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FINAL REPORT

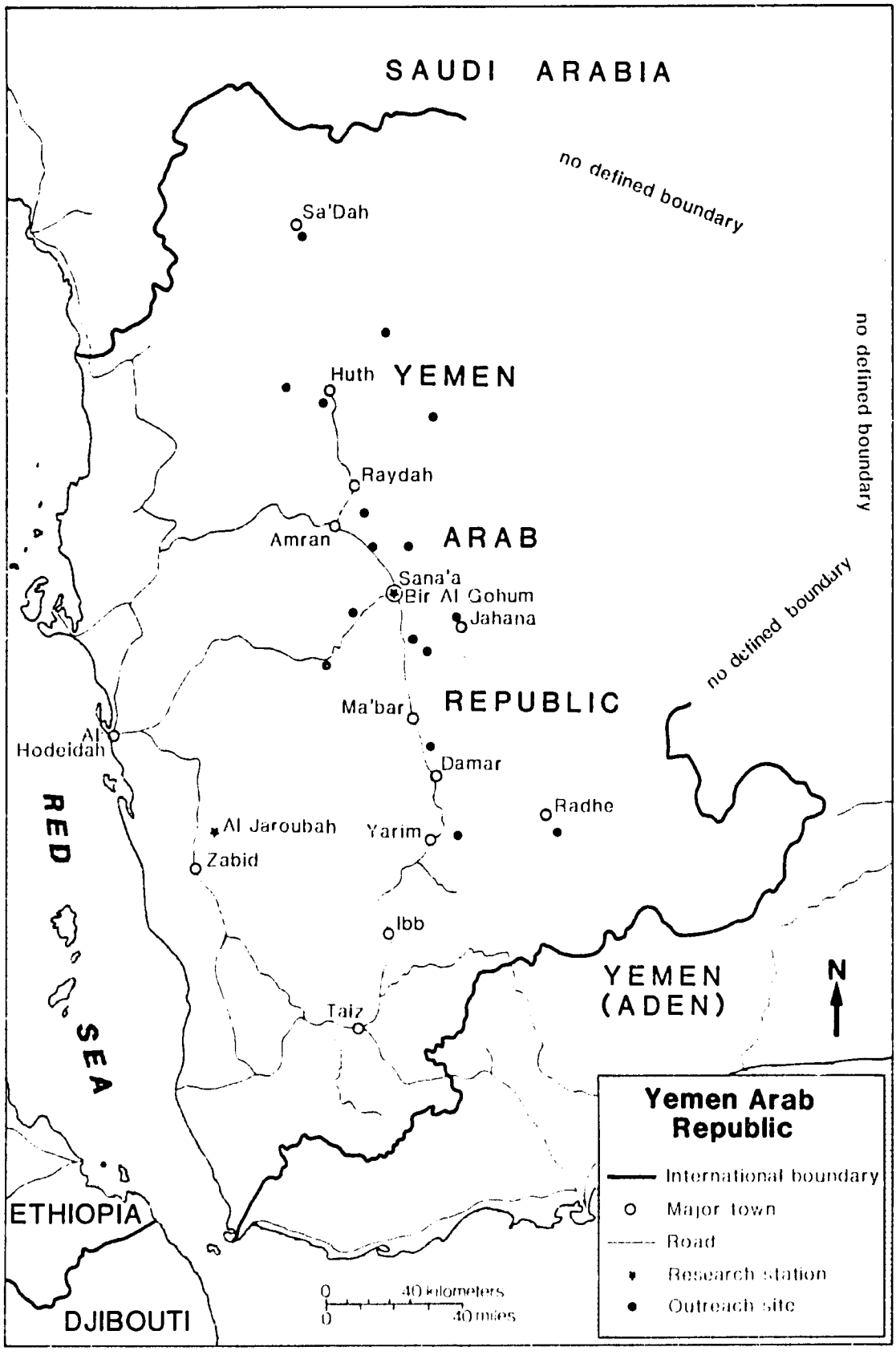
National Sorghum and Millet Crop Improvement Program

Yemen

Contract AID/NE-C-1304

June 1981

Department of Plant Sciences
Office of International Agriculture Programs
College of Agriculture
The University of Arizona
Tucson, Arizona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N
Taiz
ETHIOPIA
DJIBOUTI
0 40 kilometers
0 40 miles
Yemen Arab Republic
International boundary
Major town
Road
Research station
Outreach site

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EXECUTIVE SUMMARY

1. Project Background

Discussions between officials of the Yemen Arab Republic (YARG) and the U. S. Agency for International Development (USAID) team in September, 1972 identified assistance in sorghum and millet production as a high priority need. A preliminary sorghum development project (Project 018) was designed, and an agreement with YARG was signed on March 8, 1973. Activities to identify varieties and examine practices for improved production were started later that year with temporary personnel and assistance from the Arid Lands Agricultural Development (ALAD) program of the Ford Foundation. An evaluation of that project early in 1975 recommended that it be superceded by an expanded project.

A Project Paper for the new project to provide assistance in sorghum and millet production was approved in January, 1976. In June, a Request for Proposals was issued and The University of Arizona prepared and returned its response to that request on July 6, 1976. A contract was awarded to The University of Arizona on January 15, 1977 for the first two years of a National Sorghum and Millet Crop Improvement Program. The contract was subsequently extended to May 31, 1981.

2. Project Description

The activities which resulted are a combination of the requirements as described in the contract and the University of Arizona approach to meeting them.

Requirements

The objective of the Project was to assist YARG in establishing a national sorghum and millet crop improvement program within the Ministry of Agriculture.

The work was to be directed at national goals of: (1) increasing agricultural income through increased production and improved quality of food, and (2) saving foreign exchange by import substitution.

According to the contract (Appendix A--Operational Plan), "the contractor shall provide technical assistance to the Yemen Arab Republic in:

(1) Screening potential high producing varieties of sorghum and millet and selecting varieties suitable to varying local conditions.

(2) Re-combining varieties with superior characteristics to produce high-yielding varieties for major ecological regions of Yemen.

(3) Developing a central sorghum and millet research facility together with two or three sub-stations (8 to 20 hectares in size).

(4) Identifying and testing related cropping practices which may further increase the productivity of selected varieties.

(5) Developing a seed production capability.

(6) Moving locally tested, high-producing varieties and relevant cultural practices into the hands of farmers through various USAID and other donor assisted projects.

(7) Training counterpart Yemeni staff to undertake the foregoing and to prepare ultimately for the creation of a national agricultural research capability in sorghum and millet.

(8) Developing training requirements for participants in support of this project.

(9) Developing lists and specifications for commodities necessary to implement the Project.

(10) Providing professional and technical coordination to three agronomists and one agricultural engineer to be provided under a separate, but related, contract with a voluntary agency.

"The Contractor shall maintain close cooperation with USAID/Yemen, YARG, the contracted International Voluntary Services, Inc. (IVS) and other donors.

"In order to provide the above services, personnel with the following skills will be provided:

(1) One long-term plant breeder with a minimum of five years experience.

(2) One long-term agronomist with a minimum of five years experience.

(3) One short-term seed production specialist.

(4) One short-term plant protection specialist.

(5) Various short-term specialists in related areas."

Section 2.3.2 of this report compares the language of the Project Paper and the Contract to actual Project accomplishments.

The budget allotted to The University of Arizona for accomplishing the tasks described above was $1,285,030 (Amendment 11, 31 May 81).

3. Strategy

The University of Arizona approach to meeting the contract requirements involved a comprehensive set of interrelated activities. Briefly, they were as follows:

1. Carry out, as far as practicable, a scheme of activities beginning with facilities development, then experiment station research, then outreach/demonstration tests, then seed production and finally dissemination to farmers on a broad scale, recognizing that because of time constraints, some of these things would be done simultaneously.
2. Develop adequate facilities for conducting field research to insure its validity. Create the infrastructure necessary to support the field research activities and to store and maintain the results of the research (improved seeds).
3. Carry out a crop improvement program beginning with a study of the existing production systems and incorporating the results of previous research.
4. Establish and maintain a support group in Tucson to assist in planning, and provide technical and logistics backstopping for the University of Arizona field team.

4. Accomplishments

Prior to planting f ld experiments, the University of Arizona team organized and analyzed the results of the previous plant breeding programs. Fields were planted within two months after arrival in Yemen. In audition, the team initiated a continuing study of sorghum and millet production and agricultural practices of Yemeni farmers.

Four years of field testing and evaluation of sorgh m and other grains were carried out according to internationally accepted plant improvement procedures. Several thousand varieties (entries) of sorghum, pearl millet, maize and sudan grass were evaluated. Initial emphasis was placed on sorghum because of its overall importance in Yemen and the lack of research facilities in the Tihama region where millet is of greater importance. A major technical conclusion of the Project is that available hybrid sorghum types developed for conditions outside of Yemen (especially the United States) do not produce as well in Yemen as locally adapted types. In response to this early conclusion, plant breeding activities were orientated toward production of superior sorghum-types from work with native Yemeni varieties. As a result, superior sorghum varieties were developed whcih yield twice as much as local varieties.

A colleciton of 4,500 native sorghum varieties was made in collaboration with the United Nations Development Program (UNDP) project at Taiz. Sub-samples

of the collected seeds were sent to The University of Arizona in Tucson for processing and description for entry into the World Sorghum Collection. Seeds of 2,500 varieties were multiplied for later use and return to Yemen at the Institute for Tropical Research at Mayaguez, Puerto Rico. (Requests for a breeder's supply of seeds should be addressed to the University of Arizona coordinator for the Title XII Sorghum and Millet Collaborative Research Support Program (CRSP).)

Over 50 potentially superior sorghum varieties were tested at 18 different locations in Yemen between 1978 and 1980. The map of Yemen, inside the front cover, shows the widespread locations of the outreach sites. In more remote locations, the University of Arizona scientists were the first Americans to have visited in the area, thereby demonstrating to the people of Yemen the extent of interest of the United States in their country. Comments from participating local farmers emphasized the importance of sorghum for forage as well as grain. Cooperators also identified lines of sorghum known to be resistant to the root parasite Striga and resistant to being knocked over by high winds. Seeds from these resistant lines have been turned over to the U. S. Department of Agriculture for evaluation. Results of the outreach tests re-emphasize the environmental contrasts within Yemen and underline the need for development of a large number of improved sorghum varieties.

Based on 1980 field tests, seven genotypes have been nominated for increase and release to Yemeni farmers. In 1979, seeds from 13 short-stemmed, large-headed sorghum lines were given to Yemeni research personnel of the Surdud Experiment Farm and to the Tihama Development Authority. These varieties form the basis for a Yemen-adapted variety which may be grown in large flat fields and harvested with combines. In addition, superior adapted germplasm (seeds) developed by the University of Arizona team were shared with the joint United Nations Development Program/Food and Agriculture Organization (UNDP/FAO) sorghum program at Taiz. Seeds from the Yemen National Cooperative Breeding tests were grown by The University of Arizona at the Sana'a station. Other cooperating agencies were the Ministry of Agriculture, UNDP/FAO, Germans, Dutch, and Chinese.

Cropping practices research included the identification of 19 major diseases, weeds from 22 plant families, and 45 insect pests which inhibit the productivity of sorghum and other crops in Yemen. Limited tests and demonstrations of control methods were made. A preliminary survey of grain drying and

storage practices of Yemeni farmers revealed the lack of serious problems and the ability to markedly increase on-farm storage should increased yields become available A questionnaire on sorghum and millet production practices was developed in cooperation with the University of Sana'a and administered to 600 farmers in 1979 by University students.

Adequate research facilities are the foundation of credible plant improvement activities. The Sana'a experiment farm (Bir Al Gohum) was expanded in area, water supply was improved, and the fields were leveled. All improvements increased the consistency of experimental results. Laboratory and garage facilities were developed at the USAID compound. Seed storage facilities were improved for better control of pests.

The University of Arizona accepted direct responsibility for development of the lowland research station at Al Jaroubah following a USAID request in 1979. A new well 200 meters deep with a diesel powered turbine pump was installed. The irrigation system was improved to allow for storage of seasonal flood waters to irrigate three leveled terraces. A trailer and an abandoned building were put into livable status with sanitary water supplies and sewage disposal. An electric generator was installed to provide power for research and living needs. Sorghum and millet trials were planted in 1980. Lists and specifications for needed equipment and supplies were prepared and orders were placed and received for materials basic to plant improvement activities. Unfortunately recent changes in YARG priorities mean that the station facilities will not be available for future sorghum and millet research.

Only two Yemeni were available as counterparts to work with the Project. In addition to on-the-job training in Yemen, one of them received eight months of specially designed training at The University of Arizona in Tucson along with English language training. Locally hired technicians received on-the-job training including some formal classes in research procedures, cultivation practices, construction techniques, and operation and maintenance of field and laboratory equipment. Three IVS technicians assigned to the Project were given on-the-job training in research procedures. Professional and technical coordination of their individual work plans was provided. A six-month Arabic language program for training Yemeni students in agriculture has been designed and is available when students can be identified by the Ministry of Agriculture.

Cooperation with other projects was a major strategy for The University of Arizona. Field machinery was both borrowed and loaned; research supplies were given to the Ministry of Agriculture and other donors to keep plant improvement activities functional in spite of local shortages; pest control measures were developed and implemented; and automotive supplies, garage space and mechanics were shared with other USAID projects.

The University of Arizona team prepared bi-weekly and semi-annual reports and delivered them on schedule. In response to a later request from USAID, annual reports were also prepared. Various technical reports, trip reports and publications were written and distributed. Copies of these reports are in the Project files in Yemen and at The University of Arizona in Tucson.

5. Conclusions and Recommendations

Our experiences in Yemen lead us to conclude that it is vitally important to have a continuing sorghum and millet improvement program in Yemen. These grains are the staples of the Yemeni diet now and in the forseeable future, since sorghum and millet have great production potential for rainfed agriculture. The potential for developing superior varieties of grains from local, well-adapted genetic resources is very high. The following are prerequisites for realizing this potential for increased grain production:

1. Yemeni students must be identified for special training and trained to assume the major role in plant improvement activities; it will take a minimum of 10 years to accumulate a trained staff of Yemeni plant scientists.
2. A system of functional, permanent research stations and sub-stations for plant improvement research must be established and maintained. (Five years minimum will be required unless existing facilities can be used.)
3. Improved communication among USAID, the Ministry of Agriculture and contractors is needed to understand and plan for the evolutionary nature of plant improvement. A typical period for such work to yield results in the United States is 10 to 20 years.
4. Continued consideration should be given by USAID to contracts with institutions which have long-term interests in sorghum and millet

improvement. These institutions have trained staff with long-term experience which both pre-dates and will last beyond any single project. For example, future sorghum breeding experiments at The University of Arizona have the real possibility of yielding varieties which will be well adapted to Yemen's environmental conditions.

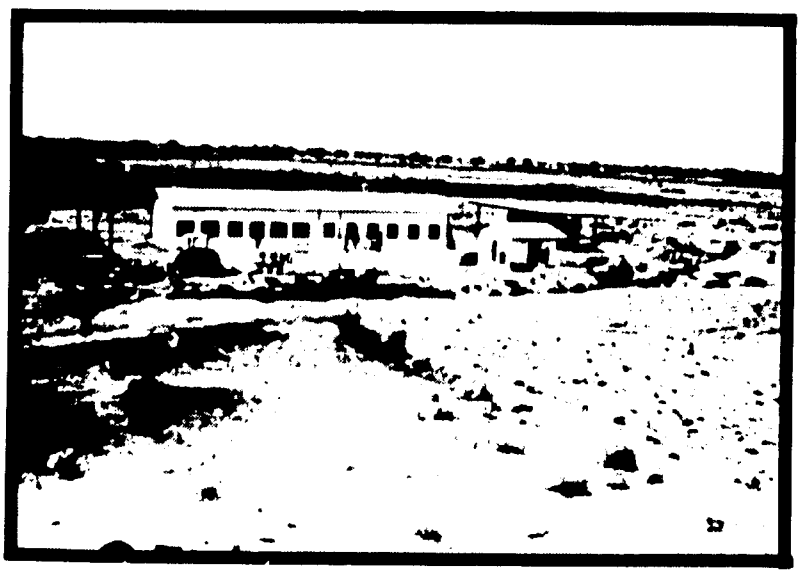
5. Future sorghum and millet improvement programs should be designed in the Collaborative Assistance mode to increase flexibility in meeting project objectives. A project planning group should include USAID, YARG, and local farmers as well as contractors. Annual Plans of Action should be required. Participant training should be contract funded, and care should be taken to allow for adequate logistic support (especially transportation). It is imperative that contracts be issued and periodically renewed with suitable amounts of lead time.

Small village in the highlands of Yemen with plowed fields in the foreground and terraced fields in the distance.

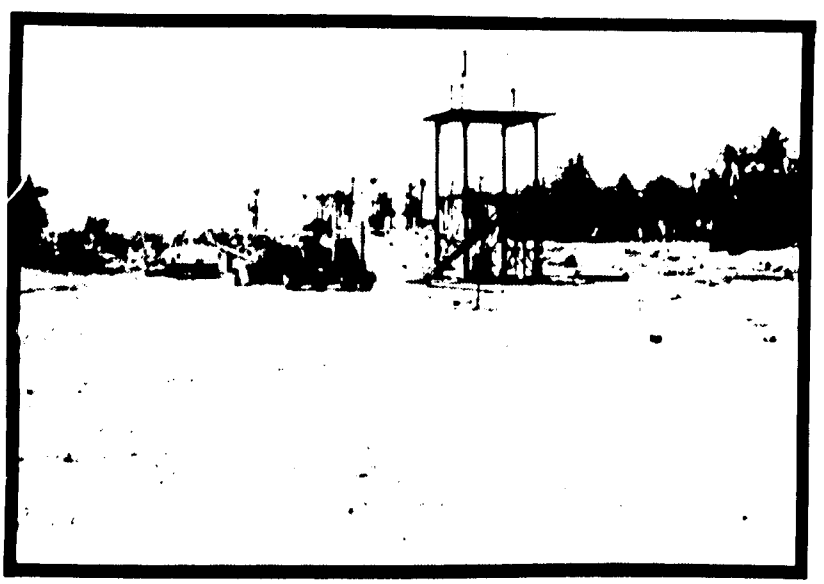
Local variety of sorghum with compact seed heads and recurved peduncles.

University of Arizona Outreach team planting test field at the village of May Moon.

Museid Attig with two Yemeni farmers at an Outreach site prior to harvest.



Al Jaroubah Research Station (left to right): posts for storage building, renovated living quarters, and generator building with trailer behind.



Water tower and tanks installed at the Al Jaroubah Research Station.

Acknowledgments

No project operates in a vacuum. Throughout the University of Arizona Sorghum and Millet Project in Yemen we interacted with many gracious people who were a great deal of help to us.

First mention and thanks goes to the Yemeni counterparts who were assigned by the Ministry of Agriculture to work with the Project: Yahya Shuga and Mahamed Bather. They not only worked as members of the University of Arizona team but provided a vital communication link with the Ministry.

Within the Ministry of Agriculture we interacted with Abdulwahal Mahmud, the Minister, during his visit to the University of Arizona campus; his predecessor as Minister, H. E. Abdulla al-Matari, during visits to the Bir Al Gohum research station; Yahya Hopshie, in touring other research stations; Ali Abd Alwahed Damaj, Director of Field Crops; Nabil Abdul Karim Alansi, plant pathologist; Kamal Mansour; Ahmed Sayed; M. M. El Ghouri and Ali Zum.

Eleven Yemeni farmers cooperated with the Outreach Program by letting us use their fields, providing local varieties of seeds and helping with planting and harvest: Nagib Salah Khalid, Mohssin Hassen, Ali Egn Ali Al Negar, Jussen Salah Zaid, Sheik Nasser, Mohammed Saad Al Oubadi, Salah Nagi, Sheik Abdela Al Faishi, Sheik Hussen Al Surabi, Mussen Dirhim, and Asker Abushuareb. Sheik Abdela Al Faishi also provided samples of sorghum and millet resistant to the root parasite, Striga.

At the University of Sana'a, Professor Nasser Aliqui mobilized his students to administer a questionnaire to about 600 Yemeni farmers eliciting numerous valuable details about sorghum and millet cultivation in Yemen. Dr. Shaukat A. Chaudhary helped identify specimens for the insect collection.

The University of Arizona was also fortunate in being able to interact with the personnel of other donor agencies in Yemen. The Yemen Sorghum collection was made as a joint endeavor with the United Nations Development Program/Food and Agricultural Organization (UNDP/FAO) Project at Taiz. Dr. Mohammed Ali El Lakany played a leading role; assisting him were Abdu Lotf, Abdulla Mukbel, Ali Mayas and Phool C. Shrestha. We also worked with Dr. B. M. Lazarevic, Dr. Hari C. Dewan, Dr. Saad Albadi, Dr. Jamal Fuad and Dr. Elham Talaat of various UNDP/FAO projects. The Institute for Tropical Research, Mayaguez, Puerto Rico, donated field space and labor to increasing the seed from the Yemen Sorghum Collection.

The German Rural Development Program had long term involvement in Yemen and personnel on that program shared their knowledge freely. In particular, we would like to thank Konrad Engleberger, Tony Kerzmann, Ludwig Hoshnu, Dr. J. Zchintzsch, Werner Moosbrugger, Dr. Gossert, Dr. Deckert, Mr. Pollen, Mr. Jon-Uwe Heckel, Dr. F. Klingauf, and Dr. R. Sikora.

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Finally, the University of Arizona team would like to thank the U. S. Peace Corps, other USAID Project staffs, USAID and non-project personnel at The University of Arizona in Tucson for their support.

We extend our apologies for any omissions or mispellings of names.

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1. Introduction

The purpose of this section is to provide the reader with an introduction to the National Sorghum and Millet Crop Improvement Project carried out in the Yemen Arab Republic by The University of Arizona under contract to the U. S. Agency for International Development (USAID).

1.1 Introduction to the Project

The University of Arizona was awarded a contract to establish a national sorghum and millet crop improvement program in Yemen in January, 1977. A technical team consisting of a chief of party/plant breeder and a cropping practices/pest management specialist was assembled immediately and began arriving in Yemen in March, 1977. An administrative support group was organized in Tucson for backstopping personnel in Yemen. During the progress of the contract numerous short term assignments by other specialists filled specific needs of the project. In addition, the original team members were replaced at the ends of their tours of duty. In all, 11 individuals were on site in Yemen during the 4 year project for long-term assignments and an additional 9 participated as short-term specialists. At The University of Arizona the backstopping took the form of part time and short term assignments for 21 individuals during the contract period.

The results of the project are described in the body of this report. Technical results and methods are discussed under the headings of plant breeding, outreach program, training program, research station development, and cropping practices research. Administrative methods used to make the project possible included on-campus backstopping, training techniques, plans of action and cooperation with other projects.

An evaluation of the project as implemented by The University of Arizona is provided by a comparison of the accomplishments of the project with the goals set forth in the Contract and the Project Paper which defined the initial objectives. Constraints to the Project are defined in terms of the problems faced. These are presented for the information of others planning to carry out similar projects in Yemen and other parts of the Middle East.

A separate section details the conclusions reached by the University of Arizona team and makes recommendations for future work in Yemen. The final section is a group of technical appendices which present detailed technical data,

a list of project participants, a list of reports generated by the project personnel, a summary of the project expenses and a chronology of major events during the life of the project.

1.2 Introduction to Agriculture in Yemen

For readers who have neither had the opportunity to be in Yemen nor to read extensively, the following section is a brief, general overview of the geography and agriculture of Yemen from the point of view of those involved in improvement of sorghum and millet crops.

The Yemen Arab Republic is environmentally diverse. Elevations vary from sea level to over 10,000 feet and soils are as different as the topography. Precipitation changes with elevation and distance from the coast. Many eastern parts of the country are in "rain shadows" down wind from mountain masses.

Agriculture is attuned to the environmental variability. Sorghum and millet are the staple food crops for the human population and also provide feed for animals. While millet cultivation is limited to rather sandy soils in the coastal region, sorghum is grown throughout the country at all elevations. The Yemeni have been harvesting water for thousands of years. Many fields at middle and high elevations are on terraces with harvested water being channeled onto successively lower levels.

Alternatively, much of the sorghum at middle and higher elevations is raised without supplemental water and depends on rainfall alone. Any year can challenge the farmer with moderate to severe drought conditions. There are limited amounts of irrigated sorghum. These are usually found at middle and lower elevations of Taiz and Tihama. Even here production is dependent on runoff from the highland.

Good land which can be irrigated is usually planted in crops which yield high incomes. Grapes and qat are typical examples. Grains such as sorghum, millet, barley and wheat are restricted to drier sites where irrigation is not practical.

Most sorghums and millets grown are varieties which have been selected by the local farmers during centuries of cultivation. These varieties are open pollinated lines rather than hybrids. Use of particular varieties is well atuned to cropping practices of the local farmers.

Sorghum is actually a dual purpose crop providing both grain and forage. The forage in the form of stalks and leaves may be worth more in the local market than the grain.

The productivity of grains in Yemen is limited by numerous factors. High paying work in the oil fields of Saudi Arabia attracts many of the young men from even remote farming communities. Farm work then falls to women, children and older men. Sorghum is grown on the poorest land, and thus the yields are limited and dependent on the vicissitudes of weather. The profits from selling grains are not sufficient to allow the farmers to reinvest in items for increasing production such as hybrid seed and fertilizers.

2. Results and Methods

The results of the University of Arizona Project may be subdivided into technical and administrative groups. Section 2.1 presents the technical results of the Project with limited discussion of the methods used to achieve the results. Section 2.2 describes the administrative methods used by The University of Arizona in implementing the Project. The final section of this chapter summarizes Project accomplishments and discusses problems faced by the Project.

2.1 Analysis of Results

The technical accomplishment of the Project are presented in sections on plant breeding, outreach activities, training program, research station development and cropping practices research.

2.1.1 Plant Breeding

In setting up procedures and practices to carry out a sound plant breeding program in Yemen, choices were made which resulted in a system which can be run by Yemeni scientists and which is compatible with current growing practices of Yemeni farmers. Procedures used were standard plant breeding procedures recognized and used worldwide.

2.1.1.1 Breeding Program

The breeding program was set up to be a continuing cycle of identifying and testing improved varieties of grain. Figure 2.1 illustrates the cycle of testing at a research station and indicates the stage at which materials can be made available for field testing by local farmers, or at other research stations in different climatic situations.

The breeding approach involved the acquisition of germplasm (seed) sources with broad genetic variability adapted to Yemen and the selection of improved individual sorghum seed heads with subsequent testing and retention of the best types.

Single plants selected from any available source, including local farmers' fields, during the first year, are put into an unreplicated head-to-row test in the second year. In a head-to-row test, seeds from a single <u>head</u> of a good parent plant are planted into a single test <u>row</u>. The plants which grow in the head-to-row test display the genetic uniformity or variability of

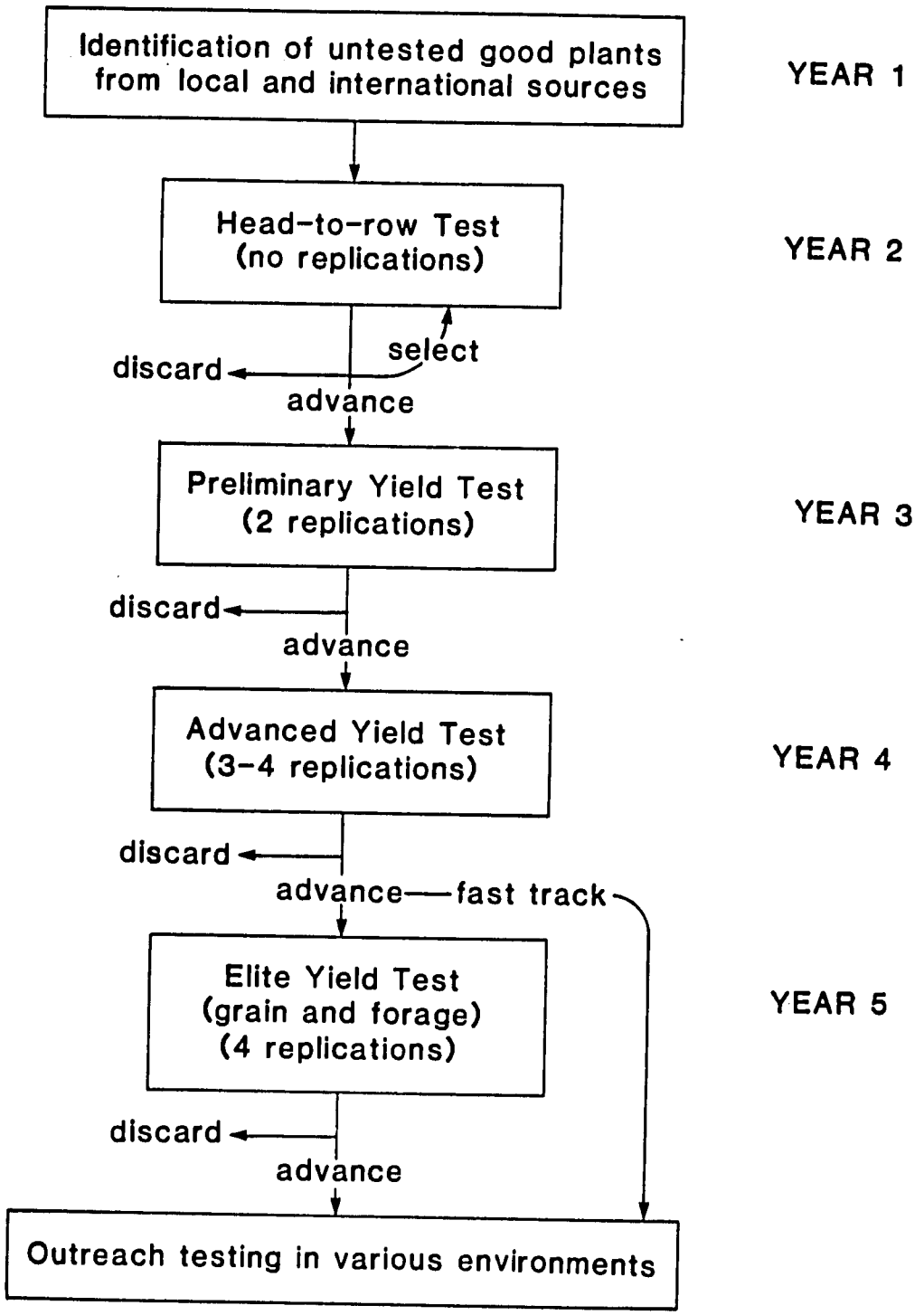


FIGURE 2.1 STANDARD PROGRAM FOR GRAIN IMPROVEMENT

the parent plant. If, for example, the parent were a naturally occurring hybrid, many of the recessive characteristics may have been masked in the F1 generation. The head-to-row plants would then be an F2 generation and would exhibit much of the genetic variation which was not obvious in the selected parent head. In cases when the head-to-row test exhibited segregation of genetic characteristics, selections were made from the head-to-row test and replanted a second year in another head-to-row test.

Those plants showing potential in head-to-row test are selected and advanced through three years of replicated yield testing (years three, four and five). The stages are designated as preliminary, advanced and elite yield tests, respectively. Yield tests are designed to grow plants under relatively uniform conditions to allow demonstration of the plants' potential to produce both grain for human consumption and foliage for forage. At the end of each growing season, only those entries showing promise when compared to local varieties (standards) are advanced to the subsequent level of yield testing. Each step in the yield tests represents improvements in the desirable characteristics of the retained entries. In the elite tests, forage yield was measured as well as grain yield.

2.1.1.2 Germplasm Resources

The initial step in the breeding program is the selection of good plants for testing. There are a variety of sources of materials available. There are numerous locally adapted sorghum varieties in Yemen. The University of Arizona team collected local varieties to make a permanent collection as described in section 2.1.1.5. Better local varieties also were pointed out to the Outreach Team during their field work and were collected by them (see discussion in section 2.1.2.5). Additional sorghum varieties exist in other parts of the world, and numerous hybrids have been developed. In a previous project, numerous cultivars (varieties and hybrids) from outside Yemen were tested for performance. In 1977, the University of Arizona team added about 650 such entries to the testing program. Several thousand potentially different adapted genotypes were on hand for further testing by the end of the 1978 season.

In 1979, selections were made of a range of genotypes for possible use under various situations in the future. Genotypes were selected with ranges in

height, rate of maturation (as indicated by the number of days to 50% flower bloom), multiple heads, and, in addition, full ranges of all plant, head and seed characteristics were selected. Some characteristics were not tested for immediate use but were stored so that this adapted germplasm will be available if needed. These selected materials are new resources and were not available before the Sorghum and Millet Project activities. They will give superior germplasm for a variety of environments in Yemen, not just Sana'a.

In 1980, sixty-five advance-generation, early-maturity, sorghum genotypes from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India were added to the testing program. Thirty cold-tolerant advanced lines of sorghum from the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and twenty lines from South Dakota and Nebraska were added. One-hundred-thirty-six new lines of Pearl Millet were obtained from ISCRISAT to increase the genetic diversity of this crop.

Soybeans, guar and maize were tested in addition to sorghum and millet. Twenty-four genotypes of miaze and 136 of soybean were planted in the fall of 1980.

A need was recognized to employ procedures to create new combinations of genetic characteristics from locally available, well-adapted varieties on continuing basis. Initial steps were taken to develop a random mating population of sorghum. As part of the establishment of such a population, plants with non-functional male reproductive structures (male steriles) are selected and used in crosses with entries showing superior characteristics in succeeding years.

A set of adapted A and B lines, a male sterile line (A) with maintainer line (B), with a good phenotype for the environment was identified from materials sent from the United States. The development of a male sterile is a procedure which requires six growing seasons to produce a line which has 98% non-restorer (B line) genetic material. This development was initiated as part of the University of Arizona Project in Yemen and is being continued without additional support at the University in Tucson in the post-project period.

Emphasis was placed on developing good, productive lines or varieties. These adapted varieties can be used directly and immediately by local farmers. They also are the basis from which hybrids can be developed when appropriate.

A major effort to identify or develop hybrids for general use in Yemen was not exerted during the Sorghum and Millet Project since Yemen currently does not have the infrastructure to produce and use hybrid seed. Limited research efforts were directed toward the development of Yemen adapted genotypes suitable for hybrids, and a few experimental hybrids were developed. Restricted testing of hybrids developed elsewhere was carried out. This minimal research on hybrids was necessary to ensure the prospects for the long-term development of hybrids in Yemen.

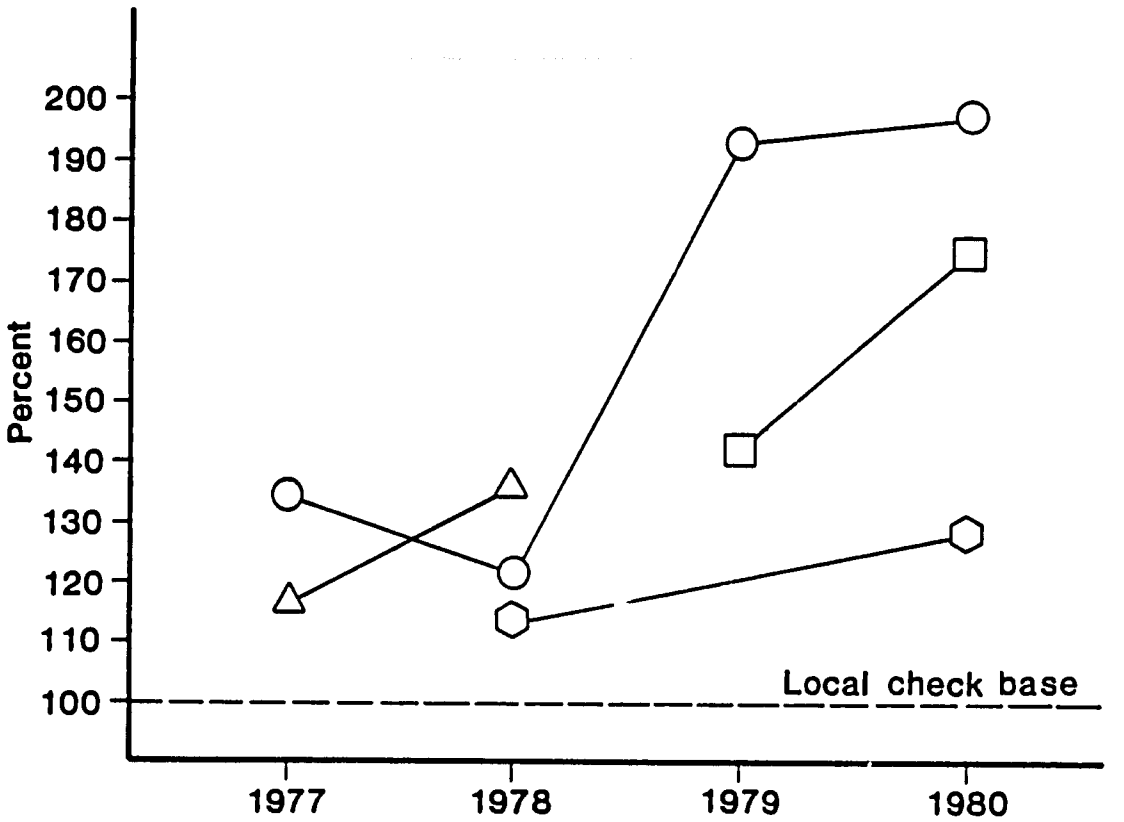
2.1.1.3 Breeding Research Results

Significant progress was made in the development of superior adapted sorghum germplasm over the four year period of the University of Arizona contract. Figure 2.2 presents in graphic form the genetic progress made relative to local check varieties used as a performance base.

The general superiority of the best sorghum materials available from previous research at the beginning of the contract period was about 25% over local check varieties during 1977 and 1978. This relatively slight difference observed at the end of the 1977 season showed that germplasm materials under test in 1976 and 1977 had very little potential. New, adapted germplasm was needed from which to make selections of improved lines and varieties.

The Arid Lands Agricultural Development Program (ALAD) of Ford Foundation had made numerous crosses of Lebanese varieties in 1975 and had grown out the first hybrid generations in 1976. The University of Arizona team tested 76 different crosses of this material (Test No. 77093) and recognized the potential superiority of this material based on its braod genetic variability and good adaptation to Yemeni conditions.

Many single plant selections were made from the 1977 tests and grown in head rows in 1978. These materials entered the yield testing program in 1979 in the Preliminary Yield Test. As a result, the average grain yield performance of the top five entries went from 20 percent superiority over the local check variety base in 1978 to 93 percent superiority in 1979. A selection of the better lines from the 1979 Preliminary Yield Test were moved ahead to the 1980 Elite Yield Test, skipping the Advanced Yield Test. The resulting performance of the top five lines in Elite Yield Test showed 75 percent superiority over the local check in 1980. The Outreach trial entries in 1980 were just beginning to show the influx of superior germplasm begun in 1978.



○ Preliminary Yield Tests– Average grain yield production of top five entries

△ Advance Yield Tests – Average grain yield production of top five entries

□ Elite Yield Tests – Average grain yield production of top five entries

⬡ Outreach Tests – Average grain yield production of top entry in 1978 and top ten entries in 1980

FIGURE 2.2 GRAIN YIELDS FOR THE TOP ENTRIES IN SELECTED TESTS EXPRESSED AS PERCENT OF YIELDS FROM LOCAL CHECK VARIETIES

The reader of Figure 2.2 is cautioned against comparing the results from the Preliminary Yield Tests and the Elite Yield Tests in the same year. Superior materials grown in preliminary tests one year appear in the elite tests the following year. Comparisons are only meaningful from year to year within the same level of testing.

Yemen and future sorghum breeding projects now have a well adapted germplasm base with broad genetic variability. By making genetic progress in an orderly fashion, materials are now available for testing for on-farm adaptation with some hope of providing the farmer with materials which are better than his local varieties. The genetic variability in the materials developed by the University of Arizona team allows tests at varied locations in Yemen to select the superior type of grain sorghum for each location. In fact, some of the new types may have broad adaptation across several environments, but this will not be known without local testing.

Grain yield and other agronomic data for the top one, five and ten entries in the 1980 Elite Yield Test at Sana'a are presented in Table 2.1. The local check base average is also presented to compare with the data presented for the experimental groups.

The source of entries for each experimental group shows the broad input from earlier tests. The maturity of the superior lines tends to be 5 to 10 days earlier than the local check. This could be an advantage under drought conditions but may result in yield reduction under somewhat higher moisture levels. The plant height of the experimental types seemed to average 10 to 30 cm less than the local. This shorter height normally causes reduced forage production.

The percent stand of the experimental materials seems to indicate a slightly lower adaptation during the period of planting and stand emergence than the local check variety. The test weights of the experimental materials were all higher than the local check. This denser, heavier grain is an indication of superior grain quality of the experimental materials over the local check.

Another accomplishment of the University of Arizona team was to devise and demonstrate a series of research techniques which work well in Yemen. The details of these techniques are described in Section 2.1.1.1. They can be carried out by the personnel in Yemen as demonstrated by the operation of the

Table 2.1. Grain Yield and Other Agronomic Performance Data of the Top One, Five and Ten Entries in Comparison with the Local Check Base in the Elite Yield Test for 1980 at Sana'a.

	Entry Sources*	Grain Yield kg/ha	Days to 50% Bloom	Plant Height (cm)	Percent Stand	Grain Test Weight kg/hectoliter
Top Entry:	1979 PYT - 1 entry	4974	109	93	75	69
Average of Top Five Entries:	1979 PYT - entries 1979 AYT - 1 entry 1979 EYT - 1 entry 1979 Short Grain - 1 entry	4529	110	107	55	66
Average of Top Ten Entries	1979 PYT - entries 1979 AYT - 2 éntries 1979 EYT - 3 entries 1979 Short Grain - 3 entries	3749	114	112	66	66
Average of Local Checks:		2589	120	123	72	63

*PYT - Preliminary Yield Test

AYT - Advanced Yield Test

EYT - Elite Yield Test

Project during the 1979 planting and growing season when no senior personnel were continuously in-country.

Along with other donor agencies, the University of Arizona team participated in National Cooperative Tests administered by the Ministry of Agriculture. The tests were a series of field performance tests of sorghum, millet and maize experimental genotypes. Donor agencies were located in widely differing environmental regions throughout Yemen. Each donor agency submitted to the Ministry seeds of each line they wished to have tested. The Ministry then distributed these seed to all other donors for field testing. This procedure gave each donor agency an idea of how well their experimental genotypes were adapted to other environments throughout Yemen. If the material proved to be adapted, the new lines could be put into use immediately by recipient donor agency.

Originally all of these tests were replicated yield trials which are quite expensive. The University of Arizona team suggested in 1977 that some of these tests could be observational. An observational type of test has been used in the U. S. and many other countries to handle large numbers of experimental lines at only a fraction of the cost of yield tests. The observational plots are smaller, unreplicated, and have no labor costs for harvest and threshing. The experimental lines that look good are yield tested the following year. The yield tests then contained only potentially superior entries.

The Ministry of Agriculture has adopted the suggested procedures. The National Cooperative Tests now contain observational and yield tests for each of the three plant species. This system is more efficient in that many more experimental lines can be evaluated by the donor agencies at much less cost.

Most all United States-adapted sorghum germplasm is rather unadapted to the high elevation uplands of Yemen. The U. S. plants are short in height and thus provide a minimum of forage. Forage is an important part of sorghum production in Yemen. Recombinations of sorghum genotypes adapted to Yemen are <u>much</u> more likely to give new adapted genotypes than importing sorghum types adapted to other parts of the world.

Early maturity is a form of drought tolerance through avoidance. Plants which mature rapidly may set seed and produce grain before the available moisture is depleted. Longer season (later maturing) plants may not be able to produce any grain before the available moisture is depleted. In mid-October,

mature sorghum heads were easily distinguished from the greener heads of later maturing entries. Plants with mature heads in October are better adapted to the local environment. A number of lines with very early maturities of only 80 to 90 days versus the usual 120 to 150 days to 50% bloom, were selected for possible future use. Higher yields of some experimental lines over local types at medium moisture levels indicates a potentially superior yield at lower moisture levels as well.

Initial tests of a sorghum-sudan grass hybrid demonstrated that it can be grown in Yemen. Production of this hybrid in irrigated fields with periodic harvesting could supply needed forage for animals. The sorghum-sudan grass hybrid seems to be better adapted to low moisture Yemeni conditions than alfalfa.

In a Date of Planting Test (77086) entries of sorghum and of millet all retained their respective days to 50 percent bloom throughout all the dates of planting. One may infer from this test that regardless of when a crop is planted (within the time frame of this test) it will require the same length of time to mature. Height decreased with later planting dates suggesting decreases in forage and grain yield.

During the four crop seasons of the sorghum and millet Project (1977-1980), ninety (90) tests were performed and several thousand entries were tested. Table 2.2 presents the numbers of different types of grains (entries) grown in yield tests at the Bir Al Gohum Research Station following the plan described above. Table 2.3 summarizes the crops tested in each growing season. Appendix 4.1.1 contains names of the tests for each growing season and additional details. While the core of tests centered on grain and forage production, data were also collected on percent of stand, the time to maturity, height, general health characteristics of plants and heads, the susceptibility to lodging (being blown or falling over) and susceptibility to damage by pests (both birds and insects).

Irrigation was used in experimental plots. Its purpose was to assure emergence or prevent later loss due to extreme drought. Tests of millet consistently showed it to be less well adapted to the climate in Sana'a than sorghum.

In addition, numerous other tests were conducted to assess the potential for hybrids in Yemen, to cooperate with other breeding activities on-going in Yemen, to assess the magnitude of problems with insects and diseases and to

Table 2.2. Tests Performed

	Number of Entries			
	1977	1978	1979	1980
Head-to-Row Test	687	1089	945	450
Preliminary Yield Test	394	56	210	540
Advanced Yield Test	175	36	16	54
Elite Yield Test	--	30	33	31
Other Tests	1218	397	231	581
	2474	1608	1435	1656

Table 2.3. Crops Tested

	Number of Entries			
	1977	1978	1979	1980
Sorghum	2232	1571	1347	1487
Pearl Millet	110	13	6	145
Maize	27	24	23	24
Sudan Grass	28	--	--	--
	2397	1608	1376	1656

preserve genotypes with potentially useful characteristics. Table 2.4 lists the titles of these additional tests.

In a Hybrid Advanced Generation Yield Depression Test of sorghum, the F_2 generation production data indicated grain yield equal to or better than the F_1. The F_3 grain yields were lower. This indicates the possibility of successfully using at least one further generation of grain of a hybrid for seed for the next crop.

Responses of grains to fertilization were not tested. The variable moisture stresses on plant growth associated with limited or sporadic rainfall or limited moisture resources of any nature makes responses variable and the use of fertilizers quite risky.

2.1.1.4 Seed Releases

Seed releases are of major interest to the Ministry of Agriculture. A committee has been set up by the Ministry to review seed varieties proposed for release. The University of Arizona has proposed seven varieties of sorghum for increase and release. Four of the proposed releases are superior in grain production: Entries 2, 8 and 21 from Test 80-006 and Entry 25 from Test 80-009. One variety is superior in forage production: Entry 23 of Test 80-009. The remaining two superior lines are Entries 48 and 66 from Test 80-007.

Research personnel from the Surdud Experiment Farm and from the Tihama Development Authority expressed a strong desire to obtain seed from a group of short-stemmed (60-70 cm) sorghum with large grain-type heads which were suitable for combine harvesting. After the 1979 yield tests, seed from the thirteen best lines (or varieties) were selected. These were sent to Surdud and Tihama via Mr. Yahya Shuga and the Ministry of Agriculture. These lines should give even larger plants and heads when grown in the milder environment at the intermediate elevation of Surdud. (Table 2.5 relates the varieties given to the Ministry to the tests which produced the seeds and to the original seed source (pedigreee)).

In addition, segregating generations (F2) of superior adapted germplasm developed by the University of Arizona team were shared with the UNDP/FAO sorghum program at Taiz. From this germplasm they were able to select some superior genotypes for their environment.

Table 2.4. Supplementary Testing of Grains

Sorghum Tests:

- Advanced Hybrid Generation Populations
- Date-of-Planting Test
- Early Maturity and Tall Hybrid Yield Test
- Experimental Hybrid Observation
- Experimental Hybrid Yield
- F_3 Selections
- F_4 Generation of Populations
- Sorghum Grain and Forage Test
- Head Smut Control Test
- Hybrid-Advanced Generation Yield Depression
- International Sorghum Cooperative Nursery
- International Sorghum Disease and Insect Nursery
- National Cooperative Sorghum Observation Nursery
- National Cooperative Sorghum Yield Trial
- NP3R Dry Steriles (Sorghum)
- Nursery
- Pest Resistance Nursery
- Sana'a-Yield Test
- Sesamia (Stem Borer) Control
- Short Grain Yield Trial
- Snowflake Fertile + Sterile Random Mating
- Sorghum Composite
- Sorghum Yield Test (from UNDP Taiz)
- Sorghum X Sudangrass and Hybrid Forage Sorghum Demonstration Test
- Sorghum X Sudangrass Green Forage Test
- 1978 International Food Grain Sorghum Yield Trial

Millet Tests:

- Date of Planting
- Big-Headed Millet Population
- International Pearl Millet Adaptation 3, Test #2
- Marana Millet Composite
- Millet-Yield Test
- Millet Yield Test (from UNDP Taiz)
- National Cooperative Pearl Millet Observation Test
- National Cooperative Pearl Millet Yield Test
- Senegal Millet Population

Maize Tests:

- East African Maize Variety Trial
- National Cooperative Maize Observation Test
- National Cooperative Maize Yield Test

Table 2.5. Released Varieties of Short Height Sorghum to Ministry of Agriculture

No.	Seed Source[a]	Pedigree[b]
1	79006-101	76026-004-4
2	79006-107	76026-070-5
3	79006-113	77093-08-8
4	79006-114	77093-22-22
5	79006-116	77093-76-6
6	79006-119	77 Composite-8
7	79006-123	77 Composite-39
8	79006-125	77 Composite-58
9	79006-128	77 Composite-73
10	79006-129	77 Composite-75
11	79006-135	NES 1570
12	79006-138	IS 410
13	79006-139	IS 410

[a]Seed source refers to the test which produced the seed. "79006-101" for example was the 006 test made in 1979. "101" refers to the 01 entry in the first replication.

[b]Pedigree refers to the test or source from which this particular entry was first identified.

2.1.1.5 Yemen Sorghum Collection

The Yemen economy and society is changing rapidly. Interaction with the rest of the world is resulting in large changes in the role of sorghum and millet in Yemen. Sorghum and millet have been traditional human food crops in Yemen for thousands of years because of their capability of some production most of the time on agricultural lands with marginal water or rainfall resources. There are large areas of Yemen where water restrictions will remain in the future, so sorghum and/or millet are still the best crops for these areas.

There are thousands of different environments in Yemen and thousands of different special sorghum genotypes have evolved over the centuries for maximum adaptation to these local environments. Within many isolated areas, great fluctuations in the timing and amount of rainfall from year to year result in early plantings or late plantings along with good or poor subsoil moisture supplies. Many local farmers have selected seed stocks with late or early maturity to compensate for fluctuating planting dates. Some farmers have special seed for seasons with either high moisture (ample rainfall or irrigation) or low rainfall conditions. The severe mountainous terrain and small isolated agricultural areas also produce rather effective genetic isolation. Most farmers are very proud of their own varieties and feel they are superior to others.

Yemen is now assimilating modern world technology at an amazing pace. These changes are starting to reach back into areas which were formerly quite isolated. Changes in the economic structure of the country as it interacts with the world are affecting the Yemen farmer greatly. The moment local farmers change from sorghum to some other crop, their particular special sorghum genotypes are forever lost to mankind. Recent development of many less marginal areas has resulted in production of new crops of greater use and economic return than sorghum. This pattern has occurred in the past in many countries.

When a breeding program is initiated to improve or change a crop in an area, it is important to save samples of the native genotypes being replaced. In 1975, the UNDP at Taiz began to collect sorghum types but had no resources to continue and complete a sorghum collection for Yemen. Beginning in 1977, the University of Arizona Project furnished the vehicles, drivers, vehicle operating costs, all salaries, all travel, per diem and all equipment and

supplies needed to complete the collection. The UNDP/FAO at Taiz furnished two to three experienced technicians to do the collecting.

Terraced fields are commonly located one directly above the other up wadis in order to collect runoff from rainfall. Some sort of vehicle trail generally goes up most of these wadis. The field collection procedure required the field collection team to proceed up the trail in each wadi or drainage way, collecting one typical sorghum head every two kilometers.

The field chosen at random from which to make the collection usually contained a population of a given race or sub-race reasonably uniform in plant and spikelet types as a result of the selection procedures fo the Yemeni farmer through many generations. However, natural selection in the various areas of differing micro-climatic conditions resulted in considerable variation among sorghum types grown in different areas but with great similarity within any specific area. A one-head sample was collected to represent each such growing type, but if any generally prevalent abnormality was noticed within the field a second sample was collected.

The location, date of the collection, the name of the local village and usually the name of the governate or area were recorded on the consecutively numbered collection bag. There were not and still are no accurate maps with all villages located and named with any standardized spelling. Consequently, there is likely to be no way to refer to a map of the country and be able to readily locate the site of many of the individual collections. Major cities or areas may be located but not many of the smaller ones.

Estimates of the elevation were made from a contour map; however, there is some doubt as to their exactness. They may be considered to be good approximations.

Samples from approximately ninety percent of the major sorghum growing areas of the country have been collected. No samples were taken from the area west-northwest of Sana'a which is approximately the area designated as the Governate of Hajja. The eastern section of Yemen extending out into the desert and bordering Saudi Arabia grows predominantly millet, barley and wheat with little or no sorghum. Few collections were made from governates there.

After collection, each entry was characterized by phenotypic characters presented in Table 2.6. A description of a small fraction of the samples collected is included in Table 2.7.

Table 2.6. Phenotypic Characteristics of Yemen Sorghum

1. Whole head weight

2. Threshed grain weight

3. Peduncle shape:
   G = recurved (gooseneck)
   E = erect

4. Panicle type:
   L = loose
   SL = semi-loose
   SC = semi-compact
   C = compact

5. Grain color:
   L = light
   D = dark
   R = red
   W = white
   Y = yellow
   Br = brown
   P = pink
   C = clear

6. Glume color:
   L = light
   D = dark
   B = black
   R = red
   Y = yellow
   W = white
   G = green
   Br = brown

7. Glume pubescence:
   FH = fully hairy 80%-100%
   SH = semi-hairy 50%
   PH = partly hairy 30%
   N = none hairy 0%

8. Glume to seed ratio:
   20%, 30%, 40%, 60%, 60%, 70%, 80%, 90%, 100%

9. Race:
   B = Bicolor
   G = Guinea
   C = Caudatum
   K = Kafir
   D = Durra
   GB = Guinea Bicolor
   CB = Caudatum Bicolor
   KB = Kaffir Bicolor
   DB = Durra Bicolor
   GC = Guinea Caudatum
   GK = Guinea Kafir
   GD = Guinea Durra
   KC = Kafir Caudatum
   DC = Durra Caudatum
   KD = Kafir Durra

Table 2.7. Variation in Characteristics of Germplasm in Yemen Sorghum Collection

Sample No.	Location	Elevation (M)	Grain Color	Head Form	Head Type	Weight Head/Gr.	Grain Weight	Glume Color	Glume/Seed Ratio	Glume Hairs
01	Bir Basa	1300	LR	E	SL	50	42	B	30%	PH
02	Mattar Kadim	1350	LR	E	SL	25	22	B	30%	PH
03	Bir Basa	1300	W	E	L	50	40	B	30%	PH
04	Mattar Kadim	1350	LR	E	L	10	7	DB	30%	PH
05	Haidran	1150	LR	E	L	28	23	DB	30%	PH
06	Haidran	1150	LR	E	SL	18	14	B	30%	PH
07	Haidran	1150	LR	E	SL	28	23	LB	30%	SH
08	Haidran	1150	W	E	L	19	14	LB	30%	PH
09	Bir Basa	1300	LR	E	SL	26	20	LB	30%	SH
10	Turba	2000	R	E	L	65	54	B	80%	SH
11	Turba	2000	Y	E	L	38	22	LR	80%	PH
12	Al Nagd	1600	LR	E	L	25	21	LB	30%	PH
13	Al Nagd	1600	DW	E	L	54	42	B	30%	PH
14	Hedran	1150	R	E	L	6	4	B	50%	PH
15	Hedran	1150	LR	E	L	18	14	DB	50%	PH
16	Bir Basa	1300	LR	E	L	16	10	DB	50%	N
17	Bir Basa	1300	W	E	L	12	9	LB	30%	PH
18	Bir Basa	1300	LR	E	L	30	24	B	30%	PH
19	Al Mattar	1350	LR	E	L	40	32	DB	30%	PH
20	Bir Basa	1300	LR	E	L	45	37	B	30%	PH
21	Al Mattar	1350	W	E	L	50	30	B	30%	PH
22	Aagaga	1300	W	E	L	46	37	B	30%	SH
23	Aagaga	1300	LR	E	L	22	19	LB	30%	PH
24	Haidran	1150	W	E	L	20	15	B	30%	PH
25	Haidran	1150	Br	E	L	45	37	R	80%	PH
26	Haidran	1150	Br	G	C	55	40	R	60%	PH
27	Haidran	1150	Br	G	C	40	27	R	60%	PH
28	Al Fu Beiee	1150	LR	E	L	16	11	B	30%	SH
29	Al Fu Beiee	1150	W	E	L	56	45	B	30%	PH
30	Al Fu Beiee	1150	LR	E	L	42	35	B	30%	SH

One phenotypic difference becomes obvious during the description of the collection:

> Typical high elevation sorghums seemed to have a recurved (gooseneck) peduncle with a compact head contrasted with a low elevation sorghum with straight or erect peduncle with a small loose or semi-loose head.

There may be many collection items that are so similar in general phenotype as to be considered duplicates. This will have to be determined later during an increase or grow-out test. However, since there is a high degree of genetic isolation to all areas of collection and the local growers so jealously guard and increase their own seed each year, there are very likely some real genetic differences among some collection items that appear similar in gross phenotype. The many different growth environments of cold or hot weather, high or low moisture, short or long growing season, early or late planting dates, many different soils, and all of the different diseases and insects associated with the various climatic conditions have likely caused the evolution of a multitude of genotypes.

Attempts to increase the Yemen Sorghum Collection (about 4500 entries) at the British Farm in Maber in 1978 were unsuccessful because of poor control over planting and management procedures. In the winter of 1979-80, one thousand entries of the Yemen Sorghum Collection were sent to the Institute for Tropical Research at Mayaguez, Puerto Rico, for grow-out and increase. The following year another fifteen hundred entries were sent, bringing the total number of entries increased to twenty-five hundred.

The Institute at Mayaguez is a Federal Station which has furnished the majority of the resources for these increases such as the land, land preparation, all field equipment, all labor to plant and grow the crop. They have also furnished about 3/4 of the labor for selfing all heads and for harvest. The University of Arizona Sorghum and Millet Project has furnished about 500 square feet of greenhouse space and about four man-months of labor toward tending the greenhouse and threshing heads sent back from Puerto Rico.

The small lots of seed that have been increased are being prepared to be forwarded to the Plant Introduction Officer, Germplasm Resources Laboratory of the U. S. Department of Agriculture, Maryland for proper storage and computerizing of descriptive information available at this time. Thus, this

Yemen collection is proceeding well toward becoming a permanent part of the World Sorghum Collection.

Parts of it will soon be available to sorghum breeders in Yemen and all over the world. Requests for and questions about the collection should be directed to the University of Arizona coordinator for the Title XII Sorghum and Millet Collaborative Research Support Project (CRSP). Seed dispositions are made in "breeders seed" lots of about one hundred seed. The recipients must then increase their own supply to the amount they need.

Based on observations in Puerto Rico, three distinct sorghum types (A, B and D) have been identified from the Yemen materials:

1. Type A was predominant and was described as a grain/grass type; tillering (more than 5 stems per plant); fine stems, narrow leaves; white midvein; 2E head type, very loose erect primary branches, head pyramidal in shape, short awns; spikelet type generally Caudatum; seed color generally reddish, some white; race Guinea-Caudatum; single seeded florets; plant height 5 to 6 feet; purple plant color.
2. Type B. About 5 feet in height; recurved peduncle; A7 ear compactness and shape, panicles not solid but about two inches in diameter; very long awns, small reddish-brown seed which threshes freely from the glumes; white midveins; non-tillering; a Durra-Kafir; single-seeded florets; reddish purple plant color.

The stems of this type were mostly bloomless (lacking a waxy cuticle, like corn). This trait is rare. Recently in the U. S., the character has been found to be associated with improved feed value as a forage. Bloomless plants, however, are not as drought tolerant as are normal.

3. Type D. This is another unusual type since most plants have a kafir-type seed with yellow endosperm similar to the Kauras found in northern Nigeria. The plant and head types, however, are different. Plant height, 6-8 feet; short recurved peduncle; poor head exsertion; #5 semi-compact heads ranging from a kafir to a durra type; very pubescent glumes; white midvein, purple plant color; generally awned.

2.1.2 Outreach Program

The purpose of the Outreach Program was to establish yield trials on individual farms to evaluate and compare performance of the farmers' local varieties of sorghum with other local and introduced cultivars. The program was

also designed to gain a clearer insight and understanding into the agronomic needs and interests of the Yemeni farmers at the operating level. Attention was directed to weed problems and demonstration of control measures through "spot applications" of appropriate herbicides. Pests and diseases causing damage to the crop were identified and control measures were demonstrated through timely applications of specific pesticides. Local varieties of sorghum and millet with probable genetic resistance to insects, diseases and weeds were identified. Test sites were described by elevation (approximate) and soil characteristics to aid in the interpretation of yield results.

The Outreach Program was active during three growing seasons: 1978, 1979 and 1980. A total of eighteen different locations were involved in the program. Sites in Sa'Dah, Al Jaroubah and Radah were most distant from Sana'a: 240 kilometers to the north, 329 kilometers to the southwest, and 150 kilometers to the southeast, respectively. The map inside the front cover shows outreach site locations. The site locations, test numbers, and direction and distance from Sana'a, and plot descriptions are given in Tables 2.8, 2.9 and 2.10.

2.1.2.1 Operation of Outreach Program

In 1978, the seeds provided to the farmer for planting were Sana'a 1 and Sana'a 7 selections from the seed nursery at the Bir Al Gohum research station, and one or more U. S. hybrids selected from four entries (ACCO R920, Ferry Morse A53A, Pioneer 894, and Northrup King 125). The farmer provided seeds of the local variety.

In the establishment of the trial, the farmer furnished his own plow and animal power and participated in sowing the seed using his own row and hill spacing and method of thinning and weeding. Although no commercial fertilizer was furnished, one farmer applied animal manure at soil preparation time.

The Outreach Team made visits to each location at approximately two week intervals. These visits during the growing season helped maintain the interest of the farmer and allowed application of appropriate chemicals for pest control. When the crop was mature, it was understood that the farmer would work cooperatively with the team in harvesting operations.

In 1979, it was observed that there were large, easily recognized, phenotypic differences in both grain and forage potential among genotypes among locations. By making evaluations through observations, more and faster

Table 2.8. Outreach Tests, 1978.

Test Location No.	Cooperating Farmer	Closest Village	Distance from Sana'a (kms)	Approx. Elevation (meters)
OR78-1	Nagib Ali Salah Khaled	Hedran	50 NE	2424
OR78-2	Mohssin Hussen	May Moon	34 NW	2270
OR78-3	Ali Ebn Ali Al Negar	Hizyez	17 S	2242
OR78-4	Hussen Salah Zaid	Dubre Sunhan	27 S	2424
OR78-5	Mohamed Saad Al Oubadi	Maf-Dan	43 SW	3000
OR78-6	Salah Nagi	Yazle	35 SW	2424
OR78-7	Sheikh Abdela Faishi	Batina	148 NW	1100
OR78-8[a]				
OR78-9	Sheikh Al Surabi	Sa'Dah	240 N	1818
OR78-10	Mohssin Dirhim Samin	Khaywan	140 NE	1930
OR78-11	Asker Abulshowarib	Bilsin	101 NE	436
OR78-12	Konrad Engleberger (German Aric. Extension--Al Baun Project)	Raydah	68 NE	636

[a]Location No. 8 was discontinued on July 12, 1978, due to excessive feeding on sorghum leaves by a nearby flock of barnyard poultry.

Table 2.9. Outreach Tests, 1979.

Test Location Number	Closest Village	Distance and Direction from Sana'a
OR79-1	Yazle	35 km SW on Hodeidah Road
OR79-2	Maf-Dan	43 km SW on Hodeidah Road
OR79-3	May Moon	34 km NW on Sa'Dah Road

Table 2.10. Outreach Tests, 1980 (80-010).

Location No.	Location	No. of Entries	No. of Rep.	Plot Size
OR80-01	Al-Rasah (Maf-Dan)	50	3	0.75x5m
OR80-02	Damar (British Farm)	50	3	0.75x5m
OR80-03	Mahaweit	50	2	0.75x5m
OR80-04	Jahana (Ministry Farm)	50	2	0.75x5m
OR80-05	May Moon	50	2	0.75x5m
OR80-06	Radhe (Dutch Project)	50	2	0.75x5m
OR80-07	Amran (German Farm)	50	2	0.75x5m
OR80-08	Sana'a	50	2	0.75x5m
OR80-09	Al Jaroubah (Tihama)	50	2	0.75x5m

progress could be made in Outreach tests by using smaller plots, no more than two replications, more entries per location (perhaps 20 or 30), and not measure actual yield at first. In 1980, fifty superior genotypes were planted.

2.1.2.2 Demonstration Activities

Demonstrations of weed control and pest control were carried out during the 1978 growing season. Weed control was of particular interest to the farmer/cooperators. The increasing labor shortage in agriculture and escalating wage rates for labor make hand weeding too expensive for most farmers. (Daily wages in 1978 ranged from 50 yr (U. S. $11.03) and up.)

The five most prevalent and troublesome weeds in Yemen are listed in Table 2.11. The Outreach Team demonstrated "spot spraying" on eight farm locations. This resulted in excellent control of the target weed on these farms. After viewing the results of the herbicide treatments, many farmers indicated an interest in chemical weed control.

Hayel Saeed Anam Company in Sana'a carries a Swiss hand sprayer, spare parts for this sprayer and a complete line of herbicides and pesticides. However, it should be emphasized that on-the-farm training courses in application techniques and hazards associated with herbicides are prerequisite for chemical weed control in Yemen.

The pink stem borer (Sesamia cretica) and aphids were two serious pest problems in the fields participating in the Outreach Program. Thiodan 35 was found to be more effective in controlling the stem borer than Dipterex 30. Nine locations were sprayed once and locations 1 and 9 were sprayed twice to control the borers.

In a periodic visit to location 5, a mountain terrace (elevation 3,000 meters) on the Hodeidah Road, a heavy infestation of aphids was observed. A single spray application with Drawin 755 (West German pesticide) gave effective control.

2.1.2.3 Description of Outreach Sites

Table 2.12 gives data on the soil structural and chemical characteristics of the Outreach plots. In general, Yemen soils have relatively large amounts of calcium carbonate in loess-like soils with pH readings as high as 8.2. Sorghum is mostly grown on terraces with high silt and low clay content. The soils are virtually void of organic matter.

Table 2.11. Common Weeds in Yemen

Common Name	Plant Family	Scientific Name	Demonstration Location
"Zoheyra" or "Makhreba"	Compositae	*Flaveria repanda* Lag.	148 Km/NW - Sana'a
"Wobel" or "Zeel" (Bermuda Grass)	Gramineae	*Cynodon dactylon* (L.) Pers.	Near Huth - 126 Km/N - Sana'a
"Helgub" or "Shager"	Cruciferae	*Diplotaxia erucoides* L.	Maf-Dan, 43 Km/N - Sana'a
"Se'ed"	Cyperaceae	*Cyperus rotundus* L.	--
"Edar"	Scrophulariaceae	*Striga Hermonthica Benth.*	--

Table 2.12. Soil Structure and Chemical Analyses from Outreach Sites

Test Location No.	Soil Structure				Soil Chemistry				
	Fine Sand %	Silt %	Clay %	Organic Matter %	pH	Available/ppm P_2O_5	Available/ppm K_2O	Total N	E.C. mmho*
OR 78-1	60	30	10	tr	7.9	5.75	390	0.015	1.15
OR 78-2	40	20	40	tr	7.8	2.30	360	0.017	0.96
OR 78-3	95	--	5	tr	8.1	7.53	840	0.071	1.16
OR 78-4	60	25	15	tr	7.7	1.15	420	0.055	1.53
OR 78-5	25	45	30	tr	8.0	3.91	840	0.050	1.03
OR 78-6	80	15	5	tr	7.8	1.15	258	0.046	1.04
OR 78-7	13	40	45	2	7.6	2.3	240	0.118	1.14
OR 78-9	90	10	--	tr	8.0	1.61	138	0.042	1.14
OR 78-10	--	95	5	tr	7.7	5.75	264	0.008	1.01
OR 78-11	5	95	0	tr	7.8	3.91	540	0.038	1.05
OR 78-12	87	10	3	tr	7.9	8.74	396	0.029	0.35
	--	--	--	--	8.1	2.07	420	0.038	0.44

*Electrical Conductivity--millimhos.

When the site soils were classified on the basis of structure, OR 78-7 was the only one classified as sandy loam whereas OR 78-1, 2, 4, 5, 6, and 10 were sandy-silt-clay; OR 78-9, 11, and 12 were sandy-silt; and OR 78-3 was 95% sand. These data illustrate the tremendous diversity in the structure of Yemen soils.

Soil analysis data for the Outreach locations and the Bir Al Gohum Station were determined by the Soil and Water Research Station at Taiz. The lowest pH reading of 7.60 was recorded at Al Ashe (Batina) and the highest pH of 8.20 at the Bir Al Gohum Station. The highest nitrogen reading of 0.118 was recorded at Al Ashe where animal manure is used as fertilizer and the next highest reading of 0.079 at the Bir Al Gohum Station where animal manure is also applied during soil preparation.

2.1.2.4 Results of Outreach Program

Of the sites planted, five were successfully harvested in 1978. Table 2.13 presents information on varieties harvested, percent stand, grain yield and forage yield.

In three tests for grain yield, OR 78-5, OR 78-6, and OR 78-12, Sana'a 7 ranked first with an average of 119.3%, the hybrid second with 69.4% and Sana'a 1 third with 52.2% of the local genotype (Table 2.14). However, in tes OR 78-7 (excluded from above data), Sana'a 1 with 114.0% outranked Sana'a 7 with only 18.7% of the local genotype in grain yield. It is interesting to note that this test location rated the most favorable in soil structure which was classed as a sandy soil type with 2% organic matter and had the lowest pH of 7.60. Unfortunately, birds had destroyed the grain of hybrid FMA53A before harvest.

A preliminary analysis was made of the market value of grain and forag from the harvested Outreach plots. The Yemen farmer considers stover (sorghum and millet stalks) used for animal feed and household fuel plus animal feed of green leaves clipped from growing plants prior to grain ripening, of higher value than grain. Prices (15 November 1978) at the market in Sana's were:

	Price per Kilogram	
	Y.R.	US $
Grain	1.7	0.37
Dried Stalks	0.25	0.05
Green Leaves	1.0	1.10

Table 2.13. Grain and Forage Yields in 1978 Outreach Experiments

Test Location No.	Sorghum Genotype (entry name)	Percent Stand	Plant Height (cm)	Grain Yield Kg/ha	Forage Yield Kg/ha
OR 78-3	NK 125 (hybrid grain)	100	90	474	769
	Sana'a 1 (experimental)	37	127	326	1222
	FM A53A (hybrid grain)	61	92	295	889
	Sana'a 7 (experimental)	76	102	238	395
OR 78-5	Sana'a 7 (experimental)	46	89	1134	4819
	Local	64	96	838	5338
	Ferry Morse A53A (hybrid)	98	86	488	1425
	Sana'a 1 (experimental)	62	92	325	4816
OR 78-6	Sana'a 7 (experimental)	88	100	892	1873
	Local	80	100	870	1785
	Sana'a 1 (experimental)	60	110	349	1218
	Ferry Morse A53A (hybrid)	91	82	308	506
OR 78-7	Sana'a 1 (experimental)	93	398	2687	--
	Local	94	410	2356	--
	Sana'a 7 (experimental)	91	387	441	--
OR 78-12	Sana'a 7 (experimental)	84	94	541	292
	Pioneer 894 (hybrid)	90	82	516	143
	Local	86	92	450	389
	Sana'a 1 (experimental)	82	119	349	422

Table 2.14. Grain and Forage Production of Experimental Sorghum Genotypes as Percent of Production from Genotypes in 1978 Outreach Tests

Outreach Test	Sorghum Genotype	Grain Production (% of Local)	Forage Production (% of Local)
OR 78-5	Hybrid	58.2	26.7
	Sana'a 1	38.8	90.2
	Sana'a 7	135.3	90.3
OR 78-6	Hybrid	35.4	28.3
	Sana'a 1	40.1	68.2
	Sana'a 7	102.5	104.9
OR 78-7*	Hybrid	**	--
	Sana'a 1	114.0	--
	Sana'a 7	18.7	--
OR 78-12	Hybrid	114.7	36.8
	Sana'a 1	77.6	108.5
	Sana'a 7	120.2	75.1
Average (Without OR 78-1)	Hybrid	69.4	30.6
	Sana'a 1	52.2	89.0
	Sana'a 7	119.3	90.1

*Difficulties of obtaining research plot production data from OR 78-7 prevented obtaining some data and made the data that were collected somewhat questionable. They were not used in computing average performance.

**Destroyed by birds.

In tests OR 78-5, OR 78-6, and OR 78-12, the per hectare grain value of Sana'a 7 averaged US $264 compared to US $221 for the local genotype (Table 2.15). In only one test (OR 78-7), Sana'a 1 with US $829 surpassed the local genotype ($727) and Sana'a 7 ($136). In test OR 78-3, hybrid NK 12 with US $146 surpassed hybrid FM A53A ($91), Sana'a 1 ($100) and Sana'a 7 ($73). There was no local genotype in this test.

These data, based on three tests, OR 78-5, OR 78-6, and OR 78-12, indicate an improved average grain value per hectare for Sana'a 7 of US $43 over the local genotype. Sana'a 7 appears to be well adapted to soil conditions in the Sana'a area and may be an improved genotype for some farmers. In contrast, test OR 7807 Sana'a 1 had an unusually high value of US $829 per hectare compared to the local genotype ($727) and only US $136 for Sana'a 7. These data may reflect improved adaptation of Sana'a 1 over Sana'a 7 on better soils.

Forage values per hectare for Sana'a 7 in tests OR 78-5, OR 78-6, and OR 78-12 averaged US $926; Sana'a 1 averaged US $856; the local genotype averaged US $996; the hybrid averaged US $275 (Table 2.15).

These data demontrate the wide gap in forage values between Yemen genotypes and U. S. hybrids. In the above example, the average forage value of the local genotype was US $721 about the U. S. hybrid. Greater vulnerability of the U. S. hybrids to bird damage due to earlier maturity of hybrids over the local genotypes was also noted.

Of the sites planted in 1979, none were successfully harvested. In 1980, nine sites were planted and three were harvested. Table 2.16 presents an overview of the results of the 1980 harvest.

2.1.2.5 Germplasm Collection Made in Conjunction with the Outreach Program

Through contact with Sheikh Al Faishi, Al Ashe (Batina) on the Outreach Program some significant characters about local cultivars were revealed. Among 25 seed samples of sorghum and one millet collected directly from farmers in 1978, the most important were from Al Ashe. These included a sorghum and three millet varieties, carrying resistance to "Edar," also known in the U. S. as "Witch Weed" (Striga hermonthica). Striga is parasitic on the roots of sorghum and millet and one of the most difficult plant parasites to control in the Middle and Near East. Small samples of these resistant types have been sent to the U. S. Department of Agriculture for testing.

Table 2.15. Market Values of Grain and Forage Production of 1978 Outreach Tests.

Outreach Test	Sorghum Genotype	Grain Yield k/ha	Forage Production k/ha	Grain Value per ha Y.R.	Grain Value per ha $	Forage Value per ha Y.R.	Forage Value per ha $	Total Value per ha Y.R.	Total Value per ha $
OR 78-3	NK 125 (hybrid)	474	769	622	146	1387	306	2049	452
	Sana'a 1	326	1222	453	100	2204	486	2657	586
	FM A53A (hybrid)	295	889	412	91	1600	353	2012	444
	Sana'a 7	238	395	331	73	711	157	1042	230
OR 78-5	Sana'a 7	1134	4819	1587	350	8698	1918	10285	2268
	Local	838	5338	1170	258	9636	2125	10806	2382
	FM A53A (hybrid)	488	1425	680	150	2571	567	3251	717
	Sana'a 1	325	4816	453	100	8693	1917	9146	2017
OR 78-6	Sana'a 7	892	1873	1247	275	3378	745	4625	1020
	Local	870	1785	1215	268	3219	710	4434	978
	Sana'a 1	349	1218	485	107	2194	484	2679	591
	FM A53A (hybrid)	308	506	430	95	911	201	1341	296
OR 78-7	Sana'a 1	2687	--	3759	829	--	--	--	--
	Local	2356	--	3296	727	--	--	--	--
	Sana'a 7	441	--	616	136	--	--	--	--
	FM A53A (hybrid)	--*	--	--	--	--	--	--	--
OR 78-12	Sana'a 7	541	292	757	167	526	116	1283	283
	Pioneer 894 (hybrid)	516	143	721	159	253	56	974	215
	Local	450	389	625	138	698	154	1323	292
	Sana'a 1	349	422	485	107	757	167	1242	274

*Damaged by birds.

Table 2.16. Results from 1980 Outreach Tests

Site Location	Rank	Pedigree	Source	% Stand	Yield kg/ha
Damar (British Farm)	1	77093-65-1	79005-2190	54	4528
	2	76026-014	79003-324	76	3610
	3	76026002-4	79005-2176	39	3535
	4	Rahda Local	79004-106	67	3459
	5	76026011-6	79005-2055	46	3449
	6	IBB 17-17	79003-316	44	3382
	7	IBB 16-2	79003-310	67	3291
	8	76026036-2	79005-2095	62	3140
	9	Local Check 3	Local Check 3	54	3022
	10	77093-75-4	79005-2204	46	3003
	10	76026032-2	79006-323	61	3003
Jihena (Yemen Government Farm)	1	77093-09-3	79005-2162	98	5050
	2	Check 2	Local Check 2	100	4848
	3	Rahda Local	79004-106	98	4462
	4	Local Check 4	Local Check 4	100	4104
	5	Takil	79003-326	98	3268
	6	77093-75-4	79005-2204	100	3248
	7	77093-65-1	79005-2190	100	3200
	8	Local Check 3	Local Check 3	100	3195
	9	Local Check 5	Local Check 5	100	2973
	10	77 COMP.-74	79005-2127	96	2830
Bir Al Gohum	1	77093-55-2	79005-2108	52	4161
	2	77093-65-1	79005-2190	77	3764
	3	IBB 16-6	79003-316	75	3307
	4	NES 1773	79003-320	67	3264
	5	76026032-2	79006-323	55	3088
	6	Local Check	79005-LCh-2	43	2989
	7	76026036-2	79005-2095	54	2914
	8	76026-014	79003-324	78	2803
	9	76026068-6	79006-322	71	2727
	10	Local Check 4	Local Check 4	56	2586

The Striga resistant cultivars from Al Ashe were "Bahry" sorghum, red with a loose head, and a millet with no local name. Since Striga hemonthica is becoming more prevalent in the Al Ashe Valley, Sheikh Al Faishi plans to expand the area planted to "Bahry" in 1979. It was also learned from Sheikh Al Faishi that a local sorghum variety, "Harity" or "Beyda," a white type with a compact head, is resistant to lodging. During his many years of growing crops in the Al Ashe Valley, Sheikh Al Faishi stated that he had never observed a stem borer infestation on the local millet.

2.1.3 Training Program

Training activities were an integral part of the Project and were carried out in a manner to improve the quality of work and understanding of the project employees. The operation and continuation of a successful plant breeding program is dependent on the existnece of trained local staff to assist expatriate specialists at the beginning of such a program and to continue the breeding activities after the end of expatriate involvement. Training activities have resulted in on-the-job training for at least seventeen local employees (both project technicians and farm laborers) and the exposure of seven local technicians to plant breeding techniques and English language training for periods of from several months to several years.

During the term of the Sorghum and Millet Crop Improvement Project, a number of locally-hired individuals were involved. Technicians, while their backgrounds were varied, in general, had the equivalent of a high school education. Only a few had prior experience in research. A training program was instituted for all project staff which focused on on-the-job training combined with some classroom work.

The techniques used in plant breeding vary from season to season with planting in the spring and harvesting in the fall. Therefore, at least one complete annual cycle is necessary to expose technicians and farm laborers to the various tasks and teach them the skills required for the field work.

In addition to the continuous on-the-job training in the field, the Chief of Party and others of the University of Arizona team conducted training sessions to explain the purposes of various research activities and to discuss how and why certain techniques were carried out. Table 2.17 lists a sample of topics addressed in training sessions. For example, during the growing season, fields were sprayed with an insecticide to control pink stem borer, a

Table 2.17. Examples of Topics Addressed in Training Sessions

How to select a good variety of a grain crop.
The best sizes for experimental plots.
How to plant sorghum and millet.
The necessity of, and procedures for devising a planting plan.
How to prepare seed for planting.
How to make plant height measurements.
Assessment of fertilizer needs and application rates.
Estimation procedure for loss due to lodging.
Timing and procedures for thinning grain crops.
Procedures for harvesting, threshing and weighing of crops.

major sorghum pest in Yemen. Dr. Stewart presented a session on the life cycle and control of the stem borer. He included the examination of larval specimens of the insect and demonstrated use of the laboratory microscope in the presentation.

Typically training sessions were held once a week for the duration of the Project. However, when weather conditions prevented field work, as during the rainy season, classes were held as often as every other day.

In mid-July of 1978, an Education and Training Committee was established to learn the training needs and desires of the project personnel. Committee members were Tasawer Hussain, Chairman, Mohamed Bather, Mused Attig and Ahmed Ismail.

An agriculture library was established in the technicians' training room of the Project office and laboratory building in the USAID/Yemen Mission compound. Agricultural science books on a high school and college level were ordered, received and organized. Table 2.18 lists the books in the library. In addition, seventeen years of Crop Science Journal were scanned for articles on sorghum and millet. Nearly 300 pages of selected articles were placed in the library. These were used for study related to the training sessions and for individual home study.

In cooperation with the USAID Poultry Project, employees of the Sorghum and Millet Project were enrolled in daily English classes. All progress made contributed to improved communications within the Project.

The training efforts made in 1977 and 1978 proved to be invaluable in 1979 when no professionals (neither a plant breeder nor an agronomist) were continuously in-country during most of the growing season. The Project employees used their previous training and carried out the ongoing research in a very capable manner.

From April to November 1978, Mr. Yahya Shuga, Dr. Voigt's counterpart with the Sorghum and Millet Project, participated in a study tour of plant breeding and agricultural research activities in Tucson, Arizona. The study tour was keyed to relate to major agricultural interests in Yemen: development of research stations, irrigation, sorghum improvement, research machinery, horticultural crops and meat production. During his stay in Arizona, Mr. Shuga was given guided tours of six different research stations. He was able to see experimental sorghum work in progress, a variety of irrigation systems, machinery related to research and irrigation, greenhouses and an urban garden center. Other

Table 2.18. Books in the University of Arizona Project Library

Author or Publisher	Title
Agri-Fieldman	1978 Week Control Manual, 1 ea.
E. L. Barger	Tractors and Their Power Units, 2 ea.
W. H. Boshoff	Using Field Machinery, 1 ea.
R. H. Brown	Farm Electrification, 1 ea.
A. W. Burger	Field Crop Science Laboratory Exercises, 2 ea.
Chapman, Lark and Carter	Crop Production, Principles and Practices, 2 ea.
Common Wealth Agriculture Bureaux, England	Sorghum and Millet Abstracts, 1978 Subscription
R. J. Congdom	Introduction to Appropriate Technology, 1 ea.
Cope, Peck and Whitney	Soil Testing, 2 ea.
A. S. Crafts	Modern Weed Control, 2 ea.
Davidson and Peairs	Insect Pests of Farm, Garden and Orchard, 2 ea.
Frankel and Galun	Pollination Mechanisms, Reproduction and Plant Breeding, 2 ea.
Peter Funkel	Food from Windmills, 1 ea.
Hartman and Kester	Plant Propagation Principles and Practices, 2 ea.
Heath, Metcalfe, and Barnes	Forages, 2 ea.
Hoard and Salunkie	Post Harvest Biology and Handling of Fruits and Vegetables, 1 ea.
Institute Biological Sciences, Virginia	CBE Style Manual, 2 ea.
Israelson and Hansen	Irrigation Principles and Practices, 1 ea.
F. R. Jones	Farm fas Engines and Tractors, 1 ea.
K. F. Lazarus	Practical Insect Pest Management, 2 ea.

Table 2.18 (Continued)

Author or Publisher	Title
J. H. Martin	Principles of Field Crop Production, 4 ea.
J. C. McCullagh	Pedal Power: In Work, Leisure and Transportation, 1 ea.
McGraw-Hill	Dictionary of Life Science, 2 ea.
Ben Meadows	Ben Meadows General Catalog, 1 ea.
C. Pair	Sprinkler Irrigation, 1 ea.
Perry and Henderson	Agriculture Process Engineering, 1 ea.
J. Poehlman	Breeding Field Crops, 4 ea.
C. B. Ritchey	Agriculture Engineers Handbook, 1 ea.
D. A. Roberts	Fundamentals of Plant Pest Control, 2 ea.
E. W. Russell	Soil Conditions and Plant Growth, 2 ea.
Scarecrow Press New Jersey	Millets--A Bibliography of the World Literature Covering Years 1930-1963, 2 da.
Scarecrow Press New Jersey	The Millets and Minor Cereals, 2 ea.
Scarecrow Press New Jersey	Sorghum--A Bibliography of the World Literature, 1930-1963, 2 ea.
Scarecrow Press New Jersey	Sorghum--A Bibliography of the World Literature, 1964-1969, 2 ea.
H. Schmutter	Pests of Crops in Northeast and Central Africa, 2 ea.
G. O. Schwab	Soil and Water Conservation Engineering, 1 ea.
N. W. Simmons	Evolution of Crop Plants, 2 ea.
H. P. Smith	Farm Machinery and Equipment, 1 ea.
Society of Agronomy	Agronomy Journal, 1978/79, Subscription
Society of Crop Science	Crop Sciences, 1978/79, Subscription

Table 2.18 (Continued)

Author or Publisher	Title
M. W. Strickberger	Genetics, 2 ea.
UNIPUB, N. Y.	Intercropping in Semi-arid Areas, 2 ea.
University of Arizona	Sorghum Newsletter, 1976-1980
G. & C. Merriam Co.	Collegiate Dictionary, 2 ea.
University of Arizona Press	An Illustrated Guide to Arizona Weeds, 3 ea.
Wall and Ross	Sorghum Production and Utilization, 4 ea.
Ware and McCollum	Producing Vegetable Crops
R. J. Weave	Grape Growing, 1 ea.
Winchester Press, N. Y.	Principles of Plant Pathology, 2 ea.
F. Wright	Rural Water Supply and Sanitation, 1 ea.

crops observed included wheat, cotton, alfalfa, safflower, pecans, potatoes, tomatoes and cantaloupes.

Mr. Shuga also spent time with researchers in plant breeding learning to use the University library and being briefed on procedures used at the University Seed House for local sorghum research.

In the commercial sector he visited equipment rental stores, a farm implement dealership and a large nursery.

While in Tucson, Mr. Shuga studied English at the University of Arizona Center for English as a Second Language. Upon his return to Yemen, Mr. Shuga resumed his role as Dr. Voigt's counterpart. (He later became Director General for Agriculture for the Sana'a Governate under the Ministry of Agriculture.)

2.1.4 Research Station Development

Research stations are a vital element, along with trained manpower, in conducting plant improvement research. It is necessary to have fields which are suitable for the crops being improved, adequate water supply and distribution systems, as well as equipment, equipment maintenance, facilities and seed storage structures.

2.1.4.1 Bir Al Gohum, Sana'a

The Bir Al Gohum Station provided by the Ministry of Agriculture is surrounded by the city of Sana'a; it is two kilometers from the USAID Mission and two kilometers from the Ministry of Agriculture. The elevation, over 7,500 feet, is relatively high in comparison to the majority of agricultural regions in Yemen. The annual average precipitation is 300-600 mm and is extremely variable from year to year both in quantity and timing. Yemeni farmers in the Sana'a region grow sorghum and do not grow millet. The unpredictable rainfall makes it desirable to irrigate the experimental fields to assure that every growing season contributes to progress in breeding activities.

The surface soils at Bir Al Gohum are silt loam and silty clay loam with varying amounts of small stones in the plow layer (0-20 cm). A very compact layer was encountered at approximately 36 cm. The soils are moderately to highly calcareous materials as determined by effervesence with 10% hydrochloric acid. Alkaline earth carbonates commonly occur as silt-size fractions and are generally thought to improve the physical condition of soils. These soils

appear to be an exception to this generalization. The soils are noticeably low in organic matter which, in itself, may lead to poor soil structure. (Soil descriptions were made by Fred Turner on short-term assignment with the Project.)

Prior to the beginning of the University of Arizona Project, the Bir Al Gohum Station was in use by other USAID contractors as a research site. At one point the top meter of soil had been sold to developers in need of top soil. Field B was in best condition since it had been planted in alfalfa for several years after top soil removal. However, much of the area was unsuited for irrigation without extensive leveling; very little equipment was available; and there was little, if any, capability for maintenance or storage. From the beginning of the University of Arizona Project, activities were continually directed toward upgrading the Bir Al Gohum facility. Figure 2.3 is a sketch of the fields and well locations.

In 1977 a new well was improved and irrigation pipe purchased to make more irrigation water available and thus, make more field area usable for research. Water from both wells were shared with the adjacent Yemeni forestry project.

Since there were no research buildings at Bir Al Gohum, a new building was constructed at the USAID Mission compound to serve as the Project Laboratory.

Initially there was no provision for germplasm (seed) storage. The seed from the previous project had been left in a corner of a large warehouse used for building supplies. Birds, rats, and insects had destroyed or damaged much of the seed. The new building permitted the use of improved procedures for the control of birds and rats. Metal boxes and insecticides were used to control insects.

In mid-1978, the Yemen Government began construction of an earthen drainage way with roadways on either side through the middle of Field E. This prevented further use of the field. In 1979, a road was built through the middle of Field E.

A procedure for furrowing out and irrigating fields before planting was designed in April, 1978 by O. Fred French on short-term assignment. Use of this procedure increased precision of field plot research and decreased the variability between plots. By the end of the Project, Fields A, B, and C had been leveled and connected to the new well by irrigation pipe.

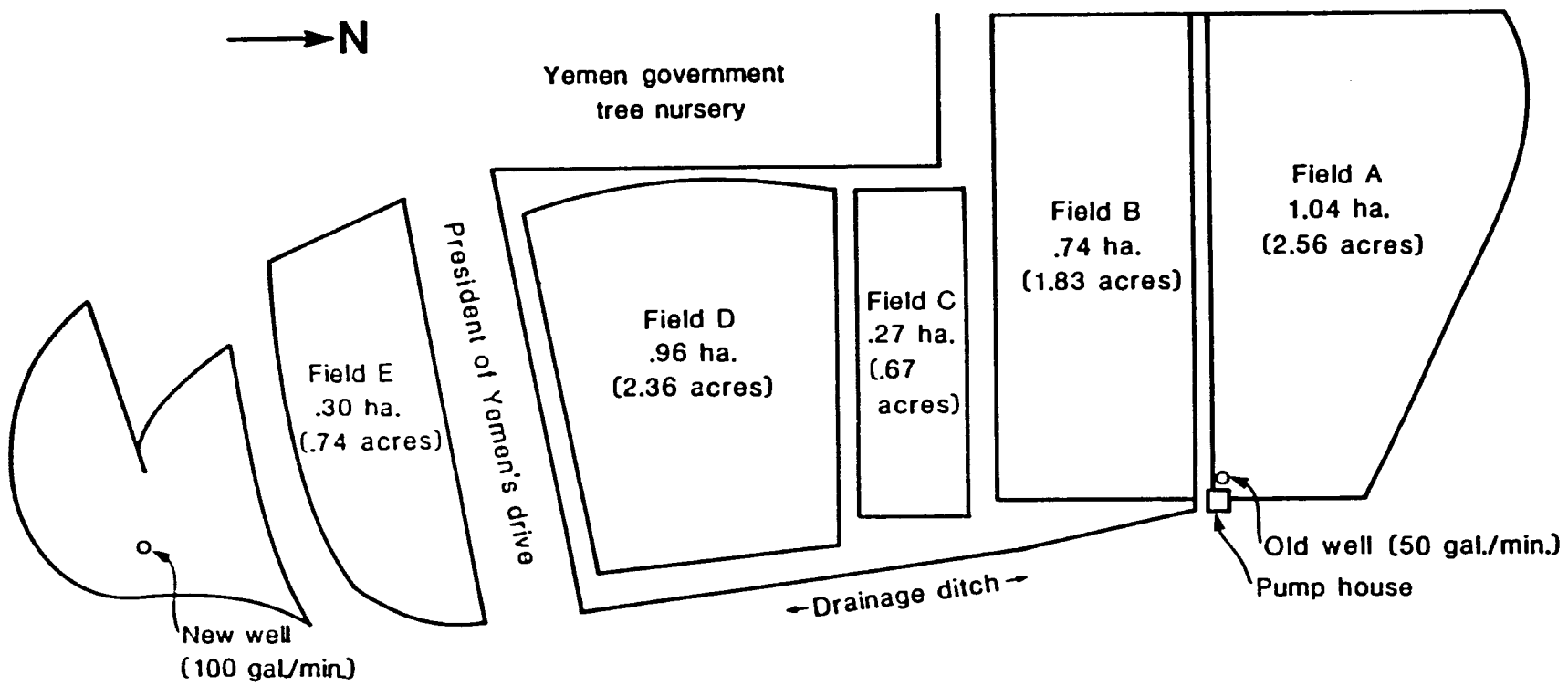


FIGURE 2.3 BIR AL GOHUM RESEARCH STATION IN SANA'A

The Ministry of Agriculture, USAID and the University of Arizona team jointly recognized the need for a new site near Sana'a. Yahya Shuga has identified several potential sites but no action had been taken at the time the contract terminated. Therefore, planting continued despite persistent rumors that the station would be terminated.

2.1.4.2 Al Jaroubah, Zabid, Timaha

The Project objectives included the development of several agricultural research stations to permit research to be conducted under various environmental conditions. The goal was to develop sorghum and millet genotypes and cultural practices suited to these environments. In 1977, a site in the Tihama region, north of the town of Zabid, 16 kilometers east of the town of Huseinia at Al Jaroubah was selected in consultation between USAID and the Minister of Agriculture. The University of Arizona team was not involved in selecting the site.

The Al Jaroubah station differs markedly from the existing site near Sana'a in many important aspects. The elevation is about 500 feet above sea-level providing a substantially milder winter climate than that at Bir Al Gohum. The high summer temperatures necessitate mid-day rest hours. Annual precipitation is subject to wide fluctuations. Millet is the major crop in this region; sorghum is grown in smaller amounts.

During 1978 and early 1979, a road was graded out from the highway to the site but was later washed out by floods. A cased well with a 6-inch pipe, a pump and motor were installed. It has an output capacity of about 4.5 liters per second.

Land for about 5 to 10 hectares was surveyed, and some leveling was done with inadequate equipment. Most of this area is planned for horticultural crops. The output of the existing well was only enough to care for the existing horticultural activities.

At the time the Al Jaroubah was chosen there were no accommodations for Project personnel at the site. All technical manpower and equipment was brought in from Sana'a, a distance of over 300 km, and had to be maintained from the Project base of operations at Sana'a. Each round-trip between the Station and Sana'a required at least two days.

The responsibility for the development of the Al Jaroubah station was accepted by the University of Arizona team following a USAID request in

November 1979. There were no functional buildings or a dependable irrigation system at the farm. Some money and effort had been invested, but not enough to satisfy the needs of a research station. USAID provided $100,000 in new funding with provisions to extend this amount, if necessary, for specific development of the Al Jaroubah site. The Ministry of Agriculture gave the University of Arizona Chief of Party permission to act as their agent in expending the allocated funds.

Table 2.19 compares the requests by USAID with the Project accomplishments at Al Jaroubah. Figure 2.4 maps the locations of fields, buildings, and irrigation structures.

In November 1979, competitive bids for drilling a new well were solicited. The George Stow Company started drilling early in 1980, and the 100 meter cased well was completed by March 1, 1980. Work during the period from November 7 to March 1 included construction of irrigation gates, vehicle repairs, effecting a transfer of a one-ton pickup truck from the USAID horticulture project (024) in trade for a carryall, procurement of oxygen bottles for metal cutting, repairing a surplus property electric welder, and salvaging a one-yard cement mixer that had been left half-full of hardened cement.

In mid-March, 1980, the Chief of Party and Yahya Abdo, the local hire field supervisor, moved to Al Hodeidah permanently. Within two weeks, four Peace Corps volunteers arrived from Sana'a to provide temporary assistance. Since there were no quarters at Al Jaroubah, the staff drove to the site and back daily. This meant a two-hour trip starting at 4:30 a.m. daily. Becuase of the intense heat, the staff left the site at about 11:00 a.m. After the first month of operation, Yahya Abdo remained permanently at the farm. The presence of the field supervisor on the job at all hours permitted a more efficient management of the local hire laborers.

At the outset, the Chief of Party requested assignment of one or more Yemeni personnel to be present during the entire development program. While the University of Arizona team could accomplish the task of farm development, the hope was that some local personnel could be present to see how things were done. This never happened.

Two of the Peace Corps Volunteers were engineers and surveyed and mapped the farm site (see Figure 2.4). While the survey was underway, the irrigation system was started, three terraces were leveled, an irrigation reservoir with

Table 2.19. Comparison of USAID Requests for Al Jaroubah Station and Work Accomplished by The University of Arizona

Requests	Accomplishments
1. Construct a shelter and cement pad for the 30-foot house trailer.	1. The trailer pad and shelter was complete and the trailer was installed with all services (water, electricity and sewer). A septic tank and leaching field was constructed to U. S. standards in front of the existing building as of June 15, 1980 (see Figure 2.4).
2. Construct a water tower capable of sufficient storage and water pressure for the house trailer and the duplex building previously started by the Soviet Union (USSR).	2. The water storage tower with 1500 gallon fiber glass tank was complete; a two-inch galvanized pipe (underground) connected the water to the building and the trailer. The entire system is closed so that the water is safe to drink.
3. Restore the existing building.	3. The existing building (24' x 80') was restored to livable status. The septic system and water source are functional. The rubble from the collapsed roof and portions of the walls about the roof line were cleaned up. The entire perimeter at the roof line was reinforced with a continuous-pour concrete bond beam with four one-half inch steel rebars. A new roof was installed. The building was completed inside and out with plastered and white-washed walls, steel shutters with security bars installed, steel doors, underground power cable from the generator house, and both water and sewer in the house. The building is a side-by-side duplex. One unit has complete bath and kitchen sinks. It has a 30 amp circuit breaker box in the house, but none of the electrical wires or outlets were installed.
4. Construct a generator building and install a suitable generator.	4. The generator building was completed. The generator was a surplus unit which was repaired with spare parts located by the University of Arizona team. The salvage of this unit represented a substantial savings. An underground power supply was installed to the trailer, and for the first time the trailer was

Table 2.19 (Continued)

Requests	Accomplishments
	4. (Continued)
	operable. This meant that during the frequent sandstorms, it was possible to take shelter.
5. Construct an equipment building for tractor storage and safe storage of tools.	5. Initially, the generator house was constructed larger than necessary to provide temporary tool storage. The building for equipment storage was started by putting in six upright steel support posts.
6. Construct a protective building over the pump motor at the new well.	6. The building to cover the pump was not started.
7. Develop an irrigation system.	7. The irrigation system was completed to the extent that three terraces could be irrigated; this was sufficient to start plant improvement work.
8. Level and terrace the farm.	8. Three existing terraces were leveled. Two bulldozers were hired to construct the reservoir and main distribution canal. Two additional large terraces were rough leveled by the bulldozers.
9. Plant sorghum and millet trials.	9. Sorghum and millet trials were planted.
10. Prepare a plot survey of the land we intended to use.	10. The plot survey of the farm was completed and delivered (see Figure 2.4).

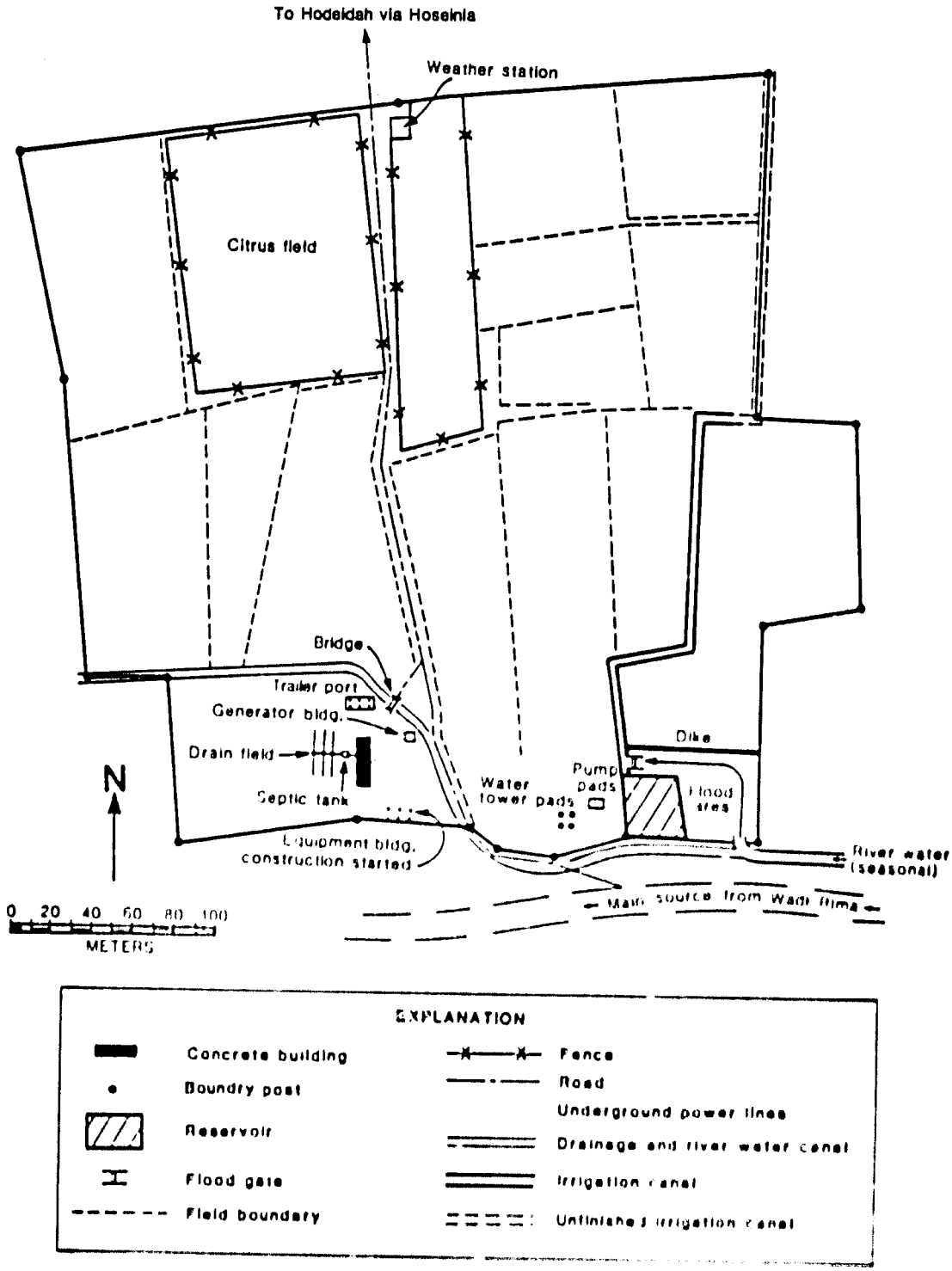


FIGURE 2.4 PLAN OF AL JAROUBAH RESEARCH STATION

one acre-foot capacity was constructed, and canals with distribution gates were built. By June 15, 1980, the first sorghum trial on a "level" terrace was given a pre-planting irrigation with a functional irrigation system and planted.

During August and September, the traditional planting period for sorghum and millet, the primary task was to plant as many of the terraces as possible with cover crops or additional trials. Building construction included completion of the generator house and installation of a new pump motor for the village and horticulture well.

Progress in development of the farm was constrained because of a problem which developed among the local tax assessor, Achmed E. Gashime, the Ministry of Agriculture employees and the University of Arizona team. Several weeks of negotiations between USAID and the Ministry were required to resolve the conflict which at one point brought all work to a standstill. The final agreement was that the team was allowed to return to Al Jaroubah for the sole purpose of completing the buildings.

2.1.5 Cropping Practices Research

Research on the cropping practices used by local farmers and various aspects of the biological environment for which improved varieties are being developed is a necessary complementary activity to plant breeding activities themselves. Varieties developed through breeding must be compatible with field practices such as spacing, mechanized versus non-mechanized harvesting, and local environmental factors. In order to provide this necessary additional information, the University of Arizona team carried out a number of activities relating to cropping practices and the pests prevalent in the region.

2.1.5.1 Farmer Survey

In 1979 the USAID financed a survey to learn what farmers' desires were regarding sorghum/millet varieties. Dr. Nasser Aliqui, a professor on the Faculty of the University of Sana'a, was in charge of the study. He was assisted in designing the study by staff from the USAID and University of Arizona team members.

A questionnaire was developed and administered to approximately 600 Yemeni farmers. The questionnaire identifies farm size and elevation, land tenure, type of access to the farm and regional location of the farm as a means

of classifying different types of farms. Farmers responded to questions about the number of varieties of sorghum grown, and the area grown and months to maturity of each of fourteen different varieties of sorghum. Area of millet grown and months to maturity were identified. Cropping practices included rainfed production and flood, stream (wadi) and well irrigation identified for each variety of sorghum grown. Farmers who intercropped identified which crops were planted with sorghum. If plants were ratooned (cut and resprouted from the roots), farmers specified their reasons for the practice. Seed sources and rates of seeding for sorghum and millet were identified. Farmers reported on the use of natural and chemical fertilizers, pesticides, and machinery use for land preparation, planting, irrigation, harvesting and threshing. The percentage of grain lost was estimated by the farmer. The percentage of millet and sorghum sold was given. Buyer, timing and reasons for selling were identified. The farmer also reported whether or not he sold animal feed as well as grain. Changes in areas of sorghum produced during the preceding 5 years were reported and reasons for change indicated. Methods of grain storage on-farm and percentages of grain lost in the first and subsequent years of storage were identified. Farmers completed their responses with identification of the major problems they encounter in sorghum/millet production. Appendix 4.1.3 is an abbreviated form of the questionnaire presented to identify variable names and format information.

Sorghum and millet project funds covered the costs of data preparation and preliminary analysis of the correlations between pairs of variables. The results of the analysis were returned early in 1981 to Dr. Aliqui for final interpretation.

2.1.5.2 On-farm Grain Storage

USAID and the Project team were concerned that post-harvest grain losses might be serious enough to counteract any increase in production that might result from the crop improvement activities. Robert A. Saul carried out a short term assignment with the University of ARizona team on grain drying and storage early in 1978. Sixteen villages were visited to question local farmers and to make observations. Eleven stops were made in the Tihama Region and five in the highlands. At each stop grain samples were taken for measurement of moisture and assessment of insect damage. Table 2.20 presents the results of this study. In general, moisture levels were low enough to be within acceptable ranges.

Table 2.20. Moisture and Insect Damage of Grain Samples

Stop No.	Percentage Moisture		Percent Insect Damage-Sorghum	Type of Storage
	Sorghum	Millet		
1	*	--		Woven basket covered with woven mat
2	12.7	--		Gunny bag under a mat outside
3	--	12.2		Gunny bag in house
4	No sample obtained--farmers unwilling			
5	--	*		Gunny bag in house
6	13.1	--	11	Gunny bags in village market square
7	13.0	13.2	8	Gunny bag in mud-wall room
8	13.0	--	0	Gunny bag in pump house by well
9	--	14.6		Gunny bag in house freshly harvested
10	13.2	--	0	Siddle
11	16.0	--	0	Siddle
12	UNDP Horticulture Research Farm			
13a	14.1	--	51	Gunny bags in market stall
13b	14.2	--	2	Same as 13a
14	*	--		Gunny bag in village market stall
15	12.6	--	6	**
16	***	--	0	**

*Sample identity lost.

**Did not see the farmer's storage--he brought out the sample.

***Sample too small (230 gm) for moisture test--250 gm needed.

The "midfan," an underground storage pit for grains, has been thought to be the typical site for grain storage in Yemen. While this seems to be the case in mountainous regions, it was not the case in the villages visited. Grains are placed in sacks or baskets which are placed on a platform of branches supported by rocks or a bed of seaweed about 1/2 meter deep. Tepee shelters are erected around the baskets to keep off the rain. This type of storage is called a "siddle."

The conclusions of this study (based on a very small sample) are that farmers have learned to protect food supplies rather well. Grains are sun dried, and therefore there is not a large cost associated with drying, and drying space in the villages does not seem to be limited. Farmers can be encouraged to place dunnage under storage bags to allow air circulation and prevent moisture migration from the floor into the bag.

2.1.5.3 Identification of Plant and Animal Pests

Plant Pathogens

Grain crops in Yemen are subject to a number of plant pathogens. It was necessary to collect and identify these organisms to take advantage of the knowledge in the international literature on measures to control them. During 1977-78, disease specimens from crop plants and common weeds were collected in Yemen. Specimens were collected from the Bir Al Gohum Sorghum-Millet Nursery, Tihama Region, Taiz, Hodeidah Road, Bany Hoshysh, Al Baun German Farm (Raydah), Al Ashe, and numerous other locations visited in connection with the Outreach Program.

Table 2.21 presents the names of the plant pathogens identified from the collected specimens along with their common names and host plants. The pathogens of two weedy species are included since weeds can serve as a natural reservoir of crop pathogens.

Weeds

Non-cultivated plants, often called weeds, can be serious competitors with cultivated crops. The University of Arizona team initiated a collection of indigenous plants including troublesome weeds and prevalent plants found in the Sorghum-Millet Nursery at Bir Al Gohum, surrounding cultivated fields in the Sana'a area and along the roadsides en route to Hodeidah, Taiz and Sa'Dah. Intact plants in various stages of growth were pressed and dried. When dried,

Table 2.21. Common Plant Pathogens of Grain Crops of Yemen

Host	Common Name	Scientific Name
Sorghum (*Sorghum vulgare*)		
	Leaf Blight	*Helminthosporium turcicum*
	Leaf Blight	*Ramulispora sorghi*
	Leaf Blight	*Ramulispora sorghicola*
	Downy Mildew	*Sclerospora sorghi*
	Covered Kernel Smut	*Sphacelotheca sorghi* Link (Clint)
	Head Smut	*Sphacelotheca cruenta* Kuhn, Potter
	Long Smut	*Tolyposporium ehrenbergii*
	Bacterial Leaf Spot	*Pseudomonas syringae* (?)
	Bacterial Stripe	*Pseudomonas andropogonis* (?)
	Yellow Stripe	Virus
Millet (*Pennisetum glaucum*)		
	"Green Ear"	*Sclerospora graminicola*, Sacc. Schrot
Wheat (*Triticum aestivum*)		
	Leaf Rust	*Puccinia recondita*, Rob. ex Desm.
	Stem Rust	*Puccinia graminis*, Pers.
Barley (*Hordeum vulgare*)		
	Leaf Rust	*Puccinia recondita*, Rob. ex Desm.
	Stem Rust	*Puccinia graminis* Pers.
	Stripe Rust	*Puccinia striiformis* West.
	Loose Smut	*Ustilago nuda* Jenson Rostr.
Maize (*Zea mays*)		
	Rust	*Puccinia sorghi*
	Leaf Blight	*Helminthosporium turcicam* Pass.
	Yellow Stripe	Virus
Common Weeds		
Euphorbia hypericifolia L.		
	Rust	*Melampsora euphorbiae*
Carthamus tinctorius L.		
	Rust	*Puccinia calcitrapae* DC V. *centaureae* (DC) Cumm. (*P. carthami* Cda.)

specimens were mounted in manila folders and filed in the Project office. Plants in the collection were identified by the University of Arizona team, with help from the faculty of the University of Sana'a and consultation with international experts. A total of 136 mounted specimens were identified. Table 2.22 lists the plant families represented in the collection. This collection may be found in the Project files at the USAID Mission in Sana'a.

During a short-term assignment in early 1978, Dr. Fred Arle conducted a test of herbicides at the Bir Al Gohum station. The purpose of the test was to evaluate the effectiveness of Banvel (dicamba) and 2,4-D on weeds encountered at Bir Al Gohum. Weeds on the plot area included Diplotaxis erucoidea (a mustard-like plant considered most troublesome), sow thistle, malva or cheeseweed and bindweed. Narrow strips (40 inches wide) over the irrigation furrows and running the length of the border were sprayed. Banvel and 2,4-D (amine formulations) each were applied at rates of .5 and 1.0 pound in 40 gallons water per acre. Initial symptoms of herbicidal activity developed rather slowly. Several days elapsed before typical bending and twisting of stems and foliage of sprayed plants became evident. Delayed activity may have been due to the cool weather prevalent during the test period. For both herbicides, the one pound rate was more effective in killing Diplotaxis than was the lower rate. 2,4-D appeared more effective than Banvel on all weeds present. It was also definitely evident that Diplotaxis develops considerable resistance to these herbicides as it approaches maturity. For best control, treatment should be made during early stages of its growth, preferably before the formation of seed heads.

Insects

The University of Arizona team also established a working collection of insects which might be destructive or threatening to sorghum-millet crops or other agricultural crops. Standard methods for the collection, killing, mounting and identification of specimens were used. In July 1978, the insect collection was of direct use to the USAID office in Sana'a. Several swarms of desert locust (Schistocerca gregaria) were reported in the Tihama region, presumably having migrated across the Red Sea from Ethiopia, which was experiencing extensive damage from this pest. The University of Arizona team was requested to survey the Sana'a area and northern regions for any swarms of the desert locust. While there were numerous observations of the migratory grasshopper

Table 2.22. Plant Families of Native Forbs (Weeds) of Yemen

AIZOACEAE
AMARANTHACEAE
BORAGINACEAE
CAPPARIDACEAE
CARYOPHYLLACEAE
CHENOPODIACEAE
COMPOSITAE
CONVOLVULACEAE
CUCURBITACEAE
CRUCIFERAE
CYPERACEAE
EUPHORBIACEAE
GRAMINEAE
LEGUMINOSAE
MALVACEAE
ORBANCHACEAE
NYCTAGINACEAE
PLANTAGINACEAE
POLYGONACEAE
SCROPHULARIACEAE
SOLANACEAE
ZYGOPHYLLACEAE

(Locusta migratoria), no swarms of desert lcoust were sighted. All insects collected were compared with the Project insect collection for identification. The University of Arizona thus was able to allay the fears of a plague of desert locusts.

The insect pests of sorghum and millet crops in Yemen were the focus of a short-term assigr.ment by Dr. Donald Tuttle in October, 1977. He identified the following group of eight insects as the most serious: Corn leaf aphid (Rhopalsiphum maidis Fitch), stalk borer (Sesamia cretica), termites (Microcerotermes diversus), flea beetles (Podagrica Spp.), sorghum shoot fly (Atherigona varia soccata R.), African or nutgrass armyworm (Spodoptera exempta (Walker)), desert grasshopper (Schistocerca gregaria), and mites (Oligonychus (Reckiella) simus P. & B.).

From limited observations and time spent in sorghum and millet fields, beneficial insects and mites appear to be abundant. These included the following: coccinellids, lacewings, syrphid flies, Orius, damsel bugs (Nabis), Phytoseiids, Erythraeids, Tydeids, and Cheyletids. Appendix 4.1.5 provides a list of insect pests of other crops in Yemen and other beneficial insects and more details on the eight pests listed above.

2.2 Administrative Methods Used

The administrative methods used for implementing the Sorghum and Millet Project are described in this section. The University of Arizona team stationed in Yemen was supported from The University of Arizona through continuous on-campus backstopping. Throughout the Project emphasis was placed on cooperation with other projects and training of Yemeni to carry out plant breeding research. Formal communication with USAID was through bi-weekly, semi-annual, and annual reports and plans of action. Methods used for the technical aspects of the Project are described in the relevant technical sections.

2.2.1 On-campus Backstopping

In general, the resources of The University of Arizona as a whole stood ready to assist the University of Arizona team in Yemen. Some needs were continuing and were met on a continuing basis while others were only necessary on particular occasions. Project administration was carried out from the campus, with periodic visits to the field. Dr. R. Phillip Upchurch, Head of the University of Arizona Plant Sciences Department, served as Campus Technical Director of the Project. He conferred with both USAID/Sana'a and AID/Washington officials in all matters of Project administration including specific reviews (formal and informal) of Project activities, identification and replacement of personnel in Yemen, clarification of the contract document, as well as supervising the overall quality of scientific research. A faculty member of the Plant Sciences Department served as Campus Assistant Technical Director. Dr. Robert Voigt held this position when he was not Chief of Party in Yemen. The Department of Plant Sciences hired a Project coordinator who was responsible for locating and shipping the equipment and supplies crucial to the execution of the Project. Department technicians helped provide logistic support.

Dr. W. Gerald Matlock, Director of the University of Arizona's Office of International Agriculture Programs (OIAP), contributed his experience with international projects to smoothing the interfaces between the University, the Project and AID/Washington and USAID/Sana'a. The OIAP staff also provided logistic support for the Project.

At the end of the Project, the two professionals who had been in Yemen relocated to The University of Arizona campus for five weeks. They, members of the Plant Sciences Department and the Office of International Agriculture Programs prepared the final reports.

Over 67,000 supply and equipment articles were procured, packaged and shipped to Yemen. Equipment items varied from office supplies to two carry-alls and appropriate spare parts to maintain them. Other examples of items shipped are 555 pounds of welding rod; safety equipment, such as first aid kits, eye fountains and face masks; hand tools; research equipment, including sample pans, soil thermometers, magni-focusers, psychrometers, microscope, irrigation valves, herbarium components, flagging tape, and threshers; farm implement and tractor parts; and fertilizer.

Supplies were shipped via the State Department pouch early in the contract. When this system failed due to the inability to trace lost items, other means of movement were utilized. These means included using a freight forwarder, air, ship, and hand-carrying by personnel traveling to Yemen. Problems arose using freight forwarders due primarily to their inability to determine status of shipments or estimated arrival dates in Yemen. During the last two years freight forwarders were not used unless absolutely necessary. Items were packaged and taken directly to Tucson International Airport where exact routing to Sana'a was specified. This system usually had the item in Yemen within a week. AID personnel in Washington were also helpful by accepting relatively small items by mail from Tucson and forwarding the package on to Yemen.

All equipment and supply items were sent insured. Items were lost, only to appear in Yemen after a second order had been shipped; and arrived damaged. Insurance claims were submitted and collected when appropriate.

A number of specialists for short-term assignments in Yemen were identified and assigned to the Project to meet needs identified by the University of Arizona team and to accomplish Project goals. The specialists sent to Yemen were selected from among those known by the faculty of The University of Arizona to have the expertise in the area of research needed by the Sorghum and Millet Project. Identification of experts for international travel and the logistics of sending them for overseas duty would have been quite difficult to accomplish without the administrative base in the United States.

The training program provided to Yahya Shuga at The University of Arizona is described in Section 2.1.3. All aspects of the program training were designed and/or provided by University of Arizona Project backstopping staff.

On numerous occasions faculty of The University of Arizona <u>not</u> directly associated or funded by the Project assisted with the technical needs

of the Project. For example, Dr. George B. Coummins and C. Michael Pfeiffer of the Plant Pathology Department identified some of the less common pathogens that were collected from crops and common weeds in Yemen (see Section 2.1.5.3--Identification of Plant and Animal Pests). Greenhouse space and technicians' time were used to increase seed needed for breeding purposes in Yemen--specifically the A and B lines mentioned in Section 2.1.1.3. Campus staff not paid by the contract rendered substantial service to the Project.

2.2.2 Cooperation

In developing-country situations such as Yemen, cooperation is not merely a courtesy; it is a logical strategy of project administration. The University of Arizona team provided assistance to numerous other projects both within USAID/Yemen and with other donor agencies. In return, the Project received much assistance on an ad hoc basis from non-U. S. donors and USAID projects alike. Before necessary implements arrived in Yemen, the United Nations Development Program (UNDP) in Taiz loaned the University of Arizona team a light weight furrow opener and a small land leveler. The use of these tools resulted in greatly improved field conditions at Bir Al Gohum. In return, The University of Arizona lend UNDP three small threshers which more than doubled their results from a wheat experiment in a single year. The two projects cooperated in making the Yemen Sorghum Collection as described in Section 2.1.1.5.

Water at the Bir Al Gohum Research station was shared with a Yemeni Forestry project and water at the Al Jaroubah Station was made available to the local village when their pump was broken.

Numerous professional courtesies were exchanged. Specialists on temporary duty to assist the University of Arizona Project also advised other USAID projects. A system for controlling pests in the USAID poultry feed facilities was designed. Advice was given on irrigation systems and field layout to the USAID Horticulture project. Also, soil samples were collected and returned to the U. S. for analysis. The German Assistance group helped the University of Arizona team in identifying plant pathogens and insects, and in recommending treatments against plant pests and a system for rat control in the seed storage area.

USAID, and therefore, the University of Arizona team, is more fortunate than United Nations donors in being able to import equipment and supplies rather

than buying what is available locally. At one time during the Project there were neither seed envelopes nor selfing bags available in Yemen. Yet both are crucial elements in plant breeding research. The University of Arizona team was able to provide these items to both the UNDP project and to the Yemen Ministry of Agriculture.

The University backstopping group assisted other USAID projects in procuring and shipping over fifty items including tractor parts, vehicle parts, and two vehicles.

2.2.3 Plan of Action

Neither the Project planning documents nor the contract between USAID and The University of Arizona specified a particular methodology for planning of project activities. However, planning was recognized as an important element for the continued progress of the Project. The major mechanism which evolved to communicate plans of action to USAID and other participants in the Project was a section called "Plans" in the bi-weekly activities reports.

A formal work plan was made for the year March 16, 1978-March 30, 1979. The plan of work included monthly summaries of planned activities for the year and an indicative list of activities for the following year. For the 1979 field season (March, 1979 through March, 1980) written instructions were prepared. Topics discussed included field preparation prior to planting; techniques and variables to consider in planting millet; thinning procedures and timing for sorghum, maize and millet; protection against stem borers; procedures and instructions for irrigation, fertilization, weeding and cultivation; management of farm labor and bird watchers; and instructions on pollination of corn, keeping field notes and the outreach program.

In describing plans of work for a plant breeding project it must be remembered that breeding activities are basically cyclic. Each year plots are prepared, irrigated before planting, planted, weeded, thinned, guarded against pests, harvested and the production measured. The data generated are evaluated and entries which show desired characteristics are selected for the following year's tests. Non-cyclic activities included: redesign and construction of research plots, installation of water supply systems to insure production of experimental crops even in years with insufficient rainfall and construction of research facilities.

The University of Arizona team devised a uniform set of project personnel job descriptions for all project employees in Yemen. The goal was to do away with inequities and inaccuracies in pay scales and in general to make job classifications and promotion more consistent. The system was adopted by USAID/Yemen for all its projects.

2.2.4 Training Methods

Training of Yemeni staff to understand and carry out the various phases of a sorghum and millet improvement program was a major objective of the University of Arizona Project. The Ministry of Agriculture in coordination with USAID was responsible for assigning Yemeni counterparts to the Project. In addition, numerous local people were hired to work with the University of Arizona team. All personnel were trained in some way. Methods selected for training were keyed to the individual participant's educational experience and their role in the project. (Details and results of training are described in Section 2.1.3.)

The counterpart of the Chief of Party received a specially designed observation/sutdy tour in the United States. During an 8 month tour, he viewed plant breeding activities of all sorts in Southern Arizona. In addition, he attended language classes to upgrade his English skills.

The major emphasis of training in Yemen was on a combination of learn-by-doing, a training lecture series on field and laboratory activities involved in the improvement of sorghum and millet and the opportunity to study English. Lectures presented to the research team were timed to avoid conflict and be consistent with field activities. For example, materials on harvesting procedures were presented just prior to the harvesting work. The assignment, explanation, and supervision of tasks included a large component of teaching. Examples were formulated, explained, and demonstrated for each activity.

As in all cases, learning is a shared experience. In numerous cases, the Yemeni staff suggested procedures based on their local experience with agriculture which contributed to the effectiveness of field activities.

2.3 Project Accomplishments

This section provides a description of the major accomplishments of the University of Arizona team toward meeting the objectives of the Project. It is organized in three parts:

1. A description of accomplishments by category of activity.
2. Comparison of relevant parts of the Project Paper, the Contract Operational Plan (Appendix A of the Contract) and accomplishments.
3. A discussion of problems faced in accomplishing the Project objectives and/or contract requirements.

2.3.1 Description of Accomplishments

The preceding sections of this document have reported the activities of the National Sorghum and Millet Improvement Project and accomplishments were mentioned in that context. The following is an overview of The University of Arizona accomplishments in more succinct form.

2.3.1.1 Research Program

Plant Improvement

Prior to planting field experiments, the University of Arizona team organized and analyzed the results of the previous plant breeding programs. Fields were planted within two months after arrival in Yemen. In addition, the team initiated a continuing study of sorghum and millet production and agricultural practices of Yemeni farmers.

The Project accomplished four years of field testing and evaluation of grain germplasm. Average grain yield of the top five entries in the Preliminary Yield Test went from 20% superiority over the local check in 1978 to 93% superiority in 1979. Similar marked improvements were noted in the 1980 Elite Yield Tests and Outreach Tests. These superior lines mature 5-10 days earlier and are 10-30 cm shorter than the local check. Earlier maturity is an advantage under low moisture conditions; however, short height plants produce less forage.

Seeds of 13 short stem, grain-type, Yemen-adapted sorghum genotypes developed by the University of Arizona team for use in areas where future production may be mechanized through harvesting were given to the Ministry of Agriculture in 1979. Based on 1980 test results, seven genotypes have been

recommended for increase and release. This plant material will be useful under current Yemeni cropping practices.

Constant improvements in field research procedures were devised and adopted to make possible more reliable data. Time was devoted to learning how to grow sorghum and millet in the soil and moisture conditions typical in Yemen. Each year prior to planting, a field research plan was prepared and discussed with USAID officials. Initial emphasis was placed on sorghum because of its overall importance in Yemen and the lack of research facilities in the Tihama region where millet is of greatest importance. The plan included cultivar evaluation, combining and crossing of genetic materials (sorghum only), testing hybrids developed outside Yemen, date of planting tests, and cultivation practices experiments. Herbarium equipment and supplies were purchased, and a collection of all native forbs in the Yemen uplands was started. One hundred and fifty specimens were obtained, pressed, catalogued (identified and labeled) and filed in Sana'a for future use.

Cropping Practices

A variety of short term activities resulted in increased information about the cropping practices of Yemeni farmers. A comprehensive questionnaire on sorghum and millet production practices was developed and administered to over 600 farmers in 1979 in cooperation with the University of Sana'a; results were summarized and returned to Sana'a for further analysis. Surveys of incidence and characteristics of major sorghum diseases and pests were made. Pathogens, weeds, and insects were identified.

A study of on-farm grain storage revealed that current practices are adequate to preserve grains until they are used and that no problems could be anticipated for storing additional production.

2.3.1.2 Yemen Sorghum Collection

A collection of 4,500 native sorghum varieties in Yemen was planned for and carried out starting in the fall of 1977. Collected seeds were sent to The University of Arizona in Tucson for processing and description for entry into the World Sorghum Collection. During the winters of 1979-80 and 1980-81 2,500 entries were increased at the Institute for Tropical Research in Mayaguez, Puerto Rico. Requests for materials from the collection may be directed to the University of Arizona coordinator for the Title XII Sorghum and Millet Collaborative Research Support Program (CRSP).

2.3.1.3 On-farm Outreach Activities

Cooperating farmers were selected in eighteen locations around Yemen for testing experimental sorghum entries under different environments. As many as fifty varieties were tested in any one year. Valuable experience was gained, useful contacts were established in many villages and much favorable public relations work was done in establishing and conducting the outreach tests.

2.3.1.4 Facilities Development

The Sana'a experiment station at Bir Al Gohum was developed as resources permitted. The new well was improved and irrigation pipe purchased to distribute water to a larger area. The existing 1.8 hectares (ha) of fields were releveled and an additional 1.2 ha were leveled and brought into use. Improved cultivation practices for use at the farm were developed and implemented.

Work on development of the Al Jaroubah Station began in 1978 after site selection a year earlier. Direct University of Arizona involvement began after a USAID request for assistance in 1979. A trailer pad and shelter were constructed. A water tower and water lines were installed. An existing building was roofed and restored to livable status. A generator building was built and a generator installed. Space for tool storage was provided. The irrigation system was enlarged to supply the leveled terraces. First research plantings were made there in 1980. A map of the site was drawn.

Lists and specifications for needed equipment and supplies were prepared. Orders were placed and received at The University of Arizona then sent to Yemen.

Buildings constructed by USAID/Yemen were put to use as offices, laboratories, maintenance shops, and storage areas for equipment and supplies. Seed storage facilities were improved to provide better control of birds, rats and insects. Equipment was installed and made operational.

Seventeen local technicians and laborers received on-the-job training including some formal classes in research procedures, cultivation, construction techniques, and operation and maintenance of field and laboratory equipment. Training was provided in use of English language in agricultural practices.

Three International Volunteer Service (IVS) technicians were given on-the-job training in research procedures. Professional and technical coordination of their individual work plans were provided.

A special training program in applied agricultural practices was provided for one Yemeni counterpart at The University of Arizona in Tucson.

A 6-month short course on Applied Agricultural Practices for secondary school graduates was developed and proposed. Copies of the proposal were given to USAID/Yemen and the Minister of Agriculture (see Appendix 4.1.6). The course, to be taught in Arabic (75%) and English (25%) at the University of Arizona Agricultural Experiment Station in Tucson and other locations, would give students hands-on experience in agricultural practices.

2.3.1.5 Cooperation with Other Projects

The University of Arizona team participated in bi-monthly coordinating meetings with Ministry of Agriculture and other donor personnel. More efficient regional screening and yield tests were suggested by University of Arizona personnel and adopted by the group. Research data and other information were exchanged. The UNDP/FAO project at Taiz was given seed from populations having outstanding segregates which enabled them to select genotypes for that environment. The University of Arizona team participated in National Cooperative Tests (yield and observation) of sorghum, millet and maize by planting superior genotypes from other research centers and furnishing them superior genotypes from our project experiments. Equipment was borrowed from and loaned to the UNDP/FAO at Taiz and the British Farm Mechanization Unit at Taiz. Selfing bags and seed envelopes were furnished to the UNDP project and the Ministry of Agriculture. Improved insect control procedures were developed in cooperation with the German farm. Two tests for head smut control and stem borer control were made with the German farm. An annual 3 or 4 day tour of all research facilities was taken by the group of expatriate research scientists and YARG representatives. (See also Yemen Sorghum Collection Section 2.3.1.2.)

University of Arizona scientists and administrators visited various national and international agencies to exchange information and ideas on sorghum and millet production. Visits were made to the Food and Agriculture Organization of the United Nations (Rome), The United Nations Development Program (New York), World Bank (Washington, D. C.), American University of Beirut (Lebanon), International Crops Research Institute for the Semi-Arid Tropics (India), and International Volunteer Service (Washington, D. C.).

Facilities for maintenance of Project vehicles and equipment were established. Automotive supplies, the Project garage, mechanics and

agricultural research supplies were shared with the USAID Mission and Projects 019 (poultry), 024 (horticulture), 042 (Ibb School), and 052 (Title XII Agricultural Development).

2.3.1.6 Administration

A packet of orientation materials was prepared for use by the Project personnel traveling to Yemen. A description of agriculture in Yemen was written and included. Project administrators regularly visited Yemen to consult with Project personnel, USAID and YARG officials. Trips were made to Washington, D. C. for consultations with AID/Washington.

In July, 1980, The University of Arizona was asked to assume responsibility for certain local expenditures. An administrative officer was hired and assigned to the Project. (Later the 052 project assumed tnis responsibility.)

A set of uniform job descriptions for local personnel was devised. The descriptions, which were used in classificationand promotion, were adopted later by USAID for use on all its projects.

2.3.1.7 Reports

Bi-weekly and semi-annual reports were prepared and distributed as required by the Contract. In addition, the following reports and publications were written and distributed: Annual research reports (following a special USAID request for such reports in November, 1979); annual summary of sorghum breeding results; reports of all short-term assignments and trip reports. Two descriptions of the Yemen sorghum collection were prepared: A description of the activity and the 4,500 entries and a progress report. In addition, there were administrative reports and a preliminary progress report of the period from March 1977 to October 1979. Copies of these reports are with USAID/Yemen and in the Project files at The University of Arizona in Tucson.

2.3.2 Comparison of Accomplishments and Objectives

Comparison of accomplishments and expectations provides a measure of project success. Within the U. S. Agency for International Development (USAID) there are two related documents: The Project Paper and the Contract. In the Project Paper the AID system establishes the background of a project, describes

its general characteristics, and lists the inputs required. When the Project Paper is approved, a contract may be issued. The contract itself is a subset of the Project Paper and is the agreement between USAID and the contractor, in this case, The University of Arizona, on the tasks to be accomplished.

Typically the contract is narrower in scope and more restrictive than the Project Paper from which it is derived. This is certainly the case for the Yemen National Sorghum and Millet Crop Improvement Program. Unfortunately, evaluators often are unaware of or pay little heed to the distinction between these two documents. They expect a project implemented under the terms of a contract to achieve all the objectives of its preceding Project Paper.

In Table 2.23 we compare the characteristics (features) of the Project as described in the Project Paper, the Operational Plan of the Contract (specifically Appendix A of that document) and the actual accomplishments in a tabular format. The End of Project Status is evaluated (accomplished, partially accomplished or not accomplished) in terms of the contract document since this is the actual basis for activities on the part of The University of Arizona.

In addition to the items reviewed in Table 2.23, there were numerous expectations in the Project Paper which were not included in the Contract. The tabular presentation in Table 2.24 summarizes these dropped threads and points out University of Arizona activities related to them.

2.3.3 Problems

A discussion of several problems associated with the sorghum and millet project which prevented it from accomplishing all of the expected or planned objectives is presented here to provide later evaluators with information relative to the constraints under which the Project was implemented and executed. In most cases there is considerable overlap among the problems although they are listed separately. Obviously, all these problems cannot be completely resolved in the foreseeable future. However, attention can be given to them in any continuing, similar project in Yemen.

2.3.3.1 Plant Improvement

The USAID representatives and the Yemeni officials responsible for liaison with the project did not, for the most part, have a technical background in plant sciences. This made communication with the University of Arizona team difficult and led to some basic misunderstandings about plant sciences research.

Table 2.23. Comparison of Project Paper, University of Arizona Contract and Accomplishments

Project Paper Item(s)	Corresponding University of Arizona Contract Item	Status--End of Project
Project Characteristic--A National Sorghum and Millet Crop Improvement Program under the sponsorship of the Ministry of Agriculture.	Objective--To assist YARG in establishing a National Sorghum and Millet Crop Improvement Program within the Ministry of Agriculture.	Accomplished. Comment--Without donor input, sorghum and millet research in Yemen probably will cease.
Take the lead in sorghum and millet work in Yemen under coordinated arrangements with other donors. Conduct trials on sub-stations that Food and Agriculture Organization of United Nations and the Federal Republic of Germany have established.	Continue cooperationand coordination with ALAD, Food and Agriculture Organization of the United Nations, International Crops Research Institute for the Semi-Arid Tropics, U. S. Department of Agriculture and other donors engaged in similar efforts at enhancing the quality of food production in Yemen.	Accomplished. Comment--National Cooperative Trials were modified per U. S. suggestions to Ministry of Agriculture.
Emphasize adaptive research, including off-station testing in field conditions of improved varieties of sorghum and millet. Identify and field test under varying local conditions a number of high producing varieties of sorghum and millet particularly suited to semi-arid or low rainfall circumstances.	Screen potential high producing varieties of sorghum and millet and select varieties suitable to varying local conditions. Re-combine varieties with superior characteristics to produce high yielding varieties for major ecological regions of Yemen.	Accomplished. Comment--Four years of a minimum seven years have been completed. Average yields of the top 5 entries in certain tests were twice that of local check variety.
Develop a central sorghum/millet research facility together with two or three modest sub-stations.	Develop a central sorghum and millet research facility together with two or three sub-stations (8 to 20 hectares in size).	Partially Accomplished. Comment--The central facility at Bir Al Gohum (Sana'a) was improved and the sub-station at Al

Table 2.23 (Continued)

Project Paper Item(s)	Corresponding University of Arizona Contract Item	Status--End of Project
		Jaroubah was made operational. Changing YARG priorities negate usefulness of this work for future sorghum and millet research.
Identify and test-related cropping practices which may further increase the productivity of selected varieties.	Identify and test related cropping practices which may further increase the productivity of selected varieties.	Partially Accomplished. Comment--University of Arizona team cooperated with survey of 600 Yemeni farmers; grain storage practices were surveyed; pathogens, weeds & pests were identified.
Development of seed production capability.	Develop a seed production capability.	Not Accomplished. Comment--Until superior seeds are identified there is no need for seed production capability. During the Project the UNDP planned to begin a seed increase project. USAID decided the University of Arizona should not duplicate this effort.

Table 2.23 (Continued)

Project Paper Item(s)	Corresponding University of Arizona Contract Item	Status--End of Project
Move locally tested high-producing varieties into the hands of farmers wherever feasible through various donor and USAID-assisted projects.	Move locally tested high-producing varieties and relevant cultural practices into the hands of farmers through various USAID and other donor assisted projects.	Partially Accomplished. Comment--Outreach tests were made for 3 years in cooperation with farmers; superior seeds were shared with other donors and YARG.
Train counterpart Yemeni staff to undertake the foregoing and also to prepare ultimately for the creation of a national agricultural research institution.	Train counterpart Yemeni staff to undertake the foregoing and to prepare for the creation of a national agricultural research capability in sorghum and millet.	Partially Accomplished. Comment--Local staff assigned to the project were given a combination of informal classroom and on-the-job training; the single Yemeni counterpart was trained in the U. S.
Contain a participant training component aimed largely at establishing the skills/capacity to man a research institution sometime in the near future: ALAD 112 man-months (mm); academic, 3rd country 245 mm; academic and practical U. S., 60 mm.	Develop training requirements for participants in support of this project.	Accomplished. Comment--Training program (requirements) developed but participant training was not funded under the contract. No candicates for training were identified by YARD or USAID.
An AID financed commodity and other cost input of US $1,026,000 to cover: farm machinery, irrigation equipment, vehicles, research equipment and supplies, wells, pumps, and engineers.	Develop lists and specifications for commodities necessary to implement the project.	Accomplished. Comment--Commodities having a value of over $115,000 were specified, ordered, shipped and received in Yemen.

Table 2.23 (Continued)

Project Paper Item(s)	Corresponding University of Arizona Contract Item	Status--End of Project
	Provide professional and technical coordination to three agronomists and one agricultural engineer to be provided under a separate, but related, contract with a voluntary agency.	Accomplished. Comment--Only 2 agronomists and an agricultural engineer were provided by International Volunteer Services.
Provide for linkages to those projects, extension, and seed production activities which the YARG, in collaboration with other donors and/or USAID has under development.	Maintain close cooperation with U AID/Yemen, YARG, the contracted International Voluntary Services, Inc., and other donors.	Accomplished. Comment--Communication with YARG would have been better if University of Arizona team had had Arabic language skills.
Sorghum/Millet Breeder, 72mm Agronomist/Extension Specialist, 72mm Three Station Technicians and Agricultural Engineer (contract with IVS) Plant Protection Specialist, 18mm Seed Production and Handling, 12mm TDY to be determined, 15mm.	Provide personnel with the following skills: 1) One long-term Plant Breeder with a minimum of five years experience. 2) One long-term Agronomist with a minimum of five years experience. 3) One short-term Seed Production Specialist. 4) One short-term Plant Protection Specialist.	Accomplished. Comment--Plant breeder, 48mm; Agronomist, 48mm Short-term Assignments: Irrigation Engineer, 1mm Entomologist, 1mm Weed Control specialist, 1mm Crop Storage Scientist, 1mm Soils and Irrigation, 1mm Short-term specialists limited by lack of in-country transportation.

Table 2.23 (Continued)

Project Paper Item(s)		Corresponding University of Arizona Contract Item	Status--End of Project
USAID Inputs Were:		The budget allotted to University of Arizona for accomplishing the tasks described above was $1,285,880 (Amendment 11, 31 May 1981).	Accomplished Comment--Expenditures through 31 May 1981 (actual through 22 May, estimated to 31 May) were $1,188,653.
Personnel	$1,225,000		
Participant Training	456,000		
Other Costs	767,000		
Commodities	259,000		
Total	$2,707,000		
YARC Inputs Were:			
Salaries	$ 852,000		
Total	$1,088,000		
Sub-stations (In Kind)			

Table 2.24. Project Paper Items Not Included in University of Arizona Contract

Project Paper Expectations (5 Years)	Status--End of Project--Comments
Increase overall national per hectare yield of sorghum and millet by 3%.	Unable to evaluate, no baseline data.
Identify, test, and begin to distribute orghum and millet varieties capable of boosting production in semi-arid areas by more than 20% under farm conditions.	Partially accomplished.
Link the outputs of proved production technology for sorghum and millet varieties in with established agricultural extension services and the developmental projects of other donors.	Technology not yet proved.
Accumulate and assess economic data concerning on-farm tests of sorghum and millet production and related consumption data under a number of varying conditions.	No provision in University of Arizona contract for economic survey.
Establish the foundations (in terms of trained staff and sorghum/millet research systems) for a national research institution that could either be fitted into a comprehensive agricultural research center or become the basis for creating such an entity.	Research systems foundations established; trained Yemeni staff is nil.
Strengthen the Ministry of Agriculture by expanding training and field experience opportunities	Training and field experiences were provided; limited YARG participation.
Improve the scientific and professional expertise in agriculture.	Some effort expended, little accomplished, YARG unable to supply candidates.
Increase the productivity of two crops in the mountain plains and the Tihama areas, but include the entire cultivatable area of the country.	Preliminary work done, additional years required for significant increase on country-wide basis.
Raise the nutritional standards for all citizens.	Unable to evaluate, no baseline data.
The project has a five-year time frame and calls for an intensive evaluation at the end of the three years to provide the basis for a further extension of the project.	The scheduled evaluation by comprehensive outside team was not carried out.

Table 2.24 (Continued

Project Paper Expectations (5 Years)	Status--End of Project--Comments
Institutionalization of research, the development of dissemination systems, and the testing and development of high-yielding varieties of sorghum and millet suited to climate and cultivation practices in Yemen may require as many as twenty years.	Four years of effort provided by contract as amended before termination.

For example, there was a failure to recognize the correlation between plant breeding and plant-water relations. USAID and YARG desires for quick, visible results caused them to be highly critical of a standard, recognized and reliable approach to plant improvement. Annual summaries of research results were requested by USAID in 1979, and their appearance probably helped to increase the level of understanding but at a late date in the project life.

Frequent changes in AID/Washington and USAID/Yemen personnel and lack of a permanent Agricultural Development Officer in Yemen for many months during 1979 and 1980 exacerbated the communication problem. Unrealistic goals and assumptions and overly-optimistic scheduling in the Project Paper and Project Agreement created false expectations among Yemen officials. Frequent changes in YARG personnel and consequently policies and priorities viz-a-viz the sorghum and millet project contributed to the lack of knowledge about plant improvement. Inadequate communication with YARG, partly because of the University of Arizona team's inability to speak or supply reports in Arabic, was a factor. USAID/Yemen opted for a low profile for the Project in Yemen and failed to use Project Administrators to help communicate with the Ministry of Agriculture officials, especially during the first two years of the contract.

2.3.3.2 Research Facilities

The highly variable environment of Yemen demands that research be done in permanent, representative locations on representative soils. Lacking such a base of operations, no plant improvement program can attain national proportions.

Facilities for conducting meaningful plant improvement research were inadequate from the start. They were so poor that the validity of previous research had to be questioned. Decisions on the choice of existing and new sites were made on a political basis with essentially no technical input.

Attempts were made to improve the facilities at Bir Al Gohum (Sana'a) and at Al Jaroubah and much was accomplished. A year was required to learn how to grow crops under local conditions, and much work was needed to make the stations operational and research results meaningful. The top meter of soil at Bir Al Gohum was sold before site development started. Moreover, by the end of the project there was little doubt that the Bir Al Gohum station would be lost to urbanization and that the Al Jaroubah station would be devoted solely to horticulture.

Millet research was not given much priority for lack of a suitable site to carry it out. Millet is not a major crop at higher altitudes such as in Sana'a.

2.3.3.3 Counterparts and Participants

Trained personnel were extremely scarce in Yemen, and YARG was able to supply neither enough counterparts at all levels for the University of Arizona team nor candidates for academic participant training. Hence there was essentially no progress in that category of training from the YARG point of view. The YARG would not permit training of project employees who were not 100 percent Yemeni which eliminated several potential candidates. This meant that the work to be accomplished was limited in general to that which could be done by the University of Arizona team members themselves with a crew of local, non-Yemeni. Thus there was no multiplier effect from our efforts. Furthermore the long term impact of the project is lessened because there was little residual left after the departure of the University of Arizona team. The counterpart relationship was particularly ineffective during the latter part of the project after the departure of Yahya Shuga.

2.3.3.4 YARG Characteristics

The Government of the Yemen Arab Republic had extremely limited financial and human resources and a low institutional capability for agricultural research. The agricultural sector received less attention and emphasis than others, and the YARG commitment to this project never was strong. Hence the YARG absorptive capacity or ability to benefit from the project was limited.

Technically qualified people were in short supply at all levels of YARG: administrative, professional, and support. A high turnover among government employees and officials resulted in rapidly changing priorities and policies. An example is the rapid advancement of Yahya Shuga from project counterpart to Director of Agriculture for the Sana'a Governate. This move drastically reduced his influence on the understanding of the University of Arizona Project within the Ministry of Agriculture. Support for programs with long term goals was consequently difficult to maintain, and many decisions, such as where to locate the research stations, were too heavily influenced by political factors.

The YARG had difficulty in paying salaries and other support costs. It had a limited ability to supply land for research stations at appropriate sites.

2.3.3.5 Yemen Conditions

Working in Yemen has always been challenging; during the years of this project (1977-1981) it was extremely demanding. The YARG had limited control outside of Sana'a, and border skirmishes with South Yemen were frequent. President Al Hamdi of the Republic was assassinated in October of 1977, just a few days after visiting the research station at Bir Al Gohum. President Al Ghashmi was assassinated in June of 1978. Relations with local officials at Al Jaroubah were highly volatile, and at one point in 1980 the University of Arizona team had to leave the site.

World-wide political unrest following the taking of U. S. hostages in Iran resulted in restrictions by the State Department on travel to Yemen from December, 1979 to May, 1980, further complicating the situation. Some families were evacuated. Travel within the country was difficult, and the University of Arizona team was harassed by local, often unofficial, militia.

A lack of infrastructure delayed even the simplest of tasks. Such actions as clearing shipments through customs were exceedingly time consuming. Local contractors were unavailable, and University of Arizona professionals ended up doing things that should have been done by others less qualified, and that diluted the research efforts. Escalating costs resulted in overruns on construction activities. Our inability to communicate in Arabic limited our coping with these conditions.

2.3.3.6 USAID Administration

During the life of the Project the USAID/Yemen mission was almost continuously understaffed. There was no permanent Agricultural Development Officer for long periods, and support staff positions also were vacant. Frequent personnel changes made continuity of purpose difficult; each new person brought new ideas and biases.

The USAID project support system was barely functional. Throughout the Project, the lack of vehicles for personnel transport to and from the research station and outreach trials was a limiting factor. Beginning in 1979 and continuing for the duration of the project, short-term assignments were

restricted by USAID because of a lack of vehicles which USAID/Sana'a had agreed to supply. Even the AID/Washington commitment to the whole Yemen program was questioned at one point by USAID mission personnel.

There were many unnecessary delays in getting AID/Washington or USAID/Yemen approval for contract modifications. The initial start up was not timely with respect to the cropping season because of delays in the contracting process. The contract was signed by AID/Washington in January, 1977. Personnel arrived in-country in March, 1977 to begin planting in May. Approvals of replacement personnel were delayed for 6 months in 1979. Final amendment of the contract to include names of replacement personnel occurred 16 months after initial nominations. Approval of short-term assignments was so slow that some had to be cancelled. Contract extension and funding increments were not expedited, and frequently The University of Arizona was unable to operate effectively for lack of a valid contract. A request for a change in reporting procedures was delayed so long that the response finally received was, "The contract is terminating so the change in unnecessary." (See Section 4.5 for dates of specific actions.)

Some changes in the Project were made unilaterally by USAID. The IVS technicians were discontinued at a time when they were needed greatly. Project progress suffered as a result. Even when changes were agreed on, there was no follow through to make them a matter of record. In mid-1979 The University of Arizona was asked to take over all logistic support for its activities but was not given contractual authority or funds to implement this request until mid-1980.

The overall USAID program was in a state of flux. Priorities were changing rapidly, sometimes daily, and often in response to YARG requests. The USAID commitment to develop the Al Jaroubah station was made with little consideration of the problems involved and the effect on the plant improvement aspects of the project.

Resources of the sorghum and millet Project were diverted to support other USAID projects. University of Arizona team members were asked to take on new responsibilities at Al Jaroubah and to support the horticulture project. Project vehicles, offices, shops, equipment and technicians were used to support other projects.

2.3.3.7 Evaluation

The AID system of projects includes a methodology for evaluation as the Project proceeds. In reality, evaluation begins before the field activities are initiated and continues throughout the life of a project. In this case, because the sorghum and millet project was the only viable agricultural project in the USAID/Yemen portfolio for a considerable time, it received unusual scrutiny.

There are several unfortunate aspects of that intense examination. The project design team established some evaluation criteria which were unsuitable and perhaps unfair to the project. (They are listed in Section 2.3.2.) Often there were no baseline data for the criteria, and the project (contract) had no mechanism to get any. There is a tendency to evaluate a project against the Project Paper which spawns it and to blame the contractor for any failure to measure up. The University of Arizona contract was a subset of the Project Paper and did not include some features of the Project Paper and some of those it did include were inappropriate. However, once approved, the Project Paper tends to become inviolable.

Thus there was an inflexibility imposed on the system which allowed no recognition of changing priorities in USAID or YARG. Furthermore, there was little value placed on learning during the Project and thereby improving it through change. Those changes that were agreed on and made, somehow did not become a matter of permanent record, and with later personnel changes were forgotten. Evaluators considered only the official documents.

The AID project system has a momentum of its own and inertia in the system inhibits change. Often it is easier, but certainly less efficient and effective, to let a project "crash" and be cancelled than to modify and continue it, regardless of its good attributes. A few months (or years) later the process will be repeated because the problems have not been solved.

3. Conclusions and Recommendations

The University of Arizona National Sorghum and Millet Crop Improvement Project made substantial progress. Significant accomplishments were made in initiating a comprehensive sorghum improvement program for Yemen; lesser accomplishments were made in millet improvement.

The agricultural station at Sana'a was modified to provide more consistent results from research tests. A second station was established and put into operation at Al Jaroubah. Unfortunately, changes in the priorities of the Ministry of Agriculture and USAID mean that no follow-on project for sorghum and millet improvement is planned, that the station at Al Jaroubah will be used for horticulture, not sorghum and millet improvement, and that the station at Sana'a will be lost to urbanization.

We recommend that a sorghum and millet improvement project be re-established with a long-term commitment required in crop improvement activities. To make these activities successful the Government of Yemen must provide at least one permanent site for sorghum and millet improvement research.

As a result of the University of Arizona Project there are now a number of sorghum lines, adapted to Yemeni conditions which in preliminary tests yield nearly twice as much as local checks. These superior lines exhibit a great deal of genetic variability and may be suitable for a wide variety of Yemeni environments.

We recommend that the 1981 planting plan be followed and that superior lines be increased for release at the research stations of cooperating donor agencies. The detailed 1981 planting plan is given in Section 4.1.7. Minimal continuity requires that this planting plan be followed for 1981 and that the results of the 1977, 1978, 1979 and 1980 seasons be used in future sorghum improvement activities. Lack of continuity will result in loss of the germplasm (seeds) which have been developed under USAID sponsorship through losses to pests and decreasing seed viability.

A major technical conclusion of the sorghum improvement activities was that the vast majority of sorghum types bred for situations outside of Yemen did not produce well in comparison to the local Yemeni varieties. Given this result, University of Arizona research was oriented toward creating and selecting varieties derived from superior local or adapted types.

The Yemen Sorghum Collection of 4,500 indigenous types of sorghum accumulated by The University of Arizona is a significant resource for future

sorghum improvement work in Yemen as well as other countries in the arid tropics. Continued support to The University of Arizona would speed the entry of Yemen Sorghum Collection materials into the World Sorghum Collection. Requests for Yemen sorghum materials should be addressed to the University of Arizona coordinator for the Title XII Sorghum and Millet CRSP.

In spite of the fact that USAID was kept informed of Project activities at all times and that all reports (bi-weekly and semi-annual) were issued on time, there was a lack of effective oral and written communication between The University of Arizona, USAID and the Ministry of Agriculture. During 1977, 1978 and into 1979 USAID assumed full responsibility for administrative contact with the Ministry of Agriculture. The University of Arizona Chief of Party was allowed to interact with the technical section of the Ministry of Agriculture, but since the staff was expatriate this communication was not effective. This resulted in misunderstandings of the Project accomplishments and methods.

In the future, a closer relationship should be established between the contractor and the Ministry of Agriculture. Several new features in the interaction between the contractor and USAID will substantially improve both the interactions between the parties and the success of the Project. There needs to be a mechanism to provide flexibility in meeting Project objectives. The Collaborative Assistance Mode would contribute to this flesibility. USAID, YARG, and a group of Yemeni farmers should establish a Project Planning Group to assure integration with local and national goals and needs.

The follow-on sorghum improvement project should continue the practice of frequent reporting. In addition, annual reports should begin with an overview of results and be written to be directly useful to USAID and Ministry of Agriculture managers.

Although The University of Arizona was not funded to provide training of Yemeni outside of Yemen, all parties had high expectations for the evolution of training aspects of the Project. The major constraint to the training program was that no Yemeni were identified as being available for the program.

The University of Arizona investigated training alternatives. We received responses from six non-U. S. institutions. None provided the combination of short-term agricultural training in Arabic believed to be necessary. In response to this lack, The University of Arizona has prepared a Training

Plan which details a method for providing Yemeni students with practical agricultural training in Arabic language. It is appended in Section 4.1.6. Emphasis on training needs to be shifted to more formal educational opportunities. Candidates for participant training need to be identified by the Government of Yemen. Participant training should be more closely integrated with other Project activities. An effective method for insuring integration is to make training contract-funded.

The University of Arizona team members contributed significantly to other components of the total U. S. Development Assistance Program in Yemen at the request of USAID. Examples include designing irrigation system for the horticulture project, providing culled sorghum seed to the poultry project as feed, and collecting (surveying) insects to allay the fear of a locust invasion in the Sana'a region.

As a result of the University of Arizona Project, the current generation of USAID projects can make use of the research facilities established at Al Jaroubah and Sana'a and the trained technicians. This should significantly decrease start-up time for these new projects and increase their rate of progress toward their goals.

Sorghum and millet improvement is a long term activity in Yemen as it is elsewhere. Twenty years may be required to achieve changes of great magnitude in the productivity of grains. Sorghum and millet are uniquely adapted to non-irrigated productionin arid regions and will continue to be mainstays in the Yemeni diet. In this light, the sorghum and millet improvement program was a valid activity for development projects in Yemen and will be a valid emphasis in the future.

A reconstituted sorghum and millet improvement program should be expanded to include more emphasis on the social and economic aspects of grain production. A farming systems approach and extension activities would contribute substantially to meeting new project goals.

More detailed recommendations on insect control and continuing activities at Al Jaroubah are included in Section 4.1.4.

4. Appendices

The final section of this report is designed to provide additional detail in support of the main body of the document. Section 4.1 contains technical data derived from the University of Arizona team activities. Section 4.2 is a list of Project personnel. Section 4.3 lists the reports generated by the project. Section 4.4 is a fiscal overview. Section 4.5 presents the project history in terms of benchmark activities.

4.1 Technical Data

Various summaries of technical information produced by the University of Arizona team are included in the following sections for the reader who wishes additional information.

Section 4.1.1 lists the plant improvement tests carried out each year during the Project. Section 4.1.2 explains the technical terms used in describing the Project research. It is reprinted from the 1979 Annual Report. Section 4.1.3 is the coding and format description of the Yemen Farmer Survey designed by Professor Nasser Aliqui of the University of Sana'a in cooperation with USAID and the University of Arizona team. Section 4.1.4 presents abbreviated recommendations for insect pest control and for follow-on activities at the Al Jaroubah Research station. Section 4.1.5 lists, for quick reference, the known crop pests of Yemen. Section 4.1.6 is the University of Arizona training Program for Yemeni Agriculturists including institutions contacted for information on their training programs. Section 4.1.7 is the University of Arizona Planting Plan for the 1981 season.

4.1.1 Overview of Plant Improvement Tests

Table 4.1 allows a gross comparison of 1977-1980 tests with those 1976 tests which were prior to the University of Arizona Project in Yemen. The tests carried out each year are described in terms of the number of entries tested, the replications, the rows per plot, numbers of rows and brief descriptive comments.

Tables 4.2 through 4.6 are descriptions of tests made each year. Test numbers, names, crop types and numbers of entries, replications, rows and plots are delineated.

Table 4.1. Overview of Crop Improvement Activities

Year	Number of Tests	Number of Entries Tested	Number of Rows
1977	30	2,474	5,331
1978	19	1,608	2,874
1979	18	1,435	3,310
1980	23	1,656	5,522
Total	90	7,173*	17,037
4 year average	22	1,793	4,259
1976 tests	38	1,379	3,323

*This is an overestimate since a single entry could be in more than one test and many entries were advanced in successive years.

Table 4.2. University of Arizona 1977 Field Experiments at Sana'a

Test Number	Test Name	Number of Entries	Number of Replications	Number of Plots	Rows/ Plot	Number of Rows	Crop Type	Field
77074	Early-Preliminary Yield Test	126	2	252	1	252	Sorghum	B
77075	Late-Preliminary Yield Test	113	2	226	1	226	Sorghum	B
77076	Early-Advanced Yield Test	85	4	340	1	340	Sorghum	A
77077	Late-Advanced Yield Test	90	4	360	1	360	Sorghum	A
77078	Hybrid-Advanced Generation Yield Depression Test	20	4	80	2	160	Sorghum	B
77079	Pest Resistance Nursery	24	4	96	4	384	Sorghum	B
77080	Experimental Hybrid Yield Test	49	3	1	1	147	Sorghum	B
77081	Experimental Hybrid Observation Test	82	1	82	1	82	Sorghum	B
77082	Head-to-Row Early	345	1	345	1	345	Sorghum	E
77083	Head-to-Row Late	342	1	342	1	342	Sorghum	E
77084	Miscellaneous Preliminary Yield Test	155	2	310	1	310	Sorghum	B
77085	Demonstration	77	1	77	2+	146	miscellaneous field crops	A-B
77086	Date-of-Planting Test	24	4	96	4	384	Sorg. Mill.	A
77087	IPMAT #2 International Pearl Millet Adaptation 3, Test #2	22	3	66	1	66	Millet	E

Table 4.2 (Continued)

Test Number	Test Name	Number of Entries	Number of Replications	Number of Plots	Rows/ Plot	Number of Rows	Crop Type	Field
77088	Nursery	664	1	664	1+	664	Sorghum	A
77089	International Sorghum Cooperative Nursery	34	3	102	1	102	Sorghum	E
77090	East African Maize Variety Trial	27	2	54	3	162	Corn	E
77091	Sana-Yield Test	7	4	28	1	28	Sorghum	B
77092	Millet-Yield Test	44	2	88	1	88	Millet	E
77093	F_3 Selections	76	1	76	1	76	Sorghum	A
77094	Sorghum Yield Test (from UNDP Taiz)	8	3	24	1	24	Sorghum	E
77095	Millet Yield Test (from UNDP Taiz)	4	3	12	1	12	Millet	E
77096	Sudan Grass	28	1	28	2	56	Sudan Grass	E
	Marana Millet Composite	28	1	28	2	56	Millet	A
	Sorghum Composite					101	Sorghum	A
	Sorghum Composite					24	Sorghum	B
	Big-Headed Millet Population					60		
	Snowflake Fertile + Sterile Random Mating					180		
	NP3R Dry Steriles (Sorghum)					85		
	Senegal Millet Population					69		

1977 = 30 Tests = Total entries = 2474

Table 4.3. University of Arizona 1978 Field Experiments at Sana'a

Test Number	Test Name	Number of Entries	Number of Replications	Rows Per Plot	Total Field Rows	Crop Type
78097	Head-to-Row	328	1	1	328	Sorghum
78098	Head-to-Row	251	1	1	251	Sorghum
78099	Head-to-Row	352	1	1	352	Sorghum
78100	Head-to-Row	158	1	1	158	Sorghum
78101	Preliminary Yield Test	56	1	2	112	Sorghum
78102	Advanced Yield Test	36	4	2	288	Sorghum
78103	Elite Yield Test	30	4	2	240	Sorghum
78104	International Sorghum Disease and Insect Nursery	37	2	1	74	Sorghum
78105	National Cooperative Sorghum Yield Trial	5	3	3	45	Sorghum
78106	National Cooperative Sorghum Observation Nursery	21	1	3	63	Sorghum
78107	National Cooperative Maize Yield Trial	6	3	3	54	Maize
78108	National Cooperative Maize Observation Nursery	18	1	3	54	Maize
78109	National Cooperative Pearl Millet Yield Trial	3	3	3	27	Pearl millet
78110	National Cooperative Pearl Millet Observation Nursery	10	1	3	30	Pearl millet
78111	F_4 Generation of Populations	76	1	1	76	Sorghum
78112	Advanced Hybrid Generation Populations	15	1	1-10	28	Sorghum
78113	Nursery	158	1	2	316	Sorghum

Table 4.3 (Continued)

Test Number	Test Name	Number of Entries	Number of Replications	Rows Per Plot	Total Field Rows	Crop Type
78114	1978 International Food Grain Sorghum Yield Trial	30	3	3	270	Sorghum
78115	Early Maturity and Tall Hybrid Yield Test	18	3	2	108	Sorghum
		1608			2874	

Table 4.4. University of Arizona 1979 Field Experiments at Sana'a

Test Number	Test Name	Number of Entries	Number of Replications	Rows Per Plot	Total Field Rows	Crop Type
79001	Head-to-Row	447	1	1	447	Sorghum
79002	Head-to-Row	498	1	1	498	Sorghum
79003	Elite Yield Test	33	4	2	264	Sorghum
79004	Advanced Yield Test	16	4	2	128	Sorghum
79005	Preliminary Yield Test	210	4	1	840	Sorghum
79006	Short Grain Yield Trial	42	3	2	252	Sorghum
79007	Sorghum X Sudangrass Green Forage Test	6	4	4	96	--
79008	Forage Sorghum Grain and Forage Test	6	4	4	96	Sorghum
79009	Sorghum X Sudangrass and Hybrid Forage Sorghum Demonstration Test	53	1	2	106	Sorghum X Sudangrass Sorghum
79010	Nursery and Increase Plots	68	1	2	136	Sorghum
79011	Head Smut Control Test	5	4	4	80	Sorghum
79012	Sesamia (Stem Borer) Control	4	4	7	112	Sorghum
79013	National Cooperative Sorghum Yield Test	(No test seed distributed)				--
79014	National Cooperative Sorghum Observation Test	18	7	2	36	Sorghum
79015	National Cooperative Maize Yield Test	9	3	3	81	Maize
79016	National Cooperative Maize Observation Test	14	1	3	42	Maize
79017	National Cooperative Pearl Millet Yield Test	6	4	4	96	Pearl millet
79018	National Cooperative Pearl Millet Observation Test	(No test seed distributed)				

Table 4.5. University of Arizona 1980 Field Experiments at Sana'a

Test Number	Test Name	Number of Entries	Number of Replications	Plot Size	Total Field Rows	Crop Type
80-001	Head Rows	450	1	0.75x5m	450	Sorghum
80-002	Preliminary Yield Trial I	256	2	0.75x5m	512	Sorghum
80-003	Preliminary Yield Trial II	284	2	0.75x5m	568	Sorghum
80-004	Early Maturity Trial	22	2	0.75x5m	44	Sorghum
80-005	Short Grain Field Trial	88	3	1.50x5m	528	Sorghum
80-006	Advanced Yield Trial	54	3	1.50x5m	324	Sorghum
80-007	F_1 Populations	71	1	0.75x5m 1.50x5m 2.25x5m	179	Sorghum
80-008	Male parents and Observation Test	54	1	1.50x5m	54	Sorghum
80-009	Elite Yield Test	31	3	2.25x5m	279	Sorghum
80-010	Out-Reach Test	50	2-3	1.5x5m	1000	Sorghum
80-011	Seed Multiplication	8	4	5.25x5m	224	Sorghum
80-012	Maize Observation Test	24	3	2.25x5m	216	Maize
80-013	International Sorghum Pre-Field Trial I	20	3	1.50x5m	120	Sorghum
80-014	International Sorghum Pre-Field Trial II	45	3	1.50x5m	270	Sorghum
80-015	Nat. Coop. Maize Observation Test	Seed for these two tests was not received from UNDP				--
80-016	Nat. Coop. Maize Pearl Millet Observation Test					
80-017	Pearl Millet Yield Nursery	9	3	1.50x5m	54	Pearl millet
80-018	Inter. Pearl Millet Adap. Trial	21	3	1.50x5m	126	Pearl millet
80-019	Inter. Pearl Millet Adap. Trial-78	21	3	1.50x5m	126	Pearl millet

Table 4.5 (Continued)

Test Number	Test Name	Number of Entries	Number of Replications	Plot Size	Total Field Rows	Crop Type
80-020	Inter. Pearl Millet DM Nursery	50	2	0.75x5m	100	Pearl millet
80-021	Sorghum Introductions	54	2	1.50x5m	216	Sorghum
80-023	Inter. Pearl Millet Adap. Trial 79(I)	22	3	0.75x5m	66	Pearl millet
80-025	Inter. Pearl Millet Adap. Trial 79(II)	22	3	0.75x5m	66	Pearl millet

Table 4.6. University of Arizona 1980 Field Experiments at Al Jaroubah

Test Number	Test Name	Number of Entries	Replication	Plot Size	Total Field Rows	Crop
AJ80-001	Head Rows	450	1	0.75x5m	450	Sorghum
AJ80-002 (OR80-09)	Outreach Test	50	2	1.5x5m	100	Sorghum
AJ80-003	Response Fertilizer	1	1			Maize
AJ80-004	Dwarf Sorghum Trial	1	1			Sorghum
AJ80-005	Observational Trial					Sesame
AJ80-006	Observational Trial					Cotton

4.1.2 Research Terminology

Following is a listing of various data that were collected from among the research materials being tested with a description of the data and how they were collected and calculated.

1. Pedigree: This is a plant breeding term generally referring to the cross or test and plot from which a single plant or genotype was selected to thereafter have its own identity. It may also be a number from a germplasm collection.

2. Source: Refers to the project test and plot from which actual seed was obtained for this particular planting or the name of the outside source.

3. Stand Count: The actual number of hills that grew in a plot expressed as a percent of the total number of hills that were planted in the plot. A hill with only one surviving plant was counted. These counts were made after thinning.

4. Days to 50% bloom: When the heads had emerged from the boot and were starting to bloom the date was recorded when all heads had bloomed half way down (half of the florets in the row had bloomed). This simple situation never really existed because of a range of beginning and ending of blooming among plants in the plot. An educated guess had to be made as to when the entire plot was about half way through blooming.

Considerable experience with sorghum is necessary to correctly estimate this character under these conditions.

The days to this bloom date are calculated from the date of planting in moisture or the date of first irrigation if planted dry.

5. Height: For general evaluation and comparison purposes in sorghum this is simply the average distance from the ground level to the top of the head of typical plants in the plot. Considerable judgment may be needed to estimate this character under these conditions of considerable variation among plants within plots.

The value of this character is usually expressed in centimeters.

6. Agronomic Rating of the Plant and of the Head: The average or typical plant in a plot was usually rated on a scale of 1 to 3 with a score of 1 being equal to "good," 2 equal to "average" and 3 being "poor." These evaluations are professional and experienced comparisons to the typical plant desired and needed by the Yemeni farmer. The heads on an average or typical

plant in a plot was visually rated in a similar manner on a similar scale but independent of the evaluation rating given to the plant.

These evaluations by experienced personnel are necessary to initially select experimental materials with potential for further testing. There is no other way to initially sort out promising genotypes for actual testing. There is a high degree of correlation of these visual ratings with actual grain and forage production values with experienced personnel.

7. Lodging: Just prior to their harvest for grain all plots were evaluated for lodging. These evaluations were expressed in a percent value composed of a combination of a value for number of lodged plants combined with degrees of lodging. It is necessary that the same person be experienced and do all of the evaluations since estimates would differ by individuals.

8. Grain Production: The grain was allowed to mature and dry down on the plant in the field plot in a normal manner. However, due to continual bird problems we did not delay harvest much beyond hard dough stage of development. There was variation in maturity among plants within plots so some heads were high in moisture. The harvested plots were hung up to dry under an open sided roofed area.

Bird watch personnel during daylight hours were very successful in keeping down bird damage of the plots. Most plots had little or no bird damage at all. Plot yields were adjusted for these estimated bird damages. Estimating bird damage correctly takes years of experience. The new or inexperienced researcher will always over-estimate bird damage by several times the real amount. This results in plots with the greatest bird damage always coming up with the greatest adjusted yields. Many years of experience are necessary to properly estimate this damage. It is necessary for uniformity of data that the same individual do all estimating, at least within tests.

The harvesting of the heads from each plot was done by hand. Each test was harvested separately. The total time taken to hand harvest the grain of <u>all</u> of the tests for 1978 was only about 3 days. The actual harvesting was spread out over a greater period of time because of differences in planting dates and general maturities among tests. By hand harvesting carefully every head was harvested. Nothing was lost. This sort of accuracy is not possible with machine harvesting.

As reported earlier the sacks of heads were allowed to dry down to an air dry condition suitable for threshing. No suitable mechanized threshing

equipment was available on the project for threshing these yield heads. The equipment available cracked or broke much of the local type seed which is much larger than U. S. type sorghum grain for which all of the threshers had been developed. The greatest problem was the loss of grain during threshing by throwing it out of the machine and not fully threshing out of the glumes. Threshing of the grain from the glumes by pounding by sticks on the closed sacks of dry heads was very quick and efficient with absolutely no grain loss, or cracked or broken grain. The chaff was gently fanned from the grain and then the grain was weighed for plot yield of grain.

These plot grain yields were then corrected for any percent bird damage followed by correction for percent stand count less than 100%. The resulting plot grain yield then reflected the theoretical performance of a full plot undamaged by birds.

These plot yields of grain were then converted to yields per hectare. Other grain yield values for individual genotypes were then calculated relative to height and days to maturity.

The current market values of grain by the kilo were checked in several locations and monetary values of production per hectare for each genotype were calculated.

9. Forage Production: The sorghum plant itself is of equal if not greater value than the grain in the Yemen economy. Consequently it is necessary to evaluate the experimental genotypes in the advanced or elite tests for actual forage production as well as grain production. Traditionally much of the sorghum was harvested as follows: first the leaves except for the top 2 or 3 were stripped from the stalk near soft dough stage and sold for feed. Second the heads were harvested by hand at maturity. Third the stalks were cut off at or near ground level, bundled and sold for feed or fuel. Fourth and last the stubble was sometimes plowed up and used for fuel. Currently the great on-farm labor shortage has eliminated the labor intensive leaf stripping on many farms. Most of the bundles of sorghum stalks sold in the suks (markets) have all dried leaves attached. Because of the great labor requirement to strip leaves this project also eliminated this step.

Immediately after grain harvest the plants in each plot of the advanced yield test were cut and weighed green in the field. A forage sample of 4 or 5 typical complete plants were immediately taken from the harvested plot material cut up, put in a sack and reweighed green as a sample. This representative

sample was hung up to completely air dry under roof and then reweighed dry. This drop in moisture for the sample (less the sack) gave us a percent dry matter which was applied to the original total plot yield of green material to give a forage dry matter production figure. This initial plot dry matter production figure was corrected for percent stand less than 100% to bring it up to a theoretical full plot.

These plot yields of forage per hectare were then converted to yields per hectare. Other forage yield values for individual genotypes were then calculated relative to height and days to maturity.

The current local market values of bundles of dry sorghum stalks were obtained by having Yemeni employees buy several bundles at different market locations. These bundles in the Sana'a area usually have the dried leaves fairly intact. There has not been enough labor at the farm level to strip leaves as was formerly done. The bundles were air dried like those from the plots and monetary values per kilo of dry matter were calculated. Sorghum stalks were selling as follows:

Dry sorghum stalks = YR .75 per kilo
= $ .1654 per kilo

Sorghum grain was selling as follows:

Sorghum grain = YR 1.4 per kilo
= $ .3087 per kilo
= $ 14.00 per 100 pound

10. Grain Test Weight: A measure of the quality of grain produced by each genotype was obtained by measuring their test weights in kilos per hectoliter.

4.1.3 Yemen Farmer Survey

This survey was designed by Professor Nasser Aliqui of the University of Sana'a in conjunction with USAID and the University of Arizona team (Table 4.7). Dr. Aliqui and his students administered the survey to about 600 Yemeni farmers. Questions about the results should be directed to Dr. Aliqui.

4.1.4 Miscellaneous Recommendations

Section 4.1.4.1 presents recommendations for Insect Pest Control which were formulated by Dr. Tuttle while on temporary assignment with the University

Table 4.7. Coding and Format for Yemen Farmer Survey

Card No. Column No.	Format	Variable Name: Question and Possible Answers
1:11	F1.0	SMPLANT: Have you planted sorghum or millet last year? (1) sorghum (2) millet (3) both (4) neither
1:16-20	F5.2	FMAREA: Farm area? (ha.) (99) N.R.
1:21	F1.0	FMEL: Farm elevation (meters) (1) < 500 (2) 500-1000 (3) 1000-1500 (4) 1500-2000 (5) 2000-2500 (6) 2500-3000 (7) > 3000 (8) N.R.
1:22	F1.0	ACCESS: (1) paved road (2) gravel road (3) unimproved road (4) not accessible by vehicle (5) N.R.
1:23	F1.0	TENURE: Land-tenure (1) own (2) rent/kind (3) rent/cash (4) own/rent (5) waqf (religious endowment) (6) own & waqf (7) N.R.
1:24	F1.0	NOSVAR: Number of sorghum varieties grown? (9) N.R.
2:11-15	F5.2	AS 1111: area (ha.) sorghum variety 1111 (white, open, straight, < 2 m.)
2:16-20	F5.2	AS 1112: area (ha.) sorghum variety 1112 (white, open, straight, > 2 m.)
2:21-25	F5.2	AS 1121: area (ha.) sorghum variety 1121 (white, open, curved, < 2 m.)
2:26-30	F5.2	AS 1221: area (ha.) sorghum variety 1221 (white, closed, curved, < 2 m.)
2:31-35	F5.2	AS 1222: area (ha.) sorghum variety 1222 (white, closed, curved, > 2 m.)
2:36-40	F5.2	AS 2111: area (ha.) sorghum variety 2111 (red, open, straight, < 2 m.)
2:41-45	F5.2	AS 2112: area (ha.) sorghum variety 2112 (red, open, straight, > 2 m.)
2:46-50	F5.2	AS 2122: area (ha.) sorghum variety 2122 (red, open, curved, > 2 m.)
2:51-55	F5.2	AS 2221: area (ha.) sorghum variety 2221 (red, closed, curved, < 2 m.)
2:56-60	F5.2	AS 2222: area (ha.) sorghum variety 2222 (red, closed, curved, > 2 m.)
2:61-65	F5.2	AS 3221: area (ha.) sorghum variety 3221 (yellow, closed, curved, < 2 m.)
2:66-70	F5.2	AS 3222: area (ha.) sorghum variety 3222 (yellow, closed, curved, > 2 m.)
2:71-75	F5.2	AS 4111: area (ha.) sorghum variety 4111 (grb, open, straight, < 2 m.)

Table 4.7 (Continued)

Card No. Column No.	Format	Variable Name: Question and Possible Answers
2:76-80	F5.2	AS 4112: area (ha.) sorghum variety 4112 (grb, open, straight, > 2 m.)
3:11	F1.0	MS 1111: months to maturity sorghum variety 1111 (0) N.A.
3:12	F1.0	MS 1112: months to maturity sorghum variety 1112 (0) N.A.
3:13	F1.0	MS 1121: months to maturity sorghum variety 1121 (0) N.A.
3:14	F1.0	MS 1221: months to maturity sorghum variety 1221 (0) N.A.
3:15	F1.0	MS 1222: months to maturity sorghum variety 1222 (0) N.A.
3:16	F1.0	MS 2111: months to maturity sorghum variety 2111 (0) N.A.
3:17	F1.0	MS 2112: months to maturity sorghum variety 2112 (0) N.A.
3:18	F1.0	MS 2122: months to maturity sorghum variety 2122 (0) N.A.
3:19	F1.0	MS 2221: months to maturity sorghum variety 2221 (0) N.A.
3:20	F1.0	MS 2222: months to maturity sorghum variety 2222 (0) N.A.
3:21	F1.0	MS 3221: months to maturity sorghum variety 3221 (0) N.A.
3:22	F1.0	MS 3222: months to maturity sorghum variety 3222 (0) N.A.
3:23	F1.0	MS 4111: months to maturity sorghum variety 4111 (0) N.A.
3:24	F1.0	MS 4112: months to maturity sorghum variety 4112 (0) N.A.
3:26-30	F5.2	AMIL: area in millet (ha.) (99) N.R.
3:31	F1.0	MMIL: months to maturity of millet (0) N.A.
3:36-38	F3.0	PC 1111 RF: % variety 1111 rainfed (555) N.R. (999) N.A.
3:39-41	F3.0	PC 1111 SP: % variety 1111 spate-irrigated (555) N.R. (999) N.A.
3:42-44	F3.0	PC 1111 ST: % variety 1111 stream-irrigated (555) N.R. (999) N.A.
3:45-47	F3.0	PC 1111 W: % variety 1111 well-irrigated (555) N.R. (999) N.A.
3:51-53	F3.0	PC 1112 RF: % variety 1112 rainfed (555) N.R. (999) N.A.
3:54-56	F3.0	PC 1112 SP: % variety 1112 spate-irrigated (555) N.R. (999) N.A.
3:57-59	F3.0	PC 1112 ST: % variety 1112 stream-irrigated (555) N.R. (999) N.A.
3:60-12	F3.0	PC 1112W: % variety 1112 well-irrigated (555) N.R. (999) N.A.
3:66-68	F3.0	PC 1121 RF: % variety 1121 rainfed (555) N.R. (999) N.A.

Table 4.7 (Continued)

Card No. Column No.	Format	Variable Name: Question and Possible Answers
3:69-71	F3.0	PC 1221 SP: % variety 1121 spate-irrigated (555) N.R. (999) N.A.
3:72-74	F3.0	PC 1121 ST: % variety 1121 stream-irrigated (555) N.R. (999) N.A.
3:75-77	F3.0	PC 1121 W: % variety 1121 well-irrigated (555) N.R. (999) N.A.
4:11-13	F3.0	PC 1221 RF: % variety 1221 rainfed (555) N.R. (999) N.A.
4:14-16	F3.0	PC 1221 SP: % variety 1221 spate-irrigated (555) N.R. (999) N.A.
4:17-19	F3.0	PC 1221 ST: % variety 1221 stream-irrigated (555) N.R. (999) N.A.
4:20-22	F3.0	PC 1221 W: % variety 1221 well-irrigated (555) N.R. (999) N.A.
4:26-28	F3.0	PC 1222 Rf: % variety 1222 rainfed (555) N.R. (999) N.A.
4:29-31	F3.0	PC 1222 SP: % variety 1222 spate-irrigated (555) N.R. (999) N.A.
4:32-34	F3.0	PC 1222 ST: % variety 1222 stream-irrigated (555) N.R. (999) N.A.
4:35-37	F3.0	PC 1222 W: % variety 1222 well-irrigated (555) N.R. (999) N.A.
4:41-43	F3.0	PC 2111 RF: % variety 2111 rainfed (555) N.R. (999) N.A.
4:44-46	F3.0	PC 2111 SP: % variety 2111 spate-irrigated (555) N.R. (999) N.A.
4:47-49	F3.0	PC 2111 ST: % variety 2111 stream-irrigated (555) N.R. (999) N.A.
4:50-52	F3.0	PC 2111 W: % variety 2111 well-irrigated (555) N.R. (999) N.A.
4:56-58	F3.0	PC 2112 RF. % variety 2112 rainfed (555) N.R. (999) N.A.
4:59-61	F3.0	PC 2112 SP: % variety 2112 spate-irrigated (555) N.R. (999) N.A.
4:62-64	F3.0	PC 2112 ST: % variety 2112 stream-irrigated (555) N.R. (999) N.A.
4:65-67	F3.0	PC 2112 W: % variety 2112 well-irrigated (555) N.R. (999) N.A.
5:11-13	F3.0	PC 2122 RF: % variety 2122 rainfed (555) N.R. (999) N.A.
5:14-16	F3.0	PC 2122 SP: % variety 2122 spate-irrigated (555) N.R. (999) N.A.

Table 4.7 (Continued)

Card No. Column No.	Format	Variable Name: Question and Possible Answers
5:17-19	F3.0	PC 2122 ST: % variety 2122 stream-irrigated (555) N.R. (999) N.A.
5:20-22	F3.0	PC 2122 W: variety 2122 well-irrigated (555) N.R. (999) N.A.
5:26-28	F3.0	PC 2221 RF: % variety 2221 rainfed (555) N.R. (999) N.A.
5:29-31	F3.0	PC 2221 SP: % variety 2221 spate-irrigated (555) N.R. (999) N.A.
5:32-34	F3.0	PC 2221 ST: % variety 2221 stream-irrigated (555) N.R. (999) N.A.
5:35-37	F3.0	PC 2221 W: % variety 2221 well-irrigated (555) N.R. (999) N.A.
5:41-43	F3.0	PC 2222 RF: % variety 2222 rainfed (555) N.R. (999) N.A.
5:44-46	F3.0	PC 2222 SP: % variety 2222 spate-irrigated (555) N.R. (999) N.A.
5:47-49	F3.0	PC 2222 ST: % variety 2222 stream-irrigated (555) N.R. (999) N.A.
5:50-52	F3.0	PC 2222 W: % variety 2222 well-irrigated (555) N.R. (999) N.A.
5:56-58	F3.0	PC 3221 RF: % variety 3221 rainfed (555) N.R. (999) N.A.
5:59-61	F3.0	PC 3221 SP: % variety 3221 spate-irrigated (555) N.R. (999) N.A.
5:62-64	F3.0	PC 3221 ST: % variety 3221 stream-irrigated (555) N.R. (999) N.A.
5:65-67	F3.0	PC 3221 W: % variety 3221 well-irrigated (555) N.R. (999) N.A.
6:11-13	F3.0	PC 3222 RF: % variety 3222 rainfed (555) N.R. (999) N.A.
6:14-16	F3.0	PC 3222 SP: % variety 3222 spate-irrigated (555) N.R. (999) N.A.
6:17-19	F3.0	PC 3222 ST: % variety 3222 stream-irrigated (555) N.R. (999) N.A.
6:20-22	F3.0	PC 3222 W: % variety 3222 well-irrigated (555) N.R. (999) N.A.
6:26-28	F3.0	PC 4111 RF: % variety 4111 rainfed (555) N.R. (999) N.A.
6:29-31	F3.0	PC 4111 SP: % variety 4111 spate-irrigated (555) N.R. (999) N.A.
6:32-34	F3.0	PC 4111 ST: % variety 4111 stream-irrigated (555) N.R. (999) N.A.

Table 4.7 (Continued)

Card No. Column No.	Format	Variable Name: Question and Possible Answers
6:35-37	F3.0	PC 4111 W: % variety 4111 well-irrigated (555) N.R. (999) N.A.
6:41-43	F3.0	PC 4112 RF: % variety 4112 rainfed (555) N.R. (999) N.A.
6:44-46	F3.0	PC 4112 SP: % variety 4112 spate-irrigated (555) N.R. (999) N.A.
6:47-49	F3.0	PC 4112 ST: % variety 4112 stream-irrigated (555) N.R. (999) N.A.
6:50-52	F3.0	PC 4112 W: % variety 4112 well-irrigated (555) N.R. (999) N.A.
6:56	F1.0	INTCRP: Did you intercrop (with sorghum and millet)? (1) yes (2) no (3) N.R.
6:57	F1.0	CINTCRP: Crops intercropped? (0) N.A. (1) Dug r (2) Kishd (3) Koshori (4) qitn (5) combination (6) N.R.
6:58	F1.0	RATOONNO: Number of ratoons normally produced? (0) 0 (1) 1 (2) 2 (3) N.R.
6:59	F1.0	RATOONR: Reason for ratooning? (0) N.A. (1) Forage (2) Grain (3) Both (4) N.R.
6:60	F1.0	SEEDSCE: Seed source? (1) own production (2) neighbor (3) market (4) other (5) N.R.
6:61-65	F5.1	SEED RTS: Seed rate for sorghum (kg./ha.)? (0) N.A. (99999) N.R.
6:66-70	F5.1	SEED RTM: Seed rate for millet (kg./ha.)? (0) N.A. (99999) N.R.
6:71-73	F3.0	FERTUSEN: Use of natural fertilizer (kg./ha.)? (999) N.R.
6:74-76	F3.0	FERTUSEC: Use of chemical fertilizer (kg./ha.)? (999) N.R.
6:77	F1.0	PESTUSE: Use of pesticides? (1) Yes (2) No (3) N.A.
7:11	F1.0	MSCHLPRP: Machinery use, land preparation? (0) no (1) yes (2) N.A.
7:12	F1.0	MACHPLT: Machinery use, planting? (0) no (1) yes (2) N.A.
7:13	F1.0	MACHIRIG: Machinery use, irrigation? (0) no (1) yes (2) N.A.
7:14	F1.0	MACHHAR: Machinery use, harvesting? (0) no (1) yes (2) N.A.
7:15	F1.0	MACHTHR: Machinery use, threshing? (0) no (1) yes (2) N.A.

Table 4.7 (Continued)

Card No. Column No.	Format	Variable Name: Question and Possible Answers
7:16-17	F2.0	PCGRLOST: % grain losses, all causes (pre harvest)? (99) N.A.
7:21-23	F3.0	PC 1111 S: % variety 1111 sold? (555) N.R. (999) N.A.
7:24-26	F3.0	PC 1112 S: % variety 1112 sold? (555) N.R. (999) N.A.
7:27-29	F3.0	PC 1121 S: % variety 1121 sold? (555) N.R. (999) N.A.
7:30-32	F3.0	PC 1221 S: % variety 1221 sold? (555) N.R. (999) N.A.
7:33-35	F3.0	PC 1222 S: % variety 1222 sold? (555) N.R. (999) N.A.
7:36-38	F3.0	PC 2111 S: % variety 2111 sold? (555) N.R. (999) N.A.
7:39-41	F3.0	PC 2112 S: % variety 2112 sold? (555) N.R. (999) N.A.
7:42-44	F3.0	PC 2122 S: % variety 2122 sold? (555) N.R. (999) N.A.
7:45-47	F3.0	PC 2221 S: % variety 2221 sold? (555) N.R. (999) N.A.
7:48-50	F3.0	PC 2222 S: % variety 2222 sold? (555) N.R. (999) N.A.
7:51-53	F3.0	PC 3221 S: % variety 3221 sold? (555) N.R. (999) N.A.
7:54-56	F3.0	PC 3222 S: % variety 3222 sold? (555) N.R. (999) N.A.
7:57-59	F3.0	PC 4111 S: % variety 4111 sold? (555) N.R. (999) N.A.
7:60-62	F3.0	PC 4112 S: % variety 4112 sold? (555) N.R. (999) N.A.
7:63-65	F3.0	PCMILS: % millet sold? (555) N.R. (999) N.A.
8:11	F1.0	GRNSALE: To whom was grain sold? (0) N.A. (1) _____ (2) other buyer (3) N.R.
8:12	F1.0	TIMESALE: Time of sale? (0) N.A. (1) at harvest (2) later (3) N.R.
8:13	F1.0	DECIDE: On what basis are market decisions made? (0) N.A. (1) family needs (2) market conditions (3) both (4) other (5) N.R.
8:14	F1.0	STVRSALE: Did you sell stover? (1) Yes (2) No (3) N.R.
8:15-17	F3.0	PCSTVGRR: % stover/grain ratio? (555) N.R.
8:21-24	F4.0	PCAINCDC: % sorghum area increase (decrease) over past 5 years? (5555) N.R.
8:25	F1.0	DCREASON: Reason for decrease? (0) N.A. (1) labor shortage (2) change to other crops (3) other (4) N.R. (5) combination
8:26	F1.0	OCROP: If change to other crop, which? (0) N.A. (1) vegetables (2) qat (3) other (4) N.R.
8:27	F1.0	GRNSTORE: Did you store any grain on-farm last year? (0) N.R. (1) yes (2) no

Table 4.7 (Continued)

Card No. Column No.	Format	Variable Name: Question and Possible Answers
8:28	F1.0	TYPSTORE: type of storage? (0) N.A. (1) madfan (2) drum (3) bins (4) other (5) combination (6) N.R.
8:31-33	F3.0	PCGRLSS1: % stored grain loss (< 1 yr. storage)? (555) N.R. (999) N.A.
8:34-36	F3.0	PCGRLSS2: % stored grain loss (> 1 yr. storage)? (555) N.R. (999) N.A.
8:37	F1.0	PROBLEMS: Major problems being encountered in sorghum/millet production? (0) N.R. (1) pests & disease (2) labor shortage (3) high labor cost (4) lack of agricultural inputs (5) lack of rain (6) lack of extension (7) is (1)+(2)+(3) (8) combination of above

of Arizona team in Yemen in 1977. Section 4.1.4.2 recommends the next steps to be taken in the continued development of the Al Jaroubah Research Station.

4.1.4.1 Recommendations for Insect Pest Control of Sorghum and Millet

In keeping with the current trend of pest management an Integrated Pest Management (IPM) scheme is advised. Since chemicals have been used to a very limited extent in Yemen the predator and parasite complex appears to be very effective. The best method of maintaining this natural control factor is refraining from use of pesticide. Unless a pest caused noticeable damage it seems best to tolerate slight damage and not risk disruption of beneficial species.

Sometimes it is possible to treat seedlings and small plants with pesticides and not greatly sacrifice the beneficial complex. In this regard, seed and soil treatments may be considered in a control program to establish a satisfactory stand and initial growth. Most plants are capable of outgrowing light to moderate pest infestations under normal conditions.

Although sufficient knowledge of chemicals and their effectiveness is available from other countries it will be worthwhile for those groups in Yemen projects to continue testing chemical materials at least on a small plot basis. All established agricultural projects in Yemen appear to be involved in plant protection to some extent.

There are sources to obtain pesticides from dealers at Sana'a, Taiz, and Hodeidah. One source of supply for some projects appears to be from the German Agricultural Project at Sana'a. The materials available are those in current use in several countries having a well-developed program and supply resources of pesticides. Eventually a program for registration and use of pesticides should be implemented by the Yemen Ministry of Agriculture with the assistance or cooperation of qualified consultants of the various agricultural project agencies.

Of interest is the practice of stripping leaves of sorghum plants in some areas of Yemen for animal forage. This inadvertently aids in the control of aphids, whiteflies, spider mites, and all otherinsects but reduces grain yield.

Another method of control worthy of consideration by projects is that of selection and development of crop varieties that are pest-tolerant or

pest-resistant (this procedure is already in progress in a few cases, i.e., diseases of sorghum and millet).

4.1.4.2 Next Steps at Al Joroubah Research Station

All the necessary supplies for electrical fixtures were purchased and stored in the Hodeidah house. The duplex unit at Al Joroubah can be lived in but lacks electric lights. The ceilings were only partially finished in one unit to illustrate how it was to be done. Three or four days' work should complete the installation. The material to be used is corregated roofing metal and needs only to be cut in proper lengths and placed in the provided frame. The entire building is made of iron or concrete except for the purlin on the rafters to hold the roofing. These are wood treated with creosote. Furniture installed in the house should be steel frame to prevent termite damage.

4.1.5 Miscellaneous Insects of Yemen

This information from the short-term assignment of Dr. Tuttle in 1977.

4.1.5.1 Major Insect Pests

1. Corn leaf aphid (Rhopalsiphum maidis Fitch)--This was the only aphid species identified on sorghum and millet. The corn leaf aphis is small and dark green with black cornicles. It inhabits the area at the base of leaves particularly under the leaf sheath, in the whorls, and occasionally the seed heads. Heavy infestations can reduce yields up to 20 percent. Large quantities of honeydew are produced during feeding by these sucking insects. All infestations seen were occasional and light. However, heavy infestations have been reported in June and July on small plants at Wadi Zabid. Some parasitized aphids were collected at Sana. Predators observed on infested plants were coccinellids, lacewings, Orius, and syrphid flies.

2. Stalk borer (Sesamia cretica Led.)--Light infestations of this species were seen during October and November. Growers and research personnel report extensive damage to young plants. Some plants were killed and others recovered with regrowth by tillering. Eggs are laid between the leaf sheath and stem of the plant. Emerging larvae enter the stalk and tunnel as they feed. Grain heads are distorted, stunted, and sometimes sterile. Mature larvae measure about 25 mm and most have a pink cast. The adult moths have tan forewings and white hindwings--the wing span is about 30 mm.

3. Termites (Microcerotermes diversus)--This subterranean species attacks sorghum and millet at various growth stages by tunneling in the roots. Small plants may die or blow over and mud tunnels are seen on the stalks of older plants.

4. Flea beetles (Podagrica spp.)--A small black species measuring 2.5 mm was observed in October. It appears similar to a common species which attacks a wide spectrum of plants. The "shot-hole" injury pattern is characteristic for the group. Small plants are often seriously damaged by this pest.

5. Sorghum shoot fly (Atherigona varia soccata R.)--Some damage by this muscoid fly larvae was seen at Wadi Zabid. It is reported as the most important sorghum pest of the seedling stage in Africa and Asia (Jotwani, 1972). There are several species of Atherigona and other dipterous larvae which may occur in sorghum as primary and secondary pests, as well as scavenger species. The shoot fly is small with a gray thorax and yellowish abdomen having 6 black dorsal spots. The length is about 5 mm. The larvae are white and turn yellowish in the final instar. Eggs are deposited on the underside of leaves and the newly hatched larvae move to the growing point of the plant. Plants are most susceptible 4-6 weeks after germination. Side dressing with a systemic insecticide is recommended.

6. African or nutgrass armyworm (Spodoptera exempta (Walker))--This worm is greenish and black and about 25 mm long. They damage young plants especially by feeding on the leaves of sorghum during June and July and may extend into September.

7. Desert grasshopper (Schistocerca gregaria)--This is one of several species which is occasionally a localized pest.

8. Oligonychus (Reckiella) simus P. & B.--These mites are found on the underside of leaves and cause injury in the same manner as Banks grass mite O. (R.) pratensis (Banks).

Another group of pests are those attacking the seed of sorghum and millet in storage. Collections of these were made from farms and seed storage facilities at Sana and Taiz.

Angoumois grain moth--Sitroga cerealella (Oliver)

Cereal psocid--Liposcelis diviniatorius (Mueller)

Confused flour beetle--Tribolium confusum (Duv.)

Granary weevil--Sitophilus granarius (L.)

Rice weevil--Sitophilus oryza (L.)

4.1.5.2 Miscellaneous Crop Pests of Yemen

A few collections and limited observations were made from other crops during this short-term period. Awad (1976) and others (Bartelink 1974) have documented some of the pests.

Alfalfa	
Acyrthosiphon pisum (Harris)	(pea aphid)
Aphis crassivora Koch	(cowpea aphid)
Bruchophagus roddi (Gussakovsky)	(alfalfa seed chalcid)
Chrysanthemum	
Myzus persicae (Sulzer)	(green peach aphid)
Cucurbits (muskmelons, watermelon, and cucumber)	
Aphis gossypii Glover	(melon or cotton aphid)
Asbecesta traversa	(spotted melon beetle)
Dacus ciliatus or *longistylus* Wied.	(melon fruitfly)
Epilachna chrysomelina	(12-spotted lady beetle)
Dates	
Arenipses sabella	(date moth)
Batrachedra amydraula Meyr.	(date moth)
Parlatoria blancharidii (Targioni-Tozzetti)	(parlatoria date scale)
Maize	
Chaetocnema sp.	(flea beetle)
Heliothis armigera Hubner	(corn earworm)
Rhopalosiphum maidis Fitch	(corn leaf aphid)
Sesamia cretica Led.	(stalk borer)
Spodoptera exempta (Walker)	(nutgrass armyworm)
Potato	
Chaetocnema sp.	(flea beetle)
Gryllotalpa spp.	(mole cricket)
Leptinotarsus decemineata	(Colorado potato beetle)
Myzus persicae (Sulzer)	(green peach aphid)
wireworms sp.	
Sesame	
Antigastra catalounalis	(sesame seed pod borer)
Spinach	
Aphids sp.	
Flea Beetles sp.	

Tobacco

Myzus persicae (Sulzer)	(green peach aphid)

Tomato

Blister beetles sp.	
Flea beetles sp.	
Heliothis armigera Huber	(tomato fruitworm)
Microcerotermes diversus	(subterranean termite)
Mycus persicae (Sulzer)	(green peach aphid)
Plusia sp.	(looper)

Watermelon

Myzus persicae (Sulzer)	(green peach aphid)

Wheat

Diuraphis noxia Mordvilko	(aphid)

4.1.5.3 Miscellaneous Insects Collected

A few other species of insects were collected or observed which were not associated with any particular host plant at the time. Names of these were obtained from collected material at Taiz (Ministry of Agriculture).

Adesmia interrupta	(tenebrionid beetle)
Chlorochroa sayi	(Say stink bug)
Coccinella undecimpunctata	(lady beetle)
Gryllus bimaculatus DeGreer	(black cricket)
Heliocopris gigas	(large scarab beetle)
Pachnoda histrio F.	(scarab beetle)
Pockilocerus vittatus	(lubber grasshopper)
Pontia glauconome	(pierid butterfly)
Spilostethus pandurus militaris	(lygaeid bug)
Vanessa carduii (L.)	(painted lady)
Xylocopa aestuans	(carpenter bee)

4.1.5.4 Beneficial Insects and Mites (from miscellaneous plants)

Anthocoridae

Orius spp.	(minute pirate bugs)

Cheyletidae

Cheletogenes ornatus (C. & F.)	(cheyletid mite)
Cheyletia spp.	(cheyletid mites)

Chrysopidae	
Chrysopa vulgaris Schn.	(lacewing)
Coccinellidae	
Coccinella spp.	(lady beetles)
Scymnus spp.	(coccinellids)
Phytoseiidae	
Amblyseius gossypi	(amblyseid mite)
Amblyseius spp.	(amblyseid mites)
Typhlodromus spp.	(typhlodromid mites)
Stigmaeidae	
Agistemus exertus (Gonzales)	(stogmaeid mite)
Tydeidae	
Tydeus californicus Banks	(tydeid mite)

4.1.6 Training Program for Yemeni Agriculturalists

The following pages describe the program designed for training Yemeni students in the basic skills for plant improvement work. Also included is related correspondence and a list of institutions (Table 4.8) responding to the University of Arizona request for information on training programs.

Yemen Training Proposal

Purpose: The purpose of this proposal is to provide a six month agricultural training program at the University of Arizona (UA) for trainees selected by the Yemen Arab Republic Government (YARG).

Background: The U. S. Agency for International Development (USAID) requested the University of Arizona to investigate possible sources of training, including Arabic language schools in the Middle East. Various educational institutions in the Middle East area were contacted to determine applicable course contents and availability. Training tailored to the specific needs of the Yemen attendees was not located in this search. The UA therefore investigated its own capability, and this proposal outlines the training which could be provided.

Training Concepts:

1. Trainees would be selected by the YARG and approved by USAID. Persons attending would possess a high school level education, or equivalent, as determined by the YARG.

2. Arabic would be spoken in class approximately seventy-five percent of the time. Only a limited amount of English would be utilized during instruction. It is estimated twenty-five percent would be required to familiarize the student with applicable terms. English training would be suited to the need of the students.

3. Training would emphasize helping attendees within the constraints of the Yemen environment. The training would not be "Americanized" to the point that they could not utilize it upon their return. The distinctions between laborers, supervisors, managers, and administrators in Yemen would be pointed out. Principles of agricultural research in Yemen also would be taught. These topics would show trainees their role in the system of agriculture in Yemen and also provide them with knowledge concerning their future aspirations.

4. The practical aspects of agriculture would be taught at a level suitable for the trainees. Daily course hand-out material would be provided and summarized weekly to relate new information to the environment of Yemen. They would also form a complete file of material for future use.

5. Instructors who can speak both Arabic and English would be used to assist in course development and presentation. U of A faculty who have been to Yemen would be used to assist in course development and actual instruction, where possible.

Course Topics: Examples are as follows:

1. Simple terms in English needed to familiarize students with applicable agricultural uses.
2. Measurement systems, record keeping, machine use and adjustment.
3. Tools for on-farm use.
4. How to drive and maintain a tractor. Actual driving would be provided.
5. Soil preparation.
6. Agriculture in Yemen.
7. Use and adjustment of machines.
8. Plant propagation.
9. Irrigation.
10. Farm systems.
11. Tree crops, to include grafting.
12. Root stocks.
13. Sorghum.
14. Alfalfa.
15. Pest control.
16. Weed control.
17. Fertilization.
18. Extension.
19. Research principles and goals.
20. Research stations.

Training Facilities: The University of Arizona campus, local University farms, and off-campus research stations would be used in Mesa, Marana, Yuma, Phoenix and Safford.

Housing: The students would be housed in apartments near the University Campbell Avenue Farm. USAID would provide the normal participant allowance of approximately $500 per month to cover all living expenses. Dependant housing would not be authorized.

Cost: The following cost estimate is based on ten students for the first class.

1. Salaries and fringe benefits.
   a. Faculty (9 mm) 27,000
   b. Arabic speaking program manager (12 mm)..... 36,000
   c. Administration (3 mm)..... 9,000
   d. Secretary (6 mm)..... 7,200

   TOTAL..... 79,200

2. Local transportation..... 3,000
3. Round trip air fare ($2,500 x 10).....25,000
4. Living expense ($500/month x 6 x 10).....30,000
5. Other direct costs.....10,000

   TOTAL.....$147,200

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209 NUGENT BUILDING

(602) 626-1717

October 14, 1980

To : Jeff Lee, AID/W
USAID
Department of State
Agency for International Development
Washington, D.C. 20520

From : Gerald Matlock, David Cleveland

Subject: Training program design, UA Sorghum/Millet Project, Yemen

In response to your request that we design a training program for four to five candidates from Yemen, we have been discussing desired requirements and possible programs.

There are two basic alternatives:

1. Locating a suitable program at an Arabic language institution in North Africa or the Middle East. We have sent inquires to fourteen institutions so far, outlining our requirements to them, and asking if they have appropriate programs. In addition to training in Arabic, the requirements include practical training in the field at high school graduate level and an emphasis on cereals and other subsistence crops common in Yemen. There should be flexibility in admissions requirements so that those with more or less than high school level education who could benefit from training could be included.

2. Establishing a training program at the University of Arizona. The requirements stated in 1 above would apply. We would use our own instructors (with translators where necessary), so that all instruction would be in Arabic. This would have the advantages of the UA having direct control over content, developing a base for the UA to be further involved in such training programs, and having minimal over head for personnel and equipment.

When we have had responses from the Middle East and North African institutions we will make a decision as to where the training should take place, and proceed to develop a more detailed program.

We will continue to keep you informed of our programs in developing a prpposal for training as requested.

WGM:jh

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Department of State

INCOMING TELEGRAM

PAGE 01 SANA 06074 081017Z
ACTION AID-35 056219 AID7466

ACTION OFFICE CTR-02
INFO NEPD-03 NEDP-01 CH6-01 NETC-04 NENA-03 GC-01 GCFL-01
GCNE-01 FM-02 CMGT-02 IT-06 CH8-01 RELO-01 MAST-01
0-00 /030 A2 X

INFO OCT-01 /036 W

R 080654Z SEP 80
FM AMEMBASSY SANA
TO SECSTATE WASHDC 4477

UNCLAS SANA 6074

AIDAC

E.O. 12065: NA
SUBJ: 279-0030 SORGHUM AND MILLET TRAINING

REF: SANA 5656

1. SORGHUM AND MILLET PROJECT 030 SCHEDULED TO END MARCH 31, 1981 TRAINING UNDER THIS PROJECT HAS BEEN MINIMAL. MOA HAS EXPRESSED INTEREST IN HAVING UP TO FOUR PEOPLE RECEIVE SHORT-TERM TRAINING BEFORE THE PROJECT ENDS.

2. IT WAS SUGGESTED THAT TRAINING SHOULD BE PRACTICAL FOR SIX MONTHS OR ONE CROP SEASON AT ICRISAT, ICARDA OR U.S. UNIVERSITY SUCH AS ARIZONA.

3. UNIVERSITY OF ARIZONA SHOULD DETERMINE DATES AND LOCATIONS OF TRAINING COURSES, LANGUAGE REQUIREMENTS, COSTS, AND REQUIRED QUALIFICATIONS. REQUEST AID/W CONTACT ARIZONA AND ADVISE MISSION OF AVAILABLE TRAINING COURSES.

4. CANDIDATES WILL THEN BE NOMINATED BY MOA WITH AID PROVIDING FUNDING THROUGH PIO/P FROM PROJECT 040. REFTEL REQUESTING AMENDMENT OF PROJECT 030 AUTHORIZATION DID NOT INCLUDE FUNDS FOR TRAINING. THEREFORE, PARTICIPANTS WILL BE FUNDED THROUGH A PIO/P FROM PROJECT 040 TO AVOID FURTHER AMENDMENT OF PROJECT 030.

5. SINCE ENGLISH CAPABILITY MAY BE A PROBLEM, SUGGEST UNIVERSITY OF ARIZONA GIVE CAREFUL CONSIDERATION TO LOCATING ACCEPTABLE TRAINING COURSES IN ARABIC.
LANE

SEP 1980 RECEIVED PLANT SCIENCES DEPARTMENT

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Table 4.8. Institutions with Agricultural Training Programs

Name/Address	Notes
H. Msougar, Institute Scientifique Cherifien Avenue Moulay Cherif Rabat, Morocco	
M'Hamed Sta M'Rad, Director Institut National de la Recherche Agronomique de Tunisie Ariana (Tunisie)	(25 different field stations)
Dr. Hussein Elmousa, Crop Production University of Jordan Amman, Jordan	
International Crops Research Institute for the Semi-Arid Tropics 1-11-256 Begumpet Hyderabad 500 016 Andhara Pradesh, India	(Official language--English)
Dr. Mohamed El-Khash, Director General The Arab Center for the Study of Arid Zones and Dry Lands (ACSAD) P.O. Box 2440 Damascus, Syria	
International Center for Agricultural Research in the Dry Areas c/o International Development Research Center 5 Latif Monsour, Heliopolis Cairo, Egypt	

4.1.7 Planting Plan for 1981

At the end of the 1980 season, seeds were selected and prepared for the 1981 season. Tables 4.9-4.17 present an overview of all proposed tests and the specific genotypes selected for each test.

Table 4.9. Tests Proposed for 1981 Planting

Test	Title	# of Entries	Plot Size Rows/Plot	Replications	# Rows
81-001	Head to row test	554	1	1	554
81-002	Preliminary Yield Trial	100	2	3	600
81-003	Advanced Yield Trial	72	3	3	648
81-004	Elite Yield Trial	42	4	4	672
81-005	Short Grain Head Rows	124	1	1	124
81-006	Short Grain Preliminary Yield Trial	34	2	3	204
81-007	Short Grain Advanced Yield Trial	16	3	3	144
81-008	Short Grain Elite Yield Trial	22	4	3	352

Table 4.10. Head to Row Test (81-001)

5 seeds/hill--1 row/plot

Entry No.	Source	Pedigree	Entry No.	Source	Pedigree
1	80-001-5	76026-043-3	47	80-003-156	77026-037-11
2	80-001-57	78097-R-74	48	80-003-159	77026-065-5
3	80-001-72	78099-R-4	49	80-003-162	77026-036-3
4	80-001-81	78099-R-19	50	80-003-165	77026-002-11
5	80-001-85-1	78099-R-30	51	80-003-168	77(Comp) 131
6	80-001-97	78099-R-57	52	80-003-179	Sanaa - 1
7	80-001-107	78(comp)-37	53	80-003-195	Sanaa - 6
8	80-001-109	76026-005-2	54	80-003-202	Sanaa - 9
9	80-001-112	76026-007-5	55	80-003-213	Sanaa - 1
10	80-001-116	76026-010-7	56	80-003-221	Sanaa - 3
11	80-001-127	NES1500xNES6973	57	80-003-234	Sanaa - 6
12	80-001-161	NES3329xNES6972	58	80-003-244	RADAA Local
13	80-001-162	NES3329xNES6972	59	80-003-256	P-P-14
14	80-001-197	I5509xNES6978	60	Local check	Local check
15	80-001-203	I5509xNES6978	61	80-003-258	GSA-1586F
16	80-001-217	NES2197xNES6975	62	80-003-259	GSA-30F
17	80-001-224	NES2197xNES6979	63	80-003-266	FAO-5
18	80-001-398	Local Selection	64	80-003-268	FAO-7
19	80-002-16	76026-068-10	65	80-003-269	FAO-8
20	80-002-23	79093-2-1	66	80-003-274	FAO-12
21	80-002-31	77093-72-2	67	80-003-275	FAO-13
22	80-002-44	78097-R-2	68	80-003-277	UNKNOWN - 10
23	80-002-99	78099-R-74	69	80-005-6	1977 (comp)
24	80-002-106	78099-R-88	70	80-005-7	78097-R-73
25	80-002-107	78100-R-17	71	80-005-25	IS509xNES6971
26	80-002-123	NES110xNES6976	72	80-005-28	IS9958xNES6971
27	80-002-149	NES2197xNES6973	73	80-005-73	77093-05-4
28	80-002-188	IBB-16-6	74	80-005	7616-057
29	80-002-215	76026-072-2	75	80-006-6	76026-026-5
30	80-002-217	77093-58-2	76	80-006-13	76026-053-1
31	80-002-218	77093-64-3	77	80-006-17	77(Comp)-37
32	80-002-227	77093-56-2	78	80-006-19	76026-036-2
33	80-002-242	76026-003-1	79	80-006-29	76026-075-2
34	80-002-255	77(comp)-30	80	Local check	Sanaa 7
35	80-003-25	78099-R-13	81	80-006-38	76026-06-8
36	80-003-96	NES110xNES6970	82	80-006-39	76019-001-3
37	80-003-116	NK233F_2xLocal F_2	83	80-006-40	76026-067-3
38	80-003-117	NK233F_2xLocal F_2	84	80-006-41	77093-057-4
39	80-003-126	PB-1BRxLocal	85	80-001-174-2	NES3329xNES6977
40	Local Check	Local Check	86	80-006-43	76026-072-3
41	80-003-141	76026-036-4	87	80-001-176-2	NES3329xNES6979
42	80-003-142	76026-074-3	88	80-006-47	76026-060-4
43	80-003-143	76026-074-4	89	80-006-50	76026-024-2
44	80-003-144	77093-69-1	90	80-006-52	76026-039-3
45	80-003-154	77093-63-3	91	80-006-54	76026-074-10
46	80-003-155	77093-36-4	92	80-001-1	76019-001-9

Table 4.10 (Continued)

Entry No.	Source	Pedigree	Entry No.	Source	Pedigree
93	80-001-2-1	76019-003-6	141	80-001-63-2	78097-R-86
94	80-001-2-2	76019-003-6	142	80-001-63-3	78097-R-86
95	80-001-2-3	76019-003-6	143	80-001-65	78097-R-89
96	80-001-3-1	76019-004-1	144	80-001-66	78097-R-94
97	80-001-3-2	76019-004-1	145	80-001-75	78099-R-8
98	80-001-4-1	76026-043-3	146	80-001-79-1	78099-R-16
99	80-001-4-2	76026-043-3	147	80-001-79-2	78099-R-16
100	Local check	Local check	148	80-001-79-3	78099-R-16
101	80-001-7-1	76026-053-2	149	80-001-82	78099-R-24
102	80-001-7-2	76026-053-2	150	80-001-85-2	78099-R-30
103	80-001-9	76026-064-6	151	80-001-86	78099-R-32
104	80-001-10	76026-055-1	152	80-001-87	78099-R-35
105	80-001-12	76026-059-3	153	80-001-98	78099-R-57
106	80-001-13	76026-059-7	154	80-001-99	78099-R-70
107	80-001-14	76026-060-6	155	80-001-100-2	78099-R-70
108	80-001-17	76026-070-10	156	80-001-105-1	78-(Comp)-8
109	80-001-18	76026-070-15	157	80-001-105-2	78-(Comp)-8
110	80-001-19	76026-070-16	158	80-001-106	78-(Comp)-8
111	80-001-20	77093-24-1	159	80-001-108	78-(Comp)-37
112	80-001-22	77093-24-1	160	Local check	Local check
113	80-001-23	76093-24-4	161	80-001-113	76026-008-5
114	80-001-24-1	76093-24-6	162	80-001-115	76026-010-10
115	80-001-24-2	76093-24-6	163	80-001-118	78-(Comp)-39
116	80-001-25-1	76093-39-4	164	80-001-124	NES110xNES6973
117	80-001-25-2	76093-39-4	165	80-001-128	NES1500xNES6973
118	80-001-27	76093-61-5	166	80-001-167	NES3329xNES6975
119	80-001-28	76026-71-4	167	80-001-171	NES3329xNES6976
120	Local check	Local check	168	80-001-174	NES3329xNES6977
121	80-001-29	1977 (comp)	169	80-001-176	NES3329xNES6979
122	80-001-35	1977 (comp)	170	80-001-177	NES3329xNES6980
123	80-001-36	1977 (comp)	171	80-001-178	NES3329xNES6980
124	80-001-37	78097-R-11	172	80-001-179-1	NES3329xNES6980
125	80-001-38	78097-R-16	173	80-001-179-2	NES3329xNES6980
126	80-001-40	78097-R-23	174	80-001-185	NES3329xNES6985
127	80-001-42	78097-R-26	175	80-001-191	IS509xNES6970
128	80-001-43	78097-R-30	176	80-001-192	IS509xNES6971
129	80-001-44	78097-R-30	177	80-001-201	IS509xNES6982
130	80-001-45	78097-R-42	178	80-001-202	IS509xNES6982
131	80-001-46-1	78097-R-43	179	80-001-204	IS509xNES6982
132	80-001-46-2	78097-R-43	180	Local check	Local check
133	80-001-47-1	78097-R-43	181	80-001-208	IS509xNES6986
134	80-001-47-2	78097-R-43	182	80-001-21[illegible]	NES2197xNES6970
135	80-001-49	78097-R-46	183	80-001-216-1	NES2197xNES6975
136	80-001-50	78097-R-50	184	80-001-216-2	NES2197xNES6475
137	80-001-52	78097-R-54	185	80-001-218	NES2197xNES6475
138	80-001-61	78097-R-81	186	80-001-219	NES2197xNES6475
139	80-001-63-1	78097-R-86	187	80-001-220	NES2197xNES6475
140	Local check	Local check	188	80-001-221-1	NES2197xNES6977

Table 4.10 (Continued)

Entry No.	Source	Pedigree	Entry No.	Source	Pedigree
189	80-001-221-2	NES2197xNES6977	230	80-001-388-2	79093-76-6
190	80-001-222	NES2197xNES6977	231	80-001-389	77(Comp)-1
191	80-001-223	NES2197xNES6977	232	80-001-393	77(Comp)-1
192	80-001-225	NES2197xNES6979	233	80-001-395	NES1789
193	80-001-232	NES2197xNES6985	234	80-001-396	L-Selections
194	80-001-267	(P894F_2xLocal)F_2	235	80-001-399	L-Selections
195	80-001-275	(P8681F_2xLocal)F_2	236	80-001-400	L-Selections
196	80-001-287	(NK233F_2xLocal)F_2	237	80-001-401	L-Selections
197	80-001-288	(NK233F_2xLocal)F_2	238	80-001-402	Dekalb-516
198	80-001-292-1	PB-IBR-Day	239	80-001-405	NES3392xNES6976
		NeutralxLocal	240	Local check	Local check
199	80-001-292-2	PB-IBR-Day	241	80-002-49	78097-R-25
		NeutralxLocal	242	80-002-50-1	78097-R-28
200	Local check	Local check	243	80-002-50-2	78097-R-28
201	80-001-303	PB-IBR-Day	244	80-002-52-1	78097-R-32
		NeutralxLocal	245	80-002-54-1	78097-R-44
202	80-001-305	PB-IBR-Day	246	80-002-54-2	78097-R-44
		NeutralxLocal	247	80-002-65	78097-R-79
203	80=001-307	PB-IBR-Day	248	80-002-72	78099-R-2
		SensitivexLocal	249	80-002-74-1	78099-R-6
204	80-001-322-2	76026-066-6	250	80-002-74-2	78099-R-6
205	80-001-333	77093-63-2	251	80-002-79	78099-R-17
206	80-001-355	76026-026-5	252	80-002-85	78099-R-29
207	80-001-361	77093-63-3	253	80-002-101	78099-R-61
208	80-001-365-1	76026-037-11	254	80-002-108-2	78(Comp)-18
209	80-001-365-2	76026-037-11	255	80-002-111-1	78(Comp)-24
210	80-001-367	77093-68-4	256	80-002-111-2	78(Comp)-24
211	80-001-369	77093-56-7	257	80-002-112	78(Comp)-27
212	80-001-370	76026-033-6	258	80-002-113	78(Comp)-29
213	80-001-371	76026-065-5	259	80-002-114	78(Comp)-34
214	80-001-111	76026-005-11	260	Local check	Local check
215	80-001-206	IS509xNES6982	261	80-002-118-2	NES110xNES6972
216	80-001-294	PB-IBR-Day	262	80-002-127-1	NES1500xNES6972
		NeutralxLocal	263	80-002-127-2	NES1500xNES6973
217	80-001-374	76026-036-3	264	80-002-129	NES2141xNES6975
218	80-001-375	76026-036-3	265	80-002-130	NES2141xNES6978
219	80-001-376	76026-036-3	266	80-002-132	NES2141xNES9978
220	Local check	Local check	267	80-002-133-1	NES2141xNES6983
221	80-001-377	76026-072-2	268	80-002-133-2	NES2141xNES6983
222	80-001-378	76026-053-4	269	80-002-134	NES3329xNES6971
223	80-001-379	76026-002-11	270	80-003-2112	Wadi Nakhiw
224	80-001-381	76026-032-5	271	80-002-118-1	NES110xNES6972
225	80-001-382	77093-56-5	272	80-002-135-1	NES3329xNES6975
226	80-001-383	77093-56-5	273	80-002-135-2	NES3329xNES6975
227	80-001-386-1	76026-004-4	274	80-002-138-2	IS509xNES6978
228	80-001-386-2	76026-004-4	275	80-002-139	IS509xNES6982
229	80-001-387	79093-33-5	276	80-002-140	IS509xNES6982

Table 4.10 (Continued)

Entry No.	Source	Pedigree	Entry No.	Source	Pedigree
277	80-002-141-2	IS509xNES6986	324	80-002-246-2	77093-09-3
278	80-002-142	IS509xNES6986	325	80-002-252-1	76026-052-4
279	80-002-145	NES2197xNES6971	326	80-002-252-2	76026-052-4
280	80-002-153-1	NES2197xNES6975	327	80-002-254	77093-57-5
281	80-002-153-2	NES2197xNES6975	328	80-002-23	77093-33-2-1
282	80-002-155	NES2197xNES6978	329	80-001-146-2	NES2141xNES6982
283	80-002-163	IS9958xNES6970	330	80-002-256	77093-03-5
284	80-002-164	IS9958xNES6971	331	80-002-47	78097-R-25
285	80-002-165-1	IS9958xNES6971	332	80-002-48	78097-R-25
286	80-002-165-2	IS9958xNES6971	333	80-002-49	78097-R-25
287	80-002-166	IS9958xNES6973	334	80-002-50	78097-R-28
288	80-002-168	NES3329xNES6976	335	80-002-58	78097-R-62
289	80-002-172	76026-054-1	336	80-002-69	78097-R-91
290	Local check	Local check	337	80-002-71	78097-R-95
291	80-002-173	76019-001-3	338	80-002-72	78099-R-2
292	80-002-175	76019-037-10	339	80-002-75-1	78099-R-8
293	80-002-178	Sana'a-6	340	Local check	Local check
294	80-002-184	76026-023	341	80-003-75-2	IS509xNES6982
295	80-002-186	IBB-16-2	342	80-003-77-1	NES2197xNES6974
296	80-002-187-1	76026-025	343	80-002-77-2	NES2197xNES6974
297	80-002-187-2	76026-025	344	80-003-79	NES2197xNES6975
298	80-002-194-1	76026-033	345	80-002-82	NES2197xNES6981
299	80-002-194-2	76026-033	346	80-003-85	NES2197xNES6972
300	80-002-195	Takill	347	80-003-92	IS9958xNES6973
301	80-002-196	Sana'a-7	348	80-003-97-2	NES3329xNES6976
302	80-002-202-1	76026-026-10	349	80-003-101-1	(P894F_2xLocal)F_2
303	80-002-202-2	76026-026-10	350	80-003-101-2	(P894F_2xLocal)F_2
304	80-002-204	76026-063-1	351	80-003-102	(P894F_2xLocal)F_2
305	80-002-205	76026-59-4	352	80-003-104	(P866F_2xLocal)F_2
306	80-002-207	76026-019-9	353	80-003-106	(P8681F_2xLocal F_2
307	80-002-210	76026-052-4	354	80-003-111	(P8681F_2xLocal)F_2
308	80-002-212	76026-011-6	355	80-003-114	(P8681F_2xLocal)F_2
309	80-002-213	76026-061-4	356	80-003-121-1	PB-IBR-Day
310	Local check	Local check			NeutralxLocal
311	80-002-214	76026-070-2	357	80-003-121-2	PB-IBR-Day
312	80-002-218-2	77093-64-3			NeutralxLocal
313	80-002-221	76026-063-2	358	80-003-125	PB-IBR-Day
314	80-002-226	77093-50-6			NeutralxLocal
315	80-002-228	77093-57-4	359	80-003-127	PB-IBR-Day
316	80-002-232	77(Comp)-113			NeutralxLocal
317	80-002-233-1	NES6986	360	Local check	Local check
318	80-002-233-2	NES6986	361	80-003-138	76026-067-6
319	80-002-233-3	NES6986	362	80-003-143-2	76026-074-4
320	80-003-2076	Wadi Nakhian	363	80-003-149	76026-030-1
321	80-002-235	77(Comp)-74	364	80-003-151	76026-059-4
322	80-002-237-2	77093-56-3	365	80-003-152	76026-026-5
323	80-002-246-1	77093-09-3	366	80-003-153-1	76026-044-4

Table 4.10 (Continued)

Entry No.	Source	Pedigree	Entry No.	Source	Pedigree
367	80-003-153-2	76026-044-4	414	80-006-12-2	76026-047-7
368	80-003-158-1	77093-68-4	415	80-001-185-2	NES3329xNES6985
369	80-003-158-2	77093-68-4	416	80-006-13-2	76026-053-1
370	80-003-163-2	76026-036-3	417	80-006-14-1	77093-33-4
371	80-003-163-3	76026-036-3	418	80-006-14-2	77093-33-4
372	80-003-169	76026-032-2	419	80-006-15-1	77093-52-3
373	80-003-172	77093-33-6	420	Local check	Local check
374	80-003-173-2	NES1789	421	80-006-15-2	77093-52-3
375	80-003-174	76-26-060-6	422	80-006-16-1	77093-56-4
376	80-003-176	78097-R-23	423	80-006-16-2	77093-56-4
377	80-003-177-2	78099-R-35	424	80-003-196-2	Sana'a-7
378	80-003-178	Sana'a-1	425	80-006-18	76026-037-1
379	80-003-187	Sana'a-3	426	80-005-128-2	IS9958xNES6971
380	Local check	Local check	427	80-006-20	76026-057-4
381	80-003-129	76015-110	428	80-006-21	76026-061-6
382	80-003-193	Sana'a-6	429	80-006-22	76026-070-13
383	80-003-195-2	Sana'a-6	430	80-006-23	76026-074-5
384	80-003-196	Sana'a-7	431	80-006-24	76026-072-7
385	80-003-201	Sana'a-9	432	80-006-25-1	77093-55-2
386	80-003-202-2	Sana'a-9	433	80-006-25-2	77093-55-2
387	80-003-207	Sana'a-9	434	80-006-26	77(Comp)-79
388	80-003-211	Radah Local	435	80-006-27	77093-61-3
389	80-003-212	Radah Local	436	80-006-28-1	77(Comp)-7
390	80-003-217-1	Sana'a-3	437	80-006-28-2	77(Comp)-7
391	80-003-217-2	Sana'a-3	438	80-003-1202-2	Sana'a-9
392	80-003-241	Sana'a-10	439	80-006-29-2	76026-075-6
393	80-003-242	Radah Local	440	Local check	Local check
394	80-003-243	Radah Local	441	80-006-30	Local check
395	80-003-252-1	79001-302	442	80-006-31	76026-075-1
396	80-003-252-2	79001-302	443	80-006-32-1	77(Comp)-117
397	80-003-263	FAO-2	444	80-006-32-2	77(Comp)-117
398	80-006-1-1	76026-024	445	80-006-33	77(Comp)-77
399	80-006-1-2	76026-024	446	80-006-34	77093-56-1
400	Local check	Local check	447	80-006-35	77093-53-1
401	80-006-2	76025-052	448	80-006-36	77093-42-1
402	80-006-3	IBB24-1	449	80-006-37	76026-06-4
403	80-006-4	Sana'a-1	450	80-002-1189-1	IVESS-7003
404	80-006-5	Sana'a-4	451	80-002-1189-2	IVESS-7003
405	80-002-179	IBB-17-1	452	80-006-39-2	76019-001-3
406	80-006-7	77-093-64-1	453	80-003-195-2	Sana'a-6
407	80-006-8	77(Comp)-56	454	80-002-1218-2	77093-64-3
408	80-006-9	77093-65-3	455	80-001-100-2	78099-R-70
409	80-006-10-1	77093-57-1	456	80-003-1143-2	76026-074-4
410	80-006-10-2	77093-57-1	457	80-002-1141	IS509xNES6986
411	80-006-11-1	76026-037-7	458	--	--
412	80-006-11-2	76026-037-7	459	80-002-46	78097-R-20
413	80-006-12-1	76026-047-7	460	Local check	Local check

Table 4.10 (Continued)

Entry No.	Source	Pedigree	Entry No.	Source	Pedigree
461	--	--	508	80-008-38-2	77093(Comp)128
462	80-002-48	78097-R-25	509	80-008-39	77093(Comp)128
463	80-006-49-1	NES-6983	510	80-008-40-1	NES1421
464	80-006-49-2	NES-6983	511	80-008-40-2	NES1421
465	80-021-34	CTL MX-5	512	80-008-42-1	NES1570
466	80-021-51	CTL MX-20	513	80-008-42-2	NES1570
467	80-001-6	76026-053-2	514	80-008-44-1	NES1570
468	80-001-53-1	78097-R-56	515	80-008-44-2	NES1570
469	80-001-53-2	78097-R-56	516	80-008-44-3	NES1570
470	Local check	Local check	517	80-008-45	NES1570
471	80-007-8	CK60A/76026-061-1	518	80-008-46-1	NES1570
472	80-007-13	CK60A/76026-074-8	519	80-008-46-2	NES1570
473	80-007-14	CK60A/76026-074-10	520	Local check	Local check
474	80-007-24	CK60A/76026-074-92	521	80-008-47	NES1570
475	80-007-26	CK60A/NES-1570	522	80-008-50-1	IS410
476	80-007-31	CK60A/76026-039-3	523	80-008-50-2	IS410
477	80-007-32	CK60A/76026-068-6	524	80-008-51	IS2927
478	80-007-33	CK60A/76026-074-10	525	80-008-52	IS2927
479	80-007-38	CK60A/(Comp)-72	526	80-009-1	76026-041
480	Local check	Local check	527	80-009-4-1	76025-017
481	80-007-39-1	CK60A/Comp-73	528	80-009-4-2	76025-017
482	80-007-44	CK60A/76026-032-2	529	80-009-11	76026-024
483	80-007-45	CK60A/76026-061-1	530	80-009-12	Rahda-Local
484	80-007-47-1	CK60A/76026-061-12	531	80-009-14	Sana'a-1
485	80-007-47-2	CK60A/76026-061-12	532	80-009-15	76026-025-6
486	80-007-47-3	CK60A/76026-061-12	533	80-009-18	NES1570
487	80-007-48	CK60A/76026-070-5	534	80-009-23	76026-063
488	80-007-49	CK60A/76026-074-8	535	80-009-26	77093-56-1
489	80-007-51	CK60A1/76026-074-11	536	80-021-5	79003-14
490	80-007-52	CK60A/77093-03-5	537	80-021-2-1	79003-17
491	80-007-54	CK60A/77093-08-8	538	80-021-2-2	79003-17
492	80-007-68	CK60A/NES-1780	539	80-021-2-3	79003-17
493	80-007-70	CK60A/IS-2927	540	Local check	Local check
494	80-007-71	CK60A/CIMMYT76BJ197	541	80-021-2-4	79003-17
495	80-008-9-1	76026-070-5	542	80-021-3-1	79003-3
496	80-008-9-2	76026-070-5	543	80-021-3-2	79003-3
497	80-008-9-3	76026-070-5	544	80-021-15	Dual Sorghum HSS-1
498	80-008-11-1	76026-074-10	545	80-021-16	Rancher HSS-2
499	80-008-11-2	76026-074-10	546	80-021-32	CTL MX-3
500	Local check	Local check	547	80-021-33	CTL MX-4
501	80-008-12	76026-074-10	548	80-021-38	CTL MX-9
502	80-008-13	76026-074-10	549	80-021-44	CTL MX-14
503	80-008-15	77093-05-4	550	80-021-45-1	CTL MX-15
504	80-008-18-1	77093-33-5	551	80-021-59	CTL MX-28
505	80-008-18-2	77093-33-5	552	80-021-48	CTL MX-18
506	80-008-24	77093(Comp)21	553	80-021-49	CTL MX-19
507	80-008-38-1	77093(Comp)128	554	80-021-50	Local Check

Table 4.11. Preliminary Yield Trial (81-002)

5 Seeds/Hill--1 Row/Plot

Entry No.	Source	Pedigree	Replications R1	R2	R3
1	80-001-74	78099-R-7	1001	2039	3019
2	80-001-76	78099-R-9	1002	2033	3096
3	80-001-77	78099-R-12	1003	2088	3083
4	80-001-78	78099-R-13	1004	2064	3093
5	80-001-80	78099-R-16	1005	2058	3069
6	80-001-84	78099-R-28	1006	2060	3098
7	80-001-100	78099-R-70	1007	2078	3034
8	80-001-102	78099-R-76	1008	2054	3074
9	80-001-103	78099-R-78	1009	2062	3023
10	Local check	Local check	1010	2023	3046
11	80-001-110	76026-005-10	1011	2050	3095
12	80-001-114	76026-009-7	1012	2005	3016
13	80-001-117	76026-011-1	1013	2029	3064
14	Local check	Local check	1014	2063	3055
15	80-001-125	NES110xNES6977	1015	2059	3099
16	80-001-160	NES3329xNES6972	1016	2073	3050
17	80-001-166	NES3329xNES6973	1017	2026	3052
18	80-001-198	IS509xNES6978	1018	2061	3043
19	80-001-388	79093-76-6	1019	2035	3100
20	Local check	Local check	1020	2030	3026
21	80-002-63	79093-R-69	1021	2075	3020
22	80-002-64	79093-R-76	1022	2084	3035
23	80-002-78	78099-R-14	1023	2057	3080
24	80-002-89	78099-R-37	1024	2043	3047
25	80-002-91	78099-$-38	1025	2046	3045
26	80-002-100	78099-R-59	1026	2098	3082
27	80-002-104	78099-R-78	1027	2090	3018
28	80-002-105	78099-R-82	1028	2045	3037
29	80-002-106	78099-R-88	1029	2093	3087
30	Local check	Local check	1030	2001	3094
31	80-002-119	NES110xNES6970	1031	2027	3003
32	80-002-124	NES110xNES6976	1032	2021	3024
33	80-002-141	IS509xNES6986	1033	2025	3021
34	80-002-143	NES2197xNES6970	1034	2074	3053
35	80-002-144	NES2197xNES6970	1035	2085	3072
36	80-002-146	NES2197xNES6971	1036	2053	3059
37	80-002-171	76026-061-4	1037	2031	3084
38	80-002-174	76026-043-2	1038	2008	3051
39	80-002-216	77093-55-3	1039	2077	3091
40	Local check	Local check	1040	2092	3062
41	80-002-222	76026-056-6	1041	2065	3092
42	80-002-225	77093-39-7	1042	2096	3039
43	80-002-230	77093-72-4	1043	2012	3054
44	80-002-238	77-93-48-2	1044	2051	3049
45	80-002-241	76026-041-6	1045	2087	3061
46	80-003-4	76026-056-1	1046	2015	3058

Table 4.11 (Continued)

Entry No.	Source	Pedigree	Replications R1	R2	R3
47	80-003-24	78099-R-7	1047	2020	3005
48	80-003-67	NES3329xNES6973	1048	2004	3067
49	80-003-94	IS9958xNES6979	1049	2022	3090
50	Local check	Local check	1050	2070	3007
51	80-003-99	NES3329xNES6970	1051	2019	3001
52	80-003-105	((P866)F_2xLocal)F_2	1052	2024	3086
53	80-003-108	((P8681)F_2xLocal)F_2	1053	2010	3025
54	80-003-136	76026-065-5	1054	2032	3071
55	80-003-137	76026-066-6	1055	2042	3006
56	80-003-163	76026-036-3	1056	2003	3013
57	80-003-177	78099-R-35	1057	2081	3078
58	80-003-206	Sana'a-9	1058	2018	3011
59	80-003-222	Sana'a-4	1059	2100	3004
60	Local check	Local check	1060	2049	3036
61	80-005-14	78(Comp)-18	1061	2068	3075
62	80-005-30	Local check	1062	2014	3085
63	80-005-88	NES7000	1063	2040	3038
64	80-006-3	IBB-24-1	1064	2072	3066
65	80-006-4	Sana'a-1	1065	2076	3028
66	80-006-5	Sana'a-4	1066	2038	3056
67	80-006-9	77093-65-3	1067	2056	3029
68	80-006-11	76026-037-7	1068	2097	3057
69	80-006-12	76026-047-7	1069	2071	3079
70	Local check	Local check	1070	2094	3012
71	80-006-16	77-93-56-4	1071	2028	3076
72	80-006-18	76026-037-1	1072	2002	3015
73	80-006-20	76026-057-4	1073	2069	3031
74	80-006-24	76026-072-7	1074	2007	3008
75	80-006-26	77(Comp)-79	1075	2083	3089
76	80-006-27	77093-061-3	1076	2016	3027
77	80-006-28	77(Comp)-7	1077	2086	3032
78	80-006-32	77(Comp)-117	1078	2095	3033
79	80-006-37	76026-06-4	1079	2034	3081
80	Local check	Local check	1080	2052	3030
81	80-006-46	77093-57-3	1081	2047	3068
82	80-006-48	76026-063	1082	2099	3044
83	80-006-49	NES6983	1083	2037	3060
84	80-006-51	77(Comp)-72	1084	2011	3073
85	80-006-53	76026-074-8	1085	2079	3063
86	80-007-31	CK60A/76026-039-3	1086	2036	3088
87	80-001-104		1087	2044	3042
88	80-002-41-2		1088	2017	3040
89	80-003-07		1089	2041	3014
90	Local check	Local check	1090	2091	3077
91	80-006-15		1091	2066	3041
92	80-002-41-4		1092	2089	3017
93	80-003-282		1093	2006	3010

Table 4.11 (Continued)

Entry No.	Source	Pedigree	Replications R1	R2	R3
94	80-006-36		1094	2067	3048
95	80-002-219		1095	2013	3022
96	80-003-1094-2		1096	2009	3070
97	80-003-1094-3		1097	3080	3097
98	80-005-88-2		1098	2055	3002
99	80-006-111-2		1099	2082	3065
100	80-006-112-2		1100	2048	3009

Table 4.12. Advanced Yield Trial (81-003)

5 Seeds/Hill--2 Rows/Plot

Entry No.	Source	Pedigree	Replications R1	R2	R3
1	80-001-80	78099-R-16	101	258	335
2	80-001-114	76026-009-7	102	249	334
3	80-001-125	NES110xNES6977	103	255	336
4	80-002-14	76026-059-3	104	238	354
5	80-002-53	78097-R-41	105	252	328
6	80-002-62	78097-R-69	106	272	367
7	80-002-77	78099-R-12	107	201	305
8	80-002-103	78099-R-71	108	239	301
9	80-002-108	78(Comp)-18	109	271	356
10	Local check		110	256	312
11	80-002-121	NES110xNES6978	111	216	357
12	80-002-122	NES110xNES6974	112	225	310
13	80-002-17	77093-09-1	113	212	347
14	80-002-125	NES110xNES6978	114	206	315
15	80-002-126	NES110xNES6978	115	204	345
16	80-002-131	NES2141xNES9978	116	260	369
17	80-002-137	IS509xNES6978	117	227	329
18	80-002-138	IS509xNES6978	118	269	308
19	80-002-147	NES2197xNES6971	119	226	351
20	Local check		120	267	339
21	80-002-198	78016-061	121	244	341
22	80-002-222	76026-050-6	122	268	326
23	80-002-224	76026-39-7	123	264	349
24	80-002-231	77(Comp)-113	124	236	366
25	80-002-234	Sana'a-6	125	240	303
26	80-002-236	77093-59-1	126	253	314
27	80-002-237	77093-56-3	127	234	330
28	80-002-244	77(Comp)-80	128	247	311
29	80-002-249	77093-65-1	129	243	360
30	Local check		130	245	364
31	80-003-21	78097-R-74	131	213	333
32	80-003-68	NES3329xNES6980	132	246	348
33	80-003-78	NES2197xNES6975	133	207	370
34	80-003-84	NES2197xNES6972	134	250	322
35	80-003-103	(P855F_2xLocal)F_2	135	229	363
36	80-003-139	76026-036-4	136	237	353
37	80-003-145	77093-63-2	137	215	304
38	80-003-171	77-93-33-5	138	218	317
39	80-003-173	NES1789	139	263	323
40	Local check		140	219	372
41	80-003-188	Sana'a-3	141	223	362
42	80-003-191	Sana'a-4	142	209	350
43	80-003-192	Sana'a-5	143	220	344
44	80-003-194	Sana'a-6	144	259	338
45	80-003-199	Sana'a-9	145	217	358
46	80-003-204	Sana'a-9	146	265	359

Table 4.12 (Continued)

Entry No.	Source	Pedigree	Replications R1	R2	R3
47	80-003-205	Sana'a-9	147	208	368
48	80-003-209	Sana'a-10	148	241	337
49	80-003-216	Sana'a-2	149	261	327
50	Local check		150	232	343
51	80-003-237	Sana'a-9	151	214	302
52	80-003-264		152	262	365
53	80-003-273		153	257	361
54	80-005-36	76026-019	154	221	306
55	80-005-42	77093-56-6	155	228	316
56	80-005-44	76026-067-3	156	270	346
57	80-005-47	76026-039-3	157	211	332
58	80-005-51	76026-068-12	158	266	342
59	80-005-60	Local check	159	202	313
60	Local check		160	248	307
61	80-005-7	77093-64-1	161	205	324
62	80-005-10	77093-57-1	162	254	320
63	80-005-23	76026-074-5	163	235	321
64	80-005-25	77093-55-2	164	233	309
65	80-008-50	IS410	165	242	371
66	80-008-51	IS2927	166	210	318
67	80-002-110	78(Comp)-21	167	222	331
68	80-002-159	NES2197xNES6985	168	224	340
69	80-002-250	77093-69-3	169	203	355
70	80-003-175	77093-33-24	170	230	352
71	80-003-236	Sana'a-9	171	231	319
72	80-006-1	76026-024	172	251	335

Table 4.13. Elite Yield Trial (81-004)

5 Seeds/Hill--3 Rows/Plot

Entry No.	Source	Pedigree	Replications R1	R2	R3
1	80-005-26	IS509xNES6979	101	242	336
2	80-005-31	NES9958xNES6984	102	238	325
3	80-005-52	77(Comp)-20	103	224	316
4	80-005-58-1	77093-33-5	104	218	305
5	80-005-86	76026-032	105	206	337
6	80-005-87	76026-033	106	237	324
7	80-006-2	76025-052	107	225	317
8	80-006-8	77(Comp)-56	108	215	304
9	80-006-14	77093-33-4	109	207	338
10	Local check		110	233	323
11	80-006-22	76026-070-13	111	239	318
12	80-006-30	Local check	112	223	303
13	80-006-31	76026-037-1	113	217	339
14	80-006-33	77(Comp)-77	114	205	322
15	80-006-34	77093-56-1	115	240	319
16	80-007-32	CK60A/76026-068-6	116	222	302
17	80-007-33	CK60A/76026-074-10	117	216	342
18	80-007-38	CK60A(Comp)-72	118	204	340
19	80-007-45	CK60A/76026-061-1	119	221	301
20	Local check		120	219	341
21	80-007-47	CK60A/76026-068-12	121	203	321
22	80-007-48	CK60A/76026-074-5	122	220	335
23	80-007-51	CK60A/76026-074-11	123	202	326
24	80-007-54	CK60A/77093-08-8	124	208	315
25	80-007-68	CK60A/NES1780	125	231	306
26	80-007-70	CK60A/IS410	126	214	3[illegible]
27	80-007-71	CK60A/CIMMYT 76/BJ197	127	226	334
28	80-008-11	76026-074-10	128	236	327
29	80-009-3	76012-136	129	209	314
30	Local check		130	213	307
31	80-009-10	Local check	131	227	333
32	80-009-12	RAHDA Local	132	235	328
33	80-009-18	NES1570	133	210	313
34	80-009-29	76026-072-3	134	212	308
35	80-021-37	CTL-MX-8	135	228	332
36	80-021-38	CTL-MX-9	136	234	329
37	80-021-40 (selection)	Local check	137	211	312
38	80-021-42	CTL-MX-12	138	229	309
39	80-021-50 (selection)	Local check	139	241	331
40	Local check		140	232	311
41	80-006-21	76026-061-6	141	230	330
42	80-009-5	NES7003	142	201	310

Table 4.14. Short Grain (Dwarf) Head to Row Test (81-005)

5 Seeds/Hill--1 Row/Plot

Entry No.	Source	Pedigree	Replication
1	80-001-122	NES110xNES6975	1001
2	80-001-139	NES2141xNES6975	1002
3	80-001-274	$(P8681F_2xLocal)F_2$	1003
4	80-001-304	PB-IBR-DAY Neutral x Local	1004
5	80-001-315	76026-019	1005
6	80-001-322-1	76026-066-6	1006
7	80-001-322-2	76026-066-6	1007
8	80-001-354	77093-70-2	1008
9	80-001-391	77(Comp)-1	1009
10	Local check	Local check	1010
11	80-001-411	P-P-15	1011
12	80-001-418	FAO-3	1012
13	80-001-421	FAO-5	1013
14	80-001-422	FAO-6	1014
15	80-001-423	FAO-7	1015
16	80-001-426	FAO-10	1016
17	80-001-427	FAO-11	1017
18	80-001-428	FAO-12	1018
19	80-001-430	Ferry Morris (A 53A)	1019
20	Local check	Local check	1020
21	80-002-23	77-93-33-2-1	1021
22	80-002-98	78099-R-52	1022
23	80-002-105	78099-R-82	1023
24	80-002-177	76026-032	1024
25	80-003-19	78097-R-60	1025
26	80-003-34	76026-009-7	1026
27	80-003-36	78(Comp)39	1027
28	80-003-112	$(P8681F_2xLocal)F_2$	1028
29	80-003-258	GSA1586F	1029
30	Local check	Local check	1030
31	80-003-266	FAO-5	1031
32	80-003-268	FAO-7	1032
33	80-003-276	Ferry Morris (A 53A)	1033
34	80-003-277	Unknown-10	1034
35	80-003-278	PV-530-GR	1035
36	80-001-279	PV-535-GR	1036
37	80-003-280	PV-708-GR	1037
38	80-003-281	PV-677-GR	1038
39	80-003-282	PV-729-GT	1039
40	Local check	Local check	1040
41	80-003-283	PV-6574	1041
42	80-003-284	PV-734-GR	1042
43	80-005-1	76026-071-3	1043
44	80-005-3	77093-33-2-4	1044
45	80-005-10	78-099-R-64	1045

Table 4.14 (Continued)

Entry No.	Source	Pedigree	Replication
46	80-005-11	78-009-R-66	1046
47	80-005-12	78-100-R-1	1047
48	80-005-16	78(Comp)-38	1048
49	80-005-18	76026-010-1	1049
50	Local check	Local check	1050
51	80-005-24	NES3329xNES6982	1051
52	80-005-32	NES1773	1052
53	80-005-39	Sana'a-1	1053
54	80-005-41	77(Comp)-84	1054
55	80-005-43	77(Comp)-104	1055
56	80-005-61	77(Comp)-39	1056
57	80-005-62	77(Comp)-72	1057
58	80-005-63-1	IS-410	1058
59	80-005-63-2	IS-410	1059
60	Local check	Local check	1060
61	80-005-34	NES1421	1061
62	80-006-29	NES9958xNES6983	1062
63	80-005-78-1	77(Comp)-20	1063
64	80-005-78-2	77(Comp)-20	1064
65	80-007-7	CK60A/76026-032-21	1065
66	80-007-9-1	CK60A/76026-004-41	1066
67	80-007-9-2	CK60A/76026-004-41	1067
68	80-007-23	CK60A/77(Comp)-75	1068
69	80-008-8	76026-068-12	1069
70	Local check		1070
71	80-008-16-1	77-93-08-8	1071
72	80-008-16-2	77-93-08-8	1072
73	80-008-16-3	77-93-08-8	1073
74	80-008-17	77-93-22-2	1074
75	80-008-19-1	77-93-76-6	1075
76	80-008-19-2	77-93-76-6	1076
77	80-008-22	77(Comp)-20	1077
78	80-008-23	77(Comp)-20	1078
79	80-008-25	77(Comp)-31	1079
80	Local check		1080
81	80-008-28	77(Comp)-46	1081
82	80-008-30	Local check	1082
83	80-008-31	77(Comp)-58	1083
84	80-008-32	77(Comp)-60	1084
85	80-008-33	77(Comp)-72	1085
86	80-008-34	77(Comp)-73	1086
87	80-008-35	77(Comp)-75	1087
88	80-008-36	77(Comp)-92	1088
89	80-008-37-1	77(Comp)-92	1089
90	Local check		1090
91	80-008-37-3	77(Comp)-92	1091
92	80-008-41	NES1559	1092

Table 4.14 (Continued)

Entry No.	Source	Pedigree	Replication
93	80-008-43-1	NES1570	1093
94	80-008-43-2	NES1570	1094
95	80-008-49	IS410	1095
96	80-008-53	IS2927	1096
97	80-008-54	CIMMYT76BJ197	1097
98	80-021-8-1	SD100	1098
99	80-021-8-2	SD100	1099
100	Local check		1100
101	80-021-12	SD-106	1101
102	80-021-13	SD-106 Maintainer	1102
103	80-021-26	PV-667-GR	1103
104	80-021-39	CTL-MX-10	1104
105	80-021-46	CTL-MX-16	1105
106	80-021-14	CTL-MX-22	1106
107	80-021-54	CTL-MX-23	1107
108	80-021-22	CTL-MX-24	1108
109	80-021-23	CTL-MX-25	1109
110	Local check	Local check	1110
111	80-021-24	PV-734-GR	1111
112	80-021-25	Local check	1112
113	80-021-27	CTL-MX-29	1113
114	80-021-21	SD-873-HSS-6	1114
115	80-021-28	PV-535-GR	1115
116	80-021-35	CTL-MX-13	1116
117	80-009-8	IS825	1117
118	80-009-9	76026-032	1118
119	80-008-24	77(Comp)-21	1119
120	80-003-259	GSA-30F	1120
121	80-005-20	NES1500xNES6976	1121
122	80-008-14	77093-03-5	1122
123	80-008-37-2	77(Comp)-92	1123
124	80-021-32	CTL-MX-3	1124

Table 4.15. Short Grain (Dwarf) Preliminary Yield Test (81-006)

5 Seeds/Hill--2 Rows/Plot

Entry No.	Source	Pedigree	Replications R1	R2	R3
1	80-001-123	NES110xNES6976	101	217	320
2	80-002-98	78099-R-52	102	225	308
3	80-003-64	NES3329xNES6973	103	210	311
4	80-003-65	NES3329xNES6976	104	210	325
5	80-003-112	(P8681 F_2xLocal)F_2	105	209	305
6	80-005-8	78099-R-44	106	215	329
7	80-005-9	78099-R-47	107	223	309
8	80-005-13	PB-TBR-DAY Neutral x Local	108	214	326
9	80-005-15	78(Comp)-28	109	216	334
10	Local check		110	233	312
11	80-005-22	NES2141xNES6975	111	222	302
12	80-005-27	NES2197xNES6974	112	227	327
13	80-005-34	76026-019-6	113	211	321
14	80-005-37	76019-001-4	114	221	318
15	80-005-38	76036-059	115	232	317
16	80-005-50	77093-03-5	116	230	303
17	80-005-54	77(Comp)-75	117	218	319
18	80-005-55	77(Comp)-128	118	204	324
19	80-005-59	77(Comp)-1	119	207	307
20	Local check		120	212	306
21	80-005-65	76026-074-11	121	229	328
22	80-005-66	76026-068-6	122	219	315
23	80-005-74	76026-070-5	123	226	330
24	80-005-80	IS410	124	205	301
25	80-005-81	NES1570	125	213	304
26	80-005-83	77093-22-2	126	231	332
27	80-005-19	CK60A/77(Comp)90	127	220	323
28	80-007-64-2	77(Comp)-1	128	202	322
29	80-021-11	SD-104	129	228	331
30	Local check		130	208	313
31	80-021-27	PV-708 GR	131	234	310
32	80-021-41	CTL-MX-11	132	203	316
33	80-008-20	NES110xNES6977	133	224	314
34	80-021-22	PV-657-Y	134	206	333

Table 4.16. Short Grain (Dwarf) Advanced Yield Trial (81-007)

5 Seeds/Hill--3 Rows/Plot

Entry No.	Source	Pedigree	Replications R1	R2	R3
1	80-002-121	NES110xNES6978	101	215	313
2	80-002-249	77093-65-1	102	213	315
3	80-005-17	76026-009-4	103	206	303
4	80-005-23	NES3329xNES6977	104	208	304
5	80-005-40	76026-002-2	105	204	314
6	800005-46	NES1559	106	201	307
7	80-005-49	77093-76-6	107	211	301
8	80-005-53	77(Comp)-58	108	202	306
9	80-005-67	76026-032-2	109	203	302
10	Local check		110	209	310
11	80-005-77	77(Comp)-20	111	210	311
12	80-005-84	77(Comp)-60	112	216	316
13	80-007-42	CK60A/NES1570	113	207	303
14	80-007-55	CK60A/77093-22-2	114	212	309
15	80-021-9	SD-102	115	214	305
16	80-005-68	77(Comp)-1	116	205	312

Table 4.17. Short Grain (Dwarf) Elite Yield Trial (81-008)

5 Seeds/Hill--4 Rows/Plot

Entry No.	Source	Pedigree	Replications R1	R2	R3
1	80-005-45	76026-024-9	101	213	311
2	80-005-48	NES1789	102	205	303
3	80-005-56	IS2929	103	214	309
4	80-007-23	CK60A/77(Comp)-75	104	220	301
5	80-007-29	CK60A/76026-004	105	210	317
6	80-007-41	CK60A/NES1421	102	204	319
7	80-007-43	CK60A/IS410	107	207	304
8	80-007-46	CK60A/76026-068-6	108	215	308
9	80-007-56	CK60A/77-93-76-6	109	206	310
10	Local check		110	201	321
11	80-007-64	CK60A/77(Comp)-39	111	222	302
12	80-007-66	CK60A/NES1421	112	216	320
13	80-007-69	CK60A/IS410	113	218	313
14	80-009-2	NES1773	114	221	316
15	80-009-19	77(Comp)-39	115	217	322
16	80-009-21	IS410	116	212	312
17	80-009-25	76026-036-2	117	203	307
18	80-021-23	PV-530-GR	118	208	306
19	80-021-24	PV-734-GR	119	202	315
20	Local check		120	219	305
21	80-021-25	PV-729-GT	121	211	314
22	80-007-57	CK60A/77(Comp)-1	122	209	318

4.2 University of Arizona Project Personnel

The following personnel were involved in the Project. All were from The University of Arizona except where noted.

4.2.1 Field Team (100% of full-time while in field)

Name	Position with Project	Responsibilities	Dates
Voigt, Robert L.	Plant Breeder	Chief of Party, Breeding Activities	Mar '77-Mar '79
Stewart, Donald M.	Agronomist	Pest Control, Weed Collection, Disease Control, Outreach Studies	May '77-Nov '78
Markarian, Deran	Agronomist	Chief of Party, Development of Al Jaroubah Station	Nov '79-May '81
Sandhu, Harnek S.	Plant Breeder	Breeding Activities, Outreach Studies	Nov '79-May '81
Arfa, A. David	Administrative Officer	Local Logistics Support	Jul '80-Oct '80
Hussain, Tasawar (IVS)	Assistant Agronomist	Field Supervision, Data Collection & Processing	Jan '78-Jan '80
Tacadao, Andreas (IVS)	Assistant Agronomist	Field Supervision, Data Collection & Processing	Jan '78-Oct '79
Acharya, Madhu S. (IVS)	Assistant Agricultural Engineer	Field Supervision, Data Collection & Processing	Dec '77-Dec '79
Attig, Museid Hassen	Senior Research Assistant	Field Supervision, Data Collection & Processing	Mar '78-Mar '81
Ismail, Ahmed Abdella	Agricultural Research Assistant	Field Technician	Jul '78-Mar '81
Abdo, Yahya	Senior Research Assistant	Supervisor at Bir Al Gohum & Al Jaroubah	Mar '77-Mar '81
Nasser, Mohamed Ali	Agricultural Research Assistant	Technician	Jul '78-Mar '81
Saad, Mohamed Gaed	Agricultural Research Assistant	Technician	Jul '78-Mar '81

Name	Position with Project	Responsibilities	Dates
Shaban, Mohamed	Senior Welder	Vehicle Maintenance	Jul '78-Mar '81
Herazi	Shop Foreman	In Charge of Shop	Jul '78-Mar '81
Robinson, David L.	Assistant Agronomist	Breeding Activities	Nov '78-Dec '79

Needs for short-term field personnel were identified and the following assignments were carried out:

Name	Position with Project	Responsibilities	Dates
Turner, Fred Jr.	Soil Scientist	Soil Survey Sana'a Station, Agronomic Practices	Jan-Feb '78
Bucks, Dale A.	Irrigation Engineer	Redesign Irrigation System Sana'a Station	Oct-Nov '77
French, Orrin F.	Irrigation Specialist	Develop Improved Irrigation Procedures Sana'a Station	Apr-May '78
Arle, Herman Fred	Weed Control Specialist	Study and Advise on Weed Problems	Jan-Feb '78
Tuttle, Donald M.	Entomologist	Study Insect Population, Make Collection, Identify & Classify Entries	Oct-Nov '77
Saul, Robert A. (Not UA)	Seed Storage	Survey Storage Methods and Facilities, Recomment Improvements	Feb-Mar '78
Lubbers, Edward L.	Assistant Agronomist	Development of Al Jaroubah Station	Jul '80-Sep '80
Younes, Mohamed H.	Assistant Agronomist	Development of Al Jaroubah Station	Jul '80-Sep '80
Swanson, Wallace A.	Assistant Agronomist	Devleopment of Al Jaroubah Station	Jan '81-Apr '81
Lenhart, James H., Jr.	Assistant Agronomist	Development of Al Jaroubah Station	Jan-Apr '81

4.2.2 On-campus Backstopping Personnel

Name	Position with Project	Responsibilities	Dates
Upchurch, R. Phillip	Project Director 15% of full-time	Overall Administration, Technical Direction	Jan '77-May '81
Matlock, W. Gerald	Fiector of Office of International Agriculture Programs. 8% of full-time	Administrative and Logistics Support	Jan '77-May '81
Voigt, Robert L.	Assistant Technical Director. 35% of full-time	Campus Liaison, Plant Scientist	Jul '79-May '81
Schornhorst, M. L.	Assistant Technical Director. 30% of full-time	Campus Liaison, Plant Scientist	Nov '77-Jun '79
McDonald, Dale E.	Research Assistant Various % of full-time	Procurement, Coordination	Mar '77-May '81
Webster, Orrin J.	Plant Breeder 3% of full-time	Assist in Management & Processing Sorghum	Mar-Jun '80
Marcarian, Victoria	Plant Scientist 80% of full-time	Technical Expertise	Jul-Oct '77
Scoville, Sheila	Oriental Studies Specialist	Preparation of Briefing Document	Oct-Nov '77
Ferguson, Nancy	International Programs Spec.	Preparation of Final Report	Jan-Jun '81
Nieto, Robert) Scaggs, Carl) Stevenson, Floyd) Rea, William) Collen, Mark) Schmalzel, Carl) Coren, Paul)	Research Technicians (Student Help) Various % of time	Assist in Seed Processing and Procurement	Various Dates
Fisk, Anna) Jorgensen, Evelyn) Kleem, Margaret) Heagen, Judith) Cancino, Christina)	Clerical Various % of time	Secretarial & Bookkeeping Tasks	Various Dates

4.3 Project Reports

Arle, H. Fred, 1978. Weed Problems and Herbicide Report to U. S. Agency for International Development Sorghum/Millet Project in the Yemen Arab Republic. January 18, 1978-February 15, 1978. University of Arizona, Cotton Research Center. 7 pp.

French, Orrin F., 1978. Progress Report of Visit to U. S. Agency for International Development Sorghum/Millet Project in the Yemen Arab Republic--April 12, 1978-May 17, 1978. 3 pp.

Lubbers, Edward, 1980. Trip Report: Yemen Arab Republic, Project 279-0030: Sorghum/Millet. University of Arizona. 4 pp.

Markarian, D., 1980. Quarterly Report, Jaruba Farm. Project 030, to Chester S. Bell, A.D.O., August 5, 1980. 3 pp.

Markarian, Deran, 1980. Quarterly Report from Chief of Party, Project 030 Sorghum/Millet to Charles Ward, Mission Director. November 19, 1980. 3 pp.

Sandhu, Harnek S., 1981. Annual Research Report Number 5, 1980. National Sorghum and Millet Crop Improvement. Project No.: 279-11-110-030. Contract No. AID/NE-C-1304 Yemen. 179 pp.

Stewart, Donald M., 1979. Report to U. S. Agency for International Development Sorghum/Millet Improvement Project in Yemen Arab Republic. May 4, 1979. 21 pp.

Turner, Fred Jr., 1978. Report of Technical Visit to U. S. Agency for International Development Sorghum/Millet Project in the Yemen Arab Republic. January 18, 1978-February 15, 1978. University of Arizona, Safford Experiment Station. 10 pp.

Tuttle, D. M. 1977. Preliminary Entomological Report for Yemen. University of Arizona, Yuma Branch Experiment Station. 9 pp.

University of Arizona, 1977. Semi-annual Report, January 15, 1977-September 15, 1977. Agency for International Development Negotiated Contract No. AID/NE-C-1304 (Yemen). Plant Sciences Department, Tucson. Various pagings.

University of Arizona, 1978. Second Semi-annual Report, September 16, 1977-March 15, 1978. Agency for International Development Negotiated Contract No. AID/NE-C-1304 (Yemen). Plant Sciences Department, Tucson. Various pagings.

University of Arizona, 1978. Third Semi-annual Report, March 16, 1978-September 15, 1978. Agency for International Development Negotiated Contract No. AID/NE-C-1304 (Yemen). Plant Sciences Department, Tucson. Various pagings.

University of Arizona, 1979. Fourth Semi-annual Report, September 16, 1979-March 15, 1979. Agency for International Development Negotiated Contract No. AID/NE-C-1304 (Yemen). Plant Sciences Department, Tucson. Various pagings.

University of Arizona, 1979. Fifth Semi-annual Report, March 16, 1979-September 15, 1979. Agency for International Development Negotiated Contract No. AID/NE-C-1304 (Yemen). Plant Sciences Department, Tucson. Various pagings.

University of Arizona, 1980. Sixth Semi-annual Report, September 16, 1979-March 15, 1980. Agency for International Development Negotiated Contract No. AID/NE-C-1304 (Yemen). Plant Sciences Department, Tucson. Various pagings.

University of Arizona, 1980. Seventh Semi-annual Report on Agency for International Development Negotiated Contract No. AID/NE-C-1304 (Yemen). March 15, 1980-September 15, 1980. Plant Sciences Department, Tucson. Various pagings.

University of Arizona, 1981. Eighth Semi-annual Report on Agency for International Development Negotiated Contract No. AID/NE-C-1304 (Yemen). September 15, 1980-March 15, 1981. Plant Sciences Department, Tucson. Various pagings.

Upchurch, Robert P., 1978. Report of Administrative Visit to U. S. Agency for International Development Sorghum/Millet Project in the Yemen Arab Republic--August 23, 1978-August 30, 1978. 8 pp.

Upchurch, Robert P., 1979. Report of Administrative Visit for the U. S. Agency for International Development Sorghum/Millet Improvement Project in the Yemen Arab Republic--January 21-February 3, 1979. University of Arizona, Tucson. 6 pp.

Voigt, Robert L. (no date). Annual Research Report Number 1, 1976. National Sorghum and Millet Crop Improvement. Project No.: 279-11-110-030. Contract No. AID/NE-C-1304 Yemen. 6 pp.

Voigt, Robert L. (no date). Annual Research Report Number 2, 1977. National Sorghum and Millet Crop Improvement. Project No.: 279-11-110-030. Contract No. AID/NE-C-1304 Yemen. 137 pp.

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Voigt, Robert L., 1979. Trip Report: Trip to Yemen to Complete Field Research Activities for the 1979 Crop Season. Dates of visit in country: October 13-November 20, 1979. Department of Plant Sciences, University of Arizona. 18 pp.

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Voigt, Robert L., 1980. Trip Report of TDY to Yemen A.R., November 4-21, 1980. University of Arizona, Plant Sciences Department. Various pagings.

Voigt, Robert L. and Mohamed A. El-Lakany, 1979. A Preliminary Description of the Germplasm Collection of Sorghum Varieties from the Yemen Arab Republic. University of Arizona, College of Agriculture, Plant Sciences Department, Communication Number 1. 158 pp.

Voigt, Robert L. and Orrin J. Webster, 1980. A Current Status Report on the Yemen Arab Republic Sorghum Collection Relative to Grow Out, Field Classification, Seed Increase and Future Plans. University of Arizona, Tucson. Various pagings.

4.4 University of Arizona Sorghum and Millet Project Expenditures as of 31 May 1981

Budget Items	Contract Budget	Amount Expended*
Salaries:		
Field Staff	$ 228,560	$ 214,369
Short-term Personnel	47,777	47,723
Local Hire	10,469	10,469
Campus Personnel	144,436	142,552
Fringe Benefits	63,391	64,347
Subtotals	$ 494,633	$ 479,460
Allowances	$ 83,996	$ 76,114
Per Diem (paid with USAID funds)	--	--
Travel & Transportation	$ 170,886	$ 169,504
Other Direct Costs	$ 68,900	$ 36,084
Overhead	$ 184,198	$ 164,548
Equipment & Supplies	$ 183,267	$ 146,655
Housing Support	$ 10,000	--
Local Employees	$ 90,000	$ 116,288
Subtotals	$ 791,247	$ 709,193
Totals	$1,285,880	$1,188,653

*Actual through 22 May 81; Estimated to 31 May 81.

4.5 Bench Mark Activities

1976

January	Project Paper for sorghum and millet project in Yemen signed
June	Request For Proposals (RFP) issued
July 6	University of Arizona response to RFP

1977

January 15	Contract for 2 years of a National Sorghum and Millet Crop Improvement Program awarded to The University of Arizona
February 1	Dr. Robert L. Voigt began as Chief of Party
March 16	Dr. Voigt arrived in Yemen; Mr. Yahya Shuga began as his counterpart
April	Dr. Donald M. Stewart began work
May 30	Dr. Stewart arrived in Yemen
October 11	Yemen President Al Hamdi visited research plots accompanied by U. S. Ambassador Scotes, USAID Director Neville and other officials
October 12	Dr. D. M. Tuttle arrived to begin short-term assignment as an entomologist
October 12	Mr. D. A. Bucks arrived to begin short-term assignment as irrigation engineer
October 13	President Al Hamdi assassinated in Sana'a
November 12	Tuttle and Bucks departed Yemen
November 29	Dr. R. P. Upchurch, Project Director, arrived for administrative visit
December 7	Upchurch departed Yemen
December 17	Field harvest completed
December 19	Madhu S. Acharya, IVS Agriculture Engineer, arrived with family

1978

January 18	Dr. Fred Turner, specialist in soil fertility, arrived in Yemen for short-term assignment
January 18	Mr. Fred Arle, specialist in weed control, arrived in Yemen for short-term assignment
January 25	Meeting of all sorghum improvement agencies in Yemen to discuss coordinated sorghum, millet and maize regional testing programs

February 15	Turner and Arle completed short-term assignments and left Yemen.
February 22	Robert Saul, grain storage specialist, arrived in Yemen for short-term assignment
March 8	Saul departed Yemen
March 18	Musied Attig began work as a technician, English/Arabic speaker
March 29	Shuga left Yemen for special training tour at The University of Arizona and to enter English language program. Mohamed Bother assumed the position of counterpart.
April	Planted all fields for 1978 tests using some equipment borrowed from UNDP
April 12	Dr. W. G. Matlock, Director of International Agriculture Programs, arrived for consultation with University of Arizona team and USAID officials
April 12	O. Fred French arrived in Yemen for short-term assignment
May 12	Amendment 1 sent from AID/Washington for signatures Total estimated contract cost changed to $658,679
May 17	O. Fred French left Sana'a
June 14-16	Mr. Marshall Bear from IVS/Washington visited. Voigt worked with him to develop objectives and work schedule for IVS in-country personnel which were coordinated with this project
June 24	President Al-Ghashmi of the Yemen Arab Republic was assassinated
July	Mr. Mohamed Ali Nasser bagan work in a technical capacity as an agricultural assistant
August 23-30	Dr. R. P. Upchurch made an administrative visit contacting the University of Arizona team, IVS personnel, USAID officials, and Sana'a University personnel
October 12	Request from USAID/Sana'a to University of Arizona for new personnel to replace those leaving. (NOT passed to University of Arizona by AID/Washington)
November 30	Dr. D. M. Stewart departed from Yemen
December 6	David Robinson arrived in Yemen

1979

March 14	Voigt departed Yemen at end of 2 year tour
March 29	Amendment 3 signed by AID/Washington to change completion date from 30 March 79 to 30 April 79
April 11	Voigt returned on temporary assignment to supervise planting 1979 tests
April 26	Dr. Deran Markarian nominated as agronomist
May 1	University of Arizona sent Amendment 4 to AID/Washington Increased contract value from $658,579 to $1,356,779; Changed end of contract from 30 April 79 to 31 March 81
May 4	Dr. Harnek Sondhu nominated as Project plant breeder
May 17	Voigt departed from Yemen
June 18	Markarian approved by AID/Washington
July 12	Representatives of Ministry of Agriculture and donor agencies visited Bir Al Gohum to see National Cooperative Trials
July 16-22	Mr. Rick Scott, Program Coordinator for International Volunteer Service, in Yemen
August	AID/Sana'a telegrammed to not send Markarian unless he went to Al Jaroubah
August 27-28	Abdul Momen Hazza of the Wadi Zabid Project and Gassi Nassar, Director of the Saidad Research Farm, Ministry of Agriculture visited The University of Arizona, Tucson
October	Andreas Tacadao, IVS Agronomist departed Yemen
October	Voigt arrived on temporary assignment to supervise harvesting of tests and make selections for 1980 tests
November 8	Markarian arrived in Yemen to assume duties as agronomist
November 9	Dr. Harnek S. Sandhu arrived in Yemen to assume duties as plant breeder, temporary status
November 20	Dr. Voigt departed Yemen
December	Madhu Acharya, IVS Agricultural Engineer departed Yemen

1980

January	Robinson departed Yemen
January	Tasawai Hussaei, IVS Agronomist departed Yemen
March 15	Sandhu approved for long-term status

March 16	Yahya Shuga promoted from Project counterpart to Deputy Minister of Agriculture for the Sana'a Governate
March 23	Markarian and Yahya Abdo moved permanently to Al Jaroubah
April 9	Septic system complete at Al Jaroubah
April 16	Reservoir at Al Jaroubah completed
April 24-28	Upchurch in Yemen on administrative visit
May 7	AID/Washington signed Amendment 6, a negotiated indirect cost rate agreement
May 18	Water tower at Al Jaroubah completed
May 25	Sandhu met with Minister of Agriculture
June 15	Sorghum-millet trial planted at Al Jaroubah
June 27	University of Arizona sent Amendment 5 to AID/Washington: Increased amount of contract by $92,221; substituted Sandhu and Markarian for Voigt and Stewart; enabled University of Arizona to take over logistic support for Project activities
July 2	Edward L. Lubbers and A. David Arfa arrived in Sana'a
July 4	Mohamed Younes arrived in Sana'a
August 5	AID/Yemen authorized University of Arizona to pay local employees and to cover local expenses; per Amendment 5
August 5	AID/Washington signed Amendment 5
August 7	Markarian departs for U. S. to attend CID Farming Systems Research Seminar and on leave
August 11-12	Abdulwahal Mahmud, Minister of Agriculture, visited The University of Arizona, Tucson
August 27-29	Markarian conducts Moh'd Sharif Aldin on tour of agriculture in California
September 24	Edward L. Lubbers left Sana'a
September 26	Mohammed Younes left Sana'a
October 9	Letter of nomination sent for James H. Lenhart and F. Richard Ortega to replace Younes and Lubbers
October 11	Markarian returns to Yemen
October 15	Received proposed Amendment 7 from AID/Washington
October 30	AID/Washington signed Amendment 7--budget changes
December 8	Markarian departs for medical leave

December 16	University of Arizona sent Amendment 8 to AID/Washington increasing $176,656
December 17	W. G. Matlock and R. P. Upchurch arrived in Sana'a for consultations with University of Arizona team members, USAID and YARG officials
December 22	Matlock and Upchurch left Sana'a
December 30	AID/Washington signed Amendment 8

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January 5	AID/Washington mailed Amendment 8
January 18	Lenhart arrived in Yemen
January 28	Markarian returned t Yemen with his wife; Wallace A. Swanson arrived in Yemen as a substitute for Ortega.
March 2	University of Arizona sent Amendment 9 to AID/Washington (No cost change) from $169,269 to $170,267
April 7	Keys for Al Jaroubah Station turned over to USAID
April 8	Markarian departed Sana'a for U. S.
April 9	University of Arizona Amendment 10 to AID/Washington
April 12	Swanson and Lenhart departed Sana'a for U. S.
April 15	Amendment 11 sent to AID/Washington
April 29	Sandhu departed Sana'a for U. S.