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ANNUAL TECHNICAL REPORT

OPTIMUM UTILIZATION OF WATER FOR AGRICULTURE WITH EMPHASIS ON "ON-FARM WATER MANAGEMENT"

Report Number VII
Grant No. AID/csd-2459

Utah State University
Logan, Utah
September 1976

ANNUAL TECHNICAL REPORT 211(d) PROJECT

AID/csd-2459

Title: Optimum Utilization of Water for Agriculture With Emphasis on "On-Farm Water Management."

Grantee: Utah State University

Director: H. B. Peterson

AID SPONSORING OFFICE: TAB/AGR

Statistical Summary:

Period of Grant: May 23, 1969 to June 30, 1977
Amount of Grant: $945,000
Expenditures for Reported Year: $100,821.00
Accumulated: $805,170.00
Anticipated for next year: $139,830.00

Logan, Utah
September 1976

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NARRATIVE SUMMARY

Most all of the objectives identified in the Work Plan for the report year were accomplished. As a result of a comprehensive review of the grant, a greater emphasis was placed on utilization of the competence as a means of assisting the developing countries. Our On-Farm Water Management library has been maintained and expanded. A coordinated effort through CID has resulted in the development of an information storage and retrieval system network known as CIDNET. A brochure describing the function of the network has been distributed. In excess of 100 requests for information were received from 20 different countries and 17 states of the U.S.

Professional courses in irrigation were taught in Spanish, both on and off campus by USU staff members.

Two new courses, "Trickle Irrigation" and "Irrigation Project Planning and Evaluation" were developed and taught. Most of the students taking these courses are from developing countries.

A state-of-the-art study on intercropping revealed no published information on water management for intercropping. This is identified as a major void in our knowledge. Other state-of-the-art reports were developed on schedule.

Colorado State University and Utah State University cooperated in organizing and conducting an International Symposium on Global Water Law Systems, Valencia, Spain, September 1975.

Most all requests for technical assistance were met. The Grant provided 9 staff members for 5 short-term teams to LDC's through contracts with the University. Thirteen staff members were provided for 7 teams organized by the Consortium.

A concerted effort was made to expand and strengthen the linkages with developing countries, international organizations, the inte national crop research centers, and the seven consortium universities.

A talent bank of professional staff members was developed for use by CID, AID, and the other cooperating universities.

DETAILED REPORT

General Background and Description of the Problem

There was ample evidence that in developing countries there was urgent need for more food and better nutrition. Food production is closely linked to the water available for transpiration by the growing crop and the water availability is related to On-Farm Water Management. In most LDC's there is a lack of trained people for transfer of the water management knowledge available in developed countries. The lack of technology has been a deterrent to expanded production and has restricted the effectiveness of AID and other donors in solving critical food problems common to many LDC's.

It was common knowledge that inferior and indifferent water management in LDC's was depriving the countries of needed production and wasting the water resources. Water logging and salinity were often related problems. Poor on-farm water management was often practiced under irrigation systems which might otherwise be considered to be technically sophisticated. Land was not being properly prepared for irrigation and drainage. The problems of on-farm water management are pervasive, affecting agricultural lands everywhere but are more crucial in the developing countries. Scheduling and applying the proper amount of water in an efficient manner was a goal which has in general not been reached anywhere regardless of the type of conveyance system bringing water to the farm. The problem was considered acute concerning farmers with small holdings because of the complicated distribution, lack of credit, etc.

It was reasoned that by making highly qualified and experienced professionals available from centers of competence at Universities, AID could develop and disseminate technologies that would be more effective than those being used in many countries. Through utilization of the technologies transferred, the LDC's could accelerate the rate of production expansion. By establishing strong linkages and

networks among developed and developing country institutions and agencies, an even greater quantity and quality of capability could be directed toward improving the food supply.

At the time the grant was awarded, the Department of Agricultural Engineering and related departments such as Soils and Civil Engineering had many graduate students from foreign countries. The staff and course offerings were not adequate to teach and direct the research of these students.

Utah State University had considerable competence in the areas of irrigation and water management at the time the grant was approved. It was expected that the expanded full-time professional staff, courses of study, library information, and research would enable the University to respond much more adequately than heretofore to requests concerning agricultural related water management problems from such entities as: USAID/Washington, USAID Missions, other state and federal agencies.

The proposal for a 211(d) grant to Utah State University to utilize its competence in the general area of on-farm water management was one of three submitted by universities who were members of the Council of United States Universities for Soil and Water Development in Arid and Sub-Humid Areas. This consortium was to coordinate the AID sponsored research and institutional improvement of these universities. Other universities include the University of Arizona, emphasized "Watershed management," and Colorado State University specialized in "water delivery and removal systems and relevant institutional development." The Grant Project was expected to have built-in research, training, and advisory components. It was expected that by the creation of special capability in a particular area of knowledge it would include the relevant technology and the capacity to pass it on to others.

Purpose of the Grant

The institutional Grant Program had for its purpose the development of the competence and expertise of U.S. research and educational institutions to deal with critical problems of less developed countries. There are certain identifiable shortages of properly trained personnel and gaps in knowledge and skills that restrict AID's efforts to carry out its programs of assistance in these countries. The Institutional Grants Program is designed to overcome these deficiencies. Individual projects are designed to serve the program needs of AID without a requirement for providing specific services. Institutional Grants are thus to be used to strengthen "centers of competence" within educational and research institutions and to build long-range resources in depth rather than to procure services for AID for specific limited purposes.

The specific purpose of this Grant was to expand the competency of Utah State University as a center for world-wide training and research in irrigation and drainage. As the competence has increased the purpose has gradually shifted toward sustaining and utilizing this competence in research, teaching, training, and consulting. The Grant has now been extended and revised. The purpose of this revision and extension is to focus and sustain, within a utilization framework, an institutional response capability at Utah State University in on-farm water management with emphasis on small farms.

It is one of three 211(d) water grant extensions providing a cooperative approach to assisting developing countries in solving their food and nutrition problems.

Primary emphasis will be given to the on-farm water problems as a means of improving the quality of life for the farmers in the lowest income brackets. A secondary focus of the grant extension is to permit involvement of the University in all phases of the water chain as appropriate and in cooperation with CID. It is proposed that the competence will be used to identify water management problems in

the LDC's and seek solutions to these problems through training, research, consulting, and preparation and dissemination of education materials.

The consortium will cooperate in identifying new problems, establishing priorities, and deciding on a division of labor and cooperation among the five universities in order to prevent duplication of efforts and to utilize the most qualified personnel.

Objectives of the Grant

Objectives Restated

The major objective of the initial Grant Program was to increase and expand the existing competence of Utah State University in the science and technology concerned with "on-farm management." Emphasis was on moisture environment on the farm as related to the special characteristics and problems of the less developed countries. The general approach was to integrate a quality research, teaching, training, and consultive technological program into an effective means of information transfer to developing countries.

Review of Objectives

The objectives and areas of activities, as originally identified, were broad in scope and general in nature. There have been some gradual modifications until the review when the objectives were restated as above. In the plan for implementation of the program, it was anticipated that emphasis on activities would shift. Early emphasis was on identification of staff needs, selection of professors, and language training. This was followed by a review of course content and revision and introduction of new courses. Emphasis was also placed on library improvement and expansion. As the goals in these areas have been reached, emphasis has shifted to teaching, conducting research, responding to requests for technical assistance, and increasing accessibility of the library holdings. The results from the increase in language competence is becoming evident in the research and consulting accomplishments. There is a constant demand for the

services of those on the staff who have the language competence to teach short courses or provide technical assistance in LDC's. The number of demands has exceeded our available staff.

In a proposal to extend the Grant, the purpose was to focus on the utilization of the developed competence and have more specific objectives with identified outputs, inputs, and verifications. Efforts are being made for closer coordination of the programs with other members of CID.

Review of Critical Assumptions

In the original grant proposal, most of the critical assumptions were not specified as such but were largely assumed. One assumption was that the University could increase its competence faster than the increase in demand for the assistance. This has not been the experience. It was assumed that the LDC's, AID, and Missions would cooperate with the University and a consortium in identifying problems, establishing priorities, and utilizing the capabilities; however, they have utilized the capabilities but have helped only in a limited way towards identifying problems and establishing priorities. It is a difficult task to get the specific problems of the LDC farmer to the USU scientists for solution and then transfer the information back for utilization. We are sure AID is well aware of this but have limited opportunities to assist.

The altering by AID of their policies, objectives, and procedures have changed more than were originally announced to the Grantee.

ACCOMPLISHMENTS

Introduction

Although the 211(d) Institutional Grants program was established to strengthen the grantee (university's own capabilities) rather than overseas services, the consortium institutions have attempted to integrate a quality research, teaching, training, and consultive technological program into an effective means of information transfer. During the early years of the program, considerable effort at Utah State University was directed toward increasing the number of staff, improving the library holdings, increasing the foreign language competence, revising the course offerings, and conducting needed research. During the 1975-1976 year, emphasis has been placed on utilization of the competence. In the 1975 revision of the program, five outputs were identified as follows:

Information Capacity
Education Training
Expanded Knowledge Base
Advisory capacity
Linkages Networks.

The report is divided into sections corresponding to these identified outputs.

Information Capacity

As a means for assisting in the transfer knowledge, the University has maintained a center of competence in the general field of on-farm water management. As a part of the center, a library of important documents has been maintained. The university librarian is actively working with representatives of the other CID universities, a program to integrate the activities and where possible establish an information exchange system as well as a uniform and combined retrieval system. Grant funds have been used to support participation in CID-sponsored workshops which were held in order to develop a coordinated

information data system called CIDNET. Brochures describing the Center have been sent to participating universities for distribution.

Grant funds were used to service user requests. During the reporting year approximately 100 requests were received from individuals in 20 countries and 17 states of the U.S. The supply of an old edition of Irrigation System Evaluation and Improvements has been exhausted and there has been many unfilled requests. The majority of publications were brought to the attention of individuals through the ASAE and ASCE journals, annual reports, and our staff publication brochure. During the latter portion of the year requests were coming in as a result of the publicity through the CIDNET brochure. Publications on irrigation requirements, precipitation dependability, and moisture availability in Latin American countries are most frequently requested. A copy of a letter from Navarrete of FAO (Appendix A) is illustrative of the nature of the requests. Professor Griffin had lectured at the seminar held in Brazil.

Education and Training

As scheduled, two new courses were developed and tested.

Trickle Irrigation

2 credits, Winter Quarter. The development and design of trickle and subsurface irrigation systems, emitter characteristics, filtration, system planning and layout. Also considered are design economics, applications, system operation and management.

Irrigation Project Planning and Evaluation

3 credits, Spring Quarter. This includes integrated analysis and techniques for irrigated agricultural development and project evaluation including technological water management and socio-economic considerations (for LDCs).

In our work plan, we scheduled the development of a short course dealing with the practical aspects of on-farm water management for presentation in LDCs. Utah State University was to assume primary

responsibility for organizing the course. The course is to be organized for decision makers and technicians responsible for resource planning, development, and application. A local committee was formed which consists of Drs. Alfaro, Stringham, and Peterson. Contacts have been made with FAO, CEDIAT, and the East-West Center. Course materials and programs from these agencies have been collected. We have been advised by those who have tried to conduct such a course that each offering should be directed to a specific group and that the participants should have some input into the content of the course. After completing a preliminary plan for the course, it will be necessary to obtain contributions and evaluations from cooperating CID members.

Special supervision has been provided to graduate students from LDC. The majority of the graduate students in the Department of Agricultural and Irrigation Engineering are from developing countries. The short course taught in Spanish for the engineers from Guatemala was completed and concluded with a field trip to irrigation projects in Idaho, Arizona, and California.

Expanded Knowledge Base

During the year, emphasis has been placed on preparation of state-of-the-art reports and on practical circulars and other instructional material suitable for training technicians in LDCs. An attempt was made to formulate a plan for the involving of peasant farmers in irrigation project planning. A draft summary by Nancy Adams is attached (Appendix B).

Utah State has provided the initiative in developing reports in four areas and are cooperating in the preparation of four other reports mentioned below.

Water Management for Intercropping

Intercropping has many advantages to the peasant farmer trying to feed a family with produce from a small farm or garden. This is the most intensive type of farming. It makes the best possible use

of growing time and space. It gives the family a variety in the diet and may provide protection against complete mono-crop failure.

Many of the farmers that can use the system are in tropical and semi-tropical climates where the soils have a high fertilizer requirement and also need lime. The fertilizers, if not utilized by the crops, are soon fixed by the soil or are leached from the root zone. This intensive system of farming enables the grower to recover a greater proportion of the expensive fertilizer and lime he purchases. There are, however, some hazards that accompany this type of crop culture. If there are period of drought, the crops on intensively cultivated land suffer more damage than would most single crops. Because of this hazard, the practice should be adopted only where the probability of adequate rainfall is very favorable or where irrigation can be provided. Where irrigation is necessary, the acreage should not be expanded such that water requirements of the crops exceed the supply. One problem in comparing the demand and supply lies in the fact that little information is available on the water requirements of various crop combinations at the various stages of their growth.

An attempt was made to determine the state-of-the-art of water movement for intercropping systems in various parts of the world, particularly where intercropping practices are being encouraged.

We have searched the literature in pursuit of information. We also attended a symposium on multiple cropping sponsored by the American Society of Agronomy, August 24-30, 1975, at Knoxville, Tennessee. In addition, Dr. Robert Hill visited with Dr. R. R. Harwood at the IRRI Station in Manila and at the Asian Vegetable Research and Development Center near Taiwan. There they teach students the art of intercropping but we have found they are not determining the water requirements of the various crop combinations or systems. We also contacted Dr. Peter E. Hildebrand who is studying intercropping in Guatemala and has previously conducted a testing program in El Salvador. Although he has had plots irrigated, there is no measure of the water needs nor the amounts applied.

We have been unable to find published or unpublished information on water management of multiple cropping systems. It seems that where various cropping combinations are evaluated, the growers either rely on the rainfall for the needed moisture or where water is available, they irrigate "as needed."

This popular subject needs to be researched in order to have information collected into a state-of-the-art publication.

Water Management of Heavy Soils

The first phase, an analytical review of the knowledge accumulated in the literature has essentially been completed. The present knowledge with some suggestions for use of the information is described in the report. The next phase, determining where and how the information is or can be used, has not been done. On such a broad topic as this, we are not sure how to proceed with this phase. The review as now completed, can serve as a reference for anyone involved in the solution of water management problems of heavy soils and for instruction in methods of management.

Methods of Irrigation

A committee was appointed which has been working toward the development of a report or reports. It has found this to be a very broad topic which will require more resources than were in the budget for this program. The members have prepared a proposal to AID indicating the nature of the problem and scope, a work plan for completion of the study, a budget, and an indication as to the personnel to be responsible for the various tasks (Appendix C).

As a major portion of the activity to expand the knowledge base, a photo copy ready manuscript of "Irrigation System Evaluation and Improvement" is ready for reproduction. The information contained in this manuscript is very much in demand and requests have been received for permission to translate the manuscript into Spanish.

An attempt was made to prepare a popular circular on trickle irrigation for the small peasant farmer, but the task was discontinued

because of unsuitable equipment at the price the farmers could afford to pay.

In an effort to provide information on sprinkler irrigation for the small farmer, efforts turned to development of low energy requirement low pressure systems. A draft of a report on very low pressure sprinkler irrigation has been completed by Charles Burt and Jack Keller. This is being reviewed and revised.

Food Production Technology Transfer

There has been a continued effort to develop a strategy for transferring technology to the developing countries. We believe it necessary to collect information that is not site-specific and to mesh together the component parts (climate, soils, varieties, pests, fertility and husbandry) of crop production technology in order to bring about an effective transfer. A series of papers are being prepared that show how to utilize the information on the various components. Published in 1975 was "Reference Climate Sites for Agricultural Technology Transfer." Others dealing with soils, varieties, etc., are being prepared.

In order to obtain desired transferable data on crop production, trials are being conducted by Pioneer Seed Company in Iowa, U.S.D.A. in Colorado, and by Insoy in Ecuador. Records are being taken to measure the crop phenological development in relation to temperature, radiation, moisture, etc. Colorado State has cooperated in this testing program and through their grant paid for the collection of crop data. Pioneer and Insoy have provided the data at the other locations.

The following four papers were presented during the year in order to explain the program of information transfer:

"A Strategy for Soybean Production Technology Transfer," L. N. Leininger and H. B. Peterson. World Soybean Research Conference, August 3-8, 1975, Urbana, Illinois.

"An Agricultural Technology Transfer System," Jack Keller and L. N. Leininger. Specialty Conference. Irrigation and Drainage Division, American Society of Civil Engineers. August 13-15, 1975, Logan, Utah.

"A Strategy for Corn Production Technology Transfer," L. N. Leininger and H. B. Peterson, International Maize Symposium, September 8-12, 1975, Urbana, Illinois.

"Predicting Soybean Growth as Affected by Water," R. W. Hill, K. H. Ryan, and R. H. Shaw, World Soybean Research Conference, August 3-8, 1975, Urbana, Illinois.

Supplemental to these are papers dealing with instructions on how to conduct tests, collect data, and field demonstrations. An example is the paper on "Line Source for Continuous Variable Irrigated Crop Production Studies." (Appendix D.) This is a technique for measuring the interacting crop response to water and fertilizer variables. Not only is it useful for research, but it is excellent for extension demonstration.

Water Lifting Devices

FAO agricultural development paper No. 60 published in Rome in 1956, has been out of print for several years. There is a general demand and need for such information. It was our understanding that FAO had no plans to revise the publication so it was decided at the time of the grant revision, that Colorado State would take the initiative in cooperation with Utah State, and prepare a state-of-the-art report. A meeting of staff members was held and the program organized with James Ruff and Al Wood of Colorado and Charles Burt of Utah responsible for the study. While at FAO in September of 1975, Dr. E. V. Richardson and H. B. Peterson found that plans of FAO had changed and they intended to prepare a revised publication for release. It was then decided by Colorado and Utah, that their study would be limited to primarily small pumps and wind powered pumps. Colorado has completed their report on pumps and Utah collected all the information they could find on wind operated equipment. (Charles Burt accepted employment elsewhere before completing the study.)

Legal Aspects of Water Delivery

Although the leadership responsibility was elsewhere, Utah State University, through David R. Daines, cooperated with Colorado State

University in the planning and conducting a Global Water Law Conference September 6-8, 1975, in Valencia, Spain. This conference was sponsored by AID, the Rockefeller, Ford Foundations, and other institutions. Preparations for the seminar included a trip to Spain for the purpose of organizing the conference and a number of intermediary conferences at Colorado State University. A paper on U.S. Water Law was prepared and presented by David R. Daines and George Radosevich. Daines also cooperated in the preparation and editing of the conference report which is available for purchase through the office of Dr. Radosevich at Colorado State University.

Soil Erosion

The University of Arizona has taken the leadership in organizing for and conducting a state-of-the-art study on erosion. Although there have been considerable activity and several meetings, the scope of the study has not been defined. Now the problem seems too large for one study and some way needs to be found to divide the work into logical segments. While doing this, it was evident that there is a need for a report on water harvesting. The staff at the University of Arizona has prepared a draft of such a report which USU will assist in reviewing and revising.

Advisory Capacity

The Grant Director identified for CID the USU faculty members and their specialties for inclusion in a consortium talent bank to be developed. During the year USU provided 9 staff members for 5 short term teams that went to LDCs sponsored through contract with the University. It also provided 13 staff members for 7 teams organized by CID.

As an example of a team activity, USU is providing a team for Honduras which will require 46 man weeks during the period of January 30, 1976, and February 28, 1977. Five staff members, all Spanish speaking, have participated in three trips to the country. The team is to render technical advice and assistance to the Ministry

of Natural Resources of the Government of Honduras in developing a nationwide plan for improving the utilization and management of farm resources in order to improve the well-being of small farmers. Among other things, the team will estimate the needs for and cost of irrigation systems to supplement rainfall and improve yields by crop and by region.

On campus we held a training workshop for a CID team that was going to the West African country of Niger. Information and techniques developed through our "Food Production Technology Transfer" project served as a basis for the training. It dealt with such things as the use of known genetic crop materials and simulation of different rainfall probabilities under dryland research conditions. Representative of the University of Puerto Rico were also on campus for a workshop on the utilization of the transfer technology in their LDC research. Dr. Keller is scheduled to go to Puerto Rico and Brazil as a follow-up of this activity (Appendix E).

Many teams go from the campus on short-term assignments. Information about the host country is provided. Such material is often found to be useful to others in the field and results in requests for additional information such as illustrated in a letter included as Appendix F.

Dr. Jose Alfaro was a member of a team that went to Africa. He was unable to speak or understand French. He felt this was a definite disadvantage so at his own expense, he spent two months in France in an intensive language training program.

Linkages and Network

The principal domestic linkages has been with the CID universities and the University of Puerto Rico for the tropical soil consortium. Much closer relations have been developed with FAO. The grant directors from Colorado State and Utah State conferred with the FAO staff in Rome in September. There is a continuing exchange of publications and staff members from FAO visit our universities.

During the winter, Dr. Hill attended a workshop at the East-West Center and the Water Management Training Center in the Philippines. He also visited the Asian Vegetable Research Center in Taiwan and IRRI in the Philippines. Arrangements were made for Rodolfo Undan, from the Central Luzan State University, to conduct research in Hawaii and at his home station, supported by the East-West Center. His course work has been done during the year at Utah State University where he will receive his degree.

Working relations have been developed with CIAT, CIMMYT, IRRI, World Bank, and IADB. Many contacts were also made when our staff participated in the World Soybean Research Conference and the International Maize Symposium.

A major linkage network activity has been in the area of information exchange through CIDNET.

Other Resources for Grant-Related Activities

As a direct result of the 211(d) program, the competence at Utah State University in the field of water management has been greatly improved. The number of professionals has been increased and their individual competence also improved.

It has been realized that the support from the grant program cannot be contained indefinitely; therefore, in order to maintain this competence and to protect the investment made by AID and the University, we are exploring ways in which the staff and program can be maintained. For example, a proposal has been submitted to Office of Exploratory Research and Problem Assessment of the National Science Foundation. This proposed research is on "Development and Utilization of a Food Production Technology Transfer System." In addition, negotiation has been carried out with the Inter-American Development Bank. It is interested in a joint venture entitled, "Strategies for Agricultural Technology Transfer in Latin America."

As a portion of the World Food and Nutrition Study by the National Academy of Science, our project was proposed to "develop and organize in a retrievable form the data which relates the phenological

processes and production of important food crop cultivars to specific weather-soil-water environments." If such a program is implemented, there would be utilization of our competence to implement a program that meets the objectives of AID in its efforts to make technology available to the people in developing countries.

At the present time more requests for professional assistance are coming from CID and other agencies and companies than we can supply. There seems to be a great need for the competence developed through the Grant and there is also funds available to procure the services.

Although the competence in the area of water management has been greatly increased, there remains a great need for further expansion. There is also an urgent need to maintain the gains made and guard against loosing the "critical mass" of competence and thus negate an effective force.

WORK PLAN AND ANTICIPATED EXPENDITURES

The detailed work plan and budget for the period of the Grant extension are shown in Appendix G. The anticipated expenditures are shown in Tables I, II-A and II-B of this report.

As noted in the Work Plan, some of the detailed plans are being developed in cooperation with CID and other CID universities during the year. A separate annual report is being presented by the Director of the Consortium.

Table I. Distribution of 211(d) Grant Funds and contributions from other sources of funding.* Reporting Period July 1, 1975 to June 30, 1976.

Grant Objectives/Outputs	Review Period	Cumulative	Projected to end	Non-211(d) University
Information Capacity	$ 8,350.00	$113,850.00	$ 6,650.00	$ 15,200.00
Education and Training	18,560.00	158,661.00	21,440.00	20,100.00
Expanded Knowledge Base	37,811.00	248,261.30	62,189.00	24,300.00
Advisory Capacity	18,000.25	203,500.25	27,650.74	8,650.00
Linkages and Networks	18,100.10	80,897.81	21,899.90	4,500.00
Totals	$100,821.35	$805,170.36	$139,829.64	$72,750.00

*These are best estimates

Table II-A. Actual and anticipated expenditures under Institutional Grant AID/csd-2459 Review period July 1, 1975 to June 30, 1976.

	Period Under Review	Cumulative Total	Projected to End	Totals
Salaries, Wages and Consultants	$ 62,347.08	$474,487.40	$111,352.92	$585,840.32
Travel				
(a) Foreign (7)	3,888.83	43,665.73	8,711.17	52,376.90
(b) Domestic (31)	6,117.66	28,942.33	2,282.34	31,224.67
Equipment	-0-	-0-	-0-	7,608.70
Stipends, Tuition and Fees	14,281.50	142,887.17	4,169.49	147,056.66
Supplies and Computer Use	2,649.53	35,992.74	1,850.47	37,843.21
Publications	1,536.75	21,245.13	1,463.25	22,708.38
CUSUSWASH - CID	10,000.00	50,341.16	10,000.00	60,341.16
Totals	$100,821.35	$805,170.36	$139,829.64	$945,000.00

Table II-B. 211(d) Expenditure - Reporting Year Details Under Institutional Grant AID/csd-2459, 1975-1976.

I. A. Professionals	Man Months	Salaries
H. B. Peterson	3.7	$ 11,055.00
Jack Keller	3.2	9,109.00
Robert Hill	4.1	6.569.00
Jose Alfaro	3.26	5,599.94
Charles Burt	5.0	3,125.00
Lester Leininger	6.0	12,000.00
Total Professional		47,457.94
B. Clerical Library Other Nonprofessional		2,905.00
C. Fringe Benefits - Retirement only		7,993.34
D. Wages (payroll)		1,877.30
		$ 60,233.58

II. Student Support	Country	Amount
Charles Burt	USA	$ 600.00
Ronald D. Fischer	USA	150.00
Donald Burgess	USA	1,572.50
Kent Ryan	USA	2,100.00
Nancy Adams	USA	4,272.50
Peter Canessa	USA	3,316.50
Bob Hulsman	USA	2,270.00
III. Consultants and Guest Lecturers		2,113.50
IV. Travel		
A. Domestic		6,117.66
B. Foreign		3,888.83
V. Equipment		-0-
VI. Library Acquisitions Thesis and Dissertations, Reports, Papers, etc.		1,536.75
VII. Other Telephone Postage Computer Miscellaneous		2,649.53
CID Support		10,000.00
GRAND TOTAL		$100,821.25

INVOLVEMENT OF MINORITY PERSONNEL AND WOMEN

Through the assistance of the Grant, one minority professional staff member was recruited, Dr. Jose Alfaro, Associate Professor of Agricultural and Irrigation Engineering. He has taught several irrigation classes in Spanish and has undertaken numerous consulting assignments including attendance at a seminar in Costa Rica on irrigation and drainage at the farm level for Central American countries and Panama. In 1974-1975 he spent nine months consulting for the International Development Bank in Guatemala where he was coordinating a program to assist Guatemala in implementing a plan of work for irrigated agriculture. He has done research on infiltration-runoff relations as well as frost prevention by controlling plant growth by cooling. Dr. Alfaro has also authored and co-authored the following publications: "Medidas de Agua en Canales por Medio del Aforador 'Sin Cuello'," and "Irrigation System Evaluation and Improvement." He is actively doing Spanish language versions of many of our Grant supported publications.

Nancy Adams has been employed by the Grant part-time as an undergraduate and graduate to conduct research dealing with information transfer. Ms. Adams is a graduate student in the Department of Agricultural and Irrigation Engineering. Bonnie Thompson, a technician supported by the Grant, has been instrumental in collecting data, assembling reports, and editing publications initiated by the staff members. Others supported by the Grant include Amy Krambule, clerk-steno, and Linda Van Orden, research aide.

Past efforts in recruiting minority students and staff have met with limited success. There are few women involved in the field of water management research and very few minority males. Ms. Hwei-Tzi Chu, a Chinese student, is currently enrolled in a MS program in Agricultural and Irrigation Engineering. Attempts to locate qualified people have often failed, but efforts are still being made to attract and encourage minorities. For example, Nancy Adams has been actively involved in a program to promote women in engineering.

All classified and non-classified positions at Utah State University are recruited through established procedure, utilizing and following the statement of the Office of Affirmative Action and Equal Employment.

APPENDICES

CODEVASF

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BRA/74/008

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Nº 058/76

Caixa Postal 07-0285
70.000 - Brasília - DF
Brasil

Brasília, July 6 , 1976

Dr. Richard E. Griffin
Extension Water Resources Specialist
Cooperative Extension Service.
UTAH STATE UNIVERSITY
UMC. 49 . LOGAN, UTAH, 84322 . U.S.A.

Dear Dr. Griffin:

Hereby I acknowledge receipt of your letter of last early spring. I know that now it is sommer there. Sorry for the delay.

Thanks for your comments on the seminar. So far we have not been able to publish the results. It takes along time this task.

Meanwhile, the use of Dr Hargreaves data to compute ETP in the São Francisco Vally has been oficialized in our specifications for studies to be contracted with private consulting firms. Copies of the reports you left have been reproduced (xerox) and distributed among the firms.This has been one of the most usefull results out of the seminar.

If it is convinient for you, we could use well 50 more copies of Dr Hargreaves information on water use in Brasil, and N.E .

Thanks for your help in the seminar. I will send you copies of the results as soon as they are available.

Best regards for you, Dr Hargreaves and Dr Christiansen if you happen to see him .

Sincerely Your

Jose Dulá Navarrete
Project Manager
BRA/74/008

APPENDIX B

DRAFT

ON-FARM IRRIGATION PLANNING[1/]
INVOLVING PEASANT PARTICIPATION

by

Nancy L. Adams

Success in project planning means that the project is developed in such a manner that the peasant farmer can use it immediately to improve his production and that the project will provide him with opportunities for further development of both himself and his agricultural resources. Traditionally, project development has been mostly concerned with technologically increasing agricultural production; and the vital element in the production process, the farm community, is usually ignored. If a project is to be beneficial and dynamic, consideration must be given to the abilities and goals of those who are to use it as well as to the technical design. The purpose of this thesis is to develop a method of project planning which will promote this balance.

There is evidence from research in the fields of communication and anthropology that a process of innovation which involves the people who are to make the change in the decision-making process not only increases the acceptance of the innovation but also provides input of information which actually enhances the design of the project. Thus, a method of project planning which includes the peasant farmer in system design would be of value.

The method should involve the farm community in the planning process

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1/ Summary of Master of Science thesis nearing completion.

as far as possible, by undertaking group consideration of the situation and of the possible alternatives. This would generate information for the planner which may be crucial to the design of an appropriate system and would provide the community with a feeling that they understand what the project is about and that they themselves are capable of using the system to alter their situation further.

During recent years, the Army Corps of Engineers has been compelled to undertake a similar public participation program. This requirement for public participation in project development has generated research and practices which provide a sound basis for the development of a strategy for project participation within a peasant community.

The goal of such a process is to make both the peasant and the planner aware of project development potentials within the community. Thus, the planner will be able to develop a system which is appropriate to the resource and management potentials of the local community, and the peasant farmer will gain confidence that he can indeed understand and use the system for his benefit. The sharing of understanding concerning the local situation and its potential for development between the farmer and the planner is central to this process, for it is only through this sharing that the project can be developed to conform to the local situation while providing opportunities for the farmer to actualize his potential.

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APPENDIX C

DRAFT: April 7, 1976

State of the Art on Irrigation Methods
Proposal to AID

Problem Definition

In many areas irrigation of some type is desirable or necessary to improve food production and the living standards of small family farmers. There are notable failures in implementation of irrigation projects designed to meet these social goals.

Irrigation is established by isolated efforts of individual farmers and/or as a result of government projects to develop large land areas. In planning and developing irrigation projects, the emphasis is placed on the construction of the civil (off-farm) works where the technical skills are perfected. In contrast, partly because the knowledge of farm irrigation methods is poorly organized, insufficient attention is given to the proper selection and subsequent management of the farm irrigation systems. However, without success at the farm level a project cannot meet the goals of the planners or the expectations of the family farmers and rural poor.

Successful farm irrigation requires developing and performing design and management schemes which fit indigenous site potentials, i.e., political, social, economic and management realities as well as the physical conditions relative to crop production. This is a difficult task but it can be made considerably easier and consequently more likely to be done if strategies for assessing site potentials in terms of the available descriptive information and site requirements of the various irrigation methods were better organized. Good planning is indispensable as small family farmers can hardly be expected to make ill suited (socially, physically, etc.) farm irrigation systems workable.

We believe we will contribute significantly to the success of irrigation projects by organizing the site potential-irrigation

methods description information. The key to accomplishing this will be to appropriately identify the components and subcomponents of the various irrigation methods into a taxonomy of irrigation methods in terms of measurable site potentials. With such a taxonomy and readily performed field observations, irrigation system selections can be matched to site conditions by those most likely to be involved in the farm system design.

Proposed State of the Art

This state of the art study will involve identification of the various irrigation methods and their components and subcomponents describing requirements which each method imposes on a site for successful operation, as well as the identification of measurable site potentials. One of the early tasks will be the development of a strategy for conducting the study in an efficient and systematic manner. This will be followed by an articulation of the design or method selection strategy, from which the taxonomy will evolve. The taxonomy is the logical identification of the important components of characterizing irrigation methods. The product of such a study will be presented in matrix form similar to Table 1.

The components listed in Table 1 do not constitute an exhaustive set, but should serve to illustrate the comprehensive nature of the project. Completion of the matrix will involve a qualitative assessment of the completeness or validity of a particular data item as well as its magnitude. In the process of locating specific information from the literature and field visits, the voids in past and present research and in practical knowledge will be exposed. The degree of urgency attached to filling a given knowledge void will provide an excellent basis for the direction of new or ongoing research in irrigation methods.

Because of the immensity of a total study on irrigation methods we propose that a logical first phase will be to develop the strategy for the study, articulate the taxonomy, and organize the available information for one or two specific system categories. An

Table 1. Characterization of Irrigation Methods

Requirement Component	Irrigation Method and Sub-Method											
	Surface			Sprinkle			Trickle			Hybrid		
	A	B	C	A	B	C	A	B	C	A	B	C
Energy Type A (Labor) Peak Time Distribution Type B (fossil fuel) Type C, etc.												
Management Knowledge A. Mechanical B. Personnel												
System Efficiency A. Optimum condition B. Average C. Poor												
Operational Problems A. Mechanical B. Labor C. Parts supply												
Financial Requirements A. Initial capital B. O and M												
Soils A. Heavy B. Medium C. Coarse												
Erosion-Sensitivity												
General Description of method												
Location in World where practiced												

appropriate system category for small family farmers which we propose for the initial study is "low cost, low energy, non-sophisticated closed conduit irrigation systems."

Plan of Work

The following Work Plan relates specifically to the development of an irrigation method taxonomy plus a study of one selected priority system category applicable to LDC utilization.

Task		Person month Requirements Prof	Tech	Chronological order of accomplishment (sequence of months
I.	Problem definition and determination of solution strategy	6	2	1-6
	A. Organization of strategy and taxonomy identification team			
	B. Preliminary literature review			
	C. Component identification and development of taxonomy			
	D. Determination of solution strategy			
	E. Strategy and taxonomy report			6
II.	Application of the strategy	3	2	4-7
	A. Methods literature search			
	B. Selection of Priority Systems Category			7
III.	Expanded Knowledge search			
	A. Comprehensive literature review	4	10	6-15
	B. Field visits (8 trips)	8		6-17
	C. Consultation with AID personnel	3		0-24
IV.	Integration of acquired knowledge into document form and identification of information voids	5	2	15-21
V.	Dissemination			
	A. Workshops (3 at 2 man weeks each)	1-1/2	1	15-24
	B. Publication	2	5	21-23
	TOTAL MONTHS	32.5	22	

Budget (2 year project, no overhead)

Item	Cost
Professional - 32-1/2 months at $2,000 month	$65,000
Technician - 22 months at $1,000/month	22,000
Travel: 8 trips out of country at $1,500 each (includes sharing with other projects)	12,000
Information retrieval systems costs	5,000
Publication	1,000
Workshop information (3 at $500)	1,500
TOTAL	$106,500

Personnel Assignments

Task	Personnel
I, II	Jose Alfaro, R. W. Hill, H. B. Peterson, G. E. Stringham, A. A. Bishop, K. Unhanand, J. Keller
III A	J.A., R.W.H.
III B (field visits)	J.A., J.K., R.W.H., A.A.B.
III C	H.B.P., A.A.B., J.K.
IV	H.B.P., J.K., J.A., R.W.H.
V A&B	H.B.P., J.K., A.A.B., J.A., R.W.H.

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Line Source Sprinkler for Continuous Variable Irrigation-crop Production Studies[1]

R. J. HANKS,[2] J. KELLER,[3] V. P. RASMUSSEN,[2] AND G. D. WILSON[2]

ABSTRACT

The design details and a sample set of field test results for a line source sprinkler plot irrigation system are presented. The system produces a water application pattern which is uniform along the length of the plot and continuously, but uniformly variable across the plot.

By applying a fertility variable along a plot (at right angles to the water variable) planted in some test crop, the system offers a convenient means for developing crop production function data. The system test area and water supply are both small. However, the application of the system may be limited by wind and all water application levels within a plot must be supplied at the same irrigation frequency.

Additional Index Words: **water use studies, experimental plot irrigator, water-fertility interactions.**

CROP PRODUCTION surfaces as influenced by water levels are needed for many analyses to relate economic return to soil water management practices. Fox (1973) reported on a system for producing these surfaces using a large number of N fertility treatments which varied systematically from one end of a single plot to the other. Fox suggested that water could be varied at right angles to N fertility treatments. Bauder et al. (1975) reported on a study where N fertility levels were imposed at right angles to the water levels. This system has an advantage in that the crop pro-

[1]Contribution from Utah State Univ. in cooperation with the Utah Agric. Exp. Stn., Logan, UT 84322. Journal Paper no. 2049. Supported in part by Grant B121, Utah Center for Water Resources Research, Grant C5189, Consortium for International Develop., Office of Water Research and Technology, USDI and Contract AID-csd-2459 U.S. Agency for International Development. Received 11 Nov. 1975. Approved 24 Jan. 1976.

[2]Professor and Research Assistants, respectively, Dep. of Soil Science and Biometeorology.

[3]Professor, Dep. of Agric. and Irrig. Eng.

duction surface can be seen visually in the field. The need for a buffer area around each treatment was eliminated since the incremental change between adjacent treatments is small.

Accurate water control is necessary to produce the numerous water levels required to generate the desired production surface. Bauder et al. (1975) used a trickle (drip) irrigation system to obtain the high degree of water control needed. The trickle system gave good control of the irrigation water added, but was quite expensive and required considerable manpower to operate effectively. The trickle system used for corn was 10 rows wide (row width 76 cm) and about 24 m (80 feet) long which had about 400 tricklers. This plot was replicated four times. Periodic and extensive metering and testing of emitters was necessary to determine the exact water application time for the small incremental availability differences required. An additional problem was the need to filter the water very thoroughly. Because of these problems, alternate schemes of irrigating at varying, but consistent levels were tried in an effort to obtain a more efficient system. A system developed in 1973 that works well is a design which used a single line of sprinklers down the center of the plot. The purpose of this paper is to describe the design and layout of this line source sprinkler plot irrigation system and some of the results obtained with it. The design is currently being used in Arizona, California, Colorado, and Utah for an experiment involving irrigation, stage of plant growth, and salinity; all as related to corn (*Zea mays* L.) production.

PROCEDURE

System Layout

The design criteria for the water application pattern from a line sprinkler plot irrigation system are: To obtain the desired "triangular pattern line source" effect, sprinklers should be closely spaced along the water supply line. Furthermore, the individual sprinklers should be the same and each produce a triangular shaped profile when operated in low winds at the design pressure. The best or ideal spacing is a compromise between:

1) Uniformity along the plot which is optimum with sprinklers spaced at approximately 10% of the wetted diameter or closer and reasonable for spacings up to approximately 20–25% of the wetted diameter.
2) Application rate and system flow rate which vary inversely with the sprinkler spacing.
3) System cost which increases as the sprinkler spacing is decreased.
4) Compact to minimize the size of the required end buffer zones.

Because of application rate and costs, it is generally desirable to use the widest spacing which will give reasonable uniformity, i.e., variations along the line not exceeding approximately ± 10% of the mean.

The maximum spacing limits for reasonable uniformity which are above were arrived at by analyzing a number of sets of overlapped "can catch data" which synthesized various sprinkler spacings along the lateral from single sprinkler catch data. A computer program was used to expedite the overlapping process and primary catch data from several sprinkler body-nozzle-pressure combinations were analyzed. In general a "reasonable" uniformity along the line was achieved under calm conditions by applying the 20–25% spacing criteria regardless of the sprinkler body-nozzle-pressure relationship. However, the sprinkler body-nozzle configurations described below which we chose for our field system produced the "best" triangular pattern.

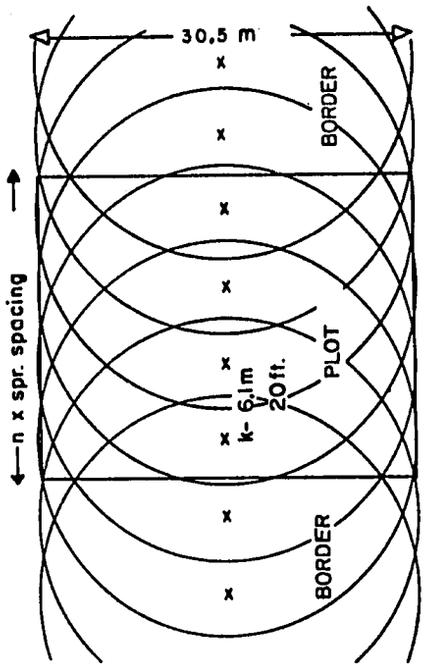

Fig. 1—Schematic diagram of the line sprinkler plot showing wetted perimeter of each sprinkler. A border area of about 1 m is needed on the sides of the plot.

Figure 1 shows a schematic layout of the line sprinkler plot design to meet these criteria. The line of sprinklers is through the center of the plot and parallel to the row direction. The length of the plot can be increased by adding more sprinklers. However, the width of the plot is governed by the wetted diameters of the sprinklers. There are two replications—one on each side of the sprinkler. A border of about 1 m, not shown in Fig. 1, is needed on the edges of the plot.

To obtain the "line source" effect, sprinklers should be spaced as closely as practical on the water supply line with spacing not exceeding 25% of the wetted diameter. Furthermore, the individual sprinklers should produce a triangular shaped profile when operated in low winds at the design pressure.

The test system (results shown in Fig. 2) had eight sprinklers spaced at 6.1 m (20 feet) which gave an overall usable plot of 24.4 by 30.5 m (80 × 100 ft). Model 30 TNT sprinklers with a 4.8-mm (3/16 inch) range by 2.4-mm (3/32 inch) spreader nozzles produced by Rain Bird Sprinkler Manufacturing Company of Glendora, Calif., USA, were selected for the layout. The sprinklers were operated at approximately 3 bars (45 psi) and produced a wetted radius of approximately 15 m (50 feet). Satisfactory results have been obtained with the same sprinklers operated at pressures up to 4 bars (60 psi).

The plot area was essentially level and the sprinklers were placed on 60 cm (2 feet) high by 2.5 cm diameter (1 inch) risers attached to a 7.5-cm diameter (3 inch) quick coupling portable aluminum supply line. The supply line had nondrain gaskets. The pressure head difference between the ends of the line was approximately 1% of the inlet pressure and each sprinkler discharged 0.54 liters/sec (8.5 gpm) giving a total system discharge of 4.32 liters/sec (68 gpm).

RESULTS

Table 1 shows the results of a test to determine the influence of distance from the sprinkler line and position along, but at right angles, to the sprinkler line on irrigation applied. Adjacent to the sprinklers the irrigation applied was greater than between sprinklers. At distances greater than about 1 m from the line, the differences at the sprinkler and

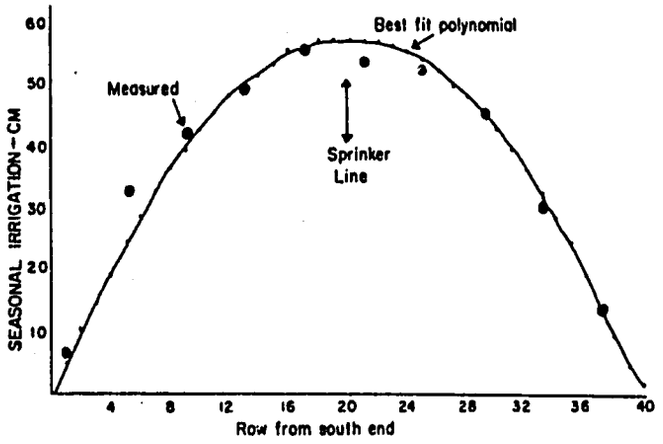

Fig. 2—Cumulative irrigation as related to the distance from the sprinkler line for corn trials at Logan, Utah, 1974. Row width was 0.75 m (2.5 feet).

Table 1—Relative irrigation measured as a function of distance from the sprinkler line and position along sprinkler line

Distance from sprinkler line	At sprinklers			Between sprinklers			Difference
	Rep 1	Rep 2	Avg	Rep 1	Rep 2	Avg	
South 13.3 m	0.0	0.0	0.0	0.0	0.0	0.0	
11.8	0.03	0.03	0.03	0.04	0.04	0.04	-0.01
10.3	0.12	0.13	0.12	0.14	0.13	0.14	-0.02
8.7	0.30	0.24	0.27	0.27	0.29	0.28	-0.01
7.2	0.48	0.37	0.43	0.39	0.38	0.38	+0.05
5.7	0.50	0.47	0.48	0.47	0.46	0.46	+0.02
4.2	0.55	0.61	0.58	0.56	0.62	0.59	-0.01
2.7	0.64	0.70	0.67	0.70	0.77	0.74	-0.07
1.1	0.87	0.80	0.84	0.78	0.78	0.78	+0.06
North 0.4	1.00	0.91	0.94	0.80	0.79	0.80	+0.14
1.9	0.76	0.79	0.78	0.70	0.83	0.77	+0.01
3.4	0.60	0.70	0.65	0.65	0.59	0.62	+0.03
4.9	0.43	0.63	0.53	0.51	0.50	0.50	+0.03
6.5	0.43	0.52	0.48	0.42	0.47	0.44	+0.04
8.0	0.37	0.43	0.40	0.41	0.50	0.46	-0.06
9.5	0.35	0.37	0.36	0.34	0.35	0.34	+0.02
11.0	0.26	0.22	0.24	0.26	0.23	0.24	0.0
12.6	0.08	0.05	0.06	0.08	0.09	0.08	-0.02
14.2	0.0	0.0	0.0	0.01	0.0	0.0	

Table 2—Relative irrigation measured at different distances from the sprinkler line during the 1974 season at Logan, Utah. The average irrigation received at 1.9 m north and south assumed 1.0

Date	Distance from sprinkler line									
	South					North				
	m									
	14.1	11.0	8.0	4.9	1.9	1.9	4.9	8.0	11.0	14.1
6-15	0.09	0.31	0.75	0.93	0.98	1.02	1.08	0.81	0.57	0.15
6-22	0.04	0.43	0.72	..	1.00	..	0.91	0.68	0.43	0.19
6-29	0.03	0.32	0.71	0.74	0.95	1.05	0.89	0.71	0.47	0.05
7-9	0.0	0.0	0.13	0.16	1.00	1.00	1.08	1.12	0.54	0.24
8-21	0.12	0.52	0.76	0.98	1.00	1.00	0.86	0.81	0.62	0.31
8-28	0.13	0.56	0.75	0.92	1.00	1.00	1.02	0.77	0.63	0.28
9-3	0.12	0.71	0.86	0.90	1.05	0.95	0.86	0.67	0.57	0.29
9-10	0.10	0.61	1.01	0.91	1.11	0.89	0.71	..	0.38	0.10
Avg.	0.08	0.44	0.72	0.79	1.01	0.99	0.93	0.80	0.53	0.20
Avg.†	0.09	0.50	0.80	0.90	1.01	0.99	0.90	0.94	0.52	0.20
S_x	0.05	0.22	0.26	0.29	0.05	0.05	0.13	0.15	0.09	0.10
S_x†	0.04	0.14	0.10	0.08	0.05	0.06	0.12	0.06	0.10	0.10

† Excluding the data on 7-9 which was windy.

between the sprinklers were about the same as between replicates. The peak application rate was shifted to the north by a slight breeze from the south. The results of Table 1 indicate that the irrigation application rate falls off approximately linearly with distance from the line sprinkler source as desired.

Therefore, the line sprinkler source system was used in 1974 as a part of a larger experiment. Table 2 shows the irrigation application for different dates during the season. Practical use of the system during 1974 indicated that the principal disadvantage was wind drift. Efforts were taken to only sprinkle on days when wind was small, but this was not always possible. An extreme example was 9 July 1974. We waited several days for a calm period, but it did not occur so irrigation was done. The data show a shift of the peak at about 8 m. When the standard deviation was computed on relatively calm days, it was about 0.1 and was about the same at all distances from the line. Including the windy day data caused the standard deviation to increase to about 0.2 (or more on the south end).

When the data are summed up over a season, the normal wind variation tends to make the shape of the water distribution curve more curvilinear as shown in Fig. 2. To estimate the irrigation as a function of position, a second degree polynomial was fitted to the measured data as shown in Fig. 2.

The system was used in 1973 and 1974 to determine corn production as related to irrigation. To maintain a clearance of 30 cm above the crop, the sprinkler heads were raised periodically during the season. At the end of the season, the sprinkler heads were 3.05 m high (10 feet). Small rain gages set at right angles to the irrigation line in 3.05-m (10 feet) intervals measured the water applied. These were raised during the season to be just above the crop canopy.

Figure 3 shows the dry matter and corn yields as related to estimated evapotranspiration (sum of water applied plus rain and soil water depletion) resulting from system use in 1974. There were 40 rows in the plot with every other row harvested for dry matter yield and the adjacent rows harvested for grain yield. The outside rows had a large border effect (as evidenced by a larger yield) so the data are not used. The data from the two inside rows next to the sprinkler line are not used because of leakage from the pipe junction. Evapotranspiration was estimated assuming runoff and drainage or upward flow during the season was negligible. Soil water depletion was measured using a neutron probe to 2.7 m (9 feet) depth. Irrigation was applied in intervals to keep runoff zero. When runoff started irrigation was stopped. This problem was highly dependent on soil condition.

The data of Fig. 3 show a strong linear relation between dry matter yield and estimated evapotranspiration, as has been shown for many studies. For the same estimated evapotranspiration, the north side of the plot gave slightly higher yields. This variation may be due to unknown factors such as fertility differences or measurement errors. Figure 3 also shows a linear relationship between grain yield and estimated evapotranspiration, but there is more variation in the data than for dry matter yields. The increased variation is expected because grain yields are more sensitive to influence during the season than is dry matter production (Hanks, 1974).

These data are similar to those of Hillel and Guron (1973) who used the traditional plot technique with four irrigation

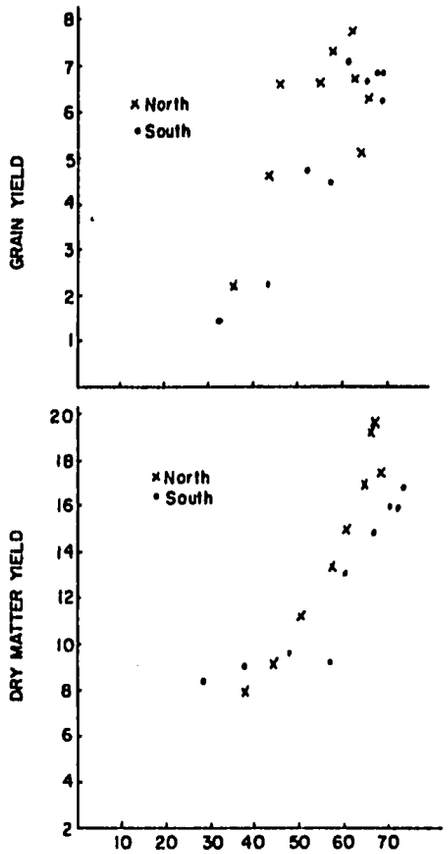

Fig. 3—Dry matter and grain yield (metric tons/ha) for corn as related to evapotranspiration as produced by the line sprinkler system at Logan, Utah in 1974.

variables. The line sprinkler system described allows for more irrigation variables than the traditional system. With our system we had 18 irrigation variables which are repeated on each side of the sprinkler line.

We believe that the addition of more treatments covering the range of water variables is a distinct advantage for many purposes, especially those involving evaluation of optimum economic return, because the entire range of water application is covered.

LIMITATIONS

There are several limitations of the line source sprinkler plot irrigator which should be considered before laying out an experimental plot. These include the following:

1) Even low winds significantly alter the sprinkling patterns. The symmetry of the patterns can best be maintained by operating the system only during calm periods and laying the line of sprinklers parallel to the direction of the wind. Irrigation was generally applied only when the winds were < 3 km/hour (2.0 miles/hour) at right angles to the line and 8 km/hour (5.5 miles/hour) parallel to the row. However, even these light general winds caused an average variation of up to 2 m in the maximum irrigation rate.

2) All irrigation must be added at the same frequency on any given plot. This is an inherent feature of the line source concept. However, for some water use studies, it may be desirable to manipulate the water availability by utilizing different frequencies.

3) The maximum application rate along the line of sprinklers for the system design presented is approximately 20 m/hour (0.79 inch/hour). While a relatively high application rate provides flexibility for irrigating only during calm wind periods, ponding or runoff may be a problem. However, there are several solutions for these problems which include: operating the sprinklers intermittently, i.e., 15 min on, then 15 min off, etc.; operating every other sprinkler, apply half of total irrigation, then switch to the in-between sprinklers; automatically sequence the sprinklers one at a time; or provide small dams or pits at 1.0 m (3.3 feet) intervals along the length of the furrows to trap the ponded water and eliminate runoff.

4) Since wind distortion is a problem, it is advisable to monitor the water application by collecting water application data across the plot during each irrigation. For studies on tall crops such as corn, this can be a problem.

CONCLUSIONS

The use of the line source sprinkler plot irrigation system described herein appears to offer a reliable and convenient method for applying to a plot a two-dimensional, continuous-uniformly-varying level of water. By applying a fertility or other variable at right angles to the water variable, it appears that this method should be useful for developing crop production function data. The system is economical and simple to install and operate. Furthermore, both the test area and water supply can be relatively small.

LITERATURE CITED

1. Bauder, J. W., R. J. Hanks, and D. W. James. Crop production function determinations as influenced by irrigation and nitrogen fertilization using a continuous variable design. Soil Sci. Soc. Am. J. 39:1187-1192.
2. Fox, R. L. 1973. Agronomic investigations using continuous function experimental designs-nitrogen fertilization of sweet corn. Agron. J. 65:454-456.
3. Hanks, R. J. 1974. Model for predicting plant yield as influenced by water use. Agron. J. 65:660-665.
4. Hillel, D., and V. Guron. 1973. Relation between evapotranspiration rate and maize yield. Water Resour. Res. 9:743-749.

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FACULTY OF AGRICULTURE
DEPARTMENT OF AGRONOMY

PROJECT FOR THE DEVELOPMENT OF EXCELLENCE IN THE TEACHING AND RESEARCH IN TROPICAL SOILS 211 (D)

August 3, 1976

Dr. Jack Keller
Department of Agricultural and
Irrigation Engineering
U M C 41
Utah State University
Logan, Utah 84 322

Dear Jack:

This is in response to Howard Peterson's letter of July 12. We are happy to learn that you or Kern Stutler might be able to find time to assist us here and in Minas Gerais.

We are not too sure when is the most appropriate time for the visit to Brazil, however, Chris Seubert has suggested some time during the 1st two weeks of September. That may be too soon for you and also there may be unexpected delays in completing the well at Jaiba. We should know more about this when Chris comes to Puerto Rico on August 14. As far as we in Puerto Rico are concerned, anytime in September or October will do and probably 1 1/2 to 2 days here will be adequate. We think that 3 days or more will be desirable in Brazil. Probably the EPAMIG staff in Minas Gerais will appreciate your advice in some situations there and I don't know where that would be or how long it might take. Chris will likely have some knowledge about that when he comes. One day should be enough time at the Jaiba site.

I am sorry that we cannot be more specific as to dates at this time. If you have a preference during the September - October period we would like to know about it. It seems that a very minimum of one week including travel time will be desirable.

With best regards.

Sincerely yours,

Gene L. Spain
Associate Agronomist

cc: F. H. Beinroth
C. E. Seubert

INTECH, INC.

RESOURCE ANALYSIS GROUP
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SILVER SPRING, MARYLAND 20910
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December 1, 1975

Professor George H. Hargreaves
Department of Irrigation and Engineering
Utah State University
Logan, Utah 84322

Dear Professor Hargreaves:

I recently spent three weeks in Upper Volta, where I had the pleasure of making the acquaintance of a visiting team from Utah State composed of Jim Bennett, Wesley Maughan and Rudy Griego. These gentlemen showed me a copy of a computer printout of monthly calculations of potential evapotranspiration and moisture availability indices for Upper Volta produced by a program under your direction.

I am very interested in these calculations, and I understand you have similar ones available for other countries as well. If it would not be too much trouble to you, could you kindly mail me such computer printouts for (1) Upper Volta, (2) Niger, (3) Mali, (4) Morocco, and (5) the Mediterranean region of France? I would be very grateful to you for this.

Sincerely yours,

Arthur J. Dommen

Arthur J. Dommen, Ph.D.
Agricultural Economist

APPENDIX G
WORK PLAN

July 1, 1975 to June 30, 1977

This plan of work is structured to conform with recent instructions issued by the TA/PPU Grants Coordinator and indicates the specific programs, man months of staff time, scheduled events/targets, expected results and costs by program category.

I. Information Capacity

A. On-farm Water Management Documents Procurement Center

To the already substantial library holdings at U.S.U. in the biologic, hydrologic, engineering and socio-economic aspects of on-farm water management, new documents, as they become available, will be added to the collection and recorded on the magnetic tape on which the current holdings are recorded.

Sources of these documents, especially from developing countries will be expanded. This will include foreign language publications.

Staff to be involved

One man month of a professional time and one man month of technician time will be paid from the grant.

Scheduled Target

Acquisitions are expected to increase by June 30, 1977, from the present holdings of 1300 documents by 10%.

Expected Results

The new materials plus documents currently on hand will provide the inputs for the cataloging and distribution programs to be described subsequently. This, together with companion documents held by the other CID universities, can provide the most complete accessible library of on-farm water management documents in existance. U.S.U. will cooperate

with CID universities in developing a means for making the holdings available to more users.

Estimated Costs

Salaries and fringes	$2,400
Acquisitions	2,000
Supplies	200
Other Direct Costs	400
Total	$5,000

B. Computerized Information Storage Retrieval and Transmittal System.

In cooperation with CID, the current documents plus those required under program I-A above will be considered for indexing for easier computer access under such categories as arid, semi-arid, sub-humid, and humid environments. Special emphasis will be placed on acquiring and indexing documents on erosion control on small farms.

Accessibility by user location and category will also be investigated to determine how land managers, students, planners, researchers, and others throughout the world could access the documents, especially by requests for searches on specific topics. The feasibility of providing an abstract of the documents will also be investigated.

The U.S.U. system will be considered for integration with those at other CID universities and with agency document centers such as those of AID, FAO, and other major related tecnical libraries.

Staff to be Involved

Four man months of time are required. Professor Palmer and Bonnie Thompson will represent U.S.U. in the development of the cooperative program.

Scheduled Events

Linda White from Arizona will visit each of the CID universities during June of 1975. She will make preliminary arrangements for participation in a conference to be held at Tucson in September 1975.

Palmer, Peterson and Thompson are scheduled to participate. At this workshop other meetings will be scheduled to improve the network.

By June 1976 the initial programming proposal will be completed. By June 1977, in cooperation with CID, a detailed plan for access to the documents should be finalized.

The grant period will be used to build the design for an inter-university and inter-agency acquisition, storage and retrieval system. Concurrently, strategies will be developed to secure sources of operating funds to carry on the program after the grant has terminated.

Expected Results

The system will be designed whereas when functioning, all the documents are accessible and subject bibliographies can be printed out immediately on demand. Depending on the results of the abstracting feasibility study, a detailed program for this service will be ready for implementation by the end of the grant period.

Estimated Costs

Salaries and fringes	$2,400
Travel	1,500
Other Direct Costs	1,100
Total	$5,000

C. Client Education Program

In order to maximize utilization of the On-Farm Water Management Document Center, careful coordination with CID and the other linkages already mentioned must prevail. In addition, a major effort is needed to identify and educate potential users. This will be programmed through the cooperative development of brochures, journal articles, professional meeting presentations, and workshops.

Staff to be Involved

Three man months

Scheduled Events

CID liaison by October 1975.

Other agency liaison by February 1976

Brochure design by July 1976

Newsletter feasibility study August 1976

Workshop August 1976

Expected Results

It is difficult at this time to forecast the client user rate for the system. By June 1977 an estimate will be available. A long term education program will by June 1977 also have been developed.

Estimated Costs

Salaries and fringes	$2,400
Travel	500
Direct Costs	2,100
Total	$5,000

II. Education and Training

A. Regular Course Augmentation

The increasing demand by foreign as well as American students for courses on the most effective technologies to plan and operate irrigation systems has indicated the need to add two new courses to the curriculum of the Department of Agricultural and Irrigation Engineering. These are "Irrigation Project Planning," and "Trickle and Subsurface Irrigation." Both courses will meet urgent needs in the many areas where irrigation projects, especially those with limited water supplies are planned. The first course will include topics on economics, system planning, operation, and management. The second will include emitter characteristics, filtration, layout and design, and operation and maintenance. They will be offered at the graduate level.

Staff to be Involved

Drs. Alfaro and Keller will develop and teach these courses. These will be offered annually for one quarter each. Seven man months will be required for development and presentation time.

Expected Results

The presentation of two cycles of these courses will add significantly to the technological capabilities of about 30 foreign students plus a number of Americans.

Estimated Costs

Salaries and fringes	$14,000
Direct cost	1,000
Total	$15,000

B. Short Courses

In collaboration with other CID universities, U.S.U. will organize and direct the presentation of a short course on the practical aspects of on-farm water management. This will be designed to help decision makers and the technicians who are responsible for resource planning, development and application to understand how water is managed on the farm, and how it relates to agricultural production by the small farmer. From July 1, 1975, until January 1, 1976, a review of existing courses taught by CIDIAT, the East-West Center, etc., will be made.

Staff to be Involved

Seven man months of professional staff time will be used to develop the courses, make the necessary liaison and advertising contacts, and present them. Professors Alfaro, Peterson, and Stringham will be primary developers of the course.

Scheduled Events

Staff assigned July 1, 1975

Course materials developed, March 1976

Programming completed, July 1976

During the period August 1976-June 1977 the courses will be presented. The number depending on the demands and funding available.

Expected Results

The primary objective of this course is to sensitize planners and other technical personnel to the needs and problems of the farmer in operating an irrigated farm. It will also show what irrigation projects need from decision makers in order to successfully serve the farmer. Initial results will be measured in terms of number of course participants. The potential impact of the course on small farmer operations will be evaluated by regular course evaluations by the participants. Later, followups evaluation will depend on availability of funding after June 1977.

Estimated Cost

Salaries and fringes	$13,000
Travel	2,000
Total	$15,000

C. Collaboration with Colorado State University and the University of Arizona.

U.S.U. will participate in the courses proposed by the other CID universities, specifically the short course on Irrigation Water Delivery and Removal Systems by Colorado State University and two short courses in watershed management by the University of Arizona.

Staff

Three man months of professional time will be allocated to this activity.

Scheduled Events

As described in the work plans of the sister universities, the materials for the Water Delivery and Removal Systems course will be ready by Spring, 1976, with presentation to follow as scheduled by C.S.U. An Arizona initiated watershed management course is scheduled for presentation in the Philippines or Pakistan before the end of the grant period. The course pilot tested by Arizona in cooperation with C.S.U. and U.S.U., should be ready for additional use by December 1976.

Expected Results

As in the U.S.U. initiated short course, results will be in terms of personnel trained and their initial evaluation of course effectiveness with any followup evaluation dependent on subsequent funding.

Estimated Costs

Salaries and fringes	$5,000
Travel	1,000
Total	$6,000

D. Ongoing Training on Campus

There are presently 15 M.S. and 4 Ph.D. students from LDC's engaged in water management studies. Enrollment is expected to continue at about this level. These students require a great deal of extra effort from faculty in supervision, especially since U.S.U. attempts to have their research topics relate to problems of their own countries.

Staff Involved

The difference between staff supervision for Americans and foreigners is estimated at two man months over the period of the grant. The professors involved will depend on the choice of advisors by the students.

Costs

Salaries and fringes	$4,000

III. Extended Knowledge Base and Research Capability

A. State-of-the-art reports.

A major effect will be devoted to development of these reports. A number of state-of-the-art reports, oriented largely toward the needs of very poor farmers will be developed in cooperation with the

other CID universities. U.S.U. will provide leadership in developing reports on intercropping, water management of heavy soils, methods of irrigation and water oriented food production technology. U.S.U. will participate in the reports proposed by Colorado State University and the University of Arizona, namely waterlogging and salinity control, water delivery, rules and procedures, pumping systems, and erosion control.

Staff Requirements

22 man months of professional

20 man months of technologist, secretarial and graduate student

Scheduled Events

These state-of-the-arts studies will be done by literature reviews, consultations with LDC, AID, international organizations, and sister universities. These reviews and consultations will help define knowledge gaps and additional research needs. During the period from July 1, 1975, to October 1, 1975, schedules will be worked out with the cooperating CID universities. Three committees will meet during August 1975 at Logan to develop schedule details. At that time the information developed at the workshop in Hawaii should be available for use in making the schedules.

Much of the data collection will take place before June 1976. At that time it will be possible to determine the costs for completion of the studies and determine the support available so schedules for completion can be made.

Expected Results

The documents will be widely distributed. The primary objective is to provide professionals who deal with poor farmers with simple, easily transferable, and useful information. This will counteract the tendency of professionals to talk over the heads of the advisors to farmers.

It is expected that some of the documents will be finished sufficiently before the end of the grant period to field test and report on them.

Estimated Costs

Salaries and fringes	$76,300
Travel	8,000
Consultants	5,000
Supplies	4,000
Other direct costs	6,700
Total	$100,000

IV. Advisory Capacity

A. Release Time

Additional staff will be funded in order to provide release time flexibility to respond to requests for technical assistance from LDC's. A variety of disciplines are represented among the staff who can be made available. (See Appendix A). This release time capability is an essential requirement for AID to secure access to staff whose normal commitments could not otherwise be met. These faculty members will also teach, perform application oriented research, related to problems in developing nations, and participate in the state-of-the-art studies.

Eight man months of released time will be allocated at an estimated cost of $16,000. The faculty members will be funded in the programs as their services are required.

B. Short-Notice Consulting Time

In emergencies, when individuals are needed on very short notice and when other instruments cannot be used without causing unacceptable delay, a nominal portion of the grant has been budgeted to cover this contingency.

Staff Involved

Three man months have been included in the budget.

Estimated Cost

Salaries and fringes	$ 6,000
Travel	3,500
Direct costs	500
Total	$10,000

C. Consortium and Other Institutional Advisory Capacity

In order to optimize U.S.U.'s potential contribution to LDC development in both on-farm water management and other related areas, especially those being stressed by the other CID members and the soils consortium, a secondary advisory capacity will be maintained. This secondary capacity provides an expanded range of talent for cooperative efforts with these institutions. This will include but not be limited to providing expertise in problem identification and analysis, and project design and evaluation, functions which AID anticipates will become increasingly important.

Staff to be Involved

U.S.U. will identify faculty members and their specialties for inclusion in a talent bank to be developed by CID. The Grant Program Director will become the CID "systems manager" for that portion of the talent bank dealing with on-farm water management expertise. The type of information recorded for each individual is shown in Appendix B.

Ten man months have been allocated for this activity.

Estimated Costs

Grant funds will be used for short-term consulting, for release time of faculty members, for staff training and for the development, and improvement of the talent bank.

Salaries and fringes	$15,000
Consulting	2,000
Travel	2,000
Total	$19,000

V. Linkages and Networks

Relationships with a network of domestic and multinational organizations will be maintained for the purpose of collaborating in a joint problem-solving approach, developing cooperative research, and becoming involved in information exchange and dissemination.

A close collaborative and professional relationship will be maintained with AID missions and the Regional and Technical Assistance Bureaus in achieving the purpose of the grant.

Principal domestic linkages include CID and the Tropical Soils Consortium. The U.S.U. Grant Program Director will become the systems leader within CID for on-farm water management and linkages between that and dryland farming, watershed management, water delivery, and removal/drainage systems. The grant will provide some funding for support of the newly assigned leadership and coordination role of CID.

Close linkage with the tropical soils consortium will be required to carry out the state-of-the-art reports which will be produced on the subject of soil and water management for erosion control and water management for heavy soils.

Linkages with several world-wide and regional organizations will be necessary to meet the condition of this grant. Of these, the primary multilateral organization contact will with FAO so as to determine the avaiability to CID and this grantee of water management specialists.

Linkages supporting U.S.U.'s state-of-the-art study on water management as an integrating factor in crop production will be sought with two regional organizations (CIMMYT and CIAT) to provide data from different climatic areas.

Funds under this grant will provide seven man months of faculty time and travel for linkages involving CID, the Tropical Soils Consortium, FAO, and regional organizations.

Estimated Costs	
Salary and fringes	$14,000
Travel	6,000
CID Administration	20,000
Total	$40,000