1040 PD-AAD-257

AID 1360-1X (7-71)

PIO/T

DEPARTMENT OF STATE
AGENCY FOR
INTERNATIONAL DEVELOPMENT

PROJECT IMPLEMENTATION ORDER/TECHNICAL SERVICES

1. Cooperating Country: TA Bureau

Page 1 of 6 Pages

2. PIO/T No. 931-1040-3177623

3. [X] Original or Amendment No. 15p

4. Project/Activity No. and Title: Improvement of Pearl Millet - Kansas State University

DISTRIBUTION

5. Appropriation Symbol: 72-11x1023

6.A. Allotment Symbol and Charge: 402-31-099-00-22-71

6.B. Funds Allotted to: [X] A.I.D./W [ ] Mission

7. Obligation Status: [X] Administrative Reservation [ ] Implementing Document

8. Funding Period (Mo., Day, Yr.) From 9/15/77 To 9/14/79

9.A. Services to Start (Mo., Day, Yr.) Between 9/15/77 and 9/14/79

9.B. Completion date of Services (Mo., Day, Yr.) 9/14/80

10.A. Type of Action: [X] A.I.D. Contract [ ] Cooperating Country Contract [ ] Participating Agency Service Agreement [ ] Other

10.B. Authorized Agent

Estimated Financing $1.00=		(1) Previous Total	(2) Increase	(3) Decrease	(4) Total to Date
11. Maximum A.I.D. Financing	A. Dollars		$505,000		$505,000
	B. U.S.-Owned Local Currency				
12. Cooperating Country Contributions	A. Counterport			FUNDS RESERVED BY [signature]	
	B. Other			POSTED 8/30/77 SER/FM/CSD	

13. Mission References

14. Instructions to Authorized Agent

This PIO/T authorizes the Contract Office to negotiate a 3 year contract with Kansas State University for the project: "Improvement of Pearl Millet". Incremental funding for the first two years of the proposed three year contract is estimated to be $505,000 for the period 9/15/77 to 9/14/79. Final funding of the third year is expected to be approximately $265,000.

The RAC recommended approval of this project for three years on July 14, 1977, with 3 provisos (see attached RAC recommendation).

See Continuation Sheet for Block #14.

15. Clearances – Show Office Symbol, Signature and Date for all Necessary Clearances.

A. The specifications in the scope of work are technically adequate
TA/AGR/CP, E. Leng [signature] Date: 7/14/77

B. ~~Funds for the services requested are available~~
TA/RES, J. Erickson [signature] Date: 7/25/77
TA/RES, M. Rechcigl [signature] Date:

C. The scope of work lies within the purview of the initiating and approved Agency Programs
TA/AGR, G. Baird [signature] Date: 7/14/77

D.
TA/PPU, C. Molfetto [signature] Date: 8/19/77

E. TA/AGR, D. Clark [signature] Date: 7/18/77
TA/AGR, L. Hesser [signature] Date: 7/22/77

F.
TA/PPU, M. Mozynski [signature] Date: 8/30/77

16. For the cooperating country: The terms and conditions set forth herein are hereby agreed to

Signature and date:

Title:

17. For the Agency for International Development

Signature: Kenneth G. Milow

Title: Chief, Program Office, TA/PPU

18. Date of Signature: 8/30/77

Project/Activity No. and Title
Improvement of Pearl Millet

SCOPE OF WORK

19. Scope of Technical Services

A. Objective for which the Technical Services are to be Used To utilize linkages and cooperation between U. S. institutions and ICRISAT, as well as research and extension agencies in LDCs, to improve production and utilization of pearl millet.

B. Description

Objectives of Proposed Program

a. Accelerate improvement in pearl millet grain yield by creating widely adapted high yielding populations and synthetic varieties and investigate possibilities of creating inbred lines and hybrids for use in developing countries.

b. Determine factors related to and genetric variability in seed and seedling vigor, water use, drought resistance, and herbicide susceptibility of pearl millet.

c. Determine the nutritional quality and digestibility of pearl millet grain by analyzing protein in germplasm introductions and breeding materials and determining magnitudes of variation in lysine content among and within populations and varieties. Determine the characteristics and digestibility

(Continued on page 6)

C. Technicians

(1) (a) Number	(b) Specialized Field	(c) Grade and/or Salary	(d) Duration of Assignment (Man-Months)
2	Agronomists	Full Professor	15
1	Soils Scientist	" "	3
1	Pathologist	" "	2
1	Grain Scientist	" "	6
1	Food Scientist	Asst. Professor	6
	Nonprofessionals (Graduates, technicians, etc.)		236
		Two Year Total	268

(2) Duty Post and Duration of Technicians' Services

Kansas State University

(3) Language requirements

N/A

(4) Access to Classified Information

N/A

(5) Dependents ☐ Will ☒ Will Not Be Permitted to Accompany Technician

D. Financing of Technical Services

(1) By AID - $ 378,000 (2) By Cooperating Country –

20. Equipment and Supplies *(Related to the services described in Block 19 and to be procured outside the Cooperating Country by the supplier of these services)*

A. (1) Quantity (2) Description (3) Estimated Cost (4) Special Instructions

	1st year	2nd year
Equipment	$51,000	----
Materials & Supplies	30,000	40,000
Publications	2,000	4,000
Totals	$83,000	$44,000

B. Financing of Equipment and Supplies

(1) By AID - $127,000 (2) By Cooperating Country - N/A

21. Special Provisions

☒ A. This PIO/T is subject to AID (contracting) (PASA implementation) regulations.

☒ B. Except as specifically authorized by AID, or when local hire is authorized under the terms of a contract with a U.S. Supplier, services authorized under this PIO/T must be obtained from U.S. sources.

☒ C. Except as specifically authorized by AID/W, the purchase of commodities authorized under this PIO/T will be limited to the U.S. under Geographic Code 000.

☒ D. Other *(specify)*: Prior to making any visits to LDCs, the contractor will review his plans with TA/AGR*. He will keep AID Missions in countries to be visited fully informed of proposed visits, ask them to provide any advice they wish regarding timing and content of the visits and to participate if they desire, and will inform the Missions of the outcome of consultations. He will make his own appointments and logistics arrangements directly. Upon completion of any project funded travel, a copy of the trip report will be provided to the TA/AGR project manager. The report format will be established jointly by the contractor and the project manager.

*Also, contractor will obtain clearances from USAIDs and concerned Regional Bureaus prior to any visitations to LDCs.

22. Reports by Contractor or Participating Agency (Indicate type, content and format of reports required, including language to be used if other than English, frequency or timing of reports, and any special requirements)

Contractor shall submit three copies of all reports listed as being a product of the contract (administrative, progress, final and technical reports containing R&D findings) to the Documentation Coordinator, TA/PPU/EUI, Technical Assistance Bureau, Agency for International Development, Washington, D.C. 20523, or his designee. Such reports shall include a title page showing the title of the report, project title as set forth in this contract (or grant) and the contract number. One copy of each report shall be clearly typed or printed on white paper so that it may be photographed to produce a microfilm master. Technical reports shall be accompanied by an author-prepared abstract.

23. Background Information (Additional information useful to Authorized Agent and Prospective Contractors or Participating Agency; if necessary cross reference Block 19.C(4) above.)

Exchanges of germplasm, results, ideas, joint research and conduct of International Pearl Millet Trials with ICRISAT.

Coordination with the African Bureau regional project on Semiarid Food Grains Research and Development (SAFGRAD).

Pearl Millet studies at the University of Nebraska, Texas A&M, University of Arizona and the Georgia Coastal Plain Experiment Station.

RAC Minutes
Project Paper

24. Relationship of Contractor or Participating Agency to Cooperating Country and to AID

A. Relationships and Responsibilities

N/A

B. Cooperating Country Liaison Official

C. AID Liaison Officials

Dr. E. Leng	TA/AGR
Dr. G. Baird	TA/AGR
Dr. L. Hesser	TA/AGR

LOGISTIC SUPPORT

25. Provisions for Logistic Support	IN KIND SUPPLIED BY		FROM LOCAL CURRENCY SUPPLIED BY		TO BE PROVIDED OR ARRANGED BY SUPPLIER
A. Specific Items *(Insert "X" in applicable column at right. If entry needs qualification, insert asterisk and explain below in C. "Comments")*	AID	COOPERATING COUNTRY	AID	COOPERATING COUNTRY	
(1) Office Space	X*				
(2) Office Equipment					
(3) Housing and Utilities					
(4) Furniture					
(5) Household Equipment *(Stoves, Refrig., etc.)*					
(6) Transportation in Cooperating Country	X*				
(7) Transportation To and From Country					
(8) Interpreter Services/Secretarial	X*				
(9) Medical Facilities					
(10) Vehicles (official)					
(11) Travel Arrangements/Tickets					
Other: (specify) (12)					
(13)					
(14)	*(For visiting contractor personnel)				
(15)					

B. Additional Facilities Available From Other Sources

☐ APO ☐ PX ☐ COMMISSARY

☐ OTHER (specify, e.g., duty free entry, tax exemption)

Kansas State University holds a seed import permit for pearl millet and sorghum, issued by APHIS to L.K. Edmunds, ARS, USDA, and Kansas State University. Under this permit, seed from presently restricted sources in Africa and Asia is channeled through APHIS to Kansas State University for grow-out under quarantine in an isolated greenhouse on the campus. Present capacity, depending on amount of replication desired and occasional service to related programs at other land grant institutions, should allow up to 50 entries per year. It is anticipated that such capacity will be sufficient.

Comments

Pearl millet improvement has been neglected worldwide as compared with work on other major food crops. The only significant pearl millet grain programs outside the U.S. have been some U.S.-supported work in Africa, the India national and state programs, the IRAT program in Senegal, the former EEAFRO program in Uganda and, more recently, the program of ICRISAT in India. In the U.S., only the Kansas State/ARS Program is of significant size.

The Kansas State University-ARS, USDA program has the only active U.S. team of personnel and facilities engaged in pearl millet research that can assist and reinforce developing countries' efforts in millet improvement. The team can make improved germplasm available to developing countries' national programs, devise methods for improving pearl millet releases of national programs, improve nutritional quality of pearl millet food products, and foster cooperation among pearl millet workers.

The field outreach aspects of this project under contract with Kansas State University will be primarily the responsibility of ICRISAT.

AID-1300-1X (7-69) CONTINUATION SHEET	DEPARTMENT OF STATE AGENCY FOR INTERNATIONAL DEVELOPMENT	[X] Worksheet [ ] Instance	PAGE 6 OF 6 PAGES
FORM SYMBOL	TITLE OF FORM	1. Cooperating County TA Bureau	2.a. Code No.
		2.b. Effective Date 9/15/77	2.c. [X] Original OR Amendment No:
	PROJECT IMPLEMENTATION ORDER/ TECHNICAL ASSISTANCE	3. Project/Activity No. and Title Improvement of Pearl Millet	

Indicate block numbers.

Use this form to complete the information required in any block of a PIO or PA/PR form.

Continued from page 2, item 19:

of pearl millet protein and carbohydrates.

d. Determine the storage stability of pearl millet grain and millet meal by determining the factors contributing to grain losses during storage and determining the factors contributing to the development of rancidity in millet meal.

"Article # Voucher Identification. In each instance of voucher (SF1034) submission made by the contractor for payment hereunder, the following identification data will appear on the face of the voucher:

Contract: AID/_____
Project 931-_____
Project Office TAB/_____"

Attachment A -- Work Plan

Attachment B -- Budget

Work Plan

Time-phased Work Plan.

The following section details the research effort needed to complement pearl millet improvement by ICRISAT and other agencies. The areas where research emphasis is to be applied were identified during consultation and visitation with ICRISAT administrators and scientists. The areas are also those where particular expertise exists at Kansas State University. This plan as presented contains dates based on the assumption that the work could begin with the 1977 crop season.

Objective 1. (25% of the total effort)

a. Population Improvement.

(1) 1977.

(a) Conduct the Cycle 1 S_1 progeny performance of Hays populations 550, 553, and 557A. Trials will contain 100 to 200 S_1 lines of each population.

(b) Produce the Cycle 1 S_0 generation of Hays populations 600, 1002, and 1700. Bag 800 to 1500 plants within each population to produce S_1 seed.

(c) Introduce dwarf plant height, early maturity, B_1 and B_2 male-fertility maintenance, and large seed characteristics into a bulk population composed of the random-mated mass selected progeny of the world pearl millet collection. Seeds harvested from dwarf B_1 and B_2 plants will be maintained separately and designations will be Hays populations WC1 and WC2.

(2) 1977-1978 winter.

(a) Evaluate seedling reactions of selected S_1 lines of Hays populations 550, 553, and 557A to the greenbug aphid, *Schizaphis graminum*, in cooperation with Dr. T. L. Harvey, Entomologist.

(b) Recombine the top 10 to 15 percent of the lines within Hays populations 550, 553, and 557A in Puerto Rico.

(3) 1978.

(a) Grow the Cycle 2 S_0 generation of Hays populations 550, 553, and 557A to produce seed for S_1 progeny testing.

(b) Conduct the Cycle 1 S_1 progeny testing phase of Hays populations 600, 1002, and 1700.

(c) Mass select within Hays populations WC1 and WC2 tall agronomically desirable F_1 plants.

(4) 1978-1979 winter.

(a) Evaluate seedling reactions of selected S_1 lines of Hays populations 600, 1002, and 1700 to the greenbug aphid, in cooperation with Dr. T. L. Harvey.

(b) Recombine the top 10 to 20 percent of the lines within Hays populations 600, 1002, and 1700 in Puerto Rico.

(5) 1979.

(a) Conduct the Cycle 2 S_1 performance trials of Hays populations 550, 553, and 557A. Initiate inbred line development by self-pollinating agronomically desirable plants.

(b) Produce the Cycle 2 S_0 generation of Hays populations 600, 1002, and 1700.

(c) Select and self-pollinate desirable dwarf plants segregating within Hays populations WC1 and WC2. These selections are to be evaluated in head rows in 1980. Superior materials will then be grown in random-mating, mass-selected populations.

b. Hybrid Possibilities.

Presently available dwarf, forage-type cytoplasmic male-steriles (A lines) and their inbred fertility maintainer counterparts (B lines) require 77 to 85 days from planting to anthesis. Dwarf, large-seeded, grain-type A and B lines requiring 55 to 70 days to reach anthesis are being developed. Dwarf B_1 and B_2 derivatives of PI 185642 are being used as the recurrent parents in backcrosses to their respective dwarf A_1 and A_2 counterparts.

The development of male-fertility restoration lines having dwarf stature and desirable agronomic characteristics has proceeded concurrently with the development of the cytoplasmic male-sterile lines. Lines ranging from F_3 to F_8 were derived from crosses involving 56 plant introductions, Tift 23 DA_1 and DB_2, Tift 239 DA_2 and DB_2, Serere 3A, Serere 17, and PI 185642. Approximately 135 top crosses were made in 1976 between superior PI 185642 DA_1 lines and R lines.

(1) 1977-1978 Greenhouse.

(a) PI 185642 DA_1 lines ranging from BC_2 to BC_6 will receive a further cycle of backcrossing from their DB_1 counterparts which range from BC_1 F_5 to F_7 and BC_2 F_4 and F_5. The DB_2 lines will be backcrossed for the first time into the DA_1 F_4's.

(b) Advanced generation steriles will be pollinated by selected R lines.

(2) 1978.

(a) Backcrossing of the DB_1 and DB_2 progenies into the A_1 and A_2 cytoplasms will be advanced one generation with appropriate selection pressure applied for male-sterility and desirable agronomic characteristics.

(b) Selected lines will be advanced one generation and superior lines will be crossed to PI 185642 DA_1 lines.

(c) Depending on available quantities of seeds the F_1 hybrids produced in the 1976 field and 1976-1977 greenhouse will be placed in early-planted single-row observation nurseries and replicated yield trials at two locations (upland and bottomland) on the Fort Hays Experiment Station.

(d) Late-planted crossing nurseries will be used to produce sufficient seed of promising hybrids for 1978 observation nurseries and yield trials at several locations across the state.

(3) 1978-1979 Greenhouse.

(a) The DA_1 and DA_2 lines will be advanced one generation by backcrossing to their respective DB lines.

(b) Selected R lines will be grown and topcrossed to DA_1 lines.

(4) 1979.

(a) Superior DA_1 and DA_2 lines will be advanced one generation by backcrossing to their respective DB lines.

(b) New inbred R lines will be crossed to DA_1 and DA_2 lines for observation of their F_1 hybrids in 1979.

(c) Hybrids showing promise in 1977 yield trials will be reproduced in small isolated crossing blocks containing their respective A and B lines. F_1 seed produced in these crossing blocks will be used for additional statewide testing and in regional observation nurseries in other states in 1979.

Objective 2. (25% of total effort)

a. Develop techniques whereby evapotranspiration estimates can be made under various climatic regimes which would then allow soil moisture estimates (water deficit conditions) to be made.

(1) 1977.

Assess the advective contribution to total evapotranspiration by measuring canopy temperatures.

(2) 1978.

Plant millet on the Evapotranspiration Research Field and use weighing lysimeters to measure evapotranspiration.

(3) 1979.

Make energy and radiation balance measurements on millet to assess crop response to water stress.

b. Investigate plant-water relations of different genetic lines under water deficit conditions.

(1) 1977.

Stomatal resistance and xylem water potential will be measured on selected millet lines.

(2) 1978.

Under conditions of water deficit at various growth stages (performed under a rainout shelter or restricted root zone), compare stomatal resistance, xylem potential, and leaf temperature of selected millet lines.

(3) 1979.

Select and test criteria best suited for screening for drought resistance.

c. Identify seed and seedling characteristics which are associated with field performance of millet.

(1) 1977.

Standard germination and vigor tests, e.g. accelerated aging ammonium chloride treatment and cold tests, will be used on millet seed lots and correlated with field establishment under a range of climatic conditions.

(2) 1978.

The most promising vigor tests will be continued with as a wide a range of genetic material as can be obtained and where possible seed lots of the same genetic material produced in either different locations or in different years.

(3) 1979.

Materials developed in Objective 1 will be screened using the best vigor test obtained in the first two years of testing. Those showing excellent vigor will be tested under field conditions to verify their establishment capability.

d. Identify herbicide susceptibility of pearl millet to those herbicides commonly used on grain sorghum.

(1) 1977.

Herbicides which normally are used on grain sorghum and those which might be used on crops which would be expected to be grown in rotation with millet will be applied to millet using the rates and time of application of the herbicides as they would be utilized on sorghum.

(2) 1978.

Based on results on the 1977 experiments, selected herbicides would be applied to pearl millet with rates and times of applications varied to assess the sensitivity of pearl millet to these herbicides.

(3) 1979.

Materials from the breeding section (Objective 1) would be subjected to the herbicides studied in the previous two years to determine the possibilities of selection for genetic response to herbicides.

Objective 3. (40% of the total effort)

a. Determine if genetic variability in digestibility occurs within pearl millet.

(1) 1977.

Pearl millet proteins will be fractionated and characterized amino acid distributions will be determined paying particular attention to variations in lysine content among and within populations.

(2) 1978.

Rat feeding studies on traditional foods prepared from pearl millet will be conducted to determine total digestible matter and protein digestibility.

(3) 1979.

Determine if any antidigestibility factors or morphological barriers to enzymatic attack exist by using enzyme digestion techniques and scanning electron microscopy.

b. Determine the nutrient composition and availability of nutrients in pearl millet.

(1) 1977.

Pearl millet lines grown under a number of environmental conditions will be analyzed for minerals, vitamins, and amino acids.

(2) 1978.

Milled fractions obtained from pearl millet will be analyzed for minerals, vitamins, and amino acids.

(3) 1979.

Chemical and biological assays will be used to determine the retention and availability of nutrients before and after processing millet into food.

c. Characterize the carbohydrates of pearl millet to determine their susceptibility to hydrolytic enzymes and their influence on food quality and digestibility.

(1) 1977.

Determine the susceptibility of pearl millet starch to enzyme attack.

(2) 1978.

Studies on the staling rate of starch pastes made with millet starch.

(3) 1979.

Determine the amount and types of pentosans in pearl millet.

Objective 4. (10% of total effort)

a. Determine what factors contribute to the losses of pearl millet grain during storage.

(1) 1977.

Moisture isotherms for pearl millet will be determined.

(2) 1978.

The effect of storage conditions on microbial growth will be determined.

(3) 1979.

Determination of the susceptibility of stored millet to grain insects.

b. Investigate the factors contributing to the rapid development of rancidity in millet meal during storage.

(1) 1977.

Determining and characterizing the lipids in millet meal.

(2) 1978.

Determination of the types of changes occurring in lipids during the storage of millet meal under varied environmental conditions.

(3) 1979.

Identification of possible conditions which might control lipid degradation.

Plan for Dissemination and Application of Results

Expected results of the proposed program will be disseminated in several ways. Contractor will maintain direct contact with national pearl millet programs in developing countries and with the ICRISAT research and out reach programs. Both avenues will permit direct communication among these programs. Kansas State University also had a long association with Andhra Pradesh Agricultural University at Hyderabad, and will use this contact directly.

The planned program will have a number of "products" that can be applied immediately by the developing countries. Improved pearl millet populations and synthetic varieties can be used as high-yielding varieties, used to upgrade local varieties, or the widely-adapted populations can be selected further by national programs in developing countries. Introduced germplasm possessing specific desirable traits - yield potential, drought resistance, high nutritive value, etc. - can also be incorporated into the national millet breeding programs. Techniques developed for screening millet for desirable traits - selection criteria, drought resistance, nutrient-use efficiency, etc. - can also be employed by national pearl millet programs to accelerate their work. Results on effects of processing on nutritive value of pearl millet food products might be used to modify traditional processing methods if that should seem feasible.

Budget

Inputs	Year 1 W/M	Year 1 $(000)	Year 2 W/M	Year 2 $(000)
1. Salaries		89.2	134	96.6
2. Fringe Benefits		11.5		12.3
3. Indirect Costs (53.3%)		53.7		58.0
4. Travel and per diem				
a. Domestic		4.0		6.0
b. International		16.0		18.0
5. Equipment		51.0		-
6. Materials and Supplies		30.0		40.0
7. Other direct Costs		4.6		8.1
8. Publications		2.0		4.0
TOTALs		$ 262.0		$ 243.0

Outputs				
1. Breeding materials and information		65.5		60.8
2. Agronomic information		65.5		60.7
3. Nutritional information		104.8		97.2
4. Storage quality information		26.2		24.3
TOTALs		$ 262.0		$ 243.0

9311040 (5)
PD-AAD-257

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT IDENTIFICATION DOCUMENT FACESHEET

TO BE COMPLETED BY ORIGINATING OFFICE

1. TRANSACTION CODE ("X" appropriate box): [X] Original [ ] Change [ ] Add [ ] Delete

PID — DOCUMENT CODE 1

2. COUNTRY/ENTITY: Interregional - Research - KPA 2

3. DOCUMENT REVISION NUMBER:

4. PROJECT NUMBER: 1040 ~~931-17-130-632~~

5. BUREAU: a. Symbol TAB; b. Code 6

6. PROPOSED NEXT DOCUMENT: a. [ ] PRP [X] PP b. DATE (mo. yr.) 0 6 7 6

7. PROJECT TITLE - SHORT (stay within brackets): Improvement of Pearl Millet Kansas State University, Proposed

8. ESTIMATED FY OF AUTHORIZATION/OBLIGATION: a. INITIAL FY 7 7 b. FINAL FY 8 1

9. ESTIMATED COST (life of project) ($000 or equivalent, $1 = 1,750)

FUNDING SOURCE	AMOUNT
a. AID APPROPRIATED	1,750
b. OTHER U.S.	
c. HOST GOVERNMENT	
d. OTHER DONOR(S)	
TOTAL	

10. ESTIMATED COSTS/AID APPROPRIATED FUNDS ($000)

a. Appropriation (Alpha Code)	b. Primary Purpose Code	c. Primary Tech. Code	FIRST YEAR FY ___ d. Grant	e. Loan	ALL YEARS f. Grant	g. Loan
			300		1,750	
TOTAL						

11. OTHER U.S. ($000)

a. FUNDING SOURCE	b. FIRST YEAR	c. ALL YEARS
TOTAL		

12. SECONDARY TECHNICAL CODES (maximum six codes of three positions each)

13. SPECIAL CONCERNS CODE (maximum six codes of four positions each)

14. SECONDARY PURPOSE CODE

15. PROJECT GOAL (stay within brackets)

To improve the production of basic food supplies in developing countries where pearl millet is a basic food grain.

16. PROJECT PURPOSE(S) (stay within brackets)

To assure that developing countries where pearl millet is a major food grain can take advantage of the latest breeding materials and technologies for producing and utilizing this crop at the highest possible level of productivity and nutritional value, especially in areas which are marginally productive.

17. PLANNING RESOURCE REQUIREMENTS (staff/funds)

18. ORIGINATING OFFICE CLEARANCE

Signature: Alex L. Hamer

Title: Director, TA/AGR

Date Signed (mo. day yr.): 0 4 1 - 1 5 - 1 7 6

19. Date Received in AID/W, or For AID/W Documents, Date of Distribution (mo. day yr.)

4

I. Summary of the Problem and Proposed Response.

Problem:

Pearl millet (*Pennisetum typhoides*) is one of the five most important cereal grains used directly for human food (the others are rice, wheat, maize, and sorghum). In Africa and the Indian subcontinent, pearl millet is the most important food cereal in the drier cropping areas. Much less attention has been paid to the breeding, agronomy, and utilization of this crop than to the other major cereals. Yields under actual production conditions are very low, and have not shown recent improvement as has been the case in other cereals. Little is known about the possibilities for nutritional improvement or the utilization of the grain for food products other than those traditional in India or Africa.

A. Proposed solution. In close cooperation with ICRISAT, it is proposed to establish a research and development program for pearl millet at a U. S. agricultural university. The major objective will be to conduct practically-oriented studies on the production and utilization of this crop, which will serve 1) as a direct source of improved materials and technology for developing countries, and 2) as a research training and field service back-up to ICRISAT, which has been assigned international responsibility for pearl millet improvement by CGIAR.

No special environmental problems are expected to arise. No changes in energy requirements or source are expected to result directly; some of the research on cropping practices could possibly lead to energy conservation. In many of the developing countries where pearl millet is grown, women are the principal cultivators and their situation should be improved by more effective production practices.

B. State-of-the-Art. Less research and breeding work have been conducted with pearl millet than with any of the other major cereal crops. In the United States, only four universities have any significant research in progress on this crop and only one of these (Kansas State University) is devoting more than one full time equivalent research scientist's time to the crop. Breeding and agronomic studies have been underway for some time at several Indian agricultural research centers and at a few locations in Africa. More recently, ICRISAT has taken international responsibility for pearl millet improvement and its research is beginning to show promise.

Pearl millet is a cross-pollinating species and therefore highly variable as grown under usual field conditions. High-yielding hybrids were produced in India some ten years ago, utilizing a combination of types developed in the U. S. and those native to India. These hybrids have not been successful, for the most part, because of major disease problems (especially ergot, which can produce fatal poisoning in humans) and poor seed set, the causes of which are not well understood. Some of the research stations in Africa have produced varieties which yield well under experimental conditions, but there is little evidence that these have been distributed to farmers on any significant scale.

In India, pearl millet has the "folk-wisdom" reputation of being a "strengthening" food, particularly in winter. Until recently, little was known about its chemical composition or actual nutrititive value. Recent studies have indicated that it usually is higher in protein than most other cereals (averaging 13 - 15%) and also that some selections, at least, are quite high in lysine (up to 3.5% or more of total protein). It also has been determined recently that alpha-amylase activity is high in millet flour. This greatly improves the quality of risen breads made without added sugar or malt, and therefore could be important in carbohydrate utilization.

Within the past few years, Kansas State University has combined selections from Uganda with strains developed in Georgia, to produce promising breeding populations. The selections now available, while not yet ready for release to cultivators, have excellent seed set, good seed quality, short plant height, good yield under stress conditions, and very high levels of protein and lysine content. The total lysine per 100 grams of grain exceeds that in opaque-2 maize. With further selection and international testing, these types could rapidly be utilized in developing countries, either directly or as components of further breeding and improvement programs.

C. Brief project description.

1. Expected outputs. These will include:

(a) Breeding stocks useful for further improvement in country or regional breeding programs.

(b) Widely-adapted, stress-tolerant varieties suitable for use under marginal conditions in developing countries.

(c) Diverse genetic material and techniques for use in ICRISAT's improvement programs.

(d) Well trained staff for developing countries, capable of conducting effective pearl millet programs.

(e) Skilled professional consultation by contractor's staff to assist developing countries and international crops centers.

(f) Effective research and informational linkages among international institutions, developing country agencies, and U. S. research organizations concerned with pearl millet.

(g) Training and technical assistance services to supplement efforts of ICRISAT in these areas.

Technical and physical resources required.

(a) At least three professionally qualified specialists in breeding, agronomy, and utilization of pearl millet, with interest and expertise in problems of developing countries.

(b) An adequate support staff of technicians, assistants, and part time workers.

(c) Adequate field and laboratory facilities for testing performance under a variety of environmental conditions, and for measuring chemical composition and nutritional value.

(d) Special equipment for field and laboratory research and computer facilities for data processing and reporting.

3. Expected disbursement period.

The project is planned to begin about January 15, 1977 (FY 77 funding) and to continue for an initial period of five years. Since the work planned is of a continuing nature, request for renewal is possible.

D. Major assumptions. Assumptions most pertinent to project success are:

Staffing with highly competent, development-oriented professional staff.

2. Active cooperation among agencies concerned.

3. Continuing interest in pearl millet as human food.

E. Realistic alternatives.

1. All research responsibility for pearl millet could be assigned to ICRISAT, regional programs, and country research institutions. This is the present situation. It has the disadvantage that participation by highly qualified U. S. personnel is minimal and is not encouraged by the current arrangements. The proposed project would considerably strengthen the available pool of research and development expertise on pearl millet.

2. Work on this crop at U. S. institutions could be deferred until an effective program grant under Title XII could be worked out. This is a feasible alternative, and may prove to be the best course if the Title XII program is put into effect soon. This alternative is not mutually exclusive with the research contract mode; a contract program could be put into effect and the work later transferred to a Title XII programmatic grant.

F. Beneficiaries.

The major direct beneficiaries will be DC institutions and personnel with prime responsibility for adaptive research and extension of pearl millet improvement to the rural population. It is expected that products of this project will be of immediate usefulness in developing countries where pearl millet is a major crop, and thus farmers and consumers in such areas will be benefited in a reasonably direct fashion.

G. Environmental problems.

No environmental problems are expected from the proposed research activities nor from adoption of the improved materials or practices. As disease-and insect-resistant varieties are put to use, the requirements for pesticides should decrease.

H. Energy considerations.

No major change in energy requirements is expected as a direct result of the project, except for energy savings per unit of production which may result from the adoption of improved practices and higher-yielding varieties.

I. Spread effect.

This project could have an important spread effect through improving the adoption of improved practices in developing countries. Also, it should have a favorable effect on cooperation between U. S. institutions and international centers, as well as with research and extension agencies in developing countries.

II. Financial Requirements and Plans.

A. The best estimate of project cost is $1,750,000 for a five-year period. The cost for the first two-years (initial fiscal year commitment) is estimated at 300,000 .

B. Funding is expected to start in FY 77. Project activities would begin about January 15, 1977..

C. This will be a contracted, centrally-funded research project. Consideration should also be given to inclusion of this activity in a Title XII research program, should such a program be developed in an appropriate time framework.

III. Development of the Project.

A. Information is available in sufficient scope and quantity to enable the formulation of the proposal in detail. An unsolicited project proposal from a prospective contractor has been received. Details of the project and its specific orientation to various developing countries will be worked out in consultation with the regional bureaus.

B. The next document planned is a PP to be submitted by June 1, 1976.

C. No consultant services are expected to be needed.

D. The major responsibility for preparing the PP will be with TA/AGR/CP. Consultation with U. S. institutions, ICRISAT, regional bureaus and other tab offices will be accomplished. Time requirements for AID personnel outside the sponsoring office are estimated to be less than five man-days.

IV. Issues of a Policy or Programmatic Nature.

A. Relative importance of pearl millet and need for research.

AID has not previously funded research on pearl millet, except through ICRISAT and regional programs such as JP-26 in West Africa. The crop is of major importance in drier regions of Africa and the Indian subcontinent, but is virtually unknown elsewhere. This regionality of adaptation may be a concern to some regional bureaus; however, it is considered that the overall importance of the crop as a food grain in the poorer areas of many AID-concern countries adequately justifies a sizeable research effort for its improvement.

B. Location of research in the United States.

Until recently, this would have been a major concern, since there was little professional competence with this crop in U.S. institutions. However, development of staff and programs in the past five years, particularly at Kansas State University, has been sufficient to provide a competent research base. Indications from ICRISAT and other research institutions overseas are that pearl millet research is still poorly developed, and use of a U. S. institutional capability to backstop their efforts and to enlarge the world pool of knowledge would be welcomed, and would considerably strengthen the overall R&D effort on this crop.

C. Linkage relations with ICRISAT, SAFGRAD (West Africa), etc.

Appropriate linkage relationships and coordination with international and regional agencies, as well as selected country research programs, must be developed. The prospective contractor has plans for undertaking this coordination at an early stage of project development.

D. Choice of contracting institution.

Two Texas institutions (Texas A&M and Texas Tech), as well as the Georgia Coastal Plain Experiment Station (Tifton) have some capability with this crop. At present, Kansas State has a considerably larger staff effort and is considered to have predominant capability.

OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : See Attached List

Thru : LA/DR/RD, Daniel A. Chaij

FROM : LA/DR/RD, Charles A. Breitenbach

DATE: August 13, 1976

SUBJECT: The Latin American Bureau's Position on Project Papers Presented for Review to the R&DC on August 3, 1976

1. Summary of August 3rd R&DC Actions

Four project agriculture proposals were presented at the August 3, 1976 Research and Development Committee meeting. The LA Bureau was represented by Larry Smucker and Charles Breitenbach. The papers presented were as follows:

a. Development of Improved Sorghum - Physiology of Yield and Stress Reaction, University of Nebraska, TA/AGR, RDA #2, Research.

b. Barley Improvement, Montana State University, TA/AGR, RDA #2, Research.

c. Agronomic and Nutritional Improvement of Pearl Millet for Semiarid Areas, Kansas State University, TA/AGR, RDA #2, Research.

d. Improvement of Grain Sorghum for Developing Countries, Texas A&M, TA/AGR, RDA #2, Research.

The LA Bureau was favorably inclined toward projects a, b and d. Because the projects were already in progress, it was believed that their extension for another three years would allow them to reach their periods of high pay off. It was pointed out that we favored projects a and d more than project b, because of the broad-based adaptability of sorghum to the LDCs as compared to barley which is largely restricted to the temperate climates. Projects a, b and d were unanimously approved.

The LA Bureau was opposed to project c. It had strongly recommended that the pearl millet project not be carried to the project paper stage on April 16, 1974 after reviewing the proposal at the PID stage. The project was tabled

5010-110

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

2. Résume of the Discussion at the R&DC on the Pearl Millet Project Paper

It was the opinion of the LA Bureau's representatives that TAB projects should be reviewed on a basis of their priority importance to the solution of bottlenecks retarding the social and economic development of the poor sector of the population in the LDCs. By this criteria, we assigned a low priority to work on pearl millet.

Pearl millet is not grown for human consumption in the Western hemisphere. We pointed out that the U.S. does not excel in technical know-how in the breeding of millet even though Kansas State University, the proposed contractor, does have several staff members working on the crop. We contended that it should not be the U.S. role to develop such expertise in order to provide technical assistance, but that we might better concentrate AID research effort in crops where U.S. competence already exists. NE/TECH, represented by Robert Morrow also strongly backed this contention. AFR/DS, represented by Woodrow Leake, said his bureau was in favor of the project because of the importance of pearl millet as a cereal grain in many countries of Africa. ASIA/TD, represented by Calvin Martin, sided with the Latin American Bureau representatives and NE/TECH.

Both ASIA/TD and NE/TECH agreed with AFR/DS that under the right circumstances there would be justification for TA/AGR's funding of assistance to millet research. Robert Morrow pointed out, since ICRISAT has been designated as the International Agricultural Research Center responsible for the improvement of millet, TA/AGR might well consider contracting through ICRISAT to undertake any work in pearl millet research. Calvin Martin suggested that it might also be possible for TA/AGR to provide a grant in millet research to one of the Asian countries with whom ICRISAT would be working.

TA/AGR, Guy Baird, who presented the proposal, contended that it is not the role of the International Agricultural Research Centers to sub-contract for work which is not anticipated in their center's program. He said that the International Centers are not prepared to do so, and are agreeable to AID's acting in this capacity. Dr. Baird believes, however, that the Centers might well act as the coordinators of international donor assistance in those crops for which they were assigned responsibility. It was apparent that such an effort for coordination had not taken place before Kansas State University had submitted its pearl millet proposal. As a consequence, whether parts of the proposal under consideration duplicated work already contemplated by ICRISAT was not known. However, Dr. Baird said that at the International Centers Week, which had just been completed July 26 - 30, it had been agreed that members of Kansas State would work with ICRISAT to coordinate with the ICRISAT program of millet development.

A number of other issues also surfaced at the August 3 review. The point was made that, possibly with the exception of some post-graduate studies, the cost of training participants in the U.S. would prove greater than in India or at the ICRISAT where the crop is grown commercially. A similar point was raised in regard to the role of a U.S. institution managing a program of international nursery trials--it would be more economical if such work was carried out by ICRISAT.

Finally, it was pointed out that the pearl millet proposal dealt with only one of the species of millet. The question was asked whether such a project might not better include all the species of Pennisetum which are eaten as grain.

It became apparent as the review progressed that TA/AGR's efforts in the millets and the location where they could best be undertaken needed further study. AA/TA, Dr. Erven Long, characterized the sentiment of the regional bureaus well when he terminated the discussion with the observation that he sensed it was the view of the R&DC members that additional thought was needed in the presentation of a millet proposal.

3. The Present LA Bureau Position on a Millet Proposal

a. Though we consider millet to be a low priority in our region, we recognize that it has high priority value in the African and Indian continents. We would not object to a TA/AGR millet project designed to assist the development of the crop in those regions. The possibility should be investigated first of funding such activities as regional bureau projects.

b. Any TA/AGR assistance to millet production should first be coordinated with ICRISAT so as to assure that a duplication of efforts does not exist. We would not be favorably inclined towards a millet program with an American institution because millet is not grown for grain consumption in the Western hemisphere, and because we believe AID should not contract for technical assistance in the U.S. in those areas where the U.S. is not known to have a pre-eminent capability.

c. We proposed possible supplementary assistance to the work on millet at ICRISAT might be provided in a project coordinated with the ICRISAT program either if ICRISAT were to subcontract for such work in the region, or else if AID were to do the research by means of a contract with an LDC institution on the

Indian or African continents. Both the national agricultural research institutions of India and of Nigeria have developed special expertise in this crop, and either might be considered. As opposed to contracting with Kansas State University, considerable advantage could be achieved by building onto the capacity of an LDC institution where millet grain is locally consumed. Kansas State University might then participate overseas in the research either as a subcontractor or else as a copartner under Title XII.

d. We believe that programs for the testing of comparative millet nurseries and for most participant training should be assigned to ICRISAT as it is the International Center designated responsible for millet improvement. It is located in an area of extensive grain millet production, and as a consequence an economy of investment can be achieved there.

e. TA/AGR should strongly consider including other edible species of Pennisetum than pearl millet in any work it contemplates on this grain crop. Presumably, ICRISAT is working on a broad range of millet types.

Addressees:

LA/DR, RSimpson
LA/DR, WFeldman
LA/DR, DChaij
LA/DP, LSmucker
AA/TA, ELong
TA/PPU, SRFritz
TA/AGR, LHesser
TA/AGR, LOtto
TA/AGR, ELeng
AFR/DS, WLeake
ASIA/TD, CMartin
NE/TECH, RMorrow

PD-AAJ-257 931040

JUL 5 10 23 AM '77
AID
EXECUTIVE SECRETARIAT

ACTION MEMORANDUM FOR THE ACTING ADMINISTRATOR

THRU: ES

FROM: AA/TA, Curtis Farrar

Problem: Your approval is requested for the transmittal of eleven research proposals to the Research Advisory Committee (RAC) for review at its fifty-ninth scheduled meeting on July 14-15, 1977.

Discussion: Five proposals, including one project from AFR, are for extension of ongoing activities. Four proposals in food and nutrition and two in health are new projects. The proposed action will extend the project life beyond five years for Crop Production and Land Potential of Benchmark Soils of Latin America (University of Puerto Rico), Control of Vertebrate Pests (U.S. Department of Interior), and Research on the Sterility Method for Tsetse Fly Control (U.S. Department of Agriculture). All of the interregional proposals have been reviewed and approved by the Research and Development Committee (R&DC) unanimously or with no more than one bureau dissenting. As in the past, we will follow procedures by which RAC subcommittee members will receive all appropriate documents, including the regional bureau memoranda and the minutes of the R&DC, which call attention to specific issues. The R&DC minutes will also be distributed to the entire membership of RAC.

This particular group of proposals is not very representative of projects in the centrally funded research program. Seven of the eleven proposals are concerned with disease and pest control in humans and animals, a subject matter area that comprises only a small part of the total A.I.D. research effort. In general, the central research program reflects the same broad range of interests that is found throughout A.I.D.

We will advise you of RAC recommendations and, in the absence of contrary advice from you, proceed to implement the RAC recommended projects within current fund availabilities.

In the case of ongoing projects, the pipeline will be closely analyzed before any funds are added. We will adhere to the established Agency policy on the forward funding of technical assistance contracts.

Your approval to transmit the proposals listed in the enclosure constitutes the authorization to negotiate contracts for "Development Research" under Section 106(a) (3) of the Foreign Assistance Act of 1961 (as amended), and as required by Section 7-3.211 of the APR.

Recommendation: That you approve the transmittal of the eleven proposals to the RAC at its fifty-ninth scheduled meeting.

Approved: DAN *

Disapproved: _____

Date: 7/1/77

Attachment:

Summary Comments on Proposals to be Reviewed

Clearances:
GC/TFHA:ARichstein AHR Date 6/30/77
GC:MBall [illegible] Date 6/1/77

TA/RES:MRechcigl:lv:6/22/77 [illegible] 235-1720

* But please let pass these here for approval again after the RAC passes on them, as we discussed rather than proceeding straight to obligation.

DAN

Project #	Description	FY 77 Proposed Obligation	FY 79 Proposed Obligation	Total
		$000		
A. Enclosed as Proposed				
1181	Reduction of Aflatoxin in Maize (New - 3 years) Univ. of Missouri	265	165	430
	SUB TOTAL	265	165	430
B. Endorsed with Modifications				
0601	Crop Production and Land Potential of Benchmark Soils in Latin America (Ongoing - 3 year extension) Univ. of Puerto Rico	805	398	1,203
1040	Improvement of Grain Yield and Quality in Pearl Millet for Semi-Arid Areas (New - 3 years) Kansas State University	505	265	770
1026	Effects of Mechanization on Small Farmers (New - 3 years) International Rice Research Inst.	554	217	771
0526	Research on Artificial Propogation of Milkfish (Ongoing - 2 year extension) Oceanic Institute, Waimailo, Hawaii	912	0	912
0030	Research on the Sterility Method for Tsetse Fly Control (Ongoing - 2 year extension) USDA	925	0	925
0473	Control of Vertebrate Pests (Ongoing - 3 year extension) U.S. Dept. Interior, Denver Wildlife Research Center	900	500	1,400

		$000		
Project #	Description	FY 77 Proposed Obligation	FY 79 Proposed Obligation	Total
(cont.) B. Endorsed with Modifications				
1058	Alternative Malaria Control Methods (New - 3 years) USDA/Agricultural Research Service	500	0	780*
	Development of a Heat Resistant Attenuated Live Vaccine (Ongoing - 1 year extension) Parke - Davis & Co.	127	0	127
1133	Socio-Economic Analysis of the Impact of Water Projects on Schistosomiasis (New - 1 year) Resources for the Future	77	0	77
	SUB TOTAL	5,305	1,380	6,975
	TOTAL	5,570	1,545	7,395*
C. Deferred				
1038	Research on the Physiology and Ecology of Ticks (New - 3 years) International Center for Insect Physiology and Ecology			

*of which $280 is to be funded in FY 78

02
1040

Summary of RAC Recommendations - July 14-15, 1977

Improvement of Grain Yield and Quality in Pearl Millet for Semiarid Areas (New) - Kansas State University. Duration of project, 3 years; estimated cost, $770,000. *Peterson, Ludington, Moss, Swanson.

Recommendation: That the project be approved as proposed, with the recommendation: (1) that a major initial effort be directed toward production of high yielding synthetic varieties; (2) that there be free exchange of breeding materials and information between KSU and ICRISAT; and (3) that the field outreach aspects be primarily the responsibility of ICRISAT.

Note: With AID's commitment to help the world's poorest people, RAC felt research on pearl millet should be given a high priority since this crop is the staple food in the poorest LDCs of Africa and Asia. RAC felt that Kansas State University was an excellent choice as a contractor since they have over six years of research experience with pearl millet as well as excellent facilities, the proper growing climate, and a highly qualified staff. The RAC, however, recommended that a training component be built into the proposal as well as forward plans for an applied outreach program after the completion of the research phases.

*RAC review Subcommittee; chairman underscored

Improvement of Grain Yield and Quality in Pearl Millet for Semiarid Areas (New) - Kansas State University. Duration of project, 3 years; estimated cost $770,000.

Pearl millet is the 5th most important food grain in the world and is the principal food grain that can be grown in those areas that have such little rainfall as to be near-desert. Pearl millet is thus the primary food for many of the world's poorest people - those living in the Sahel of Africa, the Middle East, and in the drier parts of India. In contrast to maize, wheat, rice, and sorghum which are receiving major emphasis from international institutes and/or U.S. instutions, pearl millet has received little attention. Only one international center, the International Crops Research Institute for the Semiarid Tropics (ICRISAT) has been assigned responsibility for conducting research to increase production of pearl millet in the semiarid tropics.

The primary objectives of this project are to find pearl millet populations that have high yielding ability, drought resistance, improved nutrient content, and pest resistance. The populations will be tested in the field to identify lines that not only possess these desired features but also possess wide environmental adaptability. Other objectives include finding the physiological basis of drought resistance and the determination of the nutritional quality and digestibility of pearl millet.

This research at Kansas State is designed to complement and extend the work underway at the International Center and will form an integral part of a proposed broader-based millet and sorghum research support program by a consortium of U.S. universities under the new authorities of Title XII.

R&DC reviewed and approved this proposal in its meeting of May 3, 1977.

PD-AAD-857 9311040

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EXECUTIVE SECRETARIAT

2 AUG 1977

ACTION MEMORANDUM FOR THE ADMINISTRATOR

THRU: ES

FROM: AA/TA, Curtis C. Farrar

Problem: The Acting Administrator approved transmittal of 11 research proposals to the Research Advisory Committee (RAC) with a request that they be returned for your approval since you had not had an opportunity to review them.

Discussion: As requested by the Acting Administrator in his response to my Action Memorandum of July 5, 1977 (TAB A), I am resubmitting for your approval the 11 research proposals which were approved by Mr. Nooter for review by the Research Advisory Committee at its meeting on July 14-15, 1977. Six of the proposals are for new projects; five are for extension of current research projects. A list of the projects and funds proposed for their implementation is attached at TAB B.

A brief summary of each project and RAC recommendations resulting from their review is appended at TABs C-N. In brief, the RAC endorsed one project as proposed, recommended approval of nine projects subject to specified modifications, and deferred consideration of one project, Physiology and Ecology of Ticks, until a revised proposal is submitted. This project will come to you again prior to recommendation by the RAC.

We have accepted the RAC recommendations and are incorporating the suggested modifications, caveats and conditions of approval into the Project Authorizations (PAFs) which will be submitted for each project to the Assistant Administrators of the two sponsoring bureaus if you give your approval. Any outstanding environmental decisions will be made by the responsible Assistant Administrator at that time but prior, of course, to authorization. Negative threshold decisions have, in fact, been made for all but three of the ten projects proposed for approval.

For two projects, Alternative Malaria Control Methods and Vertebrate Pests, some further investigation is needed before the threshold decisions can be made; for the third Tsetse Fly Control, an Environmental Assessment has been completed and will be acted on shortly.

I would like to highlight two points of interest:

1. The Africa Bureau has requested that TAB accept transfer of AFR's project to develop a heat resistant measles vaccine since AFR does not have sufficient scientific expertise to continue to monitor the project. I have responded that TAB will accept technical management of the contract on behalf of AFR. (See TAB B).

2. I share both the RAC's receptivity and its concern about the Alternative Malaria Control Methods proposal of the USDA; I plan to review the proposal further with particular regard to environmental and management questions. I recommend your approval of this proposal with the understanding that I will not authorize the project until these questions are resolved.

Your approval of the 10 projects listed at TAB B (with the exception of the Tick Control project) constitutes the authorization to negotiate contracts for "Development Research" which is required by Section 7-3.211 of the AID Procurement Regulations. As stated above, research project statements and PAFs reflecting RAC recommendations will be submitted to the AA/AFR and AA/TA for authorization upon receipt of your approval.

Recommendation: That you approve the implementation of the 10 projects listed at TAB B.

Approved _____

Disapproved _____

Date 8-16-77

Attachment:a/s

Clearances:
GC,M. Ball _____ Date 8/8
GC/TRHA, A. Richstein _____ Date _____
AA/TA, E.J. Long _____ Date _____

TA/PPU:JGunning:pab:7/29/77:Ext. 59037
TA/RES:MRechcigl:7/29/77:Ext. 51720

PD-AAJ-257 9311040 (1)

MEMORANDUM

DATE: August 19, 1977

TO : AA/TA, Mr. Curtis Farrar

FROM : TA/PPU, John N. Gunning

SUBJECT: PP for Pearl Millet Improvement Project 931-1040 - Kansas State University

Attached for your review and approval is the PAF, covering memorandum, and PP for the Pearl Millet Improvement - Kansas State University research project. RAC Recommendations are discussed in the attached covering memo and included in the PAF if appropriate. The Administrator has approved the group of projects endorsed by the RAC at its July meeting (see memo attached).

Funds are available; no Congressional Notification is required. You made a negative environmental threshold decision on June 10, 1977.

I recommend you authorize this project by signing the attached PAF.

Attachments: a/s

cc: TA/AGR, Dr. L. Hesser
TA/RES, Dr. M. Rechcigl

PROJECT STATEMENT

A. Project Summary

1. Statistical

Project Title:	Agronomic and Nutritional Improvement of Pearl Millet for Semiarid Areas
New or Extension:	New
Contractor:	Kansas State University Manhattan, Kansas 66506
Principal Investigator:	Dr. Gary M. Paulsen
Coprincipal Investigators:	Dr. R. C. Hoseney Dr. A. J. Casady Dr. W. D. Stegmeier Dr. L. K. Edmunds
Duration:	Three years beginning with contracting estimated to be November 15, 1976
Total Estimated Cost:	$936,000 for three years
Funding by Fiscal Years:	FY 77 - $291,000 FY 78 - 322,000 FY 79 - 323,000

(Project may be forward - funded, combining FY 77 and 78)

Project Manager:	Earl R. Leng, TA/AGR/CP

2. Narrative Summary:

This is a proposal to reinforce cooperative international research and development activities in pearl millet (*Pennisetum americanum*), aimed at improvement of this crop for developing countries where it is an important food grain. The project will concentrate on the production and international testing of widely adapted, high yielding pearl millet populations, varieties and hybrids suitable for practical use in developing countries.

The project will develop and strengthen linkages and cooperation between the contractor and ICRISAT, as well as directly with research and extension agencies in developing countries. It has important training and field service components aimed at expediting and maximizing utilization of research findings and improved plant materials.

B. Research Purpose and Expected Products

1. Purpose

This project will utilize linkages and cooperation between U. S. institutions and ICRISAT, as well as research and extension agencies in developing countries, to improve production of pearl millet and extension of that improvement to the rural population. It is expected that products of this project will be of immediate usefulness in developing countries where pearl millet is a major crop, and thus farmers and consumers in those areas will be benefited in a reasonably direct fashion.

2. Objectives and expected products

a. Accelerate pearl millet improvement efforts in developing countries by creating for their programs widely adapted high yielding populations and varieties that have drought resistance, dwarf stature, photoperiodic insensitivity, and high nutrient content, and investigate possibilities of creating hybrids for use in developing countries.

b. Enable developing country national millet breeding programs to select for high yield, seedling vigor, high nutrient use efficiency, and drought resistance by modifying or developing selection methods for these criteria for use under developing country conditions.

c. Determine production recommendations for high pearl millet grain yields that will be applicable to conditions in developing countries or that are required for breeding efforts under the proposed plan and in developing countries.

d. Improve nutritional qualities of pearl millet grain by analyzing protein in all germplasm introductions and breeding materials; determining magnitude of variation in lysine content among and within populations and varieties; and determining characteristics of pearl millet grain protein, grain enzyme activity, and grain carbohydrate availability that influence grain quality, and determine nutrient value of traditional foods processed from millet grains.

e. Increase breeding efforts, germplasm resources, and cooperation of all pearl millet breeding programs by joining with ICRISAT and national programs in organizing and conducting International Pearl Millet Yield Trials and publishing a pearl millet newsletter.

f. Establish and maintain collections of introduced and improved pearl millet plant germplasm for distribution to researchers, national programs, and international agencies.

g. Provide international training and technical assistance to national pearl millet programs in developing countries.

C. Significance and Rationale for the Research

1. The Development Problem

Pearl millet is one of the five most important cereal grains used directly for human food (the others are rice, wheat, maize, and sorghum). In Africa and the Indian subcontinent, pearl millet is the most important food cereal in the drier cropping areas. Much less attention has been paid to the breeding, agronomy, and utilization of this crop than to the other major cereals. Yields under actual production conditions are very low and have not shown recent improvement as has been the case in other cereals. Little is known about the possibilities for nutritional improvement or the utilization of the grain for food products other than those traditional in India and Africa.

Pearl millet is typically produced on the poorest soils and consumed by the poorest people in countries where it is grown. In these areas, pearl millet is produced where no other crops will grow; sorghum and then maize are produced as the soils increase in fertility and moisture status. It is the most important food grain in the Sahel of Africa, where drought has had devastating human effects. Improved, widely adapted, drought resistant pearl millets are urgently needed for such areas.

Pearl millet improvement has been neglected worldwide as compared with work on other major food crops. The only significant pearl millet grain programs outside the U. S. have been some US-supported work in Africa, the India national and state programs, the IRAT program in Senegal, the former EEAFRO program in Uganda and, more recently, the program of ICRISAT in India. In the U.S., only the Kansas State/ARS Program is of significant size.

Although pearl millet is known as a "poor man's grain", it has a widespread favorable reputation among children, lactating mothers, and manual laborers for its nutrition properties. Chemical analyses and other research (The Millets: A Bibliography of the World Literature Covering the Years 1930-1963. 1967. The Scarecrow

Press, Inc.) indicate that this might be due to the generally excellent lysine content of pearl millet grain protein. The grain lysine content of many pearl millet lines is comparable to that of high lysine maize. However, some pearl millet lines have normal (i.e., low) cereal lysine content. The greater morphological variation and range of lysine in pearl millet than in most other cereals indicate the lysine content might be substantially further increased.

2. State-of-the-Art

In the United States, only four universities have any significant research in progress on this crop. Breeding and agronomic studies have been under way for some time at several Indian agricultural research centers and at a few locations in Africa. Recently, ICRISAT has taken international responsibility for pearl millet improvement and its research is starting to show promise.

Pearl millet is a cross-pollinating species and therefore highly variable as grown under usual field conditions. High yielding hybrids were produced in India some ten years ago, utilizing a combination of types developed in the U. S. and those native to India. These hybrids have not been successful, for the most part, because of major disease problems (especially ergot, which can produce fatal poisoning in humans) and poor seed set, the causes of which are not well understood. Some of the research stations in Africa have produced varieties which yield well under experimental conditions, but there is little evidence that these have been distributed to farmers on any significant scale.

In India, pearl millet has the "folk-wisdom" reputation of being a "strengthening" food, particularly in winter. Until recently, little was known about its chemical composition or actual nutritive value. Recent studies have indicated that it usually is higher in protein than most other cereals (averaging 13-15%) and also that some selections, at least, are quite high in lysine (up to 3.5% or more of total protein). It also has been determined recently that alpha-amylase activity is high in millet flour. This greatly improves the quality of risen breads made without added sugar or malt, and therefore could be important in carbohydrate utilization.

Within the past few years, Kansas State University has combined selections from Uganda with strains developed in Georgia to produce promising breeding populations. The selections now available, while not yet ready for release to cultivators, have excellent seed set, good seed quality, short plant height, good yield under stress conditions, and very high levels of protein and lysine content. The total lysine per 100 grams of grain exceeds that in opaque-2 maize. With further selection and international testing, these types could rapidly be utilized in developing countries, either directly or as components of further breeding and improvement programs.

Considering the paucity of past millet improvement work, the proposed project will have multifold beneficial effects on U. S. and foreign project will have multifold beneficial effects on U. S. and foreign capacity to solve developmental problems. Pearl millet has been most seriously neglected of the major food grains and, correspondingly, has the most potential for improvement. Testing pearl millet germplasm at more sites will increase its wide adaptation and yielding ability. Availability of improved germplasm and improved breeding and production techniques should accelerate release of improved varieties and increase pearl millet production in developing countries. Cooperation among Kansas State University, ICRISAT, developing country national programs, and other U. S. institutions will enhance all the programs. The number of trained millet workers in the U. S. and in developing countries is low. Increasing the number of pearl millet specialists would enable the U. S. to respond positively and competently to requests for assistance from developing countries. Raising the competency of pearl millet workers in national programs will increase their ability to meet local problems and improve the well-being of their citizens.

D. Plans to Develop Linkages and to Facilitate Utilization of Research Results

Appropriate linkage relationships and coordination with international and national and regional agencies will be developed. Kansas State University has developed plans for undertaking this coordination at an early stage of the project. These plans include:

1. ICRISAT and National Programs

Cooperation with the International Crops Research Institute for the Semiarid Tropics (ICRISAT) will be developed and continued. This cooperation will take the form of exchanges of germplasm, results, ideas, joint research, and conduct of International Pearl Millet Trials. KSU had a long association with Andhra Pradesh Agricultural University at Hyderabad. It is recognized that close coordination with ICRISAT will be required to achieve the maximum benefit, and this coordination will be established by mutual visits and discussions before the proposed project is undertaken.

National pearl millet programs will be assisted through as many channels as can be developed. The U. S. will benefit from them by knowing their needs and problems; they will benefit from

solutions, improved and introduced germplasm, and other assistance. International Pearl Millet Trials and an international Pearl Millet Newsletter will add further to cooperation with national programs in developing countries.

2. Puerto Rico and State Universities

Puerto Rico is an integral part of the proposed program. Cooperation with the Mayaguez Institute of Tropical Agriculture will be required for maximum development of improved pearl millet germplasm. The site will be used to accelerate pearl millet improvement by permitting extra generations each year. Random mating populations, germplasm increases, and breeding nurseries will be grown there. Approximately four annual trips to Puerto Rico are required to complete the anticipated work. One Research Assistant may be stationed there temporarily each winter depending on the work load. We have had similar arrangements with the Institute of Tropical Agriculture in the past and will have no difficulty with arrangements for the proposed program.

Mutual benefit will be gained from complementary pearl millet and sorghum studies at the University of Nebraska, Purdue University, Texas A&M University, and the University of Arizona. Cooperation will be developed with these institutions. This cooperation may take the form of additional sites for wide adaptation of breeding material, germplasm exchanges, specialized investigations others institutions cannot undertake, conferences, etc.

3. Dissemination and Application of Results

Expected results of the proposed program will be disseminated in several ways. The contractor expects to maintain direct contact with national pearl millet programs in developing countries and with the ICRISAT research and outreach programs. Both avenues will permit direct communication among this program, the ICRISAT program, and national programs. An international Pearl Millet Newsletter will be initiated and published. Pearl millet workers in all countries will be encouraged to contribute to the Pearl Millet Newsletter to foster exchange among national programs as well as exchange between our program and their programs. Format and purpose of the Pearl Millet Newsletter will be similar to those of the Wheat Newsletter (also edited and published at Kansas State University), the Sorghum Newsletter, etc. Research

results, descriptions of planned research, and availability and description of improved, released, and/or introduced germplasm will be published. The Pearl Millet Newsletter will be distributed without charge to contributors and programs in developing countries. Research results will also be published in the form of reports to A.I.D., technical papers, etc.; copies and reprints of these will be distributed to a mailing list of millet workers in developing countries.

The planned program will have a number of "products" that can be applied immediately by the developing countries. Improved pearl millet populations and synthetic varieties can be used as high yielding varieties, used to upgrade local varieties, or the widely adapted populations can be selected further by national programs in developing countries. Introduced germplasm possessing specific desirable traits - yield potential, drought resistance, high nutritive value, etc. - can also be incorporated into the national millet breeding programs. Techniques for screening millet for desirable traits, selection criteria, drought resistance, nutrient-use efficiency, etc., can be employed by national pearl millet programs to accelerate their work. Results on effect of processing on nutritive value of pearl millet food products might be used to modify traditional processing methods if that should seem feasible.

International pearl millet trials will have much "spin-off" value beyond their immediate objectives. Local pearl millet workers will be made aware of the availability and benefits of improved germplasm and improved production techniques. This knowledge and the constructive competition that frequently results from international trials should stimulate local programs where such stimulation is needed.

E. Management Considerations

No unusual management problems are expected to arise in connection with this project. It will be similar in concept and design to other centrally funded crop improvement research projects of TA/AGR.

Noncontract funded inputs will be substantial. These include time of two USDA/ARS investigators who will spend 25 per cent and 5 per cent of their time on the project and three KSU investigators spending 35, 20, and 40 per cent of their time on the project. Also there will be cooperation by other staff members, office and laboratory facilities, as well as use of equipment and extensive field facilities.

The project will be evaluated by a review and evaluation team visit to the campus during the first year of the project extension, probably during the growing season of 1977. In addition, management evaluations will be conducted each year and technical and managerial considerations will be under constant monitoring by the AID project manager.

Contractor will clear all manuscripts proposed for publication with the project manager, and will submit an annual report within 45 days of the close of each contract year.

F. Project Background Description

Previous millet research at Kansas State University includes:

1. Plant Improvement (USDA, Manhattan, Kansas)

During the early part of the KSU/USDA program, two open-pollinated pearl millet varieties from Uganda were grown in isolation. Seed was harvested from a number of the most agronomically desirable plants. Composited seed from each head was grown interspersed with Tift 239 (dwarf forage type from the U.S.D.A. program). F_1 populations were grown in isolation and allowed to random mate. F_2 populations were grown in isolation and selfed seed from bagged dwarf plants and open pollinated seed from dwarf plants were harvested. F_3 plants from the selfed seed were all of combine height; their grain was used for preliminary nutrition and utilization studies. The open pollinated seed from dwarf plants was composited and grown in isolation and allowed to mate randomly. Seed was harvested from the most agronomically desirable dwarf plants in each isolation. Their seed was composited and grown and about 2000 dwarf plants were bagged for selfing. Four-hundred selfed heads from plants with good seed set, good head exsertion, large seed size, and good stalk strength were harvested.

Two-hundred lines, representing the best 100 each in protein content and grain weight, were entered in replicated S_1 yield trials during 1973. Also during 1973, introduced lines were examined for stalk strength and top cross hybrids were developed for yield trials. Remnant seed of the top 20 yielding S_1 lines in the 1973 trials was grown in Puerto Rico in 1973-74 for recombination by random

mating. The population from combining the top 20 lines was released to plant breeders as RMP1 (S)CI. This is apparently the only pearl millet released for grain purposes in the U.S. to date. Seed from the random mating in Puerto Rico was grown in 1974, and 200 selfed heads were selected. Replicated S_1 yield trials were conducted in 1975, and remnant seed of the top 20 yielding lines were grown in in Puerto Rico in 1975-76 for recombination by random mating. Also in 1975 an introduced Senegal population was grown, and 200 selfed heads were selected for replicated S_1 yield trials in 1976.

2. Plant Improvement (Fort Hays Experiment Station)

Selection and breeding of pearl millet started in 1971 with varieties, lines, and bulk populations obtained from several sources. Uganda varieties Serere 3A and Serere 17 and bulk populations of their dwarf F_3 derivatives were obtained from Dr. A. J. Casady, Manhattan Kansas. Dr. G. W. Burton, Tifton, Georgia, supplied seed of several late maturing, tall and dwarf forage inbreds, and 141 plant introduction lines were received from the USDA Plant Introduction Station at Tifton, Georgia. An additional 139 plant introduction lines were obtained in 1972 and a bulk of approximately 1450 lines of the world collection of pearl millet was received from Dr. Gary Paulsen, Manhattan, Kansas, in 1974.

The Uganda varieties, particularly selections of Serere 3A, have been backcrossed two and three times to the dwarf form. Over one hundred BC_2F_4 and BC_3F_3 selections were composited and random mated in 1975. In 1976, the population will have 2000 or more plants selfed and the best 10 to 20 per cent of the S_1 lines will be grown in replicated yield trials in 1977 followed by recombination of superior lines and another cycle of selection. Selections from many of the plant introductions have been crossed to dwarf derivatives of the Uganda varieties, and inbred lines are being developed.

At the present time, selections of plant introductions are being converted to dwarf, early maturing forms through crosses involving the early maturing, large seeded PLant Introduction 185642 and Serere 3A, and with Tift $23DB_1$ and Tift $239DB_2$ contributing dwarfness, tillering ability, and fertility maintenance in the A_1 and A_2 cytoplasmic male sterility systems. Approximately two-thirds of the crosses with these 56 plant introductions will be in the F_2 or F_3 generations in 1976. The remaining plant introductions of the group of 56 are either receiving their initial crosses or are being place in three- and four-way crosses in the 1976 spring greenhouse. Some of the progenies will be maintained as inbreds and tested in F_1 hybrid combinations but the majority will be

screened for various traits and then placed in genetically broad based random mating populations, modified ear-to-row selection systems, or recurrent selection programs. Improved lines will be extracted and tested as parents in F_1 hybrid combinations.

The bulk random mating population of the 1450 lines of the world collection of pearl millet has been grown in isolation in 1974 and 1975 and will be handled similarly in 1976. Selection pressure consists of the elimination of late maturing genotypes by the shortness of the growing season and lack of moisture in the fall and by selection at harvest for desirable head, seed, and plant characteristics. Germplasm containing dwarfness, early maturity, and large seed size will be introduced in 1977 and eventually this material will be converted to a dwarf, early maturing population.

3. Agronomy and Physiology (KSU, Department of Agronomy)

Pearl millet has been treated like sorghum in previous studies; specific requirements of the species remain to be determined. Prior to 1973, the only yield data available were for a comparison of two pearl millet introductions from Uganda with two sorghum hybrids. Good yields were obtained in spite of droughty conditions, and yields of the tall introduced pearl millet varieties were not significantly different from those of the adapted sorghum hybrids.

Yield trials comparing a pearl millet line developed by A. J. Casady, a pearl millet hybrid furnished by G. W. Burton, and maize and sorghum hybrids were conducted at five Kansas locations during 1973.

Yields of the pearl millet hybrid, developed for forage use, were low because of late maturity. However, both millets contained much higher quality protein, particularly in terms of lysine content, than the maize and sorghum. A nitrogen fertility trial comparing dwarf and tall pearl millet lines, an iron nutrition trial comparing pearl millet and sorghum were also completed during 1973. Pearl millet grain for swine feeding trials was grown on about 2.5 acres; millet and maize were equally acceptable and efficient in the feeding trial.

In physiology studies, besides screening A. J. Casady's breeding lines for protein and seed weight, introduced lines were being screened for desirable traits and photosynthetic efficiency of pearl millet was determined. Approximately 130 lines obtained from the World Collection and personal contacts in Africa and India were included in the screening studies. In the photosynthesis studies, pearl millet had the same efficient photosynthesis system of corn and sorghum, not the inefficient photosynthesis system of other cereals.

4. Grain Composition (KSU, Department of Grain Science and Industry)

Protein content has been 3-4 per cent higher in pearl millet lines of A. J. Casady than in sorghum grain produced under similar conditions. The amino acid distribution has also been much better in pearl millet than in sorghum. Lysine, the major limiting amino acid in cereals, averaged 3.6 per cent of the protein in pearl millet compared with about 2.0 per cent in corn and sorghum. The lysine content of pearl millet is comparable to that of high lysine corn. Pearl millet lines obtained from other sources have ranges as low as 1.9 per cent lysine, indicating considerable genetic variability in that characteristic.

Scanning electron photomicrographs of pearl millet endosperm show both the hard and soft endosperm types similar to those found in corn and sorghum. The soft endosperm is characterized by nearly round starch granules with a thin protein matrix and a large amount of intergranular air spaces. In contrast, the hard endosperm is tightly packed with no intergranular air spaces. The starch is polygonal in shape and covered with a layer of matrix protein embedded with a large number of spherical protein bodies.

5. Grain Utilization

A composite flour (90% wheat, 10% pearl millet) gave bread with excellent loaf volume, crumb grain, and texture. A remarkable feature of the composite flour was that bread characteristics were also excellent when sugar and malted wheat flour were removed from the formula. This is presumably because of high a-amylase activity of the pearl millet flour. The bread has excellent flavor and is nutritionally superior to a 100% wheat flour loaf. This finding should be of particular importance in DCs where bread is a traditional food but wheat flour and malted wheat flour are imported and sugar is imported or is an important export item.

Procedures have been developed to produce cookies from pearl millet and sorghum flours. The procedure involved hydrating the flour for 3 hours with water followed by air drying and supplementing with soy oil. The cookies have spread and top grain characteristics equal to wheat flour cookies. The cookies are more fragile than those from wheat flour and are slightly more gritty. Mixtures of wheat flour and pearl millet flours (1:1) gave cookies that were not significantly different from 100% wheat flour cookies in eating quality or appearance as judged by a taste panel.

In rat feeding trials, growth was faster on an unsupplemented diet of bajra (pearl millet) than of ragi, (Eleusine coricana), corn, or sorghum. In these trials, lysine appeared to be the first-limiting amino acid in pearl millet, as is the case in other cereals such as maize and sorghum (Pushpamma, S., D. B. Parrish, and C. W. Deyoe. 1972. Improving protein quality of millet, sorghum, and maize diets by supplementation.) Nutrition Rpts. Intern. 5 (2):93-100. (Ph.D. Thesis, Kansas State University.)

At equal protein levels, chick performance was similar on pearl millet and sorghum rations. The amino acid profile, rate of chick gain, and efficiency of utilization of feed were better for pearl millet than for sorghum as a source of energy and protein for broiler strain chicks (Sanford, P.E., F. Camacho, R. P. Knake, C. W. Deyoe, and A. J. Casady, 1973. 62nd Annual Meeting, Poultry Science Association).

G. Project Design and Method

The major objective of this project is to conduct practical studies on the production and utilization of pearl millet, which will serve (a) as a direct source of improved materials and technology for developing countries, and (b) as a research training and field service back up to ICRISAT, which has been assigned international responsibility for pearl millet improvement by CGIAR. Specific project design activities are:

1. Improved pearl millet populations and varieties probably have more immediate use than hybrids to farmers and national programs in developing countries. Consequently, major emphasis of the proposed program will be on millet population improvement. Techniques developed for breeding maize are directly applicable to pearl millet; researchers will use a random mating and S progeny selection procedure for the most part. However, other recurrent selection methods and modified ear-to-row selection systems will be used where they are preferable.

   Superior germplasm for traits determined to be important must be identified and incorporated into improved pearl millets. Germplasm available from the Germplasm Introduction, Maintenance, and Distribution program will be evaluated for essential traits - nutrient content, yield components, lodging resistance, maturity, etc. - and desirable lines will be added to broadbased random mating populations or used to develop new random mating populations. The

populations will be grown in Kansas and Puerto Rico to eliminate day length sensitive types. Lines that show good agronomic plant type, good seed set, good standability (lodging resistance), and resistance to prevalent pests will be selfed. Yield and nutritional quality (protein and lysine) will be determined on the S_1 lines grown in low and medium rainfall areas in Kansas, and in other states. Remnant seed of the highest yielding, most nutritious lines will be combined and another cycle of random mating and S_1 progeny selection for yield and nutrient content will be carried out. The Institute of Tropical Agriculture in Mayaguez, Puerto Rico, will be used to grow random mating populations and germplasm increases to permit extra generations each year and thereby accelerate pearl millet improvement.

The cycles of random mating and S_1 progeny selection will accumulate genes for high yield and high nutrient content. Frequency of genes for low yield, poor nutrient content, site specificity, poor plant type, day length sensitivity, pest susceptibility, lodging, and poor seed set will decrease. The improved millet populations, after being tested in international trials, can be used directly or selected further to produce synthetic varieties or hybrids in developing countries. The wide adaptability of the improved populations as a result of selection and testing over a range of conditions should make them directly and immediately useful to developing countries.

2. Wide adaptability is essential for maximum distribution and utilization of improved pearl millet germplasm and for high grain yields under varying environmental conditions in developing countries. Improved pearl millets have been distributed to several states and developing countries, where they have performed significantly better than existing types. However, lack of resources has limited selection and testing of materials under the range of conditions needed to give them wide adaptability. Present pearl millets, pearl millets available from other programs, and additional improved pearl millets developed under the proposed program must be selected and tested under a greater array of conditions. This will be accomplished by increasing the number of selection sites in Kansas, expanding the Puerto Rico program, attempting to develop a testing program with programs that may be initiated in other states, and entering the most advanced materials in International Millet Yield Trials. The Kansas locations have an annual precipitation of 16 to 34 inches, giving a good range within the state. Wide adaptability of breeding materials will be achieved by introducing and accumulating genes that favor that trait into the synthetic varieties, random mating populations, and hybrid millets developed.

3. Yield components - plant number per hectare, tiller (head) number per plant, grain number per head, and weight per grain - determine total grain yield per hectare. The relative importance of each component in widely adapted improved pearl millets is unknown, but must be determined to aid in selecting S_1 and inbred lines for the breeding program. Indian studies indicate tiller number is correlated with yield, but their studies, mostly with local varieties, have not shown consistent relationship of other components with yield.

   Available improved pearl millets and diverse pearl millet plant types (height, tillering potential, head characteristics) will be grown at different plant densities under medium and low precipitation conditions. Head number, grain number, grain weight, head dimensions, and other characteristics will be determined for the tillers and main culm. The contribution of each yield component to total grain yield will be determined by correlation analysis. The traits identified as contributing most to yield will be emphasized in selection germplasm to incorporate into improved millets.

4. Pearl millet hybrids have nearly doubled experimental grain yields in India when the best hybrids were compared with local varieties (Burton, G. W. and J. B. Powell. 1968. Adv. Agron. 20:49-39). However, many of the hybrids lacked wide adaptation and were no better than local varieties when tested over a range of conditions.

   Top cross hybrids, which can be developed most rapidly, will be made and tested against their parents over a range of conditions in Kansas. Additional testing sites will also be used if arrangements can be made. Pearl millet A-lines (cytoplasmic male sterile), B-lines (sterility maintainer) and R-lines (fertility restorer) are also available and are being used. When widely adapted populations are available, they will be used to create widely adapted A-, B-, and R-lines for hybrid development. These hybrids will likewise be tested over a range of conditions in Kansas, and other sites. The lines will also be supplied to national millet programs in developing countries for testing under their conditions.

5. Day length sensitivity hampers utilization of much pearl millet germplasm because of its short day response. Lines that do not flower and mature have limited usefulness outside of the greenhouse, and desirable traits possessed by these lines often cannot be fully exploited. The Puerto Rico site will alleviate part of the problem but, to make maximum use of introduced germplasm for this program and other programs, we will convert day length sensitive introductions to day length insensitive lines. The conversion program will be mostly on a population basis. Introductions that have similar agronomic, maturity, and morphological

traits will be placed into random mating populations of photoperiod insensitive germplasm. After several generations of random mating under short day conditions in Puerto Rico, subsequent generations will be alternated between Kansas and Puerto Rico. These photoperiod insensitive short maturity populations will contain the germplasm of the original introductions.

6. Agronomy and Physiology

Present and planned pearl millet physiology projects at ICRISAT are (a) studies on carbohydrate source sink relationships, (b) studies on nutrient uptake, distribution, and translocation, (c) studies on drought endurance, and (d) studies on development of seedling, root system, and panicle (Kassam, A. H. 1975. Cereal physiology projects, Cereal Consultation Meeting, ICRISAT, Hyderabad, April 14-18). The ICRISAT work will be complemented by studies at Kansas State University that will accelerate identification and utilization of pearl millet germplasm for improving production in developing countries. Our work, combined with that at ICRISAT and elsewhere, will also contribute toward composing pearl millet "ideotypes", descriptions of ideal plant types for semiarid conditions.

7. Seedling vigor problems require excessive use of grain for high planting rates or replanting and cause inadequate stands and low productivity. Genotypes are needed that will establish themselves under adverse conditions. We will screen introduced germplasm and S_1 lines in breeding populations to identify lines that have high seedling vigor, determine the magnitude of variation in seedling vigor within populations, and relate seedling vigor to seed characteristics that can be easily screened. Standard methods of measuring seedling vigor - root and shoot yield, mechanical and osmotic stress, and adenylate charge - will be compared to determine those that are applicable to pearl millet improvement.

8. Nutrient use efficiency is more important for pearl millet than for other crops because pearl millet is typically produced on the most infertile soils. That suggests that considerable variation for nutrient use efficiency exists in pearl millet; marked resistance to iron deficiency chlorosis compared with sorghum is a case in point. Because nitrogen is the most limiting nutrient in soils where pearl millet is grown and is likely to remain so, major emphasis will be placed on that element. Possibilities and techniques for breeding for nitrogen use efficiency will be determined by growing S_1 breeding lines under nitrogen deficient and high nitrogen fertility conditions. Yields of each line will be compared and plant traits that contribute to efficient nitrogen use - activity, period, and duration of nitrogen uptake, nitrogen reduction and accumulation, and nitrogen translocation- will be

determined. Correlation analyses will identify those traits that are most useful to breeders in selecting for nitrogen use efficiency.

In a team program with CIMMYT, it was found that maize synthetic varieties yield highest only under the fertility conditions used to screen the families that compose them (Muruli, B. I. 1976. Ph.D. thesis, Kansas State University). Studies on sorghum nutrient use are presently being initiated by R. B. Clark at the University of Nebraska. The program of R. B. Clark and the program at Kansas State University differ in approach but have similar objectives. Exchange of information will enhance both programs, and can be easily accomplished by the close proximity (130 miles) of the two universities. Information on nutrient use efficiency and studies on nutrient uptake, distribution, and translocation by the ICRISAT cereal physiology group will be mutually useful. KSU will identify traits that contribute to maximum yields under nutrient limiting conditions and ICRISAT will define nutrient uptake, distribution, and translocation patterns for given yields.

9. Drought resistance is one of the most important attributes required in pearl millet because of its nearly restricted production to the most droughty soils. Breeding for drought resistance is handicapped by lack of good physiological selection criteria, particularly since drought resistance can be imparted by a number of different physiological and morphological traits. A project on drought by D. R. Krieg at Texas is determining physiological traits related to drought resistance in pearl millet and the ICRISAT cereal physiology program is studying root systems, leaf water potential, and leaf desiccation tolerance in drought endurance (Kassam, ibid.). KSU will develop information that adds to these studies on an aspect that is not being investigated by them: the role of reduced leaf area in drought resistance.

Most pearl millet genotypes grown in developing countries are tall, leafy, and have a low grain:leaf area ratio. Selecting genotypes that have high grain weight:leaf area ratio and combining that trait with traits selected at ICRISAT should enable farmers in developing countries to produce higher grain yields on limited water supplies.

Drought resistant subpopulations will be compared with original populations in irrigation trials having four drought intensity levels. If tests are successful, introduced germplasm will be screened to identify lines that have high grain yield:leaf area ratio that can be used to upgrade drought resistance of farmers'

varieties. The method has two advantages over current methods: it exploits a naturally occurring phenomenon during drought and it is easily measured. The only equipment required is a tape measure for leaf length and width. Thus, it should be more applicable to breeding conditions in many developing countries where elaborate equipment and/or time are not available to measure complex physiological phenomena.

10. Production Practices

Most production recommendations developed at Kansas State University would not be relevant to the different agronomic and environmental conditions in developing countries. Consequently, effort in this area will be restricted to providing basic information to the breeding program to increase the wide adaptability of their germplasm. The effort will concentrate on field planting density and the interaction between density and soil nitrogen availability. Information on this is required by pearl millet breeders because plant density directly affects yield components - tiller number, seed number, and seed size - that determine total grain yield. We will use dissimilar pearl millet plant types, particularly for height, tillering potential, and if available, leaf angle, and study response of yield and yield components. The studies will be conducted under a wide range of rainfall conditions, from 35 inches in eastern Kansas to 16 inches in western Kansas, to relate yield components to moisture availability. In density experiments with other crops, yield per plant and plant density have a logarithmic relationship that enables yield predictions from a limited number of treatments. Relationships of this type have not been determined for pearl millet, but will be determined under the accelerated program.

11. Plant Protection

a. Reaction of pearl millet to commercial herbicides will be determined to enable programs in developing countries to select those herbicides that will control local weeds without harming the crop. Weeds markedly reduce crop yields and compete for scarce water and fertilizer nutrients required by millet. By knowing reaction of pearl millet to commercial herbicides, specific herbicides can be used to control specific local weed problems. We will field plot test available commercial herbicides at different rates to determine reaction of pearl millet to them. Emphasis will be on herbicides that are likely to be or become available in developing countries, particularly triazine herbicides, which we have used with good success.

b. Diseases, insects, birds, and rodents are important detriments to pearl millet production wherever the crop is grown in developing countries. However, the specific problem varies from country to country and from season to season within any one country. We have few of the disease and insect pests of pearl millet in the developing countries and birds and rodents have not been problems under our conditions. Also, a CRIS (USDA Current Research Information System) retrieval found a number of U. S. supported projects on pearl millet diseases and insects being conducted in Georgia, Africa, and India. Consequently, we will note incidence and severity of diseases and insects in our pearl millet breeding materials, field trials, and introductions, but screening for specific pests will not be done. However, we can and will make improved and introduced germplasm available to developing countries national programs for screening and aid their personnel with specific recommendations for pest control.

12. Grain Nutrition and Utilization

a. Pearl millet introductions, populations, S_1 breeding lines and field trials will be routinely analyzed for protein content to maintain the generally high protein content of millet as yields increase. Protein content of pearl millet grain is as important a selection criterion as yield or any other trait.

b. Amino acid profiles, minerals, and certain vitamins will be analyzed to determine variation in these constituents among genotypes and environments. Particular attention will be paid lysine. Many populations and lines analyzed have a high grain lysine content, but some have low lysine content comparable to that in other grains. The high lysine trait must be transferred to low lysine lines and populations where it is lacking to upgrade the nutrition of persons in developing countries. Information obtained will enable the plant breeders to do this.

c. Pearl millet grain proteins will be fractionated by a modified Osborne procedure. Amino acid distribution in the isolated proteins will be determined, and the proteins will be characterized by techniques such as SGE, gel filtration, etc. Similar comparisons will be made for low and high lysine lines (already identified). This information, together with scanning electron photomicrographs of grain morphology, will be used in an attempt to develop rapid methods of detecting high lysine lines in the pearl millet breeding program.

d. Milling and other processing procedures will be developed to produce pearl millet flour and food products. Chemical analysis will be used to characterize the nutritional value of the flour and foods and compare it to the whole grain. Emphasis will be on determining how chemical composition and nutritional value are affected by various precooking processing methods. Information will also be obtained on how the chemical composition and nutritive value vary among various component parts of the pearl millet grain.

e. Feeding trials will be extended using rats as primary test animals. Objectives of the trials will be to confirm chemical analysis data and extend the information obtained thus far with rats and chicks. Primary emphasis will be on determining the biological value of traditional foods prepared from pearl millet.

f. Previous work has shown pearl millet grain to contain an extremely active a-amylase system (Badi, S. and R. C. Hoseney. 1976. Cereal Chem. In Press). This high activity, which exceeds that in any other cereals tested, would be expected to influence germination of pearl millet seed and processing and digestibility of pearl millet food products. Our work and previous Russian work also showed that pearl millet starch contains about 12 per cent amylose compared with 22 per cent in sorghum grain, for instance. The degree of genetic variability in those two factors, a-amylase and amylose, and others is unknown. The variability will be determined with emphasis on the effects of any variability on functionality of pearl millet grain for food use and digestibility of traditional food products.

13. International Pearl Millet Yield Trials

Germplasm adaptability and diversity, breeding efforts and output, and cooperation among pearl millet breeders are increased when products are compared in international trials under a range of conditions and environments. We will organize international pearl millet yield trials in cooperation with ICRISAT, developing countries' national programs, and other interested agencies. Details and responsibilities of international pearl millet yield trials - locations, entries, data obtained, etc. - will have to be worked out with all the interested agencies. Kansas State University can take overall responsibility for the trials, can put up and distribute seed, prepare field books, and process data for all locations, or can handle trials in the Western Hemisphere. Specific arrangements will depend on the needs of ICRISAT and the national programs. It is important, in any case, that international pearl millet yield trials get under way as soon as possible.

14. Germplasm Introduction, Maintenance, and Distribution

Proposer holds a seed import permit for pearl millet and sorghum, issued by APHIS to L. K. Edmunds, ARS, USDA, and Kansas State University. Under this permit, seed from presently restricted sources in Africa and Asia is channeled through APHIS to Kansas State University for grow out under quarantine in an isolated greenhouse on the campus. Present capacity, depending on amount of replication desired and occasional service to related programs at other land grant institutions, should allow up to 200 entries per year.

KSU will expand its introduction facility to establish a pearl millet germplasm introduction, maintenance, and distribution center. They already have a large refrigerated dehumidified facility for crop germplasm that will accommodate the program. All introduced and improved pearl millet germplasm will be preserved and increased as required and distributed as requested.

15. International Training and Technical Assistance

a. Benefits of multidisciplinary approaches to solving agricultural problems in developing countries have been amply demonstrated (Strategies for Agricultural Education in Developing Countries. Second Bellagio Conference, 1975. The Rockefeller Foundation). We propose a multidisciplinary team graduate program for international students in pearl millet improvement, production, and utilization. Primary objectives of the program are to develop technical knowledge and skills and instill attitude and methods of multidisciplinary research into students during graduate training. Students who meet program criteria will be selected by AID or ICRISAT. They will undertake research and course work for M.S. degrees at Kansas State University. Thesis research by the students will be on practical, applied pearl millet problems. Students will conduct their research as a team guided by a team of faculty from corresponding disciplines. Team research will be reinforced by frequent team meetings, seminars, discussions, and trips. After completing their graduate requirements, students will enter millet programs in their home countries.

Students selected for the program must meet criteria of (1) capacity and desire for training in pearl millet improvement, production, and utilization, (2) assured employment in millet programs in their home countries after completion of their

training, and (3) satisfaction of requirements for admittance to the Kansas State University Graduate School, including B. S. degree or equivalent, TOEFL examination, and medical standards. An enrollment of five international graduate students from national millet programs in developing countries is anticipated.

Direct technical assistance will be provided by conducting intensive "full-load" schools to workers in national millet programs. The "full-load" schools will present pearl millet biology, breeding and experimental methods, production and utilization recommendations, extension techniques, and sources of technical assistance, information, improved germplasm, etc. Approximately four "full-load" schools will be held in different countries during each year of the program.

Instructional and informational materials relating to millet improvement, production, and/or utilization will be prepared, translated (to French), reprinted, or published for use by national pearl millet programs in developing countries as requested by TA/AGR.

Consultation on development or reorganization of national millet programs, diagnosis of specific problems, techniques, and trainee selection will be provided to national pearl millet programs in developing countries at the request of USAIDs and TA/AGR.

An international pearl millet conference will be held at Manhattan, Kansas, during the second year of the program. The conference will be aimed primarily at directors of national pearl millet programs; travel, and subsistence funds are requested for their participation. Other participants will be from ICRISAT and other institutes, ministries of agriculture, U. S. and other universities interested in millet, USDA, and AID.

H. Time Phased Work Plan

Detailed on the following page are those research efforts needed to accelerate pearl millet improvement and to make the germplasm, training, and technical assistance available worldwide. Identified are the widespread fundamental problems which apply to pearl millet wherever it is grown.

Activities to solve these problems are divided into seven subsections (corresponding to the items shown above in "G. Project Design and Method") and each is an integral part of the overall program. All activities will be coordinated with programs at ICRISAT and other institutions.

The following work plan shows the scientists from KSU who will work with each phase of the project, depicts the total per cent of effort to be devoted to each item, and shows in general terms the breakdown by program years. More detailed work plans will be developed by contractor before field activities begin in January 1977.

H. Time-phase work plan

Activity Number	Activity Title	Scientist Responsible	% of Total Program	Year 1	Year 2	Year 3
Ga.	Breeding and Genetics		33			
(i)	Population improvement	Casady/Stegmeier	(16)	Initiate	Continue/Test	Continue/Test/Comple
(ii)	Wide adaptability	Casady/Stegmeier	(8)	Initiate	Continue/Test	Continue/Test/Comple
(iii)	Yield components	Casady/Stegmeier	(2)	Initiate	Continue/Complete	----------
(iv)	Hybrid possibilities	Casady/Stegmeier	(4)	Initiate	Continue/Test	Complete
(v)	Daylength conversion	Casady/Stegmeier	(3)	Initiate	Continue	Complete
Gb.	Agronomy and Physiology		16			
(i)	Seedling vigor	Paulsen	(4)	Initiate	Continue/Complete	----------
(ii)	Nutrient-use efficiency	Paulsen	(4)	Initiate	Continue/Test	Complete
(iii)	Drought resistance	Paulsen	(4)	Initiate	Continue/Test	Complete
(iv)	Production practices	Paulsen	(4)	Initiate	Continue/Complete	----------
Gc.	Plant Protection		4			
(i)	Herbicide reaction	Paulsen	(2)	Initiate	Continue/Complete	----------
(ii)	Plant pests	Edmunds	(2)	Initiate	Continue	Complete
Gd.	Nutrition and Utilization		16			
(i)	Protein analyses	Hoseney	(4)	Initiate	Continue	Complete
(ii)	Lysine analyses	Hoseney	(3)	Initiate	Continue	Complete
(iii)	Protein characterization	Hoseney	(3)	Initiate	Continue/Complete	----------
(iv)	Food products	Hoseney	(3)	--------	Initiate	Complete
(v)	Feeding trials	Hoseney	(2)	--------	Initiate	Complete
(vi)	Carbohydrate availability	Hoseney	(1)	Initiate	Continue/Complete	----------
Ge.	International Millet Trials	Paulsen/Casady	5	Organize	Initiate	Continue
Gf.	Germplasm Maintenance	Casady/Edmunds	5	Initiate	Continue	Continue
Gh.	International Training and assistance		20			
(i)	International grad students	Staff	(12)	Initiate	Continue	Complete
(ii)	"Full-load" schools	Staff	(3)	Initiate	Continue	Complete
(iii)	Instructional materials	Staff	(1)	--------	Initiate	Complete
(iv)	Consultation	Staff	(1)	Initiate	Continue	Complete
(v)	International Conference	Paulsen	(3)	Organize	Conduct	----------
	Millet Newsletter	Paulsen	1	Organize	Initiate	Continue

I. General Appraisal

This project has been given top level priority by the Crop Production Division and Office of Agriculture. In addition to the need for developing improved pearl millet varieties for the DCs, the strong support to be provided ICRISAT's pearl millet program is considered essential to the success of a pearl millet improvement program.

Less research and breeding work has been conducted with pearl millet than with any of the other major cereal crops. In the United States, only four universities have any significant research in progress on this crop and only one (Kansas State University) is devoting more than one full time equivalent research scientist's time to the crop.

The proposing institution has a strong staff with excellent experience in most of the developing countries. Equipment needed for the proposed project is available with the exception of adequate protein characterization equipment. A protein fractionation centrifuge for that purpose will be requested. Facilities already available include cereal chemistry and physiology laboratories, Beckman 120 B amino acid analyzers, macro- and micro-Kjeldahl equipment, four walk-in growth chambers, adequate greenhouse space, spectrophotometers, balances, centrifuges, threshers, grinders, etc. The Department of Grain Science and Industry has complete milling and processing facilities available for all aspects of the proposed activities.

An IBM 360/50 system and ETEC scanning electron microscope are available in other departments of the university. User fees are required for their operation however.

Field facilities and equipment for breeding nurseries, screening lines and introduced germplasm, conducting agronomic trials, and producing grain for feeding trials are available at Manhattan and outlying stations. The Fort Hays Branch Experiment Station, where much of the off-campus research will be conducted, is one of the largest dryland stations in the world.

The proposal is sound in design and cost estimates are appropriate in the level of effort intended. The three-year time framework proposed for the initial project is recognized as too brief to reach full results, and it should be anticipated that extension would be desirable if progress is made as anticipated.

A detailed review of the project should be conducted at the end of the second project year - to assess progress and to determine the need for possible extension.

J. Environmental Considerations.

Since this project involves only controlled experimentation on small plots, and is therefore of limited scope and under strictly controlled conditions, it has been determined that it will not result in a major federal action which will have a significant effect on the human environment. Therefore, an Environmental Impact Statement or an Environmental Assessment will not be required.

A Negative Determination for this project is attached.

WORK PLAN

CONTRACT BUDGET AND LIFE-OF-PROJECT COST ESTIMATE

INPUTS	FY 77 M/M	FY 77 $(000)	FY 78 M/M	FY 78 $(000)	TO PROJECT COMPLETION FY79 $(000)	TOTAL $(000)
1. Salaries	168	130.2	168	143.2	150.2	423.6
2. Fringe Benefits	144	15.2	144	16.8	17.5	49.5
3. Indirect Costs (53.3%)	168	77.5	168	85.3	89.4	252.2
4. International Travel		19.2		34.2	22.8	76.2
5. Domestic Travel		6.0		6.4	7.0	19.4
6. Equipment		17.9		-	-	17.9
7. Materials & Supplies		18.0		18.0	18.0	54.0
8. Other Direct Costs		6.0		12.1	14.1	32.2
9. Publications		1.0		6.0	4.0	11.0
TOTAL COSTS BY INPUTS		291.0		322.0	323.0	936.0

OUTPUTS	FY 77	FY 78	FY 79	TOTAL
1. Population Development	72.75	80.50	80.75	234.0
2. Selection Methods	37.83	41.86	41.99	121.6
3. Production Packages	46.56	51.52	51.68	149.8
4. Nutritional Evaluation	46.56	51.52	51.68	149.8
5. Linkages and International Trials	14.55	16.10	16.15	46.8
6. Germplasm	14.55	16.10	16.15	46.8
7. Training and Technical Assistance	58.20	64.40	64.60	187.2
TOTAL COSTS BY OUTPUTS	291.0	322.0	323.0	936.0

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PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY 77 to FY 79
Total U.S. Funding $935,000 - three years
Date Prepared: May 1976

Project Title & Number: Improvement of Pearl Millet #931-17-130-632

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: To increase quantity and nutritional value of food crops in developing countries.	Measures of Goal Achievement: 1. Significant increase in per capita production of pearl millet in the DCs. 2. Improvement of nutritional quality of pearl millet.	1. Official production and population statistics (DCs, FAO, Foreign Agricultural Service estimates. 2. Improvement of nutritional quality surveys in DCs.	Assumptions for achieving goal targets: 1. Staffing with highly competent professional staff. 2. Active cooperation of agencies concerned, including ICRISAT. 3. Continuing interest in pearl millet as human food. 4. Nutritional quality can be improved without major constraints on yield.
Project Purpose: To utilize linkages and cooperation between U.S. institutions, ICRISAT, and developing country research and extension agencies to improve production of pearl millet and to extend that improvement to the rural population.	Conditions that will indicate purpose has been achieved: End of project status. 1. New, superior varieties available to farmers in DCs. 2. Research and development activities in pearl millet effectively assumed by DC agencies and international institutions and linked by a communications network.	1. Publications and reports of DC governmental agencies; on-site inspections of seed supply and planted acreages. 2. On-site inspection and review by AID/W personnel, contractors, and consultants.	Assumptions for achieving purpose: 1. Contractor and cooperating groups can find solutions to major constraints. 2. Local extension services are able and willing to promote proven practices. 3. DC, regional and international research institutions develop adequate capabilities.
Outputs: 1. Breeding stocks useful for further DC breeding programs. 2. Widely-adapted, stress-tolerant varieties suitable for use under marginal conditions. 3. Diverse genetic material and techniques for use in ICRISAT's improvement programs. 4. Well trained staffs for developing countries. 5. Effective research and informational linkages among international agencies. 6. Training and technical assistance services to supplement efforts of ICRISAT.	Magnitude of Outputs: 1. At least two superior varieties per agroclimatic region. 2. Minimum one test sited in each major pearl millet growing DC. 3. Total of 10 DC trainees trained at KSU. 4. Linkages with at least two international centers and at least 8 DC institutions.	1. Reports by contractor. 2. Reports by contractor, USAIDs, DCs, cooperators, and ICRISAT. 3. Same as above. 4. Contractor reports. 5. Communications and reports from DCs, contractor, and international and regional agencies.	Assumptions for achieving outputs: 1. Research findings will be available and DCs will request assistance. 2. DCs will cooperate. 3. Interest and resources exist in the DCs. 4. Collaboration of ICRISAT and other international institutions. 5. DCs possess or are willing to train qualified personnel.
Inputs: 1. AID/W provides financial support and project guidance. 2. Contractor provides qualified personnel, facilities, coordination & training. 3. Participating personnel and cooperation provided by 1) DCs, 2) USAIDs, 3) other U. S. institutions, and 4) ICRISAT.	Implementation Target (Type and Quantity) 1. AID/W funding of approximately $300,000/year. 2. KSU provision of at least 15 m/m professional staff without charge to project. 3. KSU provision of required field, laboratory, and office facilities.	1. AID/W records. 2. Contractor reports and on-site inspections. 3 USAID reports and on-site verification.	Assumptions for providing inputs: 1. AID/funding will be available. 2. Contractor will have qualified personnel and facilities available to the project. 3. ICRISAT, other international agencies, USAIDs, and DCs will have personnel and resources to support this activity.