

office for communications purposes, arrived in Baidoa. After much debate, it was decided the computer should go to BDARS and that researchers be taught how to use it. Hedera Porter (consultant) was enlisted to teach the researchers. In January 1987 she began an introductory computer course open to all staff members. Interest was high, for it was the first computer the majority of them had seen. Handouts were prepared explaining the available hardware and software. For many staff members, unaccustomed to typing, the keyboard alone was a challenge. The programs available for use on the IBM-XT were SYMPHONY and MSTAT. The classroom situation consisted of lectures, supplemented by a set of handouts, with main points demonstrated on the computer. As a supplement to the lecture, all students were encouraged to sign up for at least two 45-minute sessions per week on the computer. This was an excellent time to practice what they had observed in class. Emphasis was placed on completion of specific work-related tasks, such as typing a simple memo, designing a data collection sheet, or typing a monthly report.

Several weeks after the course was initiated, the floppy disk drive failed. Efforts to have the machine repaired in Nairobi were unsuccessful. The only option available in-country was Lars Smith of SCANTEC. However, he did not have the necessary part in stock. This required us to place an order, resulting in several months' delay. Since the new disk drive has been installed, the computer has functioned without failure.

A single computer was clearly inadequate to service the entire station and a proposal was made to purchase additional computers. A crossroad was reached, though, because the Project had acquired two Apple computers and one IBM computer. Because the two operating systems are not compatible, they were unable to exchange information. Reports written on the IBM could not be incorporated with material produced on the Apple. In some cases, reports written on the IBM were subsequently retyped by the administrative secretary on the Apple—a waste of time and effort. After months of deliberation over the pros and cons of each system, the steering council recommended that IBM-compatible machines be the standard for the Project. Two Zenith computers were ordered for BDARS. With so many researchers at all levels of expertise, it was important to have someone devote a large portion of time to overseeing the training and maintenance of the computers. In this regard Hedera Porter (agronomist and computer specialist) was hired in June 1987. The majority of the research sections have utilized the SYMPHONY word processor and spreadsheet and MSTAT in their work. More recently, the Farming Systems Section has acquired SPSS-PC+ for use in its work. Finally, Sam Williamson (consultant) taught an introduction to two new programs, SYGRAPH and SYSTAT, in July-August 1988.

Electrical Set-Up

All the computers currently at BDARS are wired for 110 volts. Originally the IBM was running directly off the station generator via a step-down transformer with no protective devices in place. The printer being used was 220 volts. After months of operation, a shipment of inverters, battery chargers, and batteries was received. Nels Andersen (farm superintendent) set up the 110-volt inverter system for the computer. This effectively isolated the computer from voltage fluctuations. The Okidata printer, being 220-volt, could not be incorporated into the system with available supplies. This would necessitate the purchase of a step-up transformer inserted between the inverter and the printer.

The value of this system was clearly illustrated when the voltage regulator malfunctioned on the generator at Bonka. Large fluctuations in voltage were coming from the generator while both the IBM computer and printer were in use. The printer was severely damaged, while the inverter system insulated the computer from the changes in voltage. As a result of the damage to the printer, BDARS was without a printer for five months while awaiting spare parts. Currently, all three computers and their accompanying Epson printers are 110-volt and are incorporated into the inverter system. A second advantage of the inverter system is that the computers and printers can be run for several hours at a time without electricity to charge the batteries. BDARS normally runs its generator from 8 a.m. to 1:30 p.m. The use of the computers after hours or on Friday is possible with this system.

Future Recommendations

Bonka researchers have an acceptable assortment of software at their disposal. All three computers allocated for the research station are in operation. While the computers are not fully utilized year-round, seasonal peaks are evident. It would be advisable to purchase an additional computer (IBM-compatible, preferably a Zenith Z-159) for a spare in case one of the other computers malfunctions. Experience has shown it is difficult to get computers repaired in a timely manner in Somalia. The additional computer should be ordered with a 40-megabyte hard disk in order to more easily accommodate some of the larger statistical packages the Project has purchased.

Resources at Bonka Dryland Agricultural Research Station (as of August 1988)

Hardware

1- IBM-XT computer (20-megabyte hard disk, 360-kilobyte floppy drive, 110-volt, monochrome monitor)

2- ZENITH Z-159 computers (20-megabyte hard disk, 360-kilobyte floppy drive, 8087 math coprocessor, 110-volt, monochrome monitor)

3- EPSON 286e dot matrix printers (110-volt)

1- OKIDATA M193 dot matrix printer (220-volt)

3- Powerverters (inverters)

6- 12-volt tractor batteries

2- 10-amp battery chargers (110-volt)

1- 30 amp battery charger (110-volt)

1- Step-down transformer (220-110 volt)

3- Meters to monitor charge of batteries

Software

SYMPHONY version 2.0—integrated package (word processing, spreadsheet, communications, database and graphics)
MSTAT version 4.0 compiled—statistical package especially for agricultural scientists
REF-11 version 2.3—database management system for references
WORDPERFECT version 5.0 — word processor
SYGRAPH version 1.0 — Graphics package

SYSTAT version 4.0 — statistical package

SPSS-PC+ — statistical package especially for the social sciences, with data entry, publication-quality tables, advanced statistics, and chart modules

STATGRAPHICS version 2.6 — statistical package with graphics capability

SIGN DESIGNER—computer-assisted sign maker

MS-DOS Version 3.10—operating system

Chapter 13

Farm Operations

by Nels Andersen

Status of Farm Operations in July 1985

FIELD OBSERVATIONS BEGAN ON JULY 18 at BDARS, which was under construction at the time. Some of the research equipment was parked in an open area, totally exposed to the elements. One implement, the research plot planter, was noted with particular interest. Machines of this type lose their precision and accuracy from rust and corrosion when exposed to the elements for extended periods of time. Other non-sophisticated implements were also in the area. A small workshop, employing one worker, provided the maintenance for this area. Two ocean containers and two metal grain bins were utilized for storage of small tools and implements. Two 18-horsepower "garden" tractors were also in the area, but had limited use. Harvest of the legumes was proceeding at the time. Small 3-horsepower engine-powered threshers were used with a considerable amount of casual labor (young children). The lack of adequate safety equipment such as gloves and eye protection (goggles) was noted, as well as the lack of proper shielding of the moving parts on the machines.

The field tour continued to the 100-hectare farm (seed farm), where legume harvest was in progress. The staff at the farm consisted of approximately 15 people, including a farm manager, two assistant managers, three field supervisors, tractor drivers, field workers, a storekeeper, a typist, and a cleaning person. A small building, which included an office, a storeroom, and a seed store, was utilized for the administration of the 100-hectare farm. A large shed-type building, open on all sides, was used for storing the tractors, seed cleaner, selfpropelled field harvester, and mobile threshers. A 40-foot ocean container nearby housed spare parts for the equipment. Both the administration building and the ocean container were deteriorating. In the shed were three late-model Massey-Ferguson tractors, all of which were inoperable due to the lack of spare parts and poor maintenance practices. There was no mechanic at this location; when it became necessary to do mechanical work on the equipment, the tractor drivers assumed this job. However, only one tractor driver had any knowledge of mechanics; the others followed his lead. Several tillage and other field implements were parked at this location; some were new and had not seen any field use. Some were only partially assembled due to the loss of parts in transit.

Observation of the field crops revealed considerable plant variability and the total lack of visible crop residue. The farm superintendent was informed that the only implement used for making a seed bed for the crops was a 60-foot land plane.

Observation of farming techniques revealed poor soil management, due partly to the lack of proper implements for the job. Fuel shortages limited proper farming activities. Inadequate tools and maintenance facilities were also among the constraints to maintaining the equipment in an operable condition. The lack of adequate security needed to be addressed to increase productivity and efficiency in all areas of the research station.

Steps Taken to Raise the Level of Research Activity

Because production and efficiency interrelate, the area of security had top priority. The lack of fuel limits the amount of activity, so adequate measures were taken to stop fuel pilferage by changing locks, limiting the keys to only those who had an essential need, and attaching flow meters so that the amount of fuel could be accurately dispensed and recorded. After this system was implemented, the amount of fuel loss was minimal.

The next item of priority was spare parts for the inoperable equipment. Because the dryland agronomist was assigned to the research station prior to the superintendent's arrival, he had already initiated orders for the essential parts to restore the inoperable machines. However, taking into account the long delays in transit, additional spare parts were ordered. Most of the equipment was maintained at the seed farm. Because there was no mechanic at this location, a trained mechanic was requested through the research director. Because the new research station complex included a workshop, appropriate shop tools and equipment had been ordered prior to the superintendent's departure from the United States. Proper maintenance records and schedules were initiated on all the equipment so that long-term maintenance could be monitored for replacement of spare parts or vehicles.

Regarding personnel, the work day was standardized and training on a variety of jobs was initiated for all staff. Where cases of leave or illness were involved, this training was designed so another staff member could fill in without a decrease in productivity and efficiency in the Farming Operations Section. Most of the staff have, for example, now had the opportunity to calibrate a fertilizer spreader or a boom sprayer. In the past, this was limited to management personnel only.

As time progressed some members of the staff approached retirement age and elected to retire, while others found work elsewhere. At one point, the total staff at the 100-hectare farm was reduced to seven or eight, yet overall efficiency was not affected. However, because reduction below this level could have an effect on production, a recruiting program was planned. Younger people were recruited and trained so they could replace the older members as they retired.

Safety training programs were initiated for the staff. They included all areas of farming: machine operation, chemical application, safety equipment, and careful use of smaller tools. A safety seminar was presented by the farm manager in November 1986 to all research station personnel. Necessary safety equipment, such as eye protection, gloves, respirators, and so forth have been obtained, and there is now an adequate supply on hand, including first aid kits.

In March of 1986, the construction of the new building complex at BDARS was completed. During the month of April 1986, the Farm Operations Section at the 100-hectare farm was consolidated at the research station. The tools and spare parts were moved into the new workshop area and all the farm equipment was also moved to the new location. The Farm Operations Section office was located in the new office building along with the research section offices. This improved the efficiency of the entire research station. In November of this same year, the large workshop tool order arrived. Farm Operations mechanics were able to perform all types of mechanical repair necessary at the research station. The small workshop was consolidated into the new workshop; the older building was to be demolished. Spare parts and supplies were organized in the storerooms to reduce time in locating them and to provide a more efficient inventory control system for reordering. During the year additional spare parts arrived, so it was possible to get a majority of the equipment operational.

Also in November, new tillage implements arrived and proper seed beds could then be prepared in a timely and efficient manner. These new implements not only helped workers do a better job of seed bed preparation, but enabled them to do it in less time, which was more cost-effective in terms of fuel consumption. It was also demonstrated, through tillage trials with the new implements, that shallow tillage reduced moisture loss due to evaporation and allowed better control of planting depth. This improved emergence and crop yield. Other farming techniques that had an effect on soil management included diagonal cultivation in seed bed preparation and fallow weed control cultivation. By cultivating on the diagonal (45 degrees) to the direction of the planted rows, the compaction tracks made by the tractors and implement tools were disrupted. It had been observed that when the soil dried, it would crack in a straight pattern between the rows where the tractor tires had gone. As the soil continued to dry, the cracks would open wider.

Another contribution to moisture conservation was the mowing and incorporation of plant residue. After the crops were harvested, sorghum stalks and other plant residue were mowed and incorporated into the soil with a disk-harrow. This technique has two benefits: (1) restoring organic matter to the soil, which helps to improve fertility, and (2) improving the moisture-holding capacity of the soil. When the rains come, if the water can be held for a longer period on the surface before runoff, it will permeate deeper into the profile. This technique was demonstrated in the Gu 1988 season when the high-intensity rains fell. Soil that had little or no organic matter in it had considerably greater runoff than where a larger amount of residue had been incorporated.

Implement modifications were made to provide alternative methods of applying chemicals and fertilizers. Chemicals were used to control perennial weeds, reducing mechanical methods that consumed large amounts of fuel and labor. As variables were gradually reduced to a minimum, economic factors were implemented to reduce costs. One of these factors was the elimination of the farm tractors to transport casual labor from Baidoa. This was performed by the staff and worker bus that was designed for this purpose and operates much more economically.

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Farm Operations staff cultivating long-term fallow trials with tractor on BDARS 100-hectare farm.

Materials were obtained and wire security fences were constructed around all fields being farmed for research purposes and seed production. The objective was to eliminate losses due to grazing animals. Electrifying the fence was also attempted to reduce the losses from the smaller animals, but this proved unsuccessful. However, the fence did keep out the larger animals that contributed to the major portion of the crop losses. It was determined that a regular maintenance program on the fence would be necessary due to a considerable amount of vandalism.

Current Situation and Status of Farm Operations

As of August 1988, all the research farms and equipment were in excellent condition. The crops being harvested in that Gu season showed higher yield potential than in any previous season. The progress at this station is at the highest level since the Project began.

The Farm Operations Section has evolved into a significant part of the research station. Because research scientists are not always knowledgeable in field preparations, they must depend heavily on the farm operations technology to get accurate results from their research efforts. Some of these technologies include fallowing for moisture conservation and weed control, fertilizer applications, seed bed preparation, precision planting, and spraying for pest control. New equipment is in transit to further improve the productivity and efficiency of the research station. This not only includes farming equipment but research and lab equipment as well. The new equipment includes:

1. Four new tractors, which are designed for the type of agricultural use at the research station.
2. A new grain drill, designed to apply fertilizer alongside the seed at the time of planting. This will be beneficial during experiments with such crops as safflower and other cereal grain crops.
3. A fertilizer spreader that releases the fertilizer close to the ground so that it will not be affected by wind during application.
4. A 5,000-pound forklift with pneumatic tires for use at the research station when heavy items need to be loaded or unloaded. This will reduce the possibility of injury to the

workers as well as eliminate possible damage to large items.

5. A heavy-duty workshop crane. This will increase the efficiency of the workshop staff in lifting heavy items and eliminate the potential hazard of items slipping off jacks.
6. Other specialized equipment includes four-wheel-drive, all-terrain vehicles with trailers. These will aid the research personnel in transporting weeding tools and small implements, such as walk-behind rototillers. These machines are more economical to operate in terms of fuel consumption and maintenance than the larger pickups. They will also aid during harvest in transporting the trial samples. Air-blast seed cleaners were obtained to do a more refined job of cleaning seed samples. Since electricity has been available at the research station smaller machines can be operated by electric motors, which are more cost effective than gasoline engines and require less maintenance. Two more small-plot trial threshers, operating electrically, have been ordered.
7. Laboratory items, including a small batch seed treater. This will assist the research personnel in treating their seeds for planting. This machine will treat small amounts of seed, used in planting in the trials, as opposed to the larger production models or mixing by hand. Previous methods wasted chemicals as well as creating a health hazard. A lab-type oil expeller was purchased to determine the oil content of oil seed crops. This will assist in determining which oil seed crops to expand upon for production purposes. Seed germinators have been used to determine the germination potential prior to planting. This has been used for the research trials as well as seed production planting at the 100-ha farm.
8. Computers. These have been installed to analyze and store data from the research trials as well as maintain cropping records for the farm. In the future, it is hoped the computers will be used to compile all the research data, and maintain cost analysis, inventory, and administrative files.

Constraints to Efficient Farm Operations

The primary existing constraints of the farm operations are fuel shortages and storage as well as extended delays in clearing incoming supplies at the port. The shortage of fuel has been consistent every season for the past three years. Project and donor administrators have attempted to alleviate the consistency of this problem.

Considering the Future

It is hoped funding will become available in the near future so that a Phase II can be initiated to continue the much-needed research in rainfed agriculture. As the station continues to expand its research effort, funding will be needed to develop facilities. A five-year plan proposal was compiled at the research station that included some ideas for expansion of the Farming Operations Section, including an addition to the utility building that would accommodate additional space for soils and agronomy laboratories as well as an environmentally controlled seed store room and seed-processing room for use by the researchers. As the station acquires more machinery, protection from the weather is essential. Therefore, a shed-type addition to the back of the workshop is proposed. As the station expands its research efforts, larger amounts of farm and chemical inputs will be obtained that will need protective storage. This will require an additional building so chemicals can be stored separately from fertilizers and other items. Because some fertilizers are affected by humidity, a low-humidity environment will need to be considered. This type of environment would also be beneficial for long-term seed storage.

The clearing of an additional 50 hectares of land will enable existing research to continue, with introductions of new varieties of oil seeds and legumes. The new land will allow research to be conducted on weed control with various herbicides. Areas of unfertilized land will be needed for future relevant work. It is believed that with the low rainfall in this Region the emphasis on the 100-hectare farm should be cash crops with a primary tap-root. The rationale for this is that tap-rooted plants have a better capability to extract the moisture deep in the profile later in the season. This has been extensively demonstrated with the safflower crop in fertilized and non-fertilized land. Because the surface dries out rapidly, only vigorous growing plants will be able to reach maturity. Other crops that would fall into this category are the guayule (rubber plant), cotton, sugar beets, alfalfa, etc. As with many new crops, marketing and processing systems will need to be developed.

In the past year, the BDARS has become known throughout Africa and other parts of the world. As the success of the research station continues to grow, it will be necessary to propose new mandates so that the station will have a purpose and objectives toward which to work. Without sufficient mandates, the station management will have no guidance or direction. The potential of the BDARS is unlimited within the constraints of rainfed agriculture. It could be on a level equal to other research stations of the world. Proper management and organization will be the key to success at the Research Station.

Chapter 14

Research and Extension: The Linkage

by Robert Lavigne and Graham Eagleton

Bridging the Gap Between Research and the Farmer—Off-Station Testing and Demonstrations

ONE OF THE ORIGINAL OBJECTIVES of the contract was to establish a cooperative on-farm program involving research and extension. The linkage between researcher and farmer via extension is an integral part of any agricultural development project in a developing country. The rationale behind this approach has been documented amply by the Utah State Agricultural Extension and Training Project, USAID 649-0112. Unfortunately the separation of the research component of the Project from the extension service represented by AFMET has made it difficult to achieve the full intentions of the Project objectives. In its ideal form the integrated research-extension program was to operate as summarized below.

A Model for Linking Research and Extension

The system, involving improvement, production, economics, and technology transfer is organized into four parts: (1) basic agronomic research on the experiment station, (2) applied agronomic research on extension farm, (3) small-scale agronomic trials on farmers' fields, and (4) large-scale demonstrations on farmers' fields.

STAGE 1: Basic Agronomic Research on the Experiment Stations

The experiment station is used for basic agronomic research that requires highly controlled conditions and constant attention, such as (a) genetic improvement (breeding), (b) studies on the physiology of production, (c) research on new chemicals that may involve risks, (d) research on new machinery, (e) experimentation that requires the backing of laboratories or workshops, and (f) research to resolve agronomic problems of that particular experiment station.

STAGE 2: Applied Agronomic Research at the Extension Training Center

The extension service, under the auspices of AFMET, carries out applied research to identify production constraints and develops technology for the farmer through the following types of trials.

Limiting factor experiments

In this type of trial, emphasis is on the identification of a minimum number of critical, limiting, agronomic factors that are responsible for low production in the area. Their order of priority and interactions are considered. These types of trials should be conducted in the several extension training center (ETC) locations where controlled conditions increase the reliability of the results.

In sorghum, for example, one can list 20 or more factors that affect production in one way or another. However, it is essential to identify only those three or four factors having large effects on yields associated with attractive marginal rates of return. Multiple factor experiments, in which each of the various factors is compared at two levels, are considered to be very efficient at this stage. One level (the low level) of variety, insect control system, fertilizer, and so forth, is at the local level, and the other level (high level) is one that could constitute the best available alternative within the economic circumstances of the farmers in the area.

The factors identified as limitations to production at this stage in the process are investigated in more detail in the following type of experiment.

Component experiments

Experiments that permit a quantitative description of the crop response to each important component of the cropping system are laid out. Optimum levels can be determined from the viewpoint of agronomy and economics. Results are submitted to statistical and economic analyses to enable the team to formulate technological alternatives with different levels of return and associated risk.

Cropping systems trials

The experiments described above involve fairly large numbers of treatments and replications, so individual plots are small (20-50 meters square). The value of the technological alternatives resulting from the investigations carried out in these previous stages must be verified in larger-sized plots (100-500 meters square) in an integrated cropping system. Initially these should be conducted at the ETCs where farmers' conditions can be simulated, but the experimental conditions can be monitored by extension specialists.

STAGE 3: Small-scale On-Farm Trials

Component experiments

As the extension personnel (district extension officers [DEOs] and FEAs) become better trained and as good contact farmers are identified, component experiments can be conducted on these selected farmers' fields. The objectives of these experiments are the same as for those conducted at the ETCs—to obtain a quantitative description of the crop response to each important management factor. From these analyses various technological alternatives with different levels of return and associated risks can be determined.

Cropping Systems Trials

In the final analyses, results obtained in farmers' fields under the farmers' practices are the ones that will determine whether the suggested technological change will be accepted or not. The size of these trials should be much larger (100-500 meters square) than the previous small plots. They should be carried out under the direction of the extension personnel.

The farmers should participate in the management of these experiments. The plots provide good "method and result" demonstrations and will be focal points for discussions with farmers and policymakers during the complete cycle from planting to harvest. Organization of

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BDARS personnel explaining the use of animal traction equipment to extension personnel on the occasion of a visit from Saudi Arabian extensionists.

field days involving neighboring farmers permit discussion and evaluation of the proposed technologies. Extension staff can provide farmers with economic information on the various technological alternatives in the experiments, especially during field days and at the time of harvests when farmers cannot only evaluate the alternative visually, but can consider costs, returns, and risks.

STAGE 4: Large-Scale Demonstrations

One of the principal purposes of this stage is to verify, in plots of one-half hectare or larger, the technology or technologies accepted by farmers as a result of the comparison experiments. These field-scale plots give a more realistic evaluation of the technology. Such plots include many of the production hazards (low spots in the field, trees, salt patches, rocks, and so forth) that are usually excluded from the area used in small experiments. Obviously, farmers cannot avoid these production hazards and so will evaluate technologies as they perform across the various conditions encountered in their fields. Primary management responsibility of these plots is still with extension workers and farmers, with support from research as needed.

Overall Strategy

This strategy focuses on the organization and execution of a research and extension program aimed at developing and delivering technologies appropriate for target groups of farmers. It is not a strategy for transferring findings from the experiment station to the farmers' land, but rather a program of research actually conducted under farm conditions by research personnel in conjunction with extension personnel and farmers.

The system's advantage is that it is dynamic. New alternatives are derived as information on farmers' circumstances is accumulated. Also, the performance of the newly proposed technologies and the farmers' reaction to them are known before the technological recommendations are applied in the farmers' own crops.

Training

One requirement for successful implementation is training of all personnel concerned. Generally, responsibility for the training rests with the agronomists and economists who will train research and extension field personnel in the techniques of on-farm experimentation. As soon as possible after each crop cycle is completed, a workshop of all program personnel from research and extension should be held to present, discuss, and interpret the results of the previous cycle and plan for the coming crop cycle.

The concept essentially is that FEAs will supervise contact farmers and/or progressive farm leaders in conducting adoptive trials. The farmer should do the work in all steps. The role of the researcher is to provide solid information which the FEA then translates into a practical program that the farmer can apply. This is sometimes referred to as providing the farmer with a "package." The FEA is to impart ideas and to help the farmer keep records of all inputs and to measure results to determine profits. These trials, once initiated, are then used by FEAs to teach the value of the research package to other farmers. They are thus used for both method and result demonstrations. As is done now, each FEA would select a base number of contact farmers or progressive farm leaders to conduct these adoptive trials. Plans for each farm should be developed in conjunction with individual researchers. For every adoptive trial it is essential to prove the profitability of the practice. This ensures that the farmers become confident in the results and will consider the information obtained to be reliable.

Actual Achievements in Linking Research to Extension

In practice the system of research-extension cooperation that has evolved during the life of the Project has fallen short of the ideal portrayed above. Two substations have been developed as part of the BDARS research effort. These extend the range of environments in which controlled experiments can be conducted. The Forage Section leader has been instrumental in upgrading these sub-stations. The Doy Gab site is on a fertile Mode-Mode soil where vigorous natural grasses predominate. This substation has been the site used for herbicide testing and large-scale fallow trials. The Qansa Dhere substation is very different. It is on a weed-free Amin soil right next to the town. It has been carefully cleared and leveled because of its potential as a demonstration site, as well as for controlled experimentation. At BDARS the ETC has provided a similar site.

A systematic program of on-farm trials has been developed in close cooperation with the AFMET extension service. Each season between 12 and 15 trial sites are selected and planted by extension agents, under the supervision of the BDARS off-station staff. The trials have included phosphate fertilizer testing, variety comparisons, insecticide use for stalkborer control, and an examination of plant density in sorghum-cowpea intercrops. In addition to this, several sections (e.g. Soils, Plant Protection) have carried out independent experimentation.

The coordinated system of on-farm trials has evolved gradually and gained in strength. It has proven popular with extension agents and provided an important link between the two institutions. However, it has gradually become clear that this activity needs to be integrated with the Farming Systems Section activities. Agronomy cannot proceed in a vacuum. It must feed on continual input from the farming community; otherwise it ceases to be relevant.

The Farming Systems Approach to the Future

More needs to be done in the area of research-extension linkage. With the formation of a farming systems team (FST), a new mechanism has been put in place to help achieve this. FST is a six-person, multidisciplinary committee drawn from staff at BDARS, AFMET, and BRADP veterinary component, and is charged with the responsibility of formulating objectives of the on-farm program and of coordinating the joint activities of the research and extension institutions. Answerable to the FST will be a small group of staff members trained in the methods of on-farm experimentation. Initially, these staff members will be responsible for the implementation of the program of on-farm trials determined by the FST.

The farming systems team concept is the blueprint for a more effective link between research and extension and should pave the way for research to have a direct and relevant impact on farming in the Bay Region.

Chapter 15

Staff Development and Training

by Peter Guernsey

Introduction

RECENT TRAGEDIES IN SUB-SAHARAN AFRICA have demonstrated an urgent need to revitalize the agricultural productivity of the region (Simon 1988). Large gaps currently exist between actual and potential crop yields and experimental and farmer crop yields. To lessen the extent of these gaps in Somalia, our present knowledge must be further extended into Somali systems. A scientific research base is the key to success in the Somali agricultural sector, and the development of an appropriate-quality scientific capability requires improved educational opportunities for large numbers of Somali nationals. Sustainable improvements in Somali agriculture require unique and site-specific scientific accomplishments.

Because few schools exist in the rural communities of Somalia, most families are unable to formally educate their children. The subsequent lack of primary and secondary education severely hampers specialized training opportunities for Somali citizens. While Somali men have self-identified literacy rates of 12 percent, actually fewer than 5 percent have any formal government-sponsored education (Massey 1987). For those who have the opportunity to complete a high school education the Somali National University can provide basic skill training, but only a limited amount of specialized training can be implemented due to a current lack of funding, expertise, and facilities. While training in specialized agricultural fields has become a high priority in Somalia, progress in agricultural development suffers immensely from the uneducated labor supply. Consequently, overseas training is seen as absolutely necessary for improving Somalia's agriculture.

PETER GUERNSEY

Back in Wyoming, UW plant pathology student Mohamed Mohamud Sheikh analyzes statistical data in the College of Agriculture computer lab.

U.S. agricultural institutions of higher learning have been instrumental in helping many developing countries strengthen their research capacities (Brady 1988), which is critical to development efforts in Somalia. The University of Wyoming has a special potential to help Somalia because of its past record in promoting the development of highly productive agricultural systems in Wyoming, the United States, and around the world.

Newly trained students provide support for agricultural research, extension systems, and the government. In addition, training contributes directly to eliminating the causes of poverty and inequity and removing obstacles to development (Wennergren et al. 1986). M. D. Rentz (1987) indicates that one-third to one-half of the world's top positions in politics, business, and education will be filled in the next 25 years by foreign students attending U.S. schools, citing El Salvador's Jose Napoleon Duarte (Notre Dame) and the Philippines' Corazon Aquino (Mount St. Vincent, N.Y.). Additionally, the current vice minister of agriculture in Somalia, Mohamed Abdi Noor, received his master's degree from the University of Wyoming.

The University of Wyoming's efforts in Somalia began with a USAID contract covering the period 1964-1971. Under this contract UW was directed to assist the Somali government in the establishment of an agricultural experiment station and farmers' training center. As part of the overall effort, UW directed 25 participant training programs. All 14 short-term programs and nine of the 11 total degree programs were conducted at Wyoming.

Accomplishments

The BRADP grant agreements proposed utilizing USAID's $849,539 (U.S.) and World Bank's $1,111,648 for student training programs. The USAID contract indicated 12 students would be sent abroad for advanced degree training, while the World Bank contract initially stipulated 12 long-term students. This was subsequently modified to provide for the continuance of seven additional students (four of which were initially sponsored by USAID). The World Bank agreement also allowed 24 person-months of short-term, non-degree training and was amended to allow an additional 78 person-months of non-degree training.

Numerous institutions and agencies are consulted in training program preparation in order to organize the best possible course of training. Programs consider project requirements, the student's prior training, and the nature of the work expected from trainees upon their return home. Depending upon needs, the duration of training can vary considerably, from a few days for courses and conferences to several years for university degree studies.

World Bank training funds were initially obligated for this Project to augment USAID activities and further enrich Somali capabilities for research station management. These funds have therefore been incorporated in this report. Both sets of money were obligated for training simultaneously and both involve enhancing the likelihood of Project success once external support has been removed. All activities conducted after September 30, 1988, will be financed utilizing World Bank monies and will become active prior to March 31, 1989.

The "Participant Data Information Table" (Appendix 2) lists all 112 currently acknowledged past, present, and future training programs (80 students) on the BRADP, and includes both participant and in-service training. USAID funding has supported 45 programs while the World Bank has funded 59. Short-term training programs (seventy-eight total for 290.75 person-months) were implemented at various institutions around the world. This includes both short-term participant training and all in-service training programs. A total of 78 participant training programs (67 individuals) and 34 in-service training programs (24 individuals) have been implemented. University degree training (33 total for 966.75 person-months) was implemented exclusively in the United States. For degree candidates, English training has often been necessary and accounts for 87.5 person-months of the total 1,270.5 person-months (approximately 106 person-years) of training conducted.

Of the total $1,873,641(U.S.) anticipated for expenditure on this project, World Bank obligations total $968,553, including $125,221 implemented by John Bingle Pty. Ltd. USAID monies account for $882,088, while other funding sources (Consultative Group in International Agricultural Research [CGIAR], Semi-Arid Food Grain Research and Development [SAFGRAD], International Development Agency/International Fund for Agricultural Development [IDA-IFAD], African Development Fund [ADF], and International Development Research Centre [IDRC]) provided $27,200.

BRADP currently has a return rate of 67.4 percent for individuals who have completed their training programs. While far from ideal, it is nonetheless a higher rate of return than the majority of Somali projects; USDA Office of International Cooperation and Development (OICD) officials in Washington, D.C. have indicated a less than 20 percent return rate, and the current RFP for the Shebelli Irrigation/River Basin Management Project indicates a less than 50 percent return rate.

Current obligation practices requiring all new trainees to sign documentation guaranteeing their return upon program completion will likely enhance current and future return rates. Of the total 112 training programs, 31 are current or planned for implementation. These individuals, many of whom have returned to the project from past programs, are not included in the stipulated return rate. They will, however, likely return from future programs given their past actions. If, as expected, these individuals return to the Project, return rates will be 84 percent. Individuals who have returned to BRADP but subsequently left their posts are considered non-returnees; however, they may still be contributing to Somali development.

Consultants

When problems developed that were unsolvable with the available expertise, funds were available for the hiring of consultants. In addition to problem solving, many of the consultants taught short courses or were otherwise involved in the training of Somali researchers and their assistants. Over the duration of the current contract, 23 consultants were brought to the BRADP, some of them twice depending on the need. A list of consultants and their areas of expertise is included at the end of appendix 1.

Conclusion

While participant training represents only a small portion of the current BRADP technical assistance contract, participants provide far-reaching impacts, as exemplified by the current vice minister of agriculture in Somalia. Students who learn new techniques and improved methodologies and transmit them to their colleagues play an important role in the development of Somalia.

Somalia's future depends on the education and training of its people more than any other factor, as it is only individuals who can build the institutions required to support more efficient production systems. Somalis believe that the key to successful development is greater Somali involvement in the process. Investments that provide Somalis with technical agricultural skills will significantly increase the nation's economic potential for agricultural goods and services output.

Chapter 16

Implications and Recommendations

by Grant Richardson and Robert Buker

Recommended Future Research Program

General

THE MAJOR PART OF THE RESEARCH PROGRAM conducted during the last five years should be continued, and some areas should be expanded. Most certainly, there should be no change in the overall objective—the improvement in the farmers' potential to increase agricultural production and income in the Bay Region of Somalia. The introduction of new crops, the development of improved varieties, the determination of the most profitable rates of fertilizer application, the development of the most advantageous cropping systems, the determination of the proper plant densities and spacings, the development of the most suitable animal-drawn implements for seeding and weeding, the development of the most effective insect and disease control measures, and the training of the Somali researchers in proper research procedures should all be continued during the next phase of the Bay Region Agricultural Development Project. (Note that specific recommendations are included in the chapters authored by team members and also in their final reports.)

Significant progress has been made on all of the above farming practices and research techniques. However, more needs to be done before a definite set of recommendations for an improved package of farming practices can be presented. More progress has been made on the short-term improvements than on the potential long-range yield and income increases that are necessary for agriculture in the Bay Region to achieve its potential.

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Recommendations for New Research Efforts

The research component of BRADP should be expanded to include a Livestock Nutrition and Production Section. The current Forage Section should be integrated into the new section, because livestock is an integral part of the farming system of the Region. In recent years more farmers have been using animal power for pulling farm implements, especially carts. There is much interest in the use of animal-drawn implements for seeding and weeding the fields. The application of fertilizers at time of planting could be further facilitated if the recently tested experimental planters were used to place both seed and fertilizer in rows in the field. The development and testing of improved forage crops should be expanded at the same time that the research effort on livestock nutrition is inaugurated. Forage crops, both grasses and legumes, that are found growing in large areas of the Bay Region probably are well-adapted to this area and should be compared with introduced species. With proper plant spacings and fertilizer applications, the need for nutritious livestock feed for farm animals could be met by devoting a calculated portion of the farmland area to the production of adapted forage crops. The forage produced could be stored as hay and fed to the farm animals as needed. In this way the reproductive ability, milk and meat yields, and power output by the animals would be enhanced. The draft animals would be in better condition, thus stronger, for pulling the implements to be used for planting and weeding. And they would have adequate feed available during the dry seasons, when non-nutritious sorghum stalks are the only alternate source of feed.

A research program on the effects of deep tillage of soils in the Bay Region should be initiated at BDARS. Now farmers are only hand-tilling the soil to a depth of 10 to 15 cm. With the expanded use of animals for power in seed bed preparation, planting, and weeding, there is a need to determine the most beneficial depth to break the soil, especially in terms of the economic benefits. Deeper tillage could provide the usual benefits of increased water infiltration into the soil, deeper root systems, increased availability of moisture and nutrients, and reduced runoff and soil erosion. Naturally, the economics of the tillage systems, as with all new and improved practices, should be calculated to determine the expected returns to the farmer, if any.

A new crop, the pinto bean, which was recently introduced into the Bay Region, should be thoroughly tested as a possibly adapted legume for human consumption. The dry pinto bean may be a desirable source of protein in the Somali diet. It is nutritious and well-accepted in the areas of the world where it is produced and adopted.

Studies on the economic benefits of the improved practices that have been developed, such as the application of fertilizers, should be initiated immediately. The results of these studies should indicate which practices would be most profitable for the farmers to adopt, in terms of input costs and returns. The results would also indicate the most profitable amount of input to use. The reports of research results of all on-farm trials should include the costs and returns obtained from each treatment in each trial. Thus, the on-farm agronomist could accurately predict the economic benefits farmers can obtain if they adopt the improved practice. This is the final, and possibly most important, step in the whole research program. These calculations do not require the services of an economist, but can be performed by any qualified scientist.

Expanded Research Programs

A greater amount of resources needs to be used in the final step in agricultural research—the on-farm testing of improved practices. The most promising practices demonstrated in the small-plot research should be incorporated into an expanded on-farm research program. The on-farm trials should be managed by researchers until the small-plot results coincide with the on-farm results. In other words, carefully controlled on-farm trials need to be the main focus of the on-farm research program at the present time. A well-qualified agronomist, with knowledge of and experience in on-farm agronomic research, should direct this research in the Bay Region.

The need for higher levels of available soil nitrogen in the crops adapted to the Bay Region must be determined, after adequate phosphorus has been applied. The need for phosphorus has been researched and shown to be vital for increased crop yields. It is now essential to determine when and how much nitrogen should be applied, since plants do not ordinarily respond to nitrogen until there is sufficient phosphorus uptake.

Suggestions for the Future

Phosphate has been shown to be the major limiting fertilizer element. Work is in progress to determine the most economical source of phosphate (animal manure, guano, or triple superphosphate). Finding the most profitable way of applying phosphate fertilizer is also an objective.

During wet weather, pale yellow leaves appear on legumes and at times on sorghum. Undoubtedly, there are other deficient fertilizer nutrients causing chlorotic leaves that should be investigated.

Wide-row or hill planting should be tested because it will conserve phosphate fertilizer and promote the use of animal traction to control weeds. Weed control is important for future research. Chemical farming, using hand sprayers to apply herbicides, may become an economically sound method of crop production. Mechanized farming with imported fuel is impractical at this time.

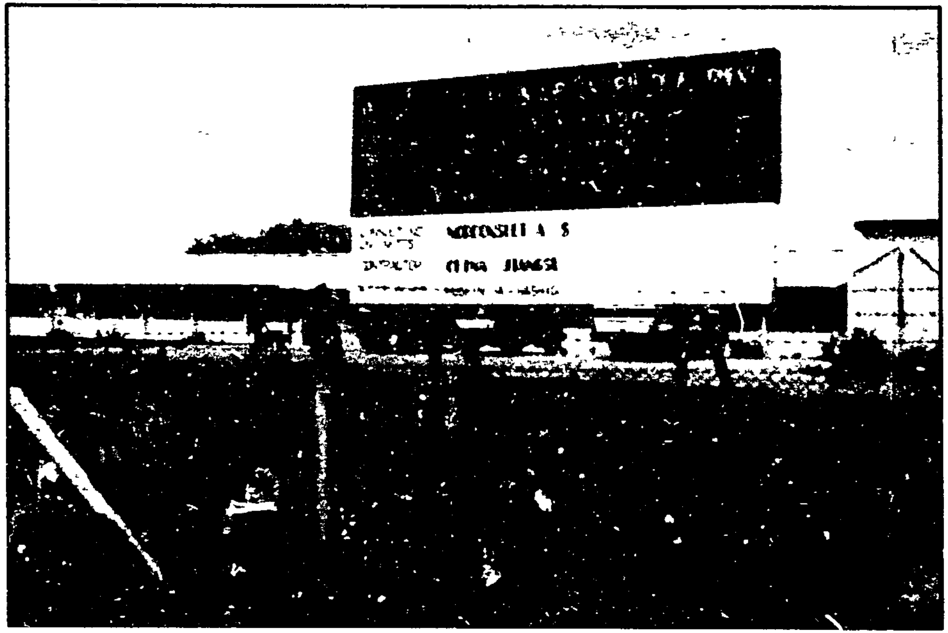
The authors of this report recommend that half of the sorghum program effort be devoted to testing hybrids, importing female lines, and searching for male lines to combine with the female lines. The first hybrid selected should be produced by an experienced foreign hybrid seed producer (probably in Kenya). It should be imported and sold by private salespersons. As the volume develops, local private seed production should be encouraged. Entrepreneurship needs to be encouraged.

Oil seed and grain legume research should aim at converting this country's sorghum monoculture to a rotation-based agriculture, with sorghum being grown in no more than two out of three seasons. This will call for an eight-fold increase in oil seed and grain legume production. Soybean yields of 2,150 kg/ha are exciting because they indicate a real potential for increasing oil production in the Bay Region. There is a substantial need for vegetable oil, as 80 percent or more is now imported. The oil seed meal would be welcomed, because a local cooperative is using soybean meal in cookies and bread. The developing chicken-feeding industry will require oil seed meal, too. The possibility of processing oil seeds in Baidoa needs special effort. Safflower is a promising crop but will have no future until it can be processed locally.

The English education program that has been established is a resounding success. It should be strengthened. Technical short courses, such as the statistics lectures the staff gave, should be a part of future plans. The Somalis should be bringing in teachers as well as sending students overseas.

Those scientists who have been trained, and those who have been sent off for further education, will ensure continued progress at this station.

NELS ANDERSEN



Bonka Dryland Agricultural Research Station (BDARS), Baidoa, Somalia.

Appendix 1

Project Personnel

ADMINISTRATIVE PROJECT MANAGEMENT

GENERAL MANAGER/PROJECT DIRECTOR	
Mohamed Warsame Duale	March 1981-present
ASSISTANT GENERAL MANAGERS FOR TECHNICAL MATTERS	
Omar Haji Duale	September 1983-December 1987
Hassan Abdo Munye	December 1987-present
DEPUTY PROJECT DIRECTOR	
Bashir Abdulle Osman	January 1983-December 1987
TECHNICAL MANAGER	
John Halpin	March 1981-January 1984
Clyde Smith	February 1984-March 1987
ADMINISTRATIVE SECRETARY	
Abdurazak Abdullahi Hersi	August 1982-present
FINANCIAL CONTROLLER	
Donald Sigsworth	September 1981-August 1984
P.O. Thomas	January 1985-present
ASSISTANT FINANCIAL CONTROLLER	
Hassan A. Iman	January 1988-present
ACCOUNTANT	
Salah Hussein Hersi	March 1981-May 1983
Hassan Abdi Jama	May 1983-present

UNIVERSITY OF WYOMING STAFF

CHIEF OF PARTY, UNIVERSITY OF WYOMING	
Bernard J. Kolp, agronomist	April 1983-April 1985
Robert J. Lavigne, entomologist	July 1985-August 1988
OTHER STAFF IN SOMALIA	
Nels H. Andersen, farm superintendent	July 1985-August 1988
Robert J. Buker, agronomist	August 1985-July 1987
Rosemary Buker, English instructor	May 1986-July 1987

Dorothy Costel, English instructor	1983-85
Gerald Costel, farm superintendent	April 1983-April 1985
Julie A. Howard, agricultural economist	April 1987-September 1988
Chai Nyet Fah, English instructor	March 1987-September 1988
typist and file clerk	March 1987-March 1988
	September-October 1988
Judith J. Lavigne, administrative secretary	July 1985-March 1987
	March-August 198
Hedera Porter, plant breeder and computer specialist	August 1986-September 1988
Paul Porter, soil scientist	January 1986-September 1988
Grant L. Richardson, agronomist and	December 1987-October 1988
acting chief of party	September-October 1988
Richard Rooney, procurement	1983-1985

UW INTERNATIONAL AGRICULTURAL PROGRAMS HOME OFFICE STAFF

William Smiley, director	1982-1984
Linda Shill, administrative secretary acting director	1982-1984
Mary Kay Wardlaw, part-time secretary	1984
Robert Julian, director	Feb 1985-June 1988
Kenneth Hoyt, program coordinator	1985-July 1988
Sharon Johnson, administrative secretary	May 1985-May 1987
Elaine Rodgers, accountant	September 1986-September 1988
Alicia Espinoza, administrative secretary	May - September 1987
Cyndi Dunn, administrative secretary	October 1987-September 1988
Jerrold Dodd, director	June 1988-September 1988
Peter Guernsey, program coordinator	September 1987-present
John Sapp, procurement officer	July 1987-July 1988
Ken Gavin, procurement officer	June 1987-present
J. Raymond Carpenter, director	September 1988
Margaret Toro, administrative secretary	September 1988

BONKA DRYLAND AGRICULTURAL RESEARCH STATION STAFF

RESEARCH DIRECTOR

Addo Adan Magan	July 1983-April 1985
M.A. Smith (acting)	April 1985-August 1985
Robert J. Buker	August 1985-July 1987
Ahmed Sheikh Hassan (acting)	July-December 1987
Ahmed Sheikh Hassan	January 1987-September 1988

ADVISER TO RESEARCH DIRECTOR

Grant L. Richardson, agronomist	December 1987-November 1988

DEPUTY RESEARCH DIRECTOR

Ahmed Sheikh Hassan Khalif	June 1983-July 1988
Abdullahi Hussein Wardere (Siiruu)	February 1988-September 1988

FARM SUPERINTENDENT

Gerald Costel	April 1983-April 1985
Nels H. Andersen	July 1985-August 1988

SECTION LEADERS/RESEARCH OFFICERS

Cereal Improvement/Sorghum Breeding

Abdullahi Hussein Wardere, section leader	July 1980-present
Hussein Mao Haji, section leader	current
Hassan Abdullahi Hussein, senior research officer	current
Ahmed Mohamed Askar, junior research officer	current
Haji Sheikh Ahmed, junior research officer	current
Muse Abdirahman Moalin, junior research officer	current
Abdulkadir Warsame Mohamed, junior research officer	current
Ibrahim Abdullahi Mohamoud, junior research officer	current
Said Hassan Said, junior research officer	current
Abdi Hussein Farah, junior research officer	current
Abdi Mohamoud Hassan	current (transferred from Regional District Office)
Yusuf Ali Salad	current
Hedera Porter, agronomist	August 1986-September 1988
Fawsia Haji Mahamoud, senior research officer (U.S.)	
Adan Abdullahi Farah, senior research officer	

Soil Fertility

Paul Porter, section leader — January 1986-September 1988
Abdirashid Dulane Rafle, senior research officer — current
Abdullahi Hussein Abdi, senior research officer — current
Adan Awil Ateye, junior research officer — current
Hinda Saleban Jama, junior research officer — current
Adan Mohamed Nur, junior research officer — current
Abdurahman Mohamed Ali — current
Shamis Abdullahi Nur (transferred to Farming Systems Section)
Adan Yarrow Adan
Abdirizak Osman Said (transferred to Dryland Cropping Systems)
Said Mohamed Jumale, junior research officer

Dryland Cropping Systems

M. A. Smith, section leader — December 1984-December 1986
Graham Eagleton, adviser to section — January 1987-October 1988
Abdi Ahmed Mohamed, section leader and senior research officer — current
Ahmed Adan Odowa, senior research officer — current
Abdirizak Osman Said, junior research officer — current
Ismail Hirsi Farah

Animal Traction

Stewart Barton, section leader — January 1987-August 1987
Graham Eagleton, advisor to section — August 1987-October 1988
Ali Obsiye Bon, section leader — October 1985 - present
Omar Mohamed Ali, junior research officer — current
Abdullahi Haji Mohamed, junior research officer — current
Ibrahim Abdi Ker, junior research officer — current
Rashid Mohamed Adan, junior research officer — current

Forage

Addo Adan Magan, section leader — current
Mohamed Awil Nur, junior research officer (transferred to Legumes)

Agronomy

Ahmed Sheikh Hassan, section leader — 1980-present
Ibrahim Abdullahi Sheikh, senior research officer — current
Abdirashid Dirir Hashi, junior research officer — current
Abdi Mahamud Hassan (worked with Grant Richardson) — current
Habiba Ali Nur, senior research officer

Plant Protection

Robert Lavigne, section leader	July 1985-January 1988
adviser	January 1988-August 1988
Ali-Nur Hussein Duale, section leader	January 1988-present
Mohamed Abdurahman Mohamed, senior research officer (Entomology)	current
Mohamed Hassan Mohamoud, senior research officer (Entomology)	current
Said Ali Abdullahi, junior research officer (Entomology)	current
Abdilatif Hamud Mohamed, junior research officer (Plant Pathology)	current
Abdinur Yusuf Irad, spray technician, Baidoa	current
Said Mohamoud Jumale, junior research officer	
Abdinur Mohamed Ismail, junior research officer	

Grain Legume and Oil Crops

Ali Mohamed Abdi, section leader	1982-1986
Amina Ali Garad, section leader	1982-June 1985
Adan Elmi Abdullahi, section leader	1984-January 1987
Adan Ali Ossoble, section leader	1987-present
Mohamed Mohamud Sheikh, junior research officer	current
Abdikarim Nur Mohamed, junior research officer	current
Ismail Abdi Ali, junior research officer	current
Ismail Abdi Hirsi, junior research officer	current
Fadumo Mohamed Osman, technician	current
Hassan Abdullahi Hussein, research assistant	current
Mohamed Awil Nur	current
Abdinur Mohamed Ismail, junior research officer	
Abbas M. Naasir, junior research officer	

Off-Station Trials

M. A. Smith, section leader	December 1984-December 1986
Graham Eagleton, section leader	January 1987-present
Hassan Ahmed Muse, junior research officer	current
Addo Adan Magan, Substation Development (also section leader, Forage)	current
Abdinur Mohamed Ismail, section leader	
Ahmed Abdullahi Mohamed, junior research assistant	

Farming Systems

Julie A. Howard, section leader April 1987-September 1988
Maryan Abdulle Mohamed, senior research officer current
Maxamed Nur Haydar, junior research assistant current

Computer Analysis

Hedera Porter, computer analyst June 1987-September 1988
Said Hassan Said, junior research officer current

FARM OPERATIONS SERVICE UNIT

Mohamed Osman Du'aale, farm manager May 1987-present
Yusuf Ahmed Gelle, farm manager September 1985 -January 1987
Mustafa Ibrahim Tubea, mechanic current
Mohamud Nur Mohamed, mechanic current
Kuusow Elmi Shire, operations assistant current
Yusuf Mohamed Salah, assistant agriculturist current
Moalin Ali Hilowle, workshop coordinator current
Abdi Mohamed Ahmed, storekeeper
Mohamed Hassan Elmi, tractor driver current
Mohamed Bile Mohamed, tractor driver current
Shure Ibrahim Amin, tractor driver current
Adan Ahmed Abdi, tractor driver current
Abdirizak Ahmed Adan Yusuf, assistant farm manager
Mohamed Hashi Farah, mechanic
Shuqayb Mohamud Qasin, storekeeper
Said Mohamed Jumale
Fadumo Yaqub Mohamed, assistant storekeeper
Hassan Jumalle Gadid, tractor driver
Mohamed Hassan Omar, tractor driver
Said Mohamud Abdi
Hassan Sheikh Ahmed, tractor driver
Mohamed Bille Mohamed, tractor driver
Mohamed Abdi Nur
Mohamed Macow Suley, tractor driver
Abdusalaan Mire Mohamed, asst tractor driver
Ismail Serar Yusuf, bus driver
Bashi Said Sursal, bus driver
Fadumo Abdurahman Sheikh, messenger
Mohamed Abdirahim Abdi
Muse Mohamed Said (transferred to MOA)
Abdullahi Omer Mohamed, pump operator
Adan Humey Isaaq, watchman
Abdikarim Mohamud Mohamed, apprentice

RESEARCH STATION OFFICE STAFF

Mumino Kalinle Barre, accountant	current
Ibrahim Mayow Mahad, clerk-typist	current
Sahro Hassan Adan, clerk	current
Nuuro Haashi Mohamed, storekeeper (transferred to PMU)	current

PLANT PROTECTION SERVICE UNIT

Abdirahim Abdullahi Ismail, regional head	1978-January 1987
Abdulkadir Ali Samatar, regional head	January 1987-January 1988
Robert Lavigne, section leader	January 1987-August 1988
Hersi Dini Hassan, district head, Baidoa	current
Hassan Mukhtar Ahmed, spray technician, Baidoa	current
Mutaf Nur Hassan, spray technician, Baidoa	current
Mohamed Nur Mohamed Ker, mechanic, Baidoa	current
Abdi Ibrahim Hassan, spray technician, Qansa Dhere	current
Mohamed Hassan Ibrahim, driver, Baidoa	current
Abdi Yarow Abdi, spray technician, Bur Hakaba	current
Hassan Yarow Hassan, Protection officer Bur Hakaba, Plant	current
Kherto Omar Mohamed, secretary	
Mohamed Isak Abdulle, Qansa Dhere (Ufurow)	
Abdirahman Ali Magan, spray Technician, Baidoa	
Abdulkadir Sheikh Isak, spray technician	
Omar Mohamed Ali, spray technician	
Said Ali Abdullahi	
Asli Moallin Ali, technician	

REGIONAL COORDINATION SECTION

Ali Yusuf Dirie, regional coordinator	-January 1987
Said Mohamoud Abdi, regional coordinator	May 1987-present
DAO, Qansa Dhere	March 1986-May 1987
Hassan Ahmed Musa, DAO, Baidoa	June 1987-September 1987
Ali Sidow Hilowle, DAO, Dinsoor	1983-September 1986
Hassan Mohamed H. Ibrahim, DAO, Dinsoor assistant DAO, Dinsoor	September 1986- present
Ahmed Mahamud Ga'al, DAO, Qansa Dhere	
Abdi Mohamoud Hassan, DAO, Qansa Dhere assistant DAO, Q/Dhere	January 1987- October 1987
Ibrahim Abdullahi Mohamoud (transferred to BDARS Sorghum Agronomy)	

Abdirisak Mohamed Abdi, DAO, Bur Hakaba
Abdirisak Jama Dugsiye, DAO, Bur Hakaba January 1987-present
Shamis Abdullahi Nur, assistant regional coordinator,
Baidoa current
Miidow Maxamed Iftiin, secretary, Baidoa current
Saynab Daahir Maxamuud, archivist, Baidoa current
Said Hassan Said, Bur Hakaba
Asli Ma'alin Ali, assistant agriculturalist, Baidoa
Jama Abdi Ahmed, assistant agriculturalist, Dinsoor
Baar Abdullahi Awaale, clerk, Baidoa
Mahudin Ahmed Mo'alin, clerk-typist, Dinsoor
Huriyo Ahmed Mohamed, clerk-typist, Dinsoor
Amino Hussein Roble, clerk-typist, Dinsoor
Hajiyo Hussein Mohamoud, clerk-typist, Dinsoor
Mohamed Isak Abdulle, sprayer, Qansa Dhere
Hajiyo Hussein Mahamud, clerk, Qansa Dhere
Ahmed Mahomed Oskar, assistant agriculturalist, Qansa Dhere
Abdulkadir Abukar Maye, clerk-typist, Bur HakabaAli Ibraahim Mohamed, radio operator, Dinsoor

CONSULTANTS

Short-Term Consultants

TDY MONTHS	NAME	TITLE	ORGANIZ.	CONSULT.
Oct-Dec '83	Lavigne, R.	Entomologist	U of Wyo	Entomology
May-Jul '84	Gray, F.	Plant Path	U of Wyo	Disease survey
Aug '84	Seamonds, W.	Agronomist	U of Wyo	Forage Research
Apr-July '85	Martin, M.	Grad Student	U of Wyo	Animal Traction
Feb '86	Hoyt, K.	IAP Training	U of Wyo	Review
Feb '86	Julian, R.	IAP Director	U of Wyo	Review
Apr-Jun '86	Barton, S.	Ag Engineer	Self-employed	Animal Traction
May-July '86	Longstreth, M.	Asst Prof	U of Ariz	Women's Time
May '86	Olson, C.	Ag Economist	U of Wyo	Farming Systems
June '86	Maranville, J.	Plant Phys	U of Neb	Plant Phys
Jun-Aug '86	Howard, J.	Summer intern	USAID	Farming Systems
Aug '86	Olson, C.	Ag Economist	U of Wyo	Farming Systems
Sep-Oct '86	Strong, W.	Soils Sci	Wheat Res Inst	Soil Fertility
Jan-Feb '87	Gray, F.	Plant Path	U of Wyo	Disease survey
Jan-May '87	Porter, H.	Computer Spec	U of Ill	Computer Trng
Jan-Aug '87	Barton, S.	Ag Engineer	Self-employed	Animal Traction
Feb-Mar '87	Kolp, B.	Agronomist	U of Wyo	Osman thesis
Mar '87	Julian, R.	IAP Director	U of Wyo	Review
Mar '87	Wangberg, J.	UW Dept Head	U of Wyo	Review
Aug-Sep '87	Shuyler, H.	Entomologist	Kansas St	Stored Grain
Sep '87	Dodd, J.	IAP Director	U of Wyo	Review
Oct-Nov '87	Gray, F.	Plant Path	U of Wyo	Disease survey
Nov '87	Kolp, B.	Agronomist	U of Wyo	Osman thesis def
Dec-Jan '87	Howard, J.	Ag Economist	U of Wyo	Farming Systems
Jan '88	Harris, L.	Vice Prin	Dalby Ag Col	Agric Educ
Feb '88	Crawford, E.	Assoc Prof	Mich St U	Farming Systems
Apr '88	Dodd, J.	IAP Director	U of Wyo	Review
Apr '88	Kaltenbach, C.	Assoc Dean	U of Wyo	Review
May-Jun '88	Foale, M.	Soil Sci	CSIRO	Soil Moisture
Jul-Aug '88	Williamson, S.	Res Sci	Fish/Wildlife	Statistician
Aug '88	Ferrell, M.	Assoc Prof	U of Wyo	Pesticide Safety

Training

Jan '86	Beckstrand, G.	COP	Utah St	Res-Extension
Jan-Feb '87	Gray, F.	Plant Path	U of Wyo	Plant Path
Sep '87	Shuyler, H.	Entomologist	Kansas St	Stored Grain
Mar '86 -May '87	Buker, Rosemary	Instructor	U of Wyo	English
Mar-Oct '88	Chai Nyet Fah	Instructor	U of Wyo	English

Appendix 2

Participant Data

Name	Fund Source	Location of Training	Dates	Length	Field of Study/ Degree Objective
ABDI, Abdrizak M.	WBB	Dalby	1/87-1/88	1 yr	Mech Production/ST
ABDI, Abdullahi H.	AID	ICRISAT	5/87-11/87	6 mo.	Crops/ST
ABDI, Abdullahi H.	AID	Conference	?-?	1 wk	Soils/ST
ABDI, Ahmed S.I.	WB	U of Wyo	8/84-8/85	1 yr	Socioeconomics/ST
ABDI, Ali M.	AID	Tex Tech	6/84-12/86	1 yr 6 mo	Agronomy/MS
ABDI, Hassan S.	WB	Mich St	1/83-4/85	2 yr 3 mo	Resource Dev/MS
ABDI, Hassan S.	WB	Harvard	6/86-8/86	2 mo	Economics/ST
ABDINUR, Mohamed	WBB	Queensland	2/88-12/88	11 mo	Plant Protection/ST
ABDULLAHI, Adan E.	CGIAR	IITA	1/86-3/86	2 mo	Legume Research/ST
ABDULLAHI, Adan E.	AID/WB	U of Ill	1/87-12/88	2 yrs	Agronomy/MS
ABDULLAHI, Said A.	WB	ICRISAT	12/88-12/88	1 mo	Crop Protection/ST
AFRA, Abdullahi A.	AID	Tex Tech	6/84-12/86	2 yr 6 mo	Crops/MS
ALI, Abdulaziz M.	AID	UC/Davis	6/85-3/88	2 yr 8 mo	Vet Science/MS
ALI, Ahmed M.	WB	U of Wyo	8/84-8/85	1 yr	Socioeconomics/ST
ALI, Ismail A.	AID	ICRISAT	5/87-11/87	6 mo	Crops/ST
ALI, Jama H.	WB	U of Wyo	10/84-6/87	2 yrs 8 mo	Ag Engineering/MS
ALI, Omar M.	WB	Nairobi	1/87-1/87	2 wks	Harness Making/ST
ALI, Siyad Y.	AID	Wyo Tech	6/84-1/86	1 yr 7 mo	Auto-Diesel Mech/AS
AMANE, Dahir F.	AID	Utah St	10/82-5/85	2 yr 8 mo	Range Ecology/MS
ASKAR, Ahmed M.	WB	ICRISAT	12/88-12/88	2 wks	Crop Protection/ST
ATEYE, Aden A.	WB	ICRISAT	?/88-?/88	6 mo	Crops/ST
BARRE, Abdullahi M.	AID	UC/Davis	5/84-3/86	2 yrs	Vet Science/MS
BARRE, Mohamed G.	WB	Harvard	6/86-8/86	6 mo	Economics/ST
BON, Ali O.	AID	ICRISAT	5/87-11/87	6 mo	Crops/ST
DIRIE, Ali Y.	AID/WB	U of Ill	1/87-12/88	2 yrs	Agronomy-Soils/MS
DUALE, Ali-Nur H.	AID	ICRISAT	12/87-12/87	1 wk	Plant Protection/ST

Type	English Training Site	Dates	Length	Cost Total	Degree Awarded	Status	Sponsor
In-Service	N/A	N/A	N/A	$15,879	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$4,200	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
Part.	N/A	N.A	N/A	$14,811	N/A	Not return	NMEF
Part.	CSU	6/84-9/84	1.5 mo	$44,109	MS	Left job	BRADP
Part.	Mich St	1/83-8/83	6 mo	$45,845	MS	NMEF	NMEF
Part.	N/A	N/A	N/A	$4,912	N/A	NMEF	NMEF
In-Service	N/A	N/A	N/A	$19,775	N/A	Current	BRADP
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$41,048	?	Not return	BRADP
Part.	N/A	N/A	N/A	$3,743	N/A	*	*
Part.	CSU	7/84-8/84	1 mo	$44,354	None	Left job	BRADP
Part.	Lewis Clark	9/85-12/85	3.5 mo	$43,541	MS	Vet C	BRADP
Part.	N/A	N/A	N/A	$14,613	N/A	Left job	NMEF
Part.	N/A	N/A	N/A	$4,200	N/A	BDARS	BRADP
Part.	CSU	10/84-6/85	8 mo	$40,058	None	Not return	BRADP
In-Service	N/A	N/A	N/A	$1,166	N/A	BDARS	BRADP
Part.	CSU	7/84-12/84	5.5 mo	$34,738	AS (2)	PMU	BRADP
Part.	*	*	*	$59,115	MS	Unknown	BRADP
Part.	N/A	N/A	N/A	$3,743	N/A	*	*
Part.	N/A	N/A	N/A	$5,865	N/A	*	BRADP
Part.	UC/Davis	9/84-12/84	2 mo	$33,533	None	MOL	BRADP
Part.	N/A	N/A	N/A	$13,207	N/A	NMEF	NMEF
Part.	N/A	N/A	N/A	$4,200	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$16,011	MS	BDARS	BRADP
In-Service	N/A	N/A	N/A	$2,267	N/A	BDARS	BRADP

Appendix 2 cont.

Name	Fund Source	Location of Training	Dates	Length	Field of Study/ Degree Objective
DUALE, Ali-Nur H.	AID	AAIS	12/87-12/87	4 da	Entomology/ST
DUALE, Ali-Nur H.	AID	ICIPE	4/88-4/88	1 wk	Plant Protection/ST
DUALE, Mohamed O.	WB	IITA	11/88-12/88	1 mo	Crops/ST
DUALE, Omer H.	AID	DC	5/85-7/85	2 mo	Project Mgt/ST
DUGSIYE, Abdrizak W.	*	ICRISAT	5/87-11/87	6 mo	Animal Traction/ST
DUGSIYE, Abdrizak W.	WB	ICRISAT	12/88-12/88	2 wks	Crop Protection/ST
ELMI, Abdulkadir M.	WB	CSU	6/84-3/87	2 yr 9 mo	Sociology/MA
AHIE, Mohamed A.	WB	CSU	8/84-8/87	2 yr 11 mo	Civil Engineering/MSIS
FARAH, Aden A.	WB	IITA	10/88-11/88	1 mo.	Ag Statistics/ST
GELLE, Yusuf A.	AID/WB	U of Neb	1/87-12/88	2 yrs	Ag Extension/MS
GULAID, Abdulkadir M	WB	U of Wyo	8/84-8/85	1 yr	Socioeconomics/ST
HAJI, Hussein M.	IDRC	E. Anglia	7/86-8/86	1 mo	Ag Res Mgt/ST
HAJI, Hussein M.	AID	Tex Tech	2/87-3/87	1 mo	Ag Sorghum/ST
HAJI, Hussein M.	IDRC	Nairobi	9/87-9/87	1 wk	Seed Production/ST
HAJI, Hussein M.	IDRC	ICRISAT	11/87-11/87	1 wk	Stemborers/ST
HASHI, Abdirashid D.	WB	ICRISAT	12/88-12/88	2 wk	Crop Protection/ST
HASSAN, Abdi A.	AID	CSU	5/83-3/84	10 mo	English/ST
HASSAN, Abdi M.	WB	U of Wyo	8/84-8/85	1 yr	Socioeconomics/ST
HASSAN, Ahmed S.	AID	U of Ariz	10/82-5/85	2 yr 7 mo	Plant Breeding/MS
HASSAN, Ahmed S.	AID	ICRISAT	2/86-2/86	1 wk	Agronomy/ST
HASSAN, Ahmed S.	AID	E. Anglia	7/86-8/86	1 mo	Ag Res Mgt/ST
HASSAN, Ahmed S.	AID	Nairobi	9/87-9/87	1 wk	Seed Production/ST
HASSAN, Ahmed S.	AID	U of Harare	3/88-3/88	1 wk	Grain Pathology/ST
HASSAN, Ahmed S.	WB	USDA/Tex	5/88-7/88	1 mo 2 wk	Ag Research/ST
HERSI, Sulieka A.	WB	USDA/GW	6/86-12/87	1 yr 6 mo	Admin Science/MA
HIRSI, Ismail A.	WB	ICRISAT	?/88-?/88	6 mo	Crops.ST
IBRAHIM, Hassan M.H.	WB	IITA	?/88-?/88	*	Farm Systems/ST
IMAN, Hussein Y.	WB	CU/Denver	5/85-8/87	2 yr 2 mo	Finance/MBA

Type	English Training Site	Dates	Length	Cost Total	Degree Awarded	Status	Sponsor
Part.	N/A	N/A	N/A	$2,267	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	$1,257	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$2,929	N/A	*	BRADP
In-Service	N/A	N/A	N/A	$9,921	N/A	MOA	BRADP
In-Service	N/A	N/A	N/A	$4,200	N/A	DAO	BRADP
Part.	N/A	N/A	N/A	$3,743	N/A	*	BRADP
Part.	CSU	7/84-8/84	1 mo	$57,041	MA	NMEF	NMEF
Part.	CSU	?	?	$47,007	?	BRADP	BRADP
Part.	N/A	N/A	N/A	$2,100	N/A	Current	BRADP
Part.	N/A	N/A	N/A	$20,046	MS	BDARS	BRADP
Part.	N/A	N/A	N/A	$14,039	N/A	NMEF	NMEF
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$942	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$3,743	N/A	*	BRADP
Part.	CSU	5/83-3/84	10 mo.	*	N/A	Unknown	*
Part.	N/A	N/A	N/A	$19,191	N/A	Not return	NMEF
Part.	*	*	*	$62,866	MS	BDARS	BRADP
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	$942	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$4,912	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$9,000	N/A	BDARS	BRADP
Part.	USDA/GW	9/86-12/86	3 mo	$30,198	None	NMEF	NMEF
Part.	N/A	N/A	N/A	$5,865	N/A	*	BRADP
In-Service	N/A	N/A	N/A	$3,601	N/A	*	BRADP
Part.	N/A	N/A	N/A	$49,934	MBA	PMU	BRADP
Part.	N/A	N/A	N/A	*	N/A	PMU	BRADP

Appendix 2 cont.

Name	Fund Source	Location of Training	Dates	Length	Field of Study/ Degree Objective
ISMAIL, Abdinur	WBB	Dalby	2/88-12/88	10 mo	Crops/ST
ISMAIL, Abdirahim A.	AID	ICIPE	4/86-4/86	1 wk	Plant Protection/ST
ISMAIL, Abdirahim A.	AID	CSU	1/87-9/87	8 mo	Plant Protection/ST
ISMAIL, Din A.	AID	U of Wyo	6/84-12/86	2 yr 6 mo	Plant Pathology/MS
ISSE, Mohamed A.	WB	U of Wyo	10/84-12/85	1 yr 2 mo	Extension/ST
JAMA, Hassan A.	ADF	Nairobi	4/87-4/87	2 wks	Loan Admin/ST
JAMMA-GARAD, Amina	AID	U of Wyo	6/85-5/86	1 yr	Agronomy/MS
MAGAN, Addo A.	WB	ILCA	10/88-10/88	2 wks	Forage/ST
MAHDI, Ali H.	WB	CSU	10/84-7/88	3 yrs 9 mo	Economics/MS
MOHAMED, Abdi A.	WB	Arizona	10/85-10/85	1 wk	Arid Land Mgt/ST
MOHAMED, Abdi A.	AID	ILCA	9/87-9/87	4 days	Soils/ST
MOHAMED, Abdi A.	AID	Nairobi	4/88-4/88	1 wk	Farming Systems/ST
MOHAMED, Abdi A.	*	Djibouti	5/88-5/88	1 wk	Farming Systems/ST
MOHAMED, Abdi A.	WB	ICRISAT	8/88-8/88	2 wks	Crops/ST
MOHAMED, Abdiladif H	WBB	S Queensland	2/88-12/88	10 mo	Plant Pathology/ST
MOHAMED, Abdulkadir	WB	ICRISAT	8/88-8/88	2 wks	Crop Protection/ST
MOHAMED, Ahmed A.	WBB	Dalby	1/87-1/88	1 yr	Mech Production/ST
MOHAMED, Khalif S	WB	Mich St	3/84-2/88	4 yrs	Economics/MS
MOHAMED, Mohamed A	AID	ICIPE	4/86-4/86	1 wk	Plant Protection/ST
MOHAMED, Mohamed A	AID	ICIPE	4/87-4/87	1 wk	Plant Protection/ST
MOHAMED, Mohamed A	WBB	U of Qnsld	2/88-12/88	10 mo	Plant Pathology/ST
MOHAMED, Mohamed I	WB	UC Rvrside	6/88-9/88	2 mo	Plant Pathology/ST
MOHAMMED, Omar H	WB	Tex Tech	4/83-9/86	3 yr 5 mo	Range Mgt/MS
MOHAMOUD, Abdikarim	WBB	S Qnsland	2/88-12/88	10 mo	Plant Pathology/ST
MOHAMOUD, Abdulkadir	WB	U OF Wyo	8/84-8/85	1 yr	Socioeconomics/ST
MOHAMOUD, Fowzia	WB	U of Wyo	8/84-1/87	2 yr 4 mo	Crops/MS
MOHAMUD, Ibrahim A.	SAF GRAD	ICRISAT	5/87-11/87	6 mo	Crops/ST
MOHAMUD, Mohamed	WB	ICIPE	6/88-11/88	5 mo	Plant Protection/ST

Type	English Training Site	Dates	Length	Cost Total	Degree Awarded	Status	Sponsor
In-Service	N/A	N/A	N/A	*	N/A	Current	BRADP
In-Service	N/A	N/A	N/A	*	N/A	Plant Pro	BRADP
Part.	N/A	N/A	N/A	$13,605	N/A	Not return	BRADP
Part.	*	*	*	$41,919	None	Not return	BRADP
Part.	CSU	10/84-3/85	5 mo	$24,583	N/A	MOA	BRADP
In-Service	N/A	N/A	N/A	*	N/A	BRADP	BRADP
Part.	CSU/L&C	10/85-5/86	6 mo	$21,109	None	MOA	BRADP
Part.	N/A	N/A	N/A	$2,891	N/A	Current	BRADP
Part.	CSU	10/84-7/85	8 mo	$78,259	MS	Current	NMEF
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$4,000	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	$1,241	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$4,453	N/A	*	BRADP
In-Service	N/A	N/A	N/A	$17,069	N/A	Current	BRADP
Part.	N/A	N/A	N/A	$3,743	N/A	*	BRADP
In-Service	N/A	N/A	N/A	$15,879	N/A	Not return	BRADP
Part.	Mich St	3/84-5/84	2 mo	$52,817	None	Not return	NMEF
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	$1,241	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	$19,775	N/A	Current	BRADP
Part.	N/A	N/A	N/A	$8,320	N/A	Current	FOA
Part.	LSU	4/83-12/83	8 mo	$54,048	*	NMEF	NMEF
In-Service	N/A	N/A	N/A	$17,069	N/A	Current	BRADP
Part.	N/A	N/A	N/A	$18,351	N/A	Left job	NMEF
Part.	CSU	10/84-5/85	6 mo	$33,958	None	Not return	BRADP
Part.	N/A	N/A	N/A	*	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$12,541	N/A	Current	BRADP

Appendix 2 cont.

Name	Fund Source	Location of Training	Dates	Length	Field of Study/ Degree Objective
MUMIN, Ismail M.	IDA/IFAD	CSU	6/87-7/88	1 yr 1 mo	Public Finance/MS
MUSA, Hassan A.	WB	IITA	9/88-9/88	2 wks	Farm Research/ST
NOOR, Abdi A.H.	AID	Mo.	9/83-11/84	1 yr 2 mo	Poultry Science/*
NUR, Abdulkadir F	AID	UW/CSU	6/85-9/85	3 mo	IPM/ST
NUR, Habiba A.	AID	U of Wyo	6/87-8/87	2 mo	Ag Education/ST
NUR, Habiba A.	WB	Utah St	4/88-7/88	3 mo	Computer Science/ST
ODOWE, Ahmed A.	WB	IITA	10/88-11/88	1 mo	Ag Statistics/ST
OMAR, Moalin A.	WB	U of Wyo	8/84-8/85	1 yr	Socioeconomics/ST
OSMAN, Abdrizak M.	WB	U of Wyo	8/84-8/85	1 yr	Ag Economics/MS
OSMAN, Mohamed A	WB	U of Wyo	8/84-12/87	3 yr 4 mo	Crop Science/MS
OSSOBLE, Adan A.	AID	Tex Tech	6/84-2/87	2 yr 8 mo	Agronomy/MS
OSSOBLE, Adan A.	AID	Thailand	11/87-11/87	1 wk	Mungbeans/ST
RAFLE, Abdirashid D.	AID	U of Ariz	6/84-1/87	2 yr 6 mo	Agronomy/MS
RAFLE, Abdirashid D.	WB	USDA/Auburn	6/88-8/88	2 mo	Soils/ST
RAFLE, Abdirashid D.	WB	ICRISAT	7/88-7/88	*	Crops/ST
SAID, Abdrizak O.	AID	IITA	2/88-3/88	2 mo	Ag & Plant Pathology/ST
SAID, Mohamed M.	AID	UC Davis	10/82-5/85	2 yr 6 mo	Vet Epidemiology/MS
SAID, Mohamed M.	AID	UC Davis	3/88-3/88	3 wks	Vet Science/MS
SAID, Said H.	SAFGRAD	ICRISAT	5/87-11/87	6 mo	Crops/ST
SAMATAR, Abdikadir A	AID	ICIPE	4/87-4/87	1 wk	Plant Protection/ST
SAMATAR, Abdikadir A	WBB	Queensland	2/88-12/88	10 mo	Plant Protection/ST
SHEIK, Mohamed M.	AID/WB	U of Wyo	10/84-12/88	4 yr 2 mo	Agronomy/BS
WARDERE, Abdullahi H	AID	U of Wyo	10/82-5/85	2 yr 6 mo	Agronomy/MS
WARDERE, Abdullahi H	WB	TxTechUSDA	2/87-3/87	1 mo	Agriculture/ST
WARDERE, Abdullahi H	*	Djibouti	5/88-5/88	1 wk	Farming Systems/ST
WARDERE, Abdullahi H	WB	ICRISAT	7/88-9/88	2 mo	Agronomy/ST
WEHELYE, Yassin J	AID	Mich St	10/82-5/85	2 yr 6 mo	Ag Economics/MS
YAHIE, Abdullahi M	WB	UCLA	9/81-6/86	5 yr 6 mo	Economics/PhD

Type	English Training Site	Dates	Length	Cost Total	Degree Awarded	Status	Sponsor
Part.	*	*	*	$18,800	*	*	BRADP
Part.	N/A	N/A	N/A	$1,911	N/A	*	BRADP
In-Service	*	*	*	$26,286	None	Left job	BRADP
Part.	N/A	N/A	N/A	$17,559	N/A	MOA	MOA
Part.	N/A	N/A	N/A	$6,912	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$5,200	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$2,100	N/A	*	BRADP
Part.	N/A	N/A	N/A	$15,053	N/A	Not return	NMEF
Part.	CSU	10/84-5/85	6 mo	$20,348	None	Unknown	MOA
Part.	CSU	10/84-3/85	4 mo	$43,145	MS	MOA	BRADP
Part.	CSU	7/84-8/84	1 mo	$46,110	MS	BDARS	BRADP
In-Service	N/A	N/A	N/A	$4,537	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$42,000	MS	BDARS	BRADP
Part.	N/A	N/A	N/A	$10,400	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$1,600	N/A	BDARS	
Part.	*	*	*	$53,996	None	BRADP	
Part.	N/A	N/A	N/A	$6,000	MS	BRADP	BRADP
Part.	N/A	N/A	N/A	*	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	$1,242	N/A	BRADP	BRADP
In-Service	N/A	N/A	N/A	$19,775	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$62,813	*	Current	BRADP
Part.	*	*	*	$60,879	MS	BDARS	BRADP
Part.	N/A	N/A	N/A	*	N/A	BDARS	BRADP
In-Service	N/A	N/A	N/A	*	N/A	BDARS	BRADP
Part.	N/A	N/A	N/A	$4,453	N/A	BDARS	BRADP
Part.	*	*	*	$44,488	MS	BRADP	BRADP
Part.	*	*	*	$30,462	PhD	NMEF	NMEF

Appendix 2 cont.

SUMMARY:

PrimaryParticipant Training Programs:

AID	45
WB	59
WBB	8
Sub-Total	112
OTHER	12
TOTAL	124

Degrees Awarded in U.S.

M.S.	11
PhD	1
S/T	77
Sub-Total	89
OTHER	3
TOTAL	93*

* This figure does not include workshop participants.

Total Training Months

AID	548.25
WB	600.75
WBB	85
Sub-Total	1234
OTHER	35.5
TOTAL	1269.5

Sponsors:

BRADP	97
NMEF	15
	(80 individuals)
Sub-Total	112
OTHER	6
TOTAL	118

English Language Training Months:

Participants	78
In-Service	34

Total Months	87.5
AID	30.5
WB	57

Cost Totals:

AID	$882,088
WB	$968,553
WBB	$125,221
Sub-Total	$1,975,862
OTHER	$23,000
TOTAL	$2,124,083

* = Unknown data
ST = Short-Term Training
In-Service - In-Service Training
Part. = Participant Training
Current = Presently in training
Left job = Resigned from in-country Somalia position
Not return = Did not return from host countrty
Unknown = Whereabouts unknown

For additional information on abbreviations, see Appendix 9, Glossary of Abbreviations

Appendix 3

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Appendix 4
Reports Produced by Bonka Dryland Agricultural Research Station Staff

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Appendix 6
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Reviews

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Appendix 7

Equipment Inventory and Evaluation

A systematic program of maintenance and servicing is conducted on all machinery. Adequate supplies of oil and arrival of previously ordered spare parts allow repairs to be made to most machines. A detailed inventory follows.

1 - Massey-Ferguson tractor - 4WD
Model 275
Year - unknown (1982?)
Mechanical evaluation: operational

2 - Massey-Ferguson tractor - 4WD
Model 275
Year - unknown (1982?)
Mechanical evaluation: operational

3 - Massey-Ferguson tractor - 4WD
Model 275
Year - unknown (1982?)
Mechanical evaluation: fair - operational

4 - Massey-Ferguson tractor w/front loader
Model 2705, 120 HP
Year: 1984
Mechanical evaluation: good

5 - Fiat tractor
Model 640
Year: unknown
Mechanical evaluation: operable - needs rewiring

6 - International tractor
Model 674
Year: unknown
Mechanical evaluation: unserviceable - in pieces

7 - Massey-Ferguson tractor
Model 185
Year: unknown
Mechanical evaluation: fair - operational

8 - International Harvester combine
Model 1420
Year 1984
Mechanical evaluation: good - used every season

9 - Eversman land plane
Model: unknown - approximately 4 m. blade
Year: unknown
Mechanical evaluation: some structures bent due to misuse

10- Lilliston planter - 4-row
Model: unknown
Year: unknown
Mechanical evaluation: fair - operational

11- Allen machine tool bar w/plot planter cones
Model: unknown
Year: unknown
Mechanical evaluation: good

12- John Deere tool bar planters (4)
Model: 71 double disc opener type
Year: unknown
Mechanical evaluation: good - used every season

13- Brillion chisel plow - 7 shanks
Model: unknown
Year: unknown
Mechanical evaluation: good - operational

14- Lilliston HD cultivator - sweeps
Model: 8500 7 shanks
Year: unknown
Mechanical evaluation: fair - used regularly

15- Massey-Ferguson disc harrow - 7 ft. cutting width
Model: unknown
Year: unknown

Mechanical evaluation: good - used regularly

16- Lilliston field cultivator - 4 meters
Model: unknown
Year: unknown
Mechanical evaluation: fair - used regularly

17- Lilliston rotary hoe cultivator - 4-row
Model: unknown
Year: unknown
Mechanical evaluation: fair

18- Massey-Ferguson field cultivator
Model: 259
Year: unknown
Mechanical evaluation: good - used very little

19- Lilliston peanut digger
Model: 5500
Year: unknown
Mechanical evaluation: fair - used very little

20- Hutchinson cleaner
Model C1600
Year: unknown
Mechanical evaluation: good - unused, parts missing

21- Lilliston chisel plow
Model 8500
Year: unknown
Mechanical evaluation: Not assembled - parts missing

22- John Deere Flail Mower
Model 25A
Year: unknown
Mechanical evaluation: good - used every season

23- International round baler
Model 2400
Year: unknown
Mechanical evaluation: New - unused, not applicable to this re search site

24- Brillion small seed applicator
Model: unknown
Year: unknown
Mechanical evaluation: good - unused, not applicable to this re search site

25- 4-wheel trailers With grain bodies (3)
Model: unknown
Year: unknown
Mechanical evaluation: good - used

26- Vac-U-Way seed cleaner, electric motor driven
Model: unknown
Year: unknown
Mechanical evaluation: fair - used

27- Seedburo threshers (2)
Model 40LP
Year: unknown
Mechanical evaluation: good - operational

28- Seedburo peanut thresher (2)
Model KPT-30
Year: unknown
Mechanical evaluation: good - operational

Small Plot Equipment

1 - Dayton 18-hp garden tractors (2), with disc harrows, cultivators and on each rototiller, rotary mower, dozer blade
Year: unknown
Mechanical evaluation: fair - used very little - lacking maintenance

2 - Dayton 8-hp walk-behind rototillers (2)
Model: unknown
Year: unknown
Mechanical evaluation: fair - operational

3 - Troy-Bilt 8-hp walk-behind rototiller
Model: unknown
Year: unknown
Mechanical evaluation: fair - operational

4 - Allen machine plot cone planters (2)
Model HPP-CTS
Year: unknown
Mechanical evaluation: good - used very little

5 - Seedburo small plot threshers (2)
Model: unknown
Year: unknown
Mechanical evaluation: fair - operational

6 - Vac-U-Way small plot seed cleaners (2)
Model 464
Year: unknown
Mechanical evaluation: fair - used very little

Appendix 8
Machine Status and Condition

July 1988

Machine	Brand	Drive	Year	Model	Qty	Serial	Engine	Eval
Air compressor	Cent	-	1986	HSC3-6, stationary	1	SC15 827	-	G-O
Baler, rnd	IH	-	1984	2400	1	-	-	N-PM
Chisel plow	Lill	-	-	8500, 7-shanks	1	-	-	G-O
Chisel plow, 7-shanks	Brill	-	1982	CD73, w/front coulters	1	-	-	G-O
Chisel plow, HD	Rhino	-	1982	156-1032-413	1	-	-	F-O
Cleaner	Hutch	-	1984	C1600	1	-	-	N-PM

Combine	IH	-	1984	1420, 12' header	1	1740217U005552	-	G-O
Cone planters, sm plot	Allen	-	1984	HPP-CTS	2	-	-	G-O
Corn header	JD	-	1986	653A, 6-row	1	-	-	G-O
Crane, eng lift	-	-	1986	3000 lb cap	1	6623	-	G-O
Cultivator, field	Lill	-	1981	4-meter, sweeps	1	-	-	G-O
Cultivator, field	MF	-	-	259, series 2379	1	500100	-	G-O
Disc-harrow	MF	-	-	2 M cutting width	1	-	-	F-O
Disc-harrow, 10', 10 blade gangs	Prime	-	1986	176, tandem bedding disc	1	27320	-	G-O
Disc-harrow, 6-4-6 blade gangs	Prime	-	1986	WOX-2, 16', off-set disc	1	27321	-	G-O

Drill, grain	MF	-	1980	2.5 m wide	1	-	-	F-PM
Elevator	Hytrol	-	1986	BL, 20' belt	1	136401	-	G-O
Fertilizer spreader	Vicon	-	1986	1400 kg, PTO op, b/c	1	76105 18861	-	G-O
Flail mower	JD	-	1984	25A, 2 M wide	1	P00025A630430	-	G-O
Generator, acetylene	FRO	-	1986	Style 7, 1000 L/hr cap	1	-	-	G-O
Grain dryer	Sukup	-	1987	D4610, 18" 5KW elec	1	-	-	N-U
Hacksaw, power	-	-	1986	3230	1	865 209	-	G-O
Inter-row cultivator	Lill	-	1981	6620, 4-row, sweeps	1	-	-	G-O
Inter-row cultivato	Lill	-	1981	2000, 4-row, rotary	1	-	-	G-O

Landplane	Evers	-	-	4 M blade	1	-	-	F-O
Mower, sickle, 7' bar	Kosch	-	1982	TM9, Trailmaster	1	-	-	N-O
Peanut digger	Lill	-	-	5500	1	-	-	F-O
Planter	Lill	-	-	8200, 4-row	1		-	G-O
Planter 4-row	Powell	-	1986	B20-868,	1		-	N-O
Planter, w/planting cones	Allen	-	1984	4R71FMO, w/tool bar	1	198-4-7	-	G-O
Rake, side-del	JD	-	1982	660	1	-	-	G-O
Rototiller	Troy	-	1983	Horse, 7hp walk-behind	1	-	-	F-O
Rototille	Troy	-	1986	Horse, 8hp walk-behind	1	811310	-	G-O
Rototiller	Troy	-	1986	Horse, 8hp walk-behind	1	811342	-	G-O

Rototiller	Troy	-	1986	Horse, 8hp 8hp walk-behind	1	811314	-	G-O
Rototiller	Troy	-	1986	Pony, 5hp walk-behind	1	8179718	-	G-O
Rototillers	Dayton	-	1983	8hp walk-behind	2	-	-	F-O
Seed cleaner	Vac	-	1981	elec mtr driven	1	-	-	F-O
Seed cleaner/treater	Petkus	-	1981	100 Kombi	1	18925	-	G-PM
Seed cleaners, small-plot	Vac	-	983	464-1	2	-	-	F-O

Seed roller, appl, sm	Brill	-	1982	SST 144, 4 M wide	1	-	-	F-NP
Seed treater	Gustaf	-	1986	S100, production	1	1795	-	N-U
Thresher	Seed	-	1981	LP40, 8hp gas eng	2	-	-	G-O
Thresher, peanut	Seed	-	1981	KPT-30, 5hp gas eng	2	-	-	G-O
Thresher, small-plot	Seed	-	1983	14", 3hp eng	1	-	-	F-O
Tire changer	Coats	-	1986	40-40S, air op	1	33356	-	G-O
Toolbar planting units	JD	-	1984	71	4	-		G-O

Tractor	MF	4WD	1981	275-BR	1	J134014	U710933	G-O
Tractor	MF	4WD	1981	275-8R	1	J134051	U710440	G-O
Tracto	MF	4WD	1981	275-BR	1	J134055	U710909	C-O
Tractor	MF	2WD	-	185	1	332153 MBH	-	F-O
Tractor	MF	2WD	1984	2705, 120 hp	1	9R013349	TU31010U657900	G-O
Tractor	Fiat	2WD	-	640	1	-	-	P-NO
Tractor	IH	2WD	-	574	1	-	-	UN-IP
Tractor, garden	Dayton	-	1983	3Z678B, 18 hp	2	C181D	-	F-O
Trailer, w/grain bodies	-	-	1982	3 T cap, 4-wheel	3	-	-	G-O

Appendix 8 cont.
Abbreviations

Brand

Brill - Brillion
Cent - Centurion
Evers - Eversman
Gustaf - Gustafson
Hutch - Hutchinson
IH - International Harvester
JD - John Deere
Lill - Lilliston
MF - Massey-Ferguson
Seed - SeedburoTroy - Troy-bilt
Vac - Vac-U-Way

Evaluation

F - Fair
G - Good
IP - In pieces
N - New
NP - Needs parts
O - Operational
PM - Parts missing
U - Unused
UN - Unserviceable

Appendix 9
Glossary of Abbreviations

AAIS	African Association for Insect Sciences
ADC	Agricultural Development Corporation
ADF	African Development Fund
AfDB	African Development Bank
AFMET	Agricultural Farm Mechanization and Extension Training Center
ARC	Agricultural Research Complex (now BDARS)
AVRDC	Asian Vegetable Research and Development Centre
BDARS	Bonka Dryland Agricultural Research Station
BRADP	Bay Region Agricultural Development Project
CARS	Central Agricultural Research Station
CGIAR	Consultative Group in International Agricultural Research
CID	Consortium for International Development, comprising universities located in the western United States
CIMMYT	International Center for Maize and Wheat Development
COP	Chief of party
CSU	Colorado State University
CV	Coefficient of variation
DAO	District agricultural officer
DAP	Diammonium phosphate
DC	Washington, D.C., USA
EEC	European Economic Community
ETC	Extension Training Center
FAO	Food and Agriculture Organization of the United Nations
FEA	Field extension agent
FOA	Faculty of Agriculture, Somali National University
GSDR	Government of the Somali Democratic Republic
GWU	George Washington University
HTSL	Hunting Technical Services, Ltd.
ICIPE	International Center for Insect Physiology and Ecology, Nairobi, Kenya
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India
IDA/IFAD	International Development Agency/International Fund for Agricultural Development
IDRC	International Development Research Centre
IITA	International Institute for Tropical Agriculture

ILCA	International Livestock Center for Africa, Addis Ababa, Ethiopia
INTSOY	International Soybean Program
IRRI	International Rice Research Institute, Los Banos, Philippines
ITCZ	Inter-tropical convergence zone
ITD	International Training and Development
MOA	Ministry of Agriculture, Somali Democratic People's Republic
MOL	Ministry of Livestock, Somali Democratic People's Republic
N	Nitrogen
NMEF	National Monitoring and Evaluation Force
OICD	Office of International Cooperation and Development
PLPRO	Plant Protection Service
P	Phosphorus
PAWC	Plant available water holding capacity
PMU	Project Management Unit, BRADP
RD	Research Director
SAFGRAD	Semi-Arid Food Grain Research and Development
SDPR	Somali Democratic People's Republic
TOEFL	Test of English as a Foreign Language
TSP	Triple superphosphate
USAID	U.S. Agency for International Development
USAID/M	U.S. Agency for International Development/Mission
USAID/W	U.S. Agency for International Development/Washington
USDA	United States Department of Agriculture
USD	United States dollar ($)
USG	United States government
UW	University of Wyoming
Vet C	Veterinary Component, BRADP
WID	Women in Development
WB	World Bank

Appendix 10

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Appendix 11

Major Events in the Development of BRADP and BDARS

1977 - Survey team made study

1978 - Appraisal report was submitted in April

1980 - Loan agreement was signed in March
- USAID project proposal was submitted in April
- PMU staff was designated in August
- World Bank, IFAD agreement became effective in September
- USAID conditions met in December

1981 - Contract approved for agriculture and extension and procurement in January
- Agricultural intensification operations were begun at 100- hectare farm and research station at the beginning of the Gu season
- Preliminary design of research station buildings completed
- Sorghum breeder, Eugene Alahayodoyan, arrived in October and initiated program of plant breeding under auspices of IDRC

1982 - BRADP project manager, M. Warsame Duale and Jack Halpin, Technical Manager, went to Wyoming to discuss items in new contract between the University of Wyoming and the government of Somalia (USAID Project 649-0113)
- Harold Tuma, dean, College of Agriculture, University of Wyoming, Bernie Kolp, proposed chief of party/research director, and William Smiley, director, UW International Agricultural Programs, went to Somalia in August to discuss finalization of contract

1983 - Socioeconomic baseline study for Bay Region contract prepared in January-February
- First University of Wyoming team consisting of chief of party/ research director Bernard J. Kolp and Jean Kolp and seed farm manager Gerald Costel and Dorothy Costel arrived in Baidoa in April to initiate research at BDARS. Richard Rooney, general services, arrived in June

- Preliminary field work by socioeconomic team, led by Garth Massey, done June-August
- Year-long collection of survey data by socioeconomic team began in September

1984 - Collection of survey data by socioeconomic team completed in August
- Final report of socioeconomic team prepared between January and December
- Dryland agronomist, Mike Smith, of Bingle Proprietary Ltd, arrived in December

1985 - Dr. and Mrs. Kolp and Mr. and Mrs. Costel departed Somalia in mid-April.
- Mike Smith functioned as acting director of research between April and July, when no Wyoming Team members were present
- Ahmed Sheikh Hassan took over as deputy director of research in July
- Second University of Wyoming team consisting of chief of party/entomologist Robert Lavigne and wife Judith, and farm superintendent Nels Andersen arrived in Baidoa to continue agricultural development program at BDARS in mid-July
- Research director Robert Buker and wife Rosemary arrived in mid-August and initiated new research emphasis
- Wyoming Team administrative secretary, Judith Lavigne, employed

1986 - Paul Porter, UW Team soils specialist, arrived in January
- New research station buildings funded by World Bank and constructed by China Jiangsu International were inaugurated in March by first vice-president of Somalia Mohamed Samatar and vice-minister of agriculture Mohamed Noor
- English instruction inaugurated for BDARS and PMU personnel under the tutelage of Rosemary Buker
- First National Sorghum Workshop, coordinated by Hussein Mao Haji, held at BDARS in mid-June
- New chemical stores building completed in June
- Dr. Eugene Alahayodoyan departed from Somalia

- USAID mission director Lou Cohen visited BDARS in July to discuss the achievements of the Project
- Hedera Porter arrived in August
- Mike Smith departed from Somalia in December

1987 - U.S. State Department deputy Director for East African Affairs Robert E. Gribbon II and U.S. charge d'affairs David Rawson visited BDARS to discuss achievements of the Project

- Graham Eagleton, dryland agronomist, Bingle Proprietary Ltd., and wife Chai Nyet Fah arrived in January
- President of Somalia, Mohamed Siad Barre, visited BDARS
- Julie A. Howard, UW Team farming systems specialist, arrived in April
- Hedera Porter employed as plant breeder/computer specialist
- Robert and Rosemary Buker departed from Somalia in mid-July
- Ahmed Sheikh Hassan appointed acting director of research
- Grant Richardson, UW team adviser to the research director, and wife, Kathleen, arrived in early December

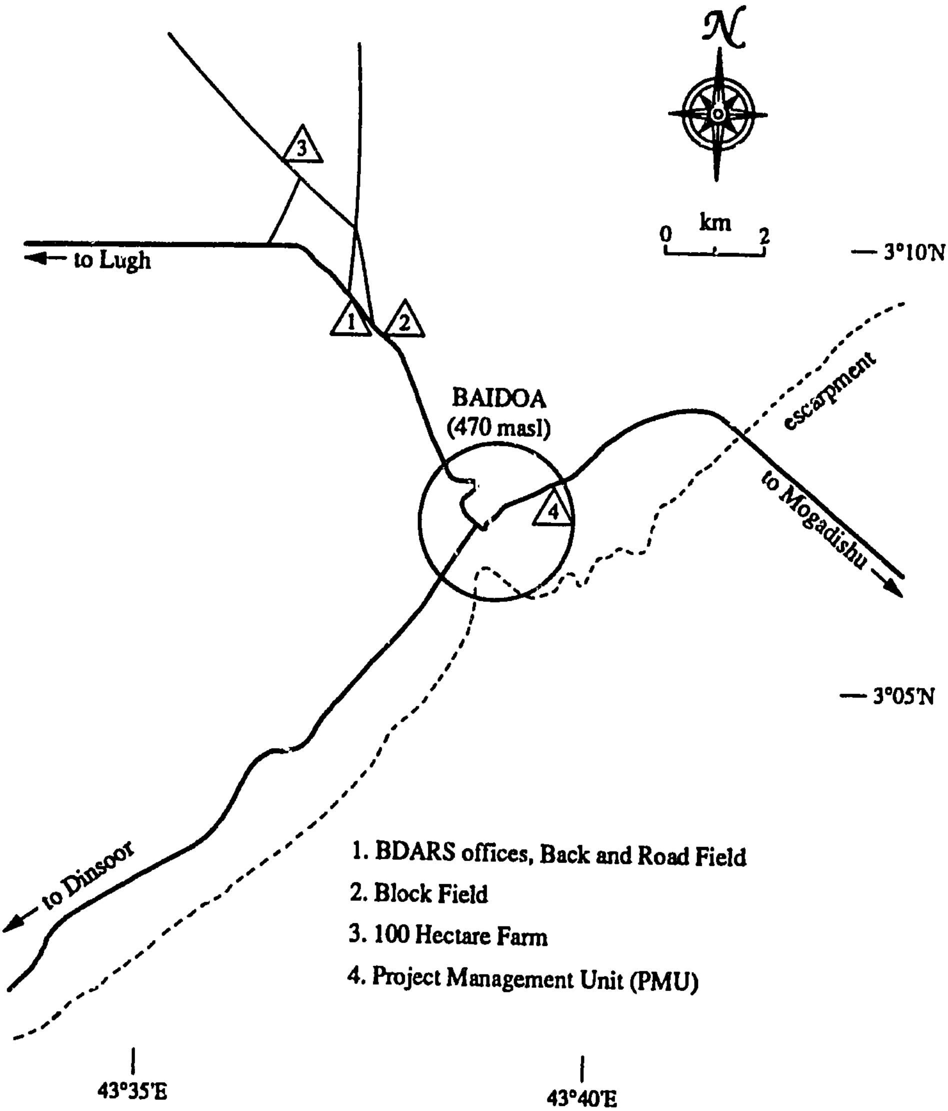
1988 - Ahmed Sheikh Hassan took over as research director in February

- Mr. Abdullahi H. Wardere took over as Deputy Research Director in February
- Land for a substation at Qansa Dhere was purchased
- Chai Nyet Fah conducted English classes
- USAID team led by Robert Duell arrived at BDARS to evaluate progress over term of Project
- USAID mission director Lois Richards visited BDARS in June to discuss the achievements of the Project
- Robert and Judith Lavigne and Nels Andersen departed at end of August
- USAID contract ended September 30 and Paul and Hedera Porter and Julie Howard departed
- Draft final report prepared between May and September
- Graham Eagleton and Chai Nyet Fah departed mid-October
- Grant L. and Kathleen Richardson departed at end of October
- Final report of Wyoming Team submitted to BRADP in December

Appendix 12

1988

Bonka Dryland Agricultural Research Station (BDARS)



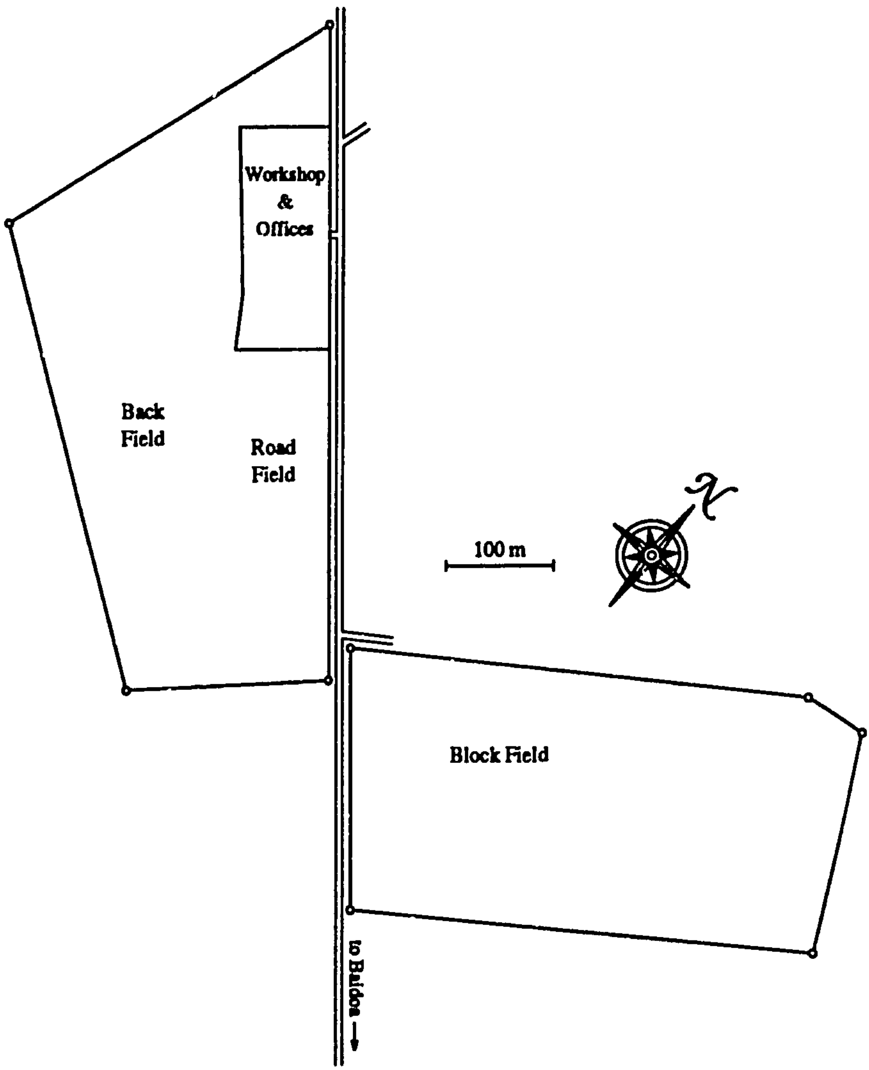
1. BDARS offices, Back and Road Field
2. Block Field
3. 100 Hectare Farm
4. Project Management Unit (PMU)

(Drawings in appendix 12 adapted from originals by Paul Porter)

1988

Bonka Dryland Agricultural Research Station

(BDARS)

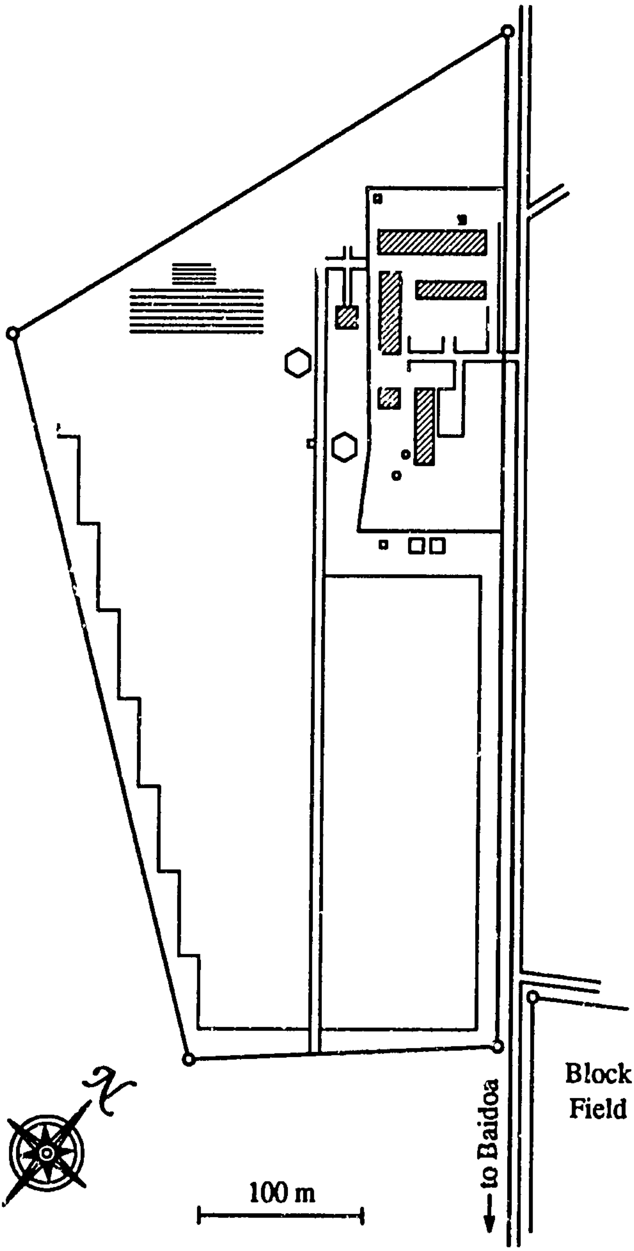


1988

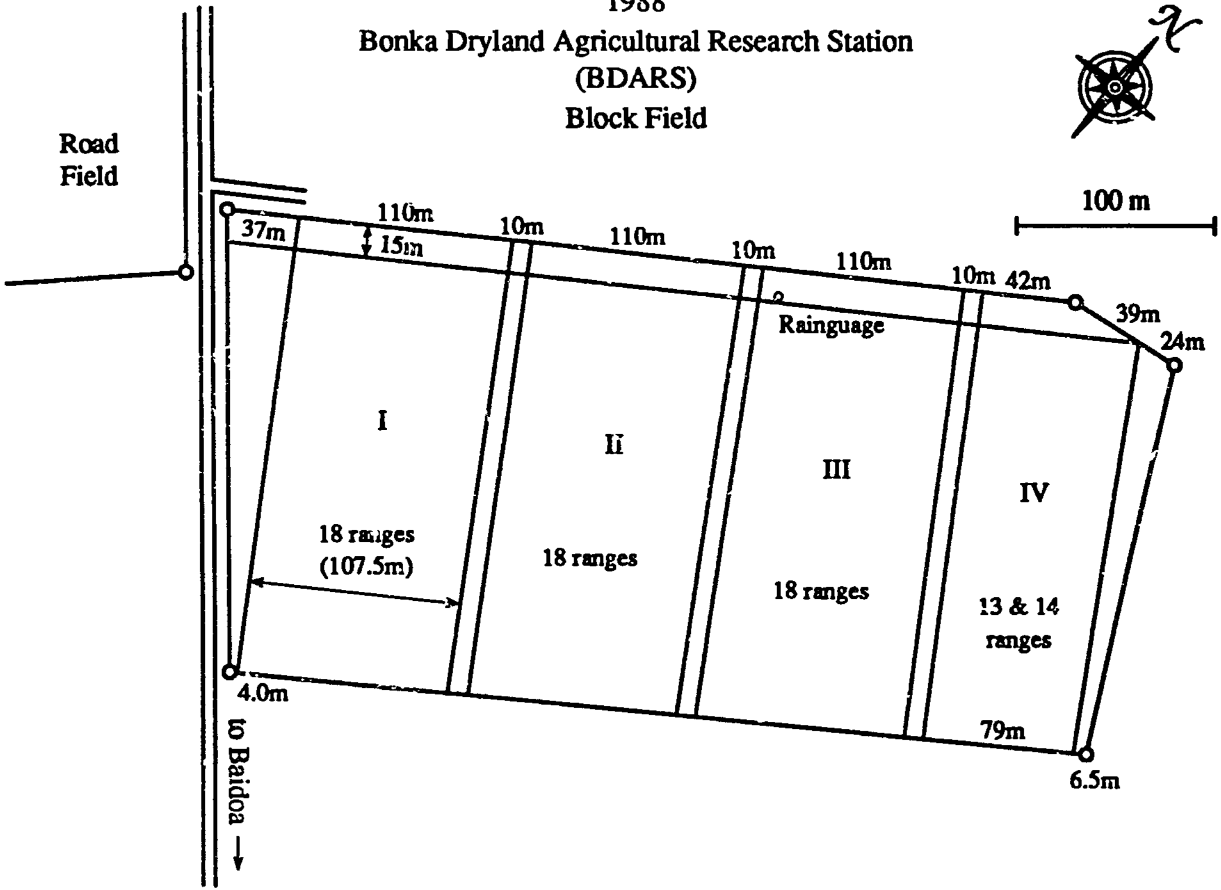
Bonka Dryland Agricultural Research Station

(BDARS)

Road and Back Field



1988
Bonka Dryland Agricultural Research Station
(BDARS)
Block Field



100ha Farm – distances