AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 87

1. SUBJECT CLASSIFICATION
A. PRIMARY: Serials — Y-AF00-0100-G788
B. SECONDARY: Food production and nutrition--Cereals--Yemen Arab Rep.

2. TITLE AND SUBTITLE
National sorghum and millet crop improvement; progress report,Sept.1977-March,1978

3. AUTHOR(S)
(101) Ariz.Univ. Dept.of Plant Sciences

4. DOCUMENT DATE: 1978
5. NUMBER OF PAGES: 98p.
6. ARC NUMBER: ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Ariz.

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(Research summary)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAF-684

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Millet
Sorghum
Yemen

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/ne-C-1304

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

THIS DOCUMENT HAS BEEN EVALUATED AS SUBSTANDARD COPY FOR ROUTINE REPRODUCTION. EFFORTS IN AID/W TO OBTAIN A MORE ACCEPTABLE COPY OF THE DOCUMENT HAVE NOT BEEN SUCCESSFUL. DESPITE THIS DISADVANTAGE, WE HAVE CHOSEN TO REPRODUCE THE DOCUMENT BECAUSE OF THE SUBJECT TREATED AND TO MAKE THE DISCERNIBLE INFORMATION AVAILABLE.

AID/ne-C-1304
Ariz. PN-AAF-684

Second
Semi-annual Report

on

Agency for International Development Negotiated
Contract No. AID/NE-C-1304 (Yemen)

Project No.: 279-11-110-030

Contract For: National Sorghum and Millet Crop Improvement

Contents consist of a substantive and administrative report in accordance with General Provisions, paragraph 12, AID1420-23C (7-1-75)

Period of Report: September 16, 1977 through March 15, 1978.

Previous Report: January 15, 1977 through September 15, 1977. The first key personnel arrived in Yemen March 16, 1977

Prepared by: University of Arizona,
Department of PLant Sciences

Copy to:

Contracting Officer (3)
Mission (4)
AID Reference Center (2)
Yemen Chief of Party (2)
Coordinator, International Agriculture Programs (1)
Department of Plant Sciences (2)

Substantive Report

1. Status of work and progress under the contract.

The following information was extracted from the Yemen bi-weekly reports. Paragraphs present a month sequence of work accomplished, problems encountered and plans for the next month.

Crossing came to a stop during the last half of September due to cool night temperatures ranging down to 5 to 10 degrees Centigrade. These night temperatures rendered much of the pollen infertile. The day temperatures also cooled off. As a result, many unadapted genotypes just bloomed and did not develop much farther. Irrigation was continued to fill out the developing seed. The bird watchers did an amazing job of holding down damage to developing seeds on the plots. Analysis of the 6 planting dates of sorghum and millet revealed the first three dates of 5 May, 18 May and 1 June to be the most productive in terms of development. The 15 June planting date had poor growth with even less growth and development occurring in the 29 June and 13 July plantings. Dr. D. M. Stewart assisted Dr. Konrad Engleberger of the German farm and Ludwig Hoshner of the Al Bonn project in making disease readings of German farm maize plots. Dr. Stewart discussed the sorghum stem borer problem with Dr. J. Zchintzsch, Head of the Yemeni-German Plant Protection Project. He identified our strain as the Pink Stem Borer (Sesamia cretica). Problems encountered included vandalism in which 10 cases of plastic irrigation pipe was broken with rocks and winds up to 40 mph starting in the early morning hours. PLans were made to: sample the 1976 yield plot seed for storage and discard the remainder, clean and air grain storage sacks; order metal boxes, to be locally made, to start a seed envelope storage system.

October brought visitors to our project. Yemen President, Al Hamdi, visited the Sorghum/Millet Research plots October 11, 1977. He was accompanied by U.S. Ambassador Scotes, US AID Director Neville, plus other officials. The 40 minute tour was conducted in Arabic by Mr. Yahya Shuga. Mr. Shuga is Dr. Voigt's plant breeding counterpart, who did an outstanding job. President Al Hamdi was very pleased with the program. It was unfortunate the President was assassinated approximately 36 hours later. Dr. D. M. Tuttle (Entomologist) and Mr. D. A. Bucks (Irrigation Engineer) arrived on schedule October 12 to fulfill duties in their respective professions as short term specialists. Mr. Bucks measured and surveyed field layouts of Bir Al Ghoum and Bir Al Shaif research farms at Sana. The irrigation water resources were evaluated for suggested maximum research acreages to be used. There was not enough water at either farm to use all the acreage available. Rainfall is sporadic, unpredictable and cannot be relied upon for research purposes. Sana did receive about 2¼ inches of rain on October 27-28. This was the first such early rain (before

November) in recorded weather history. Mr Bucks, Mr. Morgan Stickney, and Dr. Voigt, Chief-of-Party, visited the Tihama area and the new Al Garubah experiment farm near Zabid on October 25 to 27. The Al Garubah farm was inspected and evaluated as to the work necessary for development for sorghum/millet research. The land and facilities belong to the Yemen Government. Two of five new vehicles for the project were picked up at the port of Hodeidah and delivered to Sana on this trip. The project is furnishing 2 vehicles, drivers, and partial per diem to two field crews from the United nations Development Program/Food and Agriculture Organization (UNDP/FAO) at Taiz to complete a Yemen Sorghum Collection from all major production areas in the country. Dr. D. M. Tuttle collected insects from all crops on both Sana research farms, neighboring private farms and from around Yemen. Drs. Tuttle and Stewart also toured Yemen via Hodeidah and Taiz on a plant protection evaluation tour from October 23 through 30th. During the month Yahya Shuga and Yahya Hopshie, (Yemen Ministry of Agriculture) attended a Sorghum Tour with sorghum research personnel from all agencies in Yemen at Hodeidah. They also visited the Tihama development authority facilities field day on October 30th. The UNDP research facilities were visited October 31. Plants were drying and grain maturing during the month. Maturity readings were completed. Notes were taken on percent stand in plots for adjustment of yields from partial plots. More than half of the yield plots were observed with only partial stands. According to data books this adjustment had not been made in previous years. Readings of the general agronomic phenotype and readings of the head phenotypes were conducted. Plans were made to take notes on height, percent lodging and bird damage just prior to harvest. The bird watchers continued to do an excellent job of keeping birds off the research plots. There was not enough bird damage with sufficient variation among entries to make bird damage estimates meaningful. Average height measurements in centimeters to the upper leaf collar were obtained for all plants. Work progressed on the roofs for the new office and laboratory buildings.

During the month of November, plants continued to mature and dry for harvest. Sacks were cleaned and treated with Sevin in preparation for harvest of plots. Field notes were completed on percent of stand. Yield plots and visual evaluations of genotypes were tested. Project personnel were busy with tours during the early part of the month. The sorghum and millet research plots at Sana were visited on November 2 by a group of Sorghum Research personnel from various Yemen agencies. A meeting followed the tour at the Ministry of Agriculture. Dr. Azah, representing the Food and Agriculture Organization, made an inspection and tour of USAID sorghum and millet research effort in Yemen. This was a three hour inspection and briefing by Dr. Voigt and Dr. Stewart. Harvesting by hand began on the sorghum research plots on November 13 and consisted of cutting off each head and placing in a sack. Harvesting of plots stopped on November 17 and resumed November 27, 1977. Dr. D. M. Tuttle completed his entomological evaluations of Yemen and wrote up a preliminary report before departing. Mr. Bucks visited the Taiz area and evaluated the products of a plastic pipe factory. These products are proposed for use in our irrigation systems for

the 3 experiment stations. Mr. Bucks also completed a preliminary report before departing. Dr. Tuttle, Mr. Bucks had a pre-departure visit with acting director Neville and acting deputy director Young. Both departed 12 November. Eid-Al-Adha, the local holiday period extended from November 16 through November 26. The American holiday, Thanksgiving, occurred on November 26. University of Arizona research personnel were on the job unofficially for 4-6 hours per day through this whole period taking research notes and collecting seeds of genotypes under test. The Yemen sorghum collection was esentially completed. All Governates with a significant sorghum acreage have been collected. A killing frost occurred the night of November 27. Lower temperatures occurred later in the month. Dr. R. P. Upchurch, Head, Department of Plant Sciences, University of Arizona arrived on schedule November 29 to perform an administrative visit.

Research plots continued to be harvested during December. As the area of unharvested material decreased in size, some of the extra personnel used to keep birds off were terminated. The new laboratory and office spaces were roofed over. Electrical wiring and plumbing for these facilities were started. Most of the interior finishing and furnishing remained to be done at month's end. Field harvest (hand harvest of the heads) was completed on Saturday, December 17. Border rows and other miscellaneous fill-in rows were hand harvested later in the month for bulk grain for the poultry project. On December 24, project personnel started weighing "whole heads" from harvested plots preliminary to possible estimates of grain yield as 70% of total head weight. A small research type thresher was borrowed from the British at Taiz. It was a rasp bar type but undesirable in performance. It would not separate any grain from the straw and the rasp bar held part of the heads. This required cleaning the machine between plots to maintain purity. The grain and straw could only be separated by hand screening. After sorting tests for individual threshing and processing, an attempt to use the borrowed thresher followed. Its one cylinder gasoline engine had badly worn rings and burned considerable oil with the result of low horsepower and a fouled plug. A new plug was not available. The machine would only break up the heads into smaller pieces and did not thresh much of the grain from the glums. Dr. Upchurch, Technical Director from the University of Arizona made a trip through the major agricultural areas of the country on December 4-6, 1977. The trip was from Sana to Hodeidah to Taiz and return to Sana. The new Al Garubah Experiment Farm, Tihoma Development Authority, and the UNDP/FAO were visited. The varied agriculture and growth environments in the country were also observed. Dr. Upchurch departed Yemen December 7, 1977, returning to the United States. Dr. Stewart, University of Arizona agronomist serving as one of the the two key personnel in Yemen, departed December 14 for rest and recuperation (R & R) leave. Two International Voluntary Service (IVS) personnel worked on tabulating agronomic field data on research plots during morning hours. IVS personnel work from

0730 to 1200 and go to Arabic class from 1600 to 1900. Mr. Madhu S. Acharya, IVS Agriculture Engineer arrived in country with his wife and son December 19, 1977. Dr. Voigt, Chief-of-Party, Mr. Shuga and a driver made a three day trip to Hodeidah to peronally expediate the processing of USAID equipment and supplies through the port, customs, and local Governate government on December 19-21, 1977. Inventoried and checked miscellaneous equipment and supplies received through the pouch from the University of Arizona. No losses or damage have occurred thus far. A problem area was the obvious thresher defects already mentioned. Harvested materials more than filled the area of building spaces already constructed. This necessitated storing materials in the space which would eventually be used for the new machinery and shop work area. The Horticulture Project will eventually need space which will further increase the problem of space to work out of and store material. An open sided roofed area for storage of harvested material and as a work area is under contract for construction. This building is urgently needed. Equally frustrating was the fact that two plot threshers for the project were on board ship in Hodeidah, but our personnel were unable to determine when they would be unloaded or cleared for release. Plans for the month included: turn the borrowed thresher in for repair and tune up by the garage; proceed with threshing and evaluations of genotypes in the advances type of yield tests; continue to work as best possible with the limited equipment and facilities available; begin data tabulation and analysis of advanced trials for early elucidation of superior genotype for release in 1978.

January, 1978 activity involved significant progress in the contract Scope of Services in the following areas:

1. Screening of potential high producing varieties of sorghum and millet and to select varieties suitable to varying local conditions.
2. Re-combining varieties with superior characteristics to produce high yield varieties for major ecological regions of Yemen.
3. Training counterpart Yemeni staff to undertake the foregoing and to prepare ultimately for the creation of a national agriculture research capability in sorghum and millet.
4. Provide professional and technical coordination to three agronomists and one agriculture engineer to be provided under a separate but related contract with a voluntary agency. The above items are 1, 2, 7 and 10 of the scope of services. Main project activity was in the area of threshing yield plots which had been harvested by hand. Advance yield tests were threshed first for early tabulation of test results. Mr. Tacadao and Mr. Hussain (IVS agronomists) assisted with threshing and data tabulation. Mr. Acharya, IVS agriculture engineer, under item 10 of the contract surveyed field plot areas and developed plans for further irrigation and determined pipe needs. Reference item 3 (developing research facilities) the following occurred: shelving was assembled in the new spaces to

facilitate storage during construction; the driveway into Al Jarouba was surveyed out and a grader dispatched to accomplish the work; work on contract development to remodel or build necessary structures was initiated; the Mission was visited by an International Meteorological advisor to the Yemen Government on weather station installation in country. Mr. Acharya evaluated the Al Jarouba research station relative to irrigation and other agronomic needs; Mr. Acharya visited a plastic pipe factory in Taiz to determine availability and cost of irrigation pipe. Reference item 7 of the scope of services (training Yemeni personnel), one technician quit and another was hired. Some plots were harvested with sticks by farm laborers to expediate harvesting and to obtain yield data. The one single head thresher was used to clean threshed seed. Dr. Fred Turner, Soil Fertility, and Mr. Fred Arle, Weed Control, short term specialists from Arizona, arrived in country on January 18, 1978. They evaluated our project with regard to their respective professions. They accompanied Dr. Stewart and Mr. Stickney on a tour of Yemen agriculture areas by way of Taiz, Zabid, Hodeidah and return to Sana on January 29-31, 1978. A meeting was held on January 25 of all sorghum improvement agencies in Yemen to discuss coordinated sorghum, millet and maize regional testing programs. Discussion for coordinated sorghum, millet and maize regional testing programs. Discussion for coordinated regional yield and observation trials at all major agriculture research centers occurred. March 8, 1978 was tentatively selected as the date for the next meeting. Problems encountered during the month included: one USAID Blazer vehicle was scrapped for parts as a result of an accident in which another truck, loaded with rocks and on the wrong side of the road, smashed into it; no work occurred toward completion of the new laboratory and office spaces; the only head thresher failed with a shorted motor armature; the farm crew had no understanding of research procedures; the only weighing device available was a beam balance which took a lot of time to balance the weights; the lack of laboratory, office and storage space resulted in: farm and automotive equipment being piled in the midst of harvested field plots, tests being walked on and mixed up. For example, sacks of yield plot heads were walked on, pushed and carried in a careless manner which dropped out heads. They could seldom be returned to the proper sack to guarantee plot purity. This resulted in even more error. Personnel were quite unacquainted and/or unappreciative of research and the necessity for accuracy. Plans were made to continue: obtaining yield data and tabulate results; development of the Al Jarouba experiment farm; ordering equipment and supplies to develop Sana'a experiment farm and laboratory; ordering equipment and supplies from the University of Arizona; installing electrical wiring in new buildings.

February was a month of continuing the threshing, weighing and tabulating of data as explained last month. It was necessary to keep constant watch on the farm help to insure they beat the sacks sufficiently to hand thresh out most of the grain. Many research project technicians could not be depended upon to keep a close watch on this. The advanced tests were all threshed and plots weighed. Most of the data was tabulated

by month's end. Tabulation makes it possible to select superior genotypes. Two large plot threshers were finally delivered by Thabet Brothers Shipping Company on February 21, 1978. Both machines had been dropped while being unloaded at the port of Hodeidah. The machines had numerous dents and broken pieces as a result of shipment. They were placed in the garage for repair. Parts and operators manuals were placed on order from the University of Arizona. A Pettibone type crane was moved to Al Jarouba to install a pump and pipe in an irrigation well. A big effort was made from February 6-16 to get equipment to this research station for the well and to get the motor/mount installed. Dr. Turner and Mr. Arle continued their duties as short term specialists. They made a trip to the soils laboratory at Taiz and had soil and water samples analyzed. Both individuals departed for the United States on February 15, 1978. Mr. Robert Saul a short term grain storage specialist, arrived February 22, 1978. He and Dr. Stewart toured agriculture areas in Yemen for five days, starting February 27. They inspected and evaluated sorghum and millet farm storage procedures and conditions. Dr. Voigt, Dr. Stewart and Mr. Saul visited with Mr. Rahman of the Yemen General Grain Corporation concerning commercial grain storage in country. Equipment and supply orders continued to arrive by pouch from the University of Arizona. Replicated plot yield data of individual genotypes were inspected for degree of variability among replicates within the same test. Plot yield magnitudes of differences of 200 to 300 percent were found. Such differences were found among plots of the same genotypes even when all plots had had a 100 percent stand or population during the season and did not have to be corrected for partial stands. This variability of plot performance will not give reliable data. Not all entries had such variability but enough did to indicate concern for the research being run and what has been run in past years. This serious problem may be a manifestation of the very uneven plant growth and development observed in the plots during the growing season. These aberrations were described in earlier reports. Reliable plant breeding results cannot be obtained until similar plant growth and yields of like genotypes are obtained in a routine manner. The advanced yield tests composed entirely of selections inherited from past years showed no genotypes yielding more than about 50% more than the local types. It had been hoped that materials developed in past years would have greater potential.

Perhaps the yields of 300 and 400 percent of some genotypes over locals in unreplicated plots in earlier years were subject to the variability described above and were not true measures of the potential yield of the genotype. Plans were made to continue tabulating and most entries equal to or better than the local types in yield would be saved for future evaluation in 1978.

By March 15, 1978 nearly all advanced yield tests had been tabulated. Threshing, weighing and tabulating of minor tests continued. Seed was selected for regional yield trials with other Yemen cooperators. Work

continued on the Al Jarouba Experiment Farm. Part of the plastic irrigation pipe for the Al Jarouba and Sana'a farms was delivered on March 1, 1978. A contract was awarded for construction of a ramada type open shed with roofed area. This additional work area is planned for future threshing and working on research materials. The March 8, 1978 scheduled meeting of all sorghum research personnel in Yemen was cancelled due to no shows from the Ministry and most out-of-town participants. The meeting was rescheduled for March 22, 1978. Mr. Saul and Dr. Stewart returned from their 5 day inspection trip of farmer grain storage problems in various parts of Yemen. Mr. Saul did not think drying or storage of the sorghum/millet harvest was a problem. Sufficient vacant area was available in all villages visited to expand the drying yards for either larger harvests or faster harvest if mechanization should become the practice. The farmer protects his food supply rather well. Mr. Saul departed Yemen, returning to the United States on March 8, 1978 after completing his short term objectives. Equipment, supplies, machinery, lumber, fencing and other miscellaneous items all congregated around and in the research work area continued to be a problem. Plans were made to: make final test entry for advanced field tests; put up seed for 1978 evaluation trials; store and treat seed of genotypes to be carried forward; discard seed of discarded genotypes; develop improved field plot and irrigation system for the Bir Al-Ghoum farm; probe soils of the Bir Al-Ghoum farm on a grid system, continue Al-Jarouba Experiment farm development.

2. Plans for ensuing period

The preceding paragraphs individually discussed some aspects of this subject. Plans for the future involve continued work to provide assistance to fulfill all aspects included in the contract scope of services. It is anticipated the limited land, equipment and trained personnel will limit 1978 activities. Specific goals include: developing genotypes for limited moisture on the second experiment station; developing field cropping techniques and on-farm testing programs; continue on-the-job training of local personnel. Peak seasonal work, accentuated by numerous delays and Yemen frustrations present a problem of proceeding on schedule.

3. Recommendations covering current needs in field of activity.

Status of work is delayed and behind due to local situations beyond control of administrative personnel on site. The following areas provide an insight into current needs.

a. Delayed delivery of equipment and supplies seriously hinder work.
b. Construction of required facilities encounter serious delay.
c. Field plot techniques to provide reliable research data are unperfected.
d. Equipment to provide reliable research data is not presently on station.

e. Limited progress has been made in identifying superior genotypes from the data provided by previous contractors. Previous evaluations are questionable.

The selection of our own genotypes will not be available for some years which is typical for selection and evaluation in a plant breeding project. Progress is being made in all ten contract scope of service areas.

4. Additional information pertaining to this contract:

a. Communications: The usual time element of two months for an exchange of mail was discussed in the last semi-annual report. Telegrams and the telephone were used on a more frequent basis during this reporting period to cut the communications time lapse. This has increased communication expenses.

b. Delivery of personal effects and supplies: Excessive delays on delivery of air freight and surface freight continued. For example, it took almost one year for Dr. Voigt's automobile to be delivered to him via surface freight. Some supplies which were shipped air freight, still take up to three months to arrive. Pouch mail has proven to be the most dependable and fastest method of delivery in normal circumstances. Short term personnel were utilized, when possible, to hand carry small items to Yemen. A cycloptic microscope and a soil sampling kit are examples of items hand carried by short term specialists. Considerable time is still required in frequent follow up action to determine status of shipments. Allied Van Lines, Tucson, AZ, has refused to accept any more surface shipments due to past encountered difficulties.

c. The on campus backup activities were many and varied:

(1) Equipment orders increased. They were procured, inventoried, repacked for pouch mail, if possible, and/or shipped to Yemen.

(2) Five short term specialist positions were filled and individuals completed objectives in Yemen. One administrative visit was also completed. The recruitment and administrative processes for these positions were time consuming and required a considerable amount of coordination prior to actual departure. Upon completion of a short term tour, each individual submitted end of tour reports. These reports were reviewed to determine if the University of Arizona should take any action to enhance the project.

(3) Library research continued on ways to control birds and this information was forwarded to the Chief-of-Party. Cost of bird alarm system and literature describing them were also obtained and forwarded.

(4) A Phoenix weed control expert identified weed seeds which had been sent from Yemen as:

Xanthium spinosum L.
Scrophularia Xanchoglassa Bois
Solanum albicaule
Fagonia arabica L.
Senecio aegytius L.
Echinops spinosissimus turra

These seeds, plus packets of mustard seeds from Yemen were forwarded to Mr. Fred Arle, to conduct a greenhouse experiment to determine control procedures. Mr. Arle went to Yemen, as previously mentioned, during January 1978 as a weed control specialist. Upon his return, he arranged for herbicide to be sent to Yemen for control procedures. Unfortunately, Mr. Arle's unexpected death occurred before his greenhouse experiment was finished.

(5) Routine soil analysis was completed by the University of Arizona on soil Mr. Bucks brought back from the Bir Al-Ghoum farm and the Al-Jarouba farm in Yemen. Mr. Bucks forwarded the results back to Yemen. Portion of equipment order no. 12 was for irrigation material which Mr. Bucks had suggested while he was in-country. He was extremely helpful during the procurement process as some of this equipment was not available in the metric dimensions which had been requested.

(6) The International Programs Office continued follow up of previous surface and air shipments. This office provided the logistical support for transportation arrangements on all short term and consultant travel, plus the shipment of equipment and supply orders. The office served as the focal point for contact with the Agency for International Development Contracting Officer. Such matters were resolved as: Dr. Voigt's second consumable shipment, educational allowance and travel contract provisions; post allowance and post differential. Sunday differential pay for regular personnel in Yemen was also included in their written communications with the Contracting Officer. The contract will be amended to include this provision at a later date.

(7) Dr. Voigt's Yemen counterpart, Mr. Yahya Shuga, is tentatively scheduled to arrive March 27, 1978 to enter the Center for English as a Secondary Language (CESL) at the University of Arizona. Although this participation is not included in the contract, it is sponsored by the Agency for International Development. Negotiations for this arrangement started with the administrative visit of Dr. Upchurch to Yemen in the latter months of 1977. Numerous pieces of correspondence including telegrams, flowed between the University of Arizona and Yemen and back again. Qualification requirements, tuition cost and housing availability was obtained from the necessary agencies on campus, and forwarded to Yemen. As the information diplomas and forms returned to the Department of Plant Sciences, coordination was effected with the offices of: International Programs, Center for English as a Secondary Language, and Dean of Admissions Foreign Credentials. Telegrams were used to obtain information when time became the essence.

International Programs obtained an evaluation of Mr. Shuga's background from the Office of Foreign Student Admissions which stated: "A review of his background shows he did not complete the academic secondary stream to qualify in the usual way for University admission. After completion of six-year primary school program and the three-year intermediate school cycle, he completed a three-year vocational secondary school program in agriculture. His final grades in vocational school show an average of 66% marks. We normally look for 70% as the minimum grade for admission

consideration. However, in addition to twelve years of formal education, he has had further professional training and work experience in his position with the Yemen Arab Republic Ministry of Education. Because of his professional experience and maturity (age 33), we will be able to admit him as an unclassified, undergraduate initially. Upon completion of twelve semester hours credit (minimum), he may request his status changed to Freshman standing, and all work taken as an unclassified student will be counted toward a Bachelor of Science degree requirements. We understand he is to enter our CESL program this March. Once we have evidence of college-level English proficiency, he will be admitted as an unclassified undergraduate student". CESL arrangements were finalized at this point. The mission and Agency for International Development in Washington were notified of his acceptance. It is anticipated he will complete CESL and enroll to obtain a Bachelor Degree in Agriculture over the next four year period.

(8) The sorghum millet project is assisting in the augumentation of library facilities for agriculture in Yemen. The following actions have occurred.

(a) Order number 18 has been received from Yemen for research on pricing and availability of desired books and periodicals.

(b) A limited number of books have been procured and forwarded to Dr. Stewart, per his request.

(c) The American Society of Agronomy Borlaug Book Project has been contacted to determine if books and journals might be made available to the Government of Yemen.

(d) The estimated price of microfilm and microfiche equipment has been obtained for possible use in Yemen. Library research on journals available for use with this equipment has been conducted.

(e) Xerox copies of all articles pertaining to sorghum and millet for a 15 year period have been reproduced from Crop Science journals for shipment to Yemen.

(f) The Current Research Information System (CRIS) was contacted for information on sorghum and millet. The data from their computers on a nationwide basis has been forwarded to Yemen.

(9) Research on cost and availability of a self contained refrigerated seed storage room, seed germinator, herbarium, plus supplies for starting an insect collection has been conducted. Results have been forwarded to Yemen.

(10) University of Arizona, Department of Animal Sciences was contacted for their availability of a service to conduct quality analysis on sorghum grain samples. This department can provide protein content and digestibility analysis service on a limited scale, if requested to do so.

(11) Approximately 50 pine seeds were obtained for use in Yemen.

(12) As of March 15, 1978 plans were being finalized to send an irrigation specialist, Mr. Orrin F. French, to Yemen on a short term basis in April.

(13) Action was taken to recruit a research assistant to help Dr. Voigt with the project in Yemen. The recruitment process was underway as of the close out date of this report.

(14) International Programs and the Department of Plant Sciences worked together to obtain the best advice available concerning the income tax situation for the University personnel in Yemen.
(15) Library research was conducted to determine the impact of leaf removal on sorghum yield, as is the practice in Yemen. Data on this subject was very limited.
(16) The use of pot experiments to determine variations of Yemen soil nutrients was discussed with Mr. Fred Turner, prior to his participation as a short term soils specialist in country. His expertise and knowledge in this area led to suggestions on how to conduct them while he was in Yemen.
(17) On campus support continued to handle the increased administrative load as the project got into full swing.
(18) Tentative arrangements were made for Mr. Arle to return to Yemen as a weed control specialist, then aborted.

d. Mary C. Neville, Deputy Missions Director visited Tucson in December, 1977 and met the University of Arizona faculty and staff members who are supporting the project. Our special thanks are extended to the Mission and the Agency for International Development personnel who have provided excellent support to the University of Arizona in fulfilling contract obligations.

Administrative Report

This segment of the semi-annual report covers expenditures and personnel employed under the contract. A report on foreign national trainees was not applicable during this period.

Expenditures increased as expected as the various aspects of the project received attention. Supply and equipment orders from Yemen significantly increased. Equipment orders No. 5 through No. 20 were received from Yemen and action taken for procurement. Items ordered varied from small vehicle parts to large bulky items such as a subsoiler and furrow openers. Inflation was also noted as most prices of Stateside equipment increased. Order #12 was a large order with an estimated cost of approximately $14,000 not counting shipping charges. This particular order contained such items as: soil/moisture sampling and testing equipment; 36 butterfly valves for irrigation use; water flow meters; farm implements; etc. Expenditures for travel and short term specialist salaries increased as contract obligations were met in providing consultant personnel as requested. The latest inception to date computorized report dated March 31, 1978 is attached. This report was generated by the University of Arizona computerized accounting system, which is called CORE. This report can be used to determine overall expenditures from inception of contract through March 31, 1978. See attachment one.

The following personnel were employed as indicated, during this reporting period:

Dr. Robert L. Voigt, Chief of Party in Yemen, full time.

Dr. Donald M. Stewart, Agronomist in Yemen, full time.

Dr. Robert Phillip Upchurch, Head, Department of Plant Sciences, spent 15% of his time as Technical Director for the contract.

Dr. William Gerald Matlock, Coordinator for International Agriculture programs, spent 07% of his time performing duties as Campus Coordinator.

Dr. Victoria Marcarian, Department of Plant Sciences, spent 80% of her time on the project from September 15, 1977 through October 31, 1977.

Dr. Melvin H. Schonhorst, Department of Plant Sciences, spent 35% of his time since November 1, 1977 serving as overall coordinator for on-campus technical support.

Ms. Evelyn Jorgensen spent 24% of her time since November 1, 1977 serving as a secretary in the support of the project from the International programs office.

Ms. Anna M. Fisk, Department of Plant Sciences, spent 35% of her time performing secretarial duties associated with the contract.

Ms. Sheila Scoville, Oriental Studies, was hired and worked 2 months on a part time basis collecting background information and writing a briefing document on Yemen to be used by the International Agriculture Programs office in orienting regular and short term staff assigned to Yemen.

Mr. Dale E. McDonald, Department of Plant Sciences, Research Assistant, full time.

Mr. Dale A. Bucks, Research Specialist in Soils, Water and Engineering, served as a short term irrigation specialist in Yemen from October 12, 1977 to November 12, 1977.

Dr. Donald M. Tuttle, Entomology Specialist, served on a short term basis in Yemen from October 12, 1977 to November 12, 1977.

Mr. Herman Fred Arle, Weed Control Specialist, served as a short term specialist in Yemen from January 18, 1978 to February 15, 1978.

Dr. Fred Turner, Jr., Soils Specialist, served on a short term basis in Yemen from January 18, 1978 to February 15, 1978.

Mr. Robert A. Saul, Grain Storage Specialist served on a short term basis in Yemen from February 22, 1978 to March 8, 1978

Trip reports for the short term specialists are attached as indicated below:

Mr. Dale A. Bucks - Irrigation - Attachment 1
Dr. Donald M. Tuttle - Entomology - Attachment 2
Dr. Robert Phillip Upchurch - Administrative Visit
Mr. Herman F. Arle - Weed Control - Attachment 4
Dr. Fred Turner, Jr. - Soils - Attachment 5
Mr. Robert A. Saul - Grain Storage - Attachment 6

REPORT NO. GA3204
ACCOUNT NO: 867381
ACCOUNTANT: JIM COOK NON-CETA

UNIVERSITY OF ZONA
ITD RESPONSIBIL REPORT
FOR MONTH ENDI 3-31-78
YEMEN SUPPORT 501 0120

PAGE NO 1
RUN DATE 04-04-78

W G MATLOCK
036AG1

AGENCY: MDOS GRANT NUMBER: AID NE C 1304 AWARD AMOUNT: 000000000 TERMINATION DATE: 03/30/79

* * * * CURRENT MONTH * * * * BUDGET CHANGES	EXPENDITURES	ENCUMBRANCES		* * * * INCEPTION TO DATE * * * * BUDGET	EXPENDED	ENCUMBERED	AVAILABLE
			PERSONAL SERVICES & ERE	404,561			
			SALARIES				
	10,002.68	11,250.32	SALARIES		103,358	21,870	125,228-
	10,002.68	11,250.32	CLASS TOTAL		103,358	21,870	
			WAGES				
	1,147.20		REGULAR WAGES		8,472	3,187	11,659-
	1,147.20		CLASS TOTAL		8,472	3,187	
			ADJ TO SAL &/OR WAGES				
			ADJ TO SAL &/OR WAGES		335		335-
			ADJUSTMENTS TO ERE		43		43-
			CLASS TOTAL		378		
			EMPLOYEE RELATED EXPEN				
	125.88		WORKMEN'S COMP INSURA		326		326-
	64.70		UNEMPLOYMENT INSURANC		192		192-
	674.57		FICA TAX		4,642		4,642-
	117.13		RETIREMENT CONTRIBUTI		5,201		5,201-
	178.62		GROUP HEALTH INSUR PR		1,759		1,759-
	1,160.90		CLASS TOTAL		12,120		
	12,310.78	11,250.32	CATEGORY TOTAL	404,561	124,329	25,057	255,176
			OPERATING EXPENDITURES	41,127			
			OUTSIDE AND PROFESSIO				
			SUSPENSE ACCOUNT		332		332-
			CLASS TOTAL		332		

EPORT NO. GA3204
CCOUNT NO: 667361
CCOUNTANT: JIM COOK NON-CET/

UNIVERSITY OF ARIZONA
ITD RESPONSIBILITY REPORT
FOR MONTH ENDING 03-31-78
YEMEN SUPPORT 5010410120

W G MATLOCK
036AGI

GENCY: MDOS GRANT NUMBER: AID NE C 1304 AWARD AMOUNT: 0000000000 TERMINATION DATE: 03/30/79

* * * CURRENT MONTH * * * * BUDGET CHANGES	EXPENDITURES	ENCUMBRANCES		* * * * INCEPTION TO DATE * * * * BUDGET	EXPENDED	ENCUMBERED	AVAILABLE
			OFFICE SUPP. AND POSTAGE				
	26.95		OFFICE SUPPLIES		282	72	354-
			PRINTED FORMS		140		140-
	222.25		STAMPS STMPD ENV & CARDS		856		856-
	249.20		CLASS TOTAL		1,278	72	
			OPERATING SUPPLIES & SVC				
	79.56	2,541.14	RESEARCH SUPPLIES		6,024	3,096	9,120-
			EDUCATIONAL SUP - OTHER		144		144-
			RECREATIONAL SUP - OTHER			45	45-
	10.00		ANALYSIS SHOPS		10		10-
			SUSPENSE ACCOUNT		95		95-
	89.56	2,541.14	CLASS TOTAL		6,273	3,141	
			MAINTENANCE AND REPAIRS				
			REPAIRS + MAINT - OTHER		38		38-
		5.94	SUSPENSE ACCOUNT			6	6-
		5.94	CLASS TOTAL		38	6	
			TELEPHONE				
			TEL EQUIPMENT CHARGES		54		54-
	469.61		LONG DISTANCE CHARGES		652		652-
	2.35		WIDE AREA TEL SERVICE		18		18-
	93.43		TELEGRAPH		172		172-
			SUSPENSE ACCOUNT		38		38-
	565.39		CLASS TOTAL		934		
			PRINTING AND PHOTOGRAPHY				
			PRINTING - OTHER		119		119-
			CLASS TOTAL		119		

REPORT NO. GA3204
ACCOUNT NO: 667381
ACCOUNTANT: JIM COOK NON-CETA

UNIVERSITY OF ARIZONA
ITD RESPONSIBILITY REPORT
FOR MONTH ENDING 03-31-78
YEMEN SUPPORT 5010410120

RUN DATE 04-04-78

W G MATLOCK
036AGI

AGENCY: MDOS GRANT NUMBER: AID NE C 1304 AWARD AMOUNT: 000000CC00 TERMINATION DATE: 03/30/79

**** CURRENT MONTH **** BUDGET CHANGES	EXPENDITURES	ENCUMBRANCES		**** INCEPTION TO DATE **** BUDGET	EXPENDED	ENCUMBERED	AVAILABLE
			RENT				
			LEASE + RENTAL - OTHER		2,267		2,267-
			CLASS TOTAL		2,267		
			MISC AND OTHER COSTS				
			PHOTOCOPY SVC CENTER CHG		8		8-
		6,753.50	FREIGHT OUT		3,458	6,973	10,431-
	36.10		TECH AND REFERENCE BOOKS		36		36-
	24.14	24.50	OTHER EXPENSES		1,531	803	2,334-
			SUSPENSE ACCOUNT		11,141	14,037	25,178-
	60.24	6,778.00	CLASS TOTAL		16,174	21,813	
	964.39	9,325.08	CATEGORY TOTAL	41,127	27,415	25,032	11,320-
			TRAVEL	104,200			
			IN-STATE TRAVEL				
			IN-STATE SUBSISTENCE		29	150	179-
			IN-ST REG FEE-CONFERENCE		10		10-
			IN-ST OTHER TRAVEL EXP		63		63-
			CLASS TOTAL		102	150	
			OUT-STATE TRAVL-DOMESTIC				
			OUT/DOM SUBSISTENCE		8,723	213	8,936-
			OUT/DOM PUBLIC TRANS		2,037		2,037-
			OUT/DOM OTHER TRAVEL EXP		3,442		3,442-
			CLASS TOTAL		14,202	213	

REPORT NO. GA3204
ACCOUNT NO: 867381
ACCOUNTANT: JIM COOK NON-CETA

UNIVERSITY OF ARIZONA
LTD RESPONSIBILITY REPORT
FOR MONTH ENDING 03-31-78
YEMEN SUPPORT 5010410120

W G MATLOCK
036AGI

AGENCY: MDOS GRANT NUMBER: AID NE C 1304 AWARD AMOUNT: 000000CC00 TERMINATION DATE: 03/30/79

	* * * * CURRENT MONTH * * * * BUDGET CHANGES	EXPENDITURES	ENCUMBRANCES		* * * * INCEPTION TO DATE BUDGET	EXPENDED	ENCUMBERED	* * * * AVAILABLE
				OUT-ST... TRAVEL FOREIGN				
				OUT/FRN MILGE+VEH PRIVAT			37	37-
		575.50	162.00	OUT/FOREIGN SUBSISTENCE		1,047	574	1,621-
		4,169.76	3,067.00	OUT/FOREIGN PUBLIC TRANS		4,476	6,342	10,818-
		60.00		OUT/FOREIGN REG FEE-CONF		60		60-
		170.06		OUT/FOREIGN OTHER TRAVEL		301	100	401-
		4,995.32	3,229.00	CLASS TOTAL		5,884	7,053	
		4,995.32	3,229.00	CATEGORY TOTAL	104,200	20,138	7,416	76,596
				CAPITAL	55,000			
				EQUIPMENT				
		315.25	21.79	RESEARCH,TEST,OTHER TECH		3,863	6,750	10,613-
				INVENTORY EXEMPT		803		803-
		413.40	4,531.50	EQUIP - OTHER TITLE		413	4,118	4,531-
		728.65	4,553.29	CLASS TOTAL		5,079	10,868	
		728.65	4,553.29	CATEGORY TOTAL	55,000	5,079	10,868	39,053
				INTERNAL CHGS AND ALLOCA				
				DIRECT INTERNAL CHARGES				
				COST OF EDUC ALLOWANCE		2,407		2,407-
				CLASS TOTAL		2,407		2,407-
				INDIRECT COSTS				
		2,923.27		IND COSTS - APPLIED	105,977	27,893	78,085	1-
		2,923.27		CLASS TOTAL	105,977	27,893	78,085	1-
		2,923.27		CATEGORY TOTAL	105,977	30,300	78,085	2,408-
		21,922.41	28,357.69	ACCOUNT TOTAL	710,865	207,310	146,458	357,097

IRRIGATION DESIGN

Joint MOA/USAID Research Farms

Yemen Arab Republic

Initial Report

Prepared under the auspices of
Contract AID/NE-C-1304 (Yemen)
with the University of Arizona,
Tuscon, Arizona

By: Dale A. Bucks
Irrigation Engineer
USDA/ARS
U.S. Water Conservation Laboratory
Phoenix, Arizona

November 1977

Atch 1

IRRIGATION DESIGN
USAID Research Farms
Yemen Arab Republic
Initial Report

C O N T E N T S

	Page No.
INTRODUCTION	1
Background Sana Farms Soils Climate Groundwater Crops	1
Bir Al Gohum Design Water Requirements Irrigation System Management Recommendations	4
Bir Al Shaif Design Water Requirements Irrigation System Management Recommendations	9
Background Al Jarubah Farm Soils Climate Groundwater Crops	11
Al Jarubah Design Water Requirements Irrigation System Management Recommendati	13
Conclusions	15
References and Appendix	
Appendix 1	Soil Analysis - Bir Al Shaif
Appendix 2	Water Analysis - USAID Office Well
Appendix 3	Example of Water Requirement Calculations
Appendix 4	Example of Pipe-Size Determination
Appendix 5a.	Bir Al Gohum Irrigation System Map
5b.	Bir Al Gohum Irrigation System Details
Appendix 6	Bir Al Shaif Irrigation System Map
Appendix 7	Water Analysis - Al Jarubah Well
Appendix 8	Al Jarubah Preliminary Plan
Appendix 9	List of Plastic Materials

INTRODUCTION

Modification of irrigation systems are being proposed at two existing USAID Agricultural Farms near Sana, Yemen. Dir Al Gohum, located near the north side of Sana, is to be used for sorghum, alfalfa, and possibly horticulture research. Bir Al Shaif, located on the south side of Sana, is to be used for horticulture and vegetable research. A new station at the Al Jarubah State Farm, located east of Zabid and within the Wadi Rima Area in the Tihama, is being proposed for future sorghum and horticulture research. My obligation was to complete the first stage of evaluation, design and recommendation of either surface and/or trickle irrigation systems at these locations.

I was present in Sana, Yemen, from October 11 to November 11 to conduct this survey. A detailed design of surface irrigation systems for the two Sana farms are presented in this report, with flexibility for some trickle irrigation development in the future. Only a preliminary, surface-irrigation design is described for Al Jarubah, because installation of an irrigation well and crop research plans have just commenced. Tentative guidelines for irrigation management to include cultural practices and irrigation scheduling will be discussed.

Some of the major factors considered in this irrigation design and operation were: (1) maximum utilization of a limited water supply; (2) adaptation of the system to future needs, i.e., changing border width or plot sizes, adding trickle or bubbler irrigation or altering cultural practices; (3) capability of existing labor to operate the system; (4) availability of PVC plastic pipe in country; and (5) urgent need to begin construction of the systems.

BACKGROUND SANA FARMS

Soils - The most widespread soils near Sana are calcareou silt loams and silty clay loams. Final infiltration rates are moderately slow, estimated at between 0.1 to 0.15 inches per hour (2.5 to 3.8 mm/hr).

Five soil samples were taken at Bir Al Shaif in September 1977 and analized by Tuskegee Institute, Tuskegee, Alabama, as shown in Appendix 1. Results showed K, Mg, Ca, Mn, Zn, Cu, Fe and Na are high. The electrical conductivity of the soil

solution was estimated at less than 17 millimhos per cm by the fact that it should be approximately equal to the total soluble-cations in milliequivalents per liter divided by 10. The exchangeable sodium percentage was calculated at less than 4%. Therefore, the soil would be classified as saline-nonsodic for practical irrigation purposed (8).

Climate - A brief summary of the meteorological data for Sana was found in the Yemen Agricultural Handbook (1). Annual rainfall averaged 15 inches (380 mm) from 1963-68 and less than 6 inches (148 mm) from 1970 - 73. No particular trends between yearly or monthly rainfall were evident. Mean annual temperature was 63°F (17.1°C), with mean monthly temperatures ranging from 54° F to 70° F (12.2° C to 21.6° C). Relative humidity was fairly low.

Groundwater - Less than 10 percent of the agricultural land in Yemen is under irrigation. The groundwater level in Sana is extremely low, often below 325 feet (100 meters). At Bir Al Gohum, the maximum measured pump discharge was 100 gpm (6.3 l/sec). The pump is a belt-driven Caprari, Model No. V16P/4L/24A with 9 bowls. The well depth is 650 feet (198m); maximum pumping depth is 465 feet (145m); a 10 feet (3m) slotted screen is located 170 feet (52m) from the well bottom; and another 15 feet (5m) slotted screen is located 265 (81m) from the well bottom. The engine is a VM diesel from Italy, Type 1053, 60 horsepower and 2800rpm. There is a second well and pump further to the north that is almost dry.

At Bir Al Shaif, the maximum measured pump discharge was 40 gpm (2.5 l/sec). The pump is a belt-driven Caprari, Model No. V16P/3L/24A with 8 bowls. The well depth is 625 feet (190m), and a 32 feet (10m) slotted screen is at the bottom of the well. The maximum pumping depth is not known. The engine is a Blackstone, Model No. MPL75M2, 31 horsepower and 850 rpm.

A fairly complete groundwater analysis was obtained for the USAID office well, Sana. Results shown in Appendix 2 adequately represent both the Bir Al Gahom and the Bir Al Shaif wells. Classification of the water is a medium salinity and low sodium hazarard. Chloride concentration in the water should not be a problem. Boron concentrations are unknown and should be determined before sensitive crops

are grown. With some degree of certainty, this water can be used on most soils and crops. Appreciable leaching of salts may be necessary on the more sensitive fruit and nut crops, because of the moderately high salinity in the soil.

Crops - The principal crops to be grown on the Bir Al Gohum station in the next year are soghum and alfalfa. The University of Arizona will be conducting sorghum variety research for a second year. Tuskegee Institute, which is soon to send a two year team to Yemen, may establish some horticultural research on the same farm at a later date. Bir Al Shaif will be used entirely for Horticultural research. Present plans are that Tuskegee Institute will be conducting variety tests on such crops as grapes, peaches, apricots, almonds, pecans, walnuts, and various vegetable crops.

Based on the soil and water data presently available, sorghum and alfalfa can be irrigated at Bir Al Gohum. Successful irrigation of horticultural crops is certainly feasible on both farms; however, Tuskegee horticulturists should have the wells analized for boron, as a safety precaution. Most fruit and nut crops will not be injured when irrigated with waters containing less than 1 p.p.m. of boron (8). Again, many fruit and nut crops have a relatively low salt tolerance which require good water management practices.

BIR AL GOHUM DESIGN

Water Requirements - The irrigation water requirement is the amount of water that must be pumped before delivery to the field. This should not be confused with the term consumptive use, which is the amount of water used on a given area in transpiration, building of plant tissues, and evaporation from adjacent soil. Two types of efficiencies will be used in this report to determine the irrigation water requirement. First, water-application efficiency is the percentage of irrigation water delivered to the field that is stored in the soil for consumptive use by the crop. Second, where a storage reservoir is evaluated, reservoir efficiency is the percentage of irrigation water delivered to the field after evaporation and seepage. Not all the water applied to the field in addition to consumptive use is wasted. When excessive salts exist, extra water must be passed through the soil to leach salts out of the root zone. Extra irrigations are sometimes required to encourage germination. Some crops require additional water during harvest to improve quality or preserve crispness.

An estimate of the consumptive use for sorghum grown between May 1 and October 31 for Sana was computed using the Blaney-Criddle formula. Temperature data was for Sana; sunshine hours were for the Montaine Plaine area with similar temperatures (3); and the crop coefficients were for Central Arizona(2). The estimated seasonal consumptive use was about 30 inches (780 mm) with a peak consumptive-use rate of 0.26 inches/day (6.6 mm/day) occuring in late July.

Using this estimated peak consumptive-use rate, several alternatives to the total possible sorghum acreages were investigated. First, without construction of a reservoir, the system can handle almost 3.5 acres (1.4 ha) of sorghum with an average 70 percent water-application efficiency and over 4.0 acres (1.7 ha) with a higher 80 percent water-application efficiency. This is for 8 hours per day pumping for 5 days per week during the peak water demand period. Fields A and B total 4.3 acres. With a reservoir and based on average efficiencies of 80 percent reservoir and 80 percent water-application efficiency, the system capacity would be about 6.6 acres with 14 hr/day pumping. Fields A, B and C total 6.1 acres (2.5 ha) and Fields A, B, C, and D total 5.6 acres (2.3 ha). For a reservoir and maximum efficiencies of 95 percent reservoir and 80 percent

water-application efficiency for 20 hours per day pumping, the system would require 12.5 acres (5.1 ha). Fields A, B, C, D and E total 12.0 acres (4.9 ha). The last alternative is included in Appendix 3 to emphasize the limited water supply, the advantage of a reservoir, and the importance of good water management to achieve maximum efficiencies. Rainfall was not considered in the analyses because of its erratic pattern.

Based on these calculations, the following planting recommendations are proposed for Bir Al Gohum. In 1978 before a reservoir can be constructed, Fields A, B and C should be planted to sorghum and given priority to use of the water in June through August. Alfalfa could be planted on fields D, E and F and irrigated only when excess water is available. This means that the alfalfa would have to depend on rainfall during the summer and become partially dormant. In 1979 after a reservoir is constructed, additional acreage can possibly be placed into sorghum research. The more uniform soils are in Fields A, B, C, and F; whereas, Fields D and E are quite gravelly. Field D would make an excellent site for future construction, if desired.

Irrigation System - Appendix 5a shows the layout of the various fields along with the location of the proposed irrigation pipelines. Appendix 5b shows the major pipe-connection details. The system consists of 6-inch (150m) PVC* mainline. Portable 4-inch (10 cm) PVC laterals and outlet pipes will irrigate the sorghum furrows. The alfalfa will be irrigated in 60-foot (18m) wide and 175 feet (53m) long borders. The system will supply water directly from the pump for the first year and from the reservoir after its construction. Pipe-size determination considered both water sources. See Appendix 4.

It was agreed that the plastic pipe would be placed on the surface for at least the first year. PVC pipe will normally deteriorate slowly in sunlight, especially in the Southwestern United States; but temperatures are not as high in Sana. When trenching equipment becomes available in Yemen, the plastic pipe can then be buried at least 24 to 30 inches (75 cm) deep. The quality of the plastic pipe appears to be excellent; however, it should be visually observed for cracking in the field every four months.

All the fields should be eventually levelled as close as possible to zero grade. Dead-level irrigation, sometimes referred to as level border, has numerous advantages.

* Polyvinyl Chloride plastic pipe.

Many different kinds of crops can be grown in sequence without making major changes in design, layout, or operating procedures. High water-application efficiency can be obtained, particularly on soils with a low intake rate. No irrigation water is lost to runoff. Leaching operations can be accomplished without altering the method of irrigation. In addition, dead-level irrigation can be operated by inexperienced workers. It is best suited to smooth, gentle uniform land slopes, as is the case for this farm.

A grid map for land levelling was drawn for Field F and can be found in the Bir Al Gehum file. It was obvious from this elevation map that Field F can be easily levelled to zero grade, as is visually true for the other fields. Field F should be levelled into two approximately equal blocks--the north block to an elevation of about 3.8 feet (1.2m) below the bench mark, and the south block to an elevation of about 3.0 feet (0.9m) below the bench mark. The bench mark is located at the top of the concrete pump platform. A grader is available and a land plane has been ordered for the USAID Yemen research farms.

Appendix 5a gives the proposed location of approximately a 220,000 gals (833,000 l) storage reservoir. Appendix 5b shows details of its construction. The size of the reservoir is 50-feet (15.3m) wide, 100-feet (30.5m) long, and 6-feet (1.8m) deep. A 4-inch (10 cm) outlet for the reservoir should be about 12 inches (30 cm) above the bottom to provide for sedimentation. Reservoir storage capacity above the outlet calls for a 24-hour pumping plus a 25 percent freeboard. Discharge rate from the reservoir will range from about 325 gpm to 525 gpm (20.5 to 33.1 l/sec.) A 6-inch (15cm) main line will run east and north to irrigate Fields A, B, C, D and F. An additional 6-inch (15cm) main will be required to run directly east to possibly irrigate Fields E, H and I by gravity flow from the reservoir. However, Field E can be initially irrigated by the discharge pressure from the pump without the additional pipeline.

Tentative construction plans call for lining the reservoir with crushed rock and sand cementing over the rock to reduce seepage losses. Otherwise, a soil sample from the reservoir site will be returned to the University of Arizona to determine the feasibility of using a chemical sealant instead. For evaporation control, a butyl rubber cover is proposed. This design will be investigated with various researchers and manufacturers before a definite proposal is made.

There is the possibility for conducting some horticulture research at a later date at Bir Al Gehum. The sorghum research may be reduced by this time; the alfalfa acreages will be less and dryland farmed; and the reservoir will definitely need to be constructed.

At this point, trickle or bubbler irrigation would be an attractive alternative for the production, considering the limited water supply. Usage of plastic pipe distribution system for dead-level irrigat on will make the conversion easier to a trickle or bubbler irrigation system.

Management Recommendations

Suggestions made are in terms of cultural practices and water management for the minimization of the water requirements for sorghum production. Chiseling to a depth of at least 20 inches (50 cm) may improve water penetration. Soils near Sana have enough structure that chiseling should prove beneficial. Deep plowing of 10 to 12 inches (30 cm), already being practiced on the research station, should be continued. After plowing, the fields can be well levelled and furrowed out in a north-south direction. Present practices of hand furrowing, hand planting, and the irrigating for germination have resulted in soil crusting and cracking with less than desirable crop stands. One difficulty has been the very small, hand furrow, which has often led to nonuniform water distribution. The present spacing of 28 inches (70 cm) can be continued; however, a uniform furrow of at least 8 inches (20 cm) in depth is recommended. Both chisels and furrowers to fit present equipment have been discussed with USAID personnel.

In 1978, irrigating before planting should be investigated. A pre-irrigation of at least 8-inches (20 cm) is suggested for leaching of salts and encouragement of early, deep root development. Irrigation water should not be allowed to go over top of the furrows and will require refilling a number of times to apply the desired amount of water. After 5 to 10 days, depending on the rate and degree of soil dryness, fertilization and soil treatment against termites can be accomplished by hand or with a planter attachment. Dr. Robert Voigt, Sorghum breeder, University of Arizona, has plans to purchase a walk-behind planter. It is his decision as far as rate of seed planting, but it is suggested that the seed row be placed above the water line created during pre-irrigation. If problems in emergence appear to develop, a second irrigation can always be given for germination, being careful to keep the water depth in the furrow at least 1 inch (2to 3 cm) below the seed row.

Four to five irrigations of about 5 inches (13 cm) will be required after emergence. These irrigations should be given on a graduated or varied frequency based on the plant growth stage and soil moisture depletion. Until a more precise criteria for sorghum irrigations for Yemen is developed, a depletion of 60 to 65 percent of the available soil moisture in the top 2 to 3 feet (60 to 90 cm) could serve as a basis for irrigation timing. Soil sampling and soil moisture measurement equipment are being ordered for the research farms. The present practice of light, frequent irrigations every week or two will not conserve water or improve yields.

The number of furrows to be irrigated at one time will vary with the soil condition and irrigation quantity. For the sorghum plots that are 44 feet (13 m) long, an irrigation set with 24 furrows would require 1 hour and 15 minutes to apply 5 inches (13 cm) of water. Twenty-four furrows can be easily irrigated using two lengths of the 4-inch (10 cm) portable outlet pipes, constructed per details in Appendix 5b. For the limited irrigations for the alfalfa on Field F, a single border will require 5 hours and 25 minutes to apply 5 inches (13 cm) of water.

With the lengths of run and irrigation stream sizes for these two examples, water-application efficiencies of 90 to 95 percent are possible, as determined from the United States Soil Conservation Service design charts (6).

BIR AL SHAIF DESIGN

Water Requirements - The assumption was made that the research at the farm would be comprised of two-thirds horticulture and one-third vegetable crops. Taking many factors into consideration, an estimate for the average peak consumptive-use rate of young trees and mature vegetables was computed at about 0.12 inches per day (3mm/day) for the first two years. Thereafter, the mature trees and vegetables would have an average peak consumptive-use rate of about 0.2 inches per day (5.1 mm/day).

A concrete reservoir has already been built at Bir Al Shaif. The present pump and reservoir has the capacity to handle about 6.5 acres (2.6 ha) for the first two years and about 3.8 acres (1.5 ha) in the following years, based on average efficiencies of 90 percent reservoir and 70 percent water-application efficiency for 14 hours per day pumping. For maximum efficiencies of 95 percent reservoir and 80 percent water-application efficiency, the system could utilize about 11.3 acres (4.5 ha) for the first two years and henceforth about 6.6 acres (2.7 ha). Rainfall during this peak water demand period was not considered in these calculations. The conclusion was drawn that the total acreage of about 10 acres (4.1 ha) can be irrigated for the first two years, provided that some precipitation occurs and the pump discharge capacity is maintained. Thereafter, the irrigated acreage will probably have to be decreased.

Irrigation System - Appendix 6 shows the layout and some details for the Bir A. Shaif system. The design calls for dead-level irrigation method and a plastic pipe distribution network. This system was chosen for the same reasons stated under the Bir Al Gohum design. A 6-inch (15 cm) PVC mainline was selected for Fields I, II, III and IV; and a 4-inch (10 cm) PVC mainline was determined for Field V. The four fields will be irrigated from the south side of the reservoir, and Field V will be irrigated from the north. It was again agreed that the plastic pipe would be laid on the surface at least for the first year. The plastic pipe can always be buried later if necessary.

The existing reservoir has a storage capability of almost 65,000 gals (246,000 l), which is adequate for 24 hour pumping plus a 13 percent freeboard. The discharge rate from the reservoir to the four south fields can range from about 130 to 420 gpm (8.2 to 26.5 l/sec) with 4-inch (10 cm) outlet controlling at all flows. For the single north field, the discharge rate will range from about 130 to 160 gpm (8.2 to 10.1 l/sec) with the 4-inch (10 cm) outlet controlling at low flows and the 4-inch (10 cm)

mainline restricting at high flows. This reservoir is now being used by the local community for bathing and washing, which could cause minor operational problems if debris is allowed to collect in the reservoir.

Plastic lateral lines for the distribution of water to individual plots have not been included in the initial design for several reasons. First, the cropping pattern to be used by Tuskegee Institute has not been definitely decided. Second, all lengths of run are short so that earth-lined ditches will provide for excellent water-application efficiencies. Third, trickle or bubbler irrigation can be added later on tree or vine corps. Lastly, the Yemen Government may have other priority uses for a portion of the farm.

Management Recommendations - From a visual observation of the soils, land topography, and reservoir location, the following planting suggestions are included: Field I - vegetable crops; Field II - vine crops; Field III - nursery and propagation area: and Fields IV and V - fruit and nut crops. Small trees must be removed on Fields III and IV, and the large trees on Field V may cause some clearing and levelling problems. Chiseling before planting could be advantageous on the deep-rooted fruit, nut and vine crops; but it probably would not be on the shallow-rooted vegetable crops, since no real hardpan exists in the soil profile.

Fruit and nut trees can be irrigated from a 3 to 4-feet wide (1 to 1.1 m) basin for the first two years, followed by widening the basin to the dripline of the trees in successive years. Vine crops can be irrigated from single furrows on both sides of the crop. Planting beds will have to be developed for specific vegetable types. For early, spring vegetables, east-west beds are recommended with planting on the south exposure to gain heat units for crop emergence.

In my opinion, present irrigation practices of shallow, light-frequent irrigation should be discouraged, where the deal-level irrigation method is used. No irrigation of less than 4 inches (10 cm) is advisable, and at least once every year a large irrigation of about 8 inches (20 cm) is required for the leaching of salts. Plant response to irrigation water should be closely observed, especially with horticulture and vegetable crops, to prevent overirrigation.

BACKGROUND AL JARUBAH FARM

Soils - Al Jarubah State Farm is located within an alluvial fan that is regularly spate-irrigated land close to the Wadi Rima. The Wadi Rima is one of the larger perennial streams which flows through the Tihama region. A complete description of the area is found in the Montaine Plaine and Wadi Rima Report, Volume 2 (3). The region essentially is comprised immature alluvial soils (inceptisols and entisols). Generations of spate irrigation on the alluvial fan has led to the accumulation of highly silty surface deposits. The soils of the fan are typically well-drained and medium-fine texture. They have a weak surface structure and a high water holding capacity. Infiltration rates are moderate to moderately slow.

Because of the relative uniformity of the condition in the Wadi Rima area, broad reneralizations regarding soil properties were made in this report. All soils sampled contained free calcium carbonate, as was reflected in high ph values of 7.5 to 8.5. The soil organic content was very low and was possibly associated with the calcareous state of the soil since total phosphorous is moderate to high. Salinity is low in regularly spate-irrigated and rainfall areas to the east. Dr. Nari Dewan, Soil Scientist, FAO, Taiz, agreed that the soils in this area have little or no sodium or salinity problems. However, a soil sample was taken from the future research site at Al Jarubah and will be returned to the University of Arizona for further analysis.

Climate - It was unfortunate that 1975--the only year for which published records were available at Al Jarubah--appeared to be nontypical (3). This weather station adjoins the future research site. The total rainfall recorded of 24.8 inches (631 mm) in 1975 was probably about double the long term mean as judged from ecological evidence, which suggests a mean of around 13 to 14 inches (350 mm). The temperature data showed uniforily high temperatures throughout the year. Mean temperatures ranged from 79 F°to 91°F (26°to 33°C). Dust storms reduced the possible sunshine hours, expecially between December and March and periodically between April and June. The relative humidity is high for an arid environment, reflecting the proximity to the Red Sea.

Groundwater - Exploratory drilling in the Wadi Rima area revealed no deep aquifers of exceptional potential (3). The major source of recharge is from the Wadi Rima spate irrigation and baseflow; consequently, the water table is in the form of a subdued mound centered within the alluvial fan. USAID is planning to develop one of these test boreholes, WR-E8, which is located near the future research site. Results from this test well at Al Jarubah (4) gave the following information: well depth, 744 feet (226 m); screen length, 394 feet (120 m); static water level depth, 195 feet (59.6 m); 24-hour specific capacity, 7 gpm per foot (1.45 l/s/m); and test yield, 122 gpm (7.7 l/sec).

A copy of the water analysis for WR-E8 was obtained from Dr. Wari Dewan, as shown in Appendix 9. This is a moderately high-salinity and low-sodium water. Chloride concentration in this water should not be a problem. Boron concentrations are not known. Dr. Dewan indicated that the laboratory in Taiz will soon be able to determine boron.

Crops - Crops in the Wadi Rima area are limited to those suited to the tropics, except for a short period in the winter when a range of short-day, temperature crops can be grown. The traditional subsistence crops are sorghum, millet, maize, sesame and cowpeas. At the Al Jarubah Research Farm, sorghum research is to begin in early December 1977. Horticulture research on such crops as banana, citrus, mango, and papaya will probably be initiated within the next year.

AL JARUBAH DESIGN

The irrigation system designed for Al Jarubah is a preliminary one since only a test well has been drilled and only recently a site selected for sorghum research. Appendix 8 describes the site location and preliminary plan. Advantages of this location were that it was close to the new well, had less of a striga weed problem, and required less land levelling than other locations. A possible disadvantage of the sorghum site is that in a wet year it may not drain as well as other possible sites.

Water Requirements - The seasonal consumptive use for sorghum planted in the Wadi Rima during the winter months was estimated at about 20 inches (510 mm). Research results from the Wadi Zabid farm (5), operated by Tihama Development and located approximately 20 miles (32 km) from the Al Jarubah farm, indicated that the consumptive-use requirement for winter sorghum was more than 20 inches (500 mm) for the imported variety Kadamel-Hamaam. This report did not give the peak consumptive-use rate, but the calculated value was about 0.35 inches per day (8.9 mm/day).

Therefore, provided that the new well has a minimum discharge rate of 100 gpm (6.3 l/sec), the pump is operated at 20 hours per day, and the irrigation system is managed at 80 percent water-application efficiency, the proposed research site of 10.1 acres (4 ha) can be sufficiently irrigated. This does not include the estimation that spate irrigation could supply as much as 25 percent of the stored moisture needed during the period of peak water demand. When it has been determined that the new pump will produce more than the assumed quantity of water, a larger acreage can probably be irrigated.

Irrigation System - A pumping plant similar to the one now in operation at Bir Al Gohum is proposed, except for a direct-gear drive instead of a belt-driven pump. With a maximum pumping depth of 325 feet (100 m) and based on the results of the test well, the pumping should deliver between 125 to 150 gpm (7.9 to 9.5 l/sec).

After the well is operational, a temporary plastic pipe delivery system can be installed. This system consists of a 6-inch (15 cm) PVC mainline that will deliver the water to the highest point of three fields. The other fields will be irrigated from earth channels or ditches. If time permits before planting of fall sorghum, the land should be levelled

with zero slope for each field. Appendix 9 gives the list of plastic materials required for Al Jarubah as well as the Sana research farms. Again, this design is only a preliminary plan for the next few months of operation.

Management Recommendations - The suggestions that were made for cultural practices and irrigation water management for sorghum production at Bir Al Gohum should also be considered for Al Jarubah. The major difference being that chiseling may not be beneficial due to the uniformity and homogeneity of the soil. In addition, Dr. Robert Voigt, Sorghum Breeder, may wish to consider planting each individual field to separate variety to determine the uniformity of his research plots. This first year's data from field trials in a new area is often collected in preparation for future research.

CONCLUSIONS

A practical irrigation system, using the dead-level irrigation method and a plastic pipe delivery system, was designed for all three USAID research stations in the Yemen Arab Republic. This system will provide for high water-application efficiencies and is very adaptable to change in research design, layout, or operation. In the future, the system can be easily modified to the trickle or bubbler irrigation method, if desirable. The key to the successful operation of any irrigation system is the proper installation, management, and maintenance.

Before the installation of the plastic pipe begins, the following items should be completed: (1) the land at Bir Al Shaif should be cleared of debris and small trees; (2) the land levelled at all three research stations, as close as possible to zero grade, with priority going to fields where research has commenced; (3) a pump and engine installed at Al Jarubah to determine the exact well yield; (4) a boron analysis taken at all three locations, as a safety measure, before horticulture crops are planted; and (5) all plastic pipe and fittings purchased for the first stage of construction.

Considering the limited water supply, the following cultural and water management practices should be considered: (1) chiseling tried at Bir Al Gohum and Bir Al Shaif for the improvement of water penetration and crop root development; (2) pre-irrigation for sorghum germination initiated at Bir Al Gohum: and (3) the practice of shallow, light frequent irrigations should be discontinued at all three locations.

Proper maintenance and repair of the irrigation system must be utilized. At least every four months, engines, pumps, valves and plastic pipelines should be inspected for wear. During the first two years, the irrigation design should be reviewed annually to determine if the water requirements for the research crops are being met and if changes in the irrigation design or management are needed.

An attachment will be submitted to this initial report, as soon as possible, describing the final design for Bir Al Gohum reservoir and a proposal for future irrigation water management research in Yemen.

D. Bucks/pe
Sana, Yemen
November 1977

REFERENCES

1. Hartelink, A., "Yemen Agricultural Handbook," Federal Agency for Economic Cooperation, Stuttgarter Str. 10, W. Germany, 1974.

2. Erie, L. J. and etc. "Consumptive Use of Water by Crops in Arizona," Technical Bulletin 169, Agricultural Experiment Station, University of Arizona, Tucson, Arizona, 1976.

3. Ministry of Overseas Development, "Montaine Plains and Wadi Rima (MPWR) Project, Yemen Arab Republic, Initial Development Prospects, Volume 2, Wadi Rima," O. D. M. Land Resources Division, Surbiton, Surrey, 1976.

4. Robino, N.B., "MPWR Draft Final Report: Results of Groundwater Drilling," Ministry of Overseas Development, Land Resources Division, Surbiton, Surrey, 1976.

5. Shehata, A.D, and etc., "Research Results and Conclusions: Fall 1976-77, Tihama Development Authority, Ministry of Agriculture, Yemen Arab Republic, 1977.

6. Soil Conservation Service, "National Engineering Handbook: Section 15 - Irrigation," U.S. Department of Agriculture, Washington, D. C., 1964.

7. U.S. Agency for International Development, "Research Needs for On-Farm Water Management," Proceedings of an International Symposium, Park City, Utah, 1973.

8. U. S. Salinity Laboratory Staff, "Diagnosis and Improvement of Saline and Alkali Soils: Agricultural Handbook No. 60," U.S. Department of Agriculture, Washington, D. C. 1954.

APPENDIX 1

Soil Analysis - Bir Al Shief
Date of Analysis - 9/30/77
Tuskegee Institute

Average five samples:

ph - 8.3			
Ca - 9990 lbs/A	= 125 meq/1	P - 80 lbs/A	
Mg - 2000 lbs/A	= 42 meq/1	J - 372 lbs/A	
Na - 622 lbs/A	= 6.7 meq/1	Mn - 2000 lbs/A	
K - 372 lbs/A	= 2.4 meq/1	Zn - 4.2 lbs/A	
		Cu - 4.6 lbs/A	
SUM	176.1 meq/1	Fe - 64 lbs/A	

Estimated Electrical Conductivity (EC x 10^3) = 17.0 millimhos per cm.

Sodium Absorption Ratio (SAR) = $\frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$ = .73

Estimated Exchangeable Sodium Percentage (ESP)

$$\frac{100\ (-0.0126 + 0.01475\ SAR)}{1 + (-0.0126 + 0.01475\ SAR)} = 1\%$$

or

Estimated Exchangeable Sodium Percentage

$$\frac{Na}{Na + Ca + Mg + K} \times 100 = 4\%$$

Saline - NonSodic Soil (8)

EC x 10^3 > 4 millimhos per cm.
ESP < 15%
PH < 8.5

APPENDIX 2

Irrigation Water Analyses - USAID Office Well
Date of Sampling 2/18/75
Soil Research Section/Taiz

PH	7.6
E.C	49/Micromhos/cm
Ca	3.14 meq/1
Mg	0.75 meq/1
Na	1.00 meq/1
K	0.05 meq/1
HCO_3	3.34 meq/1
CO_3	Nil
Cl	0.73 meq/1
SO_4	0.54 meq/1
NO_3	0.12 meq/1

Sodium Absorption Ratio $= \frac{NA}{\sqrt{\frac{Ca + MG}{2}}} = .72$

Water Classification: C2-S1

Medium salinity, and
Low Sodium hazard.

Residual $Na_2Co_3 = (CO_3 + HCO_3) - (Ca + Mg) = 0$ meq/1

APPENDIX 3

Example of Water Requirement Calculations

Maximum acreage that can be irrigated, adding a reservoir and operating at maximum reservoir and water-application efficiencies and pumping time.

1. Maximum flow rate at well - 100 gpm.

2. Maximum rate of well operation:

   24 hr/day x 6 days/week = 144 Hrs.
   Average = 20 Hrs/day

3. Amount pumped to reservoir:

   100 gpm x 1200 min/day = 120,000 gal/day

4. Irrigation water available to farm, 95 percent reservoir efficiency:

   120,000 gal/day x 0.95 = 114,000 gal/day

5. Irrigation water available for peak consumptive use, 80 percent water-application efficiency:

   114,000 gal/day x 0.8 ÷ 7.48 gal/ft^3 = 12,200 ft^3/day

6. Maximum acreage based on estimated peak consumptive-use rate of 0.26 inch/day:

   12,200 ft^3/day ÷ 0.022 ft/day ÷ 43,560 ft^2/acre =

   12.7 acres.

APPENDIX 4

Example of Pipe-Size
Determinations for
Bir Al Gohum

1. Maximum distance from proposed reservoir to end of Field A:

   2,000 feet of pipeline.

2. Maximum allowable pressure head loss for 100 feet of pipe:

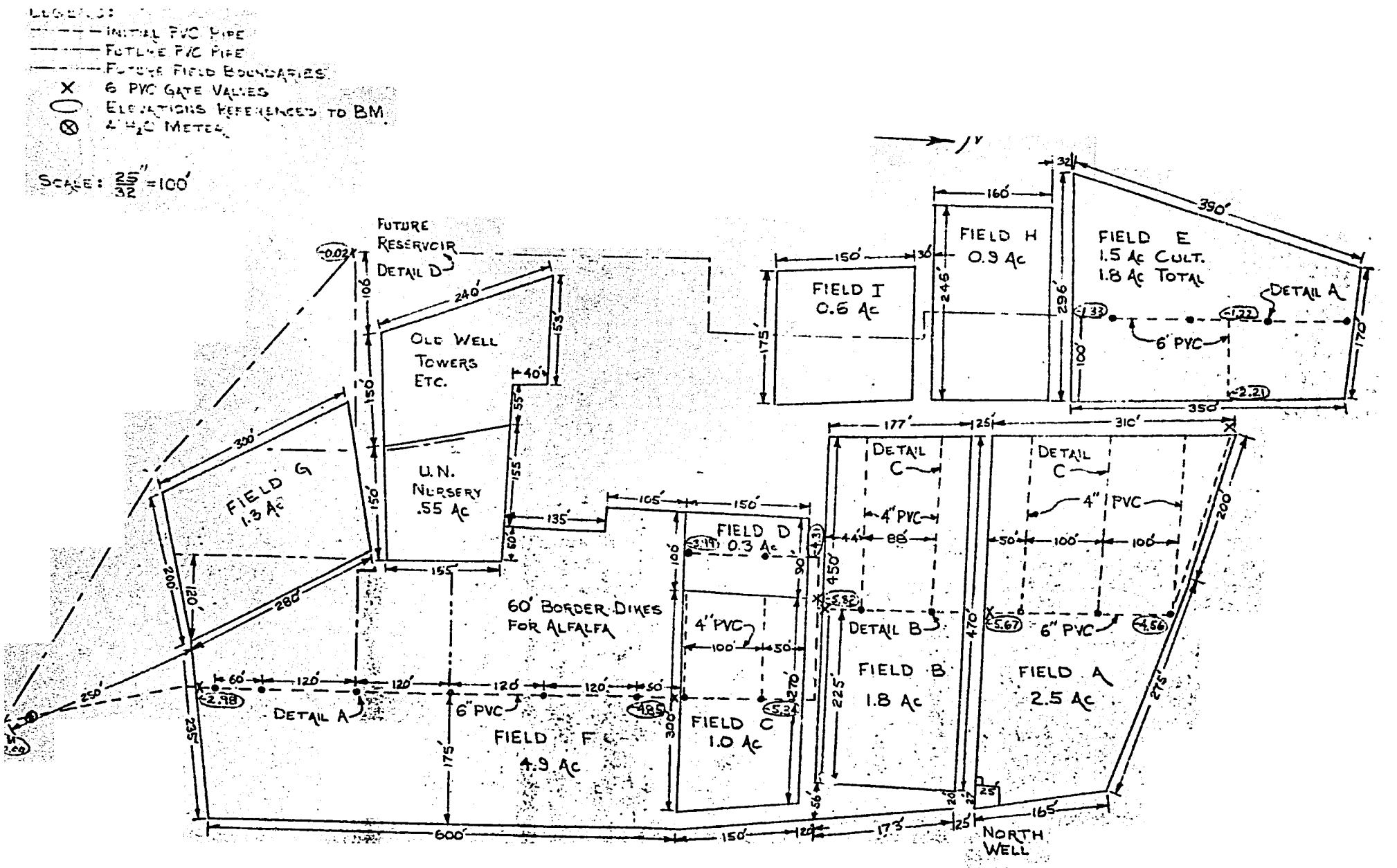
   .33 feet/100 feet of pipeline

3. Minimum required flow rate for the pipeline with reservoir:

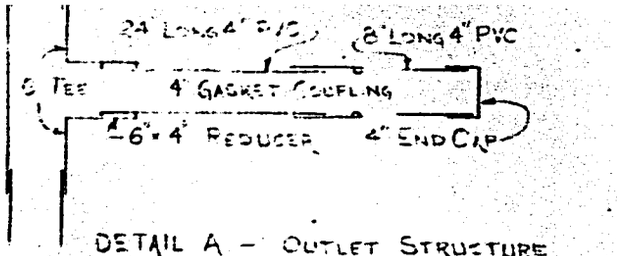
   200 gpm

4. Required Pipe Size:

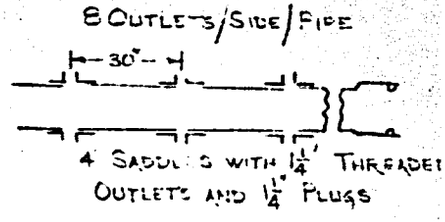
   6-inch nominal diameter



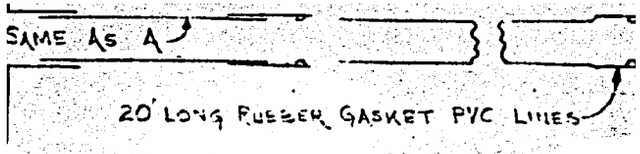
APPENDIX 5a – BIR AL GOHUM IRRIGATION SYSTEM MAP



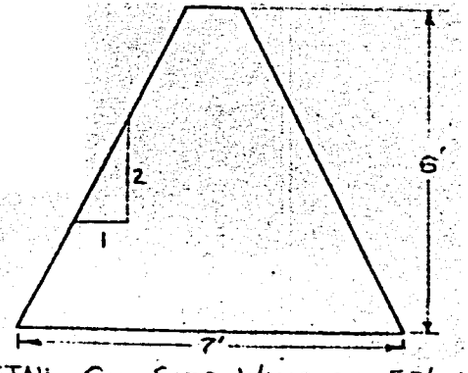
DETAIL A – OUTLET STRUCTURE
ALL PVC - 2 EACH
IN OPPOSITE DIRECTIONS
AT EVERY POINT



DETAIL C- 4" PORTABLE PVC
OUTLET PIPES
24' LONG
CONSTRUCT EIGHT

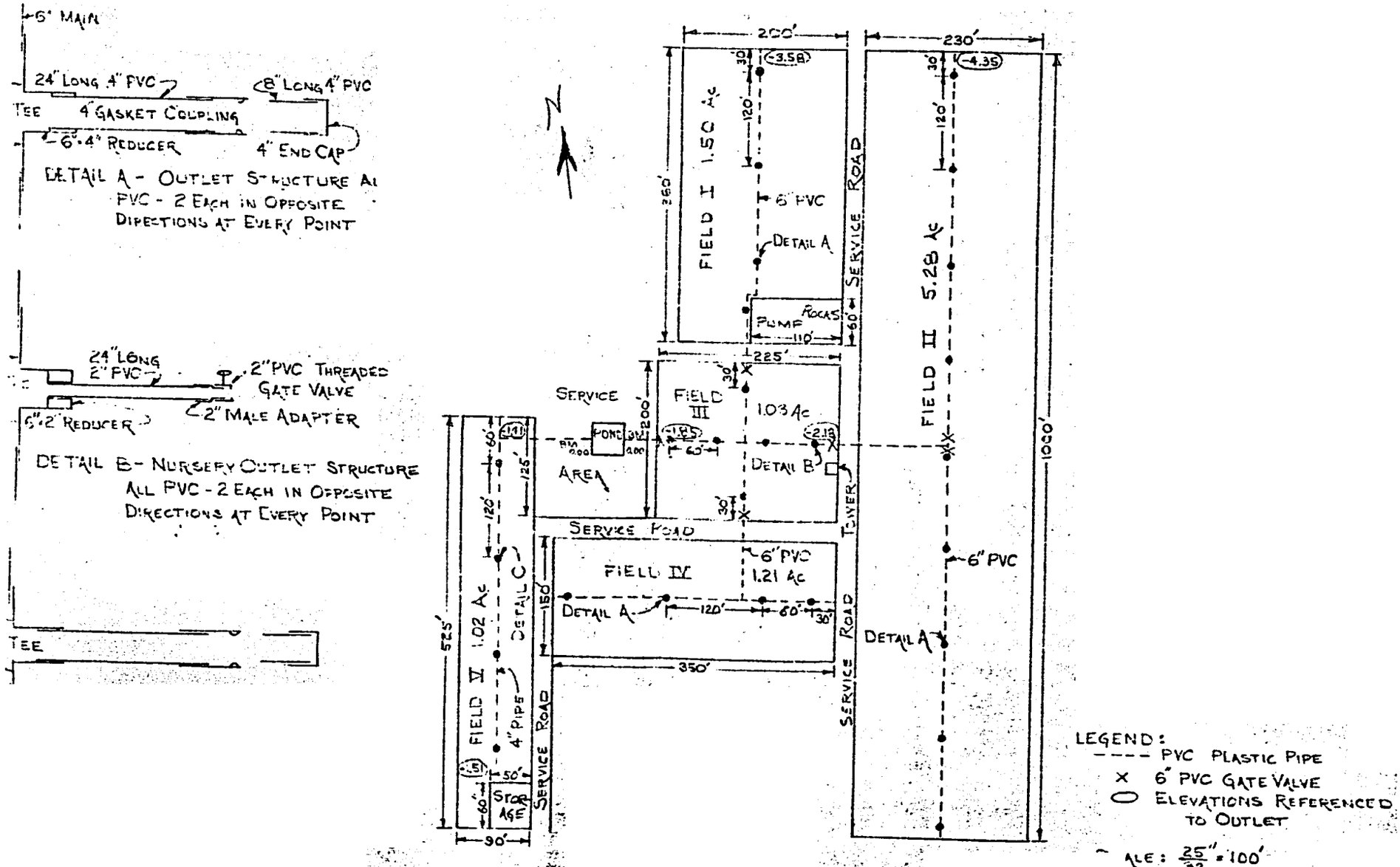


DETAIL B – 4" PORTABLE PVC LINE
CONNECTION - 2 EACH
IN OPPOSITE DIRECTIONS
AT EVERY POINT.



DETAIL C- SIDE WALLS OF 50' × 100'
RESERVOIR - BOTTOM EXISTING
GROUND LEVEL - 0.02 BELOW
BENCH MARK

APPENDIX 5b - BIR AL GOHUM IRRIGATION
SYSTEM DETAILS



APPENDIX 6 - BIR AL SHAIF IRRIGATION SYSTEM MAP

APPENDIX 7

Irrigation Water Analysis - Al Jarubah
Well No. WR-E 8
Date of Sampling - 2/25/76
Soil Research Section/ Taiz

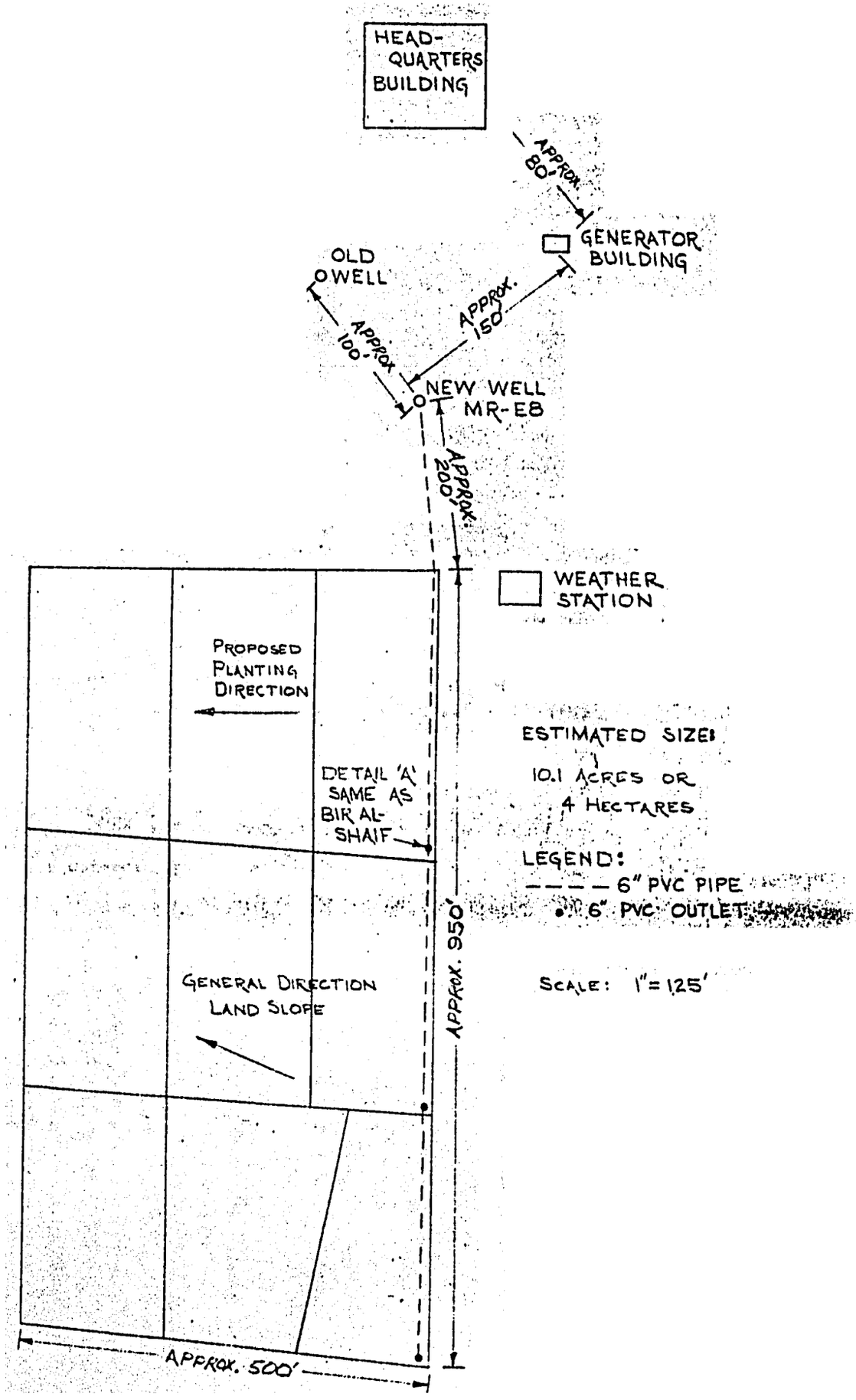
ph	7.4
E.C	800 micromhos/cm
Ca	4.20 meq/1
Mg	0.80 meq/1
Na	3.00 meq/1
K	0.12 meq/1
HCO_3	5.76 meq/1
CO_3	Nil
Cl	2.00 meq/1
SO_4	0.4 meq/1
NO_3	0.21 meq/1

Sodium Absorption Ratio = $\frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$ = 1.9

Water Classification: C3-S1

Moderately high salinity, and low sodium hazard.

Residual Na_2CO_3 = $(CO_3 + HCO_3) - (Ca + Mg)$ = .76 meq/1


HEAD-QUARTERS BUILDING
APPROX. 80'
GENERATOR BUILDING
OLD WELL
APPROX. 150'
APPROX. 100'
NEW WELL MR-E8
APPROX. 200'
WEATHER STATION
PROPOSED PLANTING DIRECTION
ESTIMATED SIZE:
10.1 ACRES OR 4 HECTARES
DETAIL 'A' SAME AS BIR AL-SHAIF
LEGEND:
6" PVC PIPE
6" PVC OUTLET
APPROX. 950'
GENERAL DIRECTION LAND SLOPE
SCALE: 1" = 125'
APPROX. 500'

APPENDIX 9

List of Plastic Pipe Materials

Item	Quantity
YEMEN	
1. 6-inch PVC pipe, 150 mm O.D., 6 kg/cm^2 325 lengths x 6m long	6500 ft.
2. 4-inch PVC pipe, 110 mm O.D., 6 kg/cm^2 50 lengths x 6 m long	1000 ft.
3. 4-inch PVC pipe, 110 mm O.D., 6 kg/cm^2, with rubber sealing rings. 75 lengths x 6 m long	1500 ft.
4. 2-inch PVC pipe, 63 mm O.D., 10 kg/cm^2 5 lengths x 6 m long	100 ft.
5. 1-inch PVC pipe, 32 mm O.D., 16 kg/cm^2 25 lengths x 6 m long	500 ft.
6. 6-inch tee, slip x slip x slip	120
7. 6-inch, 90-degree elbow, slip x slip	18
8. 6-inch, 45-degree elbow, slip x slip	12
9. 6-inch cap, slip	18
10. 6-inch x 4-inch reducers	96
11. 6-inch x 2-inch reducers	12
12. 6-inch coupling, slip x slip	24
13. 4-inch coupling, slip x slip	12
14. 4-inch coupling, slip x rubber gasket	120
15. 4-inch cap, slip	120
16. 4-inch tee, slip x slip x slip	12
17. 4-inch, 90 degree elbow, slip x slip	4
18. 4-inch saddle with 1.25-inch threaded outlets	130
19. 4-inch bilhorse with a 2-inch flange	8
20. 2-inch male adapters, thread x slip	6
21. 1-inch tee, slip x slip x slip	2
22. 1-inch, 90 degree elbow, slip x slip	12
23. 1-inch male adapters, thread x slip	8
24. 1.25-inch plug, thread	24
25. PVC Solvent Cement (15 liters)	4 gals.
26. PVC Cleaner or Primer (30 liters)	8 gals.
UNITED STATES	
1. 6-inch plastic gate valve, slip x slip	24
2. 4-inch plastic gate valve, slip x slip	12
3. 2-inch plastic gate valve, thread x thread	8
4. 1-inch plastic gate valve, thread x thread	4

Preliminary Entomological Report for Yemen

D. M. Tuttle
University of Arizona
Yuma Branch Experiment Station

Information and comments which follow are based on observations, collecting, and limited literature during the period of October 12 through November 9, 1977. Most of this time was spent at Sana and the remainder consisted of a 7-day tour (September 23-30) from Sana to Hodeidah, Wadi Rima, Wadi Zabid, Al Jarubah, Taiz, Turbah, Ibb, Yarim, and back to Sana. Identification of several species is pending due to lack of steroscope, microscope, and literature. Some material will be referred to specialists in United States for determinations. In addition to sorghum and millet a list of insects collected or observed on other crop plants are included. As time and opportunity permitted plant mites were collected on cultivated and indigenous plants. These mites (especially families Tetranychidae - spider mites and Tenuipalpidae - false spider mites) will be processed and determined later by D. M. Tuttle. Since very few records of mites from Yemen exist (if any) this portion will be published in United States.

Sorghum and Millet Insects

Seven pests found in Yemen during this short-term study are discussed briefly.

Corn leaf aphid (Rhopalosiphum maidis) - This was the only aphid species found on sorghum and millet. The corn leaf aphid 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 quanities 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 (Awad, 1976). Some parasitized aphids were collected at Sana. Predators observed on infested plants were coccinellids, lacewings, Orius, and syrphid flies.

Stalk borer (Sesamia cretica Led.) - Light infestations of this species was seen during October and November. Growers and research personnel report extensive damage to young plants. Some plants were killed and others recovered with regrow by stooling. Eggs are laid between the leaf sheath ans 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 moth have tan forewings and white hindwings - the wing span is about 30 mm.

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.

Flea beetles (Chaetocnema sp. ?) - 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.

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.

African or common armyworm (Spodoptera exempta) - 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.

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

Predators and Parasites - 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.

In addition to the pests discussed on sorghum and millet in Yemen there are other species reported from Africa, Asia, and southern Europe which may occur or are potential pests. This list includes:

Agrotis sp. (cutworm)
Anomomala sp. (white grub)
Aphis sacchari Z.
Calocoris angustatus L. (sorghum and earworm bug)
Celama sorghiella R. (Sorghum webworm)
Chilo partellus (sorghum borer)
Contarina sorghicola Coq. (sorghum midge)
Heliothis spp. (earworms)
Holotrichia sp. (white grub)
Oligonychus spp. (spider mites)
Peridroma sp. (cutworm)
Perigrinus maidis A. (sorghum shoot bug)
Pheidole spp. (thief ants)
Psuedaletia spp. (armyworms)
Schizaphis graminum (green bug)
Schizonycha sp. (white grub)
Spodoptera spp. (armyworms)
grasshopper spp.
plant bug spp.
thrips spp.

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

Sitotroga cerealla O. (Angoumois grain moth)
other spp. grain moths (to be determined)
Sitophilus oryza (L.) (rice weevil)
Tribolium confusum (Duv.) (confused flour beetle)
other spp. beetles (to be determined)
mite spp. (to be determined)

Recommendations for Insect Pest Control of Sorghum and Millet

In keeping with the current trend of pest management on intergrated pest management (IPM) 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 risking disruption of beneficial species.

Sometimes it is possible to treat seedings and small plants with pesticides and not greatly sacrifice the beneficial complex. In this regard seed and soil treatments may be considered into a control program to establish a satisfactory stand and initial growth. Most crop 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 at present.

There are sources to obtain pesticides from dealers in Yemen at Sana, Taiz, and Hodeidah. One source of supply for some projects appears to be from the German Agricultural Project in Sana. 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 implimented 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, etc. 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).

At least two entomologists are working in Yemen at present. Firstly, Dr. B. M. Lazarevic (Yugoslavia) UNDP/FAO at Hodeidah on a special problem concerning the distortion of banana fruit. Previously, he was engaged in a project assignment in Somalia working on applied control of insects affecting the major crops. Secondly, Dr. Toson M. Awad (Egypt) IBRD, Tihama Development Authority at Wadi Zabid on applied control of the principal crop pests. His doctoral training was under Dr. Brazeel at Texas A. & M., U.S.A. involving cotton insects.

CHEMICAL CONTROL FOR INSECT PESTS OF SORGHUM AND MILLET

This section is provided especially for AID and other agency personnel who are familiar with chemicals and their use. The compounds, dosages, and remarks are those which have been approved by EPA in United States. All of the materials suggested are effective and should be readily available. Also read and follow the directions on the label.

Seed Treatment

In some areas this treatment may be advisable if certain soil pests occur which effect stands (i.e. rootworms).

Chemical	Dosage lbs ai/A	Limitations
Chlordane	2.0 oz/bu	Seed treatment. Do not use as food or feed.
Diazinon	2.0 oz/bu	
Lindane	2.0 oz/bu	
Malathion	2.0 lz/bu	
Toxaphene	2.0 oz/bu	

Soil Treatment

If there are known pests as cutworms darkling beetles, rootworms, and others that attack plants as they emerge or in the seedling stage the following materials are suggested for control.

Chemical	Dosage lbs ai/A	Limitations
Diazinon	2.0 (granular)	Apply in a 10-inch band over row at planting time or when crop begins to emerge.
Di-Syston	1.0	
Toxaphene	25.0	

Foliage Application

These treatments are recommended for the seedling as well as growing and maturing stages.

Pest	Material lbs ai/A	Dosage	Limitations
Aphids (corn leaf, greenbug, etc.)			
	Diazinon	.5	Do not apply within 7 days of harvest for grain.
	dimethoate (Cygon)	.25-.5	Do not feed to livestock within 28 days of harvest.
	Di-Syston	.25-.5	Do not apply in less than 5 gallons of water.
	mevinphos (Phosdrin)	.5	Do not feed to livestock within 3 days of harvest.
	parathion	.25-.5	Do not use for forage within 12 days of harvest.
	phorate (Thimet)	.5-1.0	Do not use more than twice per season.
Flea beetles			
	carbaryl (Sevin)	2.0	21 days for grain. No time limitations for forage.
	Diazinon	.5	7 days for grain. No time limitations for forage.
	malathion	1.0	12 days of harvest or cutting for forage.
	parathion	.5	Leaf injury may occur to some varieties.
Borers and other worms			
	carbaryl (Sevin)	2.0	21 days for grain. No time limitation for forage.
	mevinphos (Phosdrin)	.5	3 days for forage and grain.
	parathion	.5-.75	12 days for forage. Leaf injury may occur to some varieties.

Storage of Sorghum and Millet

Seed or grain of sorghum and millet should be stored in a dry place having a tight enclosure. The area or containers should be clean and treated chemically if the grain is to be kept for a long period (3 or more months). These same compounds may also be sprayed on sacks and bags of grain and on the top layer of bulk storage (thoroughly mix top layer of grain with remainder when removed from storage).

Chemical	Dosage
'Acetellic'	.4 lb/1000 sq ft
allethrin	.2 lb/1000 sq ft
malathion	5 oz/1000 sq ft
methoxychlor (Marlate)	.35 lb/1000 sq ft

Grain and seed may also be treated by admixing the chemical at the time of storage. For small containers Shell "No Pest Strips" (Vapona) are effective.

Chemical	Dosage
'Actellic'	4 ppm
diatomaceious earth	5.6 lbs/actual silicon dioxide/ton of grain.
malathion	10.0 oz/1000 bu.
piperonyl butoxide	6.0 lbs/1000 bu (dust); 2.0 lbs/100 bu (spray).
pyrethrins	.6 lb/1000 bu (dust); 90 gms/1000 bu (spray).

If seed and grain becomes infested with insect pests while in storage fumigation is advisable or necessary. Materials approved for usage include: aluminum phosphide, calcium cyanide, carbon disulphide, Chloropicrin, Dowfume N (methyl bromide), methylene chloride, Pentane, and sulfur dioxide.

No chemical treatment is recommended at this time for grain stored by farmers for food consumption because of contamination hazards. Normally grain is used in a relatively short time.

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. The final determination on some of the species collected is pending.

Beans (wax and field)
- *Empoasca* sp. (leafhopper)
- flea beetles sp.
- mites sp.
- thrips sp.

Cabbage
- *Brevicoryne brassicae* (cabbage aphid)
- *Pieras rapae* (cabbage butterfly)
- *Plutella maculipennis* (diamondback moth)

Chard

Empoasca sp.	(leafhopper)
flea beetles sp.	

Coffee

Virachola bimaculata	(coffee berry butterfly)

Citrus

Aleuracanthus woglumi	(citrus black fly)
Aonidella aurantii	(red scale)
Chrysophalus aonidum	(black scale)
Microcerotermes diversus	(subterranean termite)
Phyllocnistis citrella	(citrus leaf miner)
Spanioza erythrae	(citrus psylla)

Cotton

Anomis flava	(semi-looper)
Aphis gossypii	(cotton or melon aphid)
Diapropsis watersi	(Sudan bollworm)
Dysdercus fasciatus	(cotton stainer)
Earias insalana	(spiny bollworm)
Empoasa lybica	(cotton leafhopper)
Heliothis armigera	(American bollworm)
Microcerotermes diversus	(subterranean termite)
Oxycarenus hyalipennis	(cottonseed bug)
Pectinophora gossypella	(Saunders), (pink bollworm)
Spodoptera littoralis	(cotton leafworm)
Xanthodes graelisi	(flea beetle)

Curcurbits (muskmelons, watermelon, and cucumber)

Aphis gossypii	(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)

Maize

Chaetocnema sp.	(flea beetle)
Heliothis armigera	(corn earworm)
Rhopalosiphum maidis	(corn leaf aphid)
Sesamia cretica Led.	(stalk borer)
Spodoptera exempta	(common armyworm)

Potato

Chaetocnema sp.	(flea beetle)
Gryllotalpa spp.	(mole cricket)
Leptinotarsus decemineata	(potato beetle)
wire worms sp.	

Sesame

Antigastra catalounalis (sesame seed pod borer)

Spinach

aphids sp.
flea beetles sp.

Tobacco

Myzus persicae (green peach aphid)

Tomato

blister beetles sp.
flea beetles sp.
Heliothis armigera (tomato fruitworm)
Microcerotermes diversus (subterranean termite)
Plusia sp.

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 sagi - Say stink bug
Coccinella undecimpunctata - lady beetle
Gryllas 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 - malva butterfly
Xylocopus aestuans - carpenter bee

References Cited

Awad, T.M. and T.A. Gabber. 1976. Recommendations for cotton, maize, millet, and vegetable pests control 1976/1977. IBRD, Plant Protection Div. Tech. Bull. No. 4, 10 pp.

Awad, T.M. and T.A. Gabber. 1976. Entomological data obtained from the demonstration fields (1975/76). IBRD, Plant Protection Div. Bull. No. 3, 26 pp.

Awad, T.M. and T.A. Hassan. 1976. Researches on plant protection in Wadi Zabid (Zar). IBRD, Plant Protection Div. Bull. No. 3 (series A: cotton), 16 pp.

Bartelink, A. 1974. Yemen Agricultural Handbook. Federal Agency for Economic Cooperation. Eschborn, W. Germany. (First Ed.), 75 pp.

Jotwani, M.G. and W.R. Yound, et al. 1972. Control of sorghum shoot fly. Proc. International Symposium (Andhra Pradesh, India). Oxford and Ibh Publishing Co., 324 pp.

REPORT OF ADMINISTRATIVE VISIT TO U. S. AGENCY FOR INTERNATIONAL DEVELOPMENT - SORGHUM/MILLET IMPROVEMENT PROJECT IN THE YEMEN ARAB REPUBLIC

Report prepared by:

Robert P. Upchurch, Head
Department of Plant Sciences
and
Technical Director, Contract
AID/NE-C-1304 (Yemen)
University of Arizona
Tucson, Arizona 85721

Dates of Visit - November 28, 1977 - December 7, 1977

Contract No. AID/NE-C-1304 (Yemen)

Contract For: National Sorghum & Millet Crop Improvement

Atch 3

Report of Administrative Visit to National Sorghum & Millet Crop Improvement Project in the Yemen Arab Republic

---

The University of Arizona holds Contract AID/NE-C-1304 (Yemen) to provide services to the Yemen Arab Republic Government for the purpose of establishing a national sorghum and millet crop improvement program within the Ministry of Agriculture of the Yemen Arab Republic. The contract effective date was January 15, 1977 and the estimated completion date is March 30, 1979. Under the contract provisions the Plant Sciences Department of the University of Arizona is supplying two individuals to serve for 24 month periods each in-country. Dr. R. L. Voigt is at Post serving as Chief-of-Party and Plant Breeder and Dr. D. M. Stewart is at Post serving as Agronomist. Two short term specialists (Entomology, Irrigation) have served in Yemen on the project and have returned and prepared their reports. Short term specialists on weeds, soil fertility and grain storage have been obligated and will serve within the next six months. Other specialists are in the process of being identified. Support activities are carried out on the University of Arizona campus to insure the success of the project. The part time services of Dr. M. H. Schonhorst have been secured to supply the on-campus professional support required. Since the Chief-of-Party had been at Post since March 16, 1977 an administrative visit was deemed appropriate for the November/December 1977 period. The undersigned arrived in Yemen on November 28, 1977 and departed Yemen on December 7, 1977.

General types of activities undertaken during the visit were as follows (not necessarily in order):

1. Private in-depth discussions with Chief-of-Party, Dr. R. L. Voigt.
2. Private in-depth discussions with Agronomist, Dr. D. M. Stewart.
3. Private in-depth discussions with three groups within the Mission:
   a. Ag. Development Officer, John J. Young
   b. Asst. Ag. Development Officer, E. M. Stickney
   c. Mission Director & Deputy, R. G. Huesmann and Dr. Mary C. Neville

4. On-site inspections of facilities in Sana including new project headquarters, Sorghum/Millet farm, horticultural farm and field plot research underway.
5. Joint planning sessions with
   a. R. L. Voigt and D. M. Stewart
   b. J. J. Young, E. M. Stickney, R. L. Voigt
   c. R. L. Warin (Comptroller) and R. L. Voigt
6. Field trip to inspect agricultural areas in route between Sana - Hodeida - Taiz - Sana and to meet technical personnel at Tihama Development Authority Project at Wadi Zabid and at the Taiz UNDP Project.
7. Joint exit interview with Mission Director and Deputy, Ag. Development Officer, Asst. Ag. Development Officer.

Principal observations by the writer and possible courses of action are identified below:

(1) There seems to be general agreement that reasonable progress has been made in-country on the scope of the work defined under the contract taking into consideration the limitations imposed by unavailability of technical support and the inadequacy of research tools. Sorghum harvests were underway on the research plots during the visit and an effective season of testing was just being concluded although the scope of the work and the excessive variability encountered both need to be improved and overcome, respectively. With a year of experience in hand this should now be possible.

(2) Up to this point a variety of uncertainties and lack of experience have caused project personnel to rely upon the Scope of Work as outlined in the contract as a guiding instrument. However, it is now generally agreed that a specific Plan of Action should be prepared which will clearly indicate how the scope of the work authorized is to be undertaken. The development of this plan should involve inputs from in-country contract personnel, Tucson campus personnel, Ministry and Mission personnel. In the final analysis it should have the approval of appropriate Ministry, Mission and University authorities.

(3) Now that the irrigation specialist's report is available it becomes clear as to how much experimental field work can be carried on at the two Sana field research sites. A preliminary evaluation is that the irrigation/land resources at Sana are inadequate to permit the execution of an effective sorghum/millet field research program at this general location. The Sorghum/Millet Project will proceed to define the scope of research which can be carried out with existing water/land resources and to define the amounts of such resources which might be required at certain assumed levels of operation in the future.

(4) Attention should be given now to the development of a formal seed multiplication program. Specific improved plant types have already been identified by personnel of the Tihama Development Authority and the UNDP Program at Taiz. Such a program should be national in scope and it must involve, at some point in the future, a regulatory component.

(5) A substantial amount of evidence was obtained that there is a good personal working relationship among the members of the various technical agricultural groups operating in Yemen. Considerable additional emphasis should be given to these interactions to maintain the present spirit of cooperation and so that the parties can mutually support one another.

(6) The Tihama Plain was found to be a large land resource with an undefined water potential. Plans for the development of a field research site at Al Jarubah are well along and this location holds much promise for future field research. Consideration should be given to a weed control program to permit the research to proceed effectively. Special attention should be given to the parasitic weed Striga which was noted in the vicinity of the projected research site. The importance of this weed pest and others throughout the Tihama Plain should be examined. Other problems of the Tihama deserving attention are the shifting sand dunes which need

stabilization, the cropping pattern which needs examination as to species selection, fertilization requirements, and breeding of improved crop species.

(7) Additional emphasis should be given to training in the Sorghum/Millet Project. The effort required to initiate a research program has limited training efforts up to this point. This training should proceed at all levels. Much can be done in on-the-job training which has been the principal technique used within the project up to now. This should be supplemented with formal sessions on various technical issues and on the English language. A special opportunity exists to hire very young workers to perform routine tasks in the project in hopes that good candidates for formal training can be identified.

(8) In view of the possibility of sending one counterpart to the University of Arizona for a short term intensive training course special action was taken during the visit to contact the University and to tentatively reserve a place in a 16 week intensive training program which begins in March 1978.

(9) Library Facilities. Discussions with project and mission personnel reveal that there is a need to develop agricultural library facilities in Yemen. General library facilities are visualized as being needed in Taiz and Sana and special sub-libraries are needed by each project. The Sorghum/Millet Project will proceed to make a contribution to this need within the scope of the contract. This will have a direct impact on training.

(10) Pot Experiments. The collection of samples of the major soils in Yemen and the execution of pot experiments has a great potential for identifying mineral nutrient and other soil factors limiting the growth of plants. Such studies can quickly identify specific factors which deserve more attention in the field. They also hold great potential for training purposes and allow progress with minimum expenditure of resources. Project and mission personnel and the soil fertility expert scheduled for January 1978 will give serious consideration to using this approach.

(11) The strengths and weaknesses of the University of Arizona in training students from Yemen were discussed. One of the weaknesses involves the lack of funds to support such training on campus. Indications were that training contracts could be written so as to overcome this problem.

(12) Dr. D. M. Stewart is currently without a counterpart. Mission personnel indicate that a high priority is being placed on getting such a counterpart assigned by the spring.

(13) The Chief-of-Party, Dr. R. L. Voigt, is currently overburdened with supervising details of the field research work. This limits the amount of time he can spend as Chief-of-Party. There was some hope that the three IVS personnel, two of whom are now at Post, would help relieve the burden. However, due to possible assignments anticipated for IVS personnel and other limitations there will very likely be a need to provide Dr. Voigt some assistance. This will be reviewed in one month after the IVS personnel have become settled and a recommendation developed as to a course of action. One alternative is to send a state-side support person over for an 11 month stay. This could be done under the contract with Mission/YARG approval.

(14) Results from the Sorghum/Millet Project have not been developed to the point that specific practices can be advocated for adoption at the farmer level. However, specific sorghum lines can be selected this winter which merit evaluation at several locations in yield tests to determine whether or not they are worthy of being advocated for adoption by farmers. The project needs to gain experience in such on-farm research demonstrations.

(15) Sorghum/Millet Project personnel are carrying out a variety of activities which are supportive of other projects and which bear directly or indirectly on sorghum/millet production. Such activities include a consideration of rotational or alternate crops. Project personnel should be encouraged to document these types of activities so that local files will be of greatest use as the years go by.

(16) Considerable interest was generated in discussions among project and mission personnel relative to several potential projects. Two of these were the stabilization of sand dunes and the evaluation of new crops for food production under minimum water levels. For the present it is visualized that the scope of work needed is embraced by the Sorghum/Millet Project. With the development of promising leads a more formal program of work may be required.

(17) Short term specialists. The irrigation specialist Dale Bucks and the entomologist Dr. Don Tuttle appear to have done an outstanding job on their visits in November 1977. A weed specialist, Mr. Fred Arle, and a soil fertility expert, Dr. Fred Turner, are scheduled to arrive in January 1978 for a one month stay. A grain storage specialist has been identified and will come shortly thereafter. Types of expertise possibly being required for the future were discussed as follows:

a. seed technologist

b. Striga specialist

c. irrigation specialist

d. rotational crops (Legumes)/campus back-up professional (Dr. M. H. Schonhorst)?

e. taxonomist

f. ag. economist/rural sociologist

g. extension specialist

h. nematologist

i. assistant for Voigt

The actual needs will be defined by the project/mission personnel at Post.

(18) Four memos have been prepared to implement ideas developed on the trip. Copies are attached hereto.

(19) Ideas were freely exchanged with mission and party representatives regarding the difficulties of maintaining a research party in Yemen. Special consideration was given to the difficulty of shipping personal effects and scientific materials from the U.S.A. to Yemen. Several alternatives were identified and will be explored.

My deep appreciation is expressed to all in Yemen who made my visit informative and enjoyable. A special note of appreciation is due to Director Robert G. Huesmann, Deputy Director Mary C. Neville, John Young, Morgan Stickney, Yahya Shuga, Bob and Jane Voigt and Don Stewart.

R. P. Upchurch

R. P. Upchurch, Head
Department of Plant Sciences
and
Technical Director, Contract
AID/NE-C-1304 (Yemen)
University of Arizona
Tucson, Arizona

Distribution

Dr. R. L. Voigt, Chief-of-Party	5
John J. Young, Agriculture Development Officer	2
Tom Wilson, AID Technical Officer	2
Dr. W. G. Matlock, Coordinator, Agriculture International Programs	1
Dr. R. P. Upchurch, Head, Department of Plant Sciences	2
Mr. M. H. Schonhorst, Department of Plant Sciences	2

December 12, 1977

MEMORANDUM TO: R. L. Voigt

SUBJECT: Draft on Yemen Trip

Provided herewith are two copies of a draft of my trip report. Would you please clear this with Mission personnel and give me your suggestions for incorporation into a final copy. Copies are being sent to Matlock and Schonhorst and they are requested to respond likewise.

R. P. Upchurch, Head
Department of Plant Sciences

RPU/sh

Attach.

cc: W. G. Matlock (with attachment)
M. L. Schonhorst (with attachment)

alch. 1

December 12, 1977

MEMORANDUM TO: W. G. Matlock

SUBJECT: Voigt's need for ready cash

After visiting Yemen I am convinced that it is essential for Voigt to have ready access to $5,000 to allow for medical evacuation should that become necessary. There are no suitable medical facilities in the country and a simple auto accident could require evacuation. As one alternative we discussed having $5,000 in a U. S. bank with Voigt and an alternate (Stewart) having drawing rights against the deposit for emergency. Voigt can get the Mission to cash a check. This would be for emergency purposes only. Would you please explore this possibility and/or let's discuss.

R. P. Upchurch, Head
Department of Plant Sciences

RPU/sh

cc: R. L. Voigt

December 12, 1977

MEMORANDUM TO: M. H. Schonhorst

SUBJECT: Support for Yemen Project - General

Would you please obtain information on the items indicated below and supply same to Voigt. These are items which came up for discussion during my trip to Yemen. We will not order any of these items until they are put on a list and requested by Voigt.

(1) Self-contained refrigerated seed storage room. Idea is to get a combination of low relative humidity and low temperature. Check boxes ordered by Mielke (about 6' x 8'), get approximate specs and costs and delivery date, check availability of different sizes.

(2) What service is available in U.S. to run quality analysis on say 20 sorghum grain samples - protein content, digestibility, etc., cost, lead time, size sample required, specific measurements, etc. Swingle in Animal Sciences may help.

(3) Cost, availability, specs on a seed germinator.

(4) Make brief literature survey on the impact of leaf removal on sorghum yield. Supply reprints to Voigt. Leaves are stripped from sorghum in Yemen to supply forage and this may reduce yield. I don't know if research has been done on this for sorghum but it almost certainly has been done for corn, perhaps in th 1940s.

(5) Make brief literature study on the use of pot experiments with crops, especially sorghum or possibly corn, to identify mineral nutrients as limiting factors in crop production. Supply illustrative reprints to Voigt. We want to run some pot experiments in Yemen using various soils with variations in levels of N, P, K, minor elements, pH and need copies of illustrative reports to get methodology.

(6) Each month when budget reports become available send two copies to Voigt. He will give one to Mission personnel (Morgan Stickney).

(7) Check Dr. C. T. Mason and prepare a list of materials normally required to operate a herbarium - including - cabinets, dry plant presses, wet plant collection device, forms for mounting speciments, fillers for presses, etc. Report specs, costs, etc., to Voigt.

(8) Check Dr. Don Tuttle re supplies needed for insect collections including butterfly collecting nets, killing bottles, killing fluid, storage bottles (price by gross), storage liquid - report specs, costs, availability, etc., to Voigt.

Atch 3

December 12, 1977

(9) Obtain a few seed of Mondelle pine for Stewart to take back to Yemen he returns. OALS may have some (Ed Weber).

(10) Identify and recommend elementary books in biology, plant science which could be used to train Yemeni trainees.

(11) Identify a BS or MS level graduate who could spend up to 12 months as an assistant to Voigt in Yemen. Since a family could not be sent over it is possible that an unmarried person might be more likely to accept such a position. No position yet available but may be made available in due course.

(12) Identify specs, costs, etc., for noise makers to drive birds away from sorghum plots.

R. P. Upchurch, Head
Department of Plant Sciences

RPU/sh

cc: Dr. R. L. Voigt
Dr. W. G. Matlock

December 12, 1977

MEMORANDUM TO: M. L. Schonhorst

SUBJECT: Support for Yemen Project - Library

While I was in Yemen a tentative general arrangement was made for our sorghum project to assist in the augmentation of library facilities for agricultural science in Yemen. Tentatively, plans call for the initial development of two general libraries on agricultural science and for a series of sublibraries to service various speciality projects. The general libraries would be at Sana and at Tiaz. Our sorghum/millet improvement project would have a sublibrary. In order to explore this matter further would you please take the following steps:

(1) Correspond with the American Society of Agronomy Borlaug Book Project to determine what sets of journals and books might be made available without charge to the Government of Yemen. Hopefully, two sets could be made available, one for each of the two general libraries. Presumably our sorghum/millet project could pay the required transportation charges but this would need to be verified. Report results to Voigt.

(2) Learn what journals are available on microfilm or microfische and determine costs, equipment required to view, equipment required to make reproductions, etc., report same to Voigt.

(3) Make Xerox copies of all articles in Crop Science journal pertaining to sorghum/millet for a 15 year period. Ship to Voigt for use in sorghum/millet project and record items sent. After items have been received by Voigt determine whether or not this approach is advantageous. Extend as authorized by Voigt. Determine need for one vs. two copies.

R. P. Upchurch, Head
Department of Plant Sciences

RPU/sh

cc: R. L. Voigt
W. G. Matlock

atch 4

Weed Problems and Herbicide Report to
U. S. Agency for International Development
Sorghum/Millet Project in the Yemen Arab Republic

RECEIVED
PLANT SCIENCES
DEPARTMENT

Report prepared by: H. Fred Arle, Agronomist
Department of Plant Sciences
University of Arizona
Cotton Research Center
Phoenix, Arizona 85040

Dates of Visit: January 18, 1978 - February 15, 1978

Contract No. AID/NE-C-1304 (Yemen)

Contract for: National Sorghum-Millet Crop Improvement

Atch 4

INTRODUCTION

The purpose of my visit to Yemen in connection with the USAID Agricultural program was to review the problem of weeds associated with the production of grain sorghum and millet. I was present in Sana, Yemen from January 18 to February 15, 1978.

WEED EFFECTS

Weed growth in grain sorghum and millet compete with the crop for light, water and soil nutrients. Dense infestations of weeds during the seedling stage of the crop are especially injurious as frequently they are more aggressive and quickly become the dominating constraint. When this occurs, the potential for obtaining good yields is minimized.

WEED CONTROL PRACTICES

Weeds cannot be adequately checked through the use of a single control technique. Maximum results are obtained through the use of an integrated control program which would include cropping sequence, tillage and herbicide treatments. Cropping sequence: Perennial grasses cannot be kept under control in grain sorghum, continued annual cropping of sorghum or millet results in a gradual increase of the grass infestation and an accompanying decrease in crop productivity. Whenever the cropping sequence, especially involving different seasons, can be altered then progress against these weeds can be realized. For example, infestations of Johnson grass can be gradually reduced by planting infested fields to fall seeded small grains for several years and using appropriate tillage. There is also greater choice of herbicides under a differential crop sequence.

Tillage: Effective seedbed and tillage practices following planting and emergence such as rotary hoeing (ground-driven equipment such as the Lilliston are advantageous on bedded crops), cultivation and opening furrows for irrigation can effectively control many annual weeds. Cultivation may be used for a dual purpose: killing small emerged weeds and soil incorporation of herbicides applied previously. When tillage equipment is used after sorghum emerges, the tillage tools must be carefully set regarding depth and closeness to control weed seedlings without injuring the sorghum roots.

Herbicides: There are several types of herbicides which can be used to aid in the control of weeds in grain sorghum and millet:

(1) Systemic herbicides - These are hormone-like materials which are applied to the foliage of weeds. They move into the leaf tissue either through absorption or through the stomata and then enter the conductive system and are translocated throughout the plant. The killing effect is due to a disruption of the normal photosynthetic process. This type of herbicide can be used to kill broadleaved weeds in grain crops. When applied at higher rates to the soil followed by shallow incorporation,

they also can kill germinating weeds, however, they are no longer used in this manner because more effective herbicides have become available. Examples of this herbicide type include 2, 4-D (2, 4 dichlorophenoxy) acetic acid and Banvel (common name-Dicamba) 3, 6-Dichloro-o-anisic acid. Both of these have been useful for controlling annual broadleaved weeds in grain sorghum and millet. Details of prescribed usage will be discussed later.

(2) Soil applied herbicides - These herbicides are applied to the soil, and usually lightly incorporated into the soil. Weeds are killed when the rootlets of seedling plants absorb the herbicide and a kill results soon after the chemical is moved into the above ground parts. Many of these herbicides have lengthy soil persistence and can control weeds throughout the life of the crop plant. Because of this persistence we must consider the potential hazards of residual toxicity as it regards the selection of a rotational crop. Effective rates of application are dependent upon soil composition, sand, silt, clay and organic matter. Soils high in sand content usually present a situation where the margin of safety for selectivity (kill weeds without crop injury) is at a minimum. In very sandy soils this type of treatment is most often not advisable. Soils high in clay or organic matter require higher rates of application than is necessary for lighter soils. Length of residual activity is dependant upon several factors including formulation, soil type, soil moisture and temperature.

The CIBA-GEIGY Corporation has available three herbicides which should be tried on an experimental basis to evaluate their potential for alleviating weed problems in sorghum. They are as follows:

(1) Atrazine (Trade name Aatrex 80 W), 2 chloro-4-ethyl amino-6-isopropylamino-s-triazine. It is an 80% wettable powder with a water solubility of 33 ppm. at 25°C. Because of this low solubility it has a relatively long period of residual activity. It can be expected to provide season-long control of many annual weeds in grain sorghum.

(2) Propazine (Trade name Milogard 80 W), 2 chloro-4, 6-bis (Isopropylamino)-s-triazine. It is an 80% wettable powder with a water solubility of 8.6 ppm. at 20°C. This indicates a long period of soil activity.

(3) Terbutryn (Trade name Igran 80 W), 2-tert-butylamino-4-ethylamino-6-methyl-thio-s-triazine. It is an 80% wettable powder having a water solubility of 58 ppm at 20°C. This chemical may be mixed with Atrazine or Propazine (to enlarge the spectrum of weeds controlled) for weed control in sorghum.

Details of application techniques for each of these herbicides will be discussed later.

WEEDS PRESENT

A list of weeds was recently compiled by Dr. Shaukat A. Chaudhary, Botany Department, University of Sana'a for the midlands, highlands and Sana'a basin. Included in the more prevalent area are the following (not necessarily in order of importance):

1. Diplotaxis erucoides
2. Amaranthus sp.
3. Calendula aegyptiaca
4. Senecio sp.
5. Sonchus oleraceus
6. Xanthium spinosum
7. Sisymbrium irio
8. Euphorbia schimperiana
9. Eragrostis sp.
10. Malva sp.
11. Plantago sp.
12. Tribulus terrestris

Important weeds of the Tihama area include the following:

1. Striga hermonthica
2. Amaranthus spinosa
3. Cleome viscosa
4. Dipterygium glaucum
5. Cyperus rotundus
6. Euphorbia sp.
7. Tephrosia apollinea
8. Abutilon pannosum
9. Corchorus sp.
10. Tribulus sp.

At Bir al-Ghoum the weed of primary concern at present is Diplotaxis erucoides, a broadleaved annual. It is a prolific seeder and is extremely competitive during the early stages of sorghum development.

In the Tihama area, Striga hermontica is of special concern. It is a parasitic plant originating from seed and later attaching itself to the stems of grasses such as sorghum and sugar cane. Crop vigor is lost due to the sapping of energy by the parasitic plants.

HERBICIDE POTENTIAL

Many annual broadleaved weeds (including Diplotaxis erucoides) can be killed with 2, 4-D. Rates of application ranging from two thirds to one pound per acre applied during the early stages of weed growth and when sorghum is 4 to 15 inches tall. The application may be made "over the top".

to both weeds and sorghum. Stem bending and root malformation may result but yield reductions should not occur. As 2, 4-D has little or no soil activity at the rates suggested, a following crop of annual weeds will likely occur. When applying 2, 4-D precautions must be taken to avoid spray drift. Do not spray during windy conditions. Crops such as grapes, beans, tomatoes and others can be severely affected when contacted by spray drift. Some broadleaved weeds develop resistance to 2, 4-D especially after forming seed heads. Applications therefore should be well timed to obtain maximum results.

The correct use of Banvel (Dicamba) is very similar to that of 2, 4-D. Banvel appears to be less reactive on sorghum than is 2, 4-D, however, it is frequently less effective on weeds also. Rates of application should range from .25 to 1.0 pound per acre in trial work. Precautions are identical to those which should be observed when using 2, 4-D. It is difficult to completely remove 2, 4-D or Banvel from spray equipment. A ½% solution of household ammonia rinsed through the spray equipment will remove most of it, however, such equipment should not be used in applying pesticides to 2, 4-D sensitive crops.

Soil applied herbicides (1) Atrazine (Aatrex 80 W) may be applied either before planting, at planting or after planting. Application rates will vary with soil types:

Soil Texture	Organic Matter	Rate Per Acre
Coarse-textured soils: sand, loamy sand, sandy loam and sandy clay loam	Any level	Do not use except pre-emergency on bedded sorghum
Medium fine-textured soils: silt, loam, clay loam and clay	1 - 1.5%	2.0 - 2.5 lbs.
	More than 1.5%	2.5 - 3.0 lbs.

Preplant Applications (Broadleaf and Grass control). Apply broadcast after plowing. Application may be made before, during or after final seedbed preparation. If soil is tilled or worked after application avoid deep incorporation. Best results frequently are attained when applied within 2 weeks prior to planting.

Pre-emergence Applications. Apply during or shortly after planting, but prior to weed or crop emergence at rates indicated in table above. Precaution for pre-emergence application to furrow-irrigated bedded sorghum. Do not use atrazine when sorghum is planted in a furrow. Applications made to sorghum growing on alkali soils or where cuts, fills or erosions have exposed calcareous or alkali subsoils may result in crop injury.

Postemergence Broadleaf Weed Control with Surfactant. Broadcast 1.5 pounds per acre plus .75 - 1.5 pints of surfactant per acre after sorghum reaches 6 inches in height but before weeds 1.5 inches in height. This may be a difficult situation to achieve. This treatment advisable only in fine textured soils.

Precautions for all applications to sorghum. Heavy rains immediately following application tend to concentrate herbicide in seed furrow. Applications should be avoided when sorghum is furrow planted or when deep planter marks remain until such depressions have been filled in. Following harvest of a treated crop plow and thoroughly till the soil to minimize possible injury to rotational crops.

Soil applied herbicide (2) Propazine (Milogard 80 W) is a selective herbicide that can be applied before planting or after planting but before sorghum or weeds emerge. Because propazine enters the weeds mainly through their roots, incorporation, rainfall or irrigation is needed to move it into the weed root zone. When sorghum is planted on beds, the application should be made only after bed formation. Best weed control results are obtained when propazine is applied within 4 weeks prior to planting. Shallow incorporation, not more than 2 inches deep, following application will generally result in better weed control, particularly under dry or minimum moisture conditions. For silt loam to silty clay loam (Bir al-Ghum) rates of 2.5 to 3.0 pounds per acre of propazine (Milogard 80 W) should be tried. Do not incorporate preplant applications on sandy loam soils. Fields treated with propazine may be planted to sorghum or corn 12 months after treatment. Other crops should not be planted for 18 months following treatment.

Soil applied herbicide (3) Terbutryn (Igran 80 W) is a selective herbicide that controls many annual broadleaf weeds and grasses. When applied before weeds emerge, Igran enters weeds through their roots after germination. Thus its effectiveness depends on rainfall or irrigation to move it into the soil. When applied to emerged weeds, Igran provides foliar knockdown of existing weeds and residual control of later germinating weeds. Igran must never be applied to emerged sorghum. For annual broadleaf weed control only (no grass control) use 1.5 to 2.0 pounds per acre as a pre-emergence treatment for silt loam and silty clay loam soils. If irrigation is necessary, irrigate during the first 36 hours after planting or delay until the sorghum is at least 2 inches tall, or injury may occur. Rainfall at the time of sorghum emergence and until the sorghum is 2 inches tall may cause injury to sorghum. Do not apply Igran to millets. Following sorghum harvest, the stubble should be disked or plowed under prior to planting the next crop. Crops such as corn, sorghum, spring wheat and barley may be planted the following spring in soils previously treated with Igran 80 W.

Herbicide Test Completed

To evaluate the effectiveness of Banvel and 2, 4-D on weeds encountered on the sorghum-millet project a small test was established on Field B, Bir al-Ghoum. Weeds on the plot area included Diplotaxis erucoides (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 on January 23, 1978. Banvel and 2, 4-D (amine formulations) each were applied at rates of .5 and 1.0 pound in 40 gallons water per acre. 2.17 ml. of either material in 350 ml. of water per 100 sq. ft. is equal to 1.0 pound of active ingredient 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 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.

Proposed Herbicide Experiment

Applications to be made when sorghum is 4 to 15 inches tall and weeds are small.

Border #1 Plots: 15 feet x 16-2/3 feet

1. 2, 4-D - .5 lb/A.
2. 2, 4-D - .75 lb/A.
3. 2, 4-D - 1.0 lb/A.
4. Check
5. Banvel - .5 lb/A.
6. Banvel - .75 lb/A.
7. Banvel - 1.0 lb/A.
8. 2, 4-D - .75 lb/A. + Atrazine 2.0 lb/A.
9. Banvel - .5 lb/A. + Atrazine 2.0 lb/A.

Border #2 Plots: 15 feet x 16-2/3 feet

Treatments:

1. Atrazine 1.0 lb/A (Aatrex)
2. Atrazine 2.0 lb/A "
3. Atrazine 4.0 lb/A "

4. Propazine 1.0 lb/A (Milogard)
5. Propazine 2.0 lb/A "
6. Propazine 4.0 lb/A "
7. Check
8. Igran 2.0 lb/A
9. Igran 4.0 lb/A

Field Trips

Itinerary: January 29 - Depart Sana 0900
January 29 - Arrive Taiz 1400
January 30 - Depart Taiz 1045
January 30 - Arrive Hodeidah 1700
January 31 - Depart Hodeidah 0800
January 31 - Arrive Sana 1300

While in Taiz met with Dr. Mohamed Ali El Lakhany, UNDP/FAO, and discussed results of his herbicide trials in maize. Best results were obtained with preplant-incorporated applications of simazine. Post emergence 2, 4-D applications controlled existing broadleaved weed but new emergence re-established the problem. When 2, 4-D plus simazine (separate applications) were applied, existing weeds were killed and new weeds did not emerge with following irrigation. In the Tihama area several stops were made to observe cropping systems and associated weed problems.

Itinerary: February 5 - Depart Sana 1130
February 5 - Arrive Taiz 1715
February 6 - Depart Taiz 1330
February 6 - Arrive Sana 1900

While in Taiz discussed the potential of herbicides in citrus with Dr. Saad Albadi, FAO Horticulturist. Also reviewed several items of weed control in maize and millet with El Lakhany. Both of these men thought that the use of herbicides could become an agricultural practice in Yemen. However, both also believed that this should be a program of cautious development and that errors causing crop injury on farmer's fields must be avoided. Visited research plots at the FAO station with Dr. El Lakhany and discussed planting techniques, irrigation and weed control management potential.

Report of Technical Visit to
U. S. Agency for International Development
Sorghum/Millet Project in the Yemen Arab Republic

Report prepared by:

Fred Turner, Jr.
Extension Soils Specialist
and
Superintendent, Safford Experiment Station
University of Arizona
Safford, Arizona 85546

Dates of Visit: January 18, 1978 - February 15, 1978

Contract No. AID/NE-C-1304 (Yemen)

Contract for: National Sorghum & Millet Crop Improvement

Atch 5

Technical Visit to USAID - Sorghum/Millet Project in the Yemen Arab Republic

CONTENTS

	Page No.
INTRODUCTION	1
Reasons for Visit	1
Arrival	1
Briefing Conference	1
PROCEDURES AND OBSERVATIONS	1
Literature Review	1
Soils Studies	1
Previous Water Quality Studies	3
Current Soil and Water Analyses	3
Infiltration Studies	3
Planting Methods	4
Soil Fertility Determinations	4
Meteorological Station	4
RECOMMENDATIONS	5
Cultural Methods for Field Trials	5
Pot Studies for Nutrient Needs	5
Meteorological Station	6
REFERENCES AND APPENDIX	7
Appendix 1 - Details of Pot Studies for Nutrient Needs	8
Appendix 2 - List of Meteorological Equipment	9

INTRODUCTION

Reasons for visit. Dr. R. L. Voigt, Chief-of-Party in Yemen, requested a soil fertility specialist to "(1) evaluate the capability of the in-country soils analysis laboratory and (2) make recommendations concerning the types of soil fertility studies which should be undertaken under Project 030."

Arrival. In company with Fred Arle, Weed Specialist, I arrived in Sana'a, via Rome, on schedule at 0815 January 18, 1978. I brought an Oakfield soil sampling kit (ordered by Dale Bucks), two hand electronic calculators, and plastic bags (for possible use in pot fertility studies). Arle hand-carried a microscope in case.

In conference January 21, 1978 with R. L. Voigt and Morgan Stickney, Assistant Agricultural Development Officer, need for technical assistance in the following subjects was indicated:

1. Determination of soil nutrient needs. Because land at the research farms is at a minimum, the feasibility of pot experiments should be explored.

2. Analysis of soils, to determine nutrient needs, including minor elements. Possibly this can be accomplished at the UNDP Laboratory in Taiz.

3. Meteorological measurements. Should a weather observing station be set up at AID Mission headquarters or at one of the Ministry of Agriculture farms, or can the data collected at the German farm in Sana'a be used?

4. R. L. Voigt expressly requested assistance in determining the best way to plant to insure stand. Soils at the two farms becomes very compact when irrigated. During the past season, sorghum and millet were dry planted in the furrows and irrigated up. Stands were erratic.

PROCEDURES AND OBSERVATIONS

A review of available literature was undertaken, including study of reports made by D. A. Bucks[2], irrigation engineer, who visited the project October 11 - December 11, 1977, and R. P. Upchurch[4], Head of the University of Arizona Department of Plant Sciences, who was in Yemen November 28 - December 7, 1977.

Soil Studies. Plans were made to study the three Ministry of Agriculture farms used for research by USAID/Yemen. Only the two in Sana'a were visited.

1. Bir al-Choum Farm

Located in North Sana'a, this farm is used for field crop research, primarily with sorghum and millet. Examination of soil borings and of the sorghum and millet stubbles substantiated Dr. Voigt's contention that current methods of planting have been unsatisfactory.

The fields are typically terraced and are designated as shown on the field diagram prepared by Bucks[2]. They have been farmed for a long time as attested, in part, by the presence of potsherd in at least the upper 36 cm. These same soils have been used for centuries as building material for bricks used in construction of houses and enclosures, so it is impossible to determine what, if any, was the original soil surface.

Although a complete survey was not made, spot determinations revealed surface textures of silt loam and silty clay loam with varying amounts of small stones in the plow layer (6-20 cm). A very compact or indurated layer was encountered at approximately 26 cm. The soils are moderately to highly calcareous as determined by effervescence with 10% hydrochloric acid[5]. 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. In itself, this may lead to poor soil structure.

Although salt accumulation was noted on some ridges, the soil was very compact in both ridges and furrows, all of which had been flooded to varying extent during prior irrigations. The soils appeared highly dispersed with single grain structure and with few large pores. The present method of planting in the furrow and watering-up would be expected to result in continued unreliable stands.

2. Bir al-Shaif Farm

Located in Northwest Sana'a, this farm is used primarily for studies with horticultural crops.

Bucks[2] reported chemical analysis of five soils which were taken from this farm in September 1977, and were analyzed for Tuskegee Institute at Tuskegee, Alabama by the Auburn University Soil Testing Laboratory. Depth and location of samples were not specified nor was the method of analysis. Also, electrical conductivity of a saturation extract, a critical determination in investigation of saline and sodic (alkali) soils, was not reported. Calculations by Bucks, based on the reported data, indicates a high level of salinity (EC = 17 mmhos/cm) which, by U. S. Salinity Laboratory standards[3], can be tolerated by only the most tolerant crops. Sorghum and millet yields will be adversely affected. By his calculations, sodium levels are low and not considered to be a hazard.

3. Al-Hawqubi Farm

A trip was made January 29-31, 1978, in company with M. Stickney, D. Stewart, University of Arizona Agronomist, and F. Arle, University of Arizona Seed Specialist, to observe the agricultural practices,

soils, crops and other vegetation on a route from Sana'a-Taiz-Mokka-Hodeida-Sana'a. It was planned to inspect the al-Jarouba farm, in the Tihama, near Zabid. However, time and circumstances did not permit the complete side trip to this farm.

Previous Irrigation Water Quality Studies. Water from the USAID office well was analyzed for Bucks on February 18, 1975, by the UNDP Soil Testing Laboratory in Taiz[2]. In the absence of other data, Bucks assumed that irrigation wells at both the Bir al-Ghoum and Bir al-Shaif farms drew from this same ground water basin and is of similar quality. He determined from this data that the water is of medium salinity and has a low sodium hazard.

Current Soil and Water Studies. Current, identifiable analyses of soils from the research farms and the irrigation waters used thereon was needed to properly evaluate problems associated with crop production on these farms. During the trip to Taiz and beyond on January 29-31, I conferred with Dr. Hari C. Dewan, Soil Scientist in charge of the UNDP Soil Testing Laboratory in Taiz. This facility regularly makes chemical and physical analyses of soils and waters. Their procedures are those best suited for calcareous soils[5]. Dr. Dewan agreed to analyze soil and water samples from the USAID-Ministry of Agriculture farms. The Lab cannot analyze for boron, but hopes soon to have this capability.

With the assistance of F. Arle and J. Lee, soil samples and water samples from corresponding wells were collected at the two Sana'a farms. Composite soil samples were taken for both the 0-20 cm. and 20-32 cm depths. Field 1 at the Bir al-Shaif farm and both fields A and B at the Bir al-Ghoum farm were sampled.

On February 6, 1978, the six soil samples were personally delivered to Dr. Dewan at Taiz. He agreed to analyze the samples as soon as possible and to send the results to Dr. R. L. Voigt in Sana'a. As of this writing, the analyses have not arrived.

Infiltration Studies. Water movement observed into soils in the Sana'a area is moderately slow. Bucks estimated infiltration rates at between 0.1 to 0.15 inches/hour (2.5 to 3.8 mm/hr). J. Lee observed "very little lateral movement of rain water from furrows into prepared beds" at the Bir al-Shaif farm. Determination of infiltration rates in holes at the two farms was planned. However, in later talks with M. S. Acharya, IVS Agricultural Engineer, I learned he also had plans for such studies and has on order the necessary sheet metal to locally manufacture rings with which to determine infiltration rates by the standard double-ring method[5]. As Acharya has been busy the past two weeks on other projects, we have been unable to conduct such tests.

Planting Methods. While at Taiz, I was briefed by M. El Lakhany on methods of planting and irrigation employed at that UNDP farm. They were similar to those I employ when encountering salinity problems, i.e., planting on sides of beds, above the water line, so that salt concentrations at the seed line can be kept to a minimum.

Soil Fertility Determinations. I concur with the suggestion of R. P. Upchurch(4), M. Stickney and R. L. Voigt that pot experiments are feasible for determination of soil nutrient needs. J. Lee hopes to build a shade house for starting cuttings at the Bir al-Shaif farm. I found that small plastic buckets which were locally available are suitable containers. I later confirmed this with Dewan. Bench space 1m x 9m would be needed. Lee could accommodate this need in his shade house design. Details of treatments were coordinated with Dewan.

Meteorological Station. Possible sites for a meteorological station on the AID Mission headquarters grounds were selected. A station near the entrance to the Cable and Wireless compound, immediately west of the AID headquarters, was examined. Although this station is equipped with an instrument shelter, totalizing anemometer on pole, evaporation pan with stilling well and hook gauge, rain gage, and a solar radiation measuring device (apparently recording type), there was no indication that the station was in operation. Personnel at the Cable and Wireless office had seen no activity at this station for nearly a year.

The German farm in Sana'a has a rather complete meteorological station, including soil temperatures. A Pische device, rather than evaporation pan, is used to estimate evaporation. The data is published. However, if this project is discontinued, so is the information.

On February 13, 1978, accompanied by R. L. Voigt and F. Arle, I visited the Civil Aviation and Meteorological Authority headquarters in Sana'a and met with Yahya Alhak, Acting Director, and a Mr. Soliven, UNDP World Meteorological Organization (WMO) representative. We learned:

1. Both agencies will support establishment of a meteorological station at AID Mission headquarters, Sana'a, although a complete station is in operation at the Sana'a airport. They will supply all equipment and render all technical assistance possible.

2. The meteorological station in the Cable and Wireless compound belongs to the Ministry of Agriculture and currently is not in operation. Probably this equipment could be transferred to AID.

RECOMMENDATIONS

Cultural Methods for Field Trials. Rip to at least 20 cm, deeper if possible. Plow and level. Mechanically form beds and furrows so that either:

1. The land can be pre-irrigated with 16-20 cm of water. With the apparent low infiltration rate, this may require a "set" up to 53 hours (less for al-Jarcuba farm). It is desired to achieve water penetration to fill the soil profile and move higher concentration of salts below the root zone. Take care water does not cover the beds. About half way up is desirable. Water should sub (move laterally to moisten beds). When soil has dried sufficiently, mulch beds, in so doing removing upper one-third of bed. Plant seeds at desired depth in moist soil and firm soil lightly. Water back if soil dries excessively before emergence, taking care water does not cover beds. Or,

2. Plant in dry soil on south side of beds, above proposed water line. Irrigate as in 1 above, insuring that water level does not cover seed line. Water back if necessary. Do not mulch.

3. Apply fertilizer in split applications. Since a 20-20-0 fertilizer appears to be the most available fertilizer locally, side dress 200 kg/ha at least 5 cm to the side and 5 cm lower than the seed, either at planting time (if irrigated up) or after plants are well established (if planted in moist soil). Similarly apply another 200 kg/ha of 20-20-0, or 100 kg/ha of urea (0-45-0) six weeks after emergence. Pot trials will determine if higher rates of fertilizer are needed.

4. Herbicides should be applied as recommended by Fred Arle in his separate report.

5. Infiltration studies should be carried out by M. S. Acharya as soon as possible.

Pot Studies for Nutrient Needs

1. A suitable location for these studies is a prerequisite. Construction of a shade house, as recommended by and coordinated with J. Lee, is essential.

2. Plastic buckets of approximately 5-liter capacity are available in Yemen (H. Dewan can locate quantity source). A 1.5-2.5 cm diameter hot steel rod will make a hole at the side, just above the bottom, for drainage Properly cleaned, these buckets should be suitable for even micronutrient studies.

3. Details are given in Appendix 1. One pound (one-half kilogram) samples of each bulk soil should be sent to Dr. Dewan for analysis.

4. Copies of a publication by Turner and McCall [3], detailing a pot experiment, were given to Voigt and Stickney.

Soil Survey. A soil survey should be made of each farm to better identify soil differences and to ascertain problems, such as hardpans or indurated or compacted layers which impede passage of roots and of moisture.

Meteorological Station

1. A meteorological station could be established south or southeast of the AID Mission office buildings, at least 30 meters from any obstructions (trees and buildings and parking areas). A 9m x 9m area, enclosed by an animal-proof fence, is needed. Instruments required are listed in Appendix 2.

2. Most of required instruments hopefully can be obtained by a letter to the Ministry of Agriculture, requesting that the meteorological instruments and equipment now located just inside the entrance to the Cable and Wireless compound be transferred to AID. As was requested, also send a copy of the letter to Director General, Meteorological Department, Civil Aviation and Meteorological Authority, Sana'a, YAR.

3. Mr. Soliven of the WMO has kindly offered to provide all technical assistance necessary to locate, lay out and install the equipment.

4. A technician to insure that proper readings are made and that complete records are kept.

My sincere thanks for both personal and professional assistance go to Jane and Bob Voigt, John Young, Morgan Stickney, Don Stewart and Jeff Lee.

REFERENCES

1. Awad, D. M. and Dewan, H. C. "Soil and Water Investigation Report of Bani Hushaish Area, N.E. of Sana'a." Soil and Water Research Section, Central Agricultural Research Organization Project, Taiz, UNDP/FAO/YEM/73/010. June 1977.

2. Bucks, D. A. "Irrigation Design, USAID Farms, Yemen Arab Republic. Initial Report." November 1977.

3. Turner, F. and McCall, W. W. "Studies on Crop Response to Molybdenum and Lime in Michigan." Michigan Agriculture Experiment Station Quarterly Bulletin, Vol. 40, No. 2, pp. 262-280, November 1957.

4. Upchurch, R. P. "Report of Administrative Visit to USAID-Sorghum/Millet Improvement Project in the Yemen Arab Republic." December 1977.

5. U. S. Salinity Laboratory Staff. "Diagnosis and Improvement of Saline and Alkali Soils: Agricultural Handbook No. 60." U. S. Department of Agriculture, Washington, D.C. 1954.

APPENDIX 1

Details of Pot Studies for Soil Nutrient Needs

Materials

1. 100 pots. Five-liter plastic buckets are available locally or in Taiz. Dr. Hari C. Dewan will help in locating source. Make drainage hole in each at the side and even with bottom surface with hot steel rod of 1.5-2.5 cm diameter.

2. Fertilizer

   5 lbs. Urea
   5 lbs. Treble superphosphate
   5 lbs. Potassium sulphate

Procedure and Statistical Design

A modified factorial experiment was discussed with Dr. Dewan and will be cleared with the Agricultural Experiment Station Statistician upon my return to the U.S.

Within three weeks of my return to the U.S., I will send the above fertilizers and, separately, detailed instructions for fertilizing, planting, growing, and determining yield response on soils to be tested. Alternative designs may be suggested.

A shade house, or similar structure, will be necessary to conduct these trials.

APPENDIX 2

Meteorological Equipment Needed for Climatological Station
at AID Headquarters, Sana'a, Yemen Arab Republic

Description and prices from Weather Measure Corporation Catalog 975 and Price List No. 975, effective March 1, 1976.

Address: Weather Measure Corporation
P. O. Box 41257
Sacramento, California 95841

Page	Model No.	Item	Price
15	TM1-ES	Official Mercurial Thermometer W/TM1-C Thermometer	$ 14.70
15	TM-2C	Maximum-Minimum Thermometer	54.00
15	P561-ES	Standard 8" Rain and Snow Gage w/Metric dip stick	158.00
15	HM20C	Battery-driven Fan Psychrometer	95.00
163	IS-1MRD	Instrument Shelter w/ metal legs	215.00
82	H311-S	Hygrothermograph	220.00
82	H311-HB	Replacement Hair Bundle	17.00
82	C311-W-C	Charts (Temperature -20 to +40°C, 7-day drum rotation)	7.60
184	E816	Evaporation pan	285.00
184	E814-A	Still Well (for hook gage)	75.00
184	W-164B/M	Totalizing Anemometer (metric)	265.00
184	W-164B/M	Totalizing Anemometer (metric)	265.00

(NOTE: one anemometer by evaporation pan,
one anemometer to be installed on 3 meter pole)

Appendix 2 (cont'd)

Page	Model No.	Item	Price
184	E811-C	Centigrade Maximum/Minimum Thermometer	55.00
184	E815	Hook gauge	100.00
104	R431-AS	Sunshine Duration Recorder (Campbell Stokes type)	475.00
104	C431-A	Charts for 0° to 40° latitude	44.00
143	TM532/50	Angle Stem Earth Thermometer	6.50
143	TM532/100	Angle Stem Earth Thermometer	7.00
143	TM532/200	Angle Stem Earth Thermometer	9.00
143	TM532/300	Angle Stem Earth Thermometer	12.00
		TOTAL	$2,379.80

A Farm Level Study of the Drying and Storage of Sorghum and Millet Grain in the Yemen Arab Republic to U.S. Agency for International Development

Report prepared by:

Robert A. Saul
1412 Martin Road
Albert Lea, Minnesota 56007, U.S.A.

for

The University of Arizona
Tucson, Arizona, U.S.A.

Dates of Visit: February 22 through March 8, 1978

Contract No. AID/NE-C-1304 (Yemen)

Contract for: National Sorghum & Millet Crop Improvement

ATCH 6

A Farm Level Study of the Drying and Storage of Sorghum and Millet Grain in the Yemen Arab Republic

By Robert A. Saul
for the University of Arizona

Purpose of the Study

After Dr. Don Stewart and I had been questioning a group of farmers in a small village in the Tihama region about their sorghum and millet production and storage, they turned it around and asked us why we wanted to know. I explained that the USAID wanted to know if they would be able to harvest, dry and store increased production of these grains when better seed was developed for them. They seemed very pleased with the answer. We were on a field trip to observe the on farm drying and storage of sorghum and millet grain in the Yemen Arab Republic. I was in the country from February 22 until March 8, 1978.

Plan of Study

The initial briefing on the country and the possible problems with grain storage was conducted by Dr. Robert Voigt, Chief-of-Party for the University of Arizona program on sorghum and millet improvement in Yemen, John Young and Morgan Stickney with the USAID staff in Sana'a. They indicated an interest in possible storage losses on the farm in all of Yemen but believed that the Tihama or coastal plain between the Red Sea and the mountain ranges which run parallel 20 to 40 miles inland would be a problem area. The environment in the Tihama may be characterized as having generally dry soil with hot and humid air.

Plan of Work

A field trip was planned to observe the farm storage conditions with Dr. Donald Stewart as director assisted by an interpreter and a driver to get me to the farm and help make the observations needed. A circle trip was planned by going west from Sana'a to the coastal city of Hodeida. Two days with Hodeida as headquarters to visit the Tihama region. Drive south to the road from Mokha to Taiz and then east to the highland city of Taiz where again headquarters to visit the most productive areas around the cities of Ibb and Damar north of Taiz. After two days in this area to continue north back to Sana'a. A questionnaire prepared by Dr. Voigt was to be used as a guide in our farm visits. (See Appendix A)

Observations

Sixteen stops or visits were made. Of the 11 made in the Tihama, 1 was in a village market place. Of the 5 stops in the highlands, 2 were in villages on the highway. The summary of the grain samples taken on the field trip is given in Table 1.

Tihama - The sorghum and millet we saw was stored in gunny bags or woven baskets. The woven baskets measured 1 meter in diameter and 1 meter deep containing about 20 kada. One kada is equal to 40 liters and is the basic measure for grain marketing. In Yemen grain is marketed by volume rather than by weight. At stop #1 the baskets were outside the buildings on the drive from the highway into the village. They were covered with woven straw mats. Two other farmers, stops # 10 and 11, placed the baskets on either a platform of branches supported by rocks or a bed of seaweed which was about 0.5 meters deep. Tepee shelters were erected around the baskets to keep off the rain. The farmers called this type of storage a siddle. The farmer using the seaweed claimed beneficial effects for it. He had learned of it from his father and travelled some distance to obtain it.

We continually asked about the underground pit storage called a medfun in Yemen. We found they are used only near the mountains in the Tihama. This is probably due to the sandy soil and possible high ground water near the sea. We did find one near the mountains about 10 miles east of the town of Al Zarzahi which is 6 or 7 miles south of the city of Zabid. This medfan measures about 2 meters in diameter and 4 meters deep. It was the only empty medfan we located. Other medfans were found in the highlands but they were filled and the farmers would not open them.

According to the report of D. J. Greig[2], F.A.O. consultant, of a study of the existing storage grain facilities in the Yemen Arab Republic made in the fall of 1969, the medfan was the almost universal method of cereal storage in the western slopes and highlands. A copy of his drawing of the medfan is shown in Appendix B.

Drying

Twelve samples of grain -- 9 sorghum and 3 millet -- were analysed for moisture content. The results are given in Table 1. One sorghum sample taken at stop # 12 near the southern end of the Tihama was 16% which is too wet for safe storage. One sample of millet from stop # 9 was 14.6% moisture which is also too high. Both samples were clean and free of insects however. In general, and from such a small sampling generalizations are not warranted, it appears the farmers in Yemen know how to get their grain dry using the sun and drying floors or yards. There is sufficient sunshine for this kind of drying most any time of the year. I do not think drying of the harvest of sorghum or millet is a problem at this time. There was sufficient vacant area in all of the villages to expand the drying yards for either larger harvests or faster harvest if mechanization should become the practice.

TABLE 1. Moisture and Insect Damage of Grain Samples

Stop No.	Percentage Moisture Sorghum	Percentage Moisture Millet	Percent Insect Damage-Sorghum	Type of Storage
1	(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	--	(1)		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 at 13a
14	(1)	--		Gunny bag in village market stall
15	12.6	--	6	(2)
16	(3)	--	0	(2)

(1) Sample identity lost
(2) Did not see the farmer's storage - he brought out the sample
(3) Sample too small - (230 gm) - for moisture test - 250 gm needed

Farm Storage

Gunny bags or the baskets expose a large surface of the grain to the atmosphere. The medfans are bulk storage and a relatively smaller surface with respect to the volume is exposed. The weather of Yemen is such that grain exposed to the air even in the Tihama should not become wetter than about 14% moisture. The meteorological data for Hodeida as presented in the "Yemen Agricultural Handbook" gives the annual mean relative humidity at 0600 hours as 66% and for 1400 hours as 58%. This is based on data of 1963-66. The highest monthly mean was for February and for 0800 hours was 72% and 62% for 1400 hours. According to this our sampling was done at the time of highest relative humidity in the Tihama. We found quite satisfactory moisture levels in the few samples we were able to get.

Most of the grain we examined was harvested in 1977 or early 1978. It was the most recent crop. The man selling the sorghum at the village market at stop #13 said that the sorghum sampled as 13a had been removed from a medfan storage 6 months ago so it probably was from the 1976 harvest. It was badly damaged by insects. The bag laying next to it from which sample #13b was taken was 1977 sorghum. To me there was surprisingly little insect infestation in the grain we saw. It was the worst in the market place; perhaps the farmers tend to sell their poorest grain.

Again, it appears that the farmer has learned to protect his food supply rather well. Storage as I saw it does not seem to be a problem. This conclusion does not include the underground pit storage or medfan storage since we were unable to inspect any which contained grain.

Recommendations

Farmers should be encouraged to over dry the grain as a protection against insect damage. This should not increase the cost of drying by any significant amount because of the abundance of sun energy in Yemen.

In the gunny bag storage, the farmer should be encouraged to place dunnage under the bags to allow air circulation and to prevent moisture migration from the floor -- often dirt -- into the bag.

Simple cleanliness in the storage area would probably remove most of the risk of insect damage.

A study of the medfan should be made. It would be very interesting to investigate the level of oxygen and carbon dioxide gas in the medfans now filled, at the time they are opened. If there is a low level of oxygen, then monitoring the change in a freshly filled medfan would be of great interest and would lead to better use of such storage.

A more complete study of drying and storage does not seem warranted at this time. A study of the losses associated with harvest such as shattering after grain maturity and before harvest, losses in the threshing operation, in other words, the losses from the time the grain is ready for harvest and the time it goes into storage would be interesting and probably reveal more loss than is incurred in storage.

Bibliography

1. Bartelink, Alexander. Yemen Agricultural Handbook. Federal Agency for Economic Cooperation. Federal Republic of Germany, 1974.

2. Greig, D. J. Highlands Farm Development Project, Yemen. Informal Tech. Report on Grain Storage, FAO, Rome. AGS: SF/YEM 9. 13 April 1970.

Appendix A

On-Farm Grain Storage Survey

1. Date -

2. Interview party -

3. Location name -

4. Location map description

5. Location elevation - map -
   - altimeter

6. Approximate village population -

7. Type of road to village (paved, gravel, etc.) -
   Village distance from major market center -

8. Family size farm - Size -
   - Tenant - Type of rental -
   - Owner -
   Larger farm unit - Size -

9. Kinds of grain raised -
   (sorg, millet, wheat, barley, etc.)

10. Other crops raised

11. Is the farm acreage in grain the same, higher, or lower than 5 years ago -

12. What crops have increased in acreage and what crops have decreased in acreage in last 5 years -

13. Number of grain crops per year -

14. Do they get a crop every year or only every other year, etc. -

15. Is all grain used by family -
    Is part sold -
    (% used and % sold)

16. How is grain used by family -

    Human food -

    Animal food -

    Seed -

17. Is all seed grain carried over from own production -

18. Grain sold - is it sold at harvest or stored and sold later

19. Are grains sold for cash or exchanged for produce -

20. Is grain stored on farm premises -
Where sold (major market, local, etc.) -

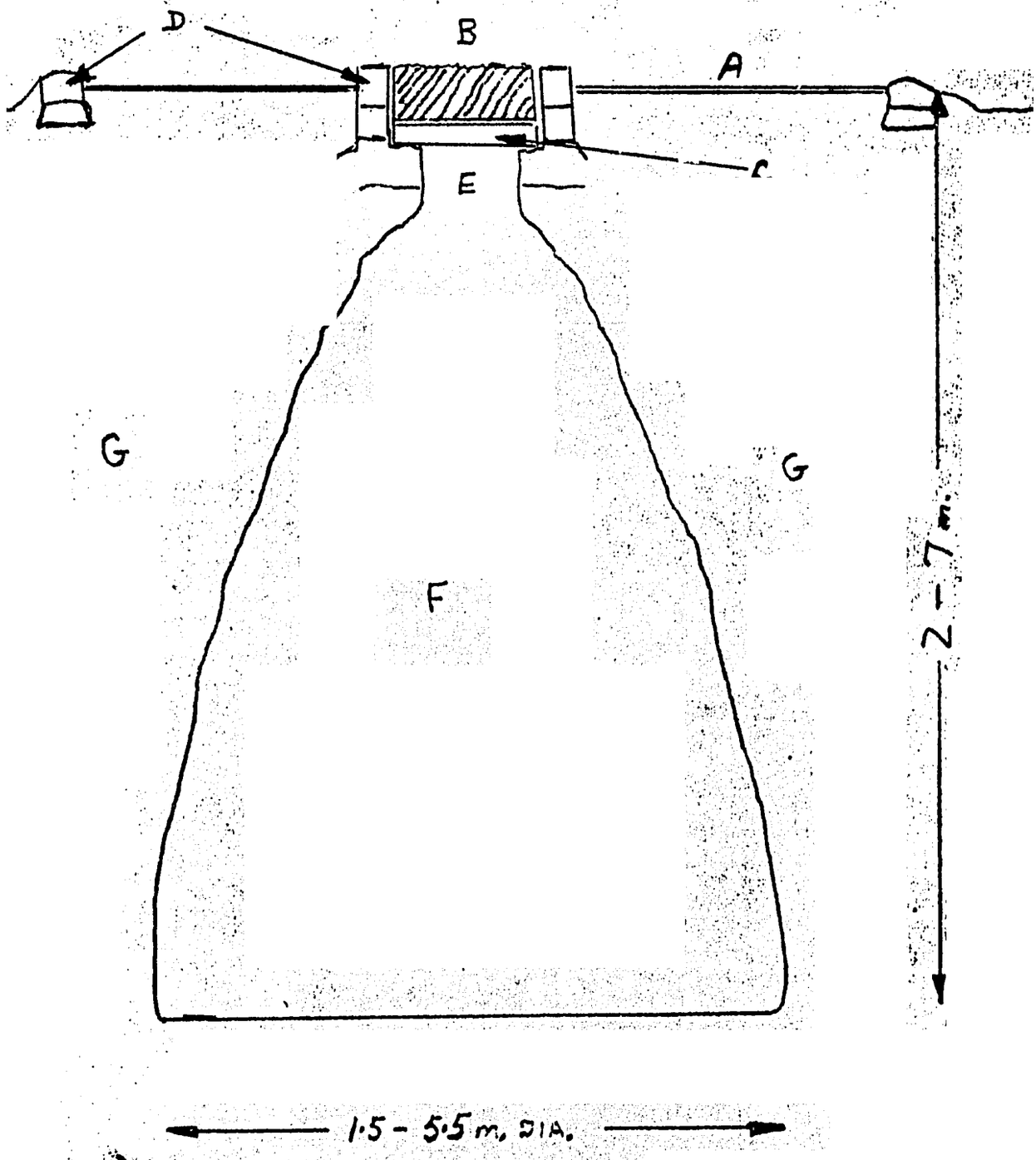
21. Describe storage facilities -
(size, construction, capacity)

22. Describe problems of storage -
(moisture, mold, insects)

23. Collect samples of deteriorated stored seed -

24. Is any grain stored more than one year -
(carry over for bad years)

25. What is the use of grain sold off-farm locally -



A - CEMENT RENDERED SURROUND
B - SEALING PLUG
C - STONE COVER
D - STONE WORK
E - FILLING NECK
F - MEDFAN CAVITY
G - ROCK

MEDFAN